# Farm management responses to natural disaster a case study Mount Sinabung eruption in North Sumatra, Indonesia.

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Research Article

# Farm Management Responses to Natural Disaster a Case Study: Mount Sinabung Eruption in North Sumatra, Indonesia

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## ABSTRACT

Indonesia is a disaster-prone country. One of the volcanic disasters having been ongoing for a quite long time is the Mount Sinabung eruption in Karo Regency, North Sumatera. This region is the producer of horticultural products (fruits and vegetables), giving an agricultural contribution of 60% to the Gross Regional Domestic Product. By employing the Farm-Household Model Approach, the research conducted aims at studying (i) farmers' responses toward the direct impacts of disasters on their farming, (ii) the socioconomic conditions that have indirect impacts on the farm management and (iii) the adaptation patterns used for overcoming the adverse effects of Sinabung eruption. The empirican findings show several impacts resulted from the eruption, among others (i) reduction in the area of land cultivated, (ii) reduction in the horticultural production, (iii) rise in the production cost and (iv) reduction in the farm income. The financial condition has been very bad that chili, tomato and carrot farming is no longer feasible, and even bears loss (R/C < 1). The socioeconomic conditions like infrastructure damage, distrubance of social relation, unavailability of pay workers in the agricultural sector and loss of access to credit of business previously provided by local informal financial institutions, have jeopardized farm management. To control the economic damage, farmers undergo technical adaptation by procuring water pumps for flushing the dust on the crops every day and by setting up nets to prevent pest outbreak. Besides, crop conversion from horticultural crops to staple food crops such as corn and dry land paddy, the cultivation of which does not require intensive labor but yields low production, is done. The crop conversion has disturbed the stability of farm household subsistency and existence, which have been supported by crop combination and rotational system with a plant hierarchy pattern.

**Key words:** Mount Sinabung Eruption, Farm Household Model, Natural Disaster and Agriculture, North Sumatra

## INTRODUCTION

Globally, the frequency and loss caused by natural disasters have been increasing from year to year. In actual values (the year 2002 serving as the base year), the average loss due to disasters in the 1960s was as much as US$ 75.5 billion and increased to US$ 138.4 billion in the 1970s, and increased again into US$ 659.9 billion and US$ 659 billion in the 1980s and 1990s, respectively (UNDP, 2004). The year 2011 was recorded as the year with the greatest loss due to disaster, namely US$ 380 billion. The total loss between 1980-2011 was estimated to be as much as US$ 3.5 trillion (Sendai Report, 2012: 8). It was not until 1991 that the United Nations conducted reconstruction to expand its roles in disaster management. This was marked with the establishment of a new department, Department of Humanitarian Affaris (DHA), which was intended to strengthen "the coordination of humanitarian emergency assistance of the United Nations" and to guarantee "better preparation for, as well as rapid and well-coordinated response to complex humanitarian emergencies as well as sudden and natural disasters" (DHA, 1994; UNDP, 2004).

Indonesia is a disaster-prone country. Every year, this country experiences various kinds of natural disasters such as flooding, drought, tornados, landslides, flash floods, earthquakes, volcanic eruptions and tsunami one after another. One of the volcanic disasters having been ongoing for a quite long time is the Mount Sinabung eruption in Karo Regency, North Sumatera. This volcano was estimated to be active for the last time in 1600 and errupted once again on 27 August 2010 (BNPB, 2013). It was reported that up until now, its activity remains high, affecting an area of 2.127 square km, which is the center

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for horticultural production (the production of fruits and vegetables in North Sumatera) with 60% Gross Regional Domestic Product derived from the agricultural sector.

The research serving as the basis for this article writing aims at studying (i) farmers' responses to the direct impacts of disasters on their farming, (ii) the socioconomic conditions that have indirect impacts on the farm management and (iii) the adaptation patterns used for overcoming the adverse effects of Sinabung eruption.

**Conseptual Framework and Literature Review**

Farm management in a developing country with small community farms like Indonesia is characterized with an integration of production unit and consumption unit at a certain level on the household scale, thus the economic activity (business) is inseparable from the household activity (domestic production). Household functions as a pool of labour to be allocated for farm production, domestic production and non-farm activities. The three integrated subsystems are referred to as farm-household-system (FAO, 1988; Upton, 1996 and Ellis, 1996) or agricultural-household-system (Singh/Squire/Strauss, 1986 and Tailor/Adelman, 2002). This model is commonly used in the analysis of policies in the agricultural and food sectors (the most recent by Louhichi/Gomez y Paloma, 2014). Beach/Poulos/ Pattanayak (2007) applied farm household model in analyzing response to a biological disaster (Avian Influenza).

Upton (1996: 24-44) describes farm household system as an open system that can be influenced by natural environment, sociocultural environment and political and institutional environment. As a whole, farm household model can be seen in Figure 1.

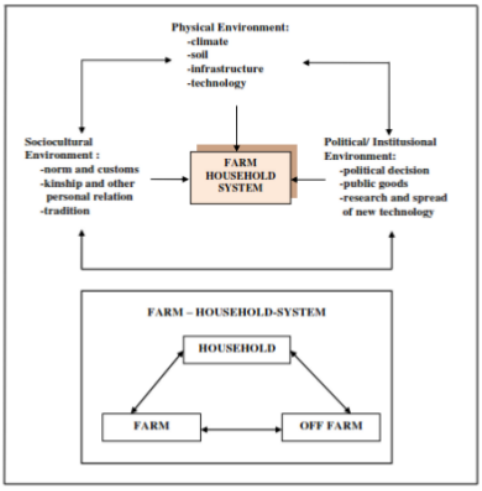


**Fig. 1:** Farm Household Model.

Natural disasters will have direct effects on the farm production activity. Indirectly, the damage of production-supporting infrastructures will negatively affect the farm activity. The disturbed social relation, especially due to relocation (evacuation), will be a stumble block for the implementation of self-help organization commonly found in village communities in the production stage that must be done as immediate as possible, for example planting and harvesting. On the other hand, the aspect of government policy may benefit from the restructuring of the agricultural sector as part of post-disaster rehabilitation program.

The direct effects of volcanic erruptions on agricultural production cover (Rahayu *et al*., 2014): (i) the loss of some or much germplasm and change in plant biodiversity, (ii) the loss of water catchment area, damage of forests, and even the blockage of water springs, as well as loss of water channels, (iii) the damage of land and danger of cold lava, (iv) burried soil and hamered soil formation due to repeated erruptions, (v) the loss of access paths to agricultural lands and loss of land ownership boundaries, (vi) materials in the form of sand and pyroclastic materials, that have the nature of sementation, requiring special techniques and technologies in the cultivation of that land as an agricultural land. Meanwhile, the Ministry of Agriculture and Forestry of New Zealand conducted an intensive study on the effect of volcanic erruptions on agriculture and forestry (Neild *et al*., 1998), and concluded that the ability of plants to cope with and recover from the effects of volcanic erruptions depends on (i) the thickness of volcanic dust covering them, (ii) the levels of disturbance continuity, and (iii) rainfall and the number of rain days. The farther the center of erruption is located, the lesser the thickness and size of volcanic dust are.

Sterling (2015) and Rahmat *et al*. (2016) describe that the sociocultural distrubance due to volcanic erruptions because fatalities followed by the loss of household labor. Meanwhile, those who manage to survive must be displaced far away from their farm lands and uprooted from social relations that have been destroyed with the destruction of social order of the village where they lived and earned a living.

UNDP (2004) observes the interplay between disasters and development, be it positive or negative, where (i) disasters may become a hinderance of economic development with the destruction of infrastructures, loss of production capacity, access to market and production facilities, and the diversion of the funds previously planned to be allocated for development into the emergency response in a considerable amount, (ii) redevelopment of the regions affected by disasters may trigger planned economic development and encourage cooperation and self-sufficiency of the communities affected, (iii) disasters may lead to other disasters, especially the disturbance of the environmental balance, for example due to deforestation and intensification of agriculture following the market demands, which may cause deforestation, landslides, and derivative effects such as forest fire and flooding, (v) development may reduce disaster risk, especially the development of technology and products for improving the security such as the construction of earthquake-resistant buildings.

**Empirical Findings and Analysis**

**Overview of mount Sinabung eruption:** The reawakening of Sinabung Volcano, North Sumatra began on 27 August 2010 after 400 years dormant. The volcano was then quiet until 15 September 2013 when eruptions

began again and have continued to the present. Since that 2010, Sinabung has been at the highest alert level three further times, in 2013, 2014 and 2015. Since 2 June 2015, the alert level of the volcano has remained in the highest level. This disaster caused three villages to be permanently relocated, 9,192 houses to be destructed and 10,768 people (2,887 families) to be dislocated.

Based on the vulnerability to disasters, the area at the foot of Mount Sinabung is divided into three zones (hazard zones).

Zone I: Within a radius of 0-3 km from the peak of Mount Sinabung, which is the deepest and the most dangerous ring area. There is a very high likelihood that this area is hit by igneous rocks greater than 6 cm in diameter as well as heavy ash rain. Valleys within this zone will potentially be struck by lava flow, hot clouds, lava falls and poisonous gas. Three hundred seventy (370) families (1,212 people) from three villages located in this zone (Bekerah, Simacem and Sukameriah) have to be relocated to a new settlement area in Siosar around 25 km away.

Zone II: The middle ring zone within a radius of 3-5 km from the peak of Mount Sinabung. There is a likelihood that this zone is hit by igneous rocks 2 – 6 cm in diameter as well as heavy ash rain. Part of this zone will potentially be struck by lava flow, hot clouds, lava falls and poisonous gas. As many as 1,683 families are in the midst of permanent relocation process.

Zone III: The outermost ring zone within a radius of 5-7 km from the peak of the volcano. This zone is also potentially hit by igneous rocks less than 2 cm in diameter. In the beginning of the erruptions, the people living in the villages located within this zone will also flee, but after the conditions back to normal, they return.

The location of the research was in Zone II, including four districts, namely Payung, Tiganderket, Simpang Empat and Naman Teran.

**Overview of horticultural production:** In table 1, the expansion of the horticultural land and increase of horticultural production (including carrot, cabbage, tomato and chili) in Karo Regency and Research Area (the districts of Payung, Tiganderket, Simpang Empat and Naman Teran) of the years 2010-2016 are presented. Similar to big eruptive patterns of Sinabung Mountain in 2010, 2013 and 2015, the holticulture production also slipped down in the following years. Tomato and chili seemed to be highly sensitive to volcanic dust, which explains why in 2011, 2014 and 2016 the production of both commodities tumbled down in comparison to the previous years, especially the year 2012, which was a relatively tranquil year.

**Response to farm management:** According to the results of interviews with 34 respondents in the research area, there was a significant change in the farm management of the horticultural production. By comparing the situations before and after Mount Sinabung erruption (2009 vs 2017), it was found out that the cropping area and productivity decreased, but on the other hand, the production cost increased. The logical consequence of the change in these three variables is the decreased farm income. The detailed information can be seen in Table 2.

The reduction in the cropping area and decrease in the production led to the decrease in the market supply, which eventually raised prices. However, the rise of the selling prices as well as the revenue were far below the level of cost increase, thus the farm income experienced a substantial decrease. Two cost components that did not occur in a normal situation are technical actions to deal with volcanic dust and avoidance of the outbreak of certain pests after erruptions. To get rid of the dust covering plant leaves, farmers flushed them, which required pumping machine as well as operational cost. Meanwhile, to prevent pest outbreak (especially against tomato crops), farmers set up nets surrounding the whole cropping area.

The financial damage caused by Mount Sinabung erruptions will be more conspicous in the results of futher farming analysis. While the business feasibility of carrot, cabbage, tomato and chili farming was good before the erruptions (R/C ratio between 1.43 and 4.79), after the erruptions, only cabbage farming was economically feasible to be conducted (R/C ratio = 2.46), while tomato, carrot and chili farming incurred loss with an R/C ratio of under 1 (Figure 2).

**Table 1:** Cropping Area and Holticultural* Production in Karo Recency and Reasearch Area**2009-2015

| Description | | Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Cropping area (ha) | | | | | | | | |
| • | Karo Regency | 12,193 | 11,273 | 12,082 | 13,098 | 16,347 | 12,217 | 12,536 |
| • | Research Area | 5,564 | 10,209 | 4,792 | 4,209 | 2,584 | 4,679 | 4,495 |
| Production (ton) | | | | | | | | |
| • | Karo Regency | | | | | | | |
| a. | Carrot | 38,955 | 22,253 | 24,906 | 30,693 | 36,257 | 46,093 | 43,089 |
| b. | Cabbage | 84,189 | 69,364 | 80,187 | 75,712 | 64,305 | 70,730 | 92,551 |
| c. | Tomato | 40,711 | 28,393 | 70,768 | 74,578 | 41,533 | 67,030 | 62,365 |
| d. | Chilli | 37,571 | 40,610 | 50,734 | 44,111 | 36,635 | 49,132 | 38,013 |
| • | Research Area | | | | | | | |
| a. | Carrot | 606 | 78 | 59 | 195 | 354 | 16,229 | 16,084 |
| b. | Cabbage | 1,970 | 1,623 | 1,577 | 853 | 954 | 29,019 | 31,982 |
| c. | Tomato | 24,906 | 697 | 48,071 | 44,308 | 6,745 | 27,808 | 18,862 |
| d. | Chili | 19,148 | 281 | 32,757 | 21,867 | 9,316 | 22,239 | 16,959 |

*) Carrot, Cabbage, Tomato and Chili; **) The Districts of Payung, Tiganderket, Simpang Empat and Naman Teran; Source: Central Bureau of Statistics (several publication years): Karo Regency in Numbers.

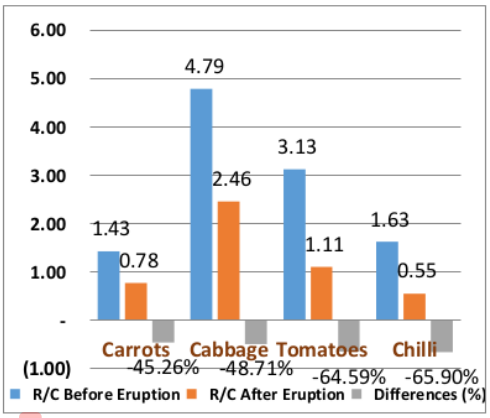


**Fig. 2:** Feasibility of horticulture production before and after mt sinabung eruption (R/C ratio comparison); source: data processed

**Table 2:** Differences in avarage of cropping area, production, costs and farm income before and after sinabung eruption

| Description | | Before | After | Differences (%)* |
|---|---|---|---|---|
| • | Cropping area (ha) | | | |
| a. | Carrot | 1.08 | 1.06 | - 1.88 |
| b. | Cabbage | 1.14 | 1.13 | - 0.88 |
| c. | Tomato | 0.35 | 0.34 | - 2.94 |
| d. | Chilli | 0.29 | 0.28 | - 3.57 |
| • | Production (ton) | | | |
| a. | Carrot | 20.47 | 18.48 | - 10.77 |
| b. | Cabbage | 44.79 | 42.57 | - 5.21 |
| c. | Tomato | 9.77 | 8.97 | - 8.92 |
| d. | Chili | 2.45 | 2.37 | - 3.38 |
| • | Cost (IDR million) | | | |
| a. | Carrot | 24.89 | 30.61 | 18.69 |
| b. | Cabbage | 27.06 | 43.08 | 37.19 |
| c. | Tomato | 9.93 | 17.87 | 44.43 |
| d. | Chili | 8.86 | 14.49 | 38.85 |
| • | Income (IDR million) | | | |
| a. | Carrot | 35.49 | 23.90 | - 48.49 |
| b. | Cabbage | 129.71 | 105.92 | - 22.46 |
| c. | Tomato | 31.10 | 19.81 | - 56.99 |
| d. | Chili | 14.42 | 8.04 | - 79.35 |

*) The results of the analysis of variance show that the difference is statistically significant at a level of confidence of 95%. Source: Accumulation of Data Processed.

In addition to technical adaptation by flushing and cleaning the volcanic dust from the crops, and the setting up of nets to control the damage by bugs, farmers also conducted adaptation by alternating crop combinations and their rotational pattern. In the last six years, it can be seen that the cropping area and the production of staple foods such as corn and dry land paddy increased greatly by 15 & 20% and 20 & 30%, respectively, while the cropping area and production of holticultural crops experienced a fluctuative decrease.

The change in the crop combinations and rotational system basically had upset the socioeconomic stability of the farmer communities around Mount Sinabung. Before eruptions, the farmer communities implemented a diversification pattern in the form of crop hierarchy, which guaranteed the subsistence and existence of household economy, some examples of which are reported by Tampubolon (1998: 169).

(i) Orange as a main long-lived crop requires investment in the first five years. This crop yields considerable products after reaching five years of age continuously.
(ii) To fund the investment in orange crops, tomato and chili are cultivated as slot plant in between the orange trees. Tomato and chili production takes 12 to 16 months. Some of the income from the tomato and chili farming is used for funding the investment in orange crops, and some other is used for financing the farmers' daily life.
(iii) To cover their finance until the tomato and chili can be harvested, farmers plant beans, which can be harvested in only two months.
(iv) If the farmers have workers, they may cultivate cabbage between beans with a production period of 45 days.

With this diversification pattern, assorted vegetables can be harvested every week, which may guarantee families' lives.

**Socioeconomic condition:** The socioeconomic condition of the communities living in the research area was perceived from four aspects, namely (i) social relation reflecting the sociocultural environment, which might infuence the farm household system, (ii) infrastructure reflecting the physical environment, (iii) farming activity and (iv) income generation via off-farm employement. Overall, the farmers rated the four aspects 55.44 (in a scale of 1-100). As expected, the worst condition occured in the infrastructure aspect with a score of 39.41. Natural disaster will destroy physical infrastructures, and in the case of Mount Sinabung eruption, the damage extermely disturbed the public services in education (25.88), health care (31.18) and access to clean water (35.29). The general overview of the socioeconomic condition of the communities living in the research area is presented in Figure 3.

The socioeconomic condition highly influential in farming is comprised of five elements, namely (i) availability of production facilities, (ii) availability of pay workers, (iii) access to small business loans, (iv) production price information and (v) farming product marketing. Among the five elements, soft infrastructures such as price information and product marketing guarantee are maintained in a condition of disaster. Given that information and wholesalers accomodating farming products usually exist outside disaster sites, these two are not disturbed and remain operating. The worst condition happens to the access to credit. It highlights the general characteristics of village financial institutions in developing countries, especially for smallholder farming, that is not directly associated with banks due to collateral reason (Mpuga, 2008: 5). They obtain services from non-formal financial institution that has individual nature, be it relative, colleague, neighbour or private money lender, on personal guarantee (Dong/Lu/Featherstone, 2010: 2). The natural disasters causing loss for the people will also affect money lenders, who as individuals will also flee and have their homes relocated. The same will apply to pay workers in the agricultural sector, who are actually from outside the disaster site, but to avoid the impact of the disaster they move to other regions. The socioeconomic condition related to farm production can be seen in Figure 4.

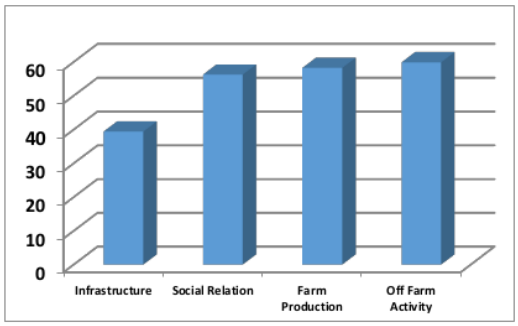


**Fig. 3:** Social economic condition of farm household after mt sinabung eruption; (score between 0 and 100); source: data processed.

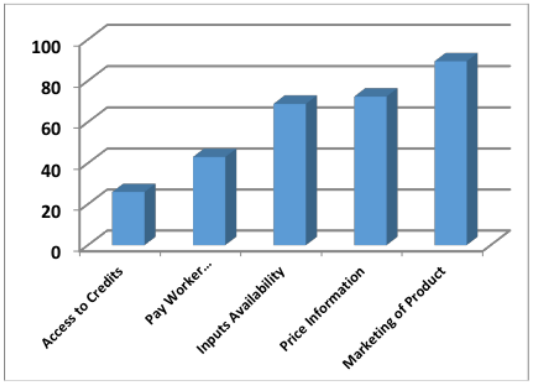


**Fig. 4:** Socioeconomic Condition Related to Farm Production; Source: Data Processed.

**Conclusion and recommendation**

Some important conclusions of this research are as follows:

(i) The erruptions of Mount Sinabung that spew volcanic dust have disturbed agricultural production activity, preventing optimum condition of the environment where crops grew and decreasing production. In order to reduce the risk of failure, farmers made extra efforts by flushing the crops and setting up nets to prevent pest outbreak. Both efforts have increaed the cost of production and decreased the farm income. Such situation is bad, thus the farming of chili, carrot and tomato is no longer financially feasible (R/C ratio of < 1).

(ii) In addition to the technical adaptation on farm, the farmers also converted the intensive-natured horticultural farming into the farming of staple food crops such as corn and dry land paddy that are extensive-natured and absorb a minimum number of workers but yields low productivity. This adapatation has disturbed the stability of household economic subsistence and existence, which has long been maintained through rotational pattern and crop combination with the characteristic of plant hierarchy.

(iii) The socioeconomic condition in the form of infrastructure damage, disturbance of social relation, in-availability of pay workers in the agricultural sector and loss of access to credit previously offered by non-formal financial institutions at the village level have exacerbated the adverse farming conditions.

In line with the conclusions, in a short term, governmental support is highly required, especially in the procurement of water pumps and agricultural enterprise credits as a part of disaster rehabilitation programs. Therefore, farmer organizing in the form of cooperation serves as the first step. Thus, the equipment may be used together and the credit fund can be supervised together as well. In a long term, the Government together with universities, research institutions and private companies must start experiments and development of high-valued crops that are resistant to volcanic dust (sharp-leaved crops) to be used as the future crops cultivated in the regions affected by volcanic eruptions as part of mitigation programs.

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