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Research Paper

Analysis of Potential Landslides Using Geographic Information System (GIS) on Rail Tunnel in Gunung Gajah Village, Lahat Regency of South Sumatra

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Abstract
Lahat Regency is one of the cities which is prone to geological disasters such as landslides. The landslide is caused by a varied topography such as flat, hilly or mountainous. On January, 23rd 2016, the landslide occurred on the mouth of a railway tunnel in Gunung Gajah Village, Lahat Regency. The purpose of this study is to determine the influence of geological factor on the slope stability. The method of research is a survey method based on geographic information systems in the form of interpretation and analysis of the causes and triggers of landslides with a direct approach in the field by doing scoring an overlay technique. The analysis obtained the parameters of landslides such as: slope, lithology/physical properties of rocks, geological structure and land use. The results and conclusions of this research are the landslide potential distribution map in Gunung Gajah Village, Lahat Regency consisting of three classes of landslide vulnerability: low, medium and high and in the focus areas of research entering the high level of vulnerability.

Keywords
Landslides, Slope Stability, Geographic Information System (GIS)

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1. INTRODUCTION

Indonesia has known as disaster-prone country because the geography of Indonesia lies in the meeting of three tectonic plates: the Eurasian plate, the Pacific plate, and the Australian plate moving on each other. As a result of the collision between the plates resulted in the formation of subduction areas that extend to the west of Sumatra Island, the southern part of Java Island to Bali and the Nusa Tenggara Islands, the North Maluku Islands and northern Papua, so Indonesia is a country prone to geological disasters (BNPB 2012). Lahat Regency is one of the cities that are vulnerable to geological disasters such as landslides (Taufik Toha, 2017).

Lahat city has a topography of the slope that varies from flat, hilly, to the mountains that extends to the Bukit Barisan with the highest peak of Mount Selero with an altitude of approximately 954 meters above sea level (Misdiyanto, 1992). (Regional Development Planning Agency of Lahat Regency 2011). On January 23th, 2016 the landslide occurred in the mouth of the tunnel in Lahat - Lubuk Linggau and Lubuk Linggau - Palembang railway tracks precisely in Gunung Gajah Village Lahat district and luckily at the time of the incident there was no train passing so that the avalanche material that closed the train immediately cleared immediately (Figure 1).

The problem of analysis this research is how to analyze the impact of geology aspect to slope stability and a common dominant factor which influencing landslide event (Bieniawski, 1989). The purpose of this research is to analyze the root of cause from landslide event and also to identify the potential landslide area which will be presenting on a map of interpreting potentially landslide area within the research location (Dibyosaputro, 1999). The Advantages of this research is to identify the natural sign of early-stage land movement, therefore trigger action can be taken by peoples and also to explain the general picture of implementation both of geological sciences and geology technic in the real field.

The Scope of Analyses this research referring to study of case landslide analyses in the gateway of train tunnel based on geological aspect ; observation of exposure rock, stratigraphy column, observing the geology structure, observing geomorphology, observing hydrogeology and interpretation of geology based on analysis os GIS and geotechnics : sampling of soil/rock mechanics and laboratory testing. The measuring of Slope geometry and also analysis of calculation slope stability

Figure 1. Avalanches in the Mouth of the Tunnel Gunung Gajah, Lahat Regency

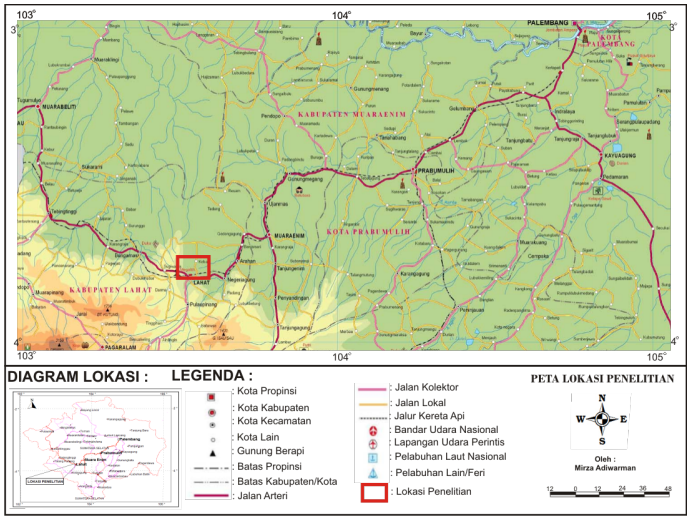

Figure 2. Map Of Research Location

2. EXPERIMENTAL SECTION

This research was conducted around railway tunnel which administratively included in the district of Gunung Gajah, Lahat Regency, South Sumatera Province where geographically located at coordinates 335500 - 336200 N and 9580500 - 9580500 E. The implementation time of the research was conducted in March-May 2016. Activities which taken are the direct observation of the location of research and data retrieval also.

The research method used is descriptive research by a survey on the field and quantitative analysis. Survey method is done by observation directly in the field of geological and geotechnical observation. Geological observation is the observation of rock outcrop, strike/dip measurement, stratigraphy profile scaling plot, plotting location/coordinate using GPS, geomorphological observation, geological observation and hydrogeological observation and for geotechnical observation such as measurement of geometry slope, hand drilling (hand auger) and sampling soil or rock for laboratory tests. While the quantitative analysis method is used to process the data obtained from observation in the field and then analyzed the data using geographic information system (GIS) which includes determining the classification of the causal parameters of land slide, the calculation of weighting values on control factors based on ranking and followed by overlapping map (Overlay) in order to know the location of the distribution of potential areas of land movement from the results of field observations will be apply data analysis and processing using geographic information system (GIS) by determining the classification of the causal parameters of landslide and from each parameter will apply scoring of analysis (scoring), and continued with overlay map (Overlay) in order to know the location of the distribution of areas with the potential for land movement

3. RESULTS AND DISCUSSION

3.1 Geology

Based on regional geology according to Barber and De Smet (2005) the research area is included in Air Benakat Formation with lithology composed by shale inserted silt and glauconite sandstone and limestone where deposited at the neritic environment at the bottom part to the shallow marine environment at the upper part. Based on direct observation in the field there are two lithology observation locations such as the eastern location and the western location. The location of the east of the tunnel with the number of drill holes as much as 7 points, 7 test wells, and test trench as much as 6 points obtained top soil ranged from 0.20 m - 0.60 meters; soil 0.20 - 1.85 m; claystone 0.20 - 0.30 m and shale > 1.40 m.

While in the western location of the tunnel with the number of drill holes as much as 4 points, test wells as much as 4 points and the test trench as much as 1 point obtained top soil ranged from 0.10 m - 0.60 meters; soil 0.20-1.00 m; claystone 0.20 - 0.40 m and shale > 1.40 m.

Table 1. Slope class relationships with the nature of the process and conditions of the land. (source: Zuidam (1979) with Modification).

Slope Class	Process, Characteristic of Land Condition
2° - 5° (0 - 5%)	Flat or almost flat, no large erosion, can be processed easily in dry conditions.
8° - 16° (5 - 9%)	The land has a steep slope, prone to landslide hazards, surface erosion and flow erosion.
16° - 35° (9 - 17%)	Land has a steep slope up steep, often occurs erosion and movement of the soil at a slow pace. Areas prone to erosion and landslides

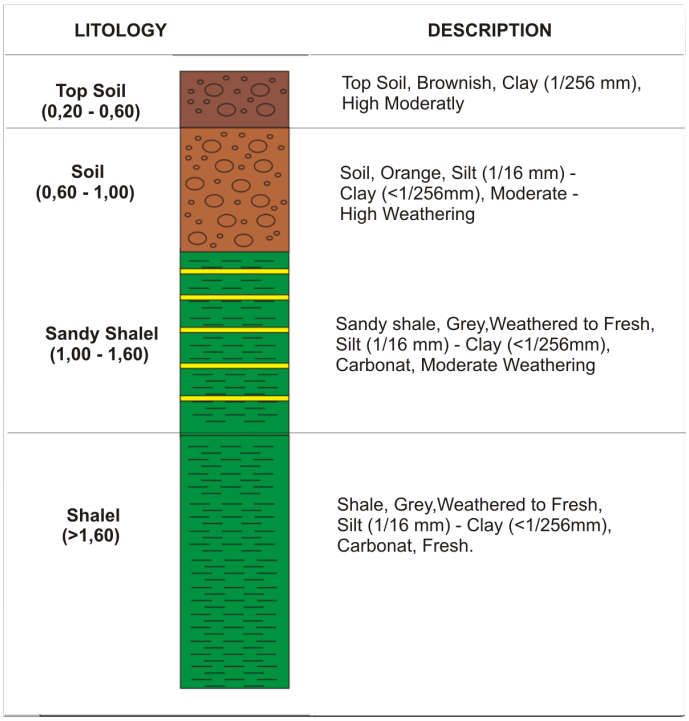

Figure 3. Rock Profile in the Eastern

3.2 Geomorphology

The slope has a major influence on the occurrence of landslides. The greater the slope value of a slope of a place the greater the potential for the occurrence of avalanches. Based on the observation and measurement of morphology in the research area and surrounding area, the slope of natural slope ranges from 25° - 40°, and the height of 10-20 m slopes. The avalanche case study takes place on a natural slope with a slip in the weathered shale layer.

Table 2. Scoring of slope can be seen on below table.(source Van Zuidam, 1985 with modification byM. Isa Darmawijaya 1990)

Slope	Criteria	Score
2° - 5°	Flat	1
8° - 16°	Medium	2
16° - 35°	Slightly High	3

Score based on a rather steep slope has a great dignity compared to sloping slopes or flat the greater the value of score the greater the effect on the occurrence of landslides. Furthermore on the extent of slope increment can be seen in (Table 2).

3.3 Rock Weathering

Weathering is a process of destruction of rocks into debris (debris) and soil (Zuidam, 1979). The type of slope in the research

Figure 4. Outcrop Rock Eastern Area

area consists of natural slopes at the top part and geotechnically slopes at the bottom part. Based on the observations result in the field, lithology in the research area consist of shale. This shale layer has a relatively strong resistance and Strength proven since built the tunnel of Mount Gajah, Lahat district in 1928. With the passage of time and influenced climatic changes such as uncertain high rainfall so that the weathering process both physically and chemically. By time process of weathering rocks initially, the upper shale rock with strong resistance and strength will be going doty and erode into a soil layer which is very potential for landslide event.

Table 3. Classification of Rock Weathering (source Bieniawski (1989))

Criteria	Lytologi type	Score
Fresh	Shale (serpih)	1
Moderately Weathered	*Sandy shale*	2
Highly Weathered	Weathered of Shale	3

Table 4. Structure of beddings Classification

Criteria	Score
Horizontal or Flat (>5°)	1
Favorable of slope (5° - 30°)	2
Unfavorable of slope (>30°)	3

Determination of Rock Weathering Classification based on the type of lithology in the study area consisting of: shale with the score 1, shale inserted by sandstone score 2 and soil produced from weathering shale with score 3 with criteria of weathering ranging from fresh (fresh), low weathered and strong weathtitleering can be seen in Table 3.

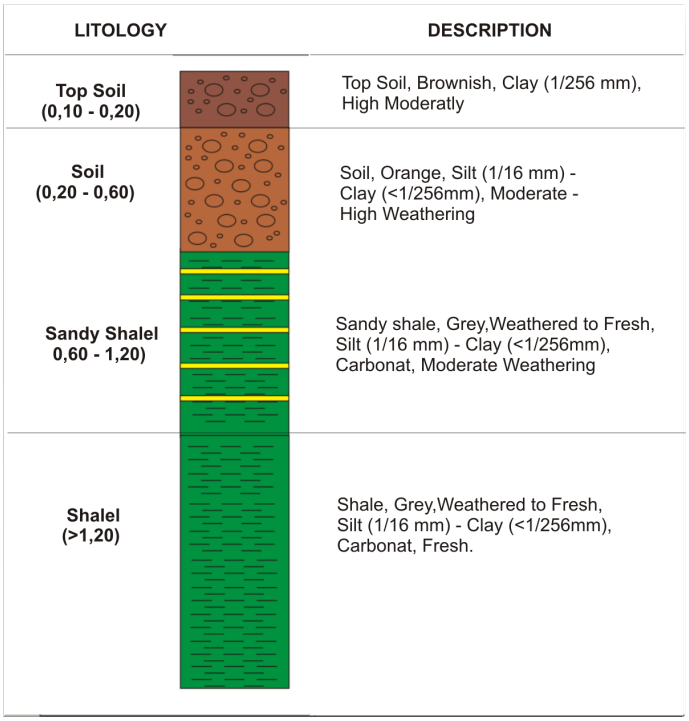

Figure 5. Rock Profile in the estern

3.4 Structure of beddings

The structure of beddings in the study area has a relatively east–west trend (strike) N 100° E and with a relative slope to the south (dip) ranging from 20° - 30°. With Trending of the slope, the layer is Horizontal/flat, opposite slope and sloping same direction with a slope.

Table 5. Land use of classification

Criteria	Score
Forest	1
Plantation	2
Settlement	3

3.5 Land Use

Land use can have a major effect on groundwater conditions, this will affect soil and rock conditions that can affect the stability of the slope. The effect may be to enlarge or minimize the sliding soil slope stress. Land use in the research area consisting of forest/ shrub, plantation, and settlement, in this case, has no significant effect on avalanche (natural). However, on the edge of the eastern slopes in the south part found residency that has potential creating landslide event. While the western area at north part found a garden that can also potentially lead to the occurrence of landslide event.

Classification of Land Use consists of: Naturally grown forest or natural forest with score 1, Plantation with score 2 and residence with the score 3. From various types of land use in research areas, Residence have the high score so that it has a major influence on the occurrence of Landslide event. (Table 5).

Figure 6. Rock outcrop in the western

Figure 7. Area Landscape Condition Research in the form of hills

Table 6. Classification of catcthment area

Criteria	Score
1000 – 2000 m3/s	1
2000 – 3000 m3/s	2
>3000 m3/s	3

3.6 Catchment Area

Catchment area can be interpreted as the area that when the rain falls then the falling rainwater discharge will accumulate and flow from a high area to a lower area. The calculation used in the determination of runoff water discharge is by Gumbel method for the 3-year rainy re-start period from 2015 to 2017. So that obtained 3 (three) locations of rainwater runoff area that is catchment area 1 east-south with the amount of water debit 3.241 m^3/s, catchment area 2 north-south with the amount

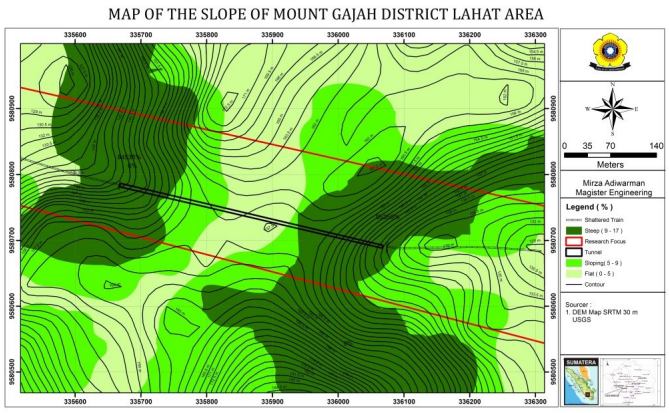

Figure 8. Slope Map Slope Area Research

Figure 10. Outcrop of Napal inserted by sandstone

Figure 9. Condition of Weathered Outcrop in the Northern Part area

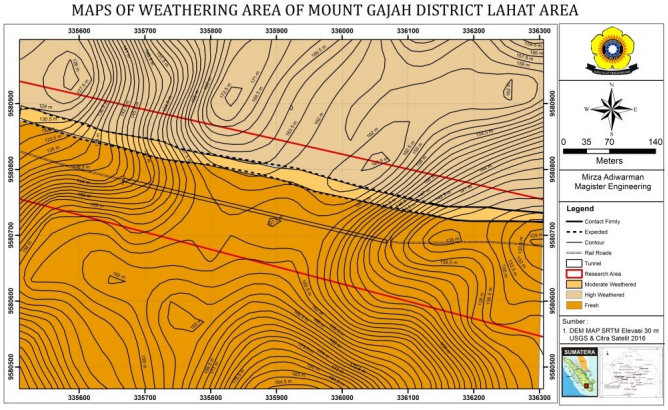

Figure 11. Map of Rock Weathering

of water debit 2,792 m^3/s and catchment area 3 west with an amount of water debit 2,039 m^3/s.

Table 7. Classification of Landslide Potential Level

No	Class	Class Interval	Hazard
1	I	4 – 6	Low
2	II	7 – 9	Medium
3	III	10 – 12	High

3.7 Analyses of Determination Potentially landslide Area

The analytical technique which used in determining the level of potentially landslide event is analysis with scoring on each parameter studied. Each parameter is given a score, the minimum score is 1 and the maximum score is 3. There are 3 parameters used as a determinant of landslide hazard. Further analysis of the determination of landslide-prone areas is with Overlapping/Overlay. Map Overlapping/overlay of this map is applied after each parameter causes the landslide event has been given a score. Then the score of each parameter will be analyzed by stories index according to the same location position (Dibyosaputro, 1999).

The calculation of the level of each class in the landslide hazard level is shown as follows: a. Number of landslide supporting parameters: 4 b. The lowest score is 1 and the highest score is 3 Thus:

$$K_i = \frac{X_t - X_r}{K} \quad (1)$$

K_i=Landslide class interval
X_t=Amount, highest value of harkat X_r=The lowest number of values K=Number of landslide hazard class desired (3)
Based on the above equations then the interval class

$$K_i = \frac{X_t - X_r}{K} = 2.6 \quad (2)$$

3.7.1 Vulnerability Zone of Small Soil Movement

1. Occupying unit of land: Flat with area 30,9%).
2. Constituent rocks: Materials that are loose soil from shale (shale).
3. Land use: Forest and Settlement.
4. Land movement does not occur.

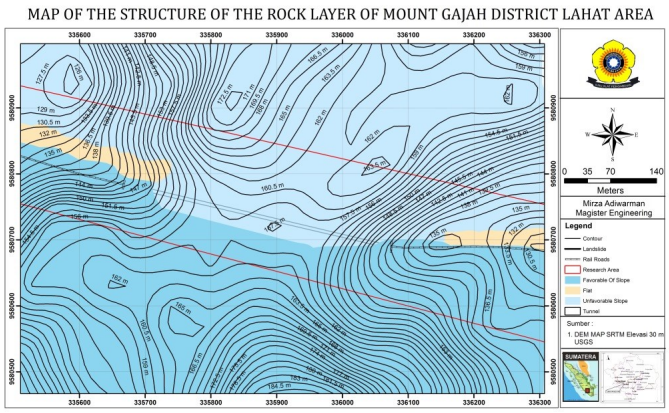

Figure 12. Structure of beddings map

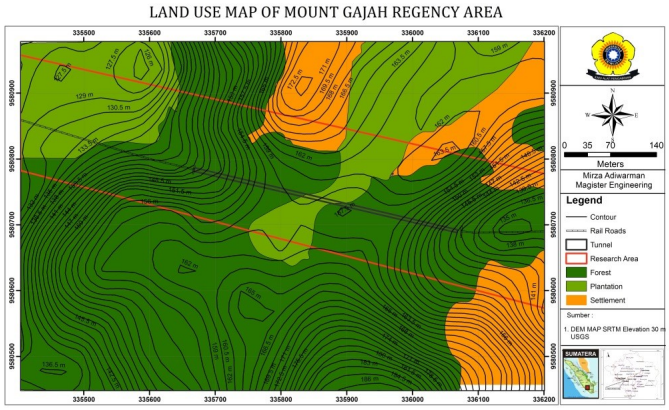

Figure 13. Land use map

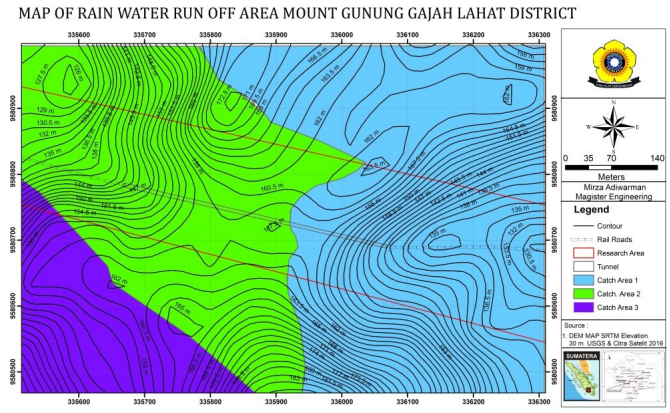

Figure 14. Catchment Area map

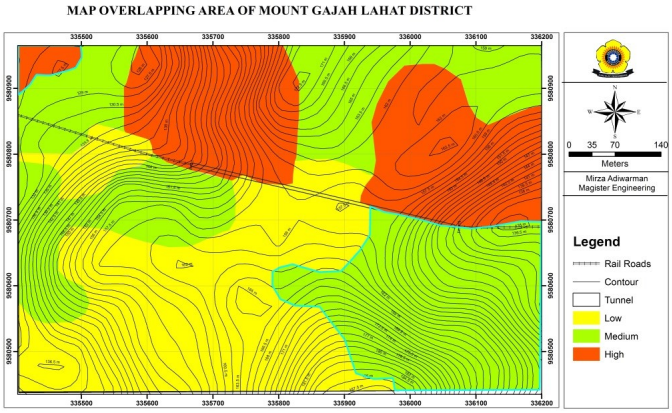

Figure 15. Map of the potential spread of landslides

3.7.2 Vulnerability Zone of Medium Land Movement

1. Occupying units of landform: hills with an areaof 2.8%).
2. Constituent rocks: Top Soil (Humus) brownish - Black, Medium - Medium, grain size - silt (<1/256 - 1/16 mm), Soil brownish brown, Medium soil, clay grain size - silt (<1 256 - 1/16 mm), shale, gray, massive, grain size (<1/256 - 1/16 mm), carbonate cement.
3. Land use: Forest, Plantation, and Settlement.
4. Soil movement may occur especially in sloped areas.

3.7.3 Highland Movement Vulnerability Zone

1. Occupying units of landform: hills with an Area of 23.8%).
2. Constituent rocks: Top Soil (Humus) brownish - Black, Medium - Medium, grain size - silt (<1/256 - 1/16 mm), Soil brownish brown, Medium soil, clay grain size - silt (<1/256 - 1/16 mm),shale, gray, massive, grain size (<1/256 - 1/16 mm), carbonate cemen.
3. Land use: Forest, Plantation, and SettlementMovement of the soil may occur especially in the slope areas by cutting roads or for plantations so that the slopes are disturbed.
4. Old soil movements can actively move again if there is a high rain trigger and a strong and intensive erosion process.

4. CONCLUSIONS

Major trigger factor which occurred on January 23, 2016, at the location of the northern eastern tunnel is due to morphological conditions which have the same trending with the slope of a layer and also influenced by geological conditions such as lithology structure which has shaly and easy to split and also consist of fractures. The Result of analysis geological influence on slope stability by using geographic information system obtained the level of potency of landslide area distribution showed that in the tunnel of Gunung Gajah, Regency of Lahat has a small, medium and high score.

5. ACKNOWLEDGMENT

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