Food security index and livelihood assets of Pandaan District, Pasuruan Regency, Indonesia

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Abstract. Food security is a situation that exists when everyone has physical, social and economic access to healthy, nutritious food that meets his/her dietary needs and dietary preferences, as well as active and healthy life. The data needed to measure the level of food security index are the availability of food, access to food, and the use of food. In addition to measuring the level of food security, this study also measured livelihood assets owned by the community. The data needed to measure the livelihood assets of the community are human assets, social assets, and economic assets. The method used in this research was descriptive quantitative with the result of the vulnerability index, CFA analysis (confirmation factor analysis) with the result of the subsistence asset building factors, and SEM analysis with the result of the relationship of latent variables between livelihood assets. The purpose of this study is to determine the level of food security, the factors that constitute livelihood assets, as well as the relationships between each component of livelihood assets. The results of the analysis showed that there are six villages in the food insecurity category. Livelihood assets in Pandaan consist of three assets, namely human assets (health, education, skills), social assets (relations between citizens and the intensity of conflicts) and economic assets (possessions, savings, economic conditions and type of work). SEM's results from Mplus analysis showed that each component of livelihood assets supports and maintains mutual relationships.

1. Introduction

Food security is one of the most critical global issues of today as it affects the economic climate. Food security has three essential dimensions, which consist of food availability, food access, and food use and misuse [1]. Problems in food security are not only caused by low food availability (first dimension) but also due to low purchasing power and low food access at the national and household levels. In the last three decades, there has been an increase in global food security, as there have also been increasing numbers of food production [2]. However, there are still over 800 million malnourished people, and almost all from developing countries [3]. The high demand for food and the decreasing productivity of crops negatively impact food access and availability for people with low incomes and poor households.
Indonesia, like many other developing countries, is significantly affected by food insecurity, domestic disasters, and environmental disasters. Two-thirds of the Indonesian populations living in rural areas are directly or indirectly dependent on agriculture for food and livelihoods [1]. Also, the majority of the rural population is composed of small-scale households, which have less than one hectare of land and have limited access to resources and services [4]. The national target of self-sufficiency in the production of food crops, especially rice, is still not achieved, and small-scale rural communities in Indonesia face the problem of declining crop productivity, food insecurity, and poverty. Data suggest that in 2018, Indonesia would import 2 million tons of food to fulfill the national stock. The global rice market at the end of 2018 estimates food reserves would increase to 173.4 million tons, contributed by the harvest in most importing countries such as China (Mainland) and Indonesia, and in major exporters, such as India and the United States [5].

However, increased reserves do not necessarily increase food security in Indonesia. The area of available land strongly influences food availability (first dimension). Population growth rates, land fragmentation for settlements, land tenure culture, and the development of supporting facilities for social activities by the government cause agricultural lands to convert into built-up lands, affecting food production in the Pandaan region significantly [4]. The conversion of agricultural land to non-agriculture will reduce agricultural areas, resulting in a decrease in total production.

Low infrastructure in rural areas and low food access (second dimension) and markets are some of the many factors that affect food security in Indonesia. Food security systems at the local level can be improved by focusing on access to food distribution systems [6-7]. A good food distribution system mainly depends on the existing type of food and market access. A good infrastructure system and secure market access can play an essential role in maintaining local food security by reducing transportation costs and food prices [8].

Increasing market access and food availability will be better if the community has a good livelihood asset. Livelihood assets that consist of human assets, economic assets, social assets, physical assets, and natural assets [9] can measure the sustainability level of rural development. In this study, livelihood assets were only assessed by three variables: human assets (AM), social assets (AS), and economic assets (AE). The knowledge of these three assets in the village is expected to improve food security in rural areas in Indonesia.

Pandaan District is one of the regions proliferating from the development of Surabaya-Malang toll road, which also causes fast land use changes. The occurring land use changes are not only from land acquisition but also the change in agricultural land into built-up land on the Pandaan Toll ring road. The purpose of this study is to analyze food security by assessing the value of the food security index and analyzing livelihood assets factors and how they contribute in the formation of the life assets of the rural communities.

2. Methods

2.1. Data Collection

Data collection methods included primary surveys and secondary surveys. The following is the data collection method used.

2.1.1. Primary Survey

The primary survey included data collection through questionnaires on food security aspects and livelihood assets in Pandaan District. The calculation of samples used a purposive random sampling of farmers and/or landowners of non-built-up land in Pandaan District that settle in Pandaan District. The
number of Family Heads (KK) in Pandaan District was 30,930 [10]. The calculation of samples using the Slovin formula with errors as 3% is as follows:

\[ n = \frac{30,930}{1 + (30,930 \times 0,03^2)} \]

\[ n = 1072,5 \]

The calculation results were rounded to 1100 respondents with the proportion of KK division in each village based on the area of non-built-up land in Pandaan District.

2.1.2. Secondary Survey

Secondary survey was in the form of literature studies through government data and research documents. The necessary data included the number of households, the area of non-built-up land in each village, and rice production per village/year.

2.2. Analysis Technique

The analysis technique used Food Security Analysis Techniques, using indicators of food insecurity analysis by adjusting the FIA (Food Insecurity Atlas) indicator of the national food insecurity analysis. This analysis identified the condition of food security in each village of Pandaan District. The analysis stages in the study are presented as follows:

1. Calculate the index of each indicator in each variable

\[ \text{Index } X_{ij} = \frac{X_{ij} = X_{\text{min}}}{X_{\text{max}} - X_{\text{min}}} \]

with

- \( X_{ij} \) : Value of \( j \) from the \( i \) indicator/parameter
- \( X_{\text{min}} \) : Minimum value of indicators/parameters
- \( X_{\text{max}} \) : Maximum value of indicators/parameters

2. The composite index was obtained by calculating all identified food security indicator indices with the following formula:

\[ IFI = \frac{1}{I = m} (I_1 + I_2 + \ldots + I_m) \]

with

- \( m \) : Number of indicators used
- \( I_m \) : indicator index of \( m \)
The composite index result were categorized to obtain high, medium, and low levels of food security classification. The next analysis technique was CFA and SEM analysis running Mplus [11]. The analysis stages are presented as follows:

1. Confirmatory factor analysis is an interdependence analysis between multivariate variables. This analysis can simplify the variables studied.

2. Model Specification
   This stage relates to the formation of the initial model of structural equations before estimation. This initial model was formulated based on a previous theory or research.

3. Compatibility Test
   This stage tested the compatibility between the model and the data. The most commonly used indexes are Chi-square, RMSEA, CFI, TLI, and SRMR so that the best model results are obtained.

   | Goodness of Fit | Requirement | Information |
   |----------------|-------------|-------------|
   | Chi Square     | < 764       | Good fit    |
   | CMIN/df        | ≤5          | Good fit    |
   | RMSEA          | < 0.080     | Good fit    |
   | CFI            | > 0.900     | Good fit    |
   | TLI            | > 0.900     | Good fit    |
   | SRMR           | <0.080      | Good fit    |

3. Discussion

3.1. Overview of Pandaan District

Pandaan District is located 30 km southwest of the Pasuruan and is 50 km south of Surabaya City. The height of Pandaan District is around 300 meters above sea level with an area of 43.27 km² [11]. Administratively, Pandaan District is bordered by the following areas:

| North  | Beji dan Gempol District |
|--------|--------------------------|
| East   | Rembang District         |
| South  | Prigen dan Sukorejo District |
| West   | Gempol dan Trawas District |
Pandaan District consists of 18 villages with the area of each village as follows (Table 2).

**Table 2** Types and proportions of land use in Pandaan District

| Village     | Field | Moor / Dry Land Farming | Building and courtyard | More | Total |
|-------------|-------|--------------------------|------------------------|------|-------|
| Pandaan     | 0,08  | -                        | 0,69                   | 0,015| 0,78  |
| Kutorejo    | 0,81  | -                        | 0,29                   | 0,05 | 1,15  |
| Jogosari    | 0,58  | -                        | 0,45                   | 0,02 | 1,15  |
| Petungasri  | 0,8   | 0,52                     | 0,19                   | 0,032| 1,55  |
| Karangjati  | 2,08  | -                        | 1,19                   | 0,06 | 3,28  |
| Wedoro      | 1,72  | 0,23                     | 0,81                   | 0,02 | 2,78  |
| Tunggalwulung| 2,29 | -                        | 0,41                   | 0,01 | 2,71  |
| Sebani      | 3,04  | -                        | 0,35                   | 0,03 | 3,42  |
| Kebonwaris  | 1,57  | -                        | 0,26                   | 0,02 | 1,86  |
| Banjarsari  | 1,51  | -                        | 0,18                   | 0,02 | 1,71  |
| Banjarkejen | 1,83  | 0,1                      | 0,21                   | 0,02 | 2,16  |
Table 2 shows that the use of paddy fields still dominates land use in Pandaan District. However, there is quite a few land use for buildings and yards, which will undoubtedly increase in the following years. The following (Figure 2) is the land use map of Pandaan District.

### 3.2. Food Availability

Aspects of food availability were analyzed regarding per capita normative consumption indicators against the ratio of the net availability of main food in Pandaan District. The main food in Pandaan District is rice. Thus researchers only calculated rice production to determine the food availability and
identify the ability of the population regarding food production. Food Availability Analysis uses the formula $R_{net} = c \times P_{net}$ where $R_{net}$ is a net production of rice, $c$ is the conversion factor of rice (0.65), and $P_{net}$ is the net availability of rice. The following is the result of the analysis of food availability in Pandaan District.

### Table 3 Food availability analysis

| Villages       | Food Availability/capita/day (gram) | Food Availability Ratio | Food Availability Index | Relative Condition       |
|----------------|-------------------------------------|-------------------------|-------------------------|--------------------------|
| Pandaan        | 36.68523                            | 8.17767907              | 1                       | High Food Insecurity     |
| Kutorejo       | 291.0353                            | 1.030802653             | 0.112493                | High Food Security       |
| Jogosari       | 129.8827                            | 2.309776163             | 0.271317                | Food Resistant           |
| Petungsasri    | 179.6859                            | 1.669579691             | 0.191817                | Food Resistant           |
| Karangjati     | 390.6475                            | 0.767955788             | 0.079852                | High Food Security       |
| Wedoro         | 1688.95                             | 0.177625158             | 0.006545                | High Food Security       |
| Tunggalwulung  | 1138.855                            | 0.263422456             | 0.017199                | High Food Security       |
| Sebani         | 1579.675                            | 0.189912426             | 0.00807                 | High Food Security       |
| Kebonwaris     | 1001.797                            | 0.299461914             | 0.021674                | High Food Security       |
| Banjarsari     | 2401.464                            | 0.12492379              | 0                         | High Food Security       |
| Banjarkejen    | 1188.866                            | 0.252341284             | 0.015823                | High Food Security       |
| Durensewu      | 605.146                             | 0.495748162             | 0.046049                | High Food Security       |
| Plintahan      | 566.3665                            | 0.529692358             | 0.050265                | High Food Security       |
| Sumbergedang   | 512.1463                            | 0.585770118             | 0.057228                | High Food Security       |
| Tawangrejo     | 226.9796                            | 1.321704955             | 0.148618                | High Food Security       |
| Sumbererejo    | 454.569                             | 0.659965789             | 0.066442                | High Food Security       |
| Kemirisewu     | 449.0651                            | 0.668054538             | 0.067447                | High Food Security       |
| Nogosari       | 464.744                             | 0.645516698             | 0.064648                | High Food Security       |

Food Availability Analysis in Table 3 shows the condition of food availability in each village. The results of the food availability analysis indicate that only one village has food insecurity conditions, namely in Pandaan Village, with an availability index of 1 (high food insecurity condition). These results correlate with the size of the agricultural land in this village, which is very small compared to other villages in Pandaan District. Jogosari and Petungsasri Village are in the food security conditions with each index value of 0.271317 and 0.91817, while the other 15 villages are in high food security conditions.

### 3.3. Food Access
The aspect of food access in Pandaan District was measured through two indicators, namely economic access, which considers the comparison of income against food expenditure, and access to infrastructure, namely electricity networks. Ideal income means that food expenditure does not exceed 50% of total income.

| Table 4 Comparison of income with food expenditures |
|-----------------------------------------------|
| Villages       | Non-Ideal Income | Ideal Income |
|----------------|------------------|--------------|
| Pandaan        | 0                | 4            |
| Kutorejo       | 10               | 18           |
| Jogosari       | 5                | 20           |
| Petungasri     | 0                | 45           |
| Karangjati     | 30               | 39           |
| Wedoro         | 20               | 55           |
| Tunggalwulung  | 24               | 66           |
| Sebani         | 24               | 80           |
| Kebonwaris     | 23               | 36           |
| Banjarsari     | 22               | 28           |
| Banjarkejen    | 0                | 60           |
| Durensewu      | 22               | 63           |
| Plintahan      | 20               | 50           |
| Sumbergedang   | 36               | 49           |
| Tawangrejo     | 12               | 18           |
| Sumberejo      | 21               | 53           |
| Kemirisewu     | 0                | 85           |
| Nogosari       | 22               | 43           |
| **TOTAL**      | **291**          | **812**      |

Comparison of monthly income against expenditure can be seen in Table 4. A total of 812 or 74% of respondents fall into the ideal income category (food expenditure does not exceed 50% of total income), while 291 or 26% of them do not have ideal income (expenditure for food > 50% of total income). The results were then calculated to obtain the food access index in each village of Pandaan District. The condition of high food security means that the population has sufficient income to buy food and other needs besides food.

| Table 5 Food access index |
|---------------------------|
| Villages | Income Index | Relative Condition |
|----------|--------------|---------------------|
| Pandaan  | 0.00         | Highly resistant    |
The calculation of the food access index shows that Pandaan District has five villages categorized as high food insecurity, namely Kutorejo, Karangjati, Banjarsari, Sumbergedang, and Tawangrejo. If analysed based on monthly income comparison data against monthly expenditures (Table 4), villages with very high food insecurity is do not have a big difference between respondents with ideal and non-ideal income.

### 3.4. Food Use and Misuse

Food use is the process of taking the nutritional value contained in food to be used optimally. The aspect of food use and misuse in Pandaan District was measured through indicators of residents with no clean water and the coverage of health facilities (Table 6).

#### Table 6 Distance> 5km to Local Health Centre (Puskesmas)

| Villages        | Distance from Local Health Center (Puskesmas) (Km) | Relative Condition          |
|-----------------|--------------------------------------------------|-----------------------------|
| Pandaan         | 3                                                | High Food Security          |
| Kutorejo        | 5                                                | High Food Security          |
| Jogosari        | 3                                                | High Food Security          |
Food security conditions based on the distance to the health center (km) show that five villages are included in the food security category, namely Tunggalwulung, Sebani, Kebonwaris, Banjarsari, and Banjarkejen (Table 6). The village is categorized in the food security condition because it has a distance of > 5 km from the Puskesmas or health center. If the population does not have access to clean water, then this can affect the food used as processing the main food ingredient without clean water which can cause disease. Table 7 shows that the whole village in Pandaan District fall into the category of food security as everyone has access to clean water.

Table 7 Population without clean water coverage

| Villages   | Flowing water | No clean water flowing | Relative condition |
|------------|---------------|------------------------|--------------------|
| Pandaan    | 4             | 0                      | Food Resistant     |
| Kutorejo   | 30            | 0                      | Food Resistant     |
| Jogosari   | 25            | 0                      | Food Resistant     |
| Petungasri | 45            | 0                      | Food Resistant     |
| Karangjati | 70            | 0                      | Food Resistant     |
| Wedoro     | 65            | 0                      | Food Resistant     |
| Tunggalwulung | 80         | 0                      | Food Resistant     |
After the results of the calculation of the food security index of each aspect were obtained, the composite value was accumulated, and a food security condition in each village was obtained in each village. There are six villages that fall into the category of food insecurity, namely: (1) Pandaan Village, food availability is categorized as in the food insecurity condition; (2) Kutorejo Village, (3) Banjarsari Village, (4) Sumbergedang and (5) Tawangrejo as the food access is considered in the food insecurity condition. The following is the food security index of each village in Pandaan District.

| Villages      | Flowing water | No clean water flowing | Relative condition |
|---------------|---------------|------------------------|--------------------|
| Sebani        | 105           | 0                      | Food Resistant     |
| Kebonwaris    | 55            | 0                      | Food Resistant     |
| Banjarsari    | 50            | 0                      | Food Resistant     |
| Banjarkejen   | 65            | 0                      | Food Resistant     |
| Durensewu     | 75            | 0                      | Food Resistant     |
| Plintahan     | 80            | 0                      | Food Resistant     |
| Sumbergedang  | 85            | 0                      | Food Resistant     |
| Tawangrejo    | 30            | 0                      | Food Resistant     |
| Sumberejo     | 105           | 0                      | Food Resistant     |

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| Villages      | Index  | Status                  |
|---------------|--------|-------------------------|
| Pandaan       | 0.50   | Rather Food insecure    |
| Kutorejo      | 0.46   | Rather Food insecure    |
| Jogosari      | 0.36   | Enough food secure      |
| Petungasri    | 0.10   | Highly resistant food   |
| Karangjati    | 0.53   | Rather Food insecure    |
| Wedoro        | 0.31   | Food security           |
| Tunggalwulung | 0.31   | Food security           |
| Sebani        | 0.26   | Food security           |
| Kebonwaris    | 0.46   | Enough food secure      |
3.5. Livelihood Assets

Livelihood assets in this study were assessed by three variables (Table 9), namely human assets (AM), social assets (AS), and economic assets (AE). Human assets (AM) were measured by three indicators: health (AM1), education (AM2) and skills (AM3). Social assets (AS) were measured by 3 indicators: relations between citizens (AS1), relations between community groups (AS2), and conflict intensity (AS3). Economic assets (AE) were measured by 4 indicators: savings ownership (AE1), saving intensity (AE2), economic conditions (AE3), and last is the type of work (AE4).

CFA analysis (Confirmatory Factor Analysis) was carried out to determine the factors that construct the livelihood assets in Pandaan District. The following is the results of the CFA:

| Villages       | Index | Status            |
|----------------|-------|-------------------|
| Banjarsari     | 0.50  | Rather Food insecure |
| Banjarkejen    | 0.01  | Highly resistant food |
| Durensewu      | 0.32  | Enough food secure |
| Plintahan      | 0.35  | Enough food secure |
| Sumbergedang   | 0.51  | Rather Food insecure |
| Tawangrejo     | 0.53  | Rather Food insecure |
| Sumberejo      | 0.35  | Enough food secure |

The next process was forming a full model of livelihood assets by SEM analysis using the Mplus software. The Full model of livelihood assets is formed based on three assumptions, namely:

1. **ASSUMPTION 1**: Human assets (AM) are predicted by economic assets (AE), social assets (AS), and economic assets (AE). The results of this model show that the relationship of the latent variables between social assets (AS) and economic assets (AE) does not have a significant relationship, whereas the survey data show that social assets support economic assets. Therefore, the model with assumption 1 is rejected because it is contrary to the situation in the field.

2. **ASSUMPTION 2**: Economic assets (AE) are predicted by social assets (AS), human assets (AM) and social assets (US). The results of this model show that there is no significant relationship between social assets (AS) and economic assets (AE), so this model is also rejected because the results are the same as model 1.

| Table 9 Factors Forming Livelihood Assets |
|------------------------------------------|
| **Human Assets**                        |
| Health (AM1)                             |
| Education (AM2)                          |
| Skills (AM3)                             |
| **Social Assets**                        |
| Relations between citizens (AS1)         |
| Conflict intensity (AS3)                 |
| **Economic Assets**                      |
| Savings ownership (AE1)                  |
| Savings intensity (AE2)                  |
| Economic condition (AE3)                 |
| Type of work (AE4)                       |
3. **ASSUMPTION 3**: social assets (AS) are predicted by economic assets (AE), human assets (AM) and social assets (AS). The results in this model indicate that all three assets show a significant relationship. This model is accepted as the results suit the field conditions. Following are the results for the three assumption model (Figure 3):

![Figure 3 Full SEM Model of Assumption 3](image)

The next process was a *GoF* (Goodness of Fit) analysis or model match test. The *GoF* test results for the full SEM model show that the model is in the fit category although there is still one *GoF* value that does not fit, namely the RMSEA 0.107 or> 0.080, the chi-square, CMIN/df, CFI, TLI, and all SRMR values fall into the fit category. The results of the GoF test can be seen in Table 10.

| Goodness of Fit | Value Test | Requirement | Information |
|-----------------|------------|-------------|-------------|
| Chi Square      | 184,185    | < 764       | Good fit    |
| CMIN/df         | 5,111      | ≤5          | Marginal    |
| RMSEA           | 0,107      | < 0,080     | Poor fit    |
| CFI             | 0,948      | > 0,900     | Good fit    |
| TLI             | 0,912      | > 0,900     | Good fit    |
| SRMR            | 0,044      | <0,080      | Good fit    |

Table 11 explains the formed relationships in each equation from the coefficient test. The results of the formed equations are as follow.
Table 11 Coefficient of Full SEM Model

| Relation                  | Estimation | SE  | CR  (Est/SE) | P_Value |
|---------------------------|------------|-----|--------------|---------|
| Economic Asset → Social Asset | -0.242    | 0.073 | -3.296       | 0.001*  |
| Economic Asset → Human Asset | 0.748     | 0.017 | 3.711        | 0.000*  |
| Human Asset → Social Asset  | 0.275     | 0.074 | 43.757       | 0.000*  |

Comment: p > 0.05 = not significant (ns) ; p < 0.05 = significant (s)

The coefficient test results can describe the relationship formed in each latent variable. The following are the details of the relationship formed:

1. The relationship of economic assets with social assets shows that people with high economic assets will also have high social assets.
2. The relationship of economic assets with human assets shows that people with high economic assets will have high human assets.
3. The relationship of human assets and social assets shows that people with high human assets will have high social assets.

It shows that the three assets mutually support each other to fulfill the needs of each household in Pandaan District, either after or before the land use change in Pandaan Regency due to the construction of toll roads.

4. Conclusion

Based on the results of the calculation of the food security index in each village of Pandaan District, several conclusions are obtained:

1. Seven villages are categorized in the somewhat food insecurity condition, namely Pandaan Village, Kutorejo Village, Karangjati Village, Banjarsari Village, Sumbergedang Village, and Tawangrejo Village.
2. Eleven (11) villages are categorized into food secure to very food secure, even with the existence of land acquisition and land use change, residents in these villages can still meet their food needs.
3. The factors that construct livelihood assets consist of:
   a. Human assets which are formed by three factors: health, education, and skills.
   b. Social assets which are formed by two factors, namely relations between citizens and conflict intensity.
   c. Economic assets which are formed by four factors, namely savings ownership, saving intensity, economic conditions, and type of work.
4. The formed relationships between human assets, social assets, and economic assets support each other to fulfill the needs of each household in Pandaan District. Based on the full SEM model, three relationships are formed, namely:
   a. The relationship of economic assets with social assets shows that people with high economic assets will also have high social assets.
   b. The relationship of economic assets with human assets shows that people with high economic assets will have high human assets.
   c. The relationship between human assets and social assets shows that people with high human assets will also have high social assets.
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