Food Insecurity Experience Scale Measurement of Agricultural Households in Indonesia: Analysis of the Agricultural Integrated Survey Results

Kadir, Kadir and Prasetyo, Octavia Rizky and Rudiana, Eka

Statistics Indonesia

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Kadir[1]
Statistics Indonesia (BPS), Jakarta, Indonesia – kadirsst@bps.go.id

Octavia Rizky Prasetyo
Statistics Indonesia (BPS), Jakarta, Indonesia – octavia.rizky@bps.go.id

Eka Rudiana
Statistics Indonesia (BPS), Jakarta, Indonesia – rudiana@bps.go.id

Abstract: Measuring the food insecurity of agricultural households is very important in the Indonesian context since the country's agricultural sector is dominated by small-scale farmers that are prone to food insecurity. Moreover, it also describes the resilience and sustainability of the agricultural sector in the country from the social dimension. However, to date, there is no study assessing the prevalence of food insecurity among agricultural households in Indonesia utilizing a nationwide agricultural survey. Hence, to fill the gap, this study aims to gauge the prevalence of food insecurity among agricultural households in Indonesia. In doing so, we applied the Rasch model to the Food Insecurity Experience Scale (FIES) data obtained from the results of first Indonesia's Agricultural Integrated Survey (AGRIS) conducted in 2021. After applying the Rasch Model on FIES data collected from 212,339 agricultural household samples responding to all FIES questions, we found that our FIES data provide a reliable measurement of food insecurity in agricultural households. Following the SDG 2.1.2 framework, the final results showed that the proportion of agricultural households in Indonesia experiencing severe levels of food insecurity was 0.29 per cent while the proportion of agricultural households experiencing moderate or severe levels of food insecurity, combined, was 3.27 per cent of around 20 million agricultural households. As expected, those households experiencing severe food insecurity only manage a small area of agricultural land, particularly on Java Island with an average of fewer than 0.5 hectares per household. This finding may suggest that food insecurity exists in Indonesia among agricultural households with limited access to agricultural land resources.

Keywords: agricultural household; FIES; AGRIS; Rasch model; Indonesia

1. Introduction

Since September 2015, UN member countries have committed to a global framework of the 2030 Agenda for Sustainable Development (Sustainable Development Goals/SDGs), including ending hunger by 2030 as its second goal. However, as many as 2.3 billion people in the world were affected by food insecurity and more than 800 million people suffered from hunger in 2021 [1]. It means that food insecurity is one of the main challenges in achieving the SGDs,

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particularly Target 2.1., which focuses on ensuring access to safe, nutritious, and sufficient food for all people by 2030 [2]. In this regard, the goal cannot be achieved unless there is an effective strategy for the country to tackle food insecurity issues among all groups of populations, especially vulnerable households.

Despite the importance of small-scale farmers in promoting food production, they are prone to the threat of food insecurity. It seems that a substantial proportion of the global population suffering from hunger lives in smallholder farming households [3]. In the Indonesian context, one-third of the country's population relies on the agricultural sector for their livelihood, and most are small-scale farmers [4]. Hence, measuring the prevalence of food insecurity among agricultural households is essential to support policymakers in keeping the SDGs target and goal on track. Additionally, the information could also describe the resilience and sustainability of the agricultural sector in the country from the social dimension.

Many countries have adopted a global tool to measure the severity of food insecurity called the Food Insecurity Experience Scale (FIES). FIES is a survey-based experiential measure developed by the United Nations Food and Agriculture Organization (FAO) through the *Voices of the Hungry* (VoH) project [4]. It is a measurement tool to gauge the food insecurity experience of a household or individual obtained from direct interviews. From FIES, the Sustainable Development Goals (SDG) 2.1.2 indicator, namely the proportion of the population experiencing moderate to severe food insecurity, can be calculated. It can be used as an indicator to monitor progress toward achieving Goal 2 of SDGs.

Principally, food insecurity is a latent trait that cannot be observed directly. However, it can be inferred by the answer to FIES questions suggesting experience associated with it. The score calculated from the answers to those questions can indicate the severity level of food insecurity experienced by the households [5,6,7]. The experience of food insecurity is characterized by a set of experiences, such as uncertainty and anxiety about access to food and changes in the quality of food intake. With the increase in food insecurity, the quantity and quality of food consumed are also reduced, meals are skipped, and at quite severe levels people do not eat for an entire day. Research results in various countries have concluded that these dimensions of food insecurity experience are generally applicable across different cultural backgrounds [8].

Since 2017, Statistics Indonesia (BPS) has implemented FIES measurements to calculate indicator 2.1.2 using data from the National Socioeconomic Survey (SUSENAS) [9]. However, it is an indicator that does not represent the agricultural household specifically since the survey was not designed for observing agricultural households distinctively. In order to measure the FIES of agricultural households with a better representation, BPS conducted the Agricultural Integrated Survey (AGRIS), which can collect information that can capture food insecurity events in agricultural households. The pilot survey was conducted in three provinces in 2020, and continued with the nationwide implementation in 2021.

Studies analyzing the FIES measurement in the Indonesian context have been conducted by some researchers [10,11]. However, they are limited to the regional context or focus on the population in general. To date, to our knowledge, there is no study assessing the prevalence of food insecurity among agricultural households in Indonesia utilizing a nationwide agricultural survey. Hence, to fill the gap, this study aims to gauge the prevalence of food insecurity among agricultural households in Indonesia using the results of a nationwide agricultural survey by analyzing the results of the 2021 Indonesian AGRIS covering all 34 provinces.

The next session of the paper presents the description of the data used, the FIES measurement applied in our research and the strategy of analysis. In section 3, we present the results of the

FIES measurement using Indonesian AGRIS data and discuss the results. In the final section, we summarize our results and suggest some relevant implications for future research.

2. Methodology

2.1. FIES Measurement

To assess the prevalence of food insecurity among agricultural households in Indonesia, we apply the Rasch model to the Food Insecurity Experience Scale (FIES) data obtained from the results of first Indonesia's Agricultural Integrated Survey (AGRIS) that is conducted by Statistics Indonesia (BPS) in 2021. FIES captures food insecurity at the individual or household level. There are eight questions of FIES 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 worries about not having enough food to eat because of a lack of money or other resources? (*Worry)*
Q2	You or others in your household unable to eat a healthy and nutritious food because of a lack of money or other resources? *(Healthy)*
Q3	You or others in your household ate only a few kinds of foods because of a lack of money or other resources? *(Fewfood)*
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? *(Skipped)*
Q5	You or others in your household ate less than you thought you should because of a lack of money or other resources? *(Ateless)*
Q6	You or others in your household ran out of food because of a lack of money or other resources? *(Runout)*
Q7	You or others in your household were hungry but did not eat because of a lack of money or other resources? *(Hungry)*
Q8	You or others in your household do not eat for a whole day because of a lack of money or other resources? *(Whlday)*

Source:.*Pedoman Pencacahan Survei Pertanian Terintegrasi (SITASI2021), Statistics Indonesia (BPS).*

The eight questions in Table 1 are asked in sequence to assess the severity level of food insecurity [8]. Each question item in the FIES represents different circumstances based on food insecurity experienced by households [12]. They focus on food-related behaviours and food access difficulties due to constraints in resources based on information directly provided by the household [10]. The order of the question conceptually follows the level of food insecurity sequentially: question items 1 to 3 is usually associated with a light level of food insecurity, question items 4 to 6 represent food insecurity at a moderate level, and question items 7 to 8 reflect a severe level of food insecurity [13]. However, it is important to notice that this order is estimated through the application of the Rasch model and therefore can be flexible to different application contexts (countries or populations of interest).

To calculate the prevalence of food insecurity based on the response to the eight questions in FIES, we applied Rasch model or one-parameter logistic model from item response theory [14,15]. The model assumes that the position of a respondent and that of the items can be located on the one-dimensional scale of severity and postulates that the probability of respondent *i* answering "yes" to item *j* is the logistics function of the difference between the severity of the food insecurity condition experienced by respondent *i* and the severity of item *j*. 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

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

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 (CML) procedure conditioning on the sum of affirmative answers given by each respondent to the FIES questions (raw score).

An application of the Rasch model provides a basis to estimate the parameter of severity related to the item and respondent and conducts statistical tests on the strength of the association of questions to latent traits (food insecurity) and the reliability of the data. The probability of agricultural household *i* of being food insecure can be estimated by applying the Rasch model to our FIES data. In this regard, it is possible for us to estimate the probability of being moderately or severely food insecure ($p_{mod+sev}$) and the probability of being severely food insecure (p_{sev}) for each agricultural household.

2.2. Strategy of Analysis

The analysis in this study refers to FAO [8]. First, we began with parameter estimation by calculating the severity of food insecurity related to each item and household. Second, statistical validation was carried out to assess the quality of our FIES data obtained from the 2021 Indonesian AGRIS or whether the data provide a reliable measurement of food insecurity. In this regard, there are three measurements used, namely *infit* to test whether each item is associated with the measure of the latent trait in the same way as the others, *Rasch reliability* to see how much variation within the observed answers within the sample, and *residual correlation* to test unidimensionality. The expected condition is that the *infit* value for each item question in Table 1 is between 0.7 and 1.3; *Rasch reliability* > 0.7; and no significant correlation remains in the residuals [5,6].

Thirdly, a food insecurity measure was calculated, which consists of the probabilities of a household experiencing moderate to severe food insecurity and severe food insecurity that were estimated from the responses to the FIES questions and the prevalence of moderate to severe food insecurity and severe food insecurity in the population. The probabilities were estimated for each corresponding agricultural household raw score, which is the sum of affirmative answers to the FIES questions. It is based on assumption that households with the same raw score belong to the same distribution of food insecurity.

Fourthly, concerning the need for a valid comparison between our measure and the global standard, we performed equating. In doing so, we calibrated the global threshold on an internationally comparable metric by equating the mean and standard deviation of the set of items that are common between our measurement and the FIES global standard scale. In this regard, we made use of the FIES Excel template provided by FAO at [8].

Through the abovementioned stages, this study could produce two important indicators by following the SDG 2.1.2 framework, namely the percentage of agricultural households in each province 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 estimated the two indicators both at national and regional levels. In addition, we also enriched our analysis by investigating how food insecurity prevalence relates to the size of agricultural land managed by agricultural households and the incidence of poverty in rural areas at the provincial level.

3. Results and Discussion

3.1. Survey realization and statistical validity and reliability

In total, the 2021 Indonesian AGRIS asked FIES questions to 213,644 agricultural households in 34 provinces. Around 99.4 per cent (212,339 households) of the samples responded completely, while the other 0.6 per cent did not respond either completely or partially to the eight FIES questions. In this study, we only analyzed households that responded to the FIES questions completely. The same applies to all provinces. All provinces have very high response rates, and the highest concentration of agricultural household samples is on Java Island. East Java Province has the largest number of samples, which are 17,742 households, and DKI Jakarta Province has the smallest number of samples 389 agricultural households.

In general, the pattern in Figure 1 points out that the percentage of "yes" responses decreases as the severity level increases. In other words, the more severe a question item is, the less likely a household is to report it during the interview [16].

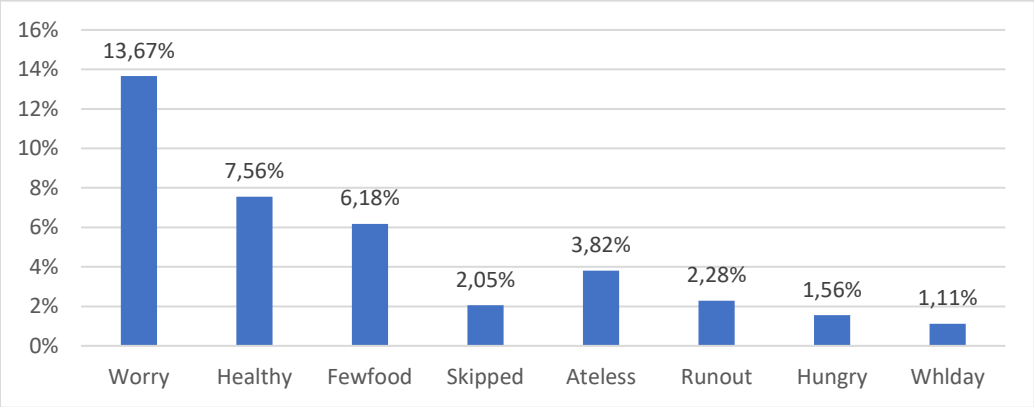

Figure 1. Percentage of respondents answering "yes" to each FIES question

As expected, item question *Worry* has the highest percentage of "yes" responses, which is 13.67 per cent. It shows that there is still a relatively substantial proportion of agricultural households that worry about not having enough food to eat because of a lack of money or other resources. In normal conditions or in the early stage of food insecurity, the first thing to appear is worrying about having no sufficient food physiologically. It is reflected by the first question in the FIES. Whereas, the question item *Whlday* has the lowest percentage of "yes" responses, which is only 1.11 per cent, showing that it is rarely experienced by agricultural households in Indonesia.

The question item *Skipped* has "yes" responses lower than the question item *Ateless*. It may indicate an inconsistency in reporting food insecurity experienced by the respondents [17]. Ideally, when a respondent reports "yes" for a certain FIES question, she/he should also report "yes" for all questions representing lower levels of severity [6]. However, the pattern does not impact the validity of the FIES measurement. It could be explained since the order of the question items cannot be considered fixed across countries or regions. Each culture or livelihood system may have a specific characteristic regarding the experience of food insecurity.

The unexpected results of the "yes" response for a particular item could also indicate that the respondents do not clearly understand the meaning of a related question during the interview. At the same time, the interviewers could not probe the information optimally as expected. Thus, this finding should improve the implementation of Indonesian AGRIS in the future by paying more attention to the clarity of the related question (*Skipped*). In this regard, FAO recommends allocating more time to explaining the meaning of each FIES question during the training, particularly for the questions that at glance look to have a similar meaning. In short, the

understanding of both the enumerators and respondents about the exact meaning of each FIES question is very crucial.

The values of *infits* statistics for all question items are in the acceptable range, which is between 0.7 and 1.3. It shows that all question items are equally discriminant along the latent trait and can be used for food insecurity measurement among agricultural households in Indonesia.

In general, the pattern in Figure 1 is consistent with the estimation results of severity parameters in Table 2, which have been calibrated using the global reference scale as recommended by FAO [5]. Except for question items *Worry* (-3.4) and *Whlday* (2.6), all items have severity parameters between the ideal range, which is between -2 and 2. It shows that the question item *Whlday* is quite difficult to be understood by the respondents. Therefore, it should get attention for the improvement of the survey. The enumerators should give more explanations and descriptions when asking the respondents about the two items.

Estimation results of *outfit* statistics for *Worry* and *Whlday* items are considered high since larger than 2. It points out that they have a few cases with highly unexpected response patterns and the presence of outliers. However, it can be ignored since the proportion of "yes" responses for the two items is lower than 25 per cent [18] and the proportion of outliers is sufficiently small.

The Rasch reliability is 0.77, which passes the acceptability threshold of 0.7. It means that around 77 per cent of the variability in the data can be explained by the Rasch model. Moreover, the residual correlation matrix shows that there is no correlation between a pair of items considered high or higher than |0.4| pointing to the unidimensionality of the scale as applied to the measure of food insecurity among agricultural households. It means that the Rasch model assumption was met, by which all correlations among items should result from their common association with the latent trait of food insecurity. It also confirms that there is no overlap in meaning between items. Therefore, there is no need to eliminate one particular item from the analysis.

The scree plot in Figure 2 exhibits an elbow pattern since the first two items capture more significant variance than the rest items. It also shows that the unidimensionality assumption is met, as most of the variability is captured by the first dimension.

Table 3. Estimation results of severity parameters, infit, and outfit statistics for each FIES question

Question item	Severity	Infit	Outfit
Worry	-3.39	1.11	2.29
Healthy	-1.73	0.87	1.07
Fewfood	-1.18	0.73	0.69
Skipped	1.19	0.99	1.13
Ateless	-0.08	0.82	0.81
Runout	0.94	0.98	1.32
Hungry	1.80	0.89	1.85
Whlday	2.63	1.16	4.30

Table 4. Residual correlation of each FIES question

Item	2	3	4	5	6	7	8
1	0.04	-0.06	-0.14	-0.10	-0.14	-0.13	-0.18
2		0.24	-0.04	-0.03	-0.09	-0.09	-0.14
3			0.06	0.24	-0.01	-0.02	-0.10
4				0.09	0.07	0.08	-0.07
5					0.14	0.09	-0.07
6						0.16	-0.00
7							0.15

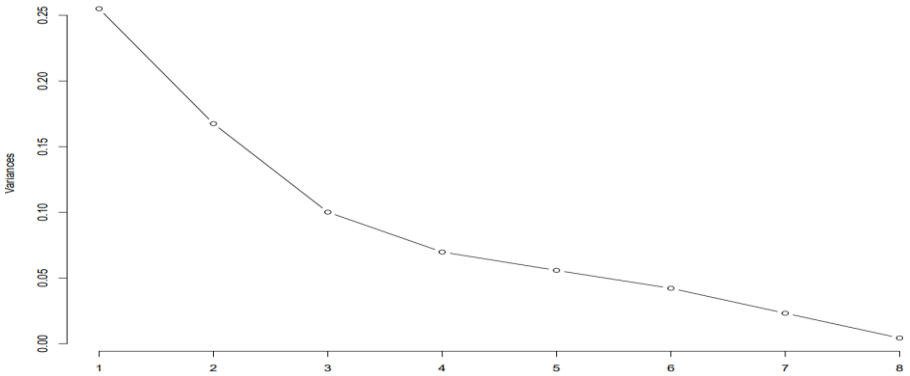

Figure 2. Scree plot of principle component analysis on the residuals

3.2. Prevalence rates and discussions

Most agricultural households in Indonesia have zero raw scores, which accounted for around 85 per cent of the total agricultural household population. It shows that the majority of agricultural households never experienced any event related to food insecurity reflected by all FIES items. The proportion of agricultural households with raw scores higher than 6 is less than 1 per cent, and the household probability of experiencing both moderate to severe and severe levels of food insecurity decreases with the raw scores. It implies a small probability for agricultural households to experience severe food insecurity.

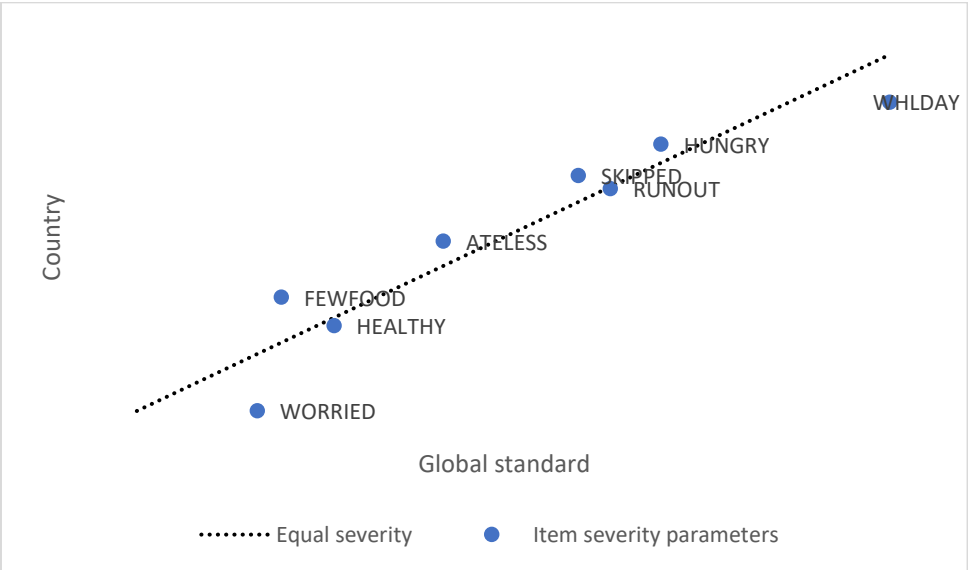

Figure 3. The equating plot

In performing equating, we considered that all items are common items since their severities are adequately similar to the global standard. As shown by the equating plot in Figure 3, in general, the alignment between the country scale and global scale is relatively close. As the result, the correlation between common items is high, which is around 94 per cent.

At the national level, the prevalence of agricultural households experiencing food insecurity at moderate to severe levels is around 3.27 per cent, while those encountering a severe level of food insecurity make up only around 0.29 per cent of the total 20 million agricultural households. Although these are quite small fractions of the agricultural population, the figure is relatively large in absolute terms. The number of agricultural households experiencing food insecurity at moderate to severe levels is around 0.7 million households. It is a serious issue since it happens among the agricultural households, which are the food producers.

In general, the highest prevalence of food insecurity occurs in provinces in the eastern part of Indonesia (Figures 5 and 6). Around 11 per cent of agricultural households in Maluku and Papua Provinces experience moderate to severe levels of food insecurity, while in Papua Province about 5 per cent of agricultural households experience a severe level of food insecurity. It is in line with the fact that those provinces and the eastern part of Indonesia, in general, are lagging behind other parts of Indonesia in terms of socio-economic advancement. When it comes to the incidence of poverty, for instance, the eastern part of Indonesia is relatively higher than other parts of Indonesia.

On average, the Java-Bali region, the most developed region in Indonesia, has the lowest prevalence of moderate to severe and severe levels of food insecurity among agricultural households compared to the other regions. Bali Province has the lowest prevalence of severe food insecurity in Indonesia, which is 0.02 per cent.

Agricultural households experiencing moderate to severe levels of food insecurity would experience at least one of these food insecurity-related events due to the lack of money or other resources: skipping a meal on one particular day, eating less than usual, or running out of food. Whereas, agricultural households experiencing a severe level of food insecurity would experience feeling hungry but not having meals or not having meals for the whole day.

It is interesting to explore in more detail the causes and socio-economic determinants of food insecurity among agricultural households since there is plenty of information collected in AGRIS that can be used for the analysis. It would also be beneficial for policy recommendations if the causes of the difference between the eastern part and other parts of Indonesia in the prevalence of food insecurity could be explained. However, they are not the scope of our study. The presence of food insecurity among agricultural households could be the result of many factors such as climate change, irrigation access and availability [19,20], and agricultural land size [19]. It seems that the last factor may be associated with food insecurity among agricultural households in Indonesia.

Our study points out that on average agricultural households experiencing food insecurity manage a smaller area of agricultural land than agricultural households that are being food secure (Figure 4). It is also confirmed by the estimation of the confidence interval mean of agricultural land and the results of the adjusted Wald test at a 5 per cent level of significance (Table 6). We also found that those experiencing severe food insecurity only manage a small area of agricultural land, particularly on Java Island with an average of fewer than 0.5 hectares per household. This finding confirms that food insecurity exists in Indonesia among agricultural households with limited access to agricultural land resources. It could also indicate that food insecurity among agricultural households in Indonesia is a small-scale food producer phenomenon.

As figured out in Figures 7 and 8, our study also shows that there is a significant (Spearman's rank) correlation at a 5 per cent significance level between the prevalence of food insecurity among agricultural households and the incidence of poverty in rural areas. Although those correlations were strongly leveraged by some data points, it could be an indication that the presence of food insecurity could be associated with factors related to poverty given there is a link between food insecurity and poverty. In the Indonesian context, poverty is a rural-agricultural phenomenon, where almost 60 per cent of poor people live in rural areas and rely on the agricultural sector as their livelihood.

Table 5. Proportion and number of households and food insecurity probabilities by raw score

Raw score	Household percentage (Weighted)	Number of households (Weighted)	Probability of moderate to severe	Probability of severe
0	85.42	1 728 8357	0.00	0.00
1	8.33	1 686 736	0.02	0.00
2	2.45	495 749	0.16	0.00
3	1.78	359 309	0.48	0.00
4	0.80	162 431	0.78	0.00
5	0.41	81 993	0.96	0.00
6	0.24	48 521	0.995	0.05
7	0.20	40 998	0.999	0.32
8	0.37	74 770	0.999	0.57
Total	-	20 238 866	-	-

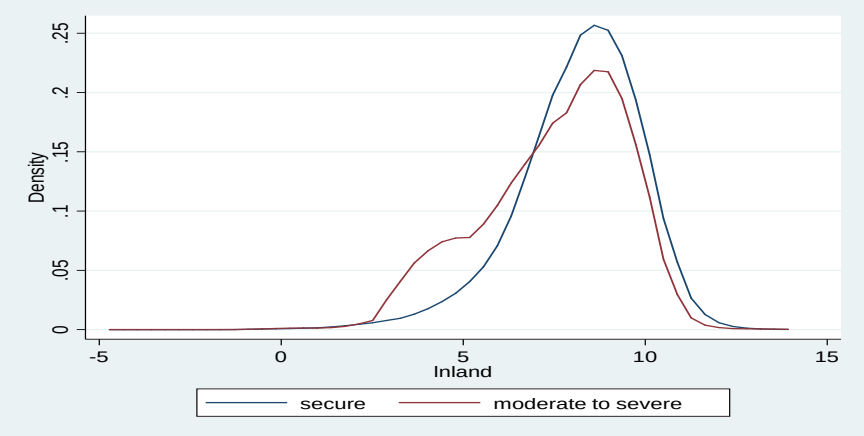

Figure 4. Kernel density distribution of land area by household food security category (natural logarithmic term; bandwidth 0.6)

Table 6. Estimation of the agricultural land area managed by households

Household category	Mean*	95% confidence interval	Adjusted Wald test results
(A) Food secure	0.76	0.75 – 0.77	$H_0: A - B1 = 0$
(B) Food insecure			p-value = 0,001
(1) Moderate or severe	0.68	0.63 – 0.72	$H_0: A - B2 = 0$
(2) Severe	0.62	0.51 – 0.73	p-value = 0,012

**) weighted*

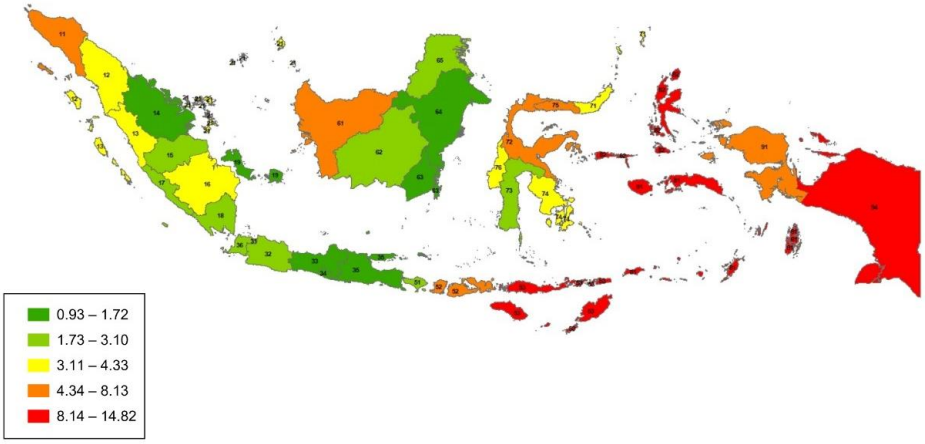

Figure 5. Percentage of agricultural households experiencing food insecurity at moderate to severe levels by province

Figure 6. Percentage of agricultural households experiencing food insecurity at severe level by province

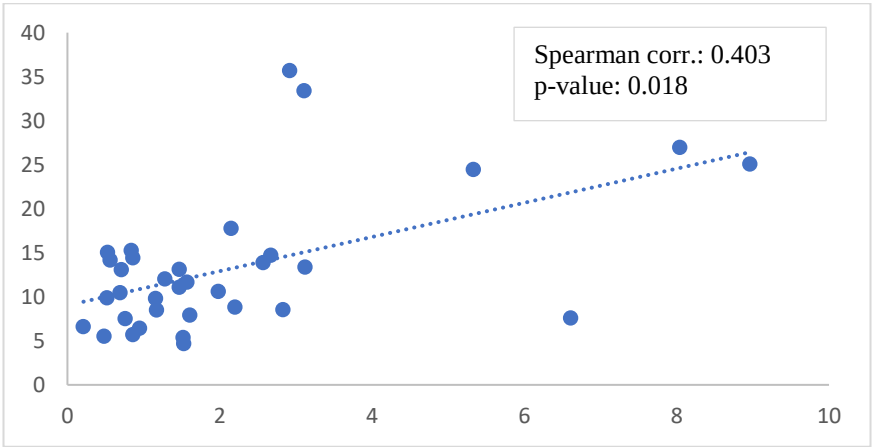

Figure 7. Scatter plot of prevalence of moderate to severe versus the incidence of poverty in rural areas (in March 2021)

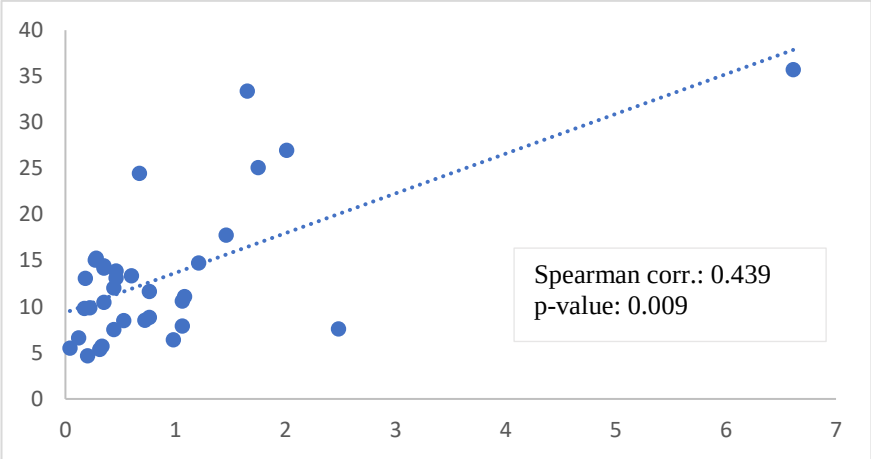

Figure 8. Scatter plot of prevalence of severe versus the incidence of poverty in rural areas (in March 2021)

4. Conclusion

This study aims to gauge the prevalence of food insecurity among agricultural households in Indonesia. In doing so, we applied the Rasch model to the Food Insecurity Experience Scale (FIES) data obtained from the results of first Indonesia's Agricultural Integrated Survey (AGRIS) conducted in 2021. Therefore, this study provides the first assessment of food insecurity in agricultural households in Indonesia based on a nationwide agricultural survey that was not available before. After applying the Rasch model on FIES data collected from 212,339 agricultural household samples responding to all FIES questions, we found that all eight FIES-related questions performed well as food insecurity measurement tools within the survey.

The Rasch model also pointed out that the FIES data obtained from the 2021 Indonesian AGRIS provide a reliable measurement of food insecurity in agricultural households. After performing equating and following SDG 2.1.2 framework, the final results showed that the proportion of agricultural households in Indonesia experiencing severe levels of food insecurity was 0.29 per cent while the proportion of agricultural households experiencing moderate or severe levels of food insecurity, combined, was 3.27 per cent of around 20 million agricultural households.

Our study did not go further by investigating the causes or socioeconomic determinants of food insecurity among agricultural households in Indonesia although the data availability collected from AGRIS is possible for the analysis. It also did not explain the causes of the spatial variability of the food insecurity prevalence among provinces in Indonesia. Therefore, there is still plenty of room to explain the results of food insecurity measurement obtained by applying FIES to Indonesian AGRIS data.

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