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Farmers' Intentions for Sustainable Fertilizer Practices: A Study of Shallot Farmers

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Abstract: Sustainable fertilizer practices are needed in the context of resource degradation, climate change and population growth. Farmers' decisions to adopt sustainable agricultural practices are influenced by economic, psycho-social and technological availability aspects. This research aims to explain the factors that influence farmers' decisions to adopt sustainable fertilizer practices. The research model uses the basic Technology Acceptance Model (TAM) and adds the socio-cultural dimension of farmers. The research was carried out by taking the case of shallot farmers' decisions regarding the use of fertilizer. The research was carried out using a survey approach of 111 shallot farmers taken using proportional sampling in the shallot production center of Brebes Regency, Central Java, Indonesia. Data were analyzed using Structural Equation Modeling-Partial Least Square (SEMPLS). The research results found that farmers' attitudes towards adopting sustainable fertilizer practices were influenced by factors such as perceived usefulness, perceived ease of use, and social influence, while farmers' intentions to adopt sustainable fertilizer practices were influenced by farmers' attitudes and habits. The conclusions of this study have implications for technological development and socio-cultural aspects to scale up sustainable fertilizer practices.

Keywords: Farmer decisions; Sustainable agricultural practices; Technology acceptance model

Introduction

The world population in 2022 is 8 billion and is estimated to increase to 8.5 billion in 2030 and increase again to 9.7 billion in 2050. Population growth increases the need for food (Babcock-Jackson et al., 2023). On the other hand, land, water and environmental quality resources are decreasing. This encourages the need for sustainable agricultural practices, including through sustainable fertilization practices. Sustainable fertilization practices not only consider production (economic) aspects, but also social and environmental aspects. Sustainable agriculture does not only use resources that are depleted in one production cycle, but in a sustainable production cycle.

Sustainable fertilization, namely through balanced fertilization by providing nutrients according to plant growth, according to the season, using organic and inorganic fertilizers that are not excessive or in the right dosage (Babcock-Jackson et al., 2023). Information on continuous plant nutritional needs is needed in sustainable fertilizer management (Calabi-floody et al., 2018; Hüttel et al., 2022). Sustainable fertilizer practices, namely using balanced fertilizers with the use of chemicals and organics according to the right dose that is not excessive, according to the type of plant, according to the type of soil, according to the growing season, through an integrated system (Hasnain et al., 2020). Sustainable fertilizer practices are useful in reducing dependence on chemical fertilizers, maintaining soil fertility, reducing production costs, while still increasing productivity and quality of agricultural products. Sustainable fertilizer practices have become a guide to overcome the challenges of a sustainable agricultural sector. However, sustainable agricultural fertilizer practices often face implementation barriers at the small-

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scale farmer level in developing countries (Siebrecht, 2020).

The challenges of sustainable fertilization practices in developing countries include the cultivation of shallot commodities in Brebes Regency, Central Java, Indonesia. Brebes Regency is one of the centers of shallot production in Indonesia. Shallot farmers in Brebes Regency use a lot of synthetic and organic fertilizers in cultivating shallots. However, the use of synthetic fertilizers tends to be excessive (Wulandari et al., 2023; Amin et al., 2017). Excessive use of synthetic fertilizers and pesticides over a long period of time can cause damage to the physical and chemical properties of the soil, as well as a decline in soil microbiology. Sustainable fertilization technology has been identified as a promising approach to overcome the challenges facing the agricultural sector in Indonesia (Babcock-jackson et al., 2023). However, despite the potential benefits, adoption of sustainable fertiliser practices among smallholders remains low. This is caused by several factors, including limited access to information and technical knowledge and the perception that traditional practices are more effective. Smallholders in Indonesia are aware of the benefits of sustainable fertilizer, but smallholders are more concerned with the production aspect and lack the technical knowledge and support to implement the technology effectively (Hasan et al., 2021; Kurniati, 2019; Wulandari et al., 2023 ; Zeolite et al., 2017).

The use of environmentally friendly fertilizer is actually nothing new for farmers in Indonesia. Traditional farmers have long used organic fertilizer in an integrated agricultural system with livestock to maintain soil fertility. Farmers used balanced use of inorganic fertilizers in the 1970-1980s to increase agricultural productivity (Purnomo et al., 2016; Tian et al., 2022). However, in its development, the use of synthetic fertilizers tends to be excessive, focusing more on productivity and ignoring environmental aspects. On the other hand, the scarcity of fertilizer and the ability of farmers to access fertilizer are also often obstacles for farmers. Sustainable fertilization is needed for a fertilizer system to increase farmer productivity, while maintaining environmental sustainability and creating access for all farmers, especially small-scale farmers.

Understanding farmer behavior in adopting sustainable fertilizers is needed. Several studies (Downey, 2014; Funk, 1982; Haidery & Kundu, 2021; Perdana et al., 2018; Purnomo et al., 2016) using the Technology Acceptance Model (TAM) to understand farmer behavior in adopting technology. TAM is a theoretical approach to understanding individual, group or society acceptance of technology. Based on TAM, it can be understood that individual attitudes towards technology are influenced by perceived usefulness and perceived ease of use. Furthermore, attitudes influence intentions and behavior (Angelica et al., 2021; Bhushan & Reddy, 2020; Geng et al., 2023; Kabir et al., 2022; Mohr & Kühl, 2021; Thomas et al., 2023).

The TAM model is related to farmers' intentions in using technology (Downey, 2014; Funk, 1982; Haidery & Kundu, 2021; Perdana et al., 2018; D. Purnomo et al., 2016), as related to the use of technology in agricultural cultivation and marketing (Geng et al., 2023; Kabir et al., 2022; Mohr & Kühl, 2021), some related to the use of clean production technologies (Le et al., 2023), environmentally friendly fertilizers (Adnan et al., 2019; Nordin et al., 2023), and digital fertilization methods (Hüttel et al., 2022) through information technology for accurate and precise fertilization according to soil conditions, plant types, climate. However, farmer decision models in sustainable fertilization are still limited (Calabi-floody et al., 2018; Zheng et al., 2022; Zhou et al., 2010). Farmers' decisions for sustainable practices are not only related to economic aspects, social influences, agricultural environmental considerations, but also cultural influences in the form of values, traditions and habits. The TAM model does not yet include socio-cultural aspects of farmers. The social influence and habits of farmers are very important for the transformation of the agricultural sector, especially in rural areas in developing countries like Indonesia. This is the motivation to fill the literature gap by developing a model of farmers' intentions towards sustainable agricultural practices by including social influence factors and farmers' habits. The study was conducted in the context of fertilizer use among shallot farmers.

The novelty of this research is that it includes social influence factors and farmers' habits in the TAM model to understand farmers' intentions in sustainable fertilizer practices. This research is needed because sustainable fertilizer practices are important in the changing agricultural environment. However, the adoption rate is low, especially by small-scale farmers in developing countries such as Indonesia. The results of this study are useful by providing an understanding of the important elements in the adoption of sustainable fertilization practices.

Method

This research was conducted using a survey approach, namely a data collection method using interviews from a group of people or samples through a list of questions. The research was conducted on 111 shallot farmers in Brebes Regency, Central Java Province, Indonesia. The selection of research objects for shallot farmers took into consideration: 1) Brebes Regency is one of the centers of shallot production in

Central Java, 2) to control the variable type of plant on fertilizer needs, so that by focusing on shallot farmers a homogeneous population will be obtained.

The indicator variables in the TAM model consisting of Perceived Usefulness, Perceived Ease of Use, Farmer Attitude and Intention for sustainable fertilization practices consist of 14 indicators developed by previous research (Mohr & Kühl, 2021). The social influence variable consists of 5 indicators developed by previous research (Diaz et al., 2021). The habits variable consists of 4 indicators developed by previous research (Ajzen, 2002; Verplanken & Melkevik, 2008; Verplanken, 2018). Based on the test results, the instrument for all variables has high reliability (Cronbach alpha value between 0.813-0.966). All scales used self-reported measures based on 5-point Likert, from 1 ("completely disagree") to 5 ("completely agree").

Data were analyzed using a structural equation model based on Partial Least Squares (SEMPLS). Model evaluation in SEMPLS uses outer model and inner model evaluation (Hair et al., 2017). Evaluation of the measurement model (outer model) through loading factor value parameters, as well as indicator reliability testing through Construct Reliability (CR), average variance extracted (AVE), as well as discriminant validity using the Fornell Larcker Criterion. An indicator is said to have good validity if the loading factor value is > 0.70. The construct used is said to have a high level of difficulty if the average variance extracted (AVE) value is > 0.5, the composite reliability value is > 0.7. To assess discriminant validity using the Fornell Larcker Criterion, namely by comparing the square root value of the AVE of each construct with the correlation between other constructs in the model. If the AVE square root value for each construct is greater than the correlation value between the construct and other constructs in the model, then the model is said to have good discriminant validity. Evaluation of structural equations using R-Square parameters, path coefficients and t-test. Hypothesis testing is based on the p value of the t-test for each hypothesis. The hypothesis is proven if the probability value (p-value) <0.05 (Hair et al., 2017) .

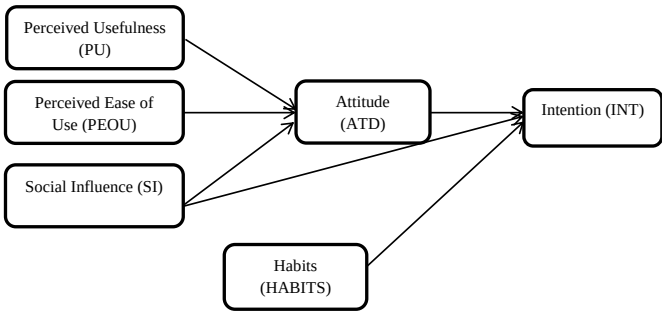

Figure 1. Conceptual framework

Result and Discussion

Testing the validity and reliability of 23 indicators (Table 1) obtained a loading factor value of more than 0.5, with a Composite Reliability (CR) value > 0.7, and an average variance extracted (AVE) value > 0.5. The results of the discriminant validity test (table 2) can be stated that the requirements for discriminant validity have been met, namely that all variables have a value of √AVE > correlation between variables. Thus it can be concluded that all indicators in the improvement model are valid and reliable.

Table 1. Contribution of Each Factor

Dimensions	Indicators	CR	AVE	Loading Factor
Perceived Usefulness (PU)	1. Sustainable fertilization practices increase productivity	0.923	0.814	0.946
	2. Sustainable fertilizer practices increase farmer income			0.949
	3. Sustainable fertilization practices make it easier for farmers to meet their fertilizer needs			0.825
	4. Sustainable fertilization practices do not harm the environment			0.884
Perceived Ease of Use (PEOU)	1. The practice of sustainable fertilization is easy to understand	0.964	0.903	0.965
	2. Sustainable fertilization practices are easy to implement			0.963
	3. Guidelines for sustainable fertilization practices are available			0.941
	4. It is possible to implement sustainable fertilisation practices without any problems.			0.930
Social Influence (SI)	1. Family members are involved in farmer decision making	0.910	0.672	0.883
	2. The experience of other successful farmers often influences me to imitate them			0.933

Dimensions	Indicators	CR	AVE	Loading Factor
	3. Information from agricultural extension officers is often used in decision making regarding agricultural cultivation			0.856
	4. Information from shops is often used in decision making regarding agricultural cultivation			0.914
	5. Sustainable fertilization practices make fertilizer affordable for all farmers			0.900
Habits	1. I don't change easily from habits that I often do			0.916
	2. Farmers in this area often carry out the production that we usually do	0.924	0.812	0.872
	3. I am easily interested in trying new things			0.887
	4. We have long carried out the agricultural culture that our predecessors practiced			0.935
Attitude (ATD)	1. I like sustainable fertilization practices			0.880
	2. I am passionate about sustainable fertilization practices	0.834	0.750	0.869
	3. I am interested in sustainable fertilization practices			0.850
Intention (INT)	1. I plan to use sustainable fertilization practices			0.905
	2. I have every intention of using sustainable fertilization practices	0.854	0.773	0.882
	3. I have no plans to use sustainable fertilization practices			0.851

Table 2. Fornell-Larcker Method Dicriminant Validity Test Value

Parameters	INT	ATD	HABIT	PEOU	PU	SI
INT	0.879					
ATD	0.524	0.866				
HABIT	0.750	0.434	0.903			
PEOU	0.428	0.795	0.376	0.950		
PU	0.589	0.703	0.495	0.768	0.902	
SI	0.393	0.801	0.361	0.724	0.742	0.898

Note: the diagonal value in bold is the square root of AVE (√AVE), the value below the diagonal is the correlation between constructs

Inner model evaluation is an analysis of the results of the relationship between constructs. The R-square for the intention to practice sustainable fertilization (INT) variable is 0.854 (Table 3), which means that the independent variable contributes an influence of 85.4 % to the Intention to practice sustainable fertilization (INT). Meanwhile, the remaining 14.6% is the influence of other unobserved factors. R-*square* for the attitude variable regarding sustainable fertilization practices (ATD) is 0.723 which means that the independent variable contributes an influence of 72.3 % to attitudes towards sustainable fertilization practices (ATD). Meanwhile, the remaining 27.7% is the influence of other unobserved factors.

Based on table 3, it can be explained that of the 5 hypotheses proposed, all hypotheses were accepted because the significance value (*p value*) was <0.05. Based on table 3, the influence of attitude (ATD) on intention to practice sustainable fertilization (INT) is significant in the 2-tailed test (*p-value* = 0.001 < 0.05). Thus, H_1 is accepted. Attitude is a predictor of intention to practice sustainable fertilization . The influence of perceived usefulness (PU) on attitude (ATD) is significant in the 2-tailed test (*p-value* = 0.000 < 0.05). Thus, H_2 is accepted. The influence between perceived ease of use (PEOU) on attitude (ATD) is significant in the 2-tailed test (*p-value* = 0.035 < 0.05). Thus, H_3 is accepted. The influence of social influence (SN) on intention to practice sustainable fertilization (INT) is significant in the 2-tailed test (*p-value* = 0.000 < 0.05). Thus, H_4 is accepted. Habits can have a direct influence on intention to practice sustainable fertilization (INT) (*p-value*= 0.000 < 0.05). Thus, H_5 is accepted.

Table 3. Summary of Hypothesis Testing Results

Parameters	*β*	*ρ-values*	
ATD -> INT	0.245	0.001	Supported
PU -> ATD	0.606	0.000	Supported
PEOU -> ATD	0.158	0.035	Supported
SI -> ATD	0.237	0.000	Supported
HABIT -> INT	0.144	0.000	Supported
R Square (R^2)			
INT	0.854		
ATD	0.723		

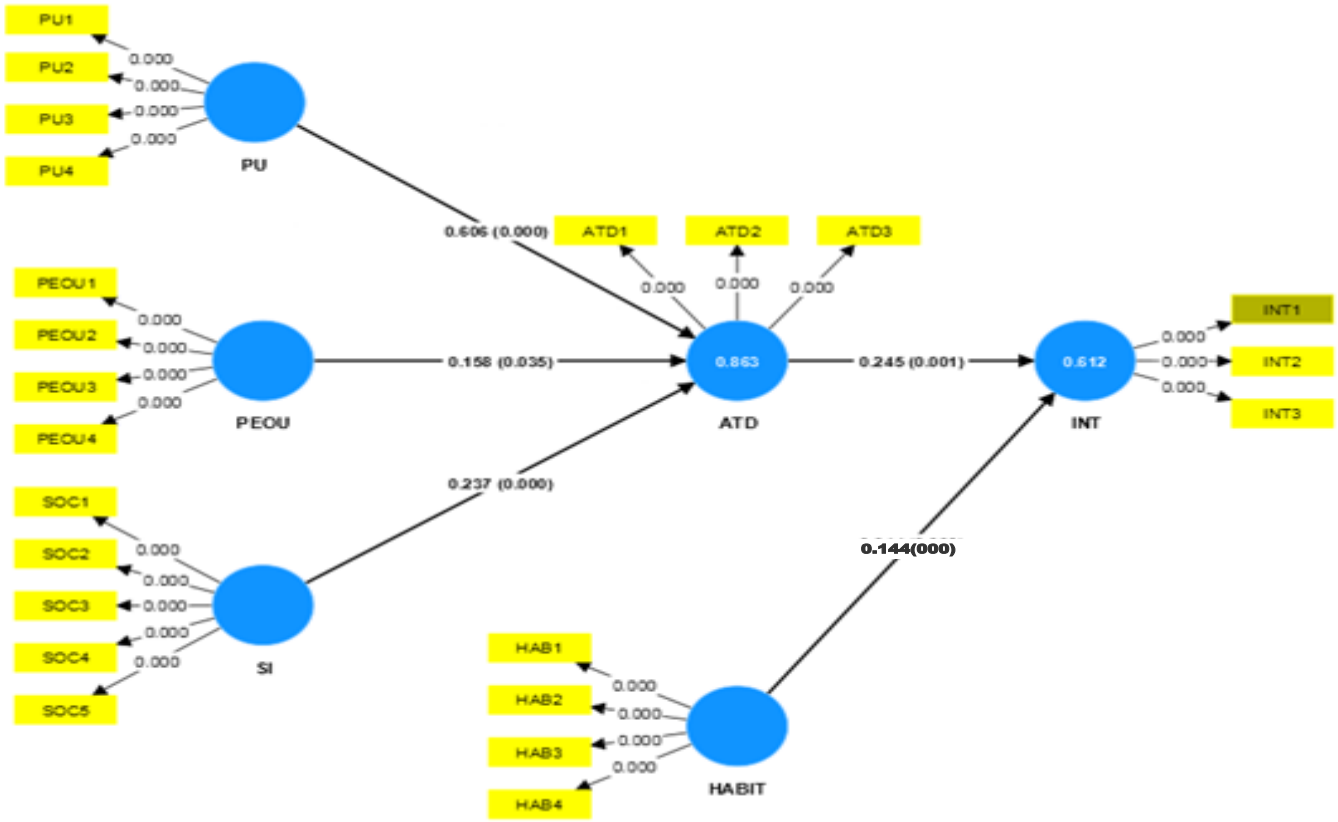

Figure 2. Structural model (path coefficient, p-value)

Discussion

The results of this study (ρ < 0.05, Table 3) found that perceived usefulness (PU) and perceived ease of use (PEOU) had a positive and significant effect on farmers' attitudes towards sustainable fertilization practices. This shows that the higher the level of perceived usefulness and perceived ease of use in sustainable fertilization practices, the greater the attitude towards sustainable fertilization practices. The results of this study support previous research (Angelica et al., 2021; Bhushan & Reddy, 2020; Geng et al., 2023; Kabir et al., 2022; Mohr & Kühl, 2021; Thomas et al., 2023) which explains that There is a relationship between perceived usefulness and perceived ease of use on attitudes towards using technology by farmers. The usefulness of sustainable fertilization practices are related to economic, social and environmental benefits. Economic benefits are related to increasing productivity and improving the quality of harvests (Downey, 2014; Funk, 1982; Haidery & Kundu, 2021; Hayati et al., 2011; Perdana et al., 2018; Petrzelka et al., 2010; D. Purnomo et al., 2016; Zhen, 2003). Social benefits related to farmers' access to fulfilling fertilizer needs for agricultural cultivation (Hayati et al., 2011; Petrzelka et al., 2010; Zhen, 2003). Farmers' access to fulfilling their fertilizer needs is both in terms of cost and ease of obtaining fertilizer. Sustainable fertilization practices mean farmers are not dependent on factory-produced synthetic products. Ecological benefits are the extent to which sustainable fertilization is environmentally friendly by not destroying soil nutrients and not destroying the ecosystem (Hayati et al., 2011; Zhen, 2003). Perception of ease is the ease of practice and not many obstacles in practice. Perceived ease, namely the extent to which it is easy for farmers to carry out sustainable fertilization practices. The easier it is for farmers to adopt sustainable fertilization practices, this has an influence on farmers' attitudes towards sustainable fertilization practices.

The results of this study also found that attitudes towards sustainable agricultural practices were proven to influence intentions for sustainable agricultural practices with a positive relationship (ρ < 0.05, Table 3). This means that the intention to adopt the same or different sustainable agricultural practices by some communities is caused by farmers' positive attitudes towards sustainable agricultural practices. This empirical study is in accordance with TAM that attitudes towards behavior influence behavioral intentions (Thomas et al., 2023). Farmers consider that if they carry out sustainable agricultural practices it will bring beneficial consequences, thus the intention to practice sustainable agriculture will increase. These findings are consistent with previous studies (Angelica et al., 2021; Bhushan & Reddy, 2020; Geng et al., 2023; Kabir et al.,

2022; Mohr & Kühl, 2021; Thomas et al., 2023) which also proves that an attitude towards a product or technology that is profitable tends to increase an individual's intention to engage in behavior using the product or technology.

The results of this study also found that social influence had a positive effect on attitudes towards sustainable fertilization practices ($\rho < 0.05$, Table 3). Farmers' attitudes towards sustainable fertilizer practices are influenced by their social environment, such as family, neighbors, farmer groups, agricultural product marketers and agricultural extension workers. The social environment influences farmers regarding information, knowledge and experience related to sustainable fertilizer practices. Farmers who have experience in successfully increasing agricultural production by using certain types of fertilizer will easily influence other farmers or their communities. The experiences of other farmers provide evidence and confidence in certain agricultural products and technology adoption. Farmers' information and knowledge from the social environment can also be sourced from local agricultural extension workers and from agricultural product marketers. Meetings between farmers and agricultural instructors are often held, for example in farmer group meetings or other social activities. Agricultural product marketers can also help provide the widest possible information and knowledge about how to use, benefits and advantages of using certain organic or inorganic fertilizers to increase plant productivity (D. Purnomo et al., 2016).

Habits were also found to have a positive effect on intentions to practice sustainable fertilization (Table 2). The more farmers become accustomed to using certain products and are successful in using them, the greater their intention to return to using sustainable fertilization practices. This also shows that the more accustomed farmers are to using old processes or technology, the more farmers will not easily switch to new technology . The more often farmers use a certain type of fertilizer, the more they will consider using it again. Farmers' habits are built from information, knowledge, experience and values inherited from previous generations. Knowledge that is valuable, considered good, develops within a social community and becomes a social tradition. Over time, some old knowledge and technology may become obsolete, replaced by new knowledge and technology. New knowledge and technology change old habits into new habits.

Conclusion

The results of this study found that the intention to adopt sustainable fertilization practices is influenced by attitudes towards sustainable fertilization practices. Attitudes towards sustainable fertilization practices are positively influenced by perceived usefulness, perceived ease of use, social influences and farmers' habits. This study makes a scientific contribution to the development of a TAM-based sustainable fertilizer practice model by including social influence factors and farmers' habits. This research has several limitations. First, the research was conducted using a survey approach using a cross-sectional design in the context of a developing country such as Indonesia. Research results may differ over time (technological, social, cultural, policy developments). Second, research was conducted on red shallot farmers in Brebes Regency, Central Java, Indonesia. These results can provide generalizations to other agricultural sectors or other countries with different technological and socio-cultural developments. Third, this study uses SmartPLS, which can have limitations compared to other SEM techniques. Fourth, this research is quantitative in nature which does not capture the rich context and subjective experiences of respondents. Future research can be conducted to enrich some of these limitations).

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Author Contributions
The author contributed to the conception and design, analysis and interpretation of the data, and the drafting of the paper. Data processing, analysis and interpretation are assisted by students.

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Conflicts of Interest
No potential conflict of interest was reported by the authors.

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