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Effect of Socio-Economic on Farmers' Decisions in Using Lowland Rice Production Inputs in Indonesia

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ABSTRACT

In Indonesia, rice was produced by small-scale farmers where yields were still generally low. This was because small-scale farmers still used poor quality seeds and unbalanced fertilizers. Therefore, this research aimed to analyze the socio-economic factors that affected the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds. This research used a double-hurdle model to answer the objectives of research and used 329 farmings which were selected randomly in Central Sulawesi Indonesia. The results show that the gender variable only affected the use of fertilizer on quality seeds. Education, access to credit, sources of income (income diversification), access to extension, meetings with farmer groups were found to be positively correlated with the decision to adopt quality seeds in lowland rice farming and use of fertilizers to quality seeds, while the number of dependents of the household head was negatively correlated. The land area of lowland rice was positively correlated with the adoption of quality seeds in lowland rice farming but negatively correlated with the number of fertilizers used for quality seeds. Based on these findings, the role of extension workers and farmer groups was needed in disseminating quality seeds, and through credit institutions, it was necessary to provide credit facilities to rice producers (farmers) so that rice productivity could be increased.

1. INTRODUCTION

Increasing rice production was an effort to meet the basic needs of the Indonesian people [1, 2]. In Indonesia, rice is produced by small-scale farmers where the results are for consumption, with some being sold [3]. Small-scale agriculture generally used labor-intensive production methods [3, 4], and harvest yields were generally still low [5]. Production inputs that contributed to low harvest yields were low-quality seeds and unbalanced fertilizers [6, 7]; the use of quality seeds and the number of fertilizers could be determined based on farmers' decisions.

The use of quality seeds was an effort to increase rice productivity. Characteristics of quality seeds are pure seeds of a variety, full size (pithy) and uniform, high growth power, free from weed seeds, diseases, pests, or other materials [8]. Quality seeds could be produced from good post-harvest handling [9]. Proper seed storage could maintain seed quality [10]. Temperature, moisture content, oxygen supply, pests and diseases, and packaging materials were factors that affected seed quality during storage [11]. According to Pradhan and Badola [10], the most important thing to note was the storage temperature and seed moisture content. The selection of seed technology would affect the costs incurred by farmers and the products produced in rice farming. According to Effendy [12], farmers as decision-makers were faced with various choices in determining the technology used to increase their farming productivity, including the choice of using seeds. Most farmers in Central Sulawesi used seeds from previous harvest yields; they were not specially trained for seed production. The seeds used were not selected and maintained properly, resulting in lower rice productivity; the rice yield in Central Sulawesi in 2019 was 2.67 tons/ha [13].

Fertilizers played an important role in increasing agriculture productivity in Indonesia [14, 15]. The achievement of food security depended on proper fertilization, since the low productivity of lowland rice in Indonesia was largely due to a lack of fertilization [16]. The use of fertilizers was still low and uneven in Indonesia due to lack of access and high costs [3], but the government had provided subsidized fertilizers for farmers. The fertilizer subsidy policy was introduced because most farmers were poor; with this subsidy farmers could access fertilizer, and it was hoped that the soil would become fertile so that national productivity could increase [17, 18]. However, if viewed from the agriculture environment, the use of fertilizers by farmers could be affected by socio-economic factors [19-21].

To increase rice productivity in Central Sulawesi, it was very important to pay attention to the use of quality seeds and balanced fertilizers. Balanced fertilization was the application of fertilizer into the soil started from the right dose, at the right time, in the right way, and in the right type [22]. Balanced fertilization could provide benefits starting from increasing productivity and quality of crop yields, increasing fertilization efficiency, increasing soil fertility, avoiding environmental pollution, and optimum yields that could make farmers profitable [22, 23]. Previous studies have shown that the use of quality seeds and balanced fertilizers could contribute to increased yields [24-27].

The use of quality seeds and balanced fertilizers was limited by several factors, such as prices relatively high for poor farmers, risk aversion by farmers, and lack of credit [28]. Several previous research results show that socio-economic characteristics and institutional variables were factors that affect the technology adoption process [29-33].

From the description above, this research aimed to analyze the socio-economic effect on farmers' decisions in using lowland rice production inputs in Central Sulawesi. Our hypothesis was that socio-economic affected farmers' decisions in using lowland rice production inputs in Central Sulawesi. The results of this research allowed the Ministry of Agriculture to identify specific issues that affected farmers' decisions to use lowland rice production inputs, in order to increase national productivity.

2. MATERIALS AND METHODS

2.1 Research area and sampling techniques

This research was done in Central Sulawesi. This area of 61,841.29 km² has a tropical climate [13]. Central Sulawesi has a rainy season from April to September and a dry season from October to March. Farmers in Central Sulawesi grow a variety of crops. Their main commercial crops are cocoa, coconut, shallots of Palu valley, and lowland rice. They also grow other food crops such as tubers, bananas, corn, vegetables, chilis, and tomatoes.

Parigi Moutong and Sigi District were selected for the research location because the location was the center of lowland rice production in Central Sulawesi with a productivity of 5.00 tons/ha and 4.56 tons/ha in 2018 and in 2019 decreased productivity to 4.79 tons/ha and 4.50 tons/ha [13]. Parigi Moutong Regency has the largest lowland rice harvest area in Central Sulawesi, namely 28.47% (52,984 ha), and Sigi Regency is 7.75% (14,428 ha). Three villages were randomly selected for each district to be surveyed (Table 1).

Table 1. Research locations and number of samples

Districts	Villages	Sample size (HH)
Sigi	Ranteleda	56
	Tanah Harapan	44
	Tongoa	52
Parigi Moutong	Balinggi	65
	Astina	52
	Nambaru	60
Total		329

Source: processed data result of 2021.

The samples used were 329 lowland rice farms which were selected randomly with a proportional approach. Data were collected from March to May 2021 using a questionnaire. The variables collected were: Prices and numbers of production inputs, prices and numbers of outputs, and socio-economic information for lowland rice farmers such as gender, age, education level, access to extension, farming experience, access to credit, number of family dependents, frequency of farmers group meetings, and off-farm income.

2.2 Analytical framework

This research used a utility framework to describe farmers' choices to use quality seeds in lowland rice farming. Farmers are assumed to maximize their utility when using quality seeds. If U_{i1} shows the utility that comes from using quality seeds and U_{i0} the utility that comes from not using quality seeds, the difference in utility from the use of quality seeds of lowland rice and not superior is symbolized by U_i. The farmer will decide to use quality seeds when it gives him greater utility, mathematically written as follows:

$$U_i=U_{i1}-U_{i0}>0 \quad (1)$$

In practice, the utility cannot be observed; what is observed is the farmers' decisions to adopt or not to adopt quality seeds in lowland rice farming. However, farmers were also faced with the decision of how many fertilizers to use for quality seeds of lowland rice. Thus, the double-hurdle model was used to estimate these factors [34]. A double-hurdle model assumed two obstacles in the process of adopting quality seeds in lowland rice farming. The first obstacle was related to the decision of farmers to adopt quality seeds in lowland rice farming, and the second was related to decisions about the number of fertilizers applied to the quality seeds of lowland rice. The double-hurdle model is expressed as follows:

Hurdle 1: Probability of adoption of quality seeds, binary probit:

$$y_{i1}^{*} = \alpha x_i + \varepsilon_1 \quad (2)$$

Decision to adopt quality seeds in lowland rice farming (2).

Hurdle 2: Number of fertilizers applied to quality seeds, truncated regression model:

$$y_{i2}^{*} = \beta x_i + \varepsilon_2 \quad (3)$$

Decision of the number of fertilizers applied to quality seeds of rice farming.

$$y_i = \beta x_i + \varepsilon_2 \text{ if } y_{i1}^{*}>0 \text{ and } y_{i2}^{*}>0 \quad (4)$$

$$y_i = 0 \text{ otherwise} \quad (5)$$

where, y_{i1}^{*} is the latent variable that describes the probability of farmer *i* to adopt quality seeds in lowland rice farming (1 if adopting quality seeds and 0 if not); y_{i2}^{*} is the latent variable that represents the number of fertilizers applied to quality seeds of lowland rice farming; x_i is a vector of independent variables; α and β are parameter vectors to be estimated; and ε are errors terms, which are assumed to be independent and normally distributed ($\varepsilon \sim N(0, 1)$ and $\varepsilon \sim N(0, \sigma^2)$).

2.3 Explanation and measurement of independent variables

Gender played an important role in the adoption of agriculture technology [35-37], so it was used as one of the independent variables on the decision to adopt quality seeds in lowland rice farming. Gender variable is a dummy variable (1=male and 0=female). Male-headed households were more likely to adopt agriculture technology than female-headed households [37-39].

The Jan [40] study noted that the age of the respondents was statistically significant and positively correlated to the application of agriculture technology. However, this was in contrast to the findings of Effendy [32] and Adejumo [41] which showed that age had a negative effect on the adoption of agriculture technology. Age was used as one of the independent variables in this research. The age of the household head is measured in years.

Education level was positively correlated with the use of superior rice varieties [27, 42, 43]. Educated farmers tended to adopt quality seeds in lowland rice farming. Education was the independent variable in this research and measured on a Liker scale (1=did not graduate elementary school, 2=graduated elementary school, 3=graduated from junior high school, 4=graduated from high school, and 5=graduated from college).

Farmers who were experienced in agriculture would adopt agriculture technology in increasing crop productivity [32, 44]. Experience in lowland rice production correlated with the possibility of adopting superior rice varieties [45]. Experienced farmers were more likely to adopt quality seeds in lowland rice farming. Experience in lowland rice farming is expressed in years.

Variables related to a farmer's working capital were access to credit, source of farmer's income, and number of dependents of the household head. Access to credit increased a farmer's working capital, so that they could purchase agriculture inputs on time [12, 46, 47]. Access to credit is a dummy variable (1=farmers who got credit, and 0=farmers who did not get credit). Sources of farmers' income are dummy variables (0=income only came from on-farm and 1=income came from on-farm and off-farm). Farmers who had income from on-farm and off-farm could increase working capital and investment in agriculture. Off farm activity had a positive correlation with the adoption of superior rice varieties [43]. The number of dependents of the household head was the cost expense of the household, which could affect the working capital of farmers. It was postulated that the number of dependents of the household head could reduce the possibility of adopting quality seeds in lowland rice farming. The number of dependents of household head in this research is expressed in souls.

Routine contact with extension workers had a positive effect on the adoption of superior rice varieties [27, 43, 48]. The more a routine that the farmers follow the extension, the higher the tendency to adopt quality seeds in lowland rice farming. Agriculture extension contacts were measured by the presence number of the household head.

The frequency of farmer group member meetings was a new technology learning network [49]. Farmer group member meetings tended to increase the adoption of superior rice varieties [43]. The meeting of farmer group members was a continuous variable, which showed the number of times farmers participated in farmer group meetings.

Large agriculture lands tended to use more resources for crop production [50]: The wider the agriculture land, the greater the possibility of adopting quality seeds. Adoption of quality seeds was correlated with the land area of agriculture [42, 51]. The land area of lowland rice is expressed in hectares.

2.4 Empirical model

The double-hurdle model used to analyze farmers' decisions to adopt quality seeds in lowland rice farming and the number of fertilizers applied to quality seeds are as follows:

Hurdle 1: Probability of adoption of quality seeds:

$$y_{i1}^{*}=\alpha_0+\alpha_1 Z_1+\alpha_2 Z_2+\alpha_3 Z_3+\alpha_4 Z_4+\alpha_5 Z_5+\alpha_6 Z_6+\alpha_7 Z_7+\alpha_8 Z_8+\alpha_9 Z_9+\alpha_{10} Z_{10}+\varepsilon_1 \quad (6)$$

Hurdle 2: Number of fertilizers applied to quality seeds:

$$y_{i2}^{*}=\beta_0+\beta_1 Z_1+\beta_2 Z_2+\beta_3 Z_3+\beta_4 Z_4+\beta_5 Z_5+\beta_6 Z_6+\beta_7 Z_7+\beta_8 Z_8+\beta_9 Z_9+\beta_{10} Z_{10}+\varepsilon_2 \quad (7)$$

where, y_{i1}^{*}=decision to adopt quality seeds in lowland rice farming (1=adopt quality seeds and 0=otherwise), y_{i2}^{*}=number of fertilizers applied to quality seeds, α_0 and β_0=intercepts, α_{1-10} and β_{1-10}=coefficients of independent variables, Z_1–Z_{10}=independent variables, ε=error term. The independent variables are defined as follows:

Z_1=gender of the household head (HH); Z_2=age of HH; Z_3=education level of HH; Z_4=farming experience of HH; Z_5=access to credit by HH; Z_6=Source of HH Income (0=income only comes from on-farm and 1=income comes from on-farm and off-farm); Z_7=Number of dependents of HH; Z_8=access to extension of HH; Z_9=Frequency of farmer group meetings; Z_{10}=land area of lowland rice.

3. RESULTS AND DISCUSSION

3.1 Socio-economic characteristics and classification of respondent farmers

The socio-economic characteristics and classification of respondent farmers are presented in Table 2.

The results of the t or $\chi 2$ test show that all independent variables were significant at α 1% except for the variable of Source of income and Number of farmer group meetings which were not significant. About 77% of respondents adopted quality seeds in lowland rice farming. Most of the samples consisted of males (74%) and 64% of them adopted quality seeds. The average age of respondents was 45 years, meaning that farmers were still energetic and more likely to adopt agriculture technology [32, 41]. Older farmers were more likely to adopt quality seeds. The education level of the respondents was an average of graduated from elementary school, and access to extension was an average of 6 times per year; this caused farmers to be less able to adopt new technology. Farmers who were educated and adopted quality seeds were 45% and 21% did not adopt quality seeds. Farmers who frequently followed counseling tended to adopt quality seeds. Respondent farmers spent an average of 15 years in lowland rice farming, which shows that the experience of farming was quite high so that the possibility of adopting agriculture technology was greater.

Around 56% of respondent farmers had access to credit so that their working capital could be increased and 50% of them adopted quality seeds. Farmers who had large working capital were more motivated to adopt agriculture technology. Large working capital could help farmers to obtain agriculture inputs such as quality seeds and fertilizers [46, 47]. The number of dependents of productive household heads was a source of labor so that they were more likely to adopt quality seeds in their farming. The average land area of respondent farmers was 1.93 hectares (ha), the larger the land area owned, the greater the possibility to adopt quality seeds.

Table 2. Socio-economic characteristics and classification of respondent farmers

Variable	Adopters (Mean)	Non-adopters (Mean)	t-test/Chi2 Value
Adoption of quality seeds (dummy)	77	23	-
Gender	0.64	0.10	46.14***
Age (year)	47.24	35.24	10.88***
Education (dummy)	0.45	0.21	62.60***
Lowland rice farming experience (year)	15.31	12.46	4.42***
Access to credit (dummy)	0.5	0.06	34.37***
Source of income (dummy)	0.25	0.09	1.29^{ns}
Number of dependents of HH (soul)	3.98	3.45	3.50***
Access to extension (number)	6.36	5.3	2.82***
Number of farmer group meetings (number)	5.49	5.49	0.002^{ns}
Land area of lowland rice (ha/farm)	2.01	1.68	4.14***

Note: *** significant at α 1%, ns = non- significant; Source: processed data result of 2021.

3.2 Types and sources of quality seeds of lowland rice

On average, 77% of respondent farmers used quality seeds in lowland rice farming, and the quality seeds used came from various varieties of lowland rice. Table 3 presents a list of varieties used by respondent farmers.

The quality seeds used by respondent farmers were stock seeds. The stock seed is F1 from the base seed or F2 from the breeder seed. Production of stock seed still maintained the identity and purity of the varieties and met the standards of seed regulations and certification by the Seed Supervision and Certification Center. The stock seeds were produced by the Seed Center or a private party registered and labeled with a purple certification [8]. Lowland rice farmers got stock seed by buying them from agro-chemical shops in villages, sub-districts, districts, and provinces.

Table 3. Varieties of lowland rice used by respondent farmers

No.	Varietas	Age (days)	Yield potential (ton/ha GKG)
1	Cigeulis	115-125	8.0
2	Mekongga	116-125	6.0
3	Ciherang	116-125	7.0
4	Cibogo	115-125	8.1

Note: GKG=Unhulled Dry paddy; Source: ARDA [52].

3.3 Factors affecting the adoption of quality seeds and number of fertilizers used

The results of the estimation of the double-hurdle model on the factors that affected the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds are shown in Table 4.

Table 4 shows a log-likelihood value of 117.99 and a Chi-square of 482.25 with a Prob of 0.00 < 1%; this supports the choice of the double-hurdle model, and overall, all the estimated coefficients had a significant effect. The implication was that all exogenous variables were relevant in explaining the possibility of adopting quality seeds in lowland rice farming and the number of fertilizers used. Gender had no effect on the decision to adopt quality seeds in lowland rice farming but had a negative and significant correlation with the number of fertilizers used for quality seeds. This implies that females were more likely to use fertilizers in lowland rice farming. This is in accordance with the findings of Nation [53] which noted that females were more willing to take risks than males to allocate resources. Education was found to be positively correlated with the decision to adopt quality seeds in lowland rice farming and the use of fertilizers for quality seeds. This shows that farmers with higher education tended to adopt quality seeds in lowland rice farming and allocate more fertilizers for quality seeds. Farmers who were more educated would have the ability to adopt new technologies. The results of this study are in accordance with the findings of Asmelash [48], Ghimire [27], and Nonvide [43] which show the role of education in the adoption of superior rice varieties.

Access to credit, sources of farmers' income, and the number of dependents of the household head were variables related to increasing farmers' working capital, so they were correlated with the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds. The decision to adopt quality seeds in lowland rice farming and the use of fertilizers on quality seeds was positively correlated with access to credit. This finding is supported by those of Chekene and Chancellor [33] and Nonvide [43] which state that access to credit was positively related to the adoption of superior rice varieties. This shows that economic conditions affected farmers in adopting quality seeds. Access to credit could increase farmers' working capital so that they could purchase agriculture inputs such as quality seeds and fertilizers to support lowland rice production so that yields could increase. Sources of income were positively associated with the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds. According to Nonvide [43], off-farm activity had a positive correlation with the adoption of superior rice varieties. This shows that farmers who had income from on-farm and off-farm (income diversification) could increase their working capital and investment in agriculture so that they could buy quality lowland rice production inputs. A negative relation was found between the number of dependents of household head and the likelihood of adopting quality seeds in lowland rice farming and the use of fertilizers on quality seeds, but only significant in the use of fertilizers. This implies that the number of dependents of household head was a cost expense in the farmer's household which could reduce working capital in farming. The number of dependents of the household head could reduce the possibility of adopting quality seeds and the use of fertilizers in lowland rice farming.

This research shows that access to extension could increase the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds. Regular contact with extension workers could increase farmers' knowledge about new technologies in lowland rice farming so that they might be more willing to adopt these technologies. This is supported by the findings of Asmelash [48], Umeh and Chukwu [45] and Nonvide [43] about the adoption of superior varieties of lowland rice which argued that contact with extension services was a place for learning about new technologies. Meetings with members of farmer groups had a positive correlation with the possibility of adopting quality seeds in lowland rice farming and the use of fertilizers on quality seeds. Rice farmers could learn about new technologies through meetings with farmer group members; through these meetings they could share experiences about agriculture technologies that provided better benefits. This was supported by the findings of Dandedjrohoun [29], Zarafshani [50] and Nonvide [43] which show the adoption of agriculture technology could occur through the social interaction of farmers.

The variable of land area of lowland rice had a positive correlation with the adoption of quality seeds in lowland rice farming and negatively correlated with the number of fertilizers used on quality seeds. This means the wider the land area of lowland rice, the higher the possibility of adopting quality seeds. The adoption of quality seeds was correlated with the agriculture land area [42, 51]. The use of fertilizers on quality seeds decreased with the increase in land area; this was related to the working capital of farmers which was decreasing because quality seeds have been bought. Large areas of agricultural land tended to use more resources for crop production so that higher working capital was needed [50].

Table 4. Estimation of the double-hurdle model on the adoption of quality seeds in lowland rice farming

Variables	Probability of adopting quality seeds (Hurdle 1)			number of fertilizers used (Hurdle 2)		
	Coefficient	Std. Err.	P value	Coefficient	Std. Err.	P value
Z1	-0.023^{ns}	0.015	0.139	-0.512**	0.246	0.037
Z2	-0.002^{ns}	0.001	0.100	-0.017^{ns}	0.013	0.195
Z3	0.048***	0.009	0.000	0.279**	0.138	0.043
Z4	0.001^{ns}	0.002	0.406	-0.000^{ns}	0.025	0.996
Z5	0.048***	0.014	0.001	0.544***	0.202	0.007
Z6	0.043***	0.015	0.004	1.310***	0.272	0.000
Z7	-0.004^{ns}	0.005	0.417	-0.143*	0.081	0.077
Z8	0.010***	0.002	0.000	0.087**	0.039	0.025
Z9	0.018***	0.003	0.000	0.116**	0.051	0.024
Z10	0.202***	0.012	0.000	-0.455***	0.158	0.004
Constant	2.166***	0.045	0.000	1.203*	0.731	0.100
Sigma constant				-2.385***	0.044	0.000
Chi^2	482.25					
Log likelihood	117.99					
Prob > chi^2	0.00					
N	329			253		

Note: *** significant at α 1%, ** significant at α 5%, * significant at α 10%, ns = non- significant.

3.4 Total factor productivity of lowland rice farming

Table 5 illustrates the average total factor productivity (TFP) of lowland rice farming that used quality seeds and those that did not use quality seeds.

Table 5. Summary of Malmquist mean index in lowland rice farming

Household	TFP	
	Mean	Std. Deviation
Adopt quality seeds	0.81^a	0.07
Non-Adopt quality seeds	0.99^b	0.11

Note: the different letters in one column means significantly different in α=5% two-tailed test; Source: processed data result of 2021.

Independent t-test analysis shows that the average total factor productivity (TFP) of lowland rice farming was significantly different between farmers who used quality seeds and those who did not use quality seeds. The average TFP of lowland rice farming used quality seeds was significantly higher than the TFP of lowland rice farming that did not use quality seeds. This result implies that quality seeds could increase the TFP of lowland rice farming. Evenson and Fuglie [54] show that technology capital had a significant impact on TFP growth. The study of Effendy [55] shows that there was a positive relationship between technical efficiency with TFP growth. A high change in TFP indicates an increase in agricultural productivity and the main factor that caused this increase was technical growth [56]. In contrast, Coelli and Rao [57] reported that agricultural productivity growth in Asia mainly came from improvements in efficiency changes. The level of agricultural productivity was also determined by financial resources and the stage of economic development [58]. The increase in agricultural TFP was due to higher technological capital formation [59].

4. CONCLUSIONS

The innovation of this research was the discovery of socio-economic factors that affected the adoption of quality seeds in lowland rice farming and the use of fertilizers on quality seeds in Central Sulawesi Indonesia. To find these factors we used qualitative and quantitative analysis (a double-hurdle model). The result shows that 77% of farmers adopted quality seeds in lowland rice farming. The lowland rice varieties used by respondent farmers were Cigeulis, Mekongga, Ciherang, and Cibogo. The first hurdle estimation shows that the variables of education, access to credit, sources of income (income diversification), access to extension, frequency of farmer group meetings, and land area of lowland rice played an important role in the decision-making process for adopting quality seeds in lowland rice farming. The result of the second hurdle shows that gender, education, access to credit, sources of income (income diversification), number of dependents of household head, access to extension, frequency of farmer group meetings, and land area of lowland rice were correlated with the use of fertilizers on quality seeds. These findings indicate that the role of extension institutions and farmer groups was needed in promoting quality seeds. Financial institutions were expected to support farmers' working capital by providing credit facilities for farming so that the productivity of lowland rice could be increased.

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