The community adaptation strategy in dealing with landslide disaster in Banaran Village Ponorogo Regency

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Abstract. A landslide disaster occurred in Tangkil, Banaran Village, Ponorogo Regency on April 1st, 2017 which caused many casualties. The objectives of this research were to determine the factors that caused the landslide and to determine the community adaptation strategy in dealing with landslide. This research applied descriptive qualitative method with its data collection included observation, interview, and documentation. The research results showed, 1) the factors causing landslide were steep slopes, fertile rocks and soils, land conversion, high rainfall, and human activities, 2) the community adaptation strategy involved adaptation and adjustment in dealing with landslide. The impacts of landslide have been felt by the community thus, they could change their behavior towards their environment and make adjustments to the new environment.

1. Introduction
Landslides often occur in various regions of Indonesia, with one of its factors is geographical condition. The symptoms indicating imminent landslides are the emergence of cracks in slopes occurring after rain, the presence of new springs, and the falling of various materials from the cliffs (Adiyoso and Kanegae, 2013). (Wang et al, 2017) stated that the occurrence of landslides is influenced by several factors, namely geology, distance from the fault, topography, vegetation, and precipitation. Landslides also often occur on natural and non-natural slopes caused by factors triggering soil displacement. Controlling changes in land use on slopes is very important as it can lead to a decrease in land stability, which in turn raises the potential of landslides during the rainy season. In addition, changes in use must be understood in detail including their effects on ecosystems, because the impacts are significant for humans (Corbett et al, 2017).

Landslides continue to increase from time to time, implying the various factors triggering the occurrences, the vulnerability of community increases through various development practices (Barasa, 2018). Landslides are lands that have various material components, forces, and motion mechanisms that cause complex hazards and landslides due to rainfall (Lin et al, 2018). The impacts caused by landslides include damages and losses that can affect people's lives. Those damages and losses can be in the form of casualties, damaged houses, and disrupted ecosystems. Therefore, it is necessary to have a good strategy and special handling measures in areas prone to landslides. Baum and Godt, (2010) found that complex landslides caused by rainfall often show characteristics of deformation, progressive failure, and threaten people's lives and property.
Ponorogo Regency is one of the areas prone to landslides due to its morphology in form of hills, highlands, and lowlands with an altitude of 92 to 2563 masl. The potential for landslides is quite high in the area of Pulung and Sawo Districts because they have altitude of more than 1000 masl. Paimin et al. (2009) explained that the level of landslides susceptibility is measured by the parameters of natural factors that make up the formula such as 3 consecutive days of cumulative daily rain (25%), slopes (15%), rocks (10%), faults (5%), soil depth to impermeable layers (5%), and management factors including land uses (20%), infrastructures (15%), and settlements (5%). Furthermore, groundwater condition, geomorphology, and soil property regulate slope instability (Wan et al., 2011).

Tangkil is located in Banaran Village, Pulung District, Ponorogo Regency. On Saturday April 1st, 2017, a landslide disaster occurred on that area. The incident occurred in the morning at 07.30 WIB, when the community carried out their daily activities in their farms. At that time, many people were harvesting ginger, as the disaster ended up with 6 death, 22 buried by landslides, and 17 suffered minor injuries. The number of refugees was 178 people in 8 points provided by the government. The victims of landslides were not only the community who harvested ginger but also those who were in their houses because landslides were close to the settlement. These geological conditions are very detrimental and human activities can deteriorate due to dangerous situations (Xu et al., 2018).

The landslide in Tangkil was preceded by signs of cracks and the high rainfall on the night before so that the entire Tangkil villagers had started leaving their homes. But, in the next morning those people returned to their home to harvest ginger. The Ponorogo Government's had advised to the community since March 13 2017 to evacuate to a safer place, but those people decided to return home as the landslide occurred in Tangkil. Bignami et al. (2018) found that strategy and public awareness need to be improved, through preparedness for the risk of landslides and floods. The purposes of this research were to determine the factors causing landslides and to determine the community’s adaptation strategy in dealing with landslides.

2. Methods
This research applied descriptive qualitative method. The data were collected using interview, observation, and documentation techniques. In order to get the correct sources and in accordance with the objectives, the researcher used purposive sampling technique. Interviews were conducted with the people of Tangkil, Banaran Village, Pulung District, Ponorogo Regency. Observation and documentation were carried out to determine the causes of landslides and to determine the community's adaptation strategy in dealing with landslides. This research used triangulation techniques, sources, and methods to test the validity of the data obtained to keep them in accordance with the research objectives.

3. Result and Discussions
Ponorogo located at (7°52'15.3 "S, 111 ° 27'44.5" E) has a wide variety of landscapes and has had 59 landslides occurring during 2012-2018. (Muriyatmoko et al, 2019) The worst landslide occurred in Tangkil, Banaran Village, Pulung District, which resulted in casualties and material losses. Banaran Village is an area with moderate class ecosystem services for regulating, protecting, and preventing disasters, which means that the land in that area has the potential for disaster when triggered by high intensity rainfall. The landscapes of Tangkil, Banaran Village, are part of the foot of Mount Liman Dorowati with a pyroclastic material, so the area is prone to landslides. (Xiao et al., 2020) research results showed that lower slope stability of 0.923% and failure probability of 98.5% with high rainfall caused landslides in Wanzhou County, Three Gorges Reservoir, China. Climate change significantly increased multiple hazards and tiered impacts on society, resulting in disasters such as landslides (Schiermeier, 2018).

3.1 The factors causing landslides
Slope
The geomorphology is formed by moderate to steep hills where under the slopes there are settlements and community-owned lands. 13 hectares of community lands were buried by landslides, causing
considerable losses because the plants on the lands were ready to be harvested. (Naryanto et al, 2019) showed that the slope in Tangkil is very steep, slanting at 70-140%.

![Figure 1](image)

**Figure 1.** The direction of the landslide

The observation result obtained that the peak height of the slopes was 900-1000 masl. The distance between the top of the slope and the end point of the landslide leading to the east was about 2000 meters. The direction of the landslide was included in the slope with a slope of 7-15%, so it was used for the community settlement. Slope conditions are actually not recommended for agriculture and settlements due to the surface water flow rate cannot be controlled. There needs to be a better understanding by providing a rigorous systematic process to improve slope management, thereby reducing landslide hazards (Dai, Lee, and Ngai, 2002).

**Rock and soil**

The rocks in Tangkil are composed of volcanic rocks that are easily broken down, have many cracks, and overlap tertiary sedimentary rocks which can form a sliding layer. The soil properties include high organic content with a texture of sandy clay and loose. The soil characteristic on the top layer is dark and the soil solum is thick. Based on observation, the soil on the slopes of Tangkil has very good fertility, as can be seen from the soil nature and soil type. The soil types are dominated by lithosol, inceptisol, and alfisol. Therefore, human activity is very high in using the lands for agricultural cultivation of seasonal crops.

The community did not understand the impact of slope soil fertility with these seasonal crops on soil structure. Inceptisol soil has a moderate level of weathering and soil development, while alfisol soil is used by the community for agriculture. If the slope is steep, the soil can only be planted with hardy plant types that can withstand erosion. However, the community used the slopes for planting ginger, so the erosion rate is quite high due to seasonal crops. (Suprato et al, 2017) found that the lithosol and andosol soil have little organic elements that if planted with unsuitable plants will cause an increase in erosion rate.

**Land conversion**

The topography and slopes with very steep criteria are utilized by the surrounding community for agricultural cultivation activities, namely ginger, because of the large yields to the international market. The community applies a terraced planting model with a width of 3 to 5 meters. Ginger is very suitable to be planted in tropical and sub-tropical areas with temperatures ranging from 20-30 °C. Tangkil meets the criteria for the cultivation of these plants. Land conversion causes a decrease in global biodiversity, given the importance of functions and ecosystems that exist in the hills (Newbold et al, 2015).

**Rainfall**

Rainfall infiltration increases pore pressure which reduces the effective stress in the soil and reduces the shear strength of the soil, eventually resulting in slope failure (Conte et al. 2017). One of the triggers of landslides in Tangkil was the high rainfall condition. High intensity rain flushed in all areas in Ponorogo.
Regency. Before the landslide in Tangkil occurred, it rained for three days. Groundwater absorption was very high due to high rainfall intensity, so that the soil on the slopes became saturated with water resulting in landslides. Seismically induced landslide failures and the resulting ground flow are essential for appropriate design precautions. Rainwater causes an increase in soil mass thereby weakening the bonds of soil particles that lead to landslides (Susanti and Miardini, 2017).

Human activity

The human factor belongs to non-natural factors and is a key factor in the occurrence of disasters, one of which is landslides. The cultivating of plants cumulatively causes soil imbalance and will have a harmful impact. (Mandasari, Arifin, and Ali, 2016) due to the limitations and high land value, some people choose to live on the hillside and take advantage of the existing land, but as a consequence, almost every year the community is affected by landslides, as what happened in Cappagalung District.

The results of observation, documentation, and interview with the people of Tangkil, Banaran Village, showed that the people made their living as agricultural cultivation of ginger, vegetable, rice, and coffee. Some of the farmers are farming on their own land and some are farming using the slopes. Those who farm on their own land cultivate rice, coffee, and vegetables while ginger is planted on slopes. Initially, the slope area was included in protected forest and the land was classified as fertile with plants that can grip the soil, such as pine. Along with the pressure from community activities in Tangkil, many people cultivate seasonal crops and are classified as plants that cannot control/maintain the soil structure.

As a result of the activities of some people in Tangkil who use the slopes, it has an impact on other farmers who farm on their own land as the landslide hit private land and caused losses and damages to family members. Regional development must adapt to the risk of natural disasters, so that people can implement disaster mitigation and prevention (Nurohmah et al, 2014).

3.2 The community adaptation strategy in dealing with landslides

The landslide disaster in Tangkil in 2017 caused many losses ranging from physical and non-physical aspects. Physical losses are related to buildings and lands damage, while the non-physical aspects are anxiety and trauma experienced by the community.

Table 1. Losses from the landslide of Tangkil

| No | Type               | Physical       | Non physical  |
|----|--------------------|----------------|---------------|
| 1. | Home               | 56             | Anxiety       |
| 2. | Production forest area | 2 Ha          |               |
| 3. | Community land     | 13 Ha          |               |

The value and usefulness of concepts, approaches, and models need to be maintained for dealing with disaster risk challenges (Okada et al, 2018). The community lacks knowledge of disasters, so the feeling of trauma and anxiety is so impactful. Therefore, awareness of natural disasters needs to be given since school due to the awareness of environmental sensitivity (Tuncel, 2018). Landslides also destroyed the environment in which they lived and forced people to adapt to their new environment.

The adaptation process was done by adjusting to a new environment as a place to live, so that the people of Tangkil, Banaran Village are ready for the adaptation in the new environment after a landslide. Everyone will find it difficult to re-adapt, considering that for years they have occupied their former places However, the adaptation process can be carried out in several stages, so that results can be achieved for the people affected by the landslide. The concept of community adaptation strategy that is applied by Berry (1980): 1) adaptation by reaction, 2) adaptation by adjustment, 3) adaptation by withdrawal.

The main adaptation strategy chosen to deal with landslides in Tangkil, Banaran Village is adaptation by adjustment. Adaptation is carried out by the community with the aim of being able to live in harmony
and integrated with the environment (Hutcheon, 2006). The hierarchy of human needs for housing fulfillment includes: survival needs, safety and security needs, affiliation needs, estern needs, as well as cognitive and aesthetic needs (Fulliove & Fulliove 3rd, 2000). Therefore, people affected by natural disasters must meet their needs and carry out their adaptation process. Adjustment of natural and human systems to the stimulus of natural disasters is required to reduce the negative impact of disasters. An adaptation by adjustment is a strategy to adapt to changes in people's behavior to the environment for the sake of better environment.

The research result, showed that adaptation by adjustment was chosen because the land cultivation was very intensive and terracing was not in accordance with conservation principles. In addition, areas prone to landslides are those with hilly and highland areas in Ponorogo Regency (Yuniarta et al, 2015). The condition of Tangkil, Banaran Village after the landslide disaster made it possible to rebuild their residence, but all people must change their behavior towards their environment; not planting ginger on the slopes. The topography in Tangkil is steep and the community uses it for plantations and applies the concept of micro conservation or terracing. The characteristic of loose soil makes rainwater infiltration effective and it is added to the cultivation of ginger, so that the plant does not have a function as a soil structure and run-of reinforcement. (Hermiyanto, Winarso, and Kusumandaru, 2016) Farmers should conduct soil tests with the aim of measuring all parameters of the chemical properties of the soil, so that they can determine suitable plants for the lands.

The impact of landslides has been experienced by the community. Therefore, people need to change their behavior towards their environment. Before the landslide, the slopes were planted with ginger which could not function properly to hold the soil structure. With an adaptation by adjustment strategy, the community will not plant plants that cannot function for the soil structure so that they replace plants that can strengthen the soil structure on the slopes. Hermon (2019) stated that controlling land use is very important because the land size is permanent while the need for land is getting higher. This can lead to a decrease in land stability so that in the rainy season the potential for landslides to occur is even greater. Perez et al (2015) mentioned that change in land use and its implications for land cover conversion rates resulting in reduced living biomass and delayed vegetation transition.

Hermon (2019) stated that every region in Indonesia has a Regional Spatial Plan (RTRW) which functions as a controlling instrument, because along with the development and progress of the area, the pressure on changes in natural spatial ecologically including in the buffer zone will also be high. Community understanding of landslides through the interpretation of the level of vulnerability that occurred in Tangkil, Banaran Village, that the level of vulnerability to landslides is high but community understanding is low. The low community understanding with a high level of landslide vulnerability can result on great losses and environmental damages. The community does not have the insight into disaster mitigation and only relies on natural phenomena in the surrounding environment. The landslide disaster
in Tangkil has attracted the sympathy of various parties, so a lot of assistance has come to meet the needs of the community.

4. Conclusion
Based on the research results, it can be concluded that the factors causing landslides in Tangkil, Banaran Village are steep slopes, rocks and soil, land conversion, high rainfall, and human activities. In addition, the community adaptation strategy in dealing with landslides used is adaptation by adjustment. Landslide destroyed the environment in which they lived and forced people adapt to their new environment. The adaptation process by adjusting to a new environment as a place to live is very important, so that the affected community must be prepared for the adaptation process in the new environment after landslide occurs.

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