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Income Diversity and Other Socioeconomic Factors That Influence the Household Food Security of Small-Scale Lowland Rice Farmers in Indonesia

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ABSTRACT

Farmers face many challenges, such as decreased agricultural productivity and decreased household income, which impact farmers' food insecurity. This study aims to analyze the effect of income diversity and other socioeconomic factors on the household food security of small-scale lowland rice farmers. This study uses multivariate logistic regression and input from 264 lowland rice families to explain the relationship between income diversification and other socioeconomic factors on household food insecurity. The results show that household heads who reported higher income diversification tend to be more resistant to food security (OR=11.59; p-value=0.02). Other socioeconomic variables associated with the household food insecurity of lowland rice farmers such as the young age of some farmers, higher education, access to extension services, access to credit, and wider agricultural land lead to a higher chance of reporting high food security (respectively: OR=1.06, $p<0.05$; OR=2.96, $p<0.01$; OR=1.69, $p<0.01$; OR=6.71, $p<0.01$; and OR=4.08, $p<0.01$), this happens because these variables affect the productivity of lowland rice. Therefore, increased productivity of lowland rice can have an impact on increasing smallholder household income. Although income diversification is a necessary strategy to improve the food security of lowland rice farmers, it must be accompanied by basic income stability.

1. INTRODUCTION

Feeding the world's population is a significant challenge for governments and policymakers [1, 2]. Tailored interventions and research to address food insecurity often take different paths. In the end, solutions tend to manage one or more of the four main pillars of food security: food availability, food access, food utilization, and food stability at various scales [3]. Beyond the issue of inadequate food production, fluctuations in food prices, high poverty rates, poor infrastructure, and weak national and local economies also have significant implications for food access [4, 5].

Diversification of household income within sustainable livelihoods is one of the models promoted by the World Bank and several NGOs to address food security in developing countries [6]. According to the basic definition of this term, income diversification is increasing the sources of income of individuals or households [6]. Although the impact of income diversification on household food security is clear, Escobal [7] found that income diversification did not necessarily lead to increased household income and a change in consumption patterns.

Since 2006 an acceleration program has been carried out in Indonesia to speed up the diversification of food consumption which aims to further increase the diverse, nutritionally balanced, and safe food intake [8]. Nevertheless, shortages and other socioeconomic factors that affect the achievement of food security remain a challenge for the Indonesian population; in this context, the effectiveness of household income diversity as a strategy to improve food security is still in question. In exploring strategies to increase food security, Tarasuk [9] argues that raising the minimum wage, providing food assistance through the Food Bank, and housing subsidies cannot improve household food security. Furthermore, Nyantakyi-Frimpong [10] states that agricultural diversity cannot increase food security among smallholder households because of the broad impact of environmental variability. Smallholders are farmers who cultivate agricultural land of less than 2 ha [11, 12].

Another approach to addressing food insecurity is agricultural productivity. Most studies have found that characteristics such as education level, age, extension access, credit access, and agricultural land area are vital variables that explain variations in agricultural productivity [13-15]. However, there is little understanding of whether these characteristics affect food security.

This research studies income diversity and other socioeconomic factors on the household food security of small-scale lowland rice farmers in Indonesia. The study began by reviewing the introduction, materials and methods, results, discussion, conclusions, and recommendations.

2. MATERIALS AND METHODS

2.1 Research sites

This research was conducted in Central Sulawesi, Indonesia. Central Sulawesi is located between 20 22' North Latitude and 30 48' South Latitude and between 1190 22'−1240 22' East Longitude, with an area of 61,841.29 km² [16]. Central Sulawesi has a tropical climate; the rainy season occurs between April and September, while the dry season occurs between October and March. Parigi Moutong Regency was chosen for this research location because it has the most expansive rice harvest area of 21.31% (43,294 ha), and most farmers are agricultural cultivation to farm rice fields of less than 2 ha. Agricultural cultivation of less than 2 ha is categorized as a smallholder [11, 12]. In addition, Parigi Moutong Regency has the highest productivity rate at 5.87 tons/ha. Six villages from this area were randomly selected to be surveyed (Table 1).

Table 1. Research area

District	Villages	Sample size (HH)
Parigi Moutong	Balinggi Jati	45
	Astina	47
	Tolai	41
	Masari	42
	Purwosari	40
	Nambaru	49
Total		264

Source: Own calculations

These communities engage in rice farming, cocoa plantations, and pig farming. In addition, there are household heads (HH) which carry out non-agricultural activities. This study surveyed 264 lowland rice farms which were selected randomly. This sample represents 15% of the total lowland rice farmer households in the villages of Balinggi Jati, Astina, Tolai, Masari, Purwosari, and Nambaru. This number is based on Sing [17] 's sample size recommendation, which suggests selecting 10-20% of the population and collecting data using a questionnaire designed to gather data on farmer households such as education levels, age, gender, farming experience, number of family members, farming scale, land use, use of production inputs, production input prices, sources of income, and consumption. Data collection was carried out between April and June, 2022.

2.2 Measuring food security

The measurement of food insecurity (dependent variable) in this study was also used by Coates et al [18]. This method uses nine question items with binary answers (yes=1 or no=0), which is called the Household Food Insecurity Access Scale (HFIAS). The food security variable in this study uses four categories developed by Coates et al. [18] by combining responses from nine questions and their frequency of occurrence. The food insecurity scale consists of food security (coded '1'), mild food insecurity (coded '2'), moderate food insecurity (coded '3'), and severe food insecurity (coded '4'), with a limit as follows:

HFIA category=1; *if* [(*Q*1*a*=0 *or Q*1*a*=1) *and Q*2=0 *and Q*3=0 *and Q*4=0 *and Q*5=0 *and Q*6=0 *and Q*7=0 *and Q*8=0 *and Q*9=0]

HFIA category=2; *if* [(*Q*1*a*=2 *or Q*1*a*=3 *or Q*2*a*=1 *or Q*2*a*=2 *or Q*2*a*=3 *or Q*3*a*=1 *or Q*4*a*=1) *and Q*5=0 *and Q*6=0 *and Q*7=0 *and Q*8=0 *and Q*9=0]

HFIA category=3; *if* [(*Q*3*a*=2 *or Q*3*a*=3 *or Q*4*a*=2 *or Q*4*a*=3 *or Q*5*a*=1 *or Q*5*a*=2 *or Q*6*a*=1 *or Q*6*a*=2) *and Q*7=0 *and Q*8=0 *and Q*9=0]

HFIA category=4; *if* [*Q*5*a*=3 *or Q*6*a*=3 *or Q*7*a*=1 *or Q*7*a*=2 *or Q*7*a*=3 *or Q*8*a*=1 *or Q*8*a*=2 *or Q*8*a*=3 *or Q*9*a*=1 *or Q*9*a*=2 *or Q*9*a*=3]

2.3 Measuring the level of income diversity

This study uses Simpson's diversity index (SDI) to measure the diversity level in the household income of lowland rice farmers. SDI is a commonly used method [19, 20] and has been adopted to measure income diversity in rural areas [20-22].

$$SDI = 1 - \sum_{i=1}^{N} P_i^2 \quad (1)$$

where,
SDI=Simpson's diversity index or income diversity index,
N=number of sources of income, and
Pi=the proportion of household income originating from the i^{th} source.

The *SDI* value is between 0 and 1; if the *SDI* is close to zero, a household has only one source of income (the higher the level of specialization), and if it is close to one the number of sources of income is large (the higher the level of diversification).

2.4 Analysis of the level of income diversity regarding food security

Ordered logistic regression analysis was used to examine the effect of income diversification on the food insecurity status of lowland rice farmer households. Ordered logistic regression analysis is based on the nature of the dependent variable (household food insecurity), whose categories range from food security to very food insecurity. The formula for ordered logistic regression is:

$$log \frac{P(Y_{ij} \leq 1)}{1 - P(Y_{ij} \leq 1)} = \alpha_0 + \sum_{k=1}^{p-1} \alpha_{jk} X_{ijk} + V_{ij},\ C = 1, \ldots \Omega - 1 \quad (2)$$

where:
$P(Y_{ij} \leq 1)$=the probability that a certain event will occur,
$1-P(Y_{ij} \leq 1$=the probability that the event will not occur,
α_{jk}=regression coefficient,
X_{ijk}=independent variable,
P - 1=last independent variable,
α_0=intercept,
V_{ij}=error in the logistic model.
The variables in this study are as follows:
P=food insecurity status of lowland rice farmers
P=1; if food security,
P=2; if mild food insecurity,
P=3; if moderate food insecurity, and
P=4; if severe food insecurity.
X_1=diversification of household income,
X_2=gender of manager (0=female, 1=male),
X_3=manager age,
X_4=manager education,

X_5=extension access,
X_6=experience in farming lowland rice
X_7=credit access (0=access to credit, 1=not access to credit), and
X_8=area of lowland rice.

Household income diversification is one of the models promoted by the World Bank to address food security in developing countries [6], but Escobal [7] found that income diversification did not necessarily increase household income and change consumption patterns, so income diversification is included in Research Model.

Gender inequality limits economic growth, so it is important to include gender in the analysis of smallholder food security [23]. Therefore, this study introduces gender in the model (gender of manager).

Farmer age affected agricultural technology adoption so that it could determine agricultural productivity [24]. Agricultural productivity was one of the factors that affected food security. The age of the head of the family was measured in years.

Education level could affect farmers in adopting new technologies [25, 26]. This could affect smallholders' agricultural productivity and income, so it tended to determine food security.

Extension access affected the adoption of lowland rice technology [27, 28]. Agricultural technology, such as the use of superior seeds and fertilizers, could increase agricultural productivity so that farmers' income also increased. Access to agricultural extension was measured by the number of household heads present.

Experience in agriculture has affected the adoption of lowland rice technology so that it could increase crop productivity [29]. Increasing the productivity of lowland rice would have an impact on farmer household income. Experience in lowland rice farming is expressed in years.

Credit access is a variable related to farmers' working capital so that they could buy agricultural inputs sufficiently and on time [30, 31]. Adequate agricultural inputs could increase the productivity of lowland rice. It tended to increase the household income for farmers.

The area of agricultural land affected crop production [32]. The wider the agricultural land tended to provide more yields so it would impact farmers' household income. Lowland rice field area is expressed in hectares.

3. RESULTS AND DISCUSSION

3.1 Respondent characteristics

A summary of the characteristics of the respondents is presented in Table 2.

Table 2 shows that the diversification of income in lowland rice farmers' households is low (0.398). The majority (73.4%) of the managers of lowland rice households are male, and the average age is 45. We also found that most lowland rice farmers had junior high school education. The average access to agricultural extension by lowland rice farming managers is eight times. In addition, the average manager's experience in farming lowland rice is 15 years. Most of the managers of lowland rice farming (67.3%) do not access credit at the bank. The average area of lowland rice fields managed by farmers is 1.8 ha. The average food security of lowland rice farmers is mild food insecurity.

Table 2. Summary of respondent characteristics

Variable	Units	Mean	Std. Dev.
Income diversity	number	0.398	0.144
Gender	dummy	0.734	0.443
Age	year	44.677	9.797
Education	ordinal	2.030	0.761
Extension access	number	7.692	2.300
Farming experience	year	14.589	5.123
Credit access	dummy	0.673	0.470
Area of lowland rice	ha/farm	1.796	0.653
Foot security	ordinal	1.559	0.749

Source: Own calculations

3.2 Dependent variable: Food insecurity

The description of food insecurity is presented in Table 3.

Table 3 shows that 15.53% of households are moderately food insecure, and about 24.62% are mildly food insecure. Most (59.85%) lowland rice farming households are in the food security category. Regarding socioeconomic disparities, homes categorized as food security have higher income diversity, female managers, primary education or better, higher rates of agricultural extension, access credit, and more expansive rice fields.

3.3 Relationship of income diversification and other socioeconomic factors regarding food security

The results of the ordered logistic regression analysis on the level of food insecurity are presented in Table 4.

Table 4 shows that of the eight independent variables that are thought to affect the level of food insecurity, seven have a p-value of less than 0.05, indicating that the independent variable partially affects the level of household food insecurity of lowland rice farmers. The seven variables are household income diversification, manager's gender, manager's age, manager's education, access to extension from managers, access to credit from managers, and area of lowland rice fields. This shows - with a 95% confidence level - the seven independent variables significantly affect the food insecurity status of lowland rice farmers.

Table 3. Description of food insecurity

Food insecurity	Total (household)	Percentage of Food insecurity (%)	X1	X2	X3	X4	X5	X6	X7	X8
Food security	158	59.85	0.42	0.83	45.99	2.23	8.77	15.16	0.85	2.06
Mild food insecurity	65	24.62	0.39	0.72	43.97	1.92	6.65	13.83	0.62	1.61
Moderate food insecurity	41	15.53	0.34	0.37	40.61	1.46	5.32	13.71	0.07	1.09
Total	264	100.00								

Table 4. Estimation of the parameters for ordered logistic regression to predict food insecurity

Variable	Coefficient	Standard Error	Odds Ratio Estimates	p-value
X1	2.450	1.194	11.591	0.0203
X2	1.222	0.364	3.393	0.0003
X3	0.054	0.024	1.056	0.0173
X4	1.084	0.238	2.955	<.0001
X5	0.523	0.082	1.688	<.0001
X6	0.008	0.044	1.008	0.9586
X7	1.904	0.365	6.713	<.0001
X8	1.406	0.308	4.078	<.0001
Intercept 1	-14.007	1.623		
Intercept 2	-10.843	1.431		
Likelihood Ratio			229.252	

Source: Own calculations

Lowland rice farming households reporting higher income diversification tend to be highly food insecure (OR=11.59; p-value=0.02). The odds ratio value for the household income diversification variable is 11.59, p-value <0.05. This means that households with a high level of income diversification have 11 times more food security status when compared to families with a low level of income diversification, assuming other independent variables are held constant. Our results agree with Aasoglenang and Bonye [33] and Silvestri et al. [34], who promote income diversification as a strategy to ensure household food security and to reduce poverty in rural areas. Tarasuk [9] argues that income diversification must be accompanied by essential income guarantee and stability. Tarasuk's analysis [9] underlines that income diversification alone cannot increase food insecurity without improving structural factors that impact income stability. Households in rural areas are more likely to diversify sources of income for food security. One of the motives for income diversification is to increase the chance of survival [35]. Overall, study findings confirm that income diversification can improve household food security and the results recommend income diversification as an antidote to chronic food insecurity [36-38]. Lowland rice households can be involved in various income-generating activities such as cocoa plantations and other agriculture, raising chickens and pigs, and small businesses such as warungs to increase food security.

Male managers were highly food insecure (OR=3.39; p-value=0.0003). The odds ratio value of 3.39 and p-value <0.01 indicate that male managers are three times more likely to have a higher food insecurity status than female managers. This considerable odds ratio value tends to be related to the efforts of female managers in meeting household needs compared to male managers, so that household members are more resistant to food insecurity. This finding contradicts Atuoye et al. [35], who states that gender had no significant effect on the food insecurity status in Ghana. Female managers are more likely to use fertilizers in lowland rice farming (Effendy et al. [28] and Nation [39] notes that women are more willing to take risks than men to allocate resources.

All of the socioeconomic variables associated with the household food insecurity of lowland rice farmers have a significant effect except for farming experience. Household managers who are younger and have education, access to extension, access to credit, and large agricultural land have higher odds of being food secure (OR=1.06, p<0.05; OR=2, respectively: OR=1.06, p<0.05; OR=2, 96, p<0.01; OR=1.69, p<0.01; OR=6.71, p<0.01; and OR=4.08, p<0.01).

Food security is also influenced by socioeconomic factors such as age, education, access to counseling, access to credit, and the area of agricultural land. Agricultural production has recently fluctuated due to climate change, low inputs, and investment in rural facilities [10, 40, 41]. This study shows that younger farmers are 1.06 times more likely to be food secure than older farmers because young farmers are still energetic and prefer adopting agricultural technology so their production tends to increase [28, 42, 22].

Educated farmers are 2.96 times more likely to be food insecure than farmers who are not educated (not finished primary school). Farmers with access to an extension are 1.69 times more food secure than farmers who do not have access to an extension. Previous research has also shown that education positively influences food security [22, 43, 44]. Farmers who are more educated and have access to the extension will be able to adopt new technologies, such as improved variety and efficient use of inputs that impact farmers' incomes [29, 45, 46]. In addition, education can empower farmers to seize various business opportunities and take the initiative to start a business [47].

Farmers who access credit are 6.71 times more likely to be resistant to food insecurity than farmers who do not access credit, and farmers who choose larger plots of agricultural land are 4.08 times more food secure. However, managing extensive farmland without sufficient capital can reduce agricultural productivity. Vast agricultural lands use more resources for crop production, so a higher working capital is required [32]. Access to credit increases a farmers' working capital, so it is correlated with the adoption of agricultural technology, such as using quality fertilizers and seeds [46, 48]. Access to credit can increase a farmers' working capital and help to manage agricultural land through using quality inputs to support land productivity so farmers' yields and income can increase. In addition, farmers can use agrarian land as collateral to access credit and they can rent agricultural land to generate revenue [47].

The variables gender of manager, manager age, manager education, extension access, credit access, and area of lowland rice affected the food security of smallholder households because these variables affected the productivity of lowland rice [28-30]. Therefore, increasing lowland rice productivity could have an impact on increasing smallholder household income.

The experience of farming lowland rice did not affect the food security of smallholder households. This is suitable with the findings of Effendy et al. [28], which show that the experience of working on lowland rice did not affect the adoption of superior seeds and fertilizers. Hence, they tended not to increase the productivity of lowland rice. However, lowland rice productivity was related to the smallholder household income in rural areas.

4. CONCLUSIONS

This study shows that household income diversification is closely related to increasing the household food security of small-scale lowland rice farmers. Diversification of household income can be the key to improving food security in rural areas. These findings also reinforce the need to consider socioeconomic factors such as gender, age, education, access to counseling, access to credit, and area of agricultural land in formulating strategies for food security in rural areas. There is

an urgent need to provide irrigation development in rural Indonesia to improve food security in rural areas. This step can increase the amount of cultivable lowland rice fields and extend the crop production period. In addition, the national food policy must encourage investment in technology, farmer education, agricultural extension, and farmer credit facilities.

This study only measured the food security status of smallholder households however did not support the significance of other socio-economic variables on lowland rice productivity, where it was known that lowland rice productivity affected smallholder household income. Furthermore, this study did not include food wasted and eaten and the household's average daily caloric intake calculation. This is the main limitation of this research. Therefore, we suggest further research to examine the effect of income diversity on food security by considering this research's cultural values, history, and shortcomings.

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