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Identification of Potential Landslide Using Remote Sensing and Geographic Information System in Upstream of Kayangan Watershed, Kulonprogo Regency, Indonesia

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Abstract**:** *Landslides occur every year in Indonesia, especially in watershed upstream. Landslides often occur in the rainy season due to rain triggered landslides through additional burden resulting in decreased soil slope. The combinations of natural and human factors cause landslides that casualties and property losses. Mitigation measures required to minimize the impact of landslides. Making the distribution of zoning areas that have spatial landslide susceptibility can help mitigate the areas that have slope more than 25%. In addition to other factors slope conditions affecting, among others, the average of rainfall over 2000 mm/year, the type of land cover/land use, elevation, rock structure or geological process, landform and soil conditions are unfavorable. The purpose of the research is to make early predictions of the level of vulnerability to landslides in the Kayangan Watershed in Kulonprogo Regency. SRTM imagery resolution of 90 meters which is used to determine the parameters of altitude and slope, land use parameters taken from topographic map of Indonesia (RBI), and the stream buffer parameters are determined using Geographic Information System (GIS). Results prediction of landslide susceptibility in the form of maps showing the spatial distribution of potential landslides is made with a specific method of weight evidence and methods of overlay.*

Keywords: *Kayangan Watershed, Landslide, Remote Sensing, GIS*

1. Introduction

Landslides are one of the frequent natural disasters in Indonesia. The hills area in Java resulted in substantial losses in terms of the economic side and the disruption of people's daily activities. Land use that is not in accordance with its designation as well as high intensity of human activity in changing land use would increase the level of risk in landslide vulnerable areas. This disaster is a natural phenomenon that influenced by several human activities that cause land instability. Natural disasters are natural events that are caused by processes that occur naturally or proceeded by human action and pose a risk or hazard to human life (Sutikno, 1985).

Study area is in Kayangan watershed that dominated by hilly relief so natural process that occurs is affected by gravity. In the case of a landslide that occurred in the watershed of Kayangan, gravity is the dominant factor affecting the materials move down a slope towards more flatty areas. Materials that are on the field that tends to slant generate gravitational force is not perpendicular to the surface, so that the gravitational force is divided into two components of force, which is the normal force perpendicular to the surface and the force acting in the direction of the sloping surface (Okarina, 2013). Level of susceptibility will increase the incidence of landslides during the rainy season, because the land mass will be heavier and stability disturbed.

Utilization of remote sensing data and geographic information systems can provide a good picture of the earth's surface with the scale as far as possible. It can be used to provide disaster information; the spatial

presentation can be easier to determine the distribution of landslide occurrences. The information presented is spatially very beneficial because the community disaster-prone location can directly recognize the environmental conditions are prone to disasters (Okarina, 2013).

The purpose of this study was to determine the distribution of the level of susceptibility to landslides that occur in the Kayangan watershed and the factors that cause a landslide. By making landslide susceptibility mapping can provide information about the potential landslide areas based on their level. In addition, this information can be used for landuse planning decisions based on Kayangan watershed to reduce the impact of disasters caused by landslides.

2. Materials

2.1 Natural Disasters and Susceptibility

According to the Head of Disaster Management (BNPB) Regulation No. 4 of 2008, disaster is an event or series of events that threaten and disrupt the lives and livelihoods caused, by natural factors and/or non-natural factors and also human factors that result in human fatalities, environmental damage, loss property, and psychological impact. Meanwhile, Verstappen (1983) divides the natural disasters on the basic of the causes, namely: a) natural disasters caused by exogenous processes, among others: floods, erosion, and soil or rock mass movement; b) natural disasters caused by endogenous processes, among others: volcanic activity and earthquakes; c) natural disasters caused by anthropogenic processes, for example land subsidence due to excessive groundwater abstraction (Sutikno, 1997).

Landslides are the natural disasters caused by exogenous factors such as mass movement and gravity due to the slope factor. Susceptibility to landslides is the physical characteristics of condition of a region which causes the region vulnerable to landslides. The term of susceptibility is a stage prior to the disaster (Scheinerbauer & Ehrlich, 2004 in Sare, 2009). There are three steps to do an effort to reduce the impact of disasters, namely: understanding susceptibility (the threats) a disaster area, to understand the vulnerability of the area and do a follow-up for example by establishing an early warning system (EWS), using disaster susceptibility/vulnerability maps and others .

2.2 Landslides

Landslides are the process of moving and mass movement with sloping or vertical direction from its original position as a result of gravity (Okarina, 2013). Landslides occur because of high rainfall intensity, conditions which tilts up steep slopes, thick weathering, rocks and geological structure of varied and use less land in accordance with the characteristics of the land (Sutikno, 1994). According to Cruden and Vernes (1992), characterized the mass movement can be divided into five kinds falls, topples, slides, spreads, including lateral spreading, and flows (Hardiyatmo, 2006).

Landslides are basically caused by five factors, according Sugalang and Saingan (1991) include: geology, morphology, rainfall, and landuse (Sutikno, 2004). Geological factors include the physical properties of rocks, engineering properties of rocks, rock/soil weathering, the structure and position of rocks (stratigraphy), and geological structure. Morphology include aspects of slope and land surface. Rainfall consists of factor intensity and duration of rainfall, and landuse consists of aspects of land management and vegetation cover.

3. Methods

3.1 Location

The location of this research is in Kulonprogo Regency, Yogyakarta, Indonesia, precisely in the upstream of Kayangan watershed. In the administrative area of research is in the village Jatimulyo, Purwosari and Kebonharjo.

3.2 Data and Materials

The data used in this study include landform/geomorphological maps, Topographic maps of Indonesia sheet Sendangagung 1408-232 and sheet Wates 1408-214, landuse data, distance to rivers data, slopes/reliefs,

the distance to roads data, and elevation/height data. The tool used is a computer/laptop, software ILWIS 3.3, software ArcGIS 10.1, software Ms. Office 2010.

3.3 Work Diagram

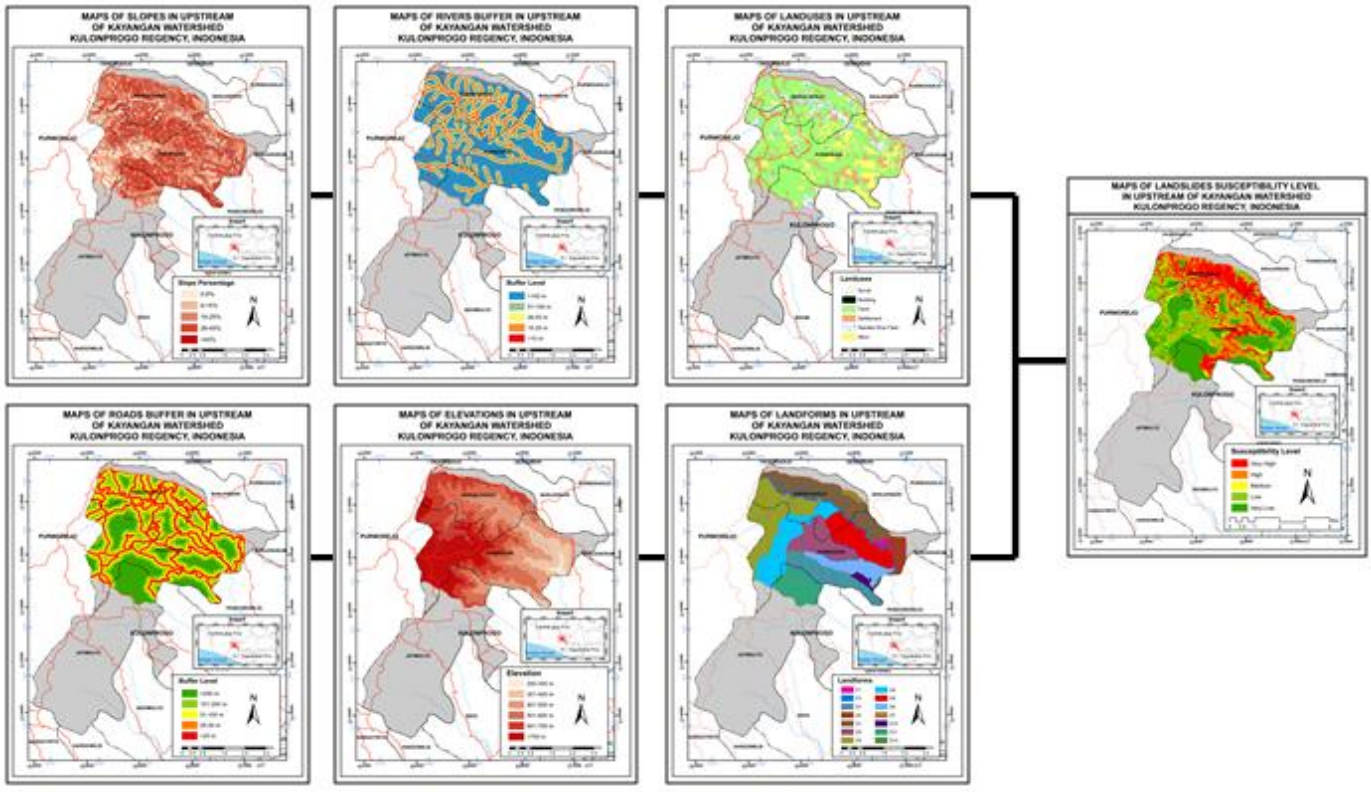
The parameters used to determine the level of susceptibility to landslides in the upstream Kayangan watershed are landuses, landforms, distance to rivers data, slopes/reliefs, the distance to roads data, and elevation/height data. The sixth parameters classifications are then given appropriate weight to its role in causing landslides. Processing is done by using ILWIS 3.3 software integrated with ArcGIS 10.1 software so as to provide an overview spatial landslide.

Data processing phase starts from the vector data conversion into raster data, create a class with a factor of landslide buffer technique, calculate the percentage of landslide with the technique of cross folder, then each class avalanche factor calculation using the Weight of Evidence ILWIS software. After all indexes factor scores then do the summation index factor to determine the level of susceptibility to landslides through the same software that is ILWIS 3.3, the formula used to add index factors:

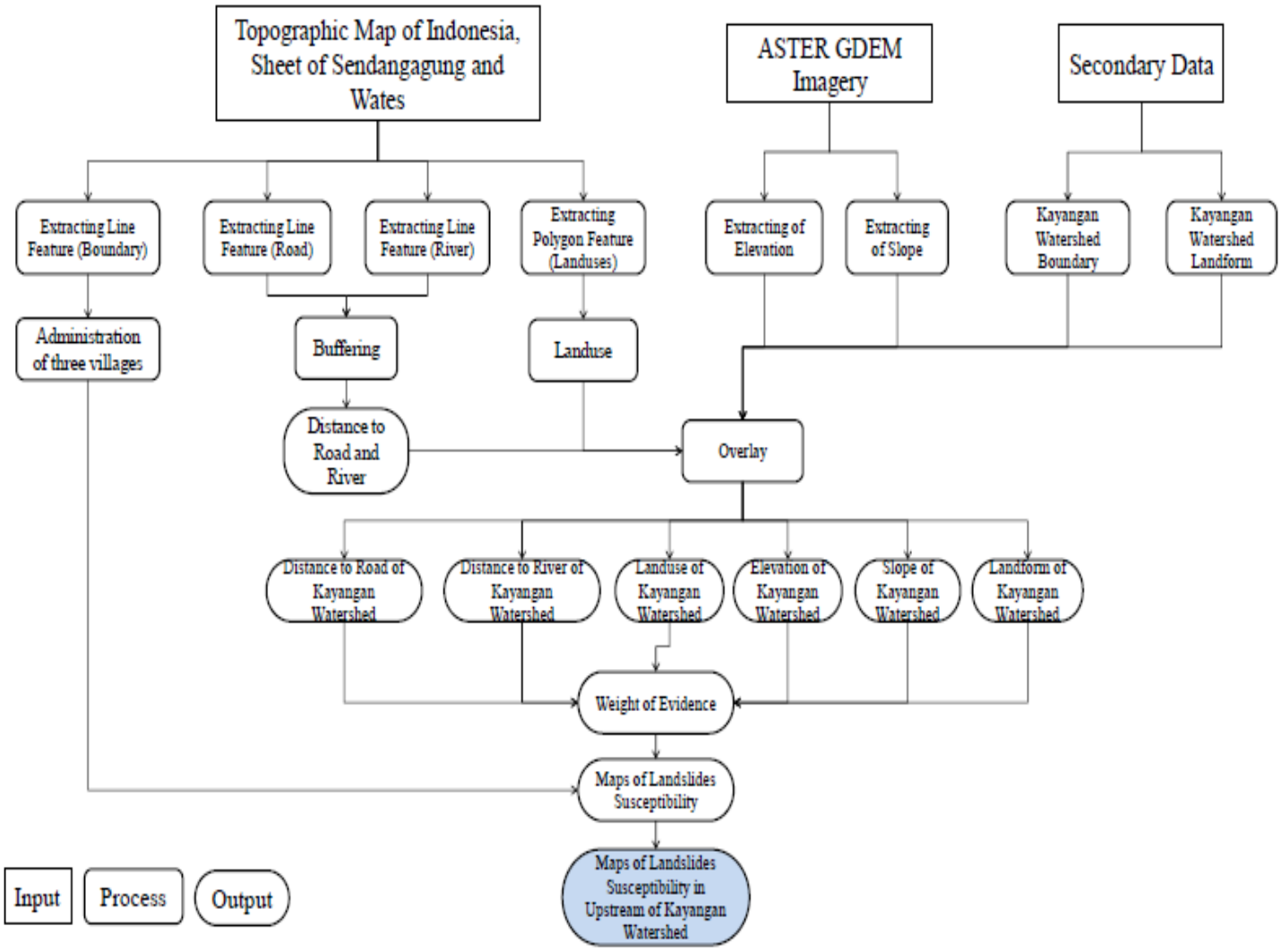
$$Susceptibility = I landform + I slope + I distance\ to\ road + I distance\ to\ river + I elevation + I landuse$$

The final stage is done to classify the level of susceptibility to landslides with slicing techniques that take into account the vulnerability index landslides which have been calculated previously.

3.4 Parameters of Landslide:



Picture 1.1 Flow Chart



4. Results

The susceptibility of existing landslides in the upper Kayangan watershed is divided into five classes are very high, high, medium, low, and very low which is influenced by the condition of the area. Landslide generally occurs in areas that have steep to very steep topography with a slope of more than 30%. Structural landforms experiencing extremely intense denudation by erosion, and the flow of water on the sliding plane is also a factor contributing to the erosion of landslides as the result becomes very easy to get carried away by the water into a relatively flat slope. Area in Kulonprogo Regency that have a potential landslide is in sub district Samigaluh and Girimulyo those supported by several factors causing landslides dominant among other landforms composed of rock that is easily eroded compiler, a fairly steep slope and landuse around it are exacerbated by their intensive infrastructure development in Kayangan watershed.

Geologically the area of this study included into the West Progo Mountains which was originally a structural landform of folding that makes up the dome. The results of the structural processes that take place has undergone a process of exogenous form of denudation processes that makes up the shape of another landform which is mountain ridge and slope denudation, the ridge slopes of the hills of the formation process is influenced by climate fluctuating changes (rainfalls and temperatures) that lead eroded rock outcrop. Bedrock constituent landforms and soils dominated by rock andesite breccia, tuff, and some are coral limestone.

Maps the susceptibility of a landslide that created the overlay method and the weight of evidence conducted to determine the degree of relatedness between potential landslides with landslide that ever happened before. The main study area on the map is in upstream of Kayangan Watershed, and the addition of administrative area as described above is to further simplify the process of analysis and assessment. On the map of landslide potential processing results indicate that the area has a very high potential in the area is the Village Kebonharjo, sub district Samigaluh, which is more than half the village area in the system of Kayangan watershed in the upstream.

The high potential for landslides in the village due to the process of assigning weights vulnerability Weight of Evidence method (WoE), almost all of the parameters that support the occurrence of landslides located in the area, such as landforms, landuse, elevation, slope, distance to the river, and distance to roads. Model of landforms that already given weight, showed the greatest weight value on landform ridge slope denudation hills composed by andesite breccia and tuff. As for the landuse, the largest is in the form of community forest/community farm. Although the forest is actually supposed to be able to prevent the occurrence of landslides, but when the forest is composed of plants that have root fibers, then it will tend to put a strain on the ground and coupled with a fairly steep slope in the area.

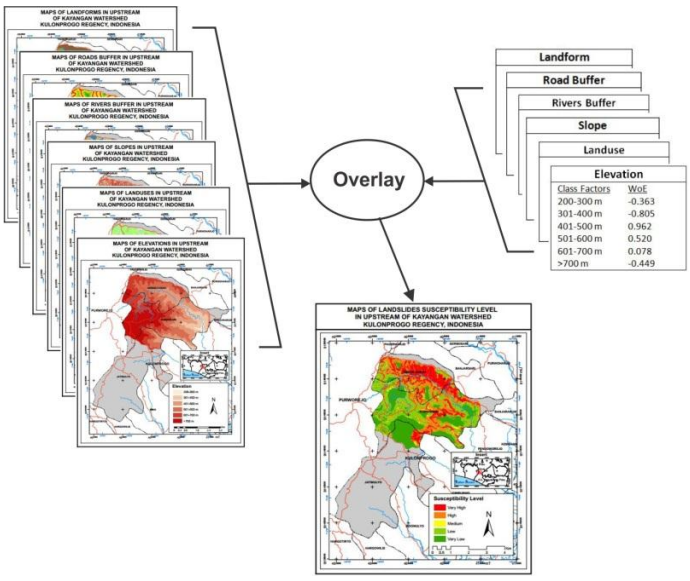


Fig 1.2 Overlays of landslide parameters

Altitude also affected, but the effect is not too large because of the altitude is generally correlated with the tilt tend steep slopes that would affect the occurrence of landslides. The use of distance to the river and the road here is a parameter that has been modified for the purposes of planning, because the distance from the river will affect the magnitude of landslides due to the slope on the river valley upstream tend to be steep when compared with the tilt of the downstream slope and distance to roads because manufacture of asphalt or concrete road use will increase the burden of the ground to trigger the movement of soil or landslides.

Low potential landslides can be seen in the western part of the village Purwosari and a bit on the northern village Jatimulyo. The low potential is due to several parameters do not support or trigger landslides as the soil load or load slope in this region is lower and coupled with the existing landform paremter also not likely to trigger landslides due ridge exposed rock hills denudation which will not grow crops but the fibrous roots are firmly rooted plants or taproot that can penetrate the rock outcrop, which can reduce the occurrence of landslides.

5. Conclusion

Locations that have the highest vulnerability to landslides is in the village of Kebonharjo, Sub district Samigaluh. The high level of susceptibility to landslides caused by almost all of the parameters that support the occurrence of landslides located in the area, such as landforms, landuse, elevation, slope, distance to the river, and the distance to the road. In areas with a high degree of susceptibility has the largest weight value in landform ridge slope denudation hills composed by andesite breccia and tuff.

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