Food security in the disaster-prone area: an empirical study from the rural area of Indonesia

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Abstract. Natural disasters affect food security due to low production in the affected areas, so that securing food is a top priority when a disaster occurs. This study aims to identify the food security status of a village located in disaster risk areas and formulates village development plans to reduce the risk of food insecurity. The case study area is Kaumrejo Village, Malang Regency as one of the most affected villages by the Kelud volcano eruption. This research employed a food security analysis based on the Ministry of Agriculture regulation regarding food security measurement and literature study. The results showed Kaumrejo village achieved food security a year after the disaster occurred. The status of this village's food security quickly recovered even though local food production was hampered because the farmlands were covered by material from the eruption. One supported factors was the high import of food stocks from other regions. During the disaster response period, this village received huge support from the volunteers and the government. Upon disaster response period ended, village communities struggled to achieve their food security status as the farmland needed time to recover. The villagers need to establish alternative income generators to buy food supplies.

1. Introduction

Indonesia is a country with an extremely high risk of natural disasters in which intensity and rate are somewhat high in almost all regions of Indonesia. Furthermore, its geographic location in the ring of fire causes its areas to have an increased risk of volcanic eruptions.

The recent eruption of Mount Kelud was in 2014. The eruption caused economic loss and forced the local community to evacuate to places other than the mountain slope [1]. Natural disasters, such as eruption, result in disturbance of food security and agricultural activities [2], while food is a basic human need [3].

Food security is related to the health condition. If one’s condition is healthy as the food requirement is fulfilled, the risk of disaster impact will reduce, especially in health aspects and eventually will support the recovery [4]. When eruption occurred, the agricultural land around the slope of Mount Kelud was covered by volcanic ash which caused the land unable to produce food provisionally. Disaster management comprises four main activities, these are mitigation, preparedness, response, and recovery [5]. During the response and recovery periods, food came from outside the village, and the local community relied on it until their land becomes useful again.

Disaster negatively affects access to food [2]. Disaster also encourages community to evacuate and leave their belonging so that in general, evacuated community does not have a lot money that decreasing their ability to purchase food or other necessity. During the recovery process, affected people usually are not able to do their job directly after the disaster. This condition is especially found...
in communities that are mainly dependent on agricultural job as they have to wait until their land have been recovered [6]. Therefore, during the post-disaster recovery process, their access to food is also obstructed [4].

Kaumrejo Village is located in Ngantang District, Malang Regency. Ngantang was one of the most severely affected districts where the farmers lost their livelihoods [6]. Kaumrejo Village also had the highest proportion of damaged agricultural land among villages in the Ngantang District [7]. Therefore, this study attempts to assess the food security status of Kaumrejo Village in 2015 and formulate the strategy of food security fulfillment.

2. Methods
This study was conducted using primary survey methods that consisted of interview, questionnaire, and observation, and secondary survey using data from the Central Bureau of Statistics (BPS), Regency Development Agency (BPK), Regional Disaster Management Agency (BPBD), Public Works Department, Agriculture Department, Regional Food Security Agency (BKP3) of Malang Regency, and Ngantang District office. The analysis methods utilized in this study were food security analysis and literature study.

2.1. Food security analysis
The variables in food security analysis were food availability, food access, and food utilization. The steps of food security analysis under the Regulation of the Minister of Agriculture number 65/Permentan/OT.140/12/2010 are as follows [8]:

The index of each variable was calculated with the following formula:

$$X_{ij} \text{ Index} = \frac{X_{ij} - X_{i \text{min}}}{X_{i \text{max}} - X_{i \text{min}}}$$

$X_{ij}$: the $J^{th}$ value of the $I^{th}$ indicator
$X_{i \text{min}}$ and $X_{i \text{max}}$: the minimum and maximum values of the indicator

The index determination utilized the comparison of the village conditions in Ngantang District. Therefore, the index value of each indicator could be discovered. The highest index value was 1, while the lowest was 0. Other than that, the supply indicator was observed by calculating the ratio between food needs and food supply with the reference of the Regulation of the Minister of Agriculture. Then, the index interpreted into six classes with an index range of 0.17 in each class.

The composite of the food security index was further obtained from the multiplication of all variable indexes with the following formula:

$$IFI = \frac{1}{3} x (I_{\text{supply}} + I_{\text{access}} + I_{\text{utilization}})$$

Explanation:
$IFI$: Index of food security
$I_{\text{supply}}$: Index of food supply
$I_{\text{access}}$: Index of food access
$I_{\text{utilization}}$: Index of food utilization

| Composite index | Status          |
|-----------------|-----------------|
| < 0.23          | Very low food security |
| 0.23 – 0.45     | Low food security |
| 0.46 – 0.69     | Marginal         |
| 0.70 – 0.93     | High food security |
| >0.93           | Very high security |

The results of index calculation were then classified into the index ranges which determine the number of class on the food security analysis which consist of very low food security, low food
security, marginal food security, high food security, and very high food security. The lowest value of the composite index was 0, while the highest was 1.17. Therefore, the composite index of food security classification is presented in Table 1 as follows.

2.2. Strategy formulation
The strategy formulation of food security acceleration employed literature study and interview results with Kaumrejo Village leaders and government institutions. The strategy formulation included the identification of supply condition, access, and food utilization through identifying the strategy implemented by the village community, comparing the strategy with literature, and structuring the strategy.

2.3. Case study area
Kaumrejo Village is located in Ngantang District, Malang Regency. This village is on the main route of Kediri-Malang. Its distance to the district capital is less than two kilometers. The village area reaches 590 ha and with 5,409 inhabitants in 2015 [9] that increased into 5,765 in 2020 [10]. The primary economic activities of this village are agriculture production and trade. The majority of the villagers work as farmers, breeders, factory workers, and traders.

The undeveloped land composition of Kaumrejo Village is greater than the developed ones. Most of the land in the village is forest and plantation. Selorejo Reservoir, for example, occupies approximately 20% of the total village land area. The developed land of Kaumrejo Village occupies 15% of the total land area, while plantation takes more than 65.7% of the village land area [10].

3. Results and discussion

3.1. Food security status of Kaumrejo Village
Food security comprises three aspects, namely supply, access, and utilization. The supply aspect includes three food sources, such as local production, food reserves, and imports from outside the village. Kaumrejo Village owned relatively narrow cropland compared to other villages in Ngantang
District [9]. This village had cropland area of 47 ha with the total annual production of 258.5 tons in 2015. In normal conditions, the agricultural land in Kaumrejo Village produced rice three times per year with two or three times of the planting periods.

Another food source of this village was food reserves from the local government's food reserves. The local government provided food reserves for the whole village. By considering the proportion of the total population, Kaumrejo Village received up to 0.45 tons. Meanwhile, the amount of imported foodstuff was 29.66 tons, which came from various places outside the village. During the post-disaster recovery period, the community received food aid from donors. The donors provide food aid both directly to individuals or groups and via government apparatus. The government apparatus then distributes the food aid proportionally. However, the flow of food aid that was sent directly to the community was not documented properly, so that the amount could not be accurately discovered.

Table 2. The condition of food security aspects of Kaumrejo Village against Ngantang District

| Indicators                        | Value     | District condition |
|-----------------------------------|-----------|--------------------|
| Population                        | 5,409     | 3,371              | 5,538              |
| Supply                            |           |                    |                    |
| Local production                  | 258.5 ton | 258.5 ton          | 676.5 ton          |
| Food reserve                      | 0.45 ton  | 0.28 ton           | 0.46 ton           |
| Imported supply                   | 29.66 ton | 6.99 ton           | 31.06 ton          |
| Access                            |           |                    |                    |
| Average income (monthly)          | 2,850,000 | 950,000            | 2,850,000          |
| Increase food price (annually)    | 3%        | 1%                 | 6%                 |
| Percentage of poor households     | 4%        | 1%                 | 6%                 |
| Food expenditure to income        | 59%       | 51%                | 87%                |
| Households with access to a road  | 91.18%    | 82.71%             | 100%               |
| Number of markets                 | 1 unit    | 0 unit             | 1 unit             |
| Percentage household with distance to commercial service less than 2Km | 91.18% | 14.29% | 100% |
| Distance to market                | less than 1 Km | less than 1 km | more than 6 km |
| Utilization                       |           |                    |                    |
| Households with access to clean water provision | 78.24% | 0% | 93.55% |

Based on Table 2, it can be inferred that the community’s food access indicates a relatively good condition compared to other villages in Ngantang District. The average monthly income of Kaumrejo villagers was the highest with the relatively stable food price, and the price increase was in the range of 3% every year. The number of poor in the village was low, about 4% of the total villagers.

The food expenditure of Kaumrejo inhabitants reached 59% of the total monthly income. Therefore, the savings proportion were pretty high. Other villages showed 87% of monthly income to purchase food that restrained their ability to save.

The physical condition of Kaumrejo Village is pretty good after the eruption of Mount Kelud. A total of 91.18% of the settlement have been connected to the good quality roads and its distance to the trading center is less than two kilometers. Kaumrejo Village also has a market unit that has a very strategic location and can be reached by all villagers. Based on the survey results, the distance between houses and the village market is less than a kilometer. The market in Kaumrejo Village also serves buyers from other villages in Ngantang District which implies that access to sell food in the market is pretty good.

The food utilization of the village is pretty good. A year after the Mount Kelud eruption, there was no issue regarding clean water fulfillment since the clean water networks and sources were not affected by the eruption. However, the number of villagers served by the clean water system was only 78.24%. Clean water system could not supply all member of community due to the geographical challenge. Yet, the community who could not receive clean water through the system capable to provide their own clean water independently. Therefore, after the eruption, there is no further issue regarding the clean water supply.
Based on Table 1, the classification is arranged to determine the index value. In brief, there are six classifications with 1 as the lowest index value, meaning highly deficit, and 6 as the highest, meaning highly surplus. Table 3 below, presents the summary index of each indicator while the food security index classified following Table 1.

Table 3. The calculation results of food security status

| Indicators                              | Index | Classification     |
|-----------------------------------------|-------|--------------------|
| Supply                                  | 0.49  | Highly deficit     |
| Demand to supply ratio                  | 0.49  |                    |
| Access                                  | 0.74  | Highly surplus     |
| Average income                          | 1.00  |                    |
| Increase food price (annually)          | 0.40  |                    |
| Percentage of poor households           | 0.60  |                    |
| food expenditure to income              | 0.62  |                    |
| Households with access to a road        | 0.38  |                    |
| Number of markets                       | 1.00  |                    |
| Percentage household with distance to commercial service less than 2 Kms | 0.90  |                    |
| Distance to market                      | 1.00  |                    |
| Utilization                             | 0.84  | Highly surplus     |
| Households with access to clean water provision | 0.84  |                    |
| Food security                           | 0.67  | Adequate food security |

Table 3 shows condition of Kaumrejo Village in 2015 that reached marginal food security. The food supply against food needs was highly deficit that it could only meet 50% of the community’s normative consumption. In other words, the high access to food and food utilization highly contribute to food security status. Economic conditions, market availability, and good access to the market help the community to access food. Therefore, the food supply can be accessed easily.

3.2. Food security strategy formulation

Local food supply collapses and farmers face difficulties to survive due to lack of agricultural capital [6]. During the disaster response phase, food source came from food reserves provided by the local government and imported food. Additionally, imported food source came from two authorities, those were food import from food traders and food aid from donors. The roles of NGOs and volunteers during the response and recovery processes are very significant [12] so that the food status does not fall to absolute zero.

A year after the eruption, food production could be revived to half of the total production in the normal condition. This condition further indicated a pretty rapid recovery process of the agricultural land and particularly related to the moderate disaster risk level of Kaumrejo Village [13].

During the recovery process of local food production, food reserves and food imports support the supply of food. In 2015, the supply condition was deficit compared to the food demand by measuring the normative consumption of 300 grams a day per person. Based on the survey results, the condition in Kaumrejo Village indicated that the consumption was lower to nearly 150 grams a day per person, which reflected an adaptation form to recover during a disaster.

Based on Table 3, economic and physical accesses have a significant role in food status. The foodstuff fulfillment from imported source became one of the suitable strategies for Kaumrejo Village. It was also endorsed by the wealthy member of community that had higher income in which supported the average monthly income to be the highest in the district.

The main occupation of the Kaumrejo community did not merely rely on agricultural activity. By district in number, factory workers and traders in the village dominated more than farmers and breeders. Hence, the damage to agricultural land and livestock did not entirely stop economic activity. The working as factory workers received help from the company and the factory re-operated two months post-eruption [14]. Therefore, the factory workers’ income could be quickly recovered.
Meanwhile, the villagers working as traders struggled to expand their business reach to find materials since the supply from Ngantang District was no longer available due to the damage on agricultural land.

During the recovery period, farmers and breeders had different conditions from the non-agricultural occupations. Farmers had to make efforts to revive the agricultural land to previous condition while breeders had issue in providing animal feed. Therefore, the government provided financial assistance and venture capital to revive agricultural and livestock activities.

Breeders received animal feed assistance from the surrounding villages, even from villages outside the regency and other provinces – a manifestation of breeders’ recovery strategy. Meanwhile, farmers fond other occupations while repairing their agricultural land to maintain their income sustainability. Thus, establishing a network, maintaining interaction, and enhancing partnerships among villagers and villages can improve recovery outcomes [15,16].

The location of Kaumrejo Village in the main route of Malang-Kediri became its geographic advantage given food import could access the village with ease. The existence of the village market and the community access to a market that was less than a kilometer also provide benefits in reviving food access. The excellent physical access condition toward food positively contributes to the village’s food security status. Moreover, the infrastructure recovery can also support the post-disaster recovery process more rapidly [17].

Food utilization did not show any serious matter. Based on the survey results, the Mount Kelud eruption did not affect the clean water system in Kaumrejo Village. After the disaster, clean water and its distribution network were not damaged that the clean water system was still able to serve most of the local community (Table 2). Meanwhile, other villagers obtained clean water by independently providing it. Therfore, all villagers could easily get clean water. Water has a significant role not only in food security but also in the fulfillment of the primary community needs [4].

Kaumrejo community periodically checks the condition of the clean water system. Unless there is any disruption during a disaster, the community maintains it like in the normal condition. Along with the recovery process of food security, the recovery of a clean water system should also be conducted [18] since both are necessities [3].

4. Conclusion
Kaumrejo Village showed a progressive recovery after the disaster; the village could achieve food security in a year. The immense contribution to the achievement of food security came from the food access and food utilization aspects. However, the food supply in 2015 was still deficit. The food supply could only meet less than half of the food needs with the normative consumption calculation.

Relying on imported food thus became a solution for food supply until the local production was recovered. Yet, it should be supported with the good economic capability and physical access. Kaumrejo community employed this strategy since their average income was pretty high in addition to its location in the main route of Kediri-Malang.

To support economic access, the Kaumrejo community returns to work as soon as possible with different strategies in every profession. The food security of Kaumrejo Village could survive since most of the villagers did not only rely their economic income only from agricultural activity. Therefore, they can got back to work as soon as possible after the recovery process.

On the other hand, the villagers who rely on agriculture needed aid from the government, private parties, and donors. During the recovery of damaged lands, farmers and breeders worked in other sectors, such as trade or other jobs according to their skills. Yet, many farmers and breeders also used their savings to survive.

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