Fuzzy logic for landslide susceptibility level in kecamatan Ungaran Barat

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Abstract. Landslide is one of the disasters that often happened in Indonesia. A way to prevent the damage effects of landslide is maping potential landslide areas. The purposes of this study is leveling of landslide susceptibility in Ungaran Barat based on geographic-topography condition by using fuzzy logic developed in MATLAB. The geographic-topography conditions used as input variables are rainfall quantity, land slope, and soil type. This research was started by choosing geographic-topography data, studying their correlation to landslide susceptibility, and then developing fuzzy logic, finally building a program for getting the level of landslide susceptibility of each observed area. Fuzzy logic developing consisted of fuzzyfication, fuzzy rule preparation, inference engine preparation, and defuzzification. In this fuzzy logic, the fuzzy rules were constructed by IF-THEN relations, the fuzzy method was Mamdani with centroid defuzzification method. Result showed that there were two levels of landslide susceptibility, *i.e.* no risk and low risk.

1. Introduction

One of the disasters that often happens in Indonesia is landslides. This is provable with data from the badan nasional penanggulangan bencana (BNPB) as national disaster management agency which stated that there had been 4947 landslides between 1815 to early July 2018 [1]. The occurrence of landslides in Indonesia in 2015 was divided into five big provinces: Central Java with 389 incidents, East Java with 307 incidents, West Java with 220 incidents, West Sumatra with 96 incidents, and Aceh with 90 incidents [2].

Kabupaten Semarang is an area with a high-risk index of landslides [3]. This is because the region has a high area and a type of land that moves easily due to a fault or shift of the main rock forming the soil. One of the kecamatan that often faces the landslides is Ungaran Barat. This is provable from the number of disasters, six times in 2016 [4], and once in 2017 [5]

There are many effects of landslide, like the loss of life, loss of property, environmental damage, and psychological impacts. One effort to face the danger of landslides is mapping potential landslides areas that could be done with a decision making system using fuzzy logic. This process has been done in various regions, such as Kabupaten Probolinggo [6], the mountain area of Fruska Gora, Serbia [7], the Pukhtun Khawa area, Pakistan [8], and Mazandaran, Iran [9]. Fuzzy logic is used in every part of our life like economy, health, industry, *etc* [10]. It is not only used in every part of daily life, but fuzzy logic is also used in every system to help with controlling and decision making. For example, fuzzy logic is used in control center saving, energy [11], control MPPT solar sel [12], and controlling system power [13]. Meanwhile, the applications of fuzzy logic to decision making are the classification level of a

stroke [14], deciding the center location of a veterinarian [15], and evaluating the service quality of a company [16].

This study focuses on making potential landslide maps in Kecamatan Ungaran Barat, using topographic and geographic data processed with fuzzy logic on MATLAB. The results of this study are expected to help inform people about the level of landslides in Kecamatan Ungaran Barat.

2. Methodology Research

In this study, the five input variables are rainfall, height, land slope, population density, and soil type.The one output variable is landslide level. Data for the input come from Semarang Regency Statistics Agency and Semarang District Public Works Agency. Then, the values are inserted into MATLAB, a process which includes selection of fuzzy methods and defuzzification, inputting the boundary values of each variable level, inputting fuzzy rules, and running programs. The membership functions used are shoulder function and trapezoid, Also, 3125 fuzzy rules are used. The rules are based on **IF-THEN** rules as a result of expert knowledge in landslide susceptibility.

3. Result and Discussion

The level of susceptibility of landslides in a region is determined based on the geography and topography. In other words, an area that has high rainfall will also have high potential for landslides [17]. Consequently, based on the height, the higher the area is the greater the potential for land falls or landslides [18]. The slope of a land also impacts its susceptibility to landslides because steep slopes or cliffs have a greater thrust [19]. Furthermore, population density and soil type also play a role in determining the level of susceptibility to landslides. The denser area has a higher potential for landslides [19], and areas with easily decayed soil types will have a high potential for landslides [17].

The classification of landslide susceptibility levels based on a combination of geographic and topographic conditions is carried out by combining **IF-THEN** rules from five variables used, namely rainfall, altitude, land slope, population density, and soil type. Combining these rules can result in as many as 3,125 rules. These rules are run with MATLAB software using fuzzy method selection, defuzzification method, trapezoidal representation, and AND operator. The results of this processing can be seen in Table 1, and the level of landslide susceptibility based on a combination of the five variables is shown in Figure 1.

Table 1. Results of Fuzzy Processing Based on Combined Geographic and Topographic Conditions.

Village	Rainfall (mm/tahun)	Altitude (m)	Slope (%)	Population Density per km^2	Soil Type	*Fuzzy* Output	Level of Susceptibility
Branjang	2750	454	20	736.49	15	11	Low
Kalisidi	2750	573	20	75.,04	15	11	Low
Keji	2750	392	20	1380.01	15	11	Low
Lerep	2750	409	43	1604.87	15	15	Medium
Nyatnyono	2750	512	43	1855.76	15	15	Medium
Gogik	2750	477	43	2378.94	15	15	Medium
Candirejo	2750	378	11.5	3902.75	15	11	Low
Langensari	2250	441	11.5	6437.13	15	11	Low
Bandarjo	2750	308	4	3396.89	35	11	Low
Ungaran	2750	321	4	7063.25	35	15	Medium
Genuk	2750	334	4	6319.06	15	11	Low

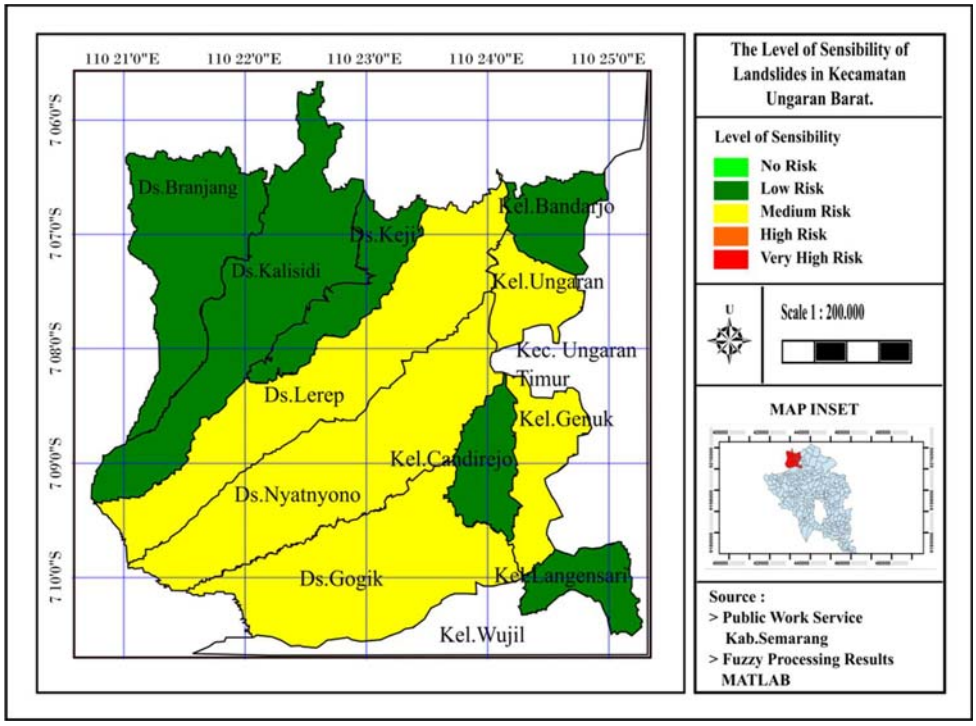

Figure 1. The Level of Susceptibility of Landslides in Kecamatan Ungaran Barat.

The results of this study are important to help inform people about the level of landslides in Kecamatan Ungaran Barat and to anticipate by preventing the damage effects of landslide. Then, to verify the truth of landslide vulnerability level map in Figure 1, the results were validated with existing data. In Semarang, the Badan Penanggulangan Bencana Daerah (BPBD) as district disaster management agency has landslide data on each sub-district each year. The journal published in January 2019 states that Kecamatan Ungaran Barat has two levels of landslide disaster risk, namely low and medium levels. In this journal, mapping is based on geographic information systems by validating data in the field. The validation process was done by comparing the landslide threat and mapping data with field data that aims to determine the suitability of processing with field conditions. Area that was chosen as the sample is a region that ever face landslide with assumed have medium or high level. So, if the results of processing at that point have a medium or high level, it meant the area was suitable, reflecting the conditions in the field. Determination of validation points using the cluster sampling method in areas that landslides often occur in 2016 and 2017 was based on recapitulation data of from BPBD Semarang Regency [20].

4. Conclusion

Landslides are the one of disasters that often happen in Indonesia. One of the area that is often hit by landslides is Kecamatan Ungaran Barat. One of the efforts to face these disasters is mapping the potential landslide areas. This mapping can be made using fuzzy logic based on the geographic and topographic conditions that impact landslides. Data for geographic and topographic conditions came from related agencies, such as the Central Bureau of Statistics and the local Public Works Agency. Based on the geography and topography in Kecamatan Ungaran Barat, there are seven villages or kelurahan with low landslide susceptibility (Branjang, Kalisidi, Keji, Candirejo, Langensari, Bandarjo, and Genuk) and four villages or kelurahan with medium landslide susceptibility (Lerep, Nyatnyono, Gogik, and Ungaran). The results of this study are important to help inform people about the level of landslides in Kecamatan Ungaran Barat and to anticipate the landslide damage effects.

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