SERIES 2

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pyBIMstab Slope Stability Analysis to Predict Landslide Coverage Area: As an Effort to Reduce Landslide Disaster Risk

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ABSTRACT
Landslides has been the most common natural disaster by far after floods and tornadoes to the last two years in Indonesia. Slope stability analysis is performed to assess the safe design of a natural slopes and the equilibrium conditions by knowing the safety factors to reduce the risk of slope areas in danger of collapse This study focuses on predicting landslide zones with the hope of accelerating landslide disaster mitigation and reducing the risk of landslide zones. We create slope plots by cross-sectional imagery of resistivity. Based on that, we compiled the slope geometry based on the soil layer and analyzed it using a new method that is with pyBIMstab software. Through this new method, the results of the analysis compared to the usual method and the result it's not too deviate. Accordingly, it will be continued with a center of mass approach to predict the range of landslide zones and the coverage areas of affected landslide zones. after finding the range, the results can be seen accompanied by help of Google Earth to find out the affected facilities and buildings. In this study, we found landslide range areas in several locations that have public facilities are densely populated and have a great risk of landslide. First area is Sukatani which has a landslide range of 24.41 meters. One of the areas that fall within the reach of landslides is one of the main public transportation lines that are often used in Indonesia, namely the train line that often operates. Second area is Sidamukti has a landslide range 60.69 meters. As seen from google earth, disaster mitigation obtained through the coverage area in Sidamukti will prevent around 32 houses and public facilities from being damaged in the event of a landslide in this area. Third area is Pasirjambu has a landslide range of 88,393 m. In this coverage area there are settlements, rice fields, cemeteries and highways. If there is a landslide, there is likely damage to about 29 buildings. Based on our research, it can be concluded through pyBIMstab software can be known landslide range distance to predict the coverage of landslide area so as to reduce the impact of damage that can occur due to landslide disasters.

Key Words: Disaster, Landslide Range, pyBIMstab, Mitigation.

1. INTRODUCTION

Geographically, Indonesia is located at the confluence of four tectonic plates, namely the Australian continental plate, the Asian continent, the Indian Ocean plate and the Pacific Ocean. This condition causes Indonesia as an archipelagic country that has the potential and is also prone to natural disasters. West Java Province is an area that often occurs landslides because the area is dominated by hills, especially during the rainy season which adds to the load on the slopes and the soil layer experiences a strong decline. Landslide is a process of slope balance disturbance that can cause the movement of soil and rock masses to move to a lower place so that the force that holds the soil mass along the slope is influenced by the physical

properties of the soil and the angle of shear resistance of the soil acting along the slope (Rizkianti et al., 2019). In most cases, rainfall-induced landslides commonly occur in cut-hillslopes, involving a huge volume of soil mass with a rapid movement (Feranie et al., 2021). The cause of landslides is the influence that causes an increase in the shear force without any change in shear strength and without any change in external conditions or an earthquake (TERZAGHI & K., 1950). Before looking for the extent of landslides, the slope safety factor in a critical condition must be modeled to determine the volume of unstable soil and landslide geometri in research area. The limit equilibrium method was used to slope stability analysis which is used to solve equilibrium equations by dividing the shear mass into slices and find factor of safety of slope area. This study will used software packages named pyBIMstab that automatically generate tortuous failure surfaces and perform 2D slope stability analysis by the LEM and also can evaluate non-circular surfaces (Montoya-Araque & Suarez-Burgoa, 2018). Center of mass approach is the end of deposit method to predict the run-out distance of landslide material which also characterized by the slope stability analysis (Firmansyah et al., 2016). This study focused to predict the runout distance of 3 landslides prone area that have public facilities are densely populated and have a great risk of landslide are the main public transportation lines that are often used in Indonesia, namely the train line that often operates, settlements, rice fields, cemeteries, highways, and public facilities from being damaged in the event of a landslide in this area. pyBIMstab is an open-source application software that was written in Python3 under the object-oriented paradigm for applying LEM through the general limit equilibrium (GLE) formulation with the aim of evaluating the slope stability consisting of either bimsoil\bimrock or homogeneous materials, it means, tortuous or circular surfaces (Montoya-Araque & Suarez-Burgoa, 2018). Slopes that can be composed by different types of soil materials can be defined by modeling using these pyBIMstab and the results of safety factors obtained provide relative results through this method compared to previous modeling methods that can use other software. By knowing the runout of distance using LEM method using pyBIMstab and Center of mass approach method, it can be a disaster mitigation in this research area.

2. METHODS

This research is located in three places in West Java, namely Sukatani (Purwakarta Regency), Sidamukti (Bandung Regency), Pasir Jambu (Bandung Regency). This area was chosen to be our research location because in the first area, namely Sukatani, it is very close to the main Sukatani-Ciganea railway line which is prone to subsidence so that the train line could be stopped and this is detrimental to public activities. In the second area, namely Pasirjambu, which is a slope adjacent to the highway as well as residents' houses and if this avalanche occurs it can hit the road and dozens of houses around the landslide area. And the third area, namely sidamukti where this area has experienced landslides before so that it is prone to medium to high landslides, this location has a lot of local residents living so it is very dangerous if an avalanche does occur.

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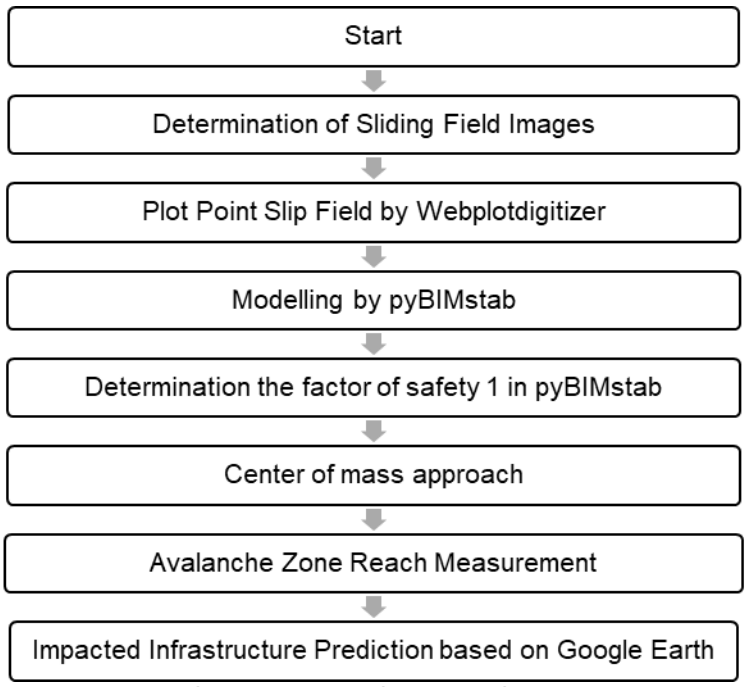

Figure 2: research stage scheme

We used secondary data of soil physical parameters and cross-sectional images. The data processing stage was first carried out by taking the coordinates of the slope points based on their elevation using a WebPlotDigitizer as the first step in modeling the slip plane. These coordinate points will be downloaded in the form of a Microsoft Excel file in the form of a column of x and y coordinates to be transferred to the pyBIMstab programming language. In addition to point coordinates, physical parameters of the soil used are also needed, namely cohesion, soil density, and shear angle. The modeling is made with an entry-exit model and setting the groundwater level to make the factor of safety is 1. After the factor of safety is obtained is 1, the avalanche-prone zone is seen as the first step in predicting the range of landslides through the center-of-mass approach. Determination of the center point of this mass is done in the form of modeling so that the radius of the landslide zone coverage is obtained. From this radius, a landslide zone circle is made and it is predicted that the infrastructure will be affected by landslides at the 3 research locations.

3. RESULT AND DISCUSSION

Sukatani is one of the regions in West Java precisely Purwakarta Regency which becomes one of the public transportation lines in Indonesia, namely railways. At the research site, there had previously been an avalanche that resulted in an avalanche on the Sukatani - Ciganea train line so that the train line was temporarily unusable. After doing modeling and simulation using pyBIMstab with the safety factor is 1 which means critical, visible critical zone of avalanche marked by red lines in the image. From the results of the modeling has been predicted that the avalanche that will occur has the radius of avalanche coverage of 24.41 meters.

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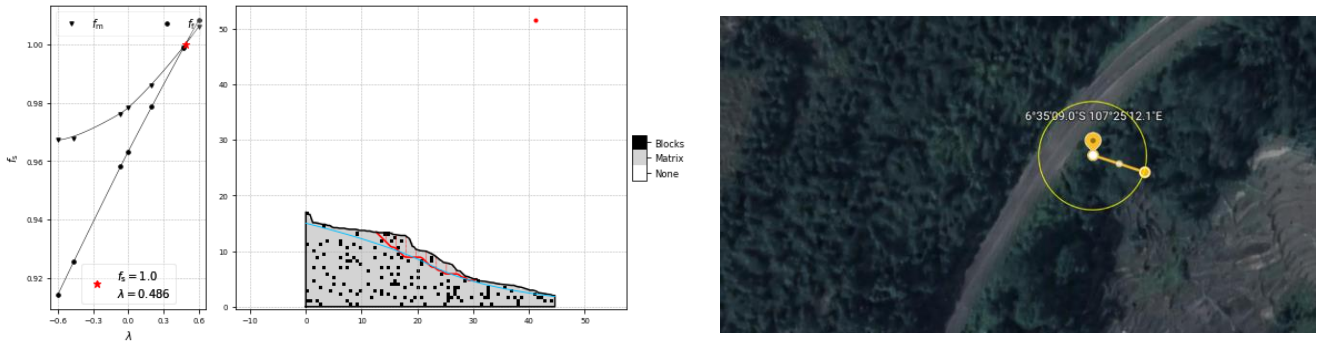
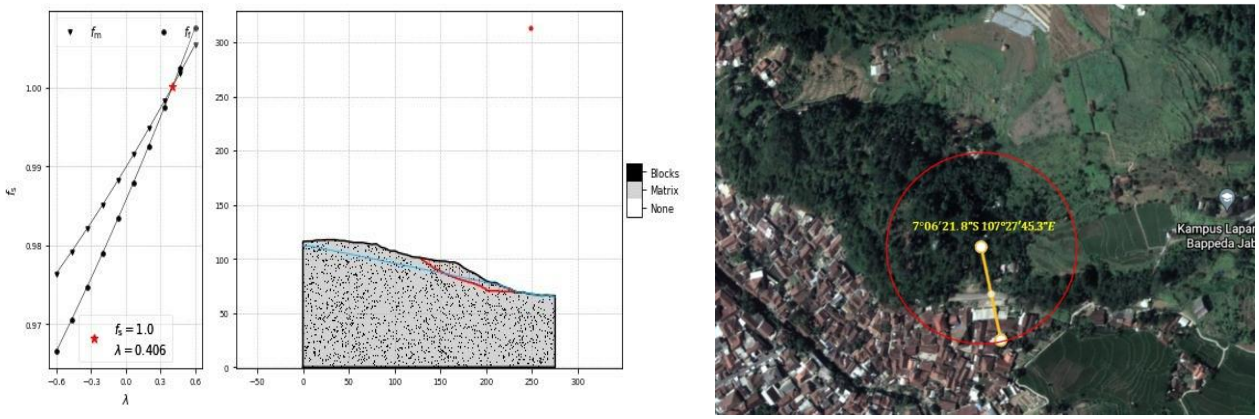


(a) (b)

Figure 2: pyBIMstab modeling results (a) and landslide area coverage (b) of Sukatani area

After analyzing landslide coverage coverage and looking at infrastructure using Google Earth imagery, the affected areas are the most important railroads. In addition to the railway line there are several areas of gardens and rice fields owned by residents who will be affected and this area is some distance from the settlement. The second area is Pasirjambu, Bandung, it is predicted that the run-out distance is 88.39 m. This distance can endanger life and property. In the coverage area there are residential houses, cemeteries, rice fields, and roads. The results of the analysis based on google earth predicted that 29 buildings could be damaged by the landslide.



(a) (b)

Figure 3: pyBIMstab modeling results (a) and landslide area coverage (b) of Pasirjambu area

The third area is Sidamukti, Pangalengan – Bandung Regency, West Java Province at coordinate point 7°10'31.4"S and 107°33'58.4"E. This area is included in the zone of medium to high earth movement potential. Pangalengan District is the area with the highest rainfall in Bandung Regency. Based on rainfall data conducted by BMKG in Pangalengan District, referring to rainfall data in Bandung Regency, the average annual rainfall is 1,718–2,603 mm/year. When viewed from a geological point of view, broadly speaking, the research location is composed of old, unresolved volcanic herbaceous sedimentary rocks in the form of fine and coarse dacitan hamblur tuff, tuffaceous breccia containing pumice and old andesite-basalan lahar deposits.

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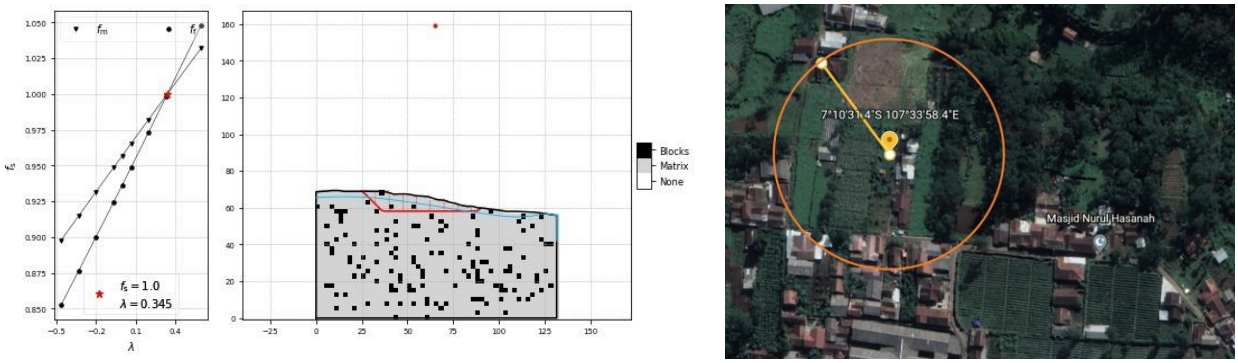

(a) (b)

Figure 4: pyBIMstab modeling results(a) and landslide area coverage (b) of Sidamukti area

Sidamukti has a landslide range 60.69 meters. As seen from google earth, disaster mitigation obtained through the coverage area in Sidamukti will prevent around 32 houses and public facilities from being damaged in the event of a landslide in this area.

4. CONCLUSION

The application of the pyBIMstab method to predict the coverage of avalanche zones which allows us to analyze the amount of infrastructure affected in an effort to mitigate landslides. This landslide coverage is combined with information contained on Google Earth so that the amount of infrastructure that will be affected if the landslide disaster is true. Further research in calculating the velocity of landslides occurring at the distance of the affected area is strongly recommended to estimate how much damage was done.

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