Determining Factors for Farmers to Engage in Sustainable Agricultural Practices: A Case from Indonesia

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Abstract: The Green Revolution still heavily influences the agricultural practices of small-scale farming enterprises employing unsustainable methods of cultivation. As a result, many initiatives have been developed to promote more environmentally friendly agricultural practices. This paper aims to seek the determinants of farmers regarding practicing more sustainable farming in Tasikmalaya Regency, Indonesia, especially in terms of the use of chemicals. Data were gained by interviewing 360 farmers at the study site. A logit regression model was then used to analyze the data. The results of the analysis indicate that the most significant determinants of sustainability in farming practices are each farmer’s standard of education and how active the farmer is in farmers’ groups. This shows the importance of positioning the farmer group as an essential factor for achieving sustainable farming in Indonesia. Consequently, transitioning to more sustainable agricultural practices requires that policymakers address the topic of economic incentives, improving market access, leveraging farmers’ groups, providing education and support, and designing policies that empower farmers as agents of change in their own communities.

Keywords: sustainable agriculture; farming practices; farming institution; agricultural communities; agricultural development

1. Introduction

Farming practices in Indonesia, just as in any other developing country, are dominated by small-scale cultivation. According to the agricultural census of 2018, 70.42% of farming households in Indonesia farm less than one hectare of land [1]. This high percentage inhibits agricultural development because small-scale farmers must cope with high transaction costs, low bargaining power, low prosperity, and insufficient capital to scale up their businesses; in addition, they are sometimes unsuitable for the pre-existing agricultural development programs, which target established farming businesses [2,3]. In responding to that need, development programs usually target farmers’ organizations to gain access to these small farmers. They can act as a vehicle for donors to contact farmers and strengthen the farmers’ positions in the marketplace [4,5].

Farmers’ organizations have several scientifically proven effects on the social economy. The authors of [4] found that there is a positive causal effect between membership of farmers’ organizations and overall agricultural profits, which showed an increase of around 50%. These organizations were also found to have contributed in other ways, including accelerating the farmers’ socioeconomic development; broadening farmers’ access to information; expanding farmers’ access to capital, infrastructure, and markets; and increasing the adoption rate of agricultural innovation [3]. Farmers’ organizations also act as a representative for the farmers, from the grassroots level to the international level, so that the farmers’ voices can be heard in negotiations with the rest of society [6].

Since Indonesia’s independence, its agricultural development program has always worked with farmers’ institutions (both farmers’ groups and individual cooperation) and
was even mentioned in Soekarno’s speech on 17 August 1952. The most notable program, the Green Revolution, also focused on formalizing the status of farmer groups, which had existed long before it was instigated but were merely informal institutions. This program, which began in Soekarno’s reign but was completed in that of Soeharto, nurtured the country’s agricultural output and led the country to food self-sufficiency in 1984 [7–9]. The Green Revolution was also the program that shaped current conventional agricultural practices. Farmers’ groups were involved in the program to help the local government achieve success with the intensification strategy. Intensification focuses on providing agricultural input subsidies, especially for fertilizer, which has brought an increase in rice production since 1970 [10]. However, the success of the intensification strategy during the Green Revolution was not without adverse consequences, especially in terms of environmental issues.

The introduction of high-yielding crop varieties (HYVs), which was accompanied by the use of chemical pesticides and chemical fertilizers, but with a lack of information about their environmental impact, led to environmental problems and shortages of water and land [11]. HYVs that were introduced from an exogenous area were typically more vulnerable to pests compared with local varieties; therefore, farmers often overused chemical pesticides, resulting in environmental damage and health issues among the farmers themselves [12,13]. Chemical fertilizer, which was initially a complementary input with organic manure, shifted to become its replacement. As a result, the soil quality suffered; it lacked a good C/N (carbon to nitrogen) ratio, organic carbon mineralization, aggregate stability, and porosity, thereby reducing soil biotic activities and hindering plant growth [14].

The commonly implemented agricultural practices in Indonesia are nowadays heavily influenced by the Green Revolution program. However, there are several post-Green Revolution programs implemented in response to the environmental impact of the Green Revolution, such as an integrated pest management (IPM) training program, the establishment of organic farming training centers, and support for organic farmers in gaining access to markets [15,16]. However, the more sustainable agricultural practices are still seldom adopted by farmers in Indonesia. This can be seen in the adoption of organic farming, one of the more sustainable farming practices, which only accounted for 1.6% of global farming land use in 2021, with an even smaller uptake in Asia, where it accounts for only 0.4% of land use [17].

This situation also applies in Tasikmalaya Regency, one of the major rice-producing areas in West Java, Indonesia. The Green Revolution shaped the farming systems currently used by farmers in Tasikmalaya. The overall sustainability index of farming in Tasikmalaya is still low, and the worst environmental aspect is that farmers are too dependent on chemical pesticides for pest control [18]. It is also reported that the soil used in conventional farming in Tasikmalaya is tainted with pesticide residue compounds, such as organochlorines, organophosphates, and carbamates [19].

This situation makes it a matter of urgency to conduct research into finding the factors driving the farmers’ adoption of sustainable farming. Farmers’ groups play a vital role in promoting more sustainable farming to their members. Previous research has found that institutions at local levels (including farmers’ groups) play a role in maintaining the productivity and involvement of their members by mobilizing resources and drawing up regulations that can direct group members toward sustainable farming [20]. Uphoff also found that farmer groups, which are considered local-level institutions that exist in almost all farming communities, make decisions, and act toward sustainable development that are more effective and long-lasting than those taken at the individual or household level.

Besides their involvement in such groups, the farmers’ socioeconomic characteristics also play an important role in their decision to engage in sustainable farming practices. They mainly influence the farmers’ capacity to adopt agricultural innovations [21]. Previous studies have shown that age has a significant effect on farmers’ adaptability to new agricultural technologies and practices. For example, in several studies [22,23], Onyenekwe and others argued that older farmers are more perceptive regarding their surroundings; this is due to their greater farming experience, making it easier for them to perceive and
process information. However, greater farming experience can also make farmers less interested in engaging with new agricultural technologies and practices [24–26]. Older age does not guarantee greater farming experience since some of the farmers began farming at an older age. A higher education level improves their literacy, which makes it easier for farmers to access and process information garnered from external sources [27]. Apart from these variables, farm size also has an influence on take-up, as this is related to the amount of capital and the wealth that they own, which is positively aligned with their adoption capability regarding new agricultural technologies and practices [28,29].

The pattern of the farmers’ intentions to shift to organic farming is a matter of concern due to its link with sustainability. One interesting question that arises from this phenomenon is, “Have the farmers’ groups influenced farmers’ decisions to transition from conventional rice farming to more sustainable rice farming, considering the influence of the successful transformation seen during the Green Revolution?” Addressing this question, this paper aims to estimate the impact of farmers’ group membership on several indicators of farming sustainability, such as the amount of fertilizer and pesticides used and the farmers’ knowledge and awareness of resource conservation. The study employs cross-sectional data obtained from a survey of rice farmers in Tasikmalaya Regency, West Java Province.

2. Materials and Methods

This is a quantitative study that adopts a survey approach, which provides a quantitative description of the trends, attitudes, and opinions of a particular population and identifies the associations among certain variables in a population by studying a sample of that population [30]. This approach was selected due to its effectiveness in answering both descriptive questions and questions about the relationships between variables.

A study on the impact of farmers’ group membership on sustainability was conducted in the village of Sukaharja in the Tasikmalaya Regency, West Java. Based on the secondary data gained from the agricultural extension information system in 2022, the population of rice farmers in the area is 674. We adopted the methods for determining the sample size of a known population developed by Krejcie and Morgan [31]. With a confidence interval of 99% and a population proportion of 0.50 to ensure maximum sample size, a minimum of 334 respondents were required for interview purposes. After considering possible missing values and the presence of outliers, 360 respondents were eventually interviewed for this study.

\[
\text{Sample size} = \frac{X^2 N p(1-p)}{d^2 (N-1) + X^2 P(1-p)}
\]

A quota sampling technique was used due to two constraints affecting the data collection process: (1) a lack of detail regarding the farmers’ addresses at the research site; and (2) efficiency regarding time when approaching respondents. The population was divided up based on their membership of a particular farmers’ group. With six groups on the research site, this study set a quota of 60 samples for each group.

Four dependent variables were tested separately; these consist of the use of chemical fertilizer in the recommended quantities, the use of organic fertilizer, taking action to prevent environmental damage, and taking action to maintain soil fertility. The recommended amount of chemical fertilizer is based on the regulations laid down by the Indonesian Ministry of Agriculture: urea (N) fertilizer use of between 200 and 300 kg per hectare, and compound fertilizer (NPK) use of between 200 and 250 kg per hectare [32]. We asked the farmers how much chemical fertilizer they would use on the land they owned, then we converted this amount to usage per hectare. If the farmers used more than the allowed amount, it was considered an overuse of chemical fertilizer (categorized as 0 in the answer). If they did not overuse chemical fertilizers, this was categorized as 1 in the answer. The same logic is also applied to determine the use of organic fertilizer. However, there are no official standards regarding organic fertilizer dosage in Indonesia. Consequently, we formulated a question to identify whether the farmers applied organic fertilizer (1 if the
The application of organic fertilizer has been proven to have a positive impact on improving soil quality [33]. The use of fertilizer was recorded according to its application during the previous season.

Actions to prevent environmental damage were identified by asking questions related to activities that can improve environmental well-being, such as waste management [34], the usage (not overuse) of chemical and organic fertilizers [13,14,33,35], integrated farming practices [36], and crop rotation [37–39]. If any of these activities were identified from the respondents’ answers, then we categorized this as 1; otherwise, it was categorized as 0.

The independent variables were age, formal education, agribusiness experience, farm size, and the level of activity and involvement in their farmers’ group. Age, agribusiness experience, and farm size were hypothesized to have a positive impact on the dependent variables, based on previous studies [5,22,23,27–29,40], as explained in the previous section. Formal education was considered ordinal data (=0 if the respondent had not completed any formal education; =1 if they completed elementary school; =2 if they completed junior high school; =3 if they completed senior high school; =4 if they completed higher education); its completion was hypothesized to have a positive impact on the dependent variable [27]. The level of involvement in the farmers’ group was a dummy variable (=1 if they were active, 0 if they were not active); it was hypothesized that the active farmers were more likely to be engaged in sustainable agricultural practices, based on the dependent variables.

The data were analyzed using descriptive statistical techniques and logit regression analysis via Stata, in order to answer the research question. Logistic regression, which is often called logit regression, was used to describe the relationship between a binary or dichotomous dependent variable and a set of independent variables [41], which technique is suitable for use with the data collected in this study. The logit regression equations for all four dependent variables are as follows.

Determinants of the use of chemical fertilizer in the recommended amount (not overused):

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

where:

- $Y$ = Use of chemical fertilizer ($Y = 1$ if the farmer did not overuse chemical fertilizer, $Y = 0$ otherwise);
- $\beta_0$ = Constant;
- $\beta$ = Coefficient;
- $X_1$ = Age (years);
- $X_2$ = Formal education (=0 if the respondent did not complete any formal education; =1 if they completed elementary school; =2 if they completed junior high school; =3 if they completed senior high school; =4 if they completed higher education);
- $X_3$ = Agribusiness experience (years);
- $X_4$ = Farm size (in hectares);
- $X_5$ = Level of involvement in the farmers’ group (=1 if they are active, =0 if they are not active);
- $\epsilon$ = error term or residual.

Determinants of the use of organic fertilizer:

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

where:

- $Y$ = Use of organic fertilizer ($Y = 1$ if the farmer uses organic fertilizer, $Y = 0$ otherwise);
- $\beta_0$ = Constant;
- $\beta$ = Coefficient;
- $X_1$ = Age (years);
$X_2 = \text{Formal education} (=0 \text{ if the respondent did not complete any formal education; } =1 \text{ if they completed elementary school; } =2 \text{ if they completed junior high school; } =3 \text{ if they completed senior high school; } =4 \text{ if they completed higher education});$

$X_3 = \text{Agribusiness experience (years)};$

$X_4 = \text{Farm size (in hectares)};$

$X_5 = \text{Level of involvement in the farmers’ group} (=1 \text{ if they are active, } =0 \text{ if they are not active});$

$\varepsilon = \text{error term or residual}.$

Determinants of taking action to prevent environmental damage:

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

where:

$Y = \text{Taking action to prevent environmental damage} (Y = 1 \text{ if the farmer takes action to prevent environmental damage, } Y = 0 \text{ otherwise});$

$\beta_0 = \text{Constant};$

$\beta = \text{Coefficient};$

$X_1 = \text{Age (years)};$

$X_2 = \text{Formal education} (=0 \text{ if the respondent did not complete any formal education; } =1 \text{ if they completed elementary school; } =2 \text{ if they completed junior high school; } =3 \text{ if they completed senior high school; } =4 \text{ if they completed higher education});$

$X_3 = \text{Agribusiness experience (years)};$

$X_4 = \text{Farm size (hectares)};$

$X_5 = \text{Level of involvement in the farmers’ group} (=1 \text{ if they are active, } =0 \text{ if they are not active});$

$\varepsilon = \text{error term or residual}.$

Determinants of taking action to maintain soil fertility:

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

where:

$Y = \text{Taking action to maintain soil fertility} (Y = 1 \text{ if the farmer takes action to maintain soil fertility, } Y = 0 \text{ otherwise});$

$\beta_0 = \text{Constant};$

$\beta = \text{Coefficient};$

$X_1 = \text{Age (years)};$

$X_2 = \text{Formal education} (=0 \text{ if the respondent did not complete any formal education; } =1 \text{ if they completed elementary school; } =2 \text{ if they completed junior high school; } =3 \text{ if they completed senior high school; } =4 \text{ if they completed higher education});$

$X_3 = \text{Agribusiness experience (years)};$

$X_4 = \text{Farm size (in hectares)};$

$X_5 = \text{Level of involvement in the farmers’ group} (=1 \text{ if they are active, } =0 \text{ if they are not active});$

$\varepsilon = \text{error term or residual}.$

3. Results

3.1. Socioeconomic Characteristics

The demographic characteristics (age, formal education, agribusiness experience, and farm size) of the farmers included in this study are presented in Table 1.
Table 1. Farmers’ socioeconomic characteristics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age of respondents in years</td>
<td>55.74</td>
<td>11.11</td>
</tr>
<tr>
<td></td>
<td>=0 if the respondent did not complete any formal education; =1 if they</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>completed elementary school; =2 if they completed junior high school; =3 if</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>they completed senior high school; =4 if they completed higher education</td>
<td>1.66</td>
<td>0.96</td>
</tr>
<tr>
<td>Formal Education</td>
<td>Total years of respondents’ experience of conducting agribusiness</td>
<td>22.21</td>
<td>9.74</td>
</tr>
<tr>
<td>Farm Size</td>
<td>Total cultivated area in the current year, in hectares</td>
<td>0.41</td>
<td>0.37</td>
</tr>
<tr>
<td>Farmer Group</td>
<td>=1 if the respondents are active in the farmers’ group, 0 otherwise</td>
<td>0.76</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Table 1 shows that the average age of farmers at the study site at the time of their interview was 55.74 years old, which is still classified as being productive by the Indonesian Bureau of Statistics. However, that number is near the upper threshold, which indicates that the next decade will be dominated by older and less productive farmers. This result also aligned with the average level of agribusiness experience, which was 22.21 years. The positive finding was that the farmers are generally trained and have sufficient knowledge derived from their long experience of agribusiness, but this also indicates that the regeneration of farming (farm succession) is still a major problem that threatens the sustainability of farming in the future.

The average education level of farmers was low, as most of them only completed elementary schooling, which is far from the compulsory standard of education in Indonesia (12 years/completing senior-high schooling). This is normal, considering the average age of the farmers; when they were young, Indonesia was still in the early stages of its independence, and the level of access to education was low. In light of Achichi’s study [27] on education levels affecting the farmers’ capability to process information, we argue that most of the farmers in our country have had below-average access to education and a below-average ability to process information from external sources.

Table 1 also shows that most of the respondents are small-scale farmers, with an average farm size of 0.41 ha. This is also problematic, as farm size determines the performance of the farm, according to many schemes [42–44]. From the economic perspective, this number is far from the economies of scale seen in paddy farms, which are approximately 10 hectares [45,46]. In Indonesia, economies of scale for paddy farming are achieved with farmland that is a minimum of one hectare in size, which will be insufficient for the farmers to maintain their livelihood [47]. In other words, Indonesian paddy farmers will not be able to rely only on their agricultural practices to sustain their income. Greater farm size also allows farmers to experiment; this has made them more likely to adopt new technologies or practices [48,49]. Small-scale farmers are more vulnerable to agricultural “squeeze”, which explains the need for farmers’ groups; they provide a place for such farmers to collaborate and strengthen their bargaining position.

Most of the farmers interviewed were engaged in farmer groups. However, 24% of respondents were still not actively involved in farmers’ groups. New qualitative information found during the study indicated that several groups are only active when driven by aid programs and are less active in other areas. This may have been caused by a top-down style of group management when they began, which gave farmers less of a sense of belonging.

From Table 2, most of the respondents were not meeting the requirements of the sustainability indicators used in this study. Organic fertilizers were only adopted by 17% of the sample, while 71% of them overused chemical fertilizers. A negative impact will emerge from this behavior in the long term if the problem is not taken seriously.
by both the government as policymakers and the farmers themselves. Organic fertilizer should be a compulsory input, not only a complementary to the chemical fertilizers. The main advantage of organic fertilizer is that it enhances beneficial soil microorganisms and improves soil physical properties that are not provided by chemical fertilizers [33,50]. The qualitative information provided by the data is that farmers are hesitant to use organic fertilizer because it is less practical and its freight cost is nearly twice that of chemical fertilizer. This issue is worsened by the overuse of chemical fertilizers. Even though chemical fertilizer helps crops to grow faster and be more productive, its drawbacks cannot be ignored. These drawbacks include disrupting the soil’s structural properties; enhancing the emission of nitrates; being costly for small farmers; increased use over time due to a lack of organic material in the soil; destroying soil-dwelling organisms; toxicity to both animals and humans [35].

Table 2. Environmental sustainability farming practice indicators.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical fertilizer use</td>
<td>=1 if respondents do not overuse chemical fertilizer, =0 otherwise</td>
<td>0.29</td>
<td>0.45</td>
</tr>
<tr>
<td>Organic fertilizer use</td>
<td>=1 if respondents use organic fertilizer, =0 otherwise</td>
<td>0.17</td>
<td>0.37</td>
</tr>
<tr>
<td>Environmental damage prevention</td>
<td>=1 if respondents engage in preventing environmental damage, =0 otherwise</td>
<td>0.31</td>
<td>0.46</td>
</tr>
<tr>
<td>Soil fertility maintenance</td>
<td>=1 if respondents engage in maintaining soil fertility, =0 otherwise</td>
<td>0.25</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Table 2 also shows that only 31% of the farmers engaged in environmental damage prevention activities, and even fewer engaged in maintaining soil fertility, at only 25%. These numbers indicate that environmental issues are still a low priority in their farming activities. The additional information shows that the farmers are aware of environmental issues but tend to ignore them because of a lack of incentives. This fact demonstrates the urgent need for policymakers to pass regulations that support environmentally friendly agricultural practices and provide incentives for farmers to comply. The incentive may be in the form of a voluntary incentive or a compulsory incentive [51,52]. Compulsory incentives, such as legal regulation, may meet a certain level of success because farmers are forced to comply with the requirements to avoid sanctions. However, careful planning is needed before implementing compulsory incentives to avoid any backlash that may happen, such as farmers feeling dissatisfaction with the government, which may lower their motivation to participate in any other programs in the future.

3.2. Respondent’s Farming System

The farming system adopted by the respondents of this study can be categorized into two types: high-input and low-input systems. A comparison of the characteristics of high- and low-input farmers in this study is presented in Table 3.

Table 3. Characteristics of high-input farmers and low-input farmers.

<table>
<thead>
<tr>
<th>Variable</th>
<th>High-Input Farmers (N = 257)</th>
<th>Low-Input Farmers (N = 103)</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>55.63</td>
<td>56.03</td>
<td>0.7591</td>
</tr>
<tr>
<td>Formal Education</td>
<td>1.6</td>
<td>1.82</td>
<td>0.0531 *</td>
</tr>
<tr>
<td>Agribusiness Experience</td>
<td>22.25</td>
<td>22.14</td>
<td>0.9237</td>
</tr>
<tr>
<td>Farm Size</td>
<td>0.35</td>
<td>0.57</td>
<td>0.0000 ***</td>
</tr>
<tr>
<td>Farmer Group</td>
<td>0.73</td>
<td>0.83</td>
<td>0.0607 *</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard errors. * p < 0.1. *** p < 0.01.
There are three variables that are significantly different between the two subsamples: formal education, farm size, and activity in the farmers’ group. Farmers who adopted low-input methods have a slightly higher mean level of formal education compared with those who adopted high-input methods, which is significant at the 0.1 level. The low-input farmer also has a much larger average farm size, with significance at the 0.01 level. As for the levels of activity in the farmers’ groups, the low-input farmers are more active in the farmers’ groups, compared with the high-input farmers. The difference in activity levels in the farmers’ groups is significant at the 0.1 level.

Determinants of the Environmental Sustainability Farming Indicators

As described in the previous section, farming practices in the study area are nowhere near being environmentally sustainable, which can lead to issues if not handled properly. One approach to resolving this is by understanding the determinants that influence farmers’ adoption of sustainable agricultural practices. In this context, a logistic regression analysis was conducted to examine the key factors that contribute to the adoption of agricultural sustainability indicators by farmers.

The results of the logistic regression are presented in Table 4, providing a comprehensive overview of the outcomes of the analysis. The analysis included a diverse range of determinants hypothesized to influence farmers’ decision-making regarding sustainability indicators. The dataset encompassed variables such as farmers’ age, level of formal education, agribusiness experience, farm size, and participation in farmers’ group activities, which were also explained in the previous section. The table also highlights the coefficient, standard error, significance levels, and marginal effects of each independent variable. Additionally, the table includes the pseudo $R^2$ from each logistic regression model, which provide a measure of the goodness of fit of the model.

**Table 4. Logit model estimates of the factors determining the agricultural sustainability indicators.**

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Chemical Fertilizer</th>
<th>Organic Fertilizer</th>
<th>Preventing Environmental Damage</th>
<th>Maintaining Soil Fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.010</td>
<td>0.032</td>
<td>0.016</td>
<td>0.030</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.013</td>
<td>0.015</td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.443</td>
<td>0.039 **</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>0.002</td>
<td>0.004</td>
<td>0.003</td>
<td>0.005</td>
</tr>
<tr>
<td>Agribusiness Experience</td>
<td>−0.006</td>
<td>−0.006</td>
<td>−0.019</td>
<td>0.011</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.014</td>
<td>0.017</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.662</td>
<td>0.740</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>−0.001</td>
<td>−0.001</td>
<td>−0.004</td>
<td>0.002</td>
</tr>
<tr>
<td>Formal Education</td>
<td>0.240</td>
<td>0.344</td>
<td>0.582</td>
<td>0.398</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.128</td>
<td>0.145</td>
<td>0.126</td>
<td>0.130</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.061 *</td>
<td>0.018 **</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>0.044</td>
<td>0.046</td>
<td>0.111</td>
<td>0.070</td>
</tr>
<tr>
<td>Activeness in farmers group</td>
<td>0.443</td>
<td>0.779</td>
<td>0.866</td>
<td>0.680</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.307</td>
<td>0.407</td>
<td>0.321</td>
<td>0.329</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.149</td>
<td>0.056 *</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>0.082</td>
<td>0.103</td>
<td>0.165</td>
<td>0.120</td>
</tr>
<tr>
<td>Farm size</td>
<td>1.595</td>
<td>0.434</td>
<td>0.536</td>
<td>0.092</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.332</td>
<td>0.353</td>
<td>0.309</td>
<td>0.332</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.033 ***</td>
<td>0.219</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>0.294</td>
<td>0.058</td>
<td>0.102</td>
<td>0.016</td>
</tr>
<tr>
<td>Intercept</td>
<td>−2.809</td>
<td>−4.691</td>
<td>−3.208</td>
<td>−4.334</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.779</td>
<td>0.956</td>
<td>0.776</td>
<td>0.838</td>
</tr>
<tr>
<td>$p &gt;</td>
<td>z</td>
<td>$</td>
<td>0.077</td>
<td>0.047</td>
</tr>
<tr>
<td>Marginal Effect</td>
<td>0.000</td>
<td>0.009</td>
<td>0.000</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Notes: * $p < 0.1$. ** $p < 0.05$. *** $p < 0.01$. 
Table 4 reveals that age, level of formal education, activeness in the farmers group, and farm size significantly influence some or all the sustainable indicators included in this study. However, agribusiness experience is not found to be significantly related to any of the indicators. All the significant variables have a positive value of marginal effect, which indicates that an increase in the value of those variables is associated with a higher likelihood of farmers adopting more environmentally sustainable farming practices.

The age of farmers was found to have a significant influence on the likelihood of farmers applying organic fertilizers and taking measures to maintain soil fertility, both at the 0.05 level. By examining the marginal effect, it can be observed that for every one-year increase in farmers’ age, the likelihood of farmers adopting organic fertilizers and taking action on maintaining soil fertility increases by 0.4% and 0.5%, respectively. This finding strengthens the statement made in the introduction section that older farmers tend to be more perceptive regarding their surroundings, particularly when it comes to environmental concerns. This heightened awareness makes them more receptive to and capable of processing information about sustainable farming practices. Furthermore, this finding is complemented by additional qualitative information collected, which suggests that older farmers have a strong emotional bond with their land and feel a greater sense of responsibility for its condition, ensuring its success for future generations.

Formal education was found to be significant in each logistic regression model used in this study. It was significant at the level of 0.1% in the chemical fertilizer model, 0.05 in the organic fertilizer model, and 0.01 in the models for taking measures in preventing environmental damage and maintaining soil fertility. All the marginal effects are positive, indicating that an increase in the level of formal education will increase the likelihood of farmers adopting more sustainable farming practices. Specifically, the marginal effects show that there is a 4.4% increase in the likelihood of farmers using chemical fertilizer in the recommended amount, a 4.6% increase in the likelihood of using organic fertilizer, an 11% increase in the likelihood of taking action to prevent environmental damage, and a 7% increase in the likelihood of taking action to maintain soil fertility. These results suggest that higher levels of formal education positively impact farmers’ decisions towards sustainable farming practices in various aspects. This finding aligns with previous studies mentioned in the introduction section, which indicate that higher education levels improve farmers’ literacy, enabling them to access and process information from external sources more effectively.

The activeness in the farmers group is significant in affecting the sustainable indicators used in this study, except the chemical fertilizer model. It is significant at the level of 0.1% in organic fertilizer model, 0.01% in preventing environmental damage model, and 0.05% in maintaining soil fertility model. The marginal effect analysis indicates that farmers who are actively involved in farmers’ groups are 10% more likely to adopt organic fertilizer, 16% more likely to prevent environmental damage, and 12% more likely to maintain soil fertility. This finding suggests that active participation in farmers’ groups plays a significant role in promoting sustainable farming practices, as it fosters knowledge sharing, collective decision-making, and a sense of responsibility towards environmental sustainability. It is ironic that despite the farmers’ group being actively involved in delivering data of the need for the subsidized chemical fertilizer of their members to the agricultural office in the study area, it has not had a significant impact on farmers’ behavior regarding the use of chemical fertilizer. It indicates that the information regarding the recommended amount of chemical fertilizer and its impact is not given enough importance among members of the farmers group, despite being available for their use.

The last independent variable that significantly affects farmers’ sustainability is the farm size. It has a significant impact on the use of chemical fertilizer at the level of 0.001 and 0.05 in preventing environmental damage. This implies that the size of the farm plays a crucial role in determining the farmers’ choices regarding the use of chemical fertilizers and their commitment to preventing environmental damage. Based on the marginal effect, for every additional hectare in farm size, the likelihood of farmers using
chemical fertilizer in the recommended amount increases by 29%, and the likelihood of preventing environmental damage increases by 10%. This suggests that larger farm sizes tend to be associated with a higher likelihood of using chemical fertilizers and taking measures to prevent environmental damage. This finding in line with previous studies mentioned in the introduction section that farm size is related to the amount of capital and the wealth that they own, which is positively aligned with their adoption capability regarding new agricultural technologies and practices. One notable factor of high significance regarding farm size and the use of chemical fertilizer is the efficiency of input. Larger farmers may experience higher input costs when using chemical fertilizer in excessive amounts compared to smaller farmers. This efficiency consideration becomes more significant as the farm size increases. It implies that larger farmers need to carefully manage their input usage to ensure cost-effectiveness and sustainable agricultural practices.

4. Discussion

The common agricultural practice in the study site, which is characterized by high chemical inputs and limited environmental awareness, is something that is built on several factors: socioeconomic characteristics, policies that are currently in effect and those of their predecessors, and market conditions over many years. Therefore, transforming this practice into more sustainable agriculture is not an instantaneous process. A statement based on the five determinants of practice adoption was introduced by Rogers [53]. This is centered on relative advantage; more sustainable farming practices seem to be not as compelling for the farmers when compared to existing practices. Sustainable practices promise healthier, more environmentally friendly, and long-lasting agriculture, in exchange for a lower economic incentive for the farmers.

Organic agricultural commodities, as an example of a product sourced from more sustainable farming practices, have proven to be more profitable as long as the product is treated as a premium item that can be sold for higher prices, and if it is shown to have a lower benefit/cost ratio and lower net returns if it were treated in the same way as conventional products [54]. Even if treated as a premium product, farmers, particularly smallholders, will struggle to produce crops that meet the criteria for premium organic agricultural products. The information gathered during the data collection process for the current study also indicates that farmers lack access to the wider market, which makes it seem unlikely that they will gain access to the premium and niche markets for organic products. In terms of yields, crops from organic farming are lower in yield compared with conventional products [9,44,54–56]. From that information, an organic farming system will only be compelling if there is intervention from other stakeholders, such as subsidies for organic inputs, or traders ensuring that organic products from the farmers can be sold in premium markets.

Because of the system’s flaws from an economic aspect, the more sustainable farming practices discussed in this research are not seen from the perspective of sustainability but are instead examined by using a smaller element of sustainability as an indicator. The indicators adopted in this study, which are derived from a study by Zhen [57], account for the amount of fertilizer and the farmers’ awareness of the importance of resource conservation as indicators of agricultural sustainability. Based on the study’s location characteristics and the possibility of data collection, four indicators have been used, which consist of chemical fertilizer used in the recommended quantities (not overused), the application of organic fertilizer, taking action to prevent environmental damage, and taking action to maintain land fertility. By fulfilling the requirements of this indicator, farmers can ensure that their farming activities are more environmentally sustainable and that they reap the benefits of sustainability, which is a more feasible approach compared with transforming farming. By considering the five stages of innovation adoption and by transferring to more sustainable practices one step at a time, farmers will be involved in increasing awareness, interest, and evaluation, and developing trial stages before the wholesale adoption of sustainable farming practices, such as organic farming.
The logistic regression model used in this study analyzed how the level of activity and involvement in their farmers’ group, which is the smallest and most accessible local farming institution, influenced the probability of farmers using sustainable indicators in their agribusiness activities. Accordingly, the level of involvement in the farmers’ group has a significant influence on three of the environmental sustainability indicators used in this study: the use of organic fertilizer, taking action to prevent environmental damage, and taking action to maintain soil fertility. Meanwhile, the level of involvement does not significantly influence farmers’ behavior regarding the overuse of chemical fertilizer.

The finding that the level of involvement in the farmers’ groups influences the rice farmers’ behavior regarding the use of organic fertilizer is in line with cases involving apple farming in China [40], smallholder farmers in Shashemene District, Ethiopia [58], and organic vegetable farming in Mahasarakham Province, Thailand [59]. This influence may have occurred because farmers’ groups in the research locations act as a venue for farmers to share their knowledge and experience of farming activities. That hypothesis is similar to the finding that farmers’ groups in Northern Ghana act as a platform for farmers to access and disseminate information and technology [60]. The level of involvement in the farmers’ group was also found to be affecting the farmers’ awareness of environmental conservation. Farmers who are active in their own farmers’ group have a significantly higher probability of working to prevent environmental damage and improve soil fertility.

Aside from the level of involvement in the farmers’ groups, the variable of education performs better in terms of influencing farmers’ decisions regarding environmental sustainability. The logit regression analysis showed that the higher the level of education that the farmer has reached, the higher the possibility that they will use chemical fertilizer in the recommended amounts, that they will use organic fertilizer, and that they will take action to prevent environmental damage and maintain soil fertility. The findings are consistent with those in an earlier study [61], which found a positive relationship between education and the farmers’ adoption rates of new technology; this study positions a more sustainable farming system as a new technology. This result is believed to be related to previous research that farmers possessing higher levels of education tend to have access to more information, which makes them more aware of environmental issues [62]. The influence of education is similar to the finding that education influences the potential likelihood of farmers adopting precision agriculture systems, one of the more sustainable farming techniques using real-time observation and measurement to increase efficiency and effectiveness in terms of inputs, as reported by the authors of [63].

Knowing that more sustainable practices are less compelling for farmers, due to their inferior economic incentives, and identifying the determinants of farmers adopting these practices is important to further the process of designing better regional agricultural policies. The model in this study proves that farmers’ groups play an important role in promoting more sustainable farming practices. Thus, future policies need to take their role into account. The positive aspect of this finding is that farmers’ groups are accessible to all farmers and are available in almost every village in Indonesia. However, many groups are not founded from the grassroots level, discouraging farmers from collaborating and the groups from having more of a role as a medium by which the government can distribute information on their programs. This finding is based on information from the key informants in this study, who stated that the rate of participation of group members rises when there are governmental aid programs, but significantly decreases when the program ends. Even though this is understandable from the farmers’ standpoint, this trend will cause (and perhaps has already caused) the farmers to become dependent on governmental aid, restricting their ability to be proactive.

The current study suggests two concepts of agricultural development policy design to improve the sustainability of rice farming in Indonesia. First, improving the incentives for farmers to engage in more environmentally friendly farming practices, such as financial and non-financial support (training and guidance, scholarships, etc.) for organic certification, grants for purchasing eco-friendly inputs and equipment, organic market access support,
and subsidies for implementing conservation measures. The second concept involves designing a program that focuses on farmers’ groups as a means of farmers’ self-development, one that positions farmers as agents of change instead of beneficiaries. The program also needs to position farmers’ groups to be at the center of farmer regeneration by involving, educating, and encouraging young farmers.

5. Conclusions

Making a sustainable farming system more acceptable to farmers is a serious challenge that needs to be addressed by government stakeholders. This research has found that the levels of activity and involvement in the farmers’ groups significantly influenced several sustainability indicators, positioning the farmers’ group as an essential factor in achieving sustainable farming in Indonesia. Education also plays a crucial role in shaping farmers’ behavior regarding environmental sustainability. However, transitioning to more sustainable agricultural practices requires that policymakers address the topic of economic incentives, improving market access, leveraging farmers’ groups, providing education and support, and designing policies that empower farmers as agents of change in their own communities. However, due to several limitations, this research only discusses a few elements of sustainability indicators, which will need to be analyzed in more depth if further study on the topic is extended by looking at environmental sustainability. Therefore, future research is needed to draw more holistic conclusions regarding the promotion of sustainable agricultural practices in Indonesia.

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