Landslide Susceptibility of Agricultural Area in Lembah Gumanti, Solok - West Sumatra Province

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Abstract. One of the factors that threaten food resilience in Indonesia is the natural disasters such as landslides. Cultivation of agricultural crops in hilly terrain with fairly steep slopes and high rainfall without regard to land conservation and good farmland cultivation practices will result in landslide disaster that could damage the irrigation and agricultural land. Soil movement is a consequence of natural dynamic phenomenon to reach new condition due to disturbance of balance in environment, either by natural or by human activity. Movement of the ground will occur on a slope, if there is a state of imbalance that causes the occurrence of a mechanical process, resulting in a part of the slope moving according to the force of gravity. The process of ground motion involves complex interactions between geological, geomorphological, hydrological, rainfall and landuse aspects. A research about landslide susceptibility of agricultural area has been conducted in Lembah Gumanti, Solok, West Sumatra Province. The research show that from the total area of 24,294 ha, high vulnerability zone is about 903 ha (4%), medium vulnerability zone is 6,913 ha (28%), and low vulnerability zone 16,478 ha (68%). Landslide vulnerability in agriculture area potentially arise on dry land farming (525 ha), paddy field (3 ha) and mixed garden (375 ha).

Keywords: Landslide; Food Resilience; and Solok

1. Introduction
From long time ago, farmers have settled and used hilly areas to fulfill their daily needs and support the family's economy by cultivating horticulture, plantations and food crops. The use of hilly land by farmers can lead to natural disasters such as landslides that will affect sustainable agricultural land. In this area the farmers mostly cultivate horticulture in hilly land with fairly steep slopes and high rainfall without regard to the principle of land conservation and cultivation procedures for sustainable agricultural land in the hilly area [1, 2, 3, 4].

The cultivation of agricultural land in West Sumatra also utilizes hilly land. One of the locations of the hilly farming system is in Lembah Gumanti District, Solok Regency. In this sub-district, there are four villages: Alahan Panjang, Sungai Nanam, Salimpat and Aie Dingin, where most of the population work as farmers that cultivate several types of horticultural crops. Landslides have occurred several times in this area which have caused land damage, such as loss of forest areas, damage to agricultural land and crop failure.

Identification of landslide susceptibility was considered necessary to avoid disasters and to design conservation systems for sustainable agricultural cultivation. The study entitled "Landslide Susceptibility of Agricultural Area in Lembah Gumanti, Solok - West Sumatra Province" has been carried out with the aim of finding out ar
eas that have potential landslides in Lembah Gumanti District in Solok Regency in order to maintain sustainable agricultural land.

2. Methods
This research was conducted in Lembah Gumanti Subdistrict, Solok Regency, while data processing was carried out at the Laboratory of Agricultural Management and Geographic Information Systems, Faculty of Agricultural Technology, Andalas University, Padang.

The material used in this study is an administrative map of Gumanti Valley, DEM maps that are utilized for making slope maps, land use maps, soil type maps, and the last 10 years rainfall data and lithology maps, ArcGIS software, GPS and others. The initial step taken for this research is the preparation of a basic map that includes information on the location of the study, administrative maps, maps of soil types, land use maps, lithology maps, rainfall maps and DEM map analysis. The last 10 years of rainfall data form the basis for making rainfall distribution maps using the Polygon Thiessen method. Thematic maps that have been collected and created were scored and weighted according to the indicator parameters as stated [5].

Landslide vulnerability was categorized into 4 classes, namely: (1) High ground movement vulnerability zone, (2) Middle ground movement vulnerability zone, (3) Low ground movement vulnerability zone, (4) Very low ground movement vulnerability zone. Field observations were also made to validate the results of the analysis with the actual conditions in the field.

3. Results and Discussion
Lembah Gumanti is one of the sub-districts located in Solok Regency, West Sumatra, Indonesia. Lembah Gumanti Sub-District has a total area of 24,293 ha, where the area is divided into four villages, including Aie Dingin, Salimpek, Sungai Nanam and Alahan Panjang. The sub-district is about 65 km from the city of Padang, and located on the eastern slope of the Kerinci Seblat National Park. Geographically, the research area is located between 00°59’0”–01°13’0” South Latitude and 100°042’0”–100°056’0” East Longitude, with altitude is about 1,400 to 1,600 meter above sea level.

The annual rainfall was 2,837 mm, that was calculated from 2 rainfall stations that represented this research area. In Lembah Gumanti there are two types of soil, namely Gley Humus soil and Cambisol soil, where the Gley Humus soil is categorized as class of soil sensitivity to low landslides and Cambisol soil is classified as medium category. There are 4 rock types in this area, namely intrusive, sedimentary, volcanic and acidic volcanic rocks.

Intrusion rocks and acidic volcanic rocks are categorized as low sensitivity to landslides while sedimentary rocks are in the category of sensitivity to moderate landslides, and volcanic rocks have a sensitivity to high landslides. Sedimentary rocks have the largest area, where these rocks have a tendency to moderate landslides, so if these sedimentary rocks are in steep slopes, they can endanger volcanic rocks, if sedimentary rocks and volcanic rocks are found in areas that are inflated and not accompanied by plants that have strong roots, landslides can occur if rainfall in the area is high.

Land use in the study area is generally dominated by forests, where protected forests have an area of 9,420 hectares and 2,514 hectares of forest, this is because the study area is in the Bukit Barisan area. The agricultural land in the study area is also categorized as large. where the agricultural land is divided into 4 namely mixed gardens, horticulture land, dry land agriculture and wetland agriculture.

Lembah Gumanti Subdistrict is more dominated by 15-45% slope class which covered 13,172 ha or more than 50% the area of Lembah Gumanti Subdistrict. Slope > 75% had an area of 1,025 ha, where this area needs to be considered as a conservation zone to avoid landslides that will negatively affect the environment.

To get a understanding about the level of landslide vulnerability in the study area, thematic maps (rainfall, soil type, lithology, land use and slope) that have been given scores and weights were overlayed together. Spatial analysis of landslide vulnerability showed that in the study area there were 903 ha of areas classified as areas with high landslide vulnerability, about 7,496 ha area with medium landslide vulnerability and 15,894 ha areas with low vulnerability (Tabel 1).
Refers to landuse in the study area, dry land is the area with the highest vulnerability of landslide in the study area, which is 525 ha, while for the vulnerability of medium landslide, dry land also occupies the widest area of 3,484 ha. Medium landslide vulnerability was more dominated by agricultural land such as dry land agriculture and mixed gardens. Dry land agriculture and mixed gardens has the largest area at the level of medium landslide vulnerability compared to low landslide vulnerability.

| Landuse       | Landslide Susceptibility Level (ha) | Total  |
|---------------|-------------------------------------|--------|
|               | High | Medium | Low   |
| Forest        | 0    | 1,759  | 10,176| 11,935|
| Mix Farming   | 375  | 2,174  | 2,026 | 4,575 |
| Holticulture  | 0    | 8      | 450   | 458   |
| Settlement    | 0    | 56     | 219   | 274   |
| Wet land      | 3    | 15     | 11    | 29    |
| Dry Land      | 525  | 3,484  | 3,012 | 7,021 |
| Total         | 903  | 7,496  | 15,894| 24,922|

The use of agricultural land in relation to surface flow and sedimentation, as well as land damage such as landslides, where such damage occurs in land clearing and processing of the land, land clearing is often carried out less in accordance with rules such as the application of conservation rules and the fields are steep slopes. In dry land agriculture, farmers cultivated horticultural crops such as shallots, tomatoes, and vegetables, while for mixed garden was located at this level of high landslide vulnerability covering an area of 375 ha and wetland agriculture such as rice field was about 3 ha. The high landslide vulnerability is dominated by agricultural land, where in this area need to be wary of both in terms of conservation and land use.

Mostly landslide occur in dry land and mixed farming area [6, 7], while cropping systems with agroforestry models are able to absorb water optimally and use it efficiently [8]. The concept of water balance in agroforestry places agroforestry in a strategic position to reduce the chance of the role of water in the occurrence of landslides. The type of vegetation recommended by the World Bank in the development and management of land in landslide areas prone to landslides is trees that can produce fruits and candlenut trees. Whereas in protected areas planted with vegetation or trees that are in accordance with local conditions such as acacia, pine, mahogany, johar, teak, pecan, and resin.

4. Conclusion

High level landslide susceptibility area in Lembah Gumanti Subdistrict covered an area of 903 ha, while medium level landslide susceptibility area was 7,496 ha and low level landslide susceptibility area was 15,894 ha. High level landslide susceptibility occured mostly in the dry land (525 ha) and mixed garden (375 ha), while other landuses contributed to medium level of landslide susceptibility.

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