Does Farm Size Matter for Food Security Among Agricultural Households? Analysis of Indonesia's Agricultural Integrated Survey Results

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Abstract. Most agricultural households in Indonesia are small-scale farmers making them prone to food insecurity. Until recently, no study has assessed the impact of farm size and sociodemographic characteristics on the food insecurity status of agricultural households using a nationwide agricultural household survey in Indonesia. Our study aims to address this gap by utilizing the results of the first Indonesian Agricultural Integrated Survey conducted by BPS in 2021. Applying the Rasch Model, Multinomial Logistic Regression, and Ordinary Least Squares Regression, we found that the farm size has a positive impact in lowering the likelihood of experiencing moderate or severe levels of food insecurity among agricultural households. Our study also found that agricultural households with a higher probability of being food insecure are characterized by having higher members of households, relying only on agricultural activities for their livelihood, lower education attainment of household heads, and being led by female farmers.

1. Introduction

Agriculture still plays a significant role in the Indonesian economy by accounting for around 12 percent of the total GDP in 2022 [1]. However, agriculture cultivation in Indonesia is dominated by small-scale farmers. Over half of Indonesian agricultural households managed less than 0.5 hectares of agricultural land in 2018 [2]. The circumstances may put their food security and sustainability under threat. A wide range of studies pointed out that the farm size affects the food security of agricultural households [3][4][5][6][7][8][9]. Food insecurity in agricultural households may also be impacted by the sociodemographic characteristics of the head of the agricultural households, such as age, gender, education, and participation in non-farm economic activities [10][11][12][13][14][6][15][16][17].

Food security happens when there is both physical and economic access to sufficient safe and nutritious food for all people at all times. Therefore, they can meet their dietary needs and food preferences for a healthy and active life [18]. Some indicators have been developed to measure the state of food security based on that definition, among others, the Food Consumption Score, Household Food Insecurity Access Scale, and Food Insecurity Experience Scale (FIES) [19]. Among these methods, FIES is widely used globally as a food security indicator [20]. The indicator can measure food security at the household level through a set of questions reflecting household experiences toward food insecurity [21].

In assessing the impact of farm size on the food insecurity of agricultural households, the issue is how to measure the farm size and define the small-scale farmers or food producers. However, the

definition of small-scale varies across studies. Generally, two proxies are widely used, absolute and relative thresholds [22]. Almost all studies investigating the influence of farm size on the food insecurity status of agricultural households in the Indonesian context have made use of the size of cultivated land to reflect the farm size (absolute thresholds). In this regard, small-scale farmers are defined as those who manage less than a certain area of land, like less than 0.5 hectares usually referred to as *petani gurem* [2]. The main drawback of this approach is that over time it could result in an adverse selection bias, which would lead to monitoring the productivity or the income of the worst performers [22]. Our study tries to address this issue by introducing a new approach by applying a method proposed by the FAO in determining what so-called small-scale food producers are. With this method, the farm size is determined by the physical size of the farm (agricultural land area and number of livestock) and the total revenue obtained from running agricultural activities [22].

In the Indonesian context, studies focusing on the influence of farm size and sociodemographic characteristics of agricultural households on food insecurity status at the agricultural household level using the results of a nationwide agricultural survey are not yet available. Therefore, there is a lack of sufficient findings about their impacts on their state of food security examined based on a nationwide agricultural survey. Our study aims to address the gap by using the current data from the results of the 2021 Agricultural Integrated Survey (AGRIS) conducted by Statistics Indonesia (BPS). The survey captured information needed to determine the food insecurity status of agricultural households in Indonesia and the sociodemographic characteristics that can explain it. The rest of the paper is organized as follows. Section 2 presents the methodology and the data used. Section 3 provides the empirical results and the analysis, and Section 4 gives the conclusion and recommendations.

2. Methodology

Our study made use of the results of the AGRIS conducted for the first time by BPS in 2021. The survey observed around 212,644 agricultural household samples in the 34 provinces and provided information on socioeconomic agricultural household characteristics, including the information needed to determine the food insecurity status of the households. The food insecurity status is determined by applying the FIES to the results of the AGRIS. FIES captures food insecurity at the individual or household level by interviewing agricultural household samples with eight questions capturing their experience related to food insecurity. Eight questions of FIES are used in this study as presented in Table 1.

Table 1. Questions Related to FIES Measurement

During the last one year, was there a time when?	
Q1	You or others in your household worry about not having enough food to eat because of a lack of money or other resources.
Q2	You or others in your household are unable to eat healthy and nutritious food because of a lack of money or other resources.
Q3	You or others in your household ate only a few kinds of foods because of a lack of money or other resources.
Q4	You or others in your household had to skip a meal on a particular day because of a lack of money or other resources.
Q5	You or others in your household ate less than you thought you should because of a lack of money or other resources.
Q6	You or others in your household run out of food because of a lack of money or other resources?
Q7	You or others in your household were hungry but did not eat because of a lack of money or other resources.
Q8	You or others in your household do not eat for a whole day because of a lack of money or other resources.

Source: *Statistics Indonesia [23].*

The eight questions in Table 1 are asked in sequence to assess the severity level of food insecurity [24]. Each question item in the FIES represents different circumstances based on food insecurity experienced by households [25]. They focus on food-related behaviours and food access difficulties due to constraints in resources based on information directly provided by the household [26].

As in [27], we calculated a household likelihood of being food insecure either moderately or severely ($p_{mod+sev}$) and the likelihood of being food insecure severely (p_{sev}) based on the response to the FIES related questions. In doing so, we applied the Rasch model [28][29] to the 2021 AGRIS results. We assume that the position of a household and that of the items can be placed on the one-dimensional scale of severity. Using the model, we also postulate that the likelihood of household *i* responding "yes" to item *j* is the logistics function of the difference between the severity of the food insecurity situation encountered by household *i* and the severity of item *j* [21]. Assuming that $X_{i,j}$ is the answer given by respondent *i* to item *j* that is coded as 1 for "yes" and 0 for "no", we have

$$p \equiv Prob(X_{i,j} = 1) = \frac{\exp(\theta_i - \beta_j)}{1 + exp\,(\theta_i - \beta_j)} \Leftrightarrow ln\left(\frac{p}{1-p}\right) = \theta_i - \beta_j \quad (1)$$

In equation (1), θ_i represents the position of the respondent (household) *i* on an underlying severity scale while β_j represents the position of item *j* in the same severity scale. Both parameters are estimated by the conditional maximum likelihood procedure conditioning on the sum of affirmative answers given by each respondent to the FIES questions (raw score).

We also estimated the percentage of agricultural households encountering moderate to severe food insecurity ($F_{mod+sev}$) and the percentage of agricultural households experiencing severe food insecurity (F_{sev}). The two indicators were calculated as the weighted sum of $p_{mod+sev}$ and p_{sev} respectively for all agricultural households in the sample.

We adopted the FAO's framework for the computation of SDG indicator 2.4.1, by which the probability of being food insecure obtained from FIES used as an indicator to measure agricultural sustainability in terms of food security. The food insecurity status of each household is categorized as follows: mild food insecurity (desirable) if $p_{mod+sev} < 0.5$ and $p_{sev} < 0.5$; moderate food insecurity (acceptable) if $p_{mod+sev} > 0.5$ and $p_{sev} < 0.5$; severe food insecurity (unsustainable) if $p_{sev} > 0.5$ [30].

In defining the farm size our study applies the concept of small-scale food producers proposed by FAO, by which the farm size is the intersection between the physical size of the farm, expressed by land size and the number of livestock, and the economic size of the farm expressed by the total revenues measured in Purchasing Power Parity terms. As illustrated in Figure 1, small-scale farmers can be defined as the food producers belonging to both the bottom 40 percent of the cumulated distribution of physical size and the bottom 40 percent of the cumulated distribution of total revenues.

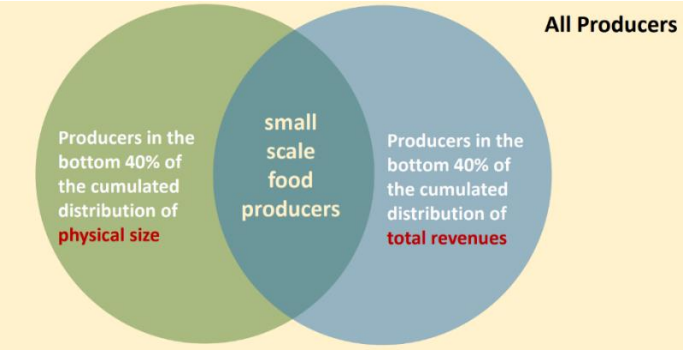

Figure 1. Illustration of the definition of small-scale food producers [22]

The multinomial logistic regression (MLR) then was used to analyze the influence of farm size and sociodemographic agricultural household characteristics on food insecurity. An MLR was used since our dependent variable is a categorical variable with three categories of food insecurity: mild food

insecurity, moderate food insecurity, and severe food insecurity. The regression model used for analysis is represented as follows:

$$Y_{ij} = \alpha_j + X'_{ij}\beta_j + \varepsilon_{ij} \quad (1)$$

In Equation 1, Y_{ij} is the sustainability status of the *i-th* household in the *j-th* category; X'_{ij} is a vector of characteristics of the *i-th* household in the *j-th* category, which consists of farm size and other sociodemographic independent variables described in Table 1; β_j a vector of regression coefficients for each household characteristic in the *j-th* category; and ε_{ij} is error component. The MLR then may be represented as:

$$\left[\frac{P(Y=j|X)}{P(Y=J|X)}\right] = \alpha_j + X'_{ij}\beta_j \quad (2)$$

where $J=3$ and $j = 1,2$. In such a way, there are two logit equations. Each of the logit equations is a linear function that models the logarithm of the odd as having response j to baseline category J [31]. In Equation (2), all logits are defined relative to a predetermined base category, which is mild secure food insecurity. The estimation of the regression coefficient (β_j) provides information on how much the change in logit occurred due to one unit increase of the value of particular household characteristics holding other variables remaining constant. For the convenience of the analysis, we also estimate the relative risk ratio (RRR), which is the exponential function of a regression coefficient, for each characteristic. The mathematical representation for RRR can be written as follows

$$\frac{P(Y=j|X)}{P(Y=J|X)} = \exp\left(\alpha_j + X'_{ij}\beta_j\right) \quad (3)$$

The interpretation of RRR is quite simple, where RRR greater than 1 means that the probability of the *j-th* category to occur is larger than the probability of obtaining the baseline category *J*. Given the sum of all probabilities $P(Y = j|X)$ for $j = 1,2,3$ equals to 1, the following expressions can be established.

$$P(Y = j|X) = \frac{\exp\left(\alpha_j + X'_{ij}\beta_j\right)}{1+\sum_{j=1}^{J-1}\exp\left(\alpha_j + X'_{ij}\beta_j\right)} \quad (4)$$

$$P(Y = J|X) = \frac{1}{1+\sum_{j=1}^{J-1}\exp\left(\alpha_j + X'_{ij}\beta_j\right)} \quad (5)$$

To enrich the analysis, we also estimate Equation 1 using Ordinary Least Squares (OLS), in which the assigned dependent variables are the probability of agricultural households experiencing moderate or severe food insecurity and the probability of being severely food insecure. The descriptions of all variables used in the model specification are presented in Table 2.

Table 2. Variable Description

Dependent variable: MLR used food insecurity status consisting of mild food insecurity (reference category), moderate food insecurity, and severe food insecurity; OLS used the probability of agricultural households being food insecure obtained by applying the Rasch Model by which there are two types of food insecurity probability assigned as the independent variables, i.e. the probability of being food insecure either moderately or severely ($p_{mod+sev}$) and the probability of being food insecure severely (p_{sev}).	
Independent variable:	
Farm scale	Agricultural households were grouped into two categories: small-scale food producers and non-small-scale food producers (reference category)
Gender	Gender of the head of the household consisting of male and female (reference category)
Age	MRL model: The age group of the head of the household consists of five categories: less than 35 years old (reference category), 35-44 years old, 45-54 years old, 55-64 years old, and more than 64 years old. OLS model: age of the head of the household in years

Independent variable:	
Education	Highest educational level completed by the head of the household consists of six categories: not completing elementary school (reference category), completing elementary school, completing junior high school, completing senior high school, completing diploma, and completing higher education.
Non-agriculture job	The job of the head of the household other than agriculture as the source of income consists of two categories: having a non-agricultural job and only agriculture (reference category)
Household size	Number of household members (continuous variable)
Region	Region of residential consisting of two categories: Jawa and outside Jawa (reference category)

3. Results and discussion

3.1. Agricultural household characteristics

Agricultural cultivation in Indonesia is mostly run by small-scale farms. Small-scale food producers make up around 70 percent of the total agricultural households. In Jawa, which is the resident of about 53 percent of the country's agricultural households, the proportion of small-scale food producers is around 78 percent which is higher compared to outside Jawa with about 61 percent of small-scale food producers. The figures are in line with the average agricultural land cultivated by agricultural households. On average, agricultural households only cultivate a relatively small area of agricultural land (around 0.75 hectares per household). However, agricultural households outside Jawa manage around 1,2 hectares of agricultural land on average, which is much larger than agricultural households in Jawa who on average only manage 0.38 hectares of agricultural land.

Agricultural households in Indonesia are led by old farmers (around 53 years old on average) and consist of around 4 household members. These characteristics apply to both Jawa and outside Jawa regions. However, farmers outside Jawa are younger, which is about 51 years old compared to Jawa farmers of around 55 years old. In terms of education, most of our farmers (around 68 percent) do not have/complete formal education or only complete elementary school. Nevertheless, farmers (the head of the agricultural households) outside Jawa have a slightly better education than farmers in Jawa. Concerning gender, our agriculture is still dominated by females, where almost 90 percent of agricultural households are led by female farmers. Meanwhile, more than half of the heads of agricultural households engage in non-agricultural jobs to earn additional income. In Jawa, around 56 percent of farmers have non-agricultural jobs, which is higher than outside Jawa of 49 percent.

Table 3. Summary of the variables

Variable	Jawa	Outside Jawa	Total
Continuous variable (mean)			
Agricultural land cultivated (hectare)	0.38	1.17	0.75
Household size (person)	4.08	4.26	4.16
Age of household head (year)	55.04	50.66	52.97
Household's moderate or severe food insecurity likelihood x 100	1.71	5.00	3.27
Household's severe food insecurity likelihood x 100	0.12	0.47	0.29
Categorical variable (percent)			
- Farm scale			
Non-small-scale food producers	22.02	38.52	29.81
Small-scale food producers	77.98	61.48	70.19
- Age group			
under 35 years old	4.19	9.37	6.64
35-44 years old	15.26	23.58	19.19
45-54 years old	28.58	29.64	29.08
55-64 years old	29.71	23.18	26.63

Variable	Jawa	Outside Jawa	Total
65+ years old	22.26	14.23	18.47
- Gender			
Female	13.80	13.56	13.69
Male	86.20	86.44	86.31
- School attainment			
No completing elementary school	21.13	20.91	21.03
Elementary school (SD)	53.96	39.70	47.22
Junior high school (SMP)	13.59	17.36	15.37
Senior high school (SMP)	9.30	18.38	13.59
Diploma	0.51	1.01	0.75
Higher education (S1/S2/S3)	1.50	2.64	2.04
- Non-agricultural job			
Only agriculture	43.42	50.71	46.86
Having non-agriculture job	56.58	49.29	53.14
- Region	52.78	47.22	100.00

Note: *The number of observations is 212.664 agricultural households (including those not only responding completely to FIES questions); sample weights were used.*

3.2. Food insecurity prevalence

The estimation results of the Rasch Model pointed out that the proportion of agricultural households experiencing food insecurity at moderate to severe levels was about 3.27 per cent in 2021, while those facing a severe level of food insecurity made up only around 0.29 per cent of the total agricultural households. The probability of agricultural households in Jawa experiencing food insecurity either moderately or severely is lower than agricultural households outside Jawa. It seems that the food insecurity accidents outside Jawa are the Eastern part of Indonesia's phenomenon. The eastern part of Indonesia, particularly Maluku, Papua, and Nusa Tenggara Timur has the highest percentage of agricultural households experiencing food insecurity either moderately or severely (Figures 2 and 3). It is consistent with the fact that those provinces are lagging behind other provinces in Indonesia in terms of socio-economic development.

Figure 2. Percentage of agricultural households experiencing food insecurity at moderate to severe levels by province

Figure 3. Percentage of agricultural households experiencing food insecurity at a severe level by province

Agricultural households experiencing food insecurity either moderately or severely are characterized by small-scale farms, having higher members of households, relying more on agricultural activities for their livelihood, lower education attainment of household heads, and being led by female farmers (Table 4). These characteristics will anticipate the results of the MLR model estimation that an agricultural household with those characteristics is more likely to experience food insecurity either moderately or severely. Interestingly, the percentage of agricultural households led by younger heads of household, which are experiencing food insecurity either moderately or severely, is lower than those led by older household heads. It is anticipate that the age of agricultural households will have a negative impact on the likelihood of the household experiencing food insecurity either moderately or severely.

Table 4. Distribution of variables by food insecurity status of the households

Variable	Mild	Moderate	Severe
Continuous variable (mean)			
Agricultural land cultivated (hectare)	0.76	0.58	0.61
Household size (person)	4.16	4.24	4.29
Age of household head (year)	53.02	51.14	50.89
Categorical variable (percent)			
- Farm scale			
Non-small-scale food producers	30.13	17.84	20.44
Small-scale food producers	69.87	82.16	79.56
- Age group			
under 35 years old	6.52	11.29	9.51
35-44 years old	19.12	21.39	23.69
45-54 years old	29.13	26.96	30.14
55-64 years old	26.71	24.05	20.77
65+ years old	18.53	16.32	15.89
- Gender			
Female	13.33	27.96	20.67
Male	86.67	72.04	79.33
- School attainment			
No completing elementary school	20.77	28.86	40.28
Elementary school (SD)	47.31	45.62	35.02
Junior high school (SMP)	15.43	13.36	13.19
Senior high school (SMP)	13.67	10.53	9.93
Diploma	0.75	0.58	0.57
Higher education (S1/S2/S3)	2.06	1.05	1.01
- Non-agricultural job			
Only agriculture	46.80	48.38	54.80

Variable	Mild	Moderate	Severe
Having non-agriculture job	53.20	51.62	45.20
- Region			
Outside Jawa	46.76	61.08	82.57
Jawa	53.24	38.92	17.43

Note: *The number of observations is 212,339 agricultural households (including those only responding completely to FIES questions); sample weights were used for estimation.*

3.3. Sociodemographic determinants of food insecurity

As anticipated, the farm size has a negative and significant impact on the odds of agricultural households experiencing food insecurity at moderate or severe levels. Holding other variables remain unchanged, the multinomial logit estimates of agricultural households belonging to small-scale food producers is 0.41 units higher in moderate food insecurity relative to mild food insecurity, and 0.76 units higher in severe food insecurity relative to mild food insecurity.

In terms of the RRR, for small-scale food producers relative to non-small-scale food producers, the relative risk for moderate food insecurity to mild food insecurity would be expected to increase by a factor of 1.5 and the relative risk for severe food insecurity to mild food insecurity would be expected to increase by a factor of 2,14 given the other variables in the model are held constant. In other words, the probability of agricultural households that are small-scale producers experiencing moderate or severe food insecurity is higher than experiencing mild food insecurity. It is in line with the estimation of the OLS regression models presented in Table 6 pointing out that small-scale food producers have a higher likelihood of moderate or severe and the likelihood of severe food insecurity than non-small-scale food producers. The findings make sense since the food production of the agricultural households and their income earned from the agricultural activities will increase with the farm scale. Our findings were also supported by other studies' findings [3][4][5][6][7][8][9].

Our findings confirm that increasing the farm size could improve agricultural households' food security. In this study, we measure the farm size by combining the physical size of the farm (land size and the number of livestock held) and the revenue obtained from running the farm. Therefore, it can be done through either increasing the productivity (land and labour productivity) or agricultural land size. The former must be prioritized by the government, among others by mechanization and digitalization. The last choice is quite challenging in the Indonesian context amid the fact that the agricultural land is consistently decreasing and land fragmentation among agricultural households.

In contrast, the age of the household head has a negative impact on the odds of agricultural households experiencing food insecurity either moderately or severely meaning that those led by younger household heads have a higher probability of being moderate or severely food insecure than those led by older household heads. It is indicated by the value of the RRR for the older age groups relative to the reference category (under 35 years old) that are lower than one and getting lower as the age group gets older. In most samples, the head of the household is the main farmer. So, it is possible to interpret the results of our regression estimation in the context of farmers. Therefore, our finding could be explained by the role of the farming experience leading to better performance in conducting agricultural cultivation [16]. With that experience, older farmers may have higher productivity than their younger counterparts. In other words, older farmers are more settled than younger ones. Moreover, our findings agree with many other studies [10][12][5][11][32][13][15]. However, the impact of age in lowering the probability of being moderately or severely food insecure is diminishing as the head of the household gets older.

As expected, agricultural household led by female has a higher probability of experiencing moderate or severe food insecurity than those led by male. It is reflected by the RRR value for males that is lower than one. It is similar to the findings of, among others [12][32][15][16]. It may happen since female farmers still have limited access to advanced farm techniques to improve their farm yield due to their position as female (gender-biased environment) [33]. Moreover, as the heads of agricultural households, females face more challenges than their male counterparts, such as more limited time and the lack of freedom to perform non-farm economic activities [16].

The estimation results of MLR confirm the crucial role of education for food security among agricultural households. It shows that the more educated the household head, the more likely the household to be food secure. It could be explained since the better of educational attainment of the household head the more opportunity for the household to diversify their source of income which, in turn, would increase their food supplies. Better education also would increase the heads' access to information, their decision-making process as well as their management technique on the food produced during the year around [13]. Our findings were supported by other related studies [10][13][6][9][17]. Unfortunately, most agricultural households are led by uneducated or low-educated heads making them prone to experience moderate or severe food insecurity.

Table 5. Estimation results of multinomial logistic regression

Independent variable (baseline: mild food insecure)	Regression coefficients		Relative risk ratio (RRR)	
	Moderate	Severe	Moderate	Severe
- Farm scale				
Small-scale food producers	0.4070***	0.7599***	1.5023***	2.1381***
	(0.0460)	(0.0932)	(0.0691)	(0.1993
- Age group				
35-44 years old	-0.2351***	0.0178	0.7905***	1.0179
	(0.0850)	(0.1436)	(0.0672)	(0.1462)
45-54 years old	-0.3973***	-0.1170	0.6721***	0.8896
	(0.0825)	(0.1399)	(0.0554)	(0.1244)
55-64 years old	-0.4940***	-0.5112***	0.6102***	0.5998***
	(0.0851)	(0.1504)	(0.0519)	(0.0902)
65+ years old	-0.4902***	-0.5572***	0.6125***	0.5728***
	(0.0897)	(0.1612)	(0.0549)	(0.0924)
- Gender				
Male	-0.4071***	-0.2842***	0.6656***	0.7526***
	(0.0541)	(0.0999)	(0.0360)	(0.0752)
- School attainment				
Elementary school (SD)	-0.5336***	-0.8693***	0.5865***	0.4192***
	(0.0518)	(0.0955)	(0.0304)	(0.0400)
Junior high school (SMP)	-0.8972***	-0.9994***	0.4077***	0.3681***
	(0.0730)	(0.1197)	(0.0298)	(0.0441)
Senior high school (SMP)	-1.0053***	-1.2812	0.3659***	0.2777***
	(0.0771)	(0.1410)	(0.0282)	(0.0392)
Diploma	-1.2118***	-1.1723***	0.2977***	0.3096***
	(0.3581)	(0.4206)	(0.1066)	(0.1302)
Higher education (S1/S2/S3)	-1.6795***	-1.5335***	0.1865***	0.2158***
	(0.2505)	(0.3844)	(0.0467)	(0.0829)
- Non-agricultural job				
Having non-agriculture job	0.0353	-0.2052**	1.0360	0.8145**
	(0.0442)	(0.0796)	(0.0458)	(0.0649)
- Household size	0.2450***	0.1296***	1.2777***	1.1384***
	(0.0204)	(0.0405)	(0.0260)	(0.0461)

Independent variable (baseline: mild food insecure)	Regression coefficients		Relative risk ratio (RRR)	
	Moderate	Severe	Moderate	Severe
- Region				
Jawa	-1.1724***	-1.7092***	0.3096***	0.1810***
	(0.0627)	(0.1359)	(0.0194)	(0.0246)
- Constant	-3.7504***	-4.8407***	0.0235***	0.0079***
	(0.1235)	(0.2374)	(0.0029)	(0.0019)

Note: *The number of observations is 212,339 agricultural households (only those responding completely to FIES questions); robust standard errors to model miss-specification in the parentheses; sample weights were used for estimation; *** is significant at 1 percent level of significance and ** is significant at 5 percent of the level of significance.*

Table 6. Estimation results of ordinary least square regression

Independent variable	Household's moderate or severe food insecurity likelihood x 100	Household's severe food insecurity likelihood x 100
- Farm scale		
Small-scale food producers	1.3073***	0.1684***
	(0.0756)	(0.0181)
- Gender		
Male	-1.1253***	-0.1136***
	(0.1327)	(0.0322)
- Age	-0.1435***	-0.0133***
	(0.0204)	(0.0050)
- $Age^2/100$	0.0992***	0.0073
	(0.0183)	(0.0045)
- School attainment		
Elementary school (SD)	-1.9210***	-0.2759***
	(0.1227)	(0.0299)
Junior high school (SMP)	-2.7667***	-0.3341***
	(0.1445)	(0.0355)
Senior high school (SMP)	-3.4654***	-0.4159***
	(0.1454)	(0.0361)
Diploma	-3.8144***	-0.3950***
	(0.3504)	(0.0736)
Higher education (S1/S2/S3)	-4.3509***	-0.4531
	(0.1986)	(0.0496)
- Non-agricultural job		
Having non-agriculture job	0.0140	-0.0522***
	(0.0800)	(0.0186)
- Household size	0.9957***	0.0701***
	(0.0784)	(0.0182)
- Region		
Jawa	-3.3604***	-0.3508***
	(0.0816)	(0.0197)
- Constant	7.5265***	0.9273***
	(0.6629)	(0.1618)

Note: *The number of observations is 212,339 agricultural households (only those responding completely to FIES questions); robust standard errors to model miss-specification in the parentheses; sample weights were used for estimation; *** is significant at 1 percent level of significance and ** is significant at 5 percent of level of significance; the age^2 divided by 100 to scale-up the level of coefficient estimation by multiplying by 100 and it does not impact the standard error.*

Since most agricultural households are small-scale food producers, having additional income from non-agriculture economic activities will be very helpful in increasing the food security status of the

households [35][36]. Diversifying agricultural households' livelihoods would make them more secure [37][38][39], particularly at the time of food shortages during the period of crop failure. The more income that agricultural households earn, the more resources to be allocated to improve agriculture production and to access more quantity and quality food [40]. Our estimation results of MLR and OLS models support this proposition. Our findings are similar to [41][32][16] and [17] findings.

In addition, having more household members could increase the probability of households being food insecure either moderately or severely. It is reflected by the value of the RRR for the number of households variable that is larger than one and significant at a 5 percent significance level. The finding aligns with [4][41][32][16] and [17] findings. It could be explained since with a larger number of households, there will be more quantity and quality food should be allocated and distributed among household members. In other words, the per capita food supplies decrease as the agricultural household size increases. Although at the same time more household members mean more availability of labour for agriculture and non-agricultural activities, the pressure on consumption would be higher, particularly for small-scale food producers or subsistence farmers with limited engagement in non-agricultural economic activities.

As anticipated, our findings also confirmed that agricultural households outside Jawa are more prone to be food insecure than agricultural households in Jawa. It is an interesting finding since agricultural households in Jawa on average have a smaller scale of farms compared to farmers outside Jawa. It may indicate that farmers in Jawa have higher productivity than their outside Jawa counterparts giving them relatively more production and income for the same area of agricultural land. The difference in sociocultural variables between the two regions may also play a role in these circumstances that need further study to be elaborated.

4. Conclusion

Our study aims to fill the gap of the lack of study focusing on the impact of farm size and sociodemographic characteristics on agricultural households' food insecurity in Indonesia using a dedicated nationwide agricultural household survey. Our study pointed out the importance of farm size, education, and sources of income other than agricultural activities to improve agricultural households' food security. Using the results of the first AGRIS conducted by BPS in 2021, we found that farm size has a positive impact in lowering the probability of agricultural households experiencing moderate or severe levels of food insecurity. Therefore, increasing the farm size could improve agricultural households' food security by either increasing the productivity (land and labour productivity) or agricultural land size. Our study also found that agricultural households with a higher probability of being food insecure are characterized by having higher members of households, relying only on agricultural activities for their livelihood, lower education attainment of household heads, and being led by female farmers. Given the food insecurity status of agricultural households is influenced by multiple socioeconomic factors, our study may overlook some important variables that better explain food insecurity. The limitation can be room for improvement for the next study with the same locus.

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