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Article

Leveraging soft infrastructure for agricultural development: A policy perspective on technology adoption among agricultural extension officers in West Java

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Abstract: Technological advancements are transforming agriculture, yet adoption rates among agricultural extension officers, especially in regions like West Java, remain modest due to several challenges. This study applies the Technology Acceptance Model (TAM) to investigate factors influencing the adoption of agricultural technologies by agricultural extension officers in West Java. Specifically, we explore the role of socialization, training, access to technology, cost, perceived ease of use, and perceived usefulness in shaping behavioral intention and actual adoption. Data were collected from 295 agricultural extension officers via structured surveys and analyzed using SmartPLS 4 software. The findings indicate that socialization and training collectively enhance both perceived ease of use and perceived usefulness, while Technology Investment Worth specifically enhances perceived usefulness by emphasizing the value of the investment. Access to technology also plays a critical role in increasing ease of use perceptions. Both perceived ease of use and usefulness positively influence behavioral intention, which in turn is a strong predictor of actual adoption. The results provide valuable insights for policymakers aiming to increase technology uptake among agricultural extension officers, promoting sustainable agricultural practices through improved access, support, and cost reduction initiatives.

Keywords: agriculture; socialization; training; TAM; technology adoption

1. Introduction

Technological advancements are fundamentally transforming the agricultural landscape, enhancing productivity and efficiency across various farming practices. In regions like West Java, Indonesia, the role of agricultural extension officers is crucial for facilitating the adoption of innovative technologies to improve crop yields and ensure sustainable agricultural development. Agricultural extension officers act as intermediaries, bridging the gap between policymakers, technology providers, and farmers. However, these officers often face significant challenges when promoting new technologies to farmers. These challenges include a lack of training, high costs associated with new tools and methods, and limited access to necessary infrastructure and resources.

Addressing these barriers requires not only a focus on technology but also the development of appropriate infrastructure and supportive policy interventions that enable agricultural extension officers to guide farmers effectively. Recent studies emphasize that technology adoption is linked to increased yield, revenue, efficiency, and overall welfare in the agricultural sector, underscoring the importance of understanding the factors that influence this process from the perspective of agricultural extension officers (Areal and Pede, 2023).

The Technology Acceptance Model (TAM) serves as a valuable theoretical framework for understanding the factors that influence the acceptance and adoption of technology. Developed by Davis in 1989, TAM posits that two primary constructs—Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)—significantly impact an individual's Behavioral Intention (BI) to use technology (Davis, 1989). In the context of agricultural extension work, these constructs are particularly relevant as they help explain how officers perceive and decide on promoting new technologies to farmers. Research indicates that perceived usefulness and ease of use are critical drivers of technology acceptance, especially in agricultural contexts where these perceptions directly influence the ability of extension officers to facilitate technology adoption among farmers (Thomas et al., 2023).

Socialization and training programs—key components of soft infrastructure—play a critical role in enhancing the understanding of agricultural extension officers regarding new technologies, thereby influencing their perceptions of usefulness and ease of use. Programs that facilitate knowledge sharing and hands-on experience can significantly improve the officers' ability to teach and guide farmers. Moreover, improving access to technology through better infrastructure, such as digital platforms or supply chains, is crucial. The easier it is for extension officers to access and demonstrate technological tools, the more likely they are to perceive them as beneficial for agricultural development. For instance, initiatives aimed at increasing access to training and resources, often supported by policy frameworks, have been shown to lead to higher rates of technology adoption in the agricultural sector (Jimenez et al., 2021).

Cost is another important factor that influences technology adoption in agriculture. However, when agricultural extension officers perceive the cost as a worthwhile investment, it can positively impact their perception of usefulness and lead to higher adoption rates. In West Java, where many officers work with resource-constrained farmers, understanding how the cost of new technologies can be framed as an investment with clear benefits is crucial for encouraging uptake. Studies suggest that offering financial support through targeted policies, subsidies, or low-interest loans can further enhance the perceived value of technology, helping agricultural extension officers advocate for its adoption among farmers (Wang et al., 2024).

Given the crucial role that agricultural extension officers play in technology adoption, this study aims to explore the factors influencing their adoption of new agricultural technologies in West Java through the lens of the Technology Acceptance Model (TAM). Specifically, this research seeks to examine how socialization and training programs influence both the perceived ease of use and perceived usefulness of agricultural technology. It also investigates the role of access to technology in shaping extension officers' perceptions of ease of use, while exploring how the perceived worth of the technology investment affects their perceptions of usefulness. Furthermore, this study considers how perceived ease of use and usefulness drive behavioral intention to adopt new technologies and how this intention translates into actual technology adoption.

2. Literature review

2.1. Technological advancements in agriculture

Technological advancements are reshaping the agricultural sector globally, offering new tools and methodologies that improve productivity, efficiency, and sustainability. In both developed and developing countries, the adoption of modern agricultural technologies, such as precision farming, Internet of Things (IoT) devices, drones, and digital management platforms, has been associated with increased crop yields, optimized resource use, and better decision-making processes (Méndez-Zambrano et al., 2023). In Indonesia, agriculture remains a cornerstone of the economy, employing millions and providing a livelihood for rural communities (Johan et al., 2024). However, despite the potential benefits of technology, many agricultural extension officers face barriers when promoting these innovations to farmers, such as limited resources, a lack of training, and infrastructural challenges (Dibbern et al., 2024).

Agricultural extension officers play a crucial role in technology dissemination and adoption by providing the necessary knowledge and support to farmers. Their role is essential in ensuring that farmers understand the advantages of adopting new tools, especially in regions like West Java, where agriculture plays a significant socio-economic role. Globally, the introduction of smart agriculture technologies, such as satellite-based monitoring systems and automated machinery, has proven transformational in enhancing farming practices. However, the success of these technological interventions depends heavily on the efforts and capabilities of agricultural extension officers, who act as the primary link between farmers and modern agricultural practices (Choruma et al., 2024). Therefore, it is essential to understand the factors influencing technology adoption from the perspective of these officers.

2.2. Technology Acceptance Model (TAM) in agriculture

The Technology Acceptance Model (TAM), developed by Davis in 1989, is widely used for studying technology acceptance and adoption. The model posits that two primary factors—Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)—determine an individual's behavioral intention to use technology (Davis, 1989). Perceived Usefulness refers to the degree to which a user believes that the technology will enhance their performance or productivity, while Perceived Ease of Use reflects the user's perception of the effort required to use the technology. TAM has been applied in various sectors, including agriculture, to explain the decision-making processes of users in adopting new technologies (Bala and Venkatesh, 2008).

In the context of agricultural extension work, the TAM framework helps explain why some extension officers are more effective in promoting technology adoption than others. Studies have shown that extension officers are more likely to advocate for technologies that they find easy to use and beneficial to their outreach efforts. For example, a study on the use of mobile-based agricultural tools in Zimbabwe found that perceived usefulness significantly influenced extension officers' willingness to recommend new technologies to farmers (Masimba and Zuva, 2022). Similarly, research conducted in China demonstrated that the ease of use of digital farming platforms played a critical role in influencing extension officers' technology acceptance and subsequent promotion to farmers (Cui and Wang, 2023).

In developing countries like Indonesia, where agricultural extension officers often operate in resource-constrained environments, the TAM framework provides valuable insights into how access to technology, training, and cost considerations influence their ability to promote new practices to farmers. By understanding these factors, policymakers can design interventions that support extension officers in their role as technology facilitators.

2.3. Socialization, training and access to technology as infrastructure

Socialization and training programs are key factors influencing technology adoption among agricultural extension officers. As part of the "soft infrastructure" necessary for agricultural development, these programs help officers become familiar with new technologies, enabling them to better educate and support farmers. Socialization efforts not only provide technical knowledge but also create a community of practice where extension officers can share experiences and strategies for promoting technology uptake (Mgendi et al., 2022).

Research from various countries highlights the importance of training programs in promoting technology adoption through extension services. For instance, in India, government-led training programs on precision farming significantly improved extension officers' ability to educate farmers on new technologies (Rakholia et al., 2024). Similarly, in Nigeria, agricultural extension services that included structured training programs for officers resulted in increased adoption of smart farming tools by farmers (Kazeem et al., 2017). In Indonesia, officers who received comprehensive training on agricultural technologies were found to be more effective in encouraging farmers to adopt these innovations, highlighting the importance of investing in extension service training (Dewi et al., 2023).

Access to technology is another critical determinant of adoption, especially in rural areas where infrastructural limitations can pose significant barriers. Agricultural extension officers need access to reliable and up-to-date technologies to effectively demonstrate their benefits to farmers. In West Java, where access to affordable and relevant technology can be limited, government initiatives, such as subsidies for digital farming tools or improved distribution networks, can help extension officers better promote these tools (Geng et al., 2024).

2.4. Cost considerations and policy interventions

For agricultural extension officers, the perceived value of technology plays a significant role in whether they recommend it to farmers. When officers view the cost of technology as a worthwhile investment, they are more likely to advocate for its adoption. Numerous studies show that when the cost of technology is perceived as prohibitive, even extension officers may hesitate to promote it, regardless of its benefits (Mobarak and Saldanha, 2022).

Reducing the financial burden of technology through subsidies, low-interest loans, or tax incentives can improve the perceived usefulness of technology. For example, in China, government subsidies covering up to 50% of the cost of smart farming tools resulted in significant increases in adoption rates, supported by agricultural extension officers who viewed the reduced cost as a positive factor (Cui and Wang, 2023). Similar interventions in Indonesia could further enhance the role of extension officers in promoting technology by alleviating cost concerns.

2.5. Perceived usefulness, perceived ease of use, and behavioral intention

The relationship between perceived ease of use and perceived usefulness is well-established in the TAM framework. When agricultural extension officers perceive a technology as easy to use, they are more likely to view it as beneficial, which strengthens their intention to recommend and use the technology in their work (He and King, 2006). This relationship is particularly important in regions where extension officers may have limited exposure to new technologies.

Research in agricultural technology adoption has consistently shown that user-friendly tools have higher adoption rates, even among those with limited technical experience. For example, a study conducted in the United States found that agricultural extension officers who perceived digital farming platforms as easy to use were more likely to promote them to farmers (Pedersen et al., 2024). In Indonesia, where extension officers play a crucial role in educating farmers about technology, ease of use can directly impact their willingness to advocate for new tools and practices (Johan et al., 2024).

2.6. Behavioral intention and technology adoption: A policy perspective

Behavioral intention is often a strong predictor of actual adoption. For agricultural extension officers, the likelihood of promoting a technology is shaped by their perceptions of ease of use and usefulness. Studies show that when officers perceive a technology as both easy to use and beneficial, they are more likely to develop positive behavioral intentions, which in turn influences the success of technology adoption among farmers (Cinar and Parmaksiz, 2023).

In West Java, policymakers can support this process by addressing both infrastructural and psychological factors that influence extension officers' behavioral intentions. Offering training programs, reducing technology costs, and improving access to digital tools can create a supportive environment that encourages extension officers to embrace and promote new agricultural technologies (Ferrer et al., 2023).

Hypothesis development

Socialization and training programs are essential for educating agricultural extension officers about new technologies, making them easier to use. Numerous studies have shown that when extension officers are given structured training and support, they develop greater familiarity and confidence in using technology, which in turn increases their perceived ease of use (Jimenez et al., 2021; Mgendi et al., 2022). These programs reduce the learning curve associated with complex technologies, ensuring that officers feel more comfortable and competent in their application. Thus, training directly contributes to improving the extension officers' perceptions of technology's ease of use (see **Figure 1** for the research framework).

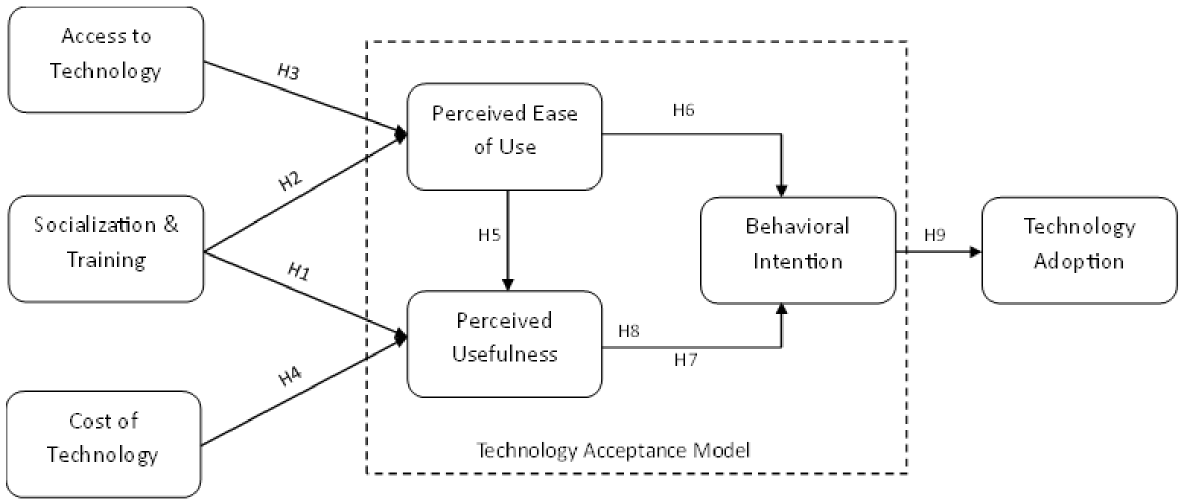

Figure 1. Research framework.

H1: Socialization and training have a positive and significant effect on the perceived ease of use of technology by agricultural extension officers.

Socialization and training not only increase the perceived ease of use but also enhance agricultural extension officers' perceptions of the usefulness of technology. Through exposure to real-world examples and hands-on training, extension officers can better understand how technology can benefit the farming communities they serve, leading to improved productivity, efficiency, and sustainability (Al-Mamary and Shamsuddin, 2015). As officers observe the practical benefits of technology during training sessions, their perception of the technology's usefulness grows, making them more likely to promote it to farmers.

H2: Socialization and training have a positive and significant effect on the perceived usefulness of technology by agricultural extension officers.

Access to technology, including the availability of tools, digital platforms, and supportive infrastructure, plays a critical role in shaping how easy technology is to use. When agricultural extension officers have reliable access to technology, they are more likely to explore and engage with it, which enhances their comfort and familiarity over time (Brown, 2002). Conversely, limited access leads to lower levels of interaction and experience, which can make technology seem more difficult to use. Studies have shown that providing extension officers with access to low-cost, easy-to-use technologies significantly increases their perception of ease of use (Kelly and Palaniappan, 2023).

H3: Access to technology has a positive and significant effect on the perceived ease of use of technology by agricultural extension officers.

The high cost of adopting new technology is one of the main barriers that reduces its perceived usefulness, especially for agricultural extension officers working with limited resources. When officers perceive the technology investment as prohibitively expensive, they may view it as less useful, regardless of its potential benefits (Dibbern et al., 2024). Financial constraints can overshadow the advantages of the technology, leading to lower adoption rates. Therefore, the perceived usefulness of technology decreases as the cost rises, unless financial support or subsidies are provided.

H4: Technology Investment Worth has a negative and significant effect on the perceived usefulness of technology by agricultural extension officers.

According to the Technology Acceptance Model (TAM), perceived ease of use positively influences perceived usefulness. When a technology is easy to use, agricultural extension officers are more likely to see it as beneficial and relevant to their work (Davis, 1989; He and King, 2006). Technologies that are perceived as difficult or complex may require too much effort to integrate into everyday outreach practices, which can diminish their perceived usefulness. As ease of use improves, extension officers are more inclined to recognize the value and applicability of the technology, making them more likely to recommend and use it.

H5: Perceived ease of use has a positive and significant effect on the perceived usefulness of technology by agricultural extension officers.

Behavioral intention, a key predictor of actual adoption behavior, is strongly influenced by perceived ease of use. Agricultural extension officers are more likely to intend to adopt and promote technology if they believe it is straightforward and user-friendly (Caffaro et al., 2020). Technologies that are complex or difficult to operate can discourage officers from considering their adoption, while technologies that are easier to learn and use encourage stronger behavioral intentions to integrate them into their outreach practices. This relationship has been widely supported in studies on technology adoption in agriculture (Widiar et al., 2023).

H6: Perceived ease of use has a positive and significant effect on agricultural extension officers' behavioral intention to adopt technology.

Perceived usefulness is a major factor that directly influences behavioral intention, according to the TAM framework. When agricultural extension officers believe that a technology will help them achieve their objectives—whether through higher productivity, improved service delivery, or efficiency improvements—they are more likely to intend to adopt and promote it (McCormack et al., 2021). Officers' perceptions of a technology's usefulness can significantly impact their decision-making process, motivating them to take the necessary steps toward adoption. This relationship between usefulness and behavioral intention has been consistently observed in agricultural context (Widiar et al., 2023).

H7: Perceived usefulness has a positive and significant effect on agricultural extension officers' behavioral intention to adopt technology.

TAM posits that perceived usefulness mediates the relationship between perceived ease of use and behavioral intention (Bala and Venkatesh, 2008; Davis, 1989). This means that while ease of use affects behavioral intention, it does so primarily through its impact on perceived usefulness. If a technology is easy to use, it enhances the perception of usefulness, which then strengthens the intention to adopt and promote the technology. Several studies have confirmed this mediation effect in various agricultural contexts (Geng et al., 2024; McCormack et al., 2021). Therefore, improving the ease of use can lead to greater perceived usefulness, which in turn boosts behavioral intention.

H8: Perceived usefulness mediates the relationship between perceived ease of use and behavioral intention to adopt technology by agricultural extension officers.

Behavioral intention is one of the most reliable predictors of actual technology adoption. Agricultural extension officers who demonstrate a strong intention to adopt and promote a technology are more likely to take concrete actions to integrate it into their outreach activities (Bala and Venkatesh, 2008). This relationship has been observed in various studies where extension officers' intentions to use new agricultural technologies led to higher actual adoption rates. In the case of West Java, officers who develop a positive behavioral intention—driven by perceptions of ease of use and usefulness—are more likely to adopt modern technologies and promote their use among farmers (Zhang et al., 2022).

H9: Behavioral intention to adopt technology has a positive and significant effect on technology adoption by agricultural extension officers.

3. Research method

3.1. Study area and sampling

This study was conducted in West Java, Indonesia, focusing on agricultural extension officers involved in promoting and facilitating the adoption of new agricultural technologies. A total of 295 valid responses were obtained through purposive sampling. The sample specifically targeted agricultural extension officers who had either access to new agricultural technologies or had participated in technology training programs. The purposive sampling method was used to ensure that respondents had relevant exposure to the technologies being studied, making them appropriate informants for assessing the factors influencing technology adoption (Mujahida et al., 2024; Mujahida, Remmang, et al., 2024). Respondents were selected based on their geographic distribution across West Java, years of experience, and their involvement in technology dissemination to farmers.

3.2. Survey instrument

Data were collected using a structured questionnaire developed based on the constructs of the Technology Acceptance Model (TAM) and other relevant factors influencing technology adoption. The questionnaire consisted of multiple sections designed to measure key constructs such as socialization and training, access to technology, perceived worth of technology investment, perceived ease of use, perceived usefulness, behavioral intention, and actual technology adoption.

The questionnaire included Likert-scale questions, with respondents asked to rate their agreement with statements on a 7-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Example items include: "I have received sufficient training on how to use new agricultural technology" for socialization and training, and "New agricultural technologies are easy to use" for perceived ease of use. Each construct was measured by multiple items adapted from previously validated studies to ensure construct reliability and validity.

3.3. Data collection process

Before the main data collection, a pilot test was conducted with 50 agricultural extension officers to ensure the clarity and reliability of the survey items. After necessary adjustments, the full-scale survey was distributed using a combination of face-to-face interviews and online platforms to ensure broad participation. Local agricultural extension organizations assisted in reaching officers, particularly those in more remote areas with limited access to digital communication tools.

3.4. Analytical method

The data were analyzed using SmartPLS 4, a software designed for Partial Least Squares Structural Equation Modeling (PLS-SEM). This method was chosen due to its flexibility in handling complex relationships between latent variables and its suitability for smaller sample sizes (Dewayani, 2024; Supiandi, 2024; Wang et al., 2022). PLS-SEM is an ideal approach for exploratory studies like this, where the primary goal is to understand and model relationships between multiple constructs.

The analysis included both the measurement model (assessing reliability and validity) and the structural model (examining relationships between constructs). For the measurement model, Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) were used to ensure internal consistency and reliability, while convergent and discriminant validity were assessed to ensure that the constructs were valid and distinct.

3.5. Model specification and variable items

The study adopted the Technology Acceptance Model (TAM) as the theoretical framework and extended it by including additional factors such as socialization, training, access to technology, and Technology Investment Worth. The **Table 1** below outlines the constructs, the variable items used to measure them, and the corresponding sources:

Table 1. Variables' items.

Construct	Item Code	Question	Source
Socialization and Training (ST)	ST1	I have received sufficient training on how to use new agricultural technology.	(Jimenez et al., 2021)
	ST2	I have participated in socialization programs that promote technology adoption.	
	ST3	The training sessions have improved my understanding of how to use technology.	
	ST4	I have learned about the benefits of technology through socialization programs.	
	ST5	The training and socialization efforts have boosted my confidence in using technology.	
Access to Technology (AT)	AT1	I have easy access to new agricultural technologies.	(Geng et al., 2024)
	AT2	There are sufficient distribution channels for agricultural technology in my area.	
Technology Investment Worth (TIW)	CT1	The cost of new agricultural technologies is reasonable given their benefits.	(Cao et al., 2022)
	CT2	I believe the financial investment required to adopt new technologies is worthwhile.	
	CT3	The costs of maintenance for new technologies are manageable and justified by their advantages.	
	CT4	The benefits of technology far outweigh the cost of adoption.	
	CT5	The Technology Investment Worth encourages me to adopt it, as the return on investment is clear.	
Perceived Ease of Use (PEOU)	PEU1	New agricultural technologies are easy to use.	(Davis, 1989)
	PEU2	I find it simple to operate new technologies for farming.	
	PEU3	Learning how to use new agricultural technologies is easy for me.	
	PEU4	It is easy to become skillful in using new agricultural technologies.	

Table 1. (*Continued*).

Construct	Item Code	Question	Source
Perceived Usefulness (PU)	PU1	Using new agricultural technologies improves my farming productivity.	(Davis, 1989)
	PU2	New technologies help me save time on farming tasks.	
	PU3	Using new technologies enhances the quality of my farm's outputs.	
	PU4	New agricultural technologies help me achieve my farming goals.	
Behavioral Intention (BI)	BI1	I intend to adopt and promote new agricultural technologies in the future.	(Bala and Venkatesh, 2008)
	BI2	I plan to use new technologies to improve my outreach and support farmers.	
	BI3	I am willing to learn about new technologies for agriculture.	
Technology Adoption (TA)	TA1	I regularly use new agricultural technologies in my work as an extension officer.	(Chakraborty et al., 2021)
	TA2	I have adopted technologies that help improve my effectiveness in assisting farmers.	

The table above highlights the main constructs used in the model, the corresponding variable items, and their respective sources. The constructs were measured using multiple items to capture the respondents' attitudes toward technology adoption comprehensively.

3.6. Reliability and validity testing

Reliability and validity testing were conducted to ensure the robustness of the measurement model. Cronbach's Alpha was used to assess the internal consistency of each construct, with values above 0.7 indicating acceptable reliability. In addition to Cronbach's Alpha, Composite Reliability (CR) was also calculated. Composite reliability offers a more accurate estimate of internal consistency than Cronbach's Alpha, as it considers the varying factor loadings of individual items. A CR value above 0.7 for all constructs confirmed that the items reliably measured the intended constructs.

To assess the convergent validity of the constructs, the Average Variance Extracted (AVE) was calculated for each construct. AVE measures the amount of variance captured by a construct's indicators relative to the variance due to measurement error. An AVE value of 0.5 or higher is considered adequate, indicating that at least 50% of the variance in the construct is explained by its items. In this study, all constructs achieved AVE values above 0.5, confirming convergent validity.

Discriminant validity was evaluated using the Fornell-Larcker Criterion, which compares the square root of the AVE for each construct with its correlations with other constructs. Discriminant validity is established if the square root of the AVE for a construct is greater than its correlations with other constructs. This ensures that the constructs are sufficiently distinct from one another. Additionally, cross-loadings were examined to verify that items loaded more strongly on their intended construct than on any other construct. Both the Fornell-Larcker Criterion and the cross-loadings indicated that discriminant validity was achieved in this study.

By ensuring both reliability and validity, the measurement model was confirmed to be both accurate and consistent, providing a solid foundation for testing the structural relationships between the variables in the TAM framework.

4. Result and discussion

The respondent profile (see **Table 2**) consists of 295 agricultural extension officers, with 61% being male and 39% female. The majority of respondents fall within the 30–40-year age group (41%), followed by those under 30 years (25%), indicating a relatively young workforce. In terms of education, most respondents hold a bachelor's degree (54%), while a smaller proportion have a diploma (24%) or master's degree (22%). Regarding experience, 34% of the officers have 5–10 years of experience, and 31% have less than 5 years, highlighting a workforce with a mix of early-career and moderately experienced professionals.

Table 2. Respondent profile.

Category	Number of Respondents
Male	180
Female	115
< 30 years	75
30–40 years	120
41–50 years	60
51+ years	40
Diploma	70
Bachelor's Degree	160
Master's Degree	65
< 5 years experience	90
5–10 years experience	100
11–20 years experience	70
20+ years experience	35

Source: Data processing, 2024.

The **Table 3** presents the results of construct validity and reliability testing, which assess how effectively the survey items measure the intended constructs.

Table 3. Construct validity and reliability.

Item	Loading Factor	Cron. Alpha	CR	AVE
AT1	0.883	0.825	0.83	0.741
AT2	0.839			
BI1	0.876	0.882	0.885	0.781
BI2	0.882			
BI3	0.789			
TIW1	0.837	0.882	0.885	0.732
TIW2	0.837			
TIW3	0.752			
TIW4	0.794			
TIW5	0.772			

Table 3. (*Continued*).

Item	Loading Factor	Cron. Alpha	CR	AVE
PEU1	0.726	0.841	0.848	0.763
PEU2	0.756			
PEU3	0.81			
PEU4	0.788			
PU1	0.799	0.838	0.838	0.721
PU2	0.731			
PU3	0.847			
PU4	0.783			
ST1	0.807	0.85	0.85	0.823
ST2	0.815			
ST3	0.778			
ST4	0.769			
TA1	0.806	0.904	0.906	0.778
TA2	0.892			

Source: Data processing.

First, the loading factors indicate the strength of the relationship between each item and its associated construct. A loading factor greater than 0.7 is considered acceptable, as it reflects a strong correlation between the item and the construct. In this table, most items have loading factors above 0.7, suggesting that they are good indicators of the respective constructs.

Cronbach's Alpha measures the internal consistency of the items within each construct, determining whether the items reliably assess the same underlying concept (Dewayani, 2024; Duc and Mujahida, 2024; Oscar and Wang, 2024; Supiandi, 2024; Yuli, 2024). A Cronbach's Alpha value above 0.7 is typically regarded as satisfactory, indicating reliable measurement. In this table, all constructs demonstrate Cronbach's Alpha values above 0.7, confirming the reliability of the items.

Similarly, Composite Reliability (CR) serves as an additional reliability indicator. A CR value above 0.7 is desirable, as it shows that the items consistently measure the construct. The CR values in this table all exceed 0.7, further affirming the reliability of the constructs.

The Average Variance Extracted (AVE) measures the amount of variance in the construct explained by the items. An AVE value greater than 0.5 is preferable, as it indicates that the construct is well represented by its items. In this table, all AVE values exceed 0.5, signifying that the items provide an adequate representation of the constructs.

Table 3 presents the discriminant validity results, which assess whether each construct is distinct from the others in the model. Discriminant validity is achieved when the square root of the Average Variance Extracted (AVE) for a construct (displayed along the diagonal in bold) is greater than the correlations between that construct and all other constructs (the off-diagonal values).

For the construct Attitude (AT), the square root of its AVE is 0.86. The correlations between AT and other constructs, such as Behavioral Intention (0.43), Construct TIW (0.65), and Perceived Ease of Use (0.63), are all lower than 0.86. This indicates that AT is distinct from these other constructs. Similarly, Behavioral Intention (BI) has a square root of the AVE value of 0.88. The correlations between BI and the other constructs, which range from 0.30 to 0.43, are also lower than 0.88. This confirms that BI is distinct and exhibits good discriminant validity.

In the case of Construct Technology Investment Worth (TIW), its square root of the AVE is 0.85, and the correlations between TIW and other constructs such as Perceived Ease of Use (0.68) and System Trust (0.70) are lower than 0.85. This shows that TIW is also adequately differentiated from other constructs. Perceived Usefulness (PU) has a square root of the AVE value of 0.85, with correlations like 0.55 with CT and 0.62 with Perceived Ease of Use. Since these values are lower than 0.85, PU maintains discriminant validity as well.

For Perceived Ease of Use (PEU), the square root of its AVE is 0.87, and the correlations with other constructs, such as TIW (0.68) and PU (0.62), are below this value. This supports the idea that PEU is distinct from the other constructs. System Trust (ST), with a square root of the AVE of 0.82, has correlations ranging from 0.42 with Technology Adoption to 0.70 with TIW, all of which are less than 0.82, confirming ST's discriminant validity.

Finally, Technology Adoption (TA) has a square root of the AVE of 0.88. The correlations between TA and other constructs, such as AT (0.55) and BI (0.43), are also lower than 0.88, ensuring that TA is distinct from the other constructs in the model.

In conclusion, the table confirms that discriminant validity is achieved for all constructs. Each construct's square root of the AVE is higher than its correlations with other constructs, indicating that the constructs are measuring distinct concepts within the model. This supports the overall validity of the measurement model used in the analysis.

The discriminant validity, as shown in **Table 4**, demonstrates that each construct is distinct from the others. The square root of the Average Variance Extracted (AVE) for each construct, displayed on the diagonal, exceeds the correlations between that construct and all other constructs, confirming discriminant validity. For example, the square root of the AVE for Access to Technology (AT) is 0.86, which is greater than its correlations with other constructs, such as Behavioral Intention (BI) at 0.43 and Technology Investment Worth (TIW) at 0.65. Similarly, Perceived Ease of Use (PEU) has a square root AVE of 0.87, higher than its correlation with other constructs like Perceived Usefulness (PU) at 0.62. This pattern holds for all constructs, indicating that each construct measures something unique and distinct from the others, supporting the model's discriminant validity. This ensures that the constructs used in this study are measuring separate aspects of technology adoption among agricultural extension officers.

Table 4. Discriminant validity.

	AT	BI	TIW	PU	PEU	ST	TA
AT	0.86						
BI	0.43	0.88					
TIW	0.65	0.40	0.85				
PU	0.52	0.39	0.55	0.85			
PEU	0.63	0.40	0.68	0.62	0.87		
ST	0.50	0.30	0.70	0.53	0.65	0.82	
TA	0.55	0.43	0.48	0.50	0.54	0.42	0.88

Source: data processing.

Hypothesis testing

The path analysis results for this model can be seen in **Figure 2**, which includes Access to Technology, Socialization and Training, Technology Investment Worth, Perceived Ease of Use, Perceived Usefulness, Behavioral Intention, and Technology Adoption, reveal several significant relationships between the constructs. Moreover, **Table 5** shows the details numbers of each hypothesis.

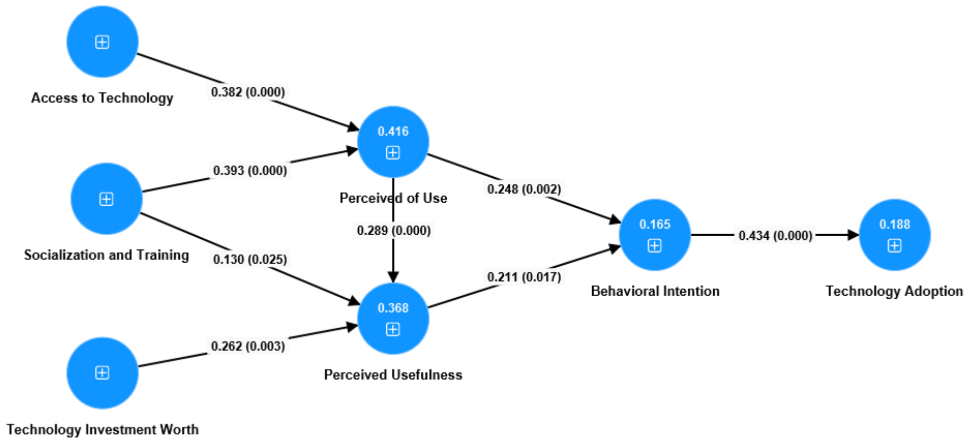

Figure 2. Graphical output.

Source: Data processing.

Table 5. Path analysis.

	Original sample	M	STDEV	T statistics	*P* values	Hypothesis	Note
ST → PU	0.13	0.131	0.058	2.245	0.025	H1	Supported
ST → PEU	0.393	0.394	0.053	7.359	0.000	H2	Supported
AT → PEU	0.382	0.384	0.055	6.954	0.000	H3	Supported
TIW → PU	0.262	0.265	0.088	2.963	0.003	H4	Supported
PEU → PU	0.289	0.29	0.082	3.508	0.000	H5	Supported
PEU → BI	0.248	0.251	0.079	3.155	0.002	H6	Supported
PU → BI	0.211	0.212	0.089	2.377	0.017	H7	Supported
PEU → PU → BI	0.061	0.06	0.029	2.126	0.034	H8	Supported
BI → TA	0.392	0.398	0.072	5.441	0.000	H9	Supported

Source: Data processing.

H1: Socialization and Training (ST) → Perceived Usefulness (PU)

The path analysis results reveal that Socialization and Training positively influences Perceived Usefulness, with a path coefficient of 0.13 and a *p*-value of 0.025. Since the *p*-value is less than 0.05, this indicates a statistically significant relationship, thus confirming H1. This finding suggests that when agricultural extension officers receive sufficient training and socialization regarding new technologies, they are more inclined to perceive these technologies as useful. Although the effect size is moderate, it underscores the importance of providing proper guidance and resources to extension officers to enhance their perception of the technology's value.

H2: Socialization and Training (ST) → Perceived Ease of Use (PEU)

The relationship between Socialization and Training and Perceived Ease of Use is significant, with a path coefficient of 0.393 and a *p*-value of 0.000, confirming H2. This result demonstrates that socialization and training have a strong positive effect on how easily agricultural extension officers perceive the technology. Officers who receive comprehensive training and education about the technology tend to find it easier to use, highlighting the critical role of support and learning in improving the usability of agricultural technologies.

H3: Access to Technology (AT) → Perceived Ease of Use (PEU)

The results show a strong and significant relationship between Access to Technology and Perceived Ease of Use, with a path coefficient of 0.382 and a *p*-value of 0.000, confirming H3. This finding suggests that greater access to technology positively affects how easy agricultural extension officers perceive it to be. When technology is more readily available, officers become more familiar and comfortable with its use, which enhances their perception of its ease of use. This highlights the importance of ensuring accessible technology to facilitate adoption and usage.

H4: Technology Investment Worth (TIW) → Perceived Usefulness (PU)

The path from Technology Investment Worth to Perceived Usefulness is significant, with a path coefficient of 0.262 and a *p*-value of 0.003, confirming H4. This result suggests that agricultural extension officers' perception of technology costs as a valuable investment significantly influences how useful they perceive the technology to be. When the cost of technology is viewed as a worthwhile investment, it enhances their perception of its usefulness. These findings underscore the importance of framing technology as a beneficial investment to increase its perceived value and encourage adoption.

H5: Perceived Ease of Use (PEU) → Perceived Usefulness (PU)

The relationship between Perceived Ease of Use and Perceived Usefulness is significant, with a path coefficient of 0.289 and a *p*-value of 0.002, confirming H5. This result indicates that when agricultural extension officers find a technology easy to use, they are more likely to perceive it as useful. Ease of use enhances their confidence in the technology's ability to meet their needs, thereby increasing its perceived usefulness. This finding highlights the importance of designing user-friendly technologies to boost their overall perceived value.

H6: Perceived Ease of Use (PEU) → Behavioral Intention (BI)

The path from Perceived Ease of Use to Behavioral Intention is significant, with a path coefficient of 0.248 and a *p*-value of 0.013, confirming H6. This indicates that when agricultural extension officers perceive a technology as easy to use, they are more likely to have the intention to adopt it. Perceived ease of use directly influences their willingness and motivation to utilize the technology in the future, emphasizing the importance of usability in fostering positive intentions toward technology adoption.

H7: Perceived Usefulness (PU) → Behavioral Intention (BI)

The relationship between Perceived Usefulness and Behavioral Intention is significant, with a path coefficient of 0.211 and a *p*-value of 0.017, confirming H7. This finding suggests that when agricultural extension officers perceive a technology as useful, they are more likely to have a stronger intention to adopt it. Perceived usefulness is a key driver influencing their decision to incorporate the technology into their daily activities, highlighting its critical role in shaping adoption intentions.

H8: Perceived Ease of Use (PEU) → Perceived Usefulness (PU) → Behavioral Intention (BI)

There is a significant mediation effect in H8, where Perceived Usefulness mediates the relationship between Perceived Ease of Use and Behavioral Intention. The path coefficient for the indirect effect is 0.126, with a *p*-value of 0.034, confirming H8. This indicates that Perceived Ease of Use influences Behavioral Intention indirectly through Perceived Usefulness. In other words, when agricultural extension officers find a technology easy to use, they are more likely to perceive it as useful, which in turn strengthens their intention to adopt the technology.

H9: Behavioral Intention (BI) → Technology Adoption (TA)

The path from Behavioral Intention to Technology Adoption is strongly supported, with a path coefficient of 0.392 and a *p*-value of 0.000, confirming H9. This demonstrates that Behavioral Intention is a strong predictor of Technology Adoption. Agricultural extension officers who intend to adopt the technology are significantly more likely to follow through and adopt it. Behavioral intention thus plays a crucial role in determining the likelihood of technology adoption.

Overall, the path analysis confirms that all hypotheses (H1 to H9) are supported by the data. The findings highlight that factors such as Access to Technology, Socialization and Training, and Technology Investment Worth play essential roles in shaping perceptions of Ease of Use and Usefulness. These perceptions, in turn, affect Behavioral Intention and lead to Technology Adoption. Both Perceived Ease of Use and Perceived Usefulness act as key mediators, illustrating how external factors influence the intention and actual adoption of technology among agricultural extension officers.

5. Discussion

The results of this study demonstrate that factors such as Access to Technology, Socialization and Training, and Technology Investment Worth play pivotal roles in shaping Perceived Ease of Use and Perceived Usefulness, both of which significantly influence Behavioral Intention and ultimately drive Technology Adoption. These findings align with several previous studies and contribute to a growing body of literature on technology adoption, particularly within industries where access and training are critical for successful implementation.

5.1. Role of socialization and training

The study confirms that Socialization and Training has a strong impact on both Perceived Ease of Use (H2) and Perceived Usefulness (H1). This finding is consistent with the work of Davis et al. (1989) which shows that proper training enhances users' understanding of new technology, making it more approachable and useful. Similarly, Nuryakin et al. (2023) highlighted that training positively influences employees' perceptions of technology's ease of use in organizational settings, emphasizing the importance of structured training programs in reducing the complexities associated with new technologies. Socialization and training equip users with the necessary skills to interact with technology, fostering confidence and competence. Thong et al. (2006) note that training sessions allow users to explore features of the technology they might not discover independently, enhancing their perceived value. In agriculture, where this study is focused, providing effective socialization and training is crucial, particularly because many users may not have prior experience with sophisticated technologies like drones or IoT-based solutions. Shah (2022) also emphasizes the need for hands-on training in agricultural technology adoption, as it addresses the gap in knowledge among rural users.

5.2. Impact of access to technology on perceived ease of use

The significant relationship between Access to Technology and Perceived Ease of Use (H3) underscores the importance of technology availability in the user adoption process. This finding aligns with Venkatesh et al. (2003), who noted that access to necessary resources is a critical factor in the Technology Acceptance Model (TAM), influencing ease of use and, consequently, the intention to adopt technology. In contexts where technology is readily available, users tend to become more familiar with it, reducing perceived barriers to use. Park (2009), in research on e-learning platforms, similarly found that the availability of technology tools plays a significant role in how easily users navigate them, supporting the idea that increased access correlates with higher perceptions of ease of use.

5.3. Technology investment worth and perceived usefulness

The relationship between Technology Investment Worth and Perceived Usefulness (H4) highlights the key role affordability plays in technology adoption. Previous studies, particularly in developing regions, confirm this connection. Research by Hassan et al. (2022) and Zawacki-Richter et al. (2019) demonstrated that high costs often serve as a barrier to technology adoption, especially when users perceive that the cost outweighs the benefits. Conversely, when technology is affordable, perceived usefulness increases, as users are more likely to see it as a valuable tool for achieving their goals. In agricultural sectors, where this study is situated, cost is a significant factor in determining whether farmers adopt new technology. Shah (2022) notes that for small-scale farmers, expensive technologies may seem out of reach, but when costs are lowered, these technologies are more likely to be perceived as useful and necessary. Zegeye (2021) similarly found that reducing Technology Investment Worth through subsidies or financial support greatly improves adoption rates among rural communities.

5.4. Perceived ease of use and perceived usefulness

The significant relationship between Perceived Ease of Use and Perceived Usefulness (H5) is consistent with the original findings of Davis (1989) in the TAM framework. When users find technology easy to use, they are more likely to view it as beneficial. Recent studies support this relationship Teo (2011), in his work on educational technology, noted that ease of use often drives perceived usefulness, as users who do not struggle with functionality are better able to focus on the technology's benefits. In the context of agricultural technology, where users may not be highly familiar with digital tools, ease of use is critical for adoption Khan et al. (2024) found that farmers were more likely to adopt digital agricultural solutions when they perceived the technology as user-friendly, even when they initially had low technological literacy.

5.5. Perceived usefulness and behavioral intention

The positive relationship between Perceived Usefulness and Behavioral Intention (H7) is well-documented in adoption literature, particularly within the TAM framework. Users who perceive technology as beneficial are more likely to develop an intention to adopt it. This finding is consistent with Venkatesh et al. (2003) and Liu and Ma (2005), who found that perceived usefulness significantly predicts behavioral intention across various technological contexts, including mobile applications, online platforms, and digital services. In agricultural settings, perceived usefulness often revolves around the technology's ability to improve productivity or simplify tasks. Meera et al. (2004) noted that when farmers believe technology will improve outcomes—such as through better crop monitoring or more efficient irrigation—they are more likely to intend to use it, a finding that aligns with the current study.

5.6. Behavioral intention and technology adoption

The relationship between Behavioral Intention and Technology Adoption (H9) is one of the most significant findings of this study, confirming that Behavioral Intention is a strong predictor of actual adoption behavior. This result is consistent with extended versions of the TAM, such as TAM2 (Bala and Venkatesh, 2008), and the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Bala and Venkatesh, 2008), which posit that behavioral intention is the primary driver of actual technology use. Recent studies in similar fields, such as Roger (2003), support this relationship across various industries, including agriculture. Khan et al. (2024) found that farmers' intention to adopt mobile-based agricultural solutions strongly predicted actual usage. Similarly, Meera et al. (2004) showed that behavioral intention was a key determinant in the adoption of smart farming techniques, in line with the findings of this study.

The findings of this study contribute to the growing body of knowledge on technology adoption by confirming that external factors such as Access to Technology, Socialization and Training, and Technology Investment Worth significantly shape users' Perceived Ease of Use and Perceived Usefulness, which, in turn, influence Behavioral Intention and ultimately lead to Technology Adoption. This study reaffirms the importance of addressing both practical factors (cost, access) and psychological factors (ease of use, usefulness) that underpin successful technology adoption, particularly in sectors like agriculture, where technological literacy may be lower. These findings are supported by a wide range of studies and contribute to the broader literature on technology adoption frameworks.

While this study provides important insights into the factors influencing technology adoption among agricultural extension officers in West Java, certain limitations should be considered when interpreting the findings. The use of purposive sampling may have led to sample bias, as the officers included in the study already had access to technology or participated in training, potentially skewing the results toward higher reported adoption rates and perceptions of ease of use and usefulness. Additionally, the cross-sectional nature of the study limits the ability to track changes in technology adoption over time, meaning the findings may not reflect long-term trends or evolving attitudes. External factors such as policy changes, economic conditions, or advancements in agricultural technology, which were not accounted for, could also influence technology adoption in ways not captured by this study. Finally, the reliance on self-reported data introduces the risk of response bias, where participants may have overstated their engagement with or perceptions of technology, impacting the generalizability of the results.

6. Implications

This study contributes to the expanding body of literature on technology adoption by extending the Technology Acceptance Model (TAM) to the agricultural sector in a developing country context, specifically among agricultural extension officers in West Java. The findings reaffirm the importance of perceived ease of use and perceived usefulness as key drivers of behavioral intention and actual technology adoption. By incorporating socialization, training, and cost into the TAM framework, the study offers a deeper understanding of how external factors influence these core constructs in agricultural settings. The results confirm that structured training programs and improved access to technology positively impact extension officers' perceptions of ease of use and usefulness, which in turn enhance their willingness to adopt and promote new technologies to farmers. Additionally, this research underscores the critical role of cost as a positive contributor to perceived usefulness, showing that when extension officers perceive the cost of technology as a valuable investment, they are more likely to advocate for its adoption. This adjustment of the TAM framework, emphasizing the positive role of cost, enhances the theoretical understanding of technology adoption processes, particularly in resource-limited contexts where financial constraints and technological literacy may hinder adoption.

From a practical perspective, the findings offer actionable insights for policymakers, agricultural organizations, and technology providers. First, the study highlights the crucial role of socialization and training programs in promoting technology adoption. Practical efforts should focus on delivering hands-on training sessions and fostering peer-to-peer knowledge-sharing initiatives among extension officers. These initiatives will allow them to build familiarity with new technologies, thereby boosting their confidence and competence in using and promoting these tools. Second, the research identifies the positive perception of cost as a key factor in technology adoption. Policymakers should implement financial mechanisms such as subsidies, low-interest loans, or cost-sharing programs to help agricultural extension officers and farmers manage the financial burden of adopting new technologies. Finally, improving access to technology by enhancing infrastructure—such as expanding digital platforms, improving internet connectivity in rural areas, and strengthening supply chains—can significantly increase the adoption of agricultural innovations. By addressing these practical challenges, stakeholders can foster greater technology adoption, leading to more efficient, productive, and sustainable agricultural practices in West Java.

7. Conclusion

This study has examined the factors influencing technology adoption among agricultural extension officers in West Java, Indonesia, using the Technology Acceptance Model (TAM) as the theoretical framework. The findings reveal that socialization and training programs, access to technology, and a positive perception of Technology Investment Worth play a significant role in enhancing extension officers' perceptions of ease of use and usefulness. These factors, in turn, shape their behavioral intention to adopt and promote new agricultural technologies. Notably, extension officers view Technology Investment Worth as a valuable investment, positively influencing their perception of its usefulness, which leads to higher adoption rates. The study confirms that perceived ease of use and usefulness are strong predictors of behavioral intention, which directly influences actual technology adoption among agricultural extension officers.

Despite its contributions, this research has several limitations. First, the study focuses solely on agricultural extension officers in West Java, which may limit the generalizability of the findings to other regions in Indonesia or other developing countries with different agricultural conditions and challenges. Second, the cross-sectional design provides a snapshot of technology adoption at a specific point in time, without capturing potential changes in behavior or perceptions over a longer period. Longitudinal studies could offer deeper insights into how extension officers' attitudes toward technology evolve with increased exposure and experience. Lastly, the study relies on self-reported data, which may be subject to response biases, especially in areas where extension officers may have limited familiarity with the technologies being discussed.

Future research should address these limitations by expanding the scope of the study to include extension officers from other regions, such as Central or East Java, or other developing countries with different agricultural practices. Additionally, longitudinal studies would allow for a more comprehensive understanding of how extension officers' technology adoption behavior changes over time. Further research could also explore additional variables, such as cultural factors, environmental sustainability, or the impact of government policies on technology adoption. Incorporating qualitative methods, such as in-depth interviews or focus groups, could provide richer insights into the specific challenges and opportunities extension officers face when adopting and promoting new technologies.

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