Livelihood adaptation patterns of sub villages community in the slope of Merapi Volcano

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Abstract. The dynamic eruption of Mount Merapi of Merapi National Park has partially changed the slope condition due to differences in the direction and scale of the eruption. National park boundary affecting the vary distance of the sub villages to the top of the mountain that influence to physical condition. This study examines the livelihood adaptation patterns of sub villages community in the slopes of Merapi. A mixed method between Geographic Information System and ethnography was used to explore the changes in physical and social conditions of the sub-villages. The study was conducted in 27 sub villages, interviewed 277 respondents and 62 key informants, field observations and study literatures. The results showed varied livelihood adaptation patterns, namely 1) the west-southwest, area most affected by pyroclastic flow (>20 times), the community have accumulated knowledge of eruption. Mining and Sallaca edulis plantation were the dominant livelihoods 2) the south-southeast, area was severely affected by eruptions and largest eruption in the past 140 years. Variety of livelihoods including livestock, farming, tourism activities and mining. The 2010 eruption has changed the ecosystem and economic sources, resulting in the shift of a part livelihood from livestock farming to tourism services. And 3) the north-east, north area was exposed by pyroclastic flows twice, and east was never directly exposed. The vulnerability of ecosystem and economic sources were low, while accumulation of community’s knowledge has not changed over a long period of time. Livestock and farming were dominant, The communities have opportunity to develop complex and advanced agricultural systems. Nevertheless the physical conditions have led to underdeveloped livestock farming systems.

1. Introduction

Merapi resents several characteristics of the most dangerous and hazardous volcano in the world [1],[2]. Merapi also is a state forest as national park named Gunung Merapi National Park (GMNP). It is surrounded by sub villages community who live on its slopes. In total, there are 71 sub villages spread across 30 villages, 7 sub district, 4 regencies (Sleman, Magelang, Boyolali and Klaten) and 2 provinces (Special Region of Yogyakarta and Centre of Java). The existence of these sub villages is strongly influenced by the activities of Merapi volcano [3],[4],[5],[6]. The dynamics of the eruption occurred 61 times since the 15 century [7], while the 2010 eruption is the largest eruption since the last 140 [8]. The pyroclastic flows in each eruption have a different direction and scale [9], only partially
significant effect. This condition influenced settlement pattern around volcano [6]. Besides the volcano activities, national park boundary has caused the difference distance of the sub villages to the summit that influence in the physical condition of sub villages.

Interrelationships between humans and mountain ecosystem have a long history and inevitable condition [5],[10],[11], even prior to the Neolithic Period [12]. Interactions of the socio-economic life of the slopes of Merapi volcano are the form of self-adaptation to the environment for generations [4],[8],[13]. The mutual relationship between social systems and natural systems has caused them to gain the abilities to manage and utilize existing resources [4],[15],[16],[17]. Ecological change is the impact of human interactions in the context of exchanges in the form of energy, material and information. The process of exchange between social systems and natural systems can take place wisely but it is often exploitative which drains resources quickly [16]. Javanese ethnic has strong interactions with the natural environment including volcanoes, rivers and the resources within them [18]. Javanese adaptability, especially for Merapi, made it possible to choose to live harmonious with disaster-prone areas [19],[17].

Study using Geographic Information System (GIS) and ethnography methods has been conducted in several places. [20] The integration of remote sensing techniques with ethnographic research in the cultural change and human perception related to the landscape. Mapping the sub culture of community surrounding Merapi was studied by [6]. Remote sensing analysis offers additional stories about changing landscapes stories that are not told by the respondents or key informants, or vice versa. The person being interviewed can tell changes that cannot be revealed by remote sensing data in more detail. Remote sensing analysis has contributed to providing a large spatial and temporal context for landscape studies and complementing the use of ethnographic data in evaluating land use dynamics.

Research by LAURA in 2012 explore the adaptation using anthropology and political ecology approach. Lack of research on adaptation pattern using mix method of GIS and ethnography, so that this study is necessary. Therefore, this study aims to explore and understand the livelihood adaptation patterns of the sub villages community on the slopes of Merapi volcano based on the dynamics of eruption and national park boundary. This research is expected to provide information that can be utilized in post-eruption rehabilitation efforts and forest management.

2. Materials and Methods

The study area was carried out in 27 sub villages on the highest slopes of Merapi volcano adjacent to the forest boundary. All sub villages are located in, 4 regencies (Sleman, Magelang, Boyolali and Klaten) and 2 provinces (Central Java and Special Region of Yogyakarta). The study was conducted from August 2017 to December 2018. The location coordinates ranged from 110°19'0" E - 110°30'0" E and 7°30'0" S - 7°37'0" S. Sub village is the smallest community unit in Java as living environment (Hudayana 1994, LAURA 2012) or is commonly known as “hamlet”. All the communities live adjacent with national park boundary, outside the park. Sub villages position range 3 km from 12 km to the summit, at 600-1,700 meters above sea level.

Purposive sampling was used to represent the diversity of sub villages. Sub villages were selected based on history of eruption, distance to the summit and topographic condition. Totally 277 respondent were purposive selected from member of 27 sub villages and people who access to the GMNP. Interviewing to respondent using structured questionnaires. Some questions ask to respondents were kind of resources gained from Merapi (before and after eruption), history of acquisition. Deep interviewed to 62 key informants were conducted by snowballing method start from GMNP staff to the sub villages community. Interviewed and field observations were conducted for twelve months. Secondary data obtained from literature, map, reports, and other document related to the study. Remote sensing and spatial data gained from BPPTKG (Lidar year of 2012, pyroelastic flow 1911-2010), Ministry of Environment and Forestry (SPOT 6 year of 2013-2017, GMNP boundary year of 2014, sub villages boundary year of 2017), Geospatial Information agency/Badan
Informasi Geospaial (base map year of 2017: contour, road, river, settlement, administrative boundary).

A mixed method between GIS and ethnography was used in this study. GIS used to classify complex types of environmental features by overlaying spatial data: dynamic eruption, forest boundary, and community’s condition. Analysis of cultural themes was carried out to look for the common thread resulting from social situations consisting of places, actors and activities from 27 sub villages. The study site can see in figure 1, and the list of sub villages can be seen in table 1.

![Figure 1](image.png)

**Figure 1.** Study site in the sub villages adjacent with Gunung Merapi National Park

**Table 1.** List of sub villages as study site

| Nu | Regency | Distric | Village     | Sub village |
|----|---------|---------|-------------|-------------|
| 1. | Sleman  | Cangkringan | Glagaharjo | Kalitengah lor |
|    |         |         | Umbulharjo | Pelemsari    |
|    |         | Pakem   | Hargobinangun | Kalirang Barat |
|    |         |         |             | Kalirang Timur |
|    |         | Turi    | Purwobinangun | Turgo        |
|    |         |         | Girikerto  | Ngandong     |
|    |         |         | Wonokerto  | Tunggulaum   |
| 2. | Magelang| Srumbang | Mranggen    | Salamsari    |
|    |         |         | Ngabak     | Jengglik     |
|    |         |         | Kemiren    | Jamburejo    |
|    |         | Dukun   | Paten      | Babadan      |
|    |         |         |             | Kringing     |
|    |         |         |             | Ngargomulyo  |
|    |         |         |             | Keningar     |
|    |         |         |             | Ngargosuko   |
| 3. | Boyolali| Selo    | Lencoh     | Plalangan    |
|    |         |         | Tlogolele  | Stabelan     |
|    |         |         | Klakah     | Bakalan      |
|    |         | Cepogo  | Wonodoyo   | Pedut        |
|    |         |         |             | Lendong      |
|    |         | Musuk   | Cluntang   | Jekol        |
|    |         |         | Miriyan    | Gobumi       |
| 4. | Klaten  | Kemalang | Tegalmulyo | Pajegan      |
|    |         |         | Sidorejo   | Grintingan   |
|    |         |         | Balerante  | Deles        |
|    |         |         |             | Sambungrejo  |
|    |         |         |             | Ngelo        |
3. Result and Discussion

3.1 Dynamic of eruption

Merapi is mountainous ecosystem based on physical characteristics with elevation of 600-2,968 meter asl [21],[22]. Dynamic of the eruption were relatively high on average 2-4 years [9]. The large eruption in 2010 had changed in the ecosystem in the GMNP, 1,242 ha heavily damaged; 1,208 ha moderately damaged; 2,544 ha lightly damaged and the rest 1,416 ha lava flow and open area [23]. The eruptions that occurred since the 18th century, there have been 5 major eruptions: Volcano Explosion Index (VEI) III in 1768, 1822, 1846, 1930 and VEI IV in 1872 [8]. The 2010 eruptions (VEI IV) exhibited behavior in a complex multi-stage event that marked a change in eruption of the magnitude and style since 1872 [24]. Historical mountain data are very important in recognizing mountainous ecosystems [21]. The chronologies of Merapi eruption 1768-1998 describe by [25],[26], BPPTKG illustrates the history and direction of pyroclastic flows 1911-2010, and [7] illustrates azymuts and travel distances for pyroclastic flows released at Merapi over the past 70 years. The intensity and direction of eruption can be seen in table 2.

Table 2. The dynamic of pyroclastic flow of Merapi eruption (1768-2010)

| No | Direction       | Frequency of eruption* | Area affected               |
|----|----------------|------------------------|-----------------------------|
|    |                | 18th century | 19th century | 20th century | 21th century | Tringsing, Senowo, Blongkeng, Batang, Krasak, Bebeng, Putih, Sat, Lamat |
| 1  | Northwest-Southwest | 1              | 5               | 13  | 2          |
| 2  | South-southeast   | 1              | 2               | 3   | 2          | Gendol, Woro, Boyong, Bebeng, Kali Adem |
| 3  | North            | -               | -               | 2   | 1          | Apu, Jnakah |
| 4  | East             | -               | -               | -   | -          |

(Source: processed from [25][26][7][9]

*the frequency of eruption written in this table is only eruption that has information of the direction of pyroclastic flow.

Merapi volcano as forest state, was directly impacted by the 2010 eruption. This eruption caused changes in land cover, leaving mixed forests, pine forests, damaged pine forests, open land, grass and shrubs [30]. The history of volcanic eruptions, physical conditions (soil, geology, rainfall and elevation), land cover, ecosystem damage, succession and restoration can be used as initial information on an ecosystem. Ecosystem conditions on each slope are different due to the eruption only having a partial impact, as we can seen in figure 2.

The destructive of volcanoes are well-known, from local to global levels [17]. Volcano eruption can damage settlements, agricultural land, and infrastructure [29],[24]. This condition certainly changes the social conditions of the communities in the affected area. The local community on the southern part of Merapi, specially at Turgo was damaged by 1994 eruption have developed a system for living on its slope and conceptualizing its hazard, which is based on naturalizing, familiarizing, and domesticating the threat from the volcano [8].The relation between humans and nature is a dynamic in which both culture and the environment constantly adapt when nature changes which is a response to another's influence. Merapi and the surrounding sub villages communities are dynamic models in terms of the environment due to high eruption activities. Although the relation between humans and mountain is formed throughout the slopes of Merapi volcano, the socio-cultural communities that surround it vary due to the effects of eruptions that have a partial impact.

Volcano not only emerge the risk and distarters but livelihood opportunities too, those opportunities form an integral part of volcanic distarter risk reductio [17]. Yet despite volcanic benefits, living with volcanic risk is not always feasible and volcanoes should not be relied on for livelihoods without careful consideration of potential drawbacks. Although the relationship between human and mountain is formed throughout the slopes of Merapi, socio-cultural communities that surround it vary due to the
partial effects of eruptions. This study is inline with Bates and Lowny [12] that state the distinctive Merapi sub-culture influences local community action during frequent eruptions. Residents in volcanic region often form a relationship with their local volcano with an attachment to its symbolic power that goes beyond the economic attractions of its fertile soils. The visible dominance of a volcano can provide inspiration for the development of distinctive sub-culture that can motivate a particular community in times of danger. These motivations can cause at risk communities to be more resilient if practices are based on experience, or more vulnerable as beliefs could offer a false sense of security [12].

![Figure 2. History of Merapi eruptions 1911-2010](image)

### 3.2 National Park Boundary

Study by Pranowo 1985 and Dove 1987 stated that Merapi volcano as a protected forest since 1912. Official document with a decree number was recorded in 1931, Besluit No. 419/B dated May 4, 1931 [30]. Forest management was then continued by Japan in 1942-1945 under Ringyo Tyuoo Zimusyo. The Government of the Republic of Indonesia in 1945 managed the forest based on Java Madura forest management. In 1950 the protected forest area in Yogya was managed by the Yogyakarta Government, while the Central Java region was officially under the management of Perum Perhuani since 1972. KPH Kedu Utara for the Protection Forest area in Magelang and KPH Surakarta for the protection forest in Boyolali and Klaten.

The entire forest area of Merapi has changed its function to become a conservation forest as a national park since 2004. The boundary of the forest area can be seen in figure 3 below. The farthest distances to the peak, especially on the western slope, are thought to have been due to an eruption in 1930 that led to the western part (12 km). The impact of this eruption, allegedly became the basis of the Dutch to make the western part as an area that free of settlement and become a state forest area. The northern and eastern part in 1930 were never directly affected by eruption. It is also suspected, the shortest distance (3 km) of national park boundary in the northern and eastern part because of minimal threat of eruption. The existence of the sub villages elevation start from 6,00 to 1,700 meter above sea level. Adaptational strategies usually relate with altitudinal vertically which allows for exploitation of
various ecological zones, diversification of diet and access to a multiplicity of resources [12]. This state strengthens the fact in the GMNP, that the boundary influence the altitude of sub villages position can makes the various adapational strategy of communities. The detail can be seen in figure 4.

![Figure 3. Forest boundary of Gunung Merapi National Park](image)

### 3.3 Livelihood adaptation pattern of sub villages community on the slope of Merapi volcano

The dynamics of eruption and national park boundary have formed patterns of livelihood adaptation of communities on Merapi volcano slopes varied. Despite their differences, the entire community respected their ties to the land as a place of birth and source of income. There is a strong bond as a human being with the land as part of nature that gives life. Sub villages community, living in a process of mutual respect and tend to leave their individual character. They have a principle of life to give a higher respect to others than themselves. The important thing in social guidance in Javanese culture is to maintain harmony in people's lives, minimize conflicts and appropriate rewards. Mutual cooperation in building houses, social activities and celebrations is reflected the kinship of the communities. Livelihood adaptation patterns of sub villages community on the slope of Merapi can be broadly classified into 3 regions, namely 1) west-southwest, 2) south-southeast and 3) north-east as we can see in figure 4.

#### 3.3.1 Region 1, West - Southwest.
The West - Southwest region is administratively located in Magelang Regency, Central Java Province. Study areas in 8 sub villages of Salamsari, Jengglik, Jamburejo, Babadan, Krinjing, Ngargomulyo, Keningar and Ngargosuko. The western part is an area often affected by eruptions (approximately 20 times since the 18th century). The sub villages community has experienced an eruption that destroyed their settlement in 1960. Two sub villages were finally moved on the lower slope. In addition to pyroclastic flow, the danger of cold lava after eruption has also destroyed settlement on the western part. Frequent eruptions that occur on a small-medium scale, past experience with eruptions has caused the sub villages community to be more aware of the eruption preparedness. Local wisdom in the Merapi volcano was formed as a result of people’s recognition of their physical environment [29]. While Lavigne et al. [31] state that the behavior in facing distarters was influence by perceptions of distarter threat.
Livelihoods in this region base on, miners, *Salacca edulis* farmers and a small part of rice fields agriculture. Mining production cycles usually begin with eruptive activity which causes an abundant supply of materials [11] followed by cold lava events. Lava that occurred in the river channel in 2010 was post-eruptive lava, meaning that it deposited after the eruption. About 70% of post-eruptive lahars occurred in the Progo watershed in the western slope and the remaining 30% occurred in the Opak watershed in southern slope. Sungai Putih is a river that had been often traversed by lava from 1782 to 2010. The largest lava event occurred in 1969 and 2010 [32]. Sand miners in western slope dominate the area adjacent with Sungai Putih. The intensity of the eruption resulted in damage to the ecosystem but on the contrary, it also provided an abundance of sand resources. Since the 1970s people have been using sand as a source of income. Merapi's volcano sand is well known for its quality. Sungai Putih is located inside the GMNP until it flows out of the forest area. Mining is carried out inside and outside the GMNP.

**Figure 4.** Range position (distance and altitude) of the sub villages community.

Mining carried out within the forest area has been going on for a long time and has been declining. Because mining within the forest area is one of the banned activities, the location is a conflict area between GMNP authority and the community. After 2010 eruption, conflict of sand mining occur between GMNP, Balai Besar Serayu Opak Progo, manual miners and mechanical miners (capitalist) and non-miner community [33]. Direct threat to ecosystem is conflict between manual and mechanical miners faced the decrease of material.
Base on deep interview and field observation, Chronology of the Sungai Putih-Jurang Jero sand mining within the national park area:

- 1990s: heavy equipment and financiers and even workers from outside (including Wonosobo) dominated mining activities. Many people around the forest area work as diggers.
- 2004: shifting the function of the forest area triggered a pro-mining of sand miners in Ngargosuko Village, fearing that their access to the sand mining area would be cut off.
- 2004-2007: as a national park, minimal socialization due to the absence of field staff and uncontrolled mining activities.
- 2007-2012: GMNP authority starts the activities in the field and the community recognized their whereabouts as forest rangers. The first activity to be remembered by the community was securing the area in the form of controlling the C mining quarry in Sungai Putih. GMNP as the authority conducted a joint operation in 2009 with a team from SPORC, the National Police, and local government support. This operation succeeded in dismantling the hut and controlling the miners who were on the upper side of Sungai Putih, and removing miners who were dominated by outsiders. According to residents, GMNP then finally tried to communicate by embracing the community and entering the field more intensely. Awareness of knowledge is slowly carried out when meeting in person. Field communication is often done informally. GMNP can understand the main needs of the community as well as the community also increasingly understanding the rules and obligations of GMNP.
- 2012-2015: closing of the gate, as a "temporary" solution to continue to provide access to mining activities. But the existence of trucks from outside the area is still mixed with many local trucks. The closure of access routes to the Sungai Putih in 2014, which caused turmoil, and community demonstrations was finally addressed by negotiations between the community and managers.
- 2015-2018: GMNP party's bargaining position was to collect data on trucks and drivers as a first step to give priority to local communities to access sand in the area. Trucks from outside may only buy in the sand outside the region as an extension of the chain, which is expected to reduce the pressure of sand activity. While at the same time giving priority to economic opportunities and access to local communities. The community stated that mining was carried out for basic necessities of life, so that an agreement was obtained on Monday-Friday pickup arrangements with an intensity of 1 time per day per truck. GMNP authority is trying to minimize, not eliminate, but rather to arrange community interaction with sand in the river flow in the forest area. In 2015 Paguyuban Merapi Hijau was established as a forum for local truck owners and miners. Actors and interests can change because of the high economic value of sand, but ongoing dialogue also continues with the management of the national park.

3.3.2 Region 2, South-Southeast.
Southern part of Merapi volcano located in Sleman Regency, Special Region of Yogyakarta. The research area covers 7 sub villages, namely Kalitengah Lor, Pelemsari, Kaliurang Barat, Kaliurang Timur, Turgo, Ngandong and Tunggul Arum. The seven sub villages have different characters. The Southeast (bordering Klaten Regency) at Kalitengah Lor and Pelemsari was severely affected by the eruption in 2010. Forest conditions were heavily damaged, settlements and uplands were destroyed. The economic system was totally paralyzed after the eruption in 2010 (the largest eruption since in the last 140 years). Initially the main livelihood was farming. The adaptation pattern of the sub villages community shows that they are able to rise from the economic downturn. Villagers choose to return to their homes as soon as possible from the refugee camps. They do not want to leave the area for too long even though the conditions are flat to the ground. Trust systems, economic opportunities on their own land, social activities are some of the things that underlie sub villages people who do not want to leave their regions. Community at Kalitengah Lor showed a high vulnerability when Merapi eruption, but community has a great social capital so it’s tightened the community relation and gives
contribution towards resilience in facing volcano eruption [34]. The availability of sand resources, the ability to read opportunities, closeness to markets and cities makes these area have a higher level of community welfare than sub villages communities on the northern and eastern part.

This paper in line with widodo et al. [35], that study at 3 sub villages in Southeast (Kalitengah Lor, Kalitengah Kidul and Srunen) result that 61.6% community feel comfort and peaceful in their area despite the distaster prone area. The comfortable caused from environmental, economic and social factor. People at Kalitengah Lor, Kalitengah Kidul and Srunen realize the risk of living in prone area but most of people did not know about the repose period of Merapi [36]. All land in the sub villages have been certified is the only reason as the opportunity and livelihood availability that offered by this area is incomparable. The rationale choice of economic value strengthens by cultural value. Napsiah et al.[37] studied at southern part of Merapi specially at Pangukrejo community (near Pelemsari sub village) resulted that community think Merapi as place of origin, secure comfort and safety, symbol of self esteem that must be maintained. They interpreted eruption is destiny and part of life cycle and makes the rationale choice for community to living harmony with the risk.

Kalitengah Lor sub village is almost the same as Pelemsari. But the tourism business is not developing as good as in Pelemsari. Sand is one of the potential resources utilized by the community at Kalitengah Lor. Gendol river is providing abundant sand and stone material. The recovery of the economy from the sand raised the economy quickly in this sub village. Both manually and mechanically, sand mining in the Gendol river flow has supported the community on the southeast slope of Merapi as wage labour, truck drivers, and truck owners. Although sand excavation was not as vibrant as in 2012, this activity is still on going. Difference with mining activity at western slope of Merapi that a part of mining activity exist inside national park, mining activity at Kalitengah Lor exist outside the national park.

Pelemsari, Kaliurang Barat and Kaliurang Timur is a place where business opportunities and rapid tourism floating with the jeep lava tour vehicle business. The development of the existence of vehicle services in the form of Jeep Lava Tour has continued to increase since the beginning of 2012. The vehicle service business began when many people came to see the impact of the eruption in 2010, but could not reach the location due to heavy terrain. Seeing this opportunity, the community offered a jeep to reach the area: my treasure museum, Kaliadem bunker, alien stones and the house of Mbah Maridjan. Starting from 1 community that has 9 jeeps currently has grown to 29 communities with a total of 960 jeeps. Over a period of 6 years (2012-2018), stretching this transportation service business provides a very tangible economic benefit in increasing people's income.

This jeep service business is inseparable from the impact of the 2010 Merapi eruption, which made it an alternative tourism opportunity. Efforts to recover from the economic downturn locally were carried out by residents of Pelemsari, Pangukrejo, Kaliurang Barat and Kaliurang Timur. Growth in the number of jeeps between 2012-2018 increased periodically, with an average of 100 jeeps per year. At present it is not allowed to increase the number of communities, but in 1 community it is still permissible to change or add to the jeep fleet depending on the rules in each community. Lava Tour Tourism is built by the community to revive the economy by utilizing existing natural conditions, in the form of tours throughout the affected area. The dynamics of Merapi volcano affect how humans interact with it, including how to survive and rebuild their economy and culture. Social transformation caused from lava tour business opportunities [38]. While Kumoro [39] state that the role of the youth as agent of economic change in lava tour business.

Labuhan Merapi is held every 1 Rejeb. The harbor procession is fully organized by the The Palace of Yogyakarta. The location of the harbor was affected by the eruption in 2010, so the operation of the harbor in 2011 was carried out below. Since 2014 the harbor ceremony has been held again at Srimanganti. This cultural activity is a form of gratitude towards The God.

Although occupying a quarter of Merapi volcano, the southern part is the location most visited by tourists, both the archipelago and foreign countries. Most of the in Kaliurang live mainly from tourism, both as food and beverage sellers, tour and guiding services and rental of lodgings. Kaliurang
is used as a resting place starting in the 1800s by the Dutch who wanted fresh air and beautiful scenery. In 1980 the government built the Kaliurang tourism area. Tourism activities carried out by the community, government and private sector. People who depend on tourism (buying and selling food, souvenirs and vehicle services) are outside GMNP, but are directly influenced by the management of national parks and activities Merapi volcano.

Nature tourism has supported Kaliurang Barat sub village community since the 1980s. The business of providing food and souvenirs for more than 30 years is a reflection of the economic flow obtained by residents able to meet their basic daily needs. In addition to tourist visits, the amount of research carried out on the southern part is also abundant both physical and social research. Proximity to the location of the city of Yogyakarta, which is an educational centre with the presence of public and private universities, makes the southern part a natural and social laboratory for student research. The existence of tourists, academics is strengthened by the many local and international NGOs that allocate their programs on the southern part. In general, communities on the southern part are better educated with much higher interactions with tourists, academics, and NGOs compared to the other.

Turgo is sub village affected by the eruption in 1994. Memory of eruption and efforts to recover from the eruption in 1994 are still very strong. The shift of maize food crops to non-food crops (grass and agroforestry) occurred due to the eruption in 1994. Before the eruption 1994, the area around the house was planted with corn; now many fruit plants (jackfruit, coconut, avocado, coffee) are planted with grass below. The main livelihood of the people is livestock farming. Cows are the main choice for farmer-livestock, but for the last 3 years sheep and goats have become superior livestock products. The price of goat milk and less risk make livestock farmers’ choices move. Salak pondok grew rapidly in the 1990s until the 2000s as a superior product in these villages to the border in Magelang. Soil fertility, supported by the availability of water and the expertise of Sallaca edulis farmers makes this product boost the community's economy.

3.3.3 Region 3, North-East.

The northern-eastern part is administratively located in Boyolali Regency and Klaten Regency, Central Java Province. The research area on the northern part are Plalangan and Stabelan. Soil fertility on the northern slope is used by the community to grow vegetables with a short harvest period, including carrots, cabbage and leaf bells in the rainy season. The dry season (May - August) is used to grow tobacco which is expected to have high selling points. The pattern of dry land farming, lack of water is carried out by the community on the lowest slopes around the house (the lowest slope- 1,400 meter asl), to the boundaries of the national park forest area (top slope- 1,700 masl). In addition to agriculture, the tourism potential for special interest in hiking on the Selo climbing route is officially managed by GMNP together with the community. Nowadays it starts to develop into a selfie and nature tourism spot. Regular harbor ceremonies are held every 1 Muharam. This cultural activity is a form of gratitude towards The God. This ceremony is a symbol of alms towards Merapi volcano which has provided soil fertility for the people on its slopes. Labuhan was organized with the support of the Boyolali District Tourism Office and The Palace of Surakarta.

The research area on the eastern part are Pedut, Lendong, Jelok, Gobumi, Pajegan, Grintingan. The physical character is almost the same as the northern part. One type of distinguishing plant is a rose. This type of plant had boosted the economy of the community in the 1990s, but now even though it is still widely planted it is not a superior product that sustains the community's economy. Besides roses, clove species are often found planted on community land on the eastern slope. Coffee is a type of agroforestry plant that is currently being produced again. Coffee plants that were planted for a long time were neglected due to the fall in coffee prices. This plant was eventually re-treated and harvested by the community in the last 1-2 years due to rising prices and demand market for coffee. The eastern slope area has the widest natural forest potential compared to other parts of Merapi volcano. The condition of natural forests is still well preserved due to topographical conditions and difficult access. The people still believe that the eastern part of Gunung Bibi is the mother of Merapi volcano, which is a secret area, so it is safe because it is rarely touched.
Northern and eastern part of the Merapi volcano are minimal and have not been directly affected by the eruption of pyroclastic flow. Even though they have not been damaged due to eruption in a long period, agricultural systems that should have long-term investment are not an option. Vegetables that have a short rotation even though the price is volatile actually become the main choice. Steep topographical conditions, limited agricultural land, difficult accessibility and far from urban areas are the main factors of the agricultural system underdeveloped.

4. Conclusion

The results showed that adaptation patterns can be distinguished in 3 regions, namely 1) the west-southwest side 2) the south-southeast side and 3) the north-east side. Region 1 is the area most affected by pyroclastic flow (> 20 times), the communities has accumulated knowledge about the dangers of eruptions and managing eruption resources since 1970. Region 2 is the area that has been severely affected by eruptions, and the largest eruption in the past 140 years. Communities has experience for businesses of tourism since 1980. The eruption in 2010 changed the ecosystem and economy, resulting in the shifting of part livelihoods from livestock farming to tourism service businesses. Knowledge of livestock farming is increasingly fading for the younger generation. Ecosystem and economic vulnerability are high because of the intensity and scale of the eruption. Region 3 is on two sides, an area that has exposed to pyroclastic flow twice and has never been directly exposed of pyroclastic flow. Ecosystem and economic vulnerability are minimal, so the accumulation of communities knowledge has not changed much over a long period of time. Communities have the opportunity to develop complex and advanced agricultural systems. However, with steep topography, narrow land, minimal water resources, and access that is not well connected, resulting in underdeveloped livestock farming systems. Information obtained from a combination of GIS and ethnographic methods complement each other to study the adaptation patterns of sub villages community on the slopes of Merapi Volcano.

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