Assessing of economic losses in landslide affected areas in Cibanteng Village, Cianjur District, West Java

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Abstract. Indonesia is one country that has a high incidence of natural disasters. Among the various types of disasters, landslides are one of the most common hydrometeorological disasters. One of the areas that have a high rate of landslide disaster is Cianjur district, West Java province. Assessing of economic loss due to landslide disaster in a region is one of the important tools in the recovery and reconstruction framework. The purpose of this research was to asses the indirect losses of three areas affected by landslide in Cibanteng Village, Cianjur district, West Java. In this study, the UAV (unmanned aerial vehicles) was used to create high-resolution maps of areas affected by landslide. Participatory mapping was conducted to delineate damaged land use areas and then interviewed the farmers to obtain information about the agriculture activities. The results of this study showed that the amount of indirect losses in the three location reached Rp 352,811,700 (US $ 25,200) at the landslide occurrence and Rp 1,205,152,300 (US $86,082) for the indirect losses in 2.5 years. This value can be a reference for assessing indirect losses in other areas.

1. Introduction

Natural disasters are one phenomenon that can happen anytime and anywhere. It produces harm to human life, both loss of property and human casualties. Indonesia is one of the countries with high incidence of natural disaster, physical, human, or even both are the factors to this occurrence. In the period of 2005 to 2015, BNPB recorded more than 78% (11,648) disasters were hydrometeorological disasters and only about 22% (3,810) were geological disasters [1]. Any kinds of type and scale, landslide is a major problem for all nations. From all kinds of meteorology and geological disasters, landslides are one of the most serious one and could not be avoided in mountains and areas with a steep slope [2].

Risk assessment due to natural hazards, such as landslides, is very important, especially for people who live in hazard-prone areas and for local governments that are responsible for the welfare of their community [3]. Assessment of economic losses due to natural disasters is an important tool for the government in making emergency rescue, recovery and reconstruction decisions [4]. Cibanteng village is vulnerable to landslide hazard. During the period of 2010-2017 period occurred 8 events of landslides that have caused no casualties but have resulted in economic losses [5, 6, 7].
Assessment of economic losses due to landslides is important to recover the economic conditions of the victims. As is well known, losses arising from natural disasters can be divided into direct and indirect losses [8]. Damage to human life, housing, infrastructure and natural resources are categorized as direct losses, while Indirect loss refers to a decrease in output or revenue as a consequence of direct loss or because of an impact on the supply chain [8, 9]. In the case of landslide events in the study area, the local government provided direct assistance of Rp 10 million for each affected house. However, indirect losses due to damage to agricultural land did not get compensation. Statistics in 2017 showed that 30% of households can be categorized as low-income families, so landslides can be triggered the process of impoverishment of people affected by landslides.

In this work, we present an assessment of indirect losses in three landslide-affected areas in Cibanteng village. Assessment of indirect losses was based on losses due to the failure to yield agricultural production and the length of time to reuse land for agriculture.

2. Methodology

2.1 Study Area

The Cibanteng village is a part of the Cianjur district, West Java province. The total surface area of the village is 1332 Ha. The study area is a hilly area, where the elevation varies between 350 m and 950 m a.s.l. Regions with a slopes 15 - 25% cover most area with a proportion of 60% of the total area. In 2017, the most widespread land use in Cibanteng Village was agricultural land in the form of dry land agriculture, (i.e. non-irrigated fields (‘tegalan’ in Bahasa) and mixed garden (‘kebun campuran” in Bahasa) with a proportion of 34.3% of the total area, followed by rice fields, about 31%. Meanwhile, the settlement areas cover only 28 ha or 2.1% (see Figure 1). The study area was focused on 3 landslide affected areas, i.e. Cibuntu, Gunungsalam, and Sukasirna. Landslides in these areas occurred in September 2016, March 2016 and Mei 2013 respectively (see Figure 2).

2.2 Methods

The appearance of the three areas affected by landslides and their area were obtained through image recording using UAV (unmanned aerial vehicles) with a flying height of 150-200 m. The high-resolution images were then processed using Pix4D software. High resolution images of UAVs are very helpful in the framework of disaster mitigation [10]. Furthermore, maps of affected areas were processed using GIS Software.
Map of the area affected by landslides as a result of taking pictures using the UAV was taken to the field and through participatory mapping methods, delineation of land use boundaries was done. At the same time, in-depth interviews with farmers who were victims of landslides were also carried out. Questions raised regarding indirect losses such as: (1) What type of farming was implemented for 1 year?; (2) How much profit was earned for each type of plant product harvested for 1 year? And (3) How long did it take to cultivated land damaged by landslides? From these questions, we can find out how much indirect losses experienced by farmers due to landslides.

3. Results and Discussion

3.1 Identification of areas affected by landslide with UAV Mapping

The mapping used in this study was UAV technology, where the results were in the form of .jpg images. Those images were sorted, corrected its image quality, and then processed with Pix4D software. The resulting image is good, there was no split image when done photo enlargement. Figure 3 shows an example of the UAV image for a landslide area in Sukasirna whose land has now been reprocessed for agriculture by its owner. Based on the land use map before the landslide event, the current UAV image, and community participation, then the area affected by the landslide and the type of land use could be mapped (see Figure 3).

Table 1 shows the area of affected landslides for the locations of Sukasirna, Gunungsalam and Cibuntu and the types of land use damaged by landslides. Rice fields are land use that was most widely affected by landslides, followed by non-irrigated fields. While direct damage included 63 heavily damaged houses in Sukasirna, 39 houses in Gunungsalam and 13 houses in Cibuntu.

Figure 3. Image of UAV recording for landslides in Sukasirna, Gunungsalam and Cibuntu and land use affected by landslides (Source: data processing, 2018)
3.2 Agriculture in Cibanteng Village

In the study area, rice fields are the dominant land use. Farmers can plant rice twice for a year. The results of interviews with farmers and confirmed by the village head, for every 1 ha of land could produce 3500 kg of dry grain with a selling price of Rp 4,500 for 1 kg. So for 1 year, a farmer could generate a gross profit of Rp 31,500,000 per ha of land. After deducting production costs, the net profit obtained by farmers for 1 ha of paddy fields was Rp 19,610,000 for one year.

In the non irrigated fields, most farmers growed superior vegetables, such as string beans (Phaseolus vulgaris L.) and cowpea (Vigna Sinensis L.). Production of string beans reached 6 tons/ha and cowpea at 9 tons/ha for a single planting period with a selling price for 1 kg of Rp 7,000 and Rp 5,100 respectively. For one planting period, farmers earned gross income of Rp 21,000,000 and Rp 18,450,000 per 0.5 ha of land, for string beans and cowpea respectively. Net income obtained by farmers for every 0.5 ha of land after deducting production costs is Rp 21,000,000 and Rp 18,450,000 for string beans and cowpea respectively.

Table 1. Areas and type of land use affected by landslide in the study area
(Source: Data processing, 2018)

| Location   | Area affected by landslide (in ha) | Land use affected by landslide | Area (in ha) |
|------------|-----------------------------------|-------------------------------|--------------|
| 1 Sukasirna| 16.63                             | Rice fields                   | 7.27         |
|            |                                   | Non irrigated fields          | 0.54         |
|            |                                   | Settlement                    | 0.42         |
| 2 Gunungsalam| 17.89                          | Rice fields                   | 12.54        |
|            |                                   | Non irrigated fields          | 0            |
|            |                                   | Settlement                    | 0.27         |
| 3 Cibuntu  | 1.21                              | Rice fields                   | 0.78         |
|            |                                   | Non irrigated fields          | 0.17         |
|            |                                   | Settlement                    | 0.05         |

3.3 Indirect losses by landslides in tree location in Cibanteng village

Based on the area and type of land use affected by landslides, indirect total losses due to landslides at three locations in Cibanteng village can be calculated. Indirect loss calculations referred to the main agricultural economic activities that have a direct impact on the lives of those affected by the disaster.

Table 2. Total indirect losses by landslide for tree location in Cibanteng village.
(Source: Data processing, 2018)

| Location   | Land use affected by landslide | Area (in ha) | Commodity plants | Price/kg (Rp) | Losses during the incident (Rp) | Losses after landslides (Rp) | For one planting time | Total losses for 2.5 years |
|------------|-------------------------------|--------------|------------------|--------------|--------------------------------|----------------------------|----------------------|--------------------------|
| 1 Sukasirna| Rice fields                   | 7.27         | Rice             | 4,500        | 114,502,500                    | 71,282,350                 | 399,631,900          |                          |
|            | Non irrigated fields          | 0.54         | String beans     | 7,000        | 22,680,000                     | 7,938,000                  | 54,432,000           |                          |
| 2 Gunungsalam| Rice fields                  | 12.54        | Rice             | 4,500        | 197,505,000                    | 122,954,700               | 689,323,800          |                          |
|            | Non irrigated fields          | 0            | -                | -            | -                              | -                          | -                    |                          |
| 3 Cibuntu  | Rice fields                   | 0.78         | Rice             | 4,500        | 12,004,200                     | 4,637,100                 | 30,552,600           |                          |
|            | Non irrigated fields          | 0.17         | Cowpea           | 4,000        | 6,120,000                      | 5,852,250                 | 31,212,000           |                          |
|            | Total indirect losses         |              |                  |              | 352,811,700                    | 31,212,000                | 1,205,152,300        |                          |

Table 2 shows the total indirect losses due to landslides in 3 locations in Cibanteng village. Table 2 shows the total indirect losses due to landslides in 3 locations in Cibanteng village. The calculation of
indirect loss consists of, first, losses due to damaged agricultural land. Farmers lost income from sales and production costs that have incurred. Second, farmers suffered losses because they lost the income they should get until the land can be cultivated, at the latest 2.5 years.

In Sukasirna, indirect losses at the time of the incident were recorded at Rp 137,182,500 (about US $ 9799) and Rp 453,955,700 (US $ 32,425) for 2.5 years. While in Gunungsalam was Rp 197,505,000 (US $ 14.107) and Rp 689,323,800 (US $ 49,237). Total indirect losses for 3 locations, could be valued at Rp 352,811,700 at the time of the landslides occurrence and Rp 1,205,152,300 (US $86,082) for the indirect losses in 2.5 years.

The results of this calculation can certainly be a reference in assessing indirect losses due to landslides in other areas. The absence of compensation from the local government for indirect losses certainly has an impact on people and their families. Most of the affected people could be categorized as low-income families [5], so landslides can trigger the impoverishment of affected peoples.

The results of the interviews showed that most people continued to work in the agricultural sector as farm laborers in the surrounding area. Some others work in the building sector outside the village of Cibanteng. At the time of this study, in Sukasirna, the community had reprocessed damaged land to be planted with vegetables.

4. Conclusion

Image recording using the UAV (unmanned aerial vehicles) could clearly and accurately map the affected landslide area. Based on an archived land use maps, UAV images and community participatory mapping, delineation of affected areas and types of land use can be mapped. Then, through interviewed with peoples affected by landslides and confirmed with the village head, the economic value of rice and non irrigated fields farming could be calculated. The results of the assessment show that the value of indirect losses that occurred in 3 locations affected by landslides reached Rp 352,811,700 (US $ 25,200) in the event of a landslide and Rp 1,205,152,300 (US $ 86,082) for indirect losses in 2.5 years. This value can be a reference for assessing indirect losses in other areas.

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