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THE LEVEL OF RICE FARMERS' ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES STANDARD IN INDONESIA: A DISCRETE CHOICE EXPERIMENTS

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Abstract: Sustainable Agricultural Practices (SAPs) serve as a yardstick for whether a farmer has effectively implemented sustainability principles. Several levels exist for quantifying sustainability activities. However, farmers frequently find standardised practices intimidating due to their complexity; alternatively, streamlined levels can be provided as an introductory step towards the adoption of SAPs. Assessing the extent to which farmers have embraced SAPs is an essential undertaking. This study utilises Discrete Choice Experiments to examine the preferences of farmers regarding sustainable farming practices. Results involving 407 Indonesian farmers indicate that farmers are generally receptive to adopting SAPs. Nevertheless, the extent to which farmers participate in SAP extension and their engagement in farmer-based organisations may diverge from their preferences. This study highlights the effectiveness of capacity building and information dissemination to farmers as efficient strategies for spreading knowledge, while extension agents play a crucial role as key facilitators.

Keywords: Sustainable agricultural practices, discrete choice experiments, rice farmer, preference.

Introduction

Global attention to Sustainable Agricultural Practices (SAPs) is increasing. Concerns about food safety and the environmental impacts of conventional agriculture are on the rise worldwide. According to the World Health Organisation (WHO), consumption of contaminated food causes illness in 600 million individuals and the death of 420,000 annually. The utilisation of agrochemicals is alleged to pose a threat to human well-being (Pham *et al.,* 2022). The WHO additionally affirms that the utilisation of pesticides, particularly dichlorodiphenyltrichloroethane, can result in death by poisoning, with a significant number of incidents in countries with lower- and middle-income levels. According to the Food and Agriculture Organisation (FAO), the agricultural sector accounts for about 20% of global greenhouse gas emissions. These emissions come from agrochemical inputs and waste from agricultural production. Other environmental impacts include deforestation, desertification, methane emissions, water supply pollution, and eutrophication. Studies indicate that conventional agricultural methods in Indonesia have substantial adverse effects on the environment. Specifically, the environmental carrying capacity has decreased from 26.2% in 2015 to 18% in 2021 (OECD, 2022). On the other hand, conventional farmers in Indonesia incur health expenses that are three times greater than those of organic farmers (Asfawi *et al.*, 2021).

SAPs contribute to reducing the impact of non-sustainable agriculture while also maintaining productivity and improving product quality. SAPs are considered a win-win strategy, especially for low-income developing countries, as they can improve food security while addressing environmental concerns (Ehiakpor *et al.,* 2021; Pham *et al.*, 2021; Mgomezulu *et al.*, 2023). The utilisation of enhanced varieties, integrated pest management, crop rotation, and tillage are practices that provide economic benefits through increased yields and household income. In the long run, sustainable farming systems are more effective than conventional farming systems in reducing soil erosion and maintaining soil productivity. SAPs can significantly reduce transaction costs and other input costs by encouraging the use of locally available resources, such as manure and organic fertilisers (Slijper *et al.*, 2023). Thus, SAPs can provide higher long-term economic benefits to farmers while enhancing food security and economic growth.

The adoption of SAPs in developing countries is currently relatively low. Several studies found that plot and farmer characteristics such as land quality, slope, land size, and education are determinants of SAP adoption (Bopp *et al.*, 2019; Akenroye *et al.*, 2021; Pham *et al.*, 2022). Sources of income beyond farming are also strongly correlated with SAP adoption. Furthermore, social capital influences the adoption of SAPs in developing countries. Fundamentally, the existence of economic constraints and the lack of incentives for farmers are the main causes of reluctance to implement SAPs.

To promote adoption, the design of SAPs needs to consider farmers' constraints and preferences. Therefore, a better understanding of the characteristics of SAPs that are rated most important by farmers is needed. An appropriate scientific approach to evaluate individual preferences for a non-marketed good or service is the Discrete Choice Experiment (DCE). The design of SAPs can be characterised as a policy or initiative product due to its incorporation of multiple attributes, and each of these attributes provides a unique and valuable role. In this context, DCE estimates relative values of attributes important to farmers from different SAP schemes. Identifying the attributes that are most important to farmers can help policymakers incentivise farmers to adopt SAPs that meet farmers' needs so that these programmes can be implemented effectively.

SAP adoption by Indonesian rice farmers is important for future food security. The sustainable agricultural cultivation system in Indonesia is governed by the Law of the Republic of Indonesia Number 22 of 2019, concerning the Sustainable Agricultural Cultivation System. This legislation aims to increase and broaden the range of agricultural products to address various needs, including but not limited to food, clothing, health, and domestic industry. It strives to increase exports, improve farmers' income and standard of living, and promote the expansion of sustainable agricultural practices (Republic of Indonesia Law No. 22, 2019). The "Go Organic 2010" campaign was initiated in 2001 to position Indonesia as the top exporter of organic products by 2010. Nevertheless, organic cultivation is still in its infancy, particularly in the rice industry, which is the primary source of food for most Indonesians (David & Ardiansyah, 2017).

Rice is the staple food consumed by over 85% of Indonesians (Zainul *et al.*, 2021). The overwhelming proportion of farmers in Indonesia are rice farmers, but conventional farming practices exhibit various environmental problems that threaten the sustainability of production (Pickering *et al.*, 2022). However, SAPs are a relatively complicated standard for farmers, who have been accustomed to decades of conventional farming (Campbell *et al.*, 2012). Farmers are the key actors in this issue. On the other hand, changing patterns from conventional to sustainable agriculture poses significant economic risks for farmers. Therefore, appropriate support from policymakers is needed so that farmers can adopt SAPs. The implementation of SAP standards at farms needs to take into account farmers' readiness and preferences because setting standards that are too high will make them return to conventional practices (Ehiakpor *et al.,* 2021). Policy formulation that prioritises farmers' preferences has better potential for effectiveness. However, in the existing literature, no study has proposed a SAP scheme based on rice farmers' preferences. This study seeks to contribute to the literature on policy implications related to the adoption of SAPs by rice farmers.

The objective of this study is to analyse rice farmers' preferences for SAP attributes and calculate at what level they are ready to implement SAP standards. A choice experiment approach was implemented involving SAP attributes at several levels. Furthermore, the heterogeneity of farmers influences their adoption of SAPs, so this study tries to see the relationship between farmers' characteristics and their preferences. This study will contribute to the knowledge of the readiness of rice farmers in developing countries to adopt SAP standards, especially where these standards are relatively new. Policymakers will have a clear footing on where to start, regardless of farmers' preferences and readiness.

Method

Discrete Choice Experiments

The random utility theory of McFadden and Lancaster's microeconomics serves as the model for the DCE (Lancaster, 1966; McFadden, 1974). According to both models, rational people always seek to maximise their utility, and a person's choice of a product is based more on the features rather than the product itself. DCE is widely used for identifying individual preferences based on a range of policy criteria. To properly cooperate with farmers in the SAP setting, policymakers must be aware of their choices as standard adopters. To acquire data, the DCE questionnaire offers respondents a variety of options based on their interests. Using DCE to gauge respondents' preferences is deemed to be effective because this process resembles how decisions are made in real-life (Trapero-Bertran *et al*., 2019). It is necessary to apply DCE when doing a feasibility analysis of new rules or regulations that are either not implemented in practice or do not have enough evidence to support them (Noor *et al*., 2022). DCE may calculate the average relative worth of the attributes included in a standard or policy in addition to calculating the trade-offs made by respondents.

Sample and Survey

Respondents in this study were rice farmers in three districts in East Java: Malang, Pasuruan and Mojokerto. The three locations were selected due to the presence of farmers experienced in SAPs. In addition, these three areas are sizable rice-producing regions in East Java Province. A non-probability sampling technique was used to determine the number of respondent farmers in this study. Data collection was carried out from August to October 2023. Face-to-face interviews were conducted using a structured questionnaire. In the questionnaire, a cheap talk script was provided to explain the attribute levels in the DCE question section. A cheap talk script is important to make respondents understand the selection process at the DCE question stage, besides that, a cheap talk script is also important to equalise the perception between the research objectives and the respondents' understanding (Noor *et al*., 2023). Before implementation, the questionnaire was pilot-tested on several farmers until a reliable questionnaire was obtained. Trained enumerators were deployed to conduct structured interviews with farmers. A total of 407 farmers participated in this study.

Experimental Design

The steps in DCE are determining attributes and levels, developing choice sets, and analysing data. Determining attributes is an essential stage in DCE because it determines the design of the next experiment. In this study, attributes and levels were compiled through a review of previous literature on SAPs. The SAP attributes that were examined in several studies are varied (Bopp *et al.*, 2019; Martey *et al.,* 2022; Pham *et al.*, 2022; Setsoafia *et al.,* 2022; Yang *et al.,* 2022). Several stages in the conventional rice cultivation process involve the application of chemicals, namely for pest and disease control, plant nutrition, grass control and tillage. Furthermore, the DCE attributes used in this study were also determined through discussions with experts in the field of sustainable agriculture. Discussions through in-depth interviews were carried out with two practitioners in the field of sustainable agriculture, which consisted of organic farm operators and agricultural extension officers. Both of them are knowledgeable sources involved in rice production, so it is appropriate to present information concerning the attributes of SAPs that have been implemented. As a result of the literature review and discussions with experts, information on SAPs focused on practices that use natural resources such as natural predators, natural fertilisers, and mechanical control. Based on these two sources, four attributes were used in this study: pest control, tillage, weed control, and plant nutrients.

The levels of implementation of the attributes employed in the DCE of this study are categorised as SAPs. In the pest and disease control attribute, 3 categorical levels were used – using natural predators, mechanical and biochemical, and applying integrated pest control. The levels of the tillage attribute are strip tillage, hilly, and covered with straw. For weed control, the levels are organic herbicide and mechanical and manual control. For plant nutrition, the levels are compost fertiliser, forage fertiliser and precision fertilisation. Details of each attribute and their levels can be seen in Table 1.

The next step in the DCE experiment design is to construct the choice set. The choice set is constructed by combining the predetermined attribute levels. Based on the number of attributes and levels in Table 1, the full factorial combination of the experiment is 34, which is 81 combinations for one choice option. Each choice set in the DCE questionnaire contains a minimum of two options, resulting in a total of 812 choice sets, which equates to 6561 combinations. This is certainly too many combinations and may dissuade respondents from truthfully completing the questionnaire, resulting in their choices being potentially biased. Therefore, it is necessary to reduce the number of full factorials while still representing the full design. The technique used to reduce the number of combinations is fractional factorial, which adopts the principle of orthogonal balance. The reduction of choice sets is done using the help of R Software with the support of the CEs package. The "rotation design" tool in CEs mixes and matches choice combinations in this study (Johnson *et al.*, 2007). According to Aizaki and Sato (2015), the selection procedure was carried out without replacement until all options were assigned to the choice sets. Nine choice sets were generated following reduction, with each set comprising three options and excluding the "no choice" option. Three design possibilities were used in each decision set based on proportionality. Since the "No Choice" option was not implemented, limiting the respondents to two options would result in

Table 1: Attributes and levels of DCE

Attribute	Levels
Pest control	Predator and pest-tolerance varieties* Mechanical and biochemical Integrated pest management
Tillage	Stripped* Hilly Straw mulch
Weed control	Organic herbicide* Mechanical Manual
Nutrition	Compos* Green forage Precision farming

Note: * reference level

an insufficient number of choices. Additionally, offering more than three alternatives would bring more complexity to the respondents' choice-making process. The "no choice" option allows responders to reject SAPs. This doesn't fit this study's goal of assessing farmers' SAP adoption. Moreover, the alternative proposed in this study is a more mandatory condition. One example of a choice set in this study can be seen in Figure 1.

The DCE survey is presented using illustrative images to aid respondents' comprehension of the questions, as has been done in past research. The survey includes questions

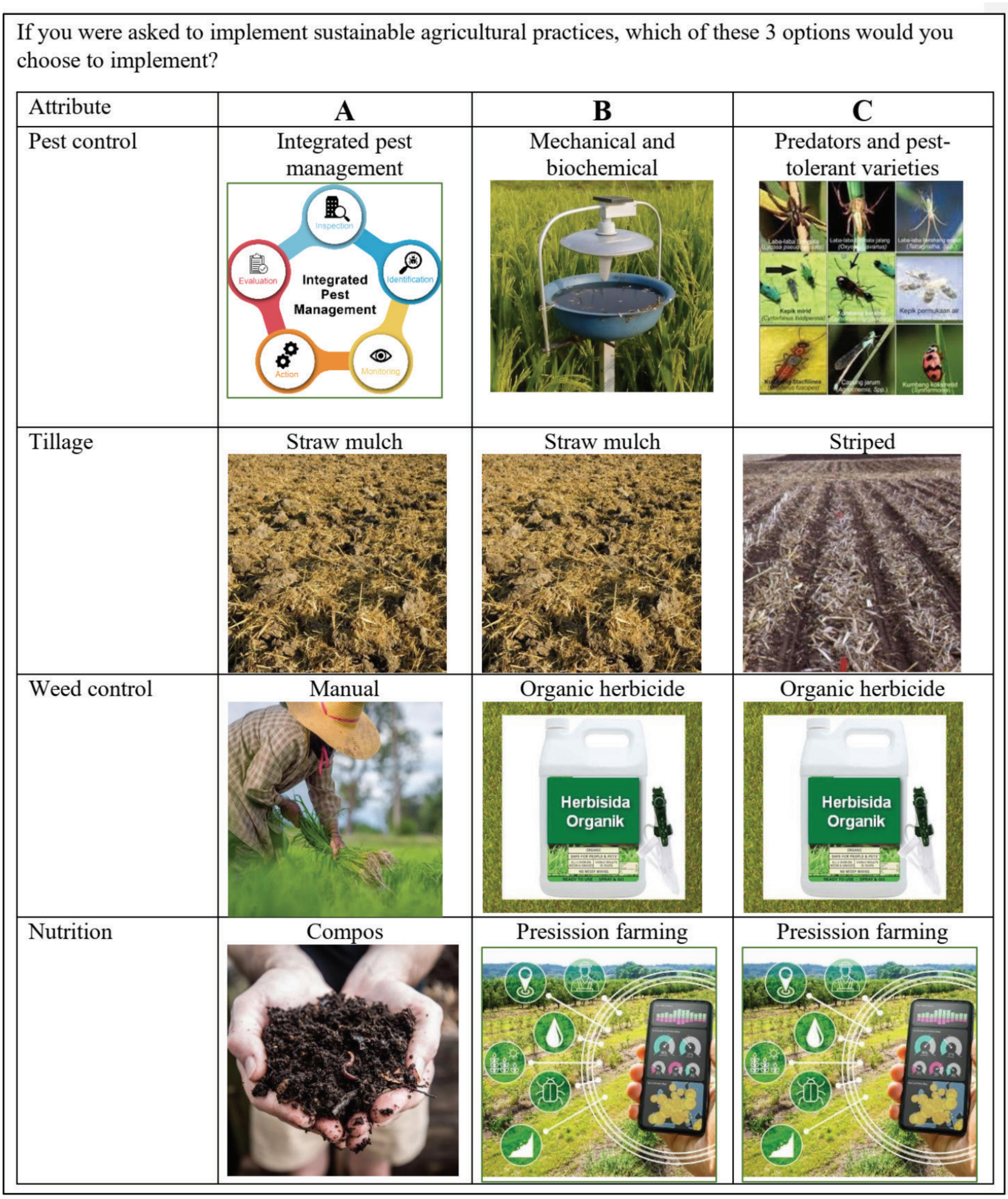

Figure 1: One of the choices sets in the study

about the traits of the farmers, farming methods, scripts for cheap talk, and DCE questions. The cheap talk script is a guide to help participants choose the best option following the study's goals. In addressing hypothetical bias in the stated preference study, this part was reasonably successful. A pilot survey was conducted to elucidate any unclear remarks before the questionnaire was implemented. Because the majority of respondents were farmers with middle-to-lower-class educational backgrounds, the pilot survey was useful for assessing a hypothetical scenario in the DCE study. This required the creation of an easily understandable questionnaire.

Data Analysis

The demographics of the respondents in this study are described by gender, age, education, marriage status, and off-farm job. Furthermore, the respondents are also described in terms of land production area, production, the received selling price of grain, participation in farmer-based organisations, and their involvement in SAP extension programs. Respondents' characteristics data were analysed using descriptive statistics. Furthermore, DCE data were then estimated using conditional logit, utilising the "survival" package in R software. The logit model assumes that respondents choose the product or service that provides the highest benefit to them (Brunet-Houdard *et al*., 2019; Kong *et al*., 2020). In DCE, respondents' preferences are measured by asking them to choose between several product or service options that have different combinations of attributes and levels. Conditional logit is a variation of the logit model that assumes that a respondent's preference for an attribute does not change as the level of another attribute changes. Simply put, conditional logit assumes independence between attributes in the consumer choice model.

In DCE data analysis, conditional logit is used to estimate the influence of each attribute on respondents' choices. The estimation is done by calculating the coefficient value for each attribute, which represents how much influence the attribute has on the respondent's choice. The results of the conditional logit analysis can be used to determine which attributes are most important to respondents and how changes in the level of these attributes can affect consumer preferences for a product or service. If β is the effect of the SAPs attribute, then is the unobservable error component, then the choice of respondent i on the j^{th} alternative is as follows:

$$V_{ij} = \beta pest_{mec} + \beta pest_{ipm} + \beta till_{hill} + \beta till_{straw} + \beta weed_{mec} + \beta weed_{man} + \beta nut_{green} + \beta nut_{prec} + \varepsilon_{ij}$$

DCE builds a choice set consisting of several choices. Each choice consists of levels of attributes that have been predetermined in the experimental design. Respondents are given the task to choose from the alternatives offered in each choice set. Based on McFadden's random utility model, the utility of respondent i in choosing option j is defined as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

Assuming the stochastic components are independent and identically distributed, and all respondents have identical preferences, the probability of individual *i* choosing alternative *j* is:

$$Prob\ \{j\} = \frac{e^{V_{ij}}}{\Sigma_{j=1}^{k} e^{V_{ij}}}$$

Relative attribute importance (AI) is calculated by multiplying the absolute parameter value in the equation above by the difference in utility values at the highest and lowest levels using the equation:

$$AI = \frac{(Attribute\ Utility\ Range)}{(Total\ Attribute\ Utility\ Range)} x\ 100\%$$

Results

Most respondents in this study were male farmers (94%). The average age of respondents was 56.89 years old, indicating maturity in age. The average respondent had 7.75 years of formal education, indicating a relatively low level of education. Furthermore, the general farming experience of the respondents was 31.77 years, indicating a fairly mature experience in agriculture. In addition, 91% of respondents had off-farm jobs, indicating that they had less leisure time. The majority of research respondents were married (93%), indicating that they had family dependents in their households. On the farming side, the average rice cultivation area is 0.4 hectares, and the average production is 7,163 Kg/ha, with farmers receiving an average price of IDR 5,495 per Kg of grain. On the institutional aspect, 75% of the farmers in this sample are members of a farmer-based organisation, and 59% of the farmers claim to have received education on SAPs. This indicates that SAPs are not something new to them.

The information on respondent farmers' current farming practices can be seen in Figure 2. Most of the farmers use improved seed varieties in rice cultivation, indicating that farmers' adoption of improved varieties is high. In addition, farmers also use drought-resistant varieties, indicating that farmers in this study have considered climate change, including the potential for drought. Moreover, only a limited number of farmers are implementing the more

Table 2: Profile of the respondents in this study

Variable	Measurement	Mean	Std. Dev.
Gender	0 = female; 1 = male	0.94	0.24
Age	Year	56.89	11.01
Education	Year	7.75	2.60
Farming experience	Year	31.77	14.52
Off-farm job	0 = No; 1 = Yes	0.91	0.29
Marriage	0 = Single; 1 = Marriage	0.93	0.25
Land production area	Hectare	0.45	0.52
Production	Kg / Hectare	7163	5583
Price per Kg grain	IDR	5495	1304
Farmer based organisation	0 = No; 1 = Yes	0.75	0.45
Receive SAPs extension	0 = No; 1 = Yes	0.59	0.49

Note: The exchange rate of IDR to USD as of November 17, 2023 is IDR 15,419

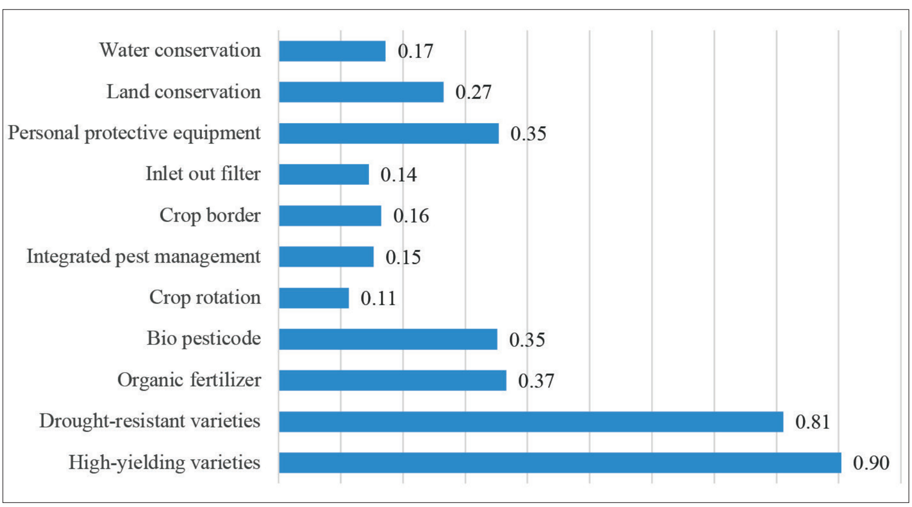

Figure 2: Farmers' cultivation practices (in %)

practical dimensions of environmentally friendly approaches, including those of individual safety. Only 35% of farmers use personal protective equipment when working in the field, including when spraying pesticides. Conservation practices, such as soil and water conservation, are minimal. Furthermore, only about 30% of farmers use organic fertilisers and biopesticides. More detailed practices, such as installing inlet-out filters and planting border crops on farms, are carried out by less than 16% of farmers. Furthermore, crop rotation is practised by only 11% of farmers, while integrated pest management is practised by 15% of farmers. This indicates that while a minority of farmers in the studied area have adopted SAPs, the practice has not garnered considerable attention; consequently, most farmers keep cultivating paddy by employing unsustainable methods.

Table 3 shows the logit estimation from DCE preference data analysis and the attribute importance. The results obtained from the logit estimation indicate that the preferences of farmers regarding attributes at the SAP level result in elevated standards. Farmers have a strong preference for using mechanical and biochemical treatments beyond natural predators and tolerant varieties for pest management, with a coefficient value of 0.1978. They exhibit a preference for implementing Integrated Pest Management over using predators and pest-tolerant varieties, with a coefficient value of 0.2749. Farmers prefer the straw mulching procedure as the preferred SAP standard over other levels, with a coefficient value of 0.7269. Additionally, they still prefer the hilly tillage method over striped tillage, with a coefficient of 0.5588. As for SAP weed management,

Table 3: Conditional Logit Estimation and Attribute Importance

Attribute levels	**Importance (%)**	**Coef.**	**Exp (Coef.)**
Pest control	11.96		
Mechanical and biochemical (Predator and pest-tolerance varieties)		0.29*** (0.05)	1.34
Integrated pest management (Predator and pest-tolerance varieties)		0.24*** (0.05)	1.28
Tillage	29.19		
Hilly tillage (Stripped)		0.55*** (0.05)	1.74
Straw mulching tillage (Stripped)		0.72*** (0.05)	2.06
Weed control	42.45		
Mechanical weed control (Organic herbicide)		1.05*** (0.06)	2.85
Manual weed control (Organic herbicide)		1.05*** (0.05)	2.87
Nutrition	16.41		
Green forage (Compos)		0.18*** (0.04)	1.20
Precision farming (Compos)		0.40*** (0.05)	1.50

Note: Reference levels are in parentheses; Model likelihood ratio test = 1266 on 8 degrees of freedom; Significance level = *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$.

farmers chose mechanical and manual methods instead of organic herbicides, with coefficients of 1.0507 and 1.0572, respectively. Contrary to expectations, the results reveal that farmers would rather use precision farming (coefficient value: 0.4086) than bio fertilisers, like green forage or compost, when it comes to nutrient management options. The estimation results in Table 3 indicate farmers' preferences are homogeneous, and do not indicate any relationship from other variables that may influence their choices. Therefore, an analysis revealing information on preferences associated with other variables is necessary.

On a scale of importance, weed control is the most important thing for farmers in SAPs (42.45%), followed by tillage (29.19%) and nutrition management (16.41%). Pest control, on the other hand, is the least important thing for farmers to be concerned about when adopting SAPs (11.96%). This result indicates that farmers tend to put greater emphasis on crop care-related attributes when coming up with SAPs. External influences typically impact farmers' attitudes toward the adoption of new farming methods or practices. This study indicates that farmer-based organisations and extension initiatives influence SAP-level preferences. Table 4 shows the estimation of farmers' preferences for SAP

Table 4: Conditional logit estimation with interactions

Level Attribute with Interaction	Coef.	Exp(coef.)
Mechanical and biochemical	0.1741 (0.1134)	1.1902
Integrated pest management	0.1272 (0.1097)	1.1357
Hilly tillage	0.4827*** (0.1065)	1.6206
Straw mulching tillage	0.7448*** (0.1101)	2.1060
Mechanical weed control	1.0027*** (0.1262)	2.7257
Manual weed control	1.0637*** (0.1156)	2.8973
Green forage	0.2819** (0.0969)	1.3257
Precision farming	0.4594*** (0.1152)	1.5832
FBO x Mechanical and biochemical	-0.0641 (0.1288)	0.9379
FBO x Integrated pest management	0.0128 (0.1246)	1.0130
FBO x Hilly tillage	-0.0033 (0.1206)	0.9966
FBO x Straw mulching tillage	0.3969** (0.1252)	1.4873
FBO x Mechanical weed control	0.3433** (0.1437)	1.4097
FBO x Manual weed control	0.1519 (0.1314)	1.1641
FBO x Green forage	-0.3942*** (0.1104)	0.6742
FBO x Precision farming	-0.0746 (0.1308)	0.9281
SAPs extension x Mechanical and biochemical	0.2973** (0.1191)	1.3462
SAPs extension x Integrated pest management	0.1871 (0.1162)	1.2058
SAPs extension x Hilly tillage	0.1430 (0.1115)	1.1538
SAPs extension x Straw mulching tillage	-0.5194*** (0.1165)	0.5948
SAPs extension x Mechanical weed control	-0.3559** (0.1329)	0.7005
SAPs extension x Manual weed control	-0.1945 (0.1221)	0.8232
SAPs extension x Green forage	0.3267** (0.1028)	1.3864
SAPs extension x Precision farming	0.0110 (0.1204)	1.0111

Note: Likelihood ratio test = 1341 on 24 df, p = < 0.000

attributes in relation to the farmers' participation in farmer-based organisations (FBO) and extension programs on SAPs.

The logit estimation with interaction results revealed that with FBO interaction, farmers preferred straw mulching tillage as the tillage method in SAPs. Interestingly, although statistically insignificant, with the interaction of the FBO variable with preference, farmers preferred striped tillage over hilly tillage in their tillage practices. Farmers in FBOs significantly preferred mechanical weed control over other weed control methods (manual and bio-herbicide). Furthermore, the interaction of preference with FBO led to new results; namely in the practice of using plant nutrients, farmers significantly favoured applying green forage over compost nutrients or precision farming techniques.

The relationship between farmers' preferences and involvement in SAP extension programs showed interesting results. Regarding pest management attribute, farmers significantly favoured mechanical and biochemical practices over integrated pest management and the use of predators and pest-resistant varieties. Regarding tillage practices, the estimation results significantly showed a negative coefficient on the application of straw mulching tillage, indicating that farmers did not like the use of straw as soil cover in the tillage process. Furthermore, the interaction of SAPs extension with weed control significantly shows a positive coefficient on mechanical weed control, indicating that farmers prefer to use mechanical equipment for rice weed control rather than using bio-herbicides or manual control. In the interaction of SAPs extension with the practice of using plant nutrients, the coefficient significantly shows a positive value at the green forage level, indicating that farmers are more likely to use green forage as rice plant nutrition than compost or precision farming.

Discussion

The setting of SAP standards through a preference approach is an attractive breakthrough in the environmental sustainability of agriculture. Based on the DCE analysis results, it is evident that farmers prefer sustainability practices that differ significantly from their current habits. For instance, in the context of integrated pest management, the data indicates that farmers currently have low adoption rates. However, the logit estimation reveals that farmers prefer integrated pest management over other methods, such as utilising predators or pest-resistant varieties. Following a thorough examination of preferences and farmers' involvement in SAP extension, the findings indicate that farmers prefer utilising mechanical and biochemical pest control tools. In Indonesia, the implementation of integrated pest management is an emerging idea, yet it has garnered significant interest among farmers. This study found that agricultural extension about integrated pest management is still inefficient in farmers' environments. This finding is in line with the study of Wuepper *et al.* (2021) of fruit farmers in Switzerland, which found that integrated pest management extension only impacted less than 10% of farmers, as indicated by their practices to prevent fruit fly infestation. On the other hand, integrated pest management is a traditional pest control concept that emphasises environmental sustainability with several tactics that pivot on economic viability, environmental safety, and social acceptability (Muhie, 2022). Farmers who adopt integrated pest management tend to have a better awareness of climate change, so the adaptations have a significant impact on environmental sustainability (Erekalo & Yadda, 2023).

The upcoming discussion delves into the research findings regarding farmers' preferences for tillage practices. The estimation results reveal variations in the interaction between FBOs and SAPs extension. The study revealed that farmers who were engaged in farmer-based organisations were more likely to adopt straw mulching tillage compared to those who were not involved, whereas farmers who participated in SAP extension programmes were less inclined to adopt straw mulching tillage. It suggests that FBOs and SAP extensions have unique impacts on the tillage system choices of farmers. One of the barriers to SAP adoption is the lack of proper support, information and promotion about SAPs from extension agents (Rodriguez *et al.*, 2009). Straw mulching reduces soil evaporation, which affects agricultural water use efficiency (Zhang *et al*., 2023). Straw mulching is often practised on traditional Indonesian farms during the waiting period, as harvested straw is a free material that farmers can utilise. Furthermore, the use of straw mulching results in easier tillage, supporting sustainable no-tillage practices (Thierfelder & Mhlanga, 2022).

In the weed control attribute, mechanical weed control practices are the most preferred technique for farmers in SAPs. Likewise, with the interaction of FBOs and counselling on SAPs, farmers still chose mechanical weed control methods. Mechanical weed control has been practised by farmers in Indonesia for a long time, which influences the choices they make in the choice set. Weed control techniques with mechanical equipment tend to be easier and more effective than using bio-herbicide, which are still doubted in terms of efficacy. Besides, manual control requires more labour and time. Weed control using mechanical equipment is one of the driving factors in the practice of SAPs, which also have a resilience impact on farmers (Mpanga *et al*., 2021). On the other hand, Vasileiou *et al*. (2023) proposed the use of artificial intelligence as an extension of mechanisation, where farmers can detect weed growth in their fields, but this idea is still under development.

Precision farming is the most preferred level of nutrient management attributes for farmers in general, but when the analysis is done deeper by involving FBO and SAPs extension variables, it is found that farmers tend to choose green forage over compost or precision farming. This finding illustrates that, in general, many farmers already know about precision farming, but the information they get from FBOs and extensions about SAPs is still limited. Precision farming has been widely promoted in Indonesia, the majority of farmers see it as part of modern agriculture, so they think that implementing it will provide incentives for them and environmental sustainability (Piñeiro *et al*., 2020). On the other hand, green forage is a component that is widely available around the farmer's environment, making it an easy choice. The findings indicate that farmers want to improve their farming practices towards precision farming, but due to the perception of the complexity and difficulty of precision farming, green forage is the easiest option. This shows that the role of FBOs and extension has a significant role; therefore, institutional capacity building among farmers needs to be improved. This supports what has been stated by Setsoafia *et al*. (2022) which states farmers' adoption of SAPs will increase with their participation in FBOs and extension. In other words, what kind of improvement is to be achieved depends on the capacity of the FBOs and extension workers themselves.

The discussion highlighted farmers' strict preferences for SAP adoption. The influence of farmers' activities in FBOs and their participation in SAP extension is a strong driver in the SAP adoption process. However, the content disseminated should be a concern, as high standards may be difficult for farmers to achieve but can be a trigger for innovation within the farming community.

Conclusions

Farmers' preference for adopting SAPs is an illustration of whether farmers will be ready to change for the sake of agricultural sustainability. The analysis using DCE shows that farmers are enthusiastic and motivated to adopt SAPs but are hampered by the flow of information they receive. The role of FBOs and their participation in SAP extension is an important point in increasing the adoption of SAPs; however, information and real support for relatively new agricultural practices must be a priority. In other words, farmers have the readiness to change, but intensive assistance needs to be done in the early phases. This also aims to provide clear and precise direction on the standard of SAPs that farmers will implement. Through this study, the most appropriate implication generated is the innovation diffusion strategy. The distribution of innovations related to SAPs needs to be done through innovator agents in the village, including active farmers. In addition, the role of the digital community also has a real impact on increasing the knowledge of farmers. However, the role of extension services in the field also has an important role in bridging farmers with the resources needed. This study provides quite rich information about the level of farmer adoption of SAPs, but keep in mind that farmers' choices in this study are generated through forced choice; farmers do not have the opportunity not to adopt SAPs, so farmers' decisions to adopt or not adopt SAPs cannot be analysed. Future research can study the incentives that farmers want, considering the application of SAPs has the risk of decreasing yields during the conversion period. Furthermore, policy objectives may encompass bolstering farmer organisations to be actively involved in agricultural sustainability and aiding their capacity for disseminating information regarding SAPs. Funding for FBOs, training initiatives, and the establishment of collaborative partnerships between FBOs and agricultural extension agents are all concrete forms of support. This study provides valuable insights, but it needs to be adapted and tailored to other developing countries' special contexts, which requires a deep understanding of local socio-cultural, economic, agroecological, institutional, and policy and regulatory factors. Farmers and other local stakeholders have to take part in SAP adoption programs' design and implementation.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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