

Behavioral intention to use biopesticides among rice farmers in Indonesia

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Abstract. The adoption rates of biopesticides by Indonesian farmers are still low, despite their benefits to the environment. The purpose of this study is to examine the determinants of non-user rice farmers' intentions to utilize biopesticide products, based on the Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2). It focuses on the variables that influence their intention to use biopesticides. A modified UTAUT 2 model was applied, incorporating five key variables: performance expectancy, followed by effort expectancy, along with social influence, in addition to facilitating conditions, and finally price value. Data were collected from 400 rice farmers in Bogor Regency, West Java, Indonesia. Structural equation modeling (SEM) was applied to analyze the data. The results show that all five variables influence non-user rice farmers' intentions to use biopesticides. In addition, the UTAUT 2 model explained 39% of the variance in intention. Practical recommendations include enhancing farmer training, promoting peer recommendations, and developing pricing strategies to improve the perceived value of biopesticides.

1 Introduction

Biopesticides have become a viable alternative to synthetic pesticides because they are eco-friendly. Despite their potential benefits, the use of biopesticides among Indonesian farmers is still low [1,2]. This issue has drawn recent interest from scholars. Previous research findings indicate that the low level of biopesticide use is caused by several factors, including uncertainty regarding its effectiveness, limited knowledge and skills, impractical application, unavailability, as well as high cost [3,4]. Therefore, it is essential to carry out research to understand why Indonesian farmers have not or do not use biopesticides on their farms. Thus, the first step in any initiative to promote its use is to understand farmers' intentions to use biopesticide products.

Diverse socio-psychological theories have been applied in previous studies on the intention to use biopesticides [5–7]. However, the current literature highlights a significant gap in research regarding a comprehensive examination of non-user rice farmers' intentions to utilize biopesticide products through the Unified Theory of Acceptance and Use of

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Technology 2 (UTAUT 2) [8]. Thus, the objective of this study is to explore the antecedents of non-user rice farmers' intentions to utilize biopesticides based on the UTAUT 2 framework.

This study focuses on studying the intention of rice farmers who are non-users to seek the factors impact their intention to utilize biopesticides. Consequently, this research will employ a modified UTAUT 2 framework due to its alignment with the research context. Therefore, the UTAUT 2 framework used in this research model includes only five variables: performance expectancy, followed by effort expectancy, along with social influence, in addition to facilitating conditions, and finally price value. The hedonic motivation and habit variables are not incorporated into this research model. While these variables are appropriate for studying the adoption of information technology, they are not applicable for examining the intention of non-user rice farmers to utilize biopesticide in this research.

This study is important as it addresses the low adoption rates of biopesticides among Indonesian farmers, providing insights into the underlying factors influencing their intentions to utilize these eco-friendly alternatives. This study aims to enhance our knowledge of the socio-psychological aspects involved in agricultural technology adoption. This study contributes to the academic discourse on biopesticide usage as well as offers recommendations for policymakers and agricultural stakeholders, facilitating the promotion of sustainable farming practices that can benefit both farmers and the environment.

2 Research methods

In this study, the theoretical framework is grounded in the UTAUT 2 (Figure 1). The study focuses on investigating the behavioral intention of non-user rice farmers in Indonesia to adopt biopesticide products. UTAUT 2 is particularly relevant because it incorporates various socio-psychological and technological factors, such as performance expectancy, effort expectancy, social influence, facilitating conditions, and price value, which are hypothesized to significantly influence farmers' intentions.

Performance Expectancy (PE). These variable measures farmers' belief that using biopesticide products will provide significant benefits, such as effective pest and disease control, safety for farmer's health, and environmental protection. Farmers' expectations of improved outcomes are essential in motivating adoption. If farmers perceive biopesticides as beneficial, they are more likely to use them.

Effort Expectancy (EE). It refers to the perceived ease of learning and using biopesticides. It includes factors like simplicity, clear instructions, and ease of becoming proficient in their use. Farmers are more inclined to use biopesticides if they perceive them as user-friendly. Complexity or unclear instructions can discourage adoption, especially for non-users.

Social Influence (SI). This measures how much farmers are influenced by the opinions of people important to them, such as relatives, fellow farmers, and extension officers. Farmers often rely on the advice and opinions of trusted individuals or groups when adopting new practices. Social influence can strongly impact their willingness to adopt biopesticides.

Facilitating Conditions (FC). This variable reflects the resources, knowledge, and support available to farmers to help them use biopesticides. It includes access to funds, information, training, and purchasing options. Farmers are more likely to adopt biopesticides if they have sufficient access to necessary resources. These variable addresses external factors that enable adoption.

Price Value (PV). This reflects farmers' perception of whether the benefits of using biopesticides outweigh their cost. It assesses whether the biopesticides products are reasonably priced and offer good value. Cost is a critical factor in farmers' decision-making.

If farmers believe the price of biopesticides is fair and justified by the benefits, they are more likely to adopt them.

Intention (INT). Intention is a key determinant of actual behavior, and measuring it provides insight into how likely farmers are to follow through with adopting biopesticides. Understanding intention helps in predicting future adoption rates and identifying the most motivated farmers.

Therefore, this study will examine five hypotheses:

- H₁: Performance expectancy influences non-user rice farmers' intentions to utilize biopesticide.
- H₂: Effort expectancy influences non-user rice farmers' intentions to utilize biopesticide.
- H₃: Social influence influences non-user rice farmers' intentions to utilize biopesticide.
- H₄: Facilitating conditions influences non-user rice farmers' intentions to utilize biopesticide.
- H₅: Price value influences non-user rice farmers' intentions to utilize biopesticide.

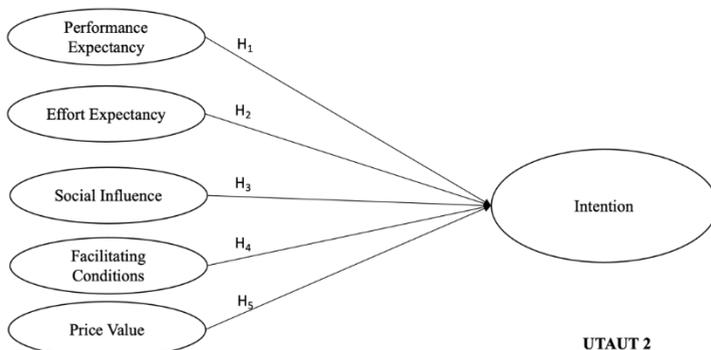


Fig. 1. Proposed conceptual framework

This study was carried out in Bogor Regency, West Java Province, Indonesia, with data collected from December 2021 to March 2022. Bogor Regency has been a pioneer in organic agriculture development in Indonesia since the 1980s, including rice cultivation. It consists of 40 sub-districts, 11 of which have been identified as having significant potential for organic and semi-organic rice farming. The study involved non-user rice farmers who possess knowledge about biopesticide products but they do not apply them. The total research sample comprised 400 respondents selected through purposive sampling techniques. Data collection was carried out using a survey method assisted by a structured questionnaire.

To analyze farmers' intentions using UTAUT 2 framework, 32 indicators were included, comprising 8 PE indicators, 4 EE indicators, 6 SI indicators, 8 FC indicators, 2 PV indicators, and 4 INT indicators. The Likert scale was used by respondents to rank their responses from 1 to 5 (strongly disagree - strongly agree). Structural equation modeling (SEM) was used to analyze the data, enabling the identification of significant pathways and explaining a substantial portion of the variance in intention. To meet the validity criteria, standardized factor loadings (SFL) value of the indicator variables is above 0.7 and Average Variance Extracted (AVE) is above 0.5, while reliability testing was conducted with the criterion that if the Cronbach's Alpha and Composite Reliability values are ≥ 0.7 , then the indicator variables are considered reliable [9,10]. Goodness-of-fit analysis of the model was performed using the Degrees of Freedom (> 0.00), Chi-square p-value (> 0.05), Root Mean Square Error of Approximation (RMSEA) (< 0.08), Goodness-of-fit index (GFI) (> 0.90), Comparative fit index (CFI) (> 0.95), Normed fit index (NFI) (> 0.90), Incremental fit index (IFI) (> 0.90), and Standardized Root mean square residual (SRMR) (< 0.05).

3 Results and discussion

3.1 Respondent Profile

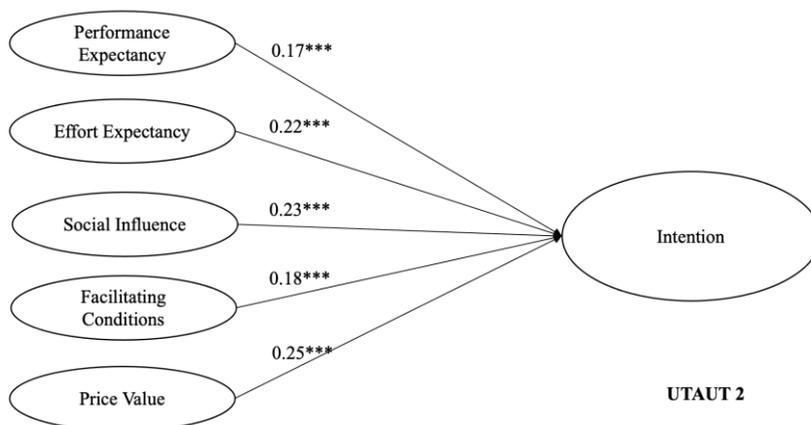
The composition of gender showed a dominance of male respondents at 74.5%. A substantial proportion of the farmers (76.3%) were between 35 - 64 years old. The majority of participants (61%) had completed elementary school as their highest level of education. Additionally, over half of the respondents (58%) reported a monthly income ranging from IDR. 1,000,000 - IDR. 2,900,000. Furthermore, approximately 59% of the farmers owned less than 0.5 hectares of land.

3.2 Result of Measurement Model Evaluation

According to the validity analysis findings, several indicators need to be removed from the model due to SFL values < 0.7 . However, the SFL values for the indicator variables retained in the model range from 0.6 to 1.0. Despite the presence of indicator variables with SFL values < 0.7 , they are still retained in the model because the validity and reliability values of the latent variables associated with these indicator variables are satisfactory. While the AVE values are as follows: PE = 0.5, EE = 0.73, SI = 0.82, FC = 0.59, PV = 0.77, and INT = 0.50. As a result, the indicator variables used are valid. For every latent variable, Cronbach's Alpha values ranged from 0.70 to 0.92, whereas Composite Reliability values varied between 0.73 and 0.92. Hence, it can be stated that the indicator variables used are reliable.

3.3 Result of Structural Model Evaluation

Out of the eight indices used to evaluate the goodness-of-fit of the model, seven indices meet the criteria (Degrees of Freedom = 91 or > 0.00 , RMSEA = 0.06 or < 0.08 , GFI = 0.93 or > 0.90 , CFI = 0.96 or > 0.95 , NFI = 0.94 or > 0.90 , IFI = 0.96 or > 0.90 , and SRMR = 0.04 or < 0.05). Thus, this model is both fit and suitable for evaluating the research hypothesis. Hypothesis testing is carried out using the p-value criterion, where hypotheses 1 - 5 are accepted if they have a p-value < 0.05 and a positive path coefficient value. Based on the p-value, all hypotheses are accepted (Table 1). The analysis of the proposed hypotheses reveals significant relationships between various variables and the intention to use biopesticides among farmers (Figure 2).



Notes: *** significant at p-value < 0.01

Fig. 2. Result of the structural model.

Table 1. Hypothesis testing results

Hypothesis	Path coefficient	p-value	Conclusion
H ₁ : Performance Expectancy → Intention	0.17	0.01	H ₁ accepted
H ₂ : Effort Expectancy → Intention	0.22	0.00	H ₂ accepted
H ₃ : Social Influence → Intention	0.23	0.00	H ₃ accepted
H ₄ : Facilitating Conditions → Intention	0.18	0.00	H ₄ accepted
H ₅ : Price Value → Intention	0.25	0.00	H ₅ accepted

The results show that performance expectancy positively influences intention (H1: $\beta = 0.17$, $p = 0.01$), indicating that farmers perceive the benefits of biopesticides in enhancing their farming practices. Effort expectancy also plays a critical role, with a stronger path coefficient (H2: $\beta = 0.22$, $p < 0.01$), suggesting that ease of use is a significant determinant of intention. Social influence (H3: $\beta = 0.23$, $p < 0.01$) further supports the notion that the opinions of peers and community members can effectively shape farmers' intentions. Additionally, facilitating conditions (H4: $\beta = 0.18$, $p < 0.01$) highlight the significance of external support systems in the adoption process. Finally, price value (H5: $\beta = 0.25$, $p < 0.01$) emerges as the strongest predictor, underscoring the critical role of cost considerations in farmers' decision-making processes.

The model is further assessed by considering the coefficient of determination (R-squared or R²). The R-squared value in the intention to use biopesticide products is 39%, indicating that the determinants of UTAUT 2 model collectively explains 39% of the variance in intention (Table 2).

Table 2. R² value for dependent latent variable

Variable	R ²
Intention	0.39

3.4 Discussion

The significant influence of performance expectancy on intention aligns with the results of earlier research [11–13], which highlight that performance expectancy is a critical factor in the intention of a technology adoption. The performance expectancy of biopesticide products can shape farmers' favorable attitudes towards achieving sustainable agriculture for future generations, consequently affecting their intentions to utilize these products.

The impact of effort expectancy on intention confirms earlier research findings [11,14–17], which show that farmers are more inclined to use new agricultural technologies when minimal effort is required. When farmers believe that using biopesticide products demands little effort, their intention to use biopesticides is subsequently increased as a result of this positive perception of effort expectancy.

Social influence also showed an impact, consistent with findings from previous studies [17,18], which indicate that farmers are more inclined to adopt new technologies when encouraged by peers who have successfully implemented such products, reinforcing the role of social networks in decision-making processes. Therefore, recommendations from fellow farmers who have previously used biopesticides can further motivate adoption.

Additionally, facilitating conditions impact farmers' intentions to utilize biopesticide products. This finding aligns with earlier studies [19,20], suggesting that farmers' intentions to use is associated with having access to training and information of biopesticide products. Farmers are more inclined to use biopesticides when supportive resources are available.

Moreover, the significant impact of price value on intention indicates that the higher the farmer's perceived price value, the greater their intention to use biopesticide products. This

result aligns with the findings of earlier studies [12,14,21–23], and aligning with the perspective of [8] who suggests that price value is positively impacted when the advantages of technology use outweigh the associated costs. Thus, perceived price value plays a pivotal role in farmers' decisions, highlighting that when the benefits of biopesticide usage outweigh the costs, intention to adopt increases significantly. Overall, these findings reinforce the importance of addressing multiple dimensions—performance benefits, ease of use, social norms, support mechanisms, and economic factors—in promoting the use of biopesticides in agricultural practices.

4 Conclusion and recommendation

This study assessed the variables influencing non-user rice farmers' intentions to use biopesticides products through the UTAUT 2 framework. The findings reveal that price value exerts the most significant influence on intention, followed by social influence and effort expectancy. Facilitating conditions rank next, with performance expectancy demonstrating the least impact on intention. This suggests that farmers are more inclined to use biopesticides when they perceive tangible benefits, find the product user-friendly, receive positive support from peers, have access to necessary resources, and view positive cost-benefit ratios favorably. These insights contribute to a better understanding of the dynamics surrounding biopesticide adoption, highlighting the multifaceted nature of this decision-making process. Thus, it is recommended that farmers receive comprehensive training and information on biopesticide products, promote social influence through peer recommendations, and address pricing strategies to enhance their perceived value of biopesticides. These efforts are essential for promoting the sustainable adoption of biopesticides among rice farmers in Indonesia.

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