Decision Science Letters 15 (2026) 447–458

Contents lists available at GrowingScience

Decision Science Letters

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Integrating technology acceptance model and theory of planned behavior to explain farmers' intention to adopt artificial intelligence in agriculture

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C H R O N I C L E

Article history:
Received October 27 2025
Received in Revised Format November 26 2025
Accepted January 19 2026
Available online January 19 2026

Keywords:
Artificial Intelligence
TAM–TPB
Technology Adoption
Agricultural Sector
Behavioral Intention

A B S T R A C T

This study aims to develop and test an integrative model of the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) to explain farmers' intentions to adopt artificial intelligence (AI) in the agricultural sector. The model positions Perceived Ease of Use (PEOU) as an initial determinant influencing Perceived Usefulness (PU), Attitude Toward AI (ATT), and Behavioral Intention to Use AI (BI), both directly and through mediating mechanisms. The study employed a quantitative explanatory design with a cross-sectional survey approach. Data were collected from 203 respondents, consisting of farmers and MSMEs and small-to-medium-scale agricultural businesses in the Greater Bandung area, from January to March 2024. The research instrument was an online questionnaire with a five-point Likert scale, and data analysis was conducted using covariance-based Structural Equation Modeling (SEM). The results showed that PEOU had a positive and significant effect on PU and ATT. Furthermore, PU, ATT, Perceived Behavioral Control, and Perceived Social Norms were shown to increase the intention to use AI in agricultural activities. Mediation tests confirmed that PU and ATT act as partial mediators in the relationship between ease of use and AI adoption intention. These findings emphasize that AI adoption in the agricultural sector is a gradual process that simultaneously involves cognitive, affective, and social factors. Theoretically, this study strengthens the relevance of TAM–TPB integration in the context of modern agriculture, while practically providing a basis for formulating strategies to accelerate sustainable digital transformation in agriculture.

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1. Introduction

Digital transformation and the use of artificial intelligence (AI) in the agricultural sector are key pillars in realizing sustainable, efficient, and adaptive agriculture to the challenges of climate change, resource constraints, and global productivity pressures. Various AI-based technologies such as precision agriculture, drones, digital farm management systems, and smart agricultural machinery have demonstrated significant potential in improving productivity, input efficiency, and the quality of farmer decision-making (Adrian et al., 2005; Hrynevych et al., 2022; Sood et al., 2024; Georgopoulos et al., 2023). However, the success of these technologies is determined not only by their availability but also by the acceptance and behavior of users, particularly farmers as the primary actors in the agricultural system. In this context, the Technology Acceptance Model (TAM) has become the dominant theoretical framework for explaining agricultural technology adoption. The two core constructs of TAM, Perceived Ease of Use (PEOU) and Perceived Usefulness (PU), have consistently been shown to influence attitudes, intentions, and behaviors toward technology adoption in the agricultural sector (Caffaro et al., 2020; Castiblanco Jimenez et

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ISSN 1929-5812 (Online) - ISSN 1929-5804 (Print)
2026 Growing Science Ltd.
doi: 10.5267/j.dsl.2026.1.006

al., 2020; Mohr & Kühl, 2021). PEOU reflects the extent to which farmers perceive technology as easy to understand and use, while PU reflects the perceived usefulness of technology in improving farm performance. Several studies have shown that technologies perceived as easy to use tend to be perceived as more useful, strengthening the causal pathway from PEOU to PU (Caffaro et al., 2020; Abdullahi & Mahmud, 2023; Cao et al., 2025).

Empirically, a direct relationship between PEOU and PU has been confirmed in various agricultural and agribusiness contexts, including the adoption of ICT, drones, IoT, and digital agricultural systems (Ahmad et al., 2023; Michels et al., 2021; Arrang et al., 2025). These findings confirm that technological complexity remains a major barrier for farmers, especially in developing countries, making ease of use a crucial prerequisite for tangible technological benefits (Chuang et al., 2020; Bagheri et al., 2024). Therefore, the hypothesis that Perceived Ease of Use positively influences Perceived Usefulness in the agricultural context has strong theoretical and empirical basis. However, the literature also indicates that the classic TAM has limitations in explaining complex and contextual agricultural technology adoption behavior. Therefore, many recent studies have integrated TAM with the Theory of Planned Behavior (TPB) to capture the role of attitudes, perceived behavioral control, and social norms in shaping behavioral intentions (Ajzen, 1980; Ajzen, 1991; Mohr & Kühl, 2021; Dong et al., 2022; Wu et al., 2024). This integration is particularly relevant in the agricultural context, where technology adoption decisions are often influenced by social pressures, community networks, institutional support, and resource constraints (Ahmed et al., 2024; Ephrem et al., 2021). Several studies have shown that PEOU and PU not only directly influence adoption intention but also shape Attitude Toward AI, which in turn serves as a key mediator in explaining adoption intention for agricultural technology (Sun et al., 2022; Mishra et al., 2024; Tama et al., 2023). Positive attitudes toward AI have been shown to enhance adoption intention, while negative attitudes, often driven by perceived complexity, risk, and uncertainty, act as key barriers to adoption (Chen et al., 2023; Shao et al., 2025). Furthermore, social norms supporting technology use and perceived control over capabilities and resources have also been shown to strengthen AI adoption intention in the agricultural sector (Guo et al., 2023; Ninsiima et al., 2025). Nevertheless, research gaps remain evident. First, most studies examine the relationship between TAM and TPB partially or separately, without comprehensively modeling the direct and indirect (mediation) pathways between PEOU, PU, attitudes, and behavioral intentions in the context of agricultural AI. Second, research explicitly examining the chain mediation mechanisms, such as the role of PU in mediating the PEOU–attitude relationship, and the role of attitude in mediating the influence of PEOU and PU on AI adoption intentions, remains relatively limited and fragmented (Chen & Aklikokou, 2020; Khan & Emon, 2024; Emon & Khan, 2025). Third, many empirical findings come from non-agricultural contexts or general digital technology contexts, so their external validity in the context of agricultural AI still needs to be tested more specifically and contextually.

Based on this gap, this study develops an integrative TAM–TPB model to explain farmers' intentions to use AI in the agricultural sector, positioning Perceived Ease of Use as an initial determinant that influences Perceived Usefulness, attitudes toward AI, and behavioral intentions both directly and through mediating mechanisms. Thus, this study not only strengthens the empirical evidence on the PEOU–PU relationship but also expands theoretical understanding of how perceived ease and usefulness of AI technology translate into attitudes and adoption intentions in the context of modern agriculture.

2. Literature Review and Hypothesis

In the Technology Acceptance Model (TAM), Perceived Ease of Use (PEOU) is positioned as an initial cognitive determinant influencing Perceived Usefulness (PU) (Davis, 1989; Venkatesh & Davis, 2000). In the agricultural context, technology perceived as easy to use allows farmers to more quickly understand functions, reduces cognitive load, and minimizes the risk of operational errors, making the technology's benefits more tangible and relevant to daily farming activities. Caffaro et al. (2020) showed that ease of use of agricultural technology significantly increased perceived usefulness among Italian farmers, particularly in production decision-making. Similar findings were confirmed by Abdullahi and Mahmud (2023) in Somali agribusiness practitioners, who found that easy-to-use ICT technologies were more likely to be perceived as beneficial for business efficiency. Recent empirical studies have also confirmed this relationship in the context of digital technology and AI in the agricultural sector. Cao et al. (2025) found that PEOU played a significant role in increasing PU in farmer cooperatives adopting digital technology, while Ahmad et al. (2023) showed that the ease of use of agricultural drones increases the perceived usefulness of these drones for microfarmers. Systematic literature also confirms that technological complexity is a major barrier to the adoption of agricultural AI, making ease of use a prerequisite for perceived usefulness (Georgopoulos et al., 2023; Mohr & Kühl, 2021). Therefore, the higher farmers' perceptions of AI ease of use, the greater their perceptions of AI's usefulness in improving agricultural performance.

H_1: *Perceived Ease of Use has a positive effect on Perceived Usefulness in agriculture.*

Attitudes toward technology reflect an individual's affective evaluation of the technology's use, which is formed through initial cognitive experiences, including perceived ease of use. In the agricultural context, farmers who perceive AI as easy to learn and operate tend to develop positive attitudes because the technology is not perceived as a threat or additional burden. Mohr and Kühl (2021) showed that PEOU significantly influenced German farmers' attitudes toward agricultural AI, particularly data-driven and automated systems.

Other studies corroborate these findings in various agricultural technology contexts. Arrang et al. (2025) found that ease of use of IoT significantly increased rice farmers' positive attitudes toward the technology. Chuang et al. (2020) also confirmed that farmers who perceived smart agricultural technology as easy to use exhibited more open and positive attitudes toward adoption. Furthermore, Mishra et al. (2024) and Sun et al. (2022) identified that perceived ease of use reduced psychological resistance and technology anxiety, ultimately improving attitudes toward AI-based agricultural innovations. Thus, perceived ease of use of AI plays a significant role in shaping farmers' positive attitudes toward AI in the agricultural sector.

H_2: *Perceived Ease of Use has a positive effect on Attitude Toward AI in agriculture.*

Perceived Usefulness (PU) is the belief that the use of technology will improve performance or work outcomes, which directly influences attitudes toward the technology. In the agricultural sector, AI perceived to increase productivity, input efficiency, and decision-making quality tends to be evaluated positively by farmers. Caffaro et al. (2020) showed that the perceived usefulness of agricultural technology significantly contributes to farmers' positive attitudes toward innovation. This finding is also supported by Ahmad et al. (2023), who found that micro-farmers in Malaysia exhibited more positive attitudes toward agricultural drones when the benefits were directly perceived.
In the context of agricultural AI, Mohr and Kühl (2021) and Sood et al. (2024) confirmed that PU is a key determinant of attitudes toward AI technology, especially when the technology is associated with improving the sustainability and efficiency of farming. Arrang et al. (2025) and Ngan et al. (2024) also found that the perceived benefits of digital technology and AI strengthen positive affective evaluations of these technologies. Thus, when farmers view AI as a truly useful tool for their farming activities, attitudes towards AI will become more positive.

H_3: *Perceived Usefulness has a positive effect on Attitude Toward AI in agriculture.*

In TAM, Perceived Usefulness is the strongest predictor of behavioral intention to use technology. In the agricultural context, farmers will intend to use AI if they believe the technology provides tangible benefits, such as increased crop yields, cost efficiency, or reduced production risks. Abdullahi and Mahmud (2023) showed that PU directly influences intention to use ICT technology in the agribusiness sector. Similar findings were also reported by Michels et al. (2021) regarding the adoption of agricultural drones in Germany. Research related to agricultural AI further confirms the central role of PU in shaping adoption intentions. Mohr and Kühl (2021) and Mishra et al. (2024) found that perceived benefits of AI significantly increased farmers' intention to use it. Furthermore, studies by Sun et al. (2022) and Wu et al. (2024) showed that when technology is perceived to support economic and sustainability goals, adoption intentions are stronger. Therefore, the higher farmers' perceptions of AI's usefulness, the greater their intention to use it in agricultural practices.

H_4: *Perceived Usefulness has a positive effect on Behavioral Intention to Use AI in agriculture.*

Perceived Behavioral Control (PBC) in the Theory of Planned Behavior reflects the extent to which an individual perceives they have the ability, resources, and opportunity to perform a behavior. In the agricultural context, AI use is often influenced by limited capital, technical skills, and infrastructure, making perceived control a crucial factor in shaping adoption intentions. Mohr and Kühl (2021) demonstrated that PBC significantly influenced farmers' intentions to adopt agricultural AI in Germany. Other studies corroborate these findings in various agricultural contexts. Dong et al. (2022) and Sarkar et al. (2022) found that farmers who perceived capacity and control over technology use tended to demonstrate higher adoption intentions. Mishra et al. (2024) also confirmed that access to training and technical support strengthens PBC and increases intentions to adopt advanced agricultural technologies. Therefore, the higher farmers' perceptions of their ability and control in using AI, the greater their intention to adopt the technology.

H_5: *Perceived Behavioral Control has a positive effect on Behavioral Intention to Use AI in agriculture.*

Perceived Social Norms represent the social pressure individuals feel to perform or not perform a behavior. In agricultural communities, technology adoption decisions are often influenced by the opinions of fellow farmers, extension workers, farmer groups, and related institutions. Mohr and Kühl (2021) demonstrated that social norms play a significant role in shaping agricultural AI adoption intentions. Guo et al. (2023) also found that social support strengthens continued AI adoption behavior. Research by Ahmed et al. (2024) and Ephrem et al. (2021) demonstrated that social networks and community norms influence farmers' decisions to adopt agricultural technologies. Studies by Wu et al. (2024) and Ninsiima et al. (2025) confirmed that positive social norms toward technology increase legitimacy and trust in AI. Therefore, when the social environment supports the use of AI, farmers will be more motivated to adopt the technology.

H_6: *Perceived Social Norms has a positive effect on Behavioral Intention to Use AI in agriculture.*

Attitudes toward AI reflect farmers' overall evaluation of AI use, including benefits, risks, and convenience. Within the TAM–TPB framework, attitudes are positioned as a key mediator linking cognitive perceptions with behavioral intentions. Mohr and Kühl (2021) demonstrated that positive attitudes toward AI significantly increase farmers' intentions to adopt the technology. This finding was also confirmed by Mishra et al. (2024) in the context of Agriculture 5.0.

Studies by Sun et al. (2022) and Tama et al. (2023) demonstrated that attitudes play a direct role in driving intentions to use digital agricultural technologies. Furthermore, Emon et al. (2023) found that positive attitudes toward AI significantly increase intentions to adopt AI technology. Therefore, the more positive farmers' attitudes toward AI, the more likely they are to intend to use AI in agricultural activities.

H_7: *Attitude Toward AI has a positive effect on Behavioral Intention to Use AI in agriculture.*

In the Technology Acceptance Model, Perceived Ease of Use (PEOU) not only directly influences attitudes but also works indirectly through Perceived Usefulness (PU). When a technology is perceived as easy to use, users are more likely to explore its features and functions, making its benefits more clear and meaningful. PU then acts as a cognitive mechanism that transforms ease of use into positive attitudinal evaluations. Khan and Emon (2024) demonstrated that PU significantly mediates the relationship between PEOU and attitudes in the adoption of visual-based AI technology. Similar findings were reported by Chen and Aklikokou (2020) in the context of e-government, and by Moslehpour et al. (2018) on e-commerce behavior. This mediation model is also consistent across various digital technology contexts, including education and public services. Toros et al. (2024) demonstrated that PU mediates the influence of PEOU on students' attitudes toward learning technology. Makmor et al. (2019) and Lui et al. (2021) found that ease of use increases positive attitudes only when users first experience tangible benefits from the technology. Furthermore, Mutahar et al. (2018) and Zubir and Abdul Latip (2024) emphasized that PU is a key mediator explaining how ease of use translates into positive attitudes. In the context of agricultural AI, this suggests that PEOU improves attitudes toward AI primarily through increased perceptions of its usefulness.

H_8: *Perceived Usefulness mediates the relationship between Perceived Ease of Use and Attitude Toward AI.*

Attitude toward technology is a central psychological variable that bridges cognitive perceptions with behavioral intentions. Within the TAM–TPB framework, Perceived Ease of Use (PEOU) indirectly influences intention to use technology through the formation of positive attitudes. When AI is perceived as easy to use, users tend to feel more comfortable and confident, ultimately forming a positive attitude toward the technology. This attitude then drives behavioral intentions. Emon and Khan (2025) and Emon et al. (2024) showed that attitude significantly mediates the relationship between cognitive factors of technology and intention to use AI among professionals. Empirical evidence across contexts further strengthens this mediating role of attitude. Becan and Çeber (2025) found that attitude toward AI is a significant mediator between technology readiness and behavioral intentions. In the agricultural context, Wang et al. (2019) and Chuang et al. (2020) showed that ease of use of agricultural technology influences adoption intentions through changes in farmers' attitudes. Mishra et al. (2024) also emphasized that attitude is the primary psychological pathway connecting technology perceptions with Agriculture 5.0 adoption intentions. Ratnawati and Darmanto's (2023) findings further confirm that PEOU does not always directly influence intentions but rather works through attitudes as a mediator. Thus, attitudes toward AI mediate the influence of PEOU on intentions to use AI in agriculture.

H_9: *Attitude Toward AI mediates the relationship between Perceived Ease of Use and Behavioral Intention to Use AI.*

In TAM, Perceived Usefulness (PU) is a key determinant shaping affective evaluations of technology, which then influence behavioral intentions through attitudes. PU provides a rational basis for users to assess whether a technology is worth using, while attitudes serve as evaluative responses that encourage or inhibit adoption intentions. Emon and Khan (2025) and Emon et al. (2024) demonstrated that attitudes toward AI significantly mediate the relationship between PU and AI use intentions. This means that perceived usefulness will more effectively drive adoption intentions when it first forms a positive attitude.
This finding is consistent with various technology use contexts. Wiprayoga et al. (2023) demonstrated that attitudes mediate the influence of PU on use intentions in agricultural technology and socio-economic contexts. Teerawongsathorn et al. (2024) also found that ChatGPT adoption is influenced by PU through attitudes toward behavior. Shao et al.'s (2025) study confirmed that perceived usefulness of AI must translate into positive attitudes before influencing use intentions. Furthermore, Liebherr et al. (2025) showed that belief in the benefits of AI and XAI influences intention through attitude. Ratnawati and Darmanto (2023) further confirmed that attitude is a key mediator between PU and intention. Thus, attitude toward AI mediates the relationship between PU and intention to use AI in the agricultural sector.

H_{10}: *Attitude Toward AI mediates the relationship between Perceived Usefulness and Behavioral Intention to Use AI.*

3. Method

This study employed a quantitative explanatory design with a cross-sectional survey approach. This approach was chosen to examine the causal relationships and mediating mechanisms between constructs in the Artificial Intelligence (AI) acceptance model, specifically Perceived Ease of Use, Perceived Usefulness, Attitude Toward AI, and Behavioral Intention to Use AI. Data analysis was conducted using Structural Equation Modeling (SEM) because it can simultaneously examine latent relationships, including mediation effects. The study was conducted in Bandung City and its surrounding areas (Greater Bandung), which represent the agricultural AI technology adoption ecosystem in urban and peri-urban Indonesia. Data collection took place from January to March 2024. The study population included business actors and workers with potential

or existing exposure to AI, particularly in the agricultural sector, particularly in the Micro, Small, and Medium Enterprises (MSMEs) and small-to-medium enterprises (SMEs). Respondents included farmers, business owners, operational managers, and key employees involved in decision-making or the use of digital technology and AI in agricultural work activities. The sampling technique used purposive sampling, with the following criteria: 1. At least 18 years old, 2. Working in an MSME or small-to-medium enterprise in the agricultural sector, and 3. Having experience or basic knowledge related to digital technology or AI. A total of 250 questionnaires were distributed to study respondents. Of these, 208 were returned, resulting in a return rate of 85%. After data screening, 5 questionnaires were deemed unsuitable for use due to incompleteness or inconsistent response patterns. Therefore, 203 questionnaires were used in the final analysis, and this number was deemed sufficient for Structural Equation Modeling (SEM) analysis.

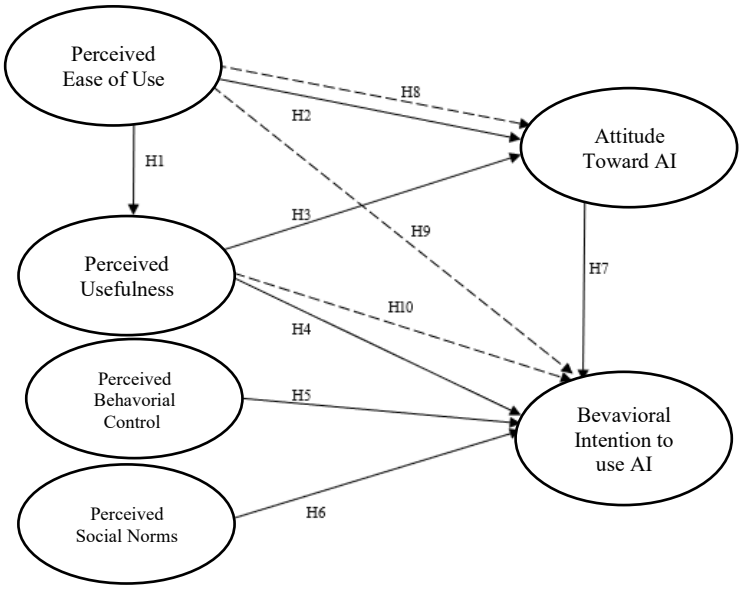

Fig. 1. Research Model

Primary data was collected using a structured questionnaire distributed online via Google Forms. All items were measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The online method was chosen to increase efficiency, respondent reach, and consistency of data entry. Each construct was measured using 3–5 indicators adapted from previous research with proven validity and reliability, particularly from Mohr & Kühl (2021) and the TAM and TPB literature in the context of AI and digital technology adoption. The analysis was conducted using covariance-based SEM (AMOS). The analysis steps included construct validity and reliability (CFA), goodness-of-fit (GFI) testing, direct effect testing, and mediation effect testing using a bootstrapping approach.

4. Results

Table 1 presents the results of construct validity and reliability tests using Confirmatory Factor Analysis (CFA) within the Covariance-Based SEM (AMOS) framework.

Table 1
Results of Construct Validity and Reliability Test (CFA)

Variable	Indicator	Std. Loading	CR	AVE	Information
Perceived Ease of Use (PEOU)	PEOU1	0.78	0.86	0.61	Valid & Relaible
	PEOU2	0.81			
	PEOU3	0.74			
	PEOU4	0.79			
Perceived Usefulness (PU)	PU1	0.84	0.89	0.67	Valid & Reliable
	PU2	0.87			
	PU3	0.80			
	PU4	0.76			
Attitude Toward AI (ATT)	ATT1	0.83	0.88	0.71	Valid & Reliable
	ATT2	0.86			
	ATT3	0.82			
Perceived Social Norm (PSN)	PSN1	0.75	0.79	0.65	Valid & Reliable
	PSN2	0.86			
Perceived Behavioral Control (PBC)	PBC1	0.72	0.82	0.60	Valid & Reliable
	PBC2	0.84			
	PBC3	0.79			
Behavioral Intention to Use AI (BI)	BI1	0.88	0.91	0.77	Valid & Reliable
	BI2	0.90			
	BI3	0.85			

Convergent validity was evaluated through standardized factor loadings, Average Variance Extracted (AVE), and Construct Reliability (CR). Referring to general SEM criteria, a standardized loading value of ≥ 0.70 indicates an indicator's strong ability to represent the latent construct, while a CR value of ≥ 0.70 indicates adequate internal consistency. Furthermore, an AVE value of ≥ 0.50 was used as a cut-off to ensure that the construct explained more than half of the variance in its indicators. The analysis results showed that all indicators within each construct had standardized loading values ranging from 0.72 to 0.90, indicating that all indicators met the convergent validity criteria and no indicators needed to be eliminated. The CR values for all constructs ranged from 0.79 to 0.91, exceeding the minimum required threshold. Therefore, it can be concluded that each construct has good reliability. Furthermore, the resulting AVE values ranged from 0.60 to 0.77, indicating a strong level of convergent validity. Overall, the CFA results confirmed that all constructs (Perceived Ease of Use, Perceived Usefulness, Attitude Toward AI, Perceived Social Norm, Perceived Behavioral Control, and Behavioral Intention to Use AI) met the criteria for validity and reliability, making them suitable for use in the next stage of structural analysis.

Table 2 presents the results of the goodness-of-fit test on the SEM model analyzed using AMOS. The model fit evaluation was conducted using various absolute, incremental, and parsimony fit indices to ensure that the proposed structural model has a good level of fit with the empirical data. The Chi-Square (χ^2) value of 412.36 with a degrees of freedom (df) of 284 indicates a relatively moderate χ^2 value. Given the sensitivity of the Chi-Square test to sample size, the interpretation of model fit is more emphasized on alternative indices. The χ^2/df (CMIN/DF) ratio of 1.45, which is below the cut-off limit of ≤ 3.00, indicates a very good level of model fit. Furthermore, the probability (p-value) of 0.062, which is greater than 0.05, indicates that there is no significant difference between the model covariance matrix and the empirical data, so the model is acceptable. The absolute and incremental fit indices also show satisfactory results. The GFI (0.91) and AGFI (0.90) values have met the criteria ≥ 0.90, indicating a good model fit. Similarly, the CFI (0.96), TLI (0.95), and IFI (0.96) values are well above the recommended cut-off, indicating that the model has strong explanatory power compared to the baseline model. In addition, the RMSEA (0.044) and SRMR (0.047) values are below the maximum limit of 0.08 indicating a low level of approximation error.

Table 2
Results of the Model Goodness-of-Fit Test

Model Feasibility Index	Cut-off Value	Model Results	Criteria
Chi-Square (χ^2)	Diharapkan kecil	412.36	—
Degrees of Freedom (df)	—	284	—
χ^2/df (CMIN/DF)	≤ 3.00	1.45	Good fit
Probability (p-value)	≥ 0.05	0.062	Acceptable
GFI (Goodness of Fit Index)	≥ 0.90	0.91	Good fit
AGFI (Adjusted GFI)	≥ 0.90	0.90	Good fit
CFI (Comparative Fit Index)	≥ 0.90	0.96	Good fit
TLI (Tucker-Lewis Index)	≥ 0.90	0.95	Good fit
IFI (Incremental Fit Index)	≥ 0.90	0.96	Good fit
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.044	Good fit
SRMR (Standardized RMR)	≤ 0.08	0.047	Good fit

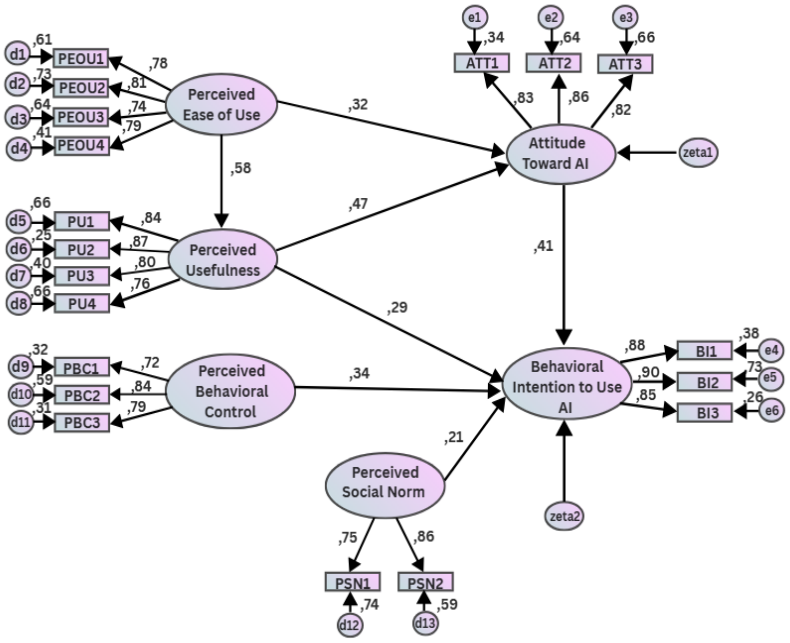

Fig. 2. Full Structural Equation Model

The results of the direct effect hypothesis testing are presented in Table 3. The first hypothesis states that Perceived Ease of Use (PEOU) has a positive effect on Perceived Usefulness (PU) in the context of AI use in the agricultural sector. The SEM test results show a path coefficient of $\beta = 0.58$, with a CR = 6.87 and a significance level of $p < 0.001$, indicating a strong and statistically significant positive effect. Based on these results, hypothesis H1 is accepted, as all structural test criteria have been met. This finding implies that when AI technology is perceived as easy to learn, understand, and use by agricultural practitioners, the technology will be increasingly perceived as useful in improving work efficiency, productivity, and decision-making quality. Therefore, ease of use becomes a key factor in building the perception of AI's benefits in the agricultural sector.

The second hypothesis states that Perceived Ease of Use (PEOU) has a positive effect on Attitude Toward AI (ATT) in the agricultural sector. The analysis results show a β value of 0.32, with CR = 4.21 and $p < 0.001$, indicating a positive and significant influence between ease of use of AI and attitudes towards AI. Thus, hypothesis H2 is accepted because the relationship between the variables is statistically proven. Substantively, these results indicate that agricultural actors who feel AI is easy to use tend to form more positive, comfortable, and open attitudes towards the technology, so that ease of use not only impacts technical aspects, but also plays an important role in shaping psychological attitudes and emotional acceptance of AI innovations in agriculture.

The third hypothesis states that Perceived Usefulness (PU) has a positive effect on Attitude Toward AI (ATT) in the use of AI in the agricultural sector. SEM test results show a β value of 0.47, with a CR of 5.96 and $p < 0.001$, indicating a strong and significant positive effect. Based on these findings, hypothesis H3 is accepted. This result implies that the higher the perception of agricultural actors regarding the tangible benefits of AI, such as increased productivity, time efficiency, and operational ease, the more positive the attitude formed toward AI use. Therefore, perceived usefulness becomes an important determinant in building technology acceptance in the agricultural sector.

The fourth hypothesis states that Perceived Usefulness (PU) has a positive effect on Behavioral Intention to Use AI (BI) in the agricultural context. The analysis results show a coefficient of $\beta = 0.29$, with a CR of 3.74 and $p < 0.001$, indicating a statistically significant effect. Therefore, hypothesis H4 is accepted. These findings indicate that when AI is perceived to provide tangible benefits to agricultural business performance, agricultural actors will have a stronger intention to adopt and use AI, both in the short and long term, so that the perception of usefulness plays a direct role in driving technology adoption decisions.

Tabel 3
Results of Direct Effects Test

Hypothesis	Path of Influence	Estimate (β)	CR	p-value	Decision
H_1	PEOU → PU	0.58	6.87	***	Accepted
H_2	PEOU → ATT	0.32	4.21	***	Accepted
H_3	PU → ATT	0.47	5.96	***	Accepted
H_4	PU → BI	0.29	3.74	***	Accepted
H_5	PBC → BI	0.34	4.89	***	Accepted
H_6	PSN → BI	0.21	2.98	0.003	Accepted
H_7	ATT → BI	0.41	5.63	***	Accepted

Information: *** $p < 0.001$; BI = Behavioral Intention; ATT = Attitude Toward AI; PU = Perceived Usefulness; PEOU = Perceived Ease of Use; PBC = Perceived Behavioral Control; PSN = Perceived Social Norms.

The fifth hypothesis states that Perceived Behavioral Control (PBC) has a positive effect on Behavioral Intention to Use AI (BI) in the agricultural sector. The test results show a β value of 0.34, with a CR of 4.89 and $p < 0.001$, confirming a positive and significant effect. Thus, hypothesis H5 is accepted. Conceptually, this result means that the greater a farmer's sense of control over AI use, whether in terms of ability, authority, or resources, the stronger their intention to use AI. Therefore, self-control is an important factor in driving the adoption of AI-based agricultural technology. The sixth hypothesis states that Perceived Social Norms (PSN) has a positive effect on Behavioral Intention to Use AI (BI) in the agricultural sector. The SEM analysis results show a β value of 0.21, with a CR of 2.98 and $p = 0.003$, indicating a statistically significant effect. Therefore, hypothesis H6 is accepted. These findings indicate that government policy support, social norms, and public expectations for agricultural modernization play a role in increasing agricultural actors' intentions to adopt AI, making social and institutional factors important drivers in the diffusion of agricultural technology. The seventh hypothesis states that Attitude Toward AI (ATT) has a positive effect on Behavioral Intention to Use AI (BI) in the agricultural context. The test results show a β value of 0.41, with CR = 5.63 and $p < 0.001$, indicating a positive and significant effect. Based on these results, hypothesis H7 is accepted. The significance of this finding is that a positive attitude toward AI reflected by comfort, confidence, and acceptance of the technology directly increases agricultural actors' intentions to use AI, making attitude a key psychological factor bridging the gap between technology perception and actual adoption decisions.

H_8 states that Perceived Usefulness (PU) mediates the relationship between Perceived Ease of Use (PEOU) and Attitude Toward AI (ATT). The test results show an indirect effect of $\beta = 0.27$, with a CR/z-value of 4.98 and $p < 0.001$, indicating a statistically significant mediation effect. Since the direct path from PEOU to ATT was also proven significant in the previous test, the type of mediation that occurs is partial mediation, thus hypothesis H8 is accepted. These findings indicate that ease

of use of AI not only directly shapes positive attitudes but also works indirectly through increasing the perception of AI's usefulness in the agricultural sector.

H_9 examines the role of Attitude Toward AI (ATT) as a mediator in the relationship between Perceived Ease of Use (PEOU) and Behavioral Intention to Use AI (BI). The analysis results show an indirect effect of $\beta = 0.13$, with a CR = 3.64 and $p < 0.001$, indicating significant mediation. With the direct path from PEOU to BI remaining significant, the resulting mediation is categorized as partial mediation, thus accepting hypothesis H9. Substantively, these results indicate that AI ease of use increases usage intention not only directly but also through the formation of positive attitudes toward AI.

H_{10} states that Attitude Toward AI (ATT) mediates the relationship between Perceived Usefulness (PU) and Behavioral Intention to Use AI (BI). The test revealed an indirect effect of $\beta = 0.19$, with CR = 4.41 and $p < 0.001$, confirming a significant mediation effect. Because the direct effect from PU to BI was also significant, ATT acted as a partial mediator, thus accepting hypothesis H_{10}. These findings confirm that perceived usefulness of AI drives usage intention both directly and through the formation of positive attitudes, thus attitudes serve as an important psychological mechanism in the AI adoption process in the agricultural sector.

Table 4
Results of Mediation Effect Testing

Hypothesis	Mediation Path	Indirect Effects (β)	CR / z-value	p-value	Types of Mediation	Decision
H8	PEOU → PU → ATT	0.27	4.98	***	Partial mediation	Accepted
H9	PEOU → ATT → BI	0.13	3.64	***	Partial mediation	Accepted
H10	PU → ATT → BI	0.19	4.41	***	Partial mediation	Accepted

Information:
*** $p < 0.001$
PEOU = Perceived Ease of Use; PU = Perceived Usefulness; ATT = Attitude Toward AI; BI = Behavioral Intention to Use AI.

Overall, the results of the mediation test strengthen the role of Perceived Usefulness and Attitude Toward AI as key variables that bridge technology perceptions with AI usage intentions, while confirming the suitability of the integration of the TAM and TPB models in explaining AI adoption behavior in agriculture.

5. Discussion

The results of this study indicate that AI adoption in the agricultural sector is influenced by a combination of cognitive, affective, and social factors, as explained in the integration of the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) (Mohr & Kühl, 2021; Arrang et al., 2025). These findings confirm that farmers' decisions to use AI are not solely about the technology itself, but also related to perceived ease of use, usefulness, attitudes, behavioral control, and social norms (Mohr & Kühl, 2021; Muazu & Abdulmalik, 2021; Alzyoud et al., 2024).

First, the relationship between Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) was found to be the strongest ($\beta = 0.58$). This confirms the classic TAM assumption that technology that is easy to use is perceived as more useful. This finding aligns with studies by Caffaro et al. (2020), Abdullahi and Mahmud (2023), and Cao et al. (2025), which showed that the ease of operation of digital agricultural technology increases its perceived benefits, particularly in the context of smallholder farmers and agricultural cooperatives. In practice, complex AI without a user-friendly interface tends to fail to demonstrate its added value for farmers. Furthermore, PEOU and PU significantly influence Attitude Toward AI (ATT). The effect of PU on attitudes ($\beta = 0.47$) is stronger than PEOU ($\beta = 0.32$), indicating that farmers' attitudes toward AI are determined more by tangible benefits than simply ease of use. This finding is consistent with research by Arrang et al. (2025), Chuang et al. (2020), and Shao et al. (2025), which emphasize that positive attitudes are formed when technology is perceived to improve agricultural productivity, efficiency, and sustainability. In the context of agricultural AI, benefits such as crop yield prediction, input efficiency, and risk reduction are the main determinants of attitudes.

The effect of Perceived Usefulness on Behavioral Intention (BI) was also significant ($\beta = 0.29$), indicating that perceived usefulness plays a direct role in driving AI adoption intentions. This finding supports the findings of Mohr and Kühl (2021), Michels et al. (2021), and Sood et al. (2024), which stated that the adoption of smart technology in agriculture is highly dependent on performance expectations and economic value. Thus, AI is viewed not simply as a technological innovation, but as a strategic instrument for improving agricultural competitiveness. Beyond the TAM construct, the TPB variables also play a significant role. Perceived Behavioral Control (PBC) has a strong influence on BI ($\beta = 0.34$), indicating that a sense of competence, resource access, and technical skills significantly influence AI adoption intentions. This finding aligns with those of Ahmed et al. (2024), Dong et al. (2022), and Sarkar et al. (2022), which emphasize that capacity and infrastructure limitations remain major barriers to the adoption of advanced agricultural technologies in developing countries. Furthermore, Perceived Social Norms (PSN) also significantly influenced AI adoption ($\beta = 0.21$). This confirms that AI adoption does not occur in a vacuum, but is influenced by social pressure, recommendations from extension workers, farming communities, and government policies. This finding is consistent with Guo et al. (2023), Ephrem et al. (2021), and Ninsiima et al. (2025), which showed that social and institutional support accelerates the acceptance of new technologies in the agricultural sector.

The influence of Attitude Toward AI on Behavioral Intention is a key finding (β = 0.41), reinforcing attitude as the primary link between perception and behavioral intention. This finding aligns with Mishra et al. (2024), Sun et al. (2022), and Tama et al. (2023), which assert that while benefits and convenience are important, adoption intention is ultimately mediated by an individual's affective evaluation of the technology.

The results of the mediation effect test further strengthen this argument. PU mediated the relationship between PEOU and ATT, indicating that ease of use increases positive attitudes primarily through perceived usefulness. This finding aligns with Chen and Aklikokou (2020), Moslehpour et al. (2018), and Khan and Emon (2024). Furthermore, ATT mediated the PEOU–BI and PU–BI relationships, confirming the role of attitude as a key psychological mechanism in the AI adoption process. These results are consistent with Verma and Sinha (2017), Wang et al. (2019), and Wiprayoga et al. (2023). Overall, this research confirms that AI adoption in the agricultural sector is a multistep process involving perceived ease of use, perceived usefulness, attitudes, behavioral control, and social norms (Mohr & Kühl, 2021; Caffaro et al., 2020; Arrang et al., 2025; Wu et al., 2024). The TAM–TPB integration has been shown to explain these dynamics in the agricultural context, while providing practical implications that AI adoption policies should emphasize user-friendly technology design, demonstration of tangible benefits, strengthening farmer capacity, and social and institutional support for sustainable agricultural digital transformation (Mohr & Kühl, 2021; Sun et al., 2022; Mishra et al., 2024; Ngan et al., 2024).

6. Conclusion

This study aims to analyze the factors influencing the intention to adopt artificial intelligence (AI) in the agricultural sector by integrating the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB). The results of the Structural Equation Modeling (SEM) analysis indicate that all tested direct effects are positive and significant. Perceived Ease of Use is proven to increase Perceived Usefulness and Attitude Toward AI, while Perceived Usefulness, Attitude Toward AI, Perceived Behavioral Control, and Perceived Social Norms significantly influence Behavioral Intention to Use AI in agricultural activities. Furthermore, the results of the mediation effect test confirm that Perceived Usefulness and Attitude Toward AI act as partial mediators in explaining the mechanism of the influence of ease of use on attitudes and intentions to adopt AI. These findings confirm that AI adoption in the agricultural sector is a gradual process that simultaneously involves cognitive, affective, and social aspects. Theoretically, this study strengthens the relevance and explanatory power of the TAM–TPB integration in the context of modern agriculture, particularly in explaining the behavior of farmers and agricultural business actors toward AI-based technology. The results emphasize the role of attitude as a key psychological mechanism bridging the perception of technological ease and benefits with adoption intentions, and underscore the importance of behavioral control and social norms in technological decision-making in collective and contextual agricultural environments. Practically, these findings imply that strategies to accelerate AI adoption in the agricultural sector should emphasize the development of user-friendly technology, the demonstration of tangible benefits for farm productivity and efficiency, and the strengthening of farmers' digital capacity and literacy. Furthermore, government policy support, the role of agricultural extension workers, and social legitimacy are crucial factors in creating a conducive environment for sustainable agricultural digital transformation.

This study has several limitations. First, the study area is limited to a specific location, requiring caution in generalizing the findings. Second, the respondents are predominantly farmers and agricultural business actors with varying levels of technological literacy. Third, the sample size is relatively limited despite meeting SEM criteria. Fourth, the research model did not specifically incorporate other variables such as risk perception, trust in AI, infrastructure support, or the role of extension institutions. Therefore, future research is recommended to expand the study area, enrich the sample characteristics, and develop the model with additional variables to provide a more comprehensive understanding of AI adoption in the agricultural sector.

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