

# Applied GIS in Slope Failure: An Analysis

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## Abstract

Slope failure becomes major issues and problems in dangerous human life and properties. This research study carried out to determine factors that affect the hill slope in contribute to slope failure using GIS approach. GIS techniques required several data for analysis, namely elevation data and contour maps, land used map data, original map data, and vegetation map data; which can be received from government department or agencies, height and topographic data maps, data from internet sources, and data from documentation includes publications. The selected area for this research study is Selangor State, which highlighted rapid development of land used for human activities. Accordingly, the first step will be entering all data into database, which involve with the physical and environment components; while the second step will be identification and preparation based on the data layers that required in the research study; and the third step are storing data into database for designed. The storage is referring to non-spatial data elements and geographical data. Results indicate three categories of factors, namely steepness factors, land used activities, and vegetation cover factors. Although the GIS indicate the three factors as main influenced of slope failure, however, the slope failure will still continue to danger the human life and properties. Department of Town and Country Planning should control and prevent any development to carry out surrounding the hill of slope.

**Keywords:** GIS, steepness factors, land used activities, vegetation cover factors

## 1. Introduction

Malaysia is working hard to become a developed country through multiple large projects of development. Indirectly, majority development will result in land used area, especially involve with hilly site and high attitudes. Therefore, the issues of slope failure or landslides are often to become major issues when there are news about the loss of life and property. Slope failure is an issue that should take seriously considered, especially when there is development on the slope. Slope stability will affect the level of safety and durability of soil structure because any interruption on the soil structure will cause the land to crack and can cause debris to happen. Generally, main factors to cause slope failure are human interruption especially through land used activities, which can be involve with settlements, agriculture, education, industry, and so on, due to the demand in fulfillment for human activities. In surprising, there are also irresponsible attitude that less concerned on safety and appropriate site selection for construction are being developed.

Planning approach based on information technology is the latest solution in analyzing and identifying problems faced slope failure by humans. Application of Geographic Information System (GIS) is a technology used space-based information, according to Clark (1997) has proposed a common

definition for GIS data are as unique spaces that can be connected to a geographical map. In summary, GIS can be regarded as a database and information, which is used in particular to assist the parties in making a decision on a development plan. For example, the develop projects in hilly terrain and high altitudes. GIS applications are also very instrumental in determining whether an area to be developed is appropriate and safe as site development. Application of Geographic Information System (GIS) is also an information technology used to analyze and identify the hilly terrain, and makes the hill slope failure as one of the important studies. The slope failure was originally natural environmental processes are common. However, when people began to interact with the natural environment, especially on hilly terrain or high altitudes, the problem of slope failure is a major issue and a threat to humans. Therefore, GIS is an information system is essential nowadays to be considered in the planning of national development projects. Therefore, this research study carried out to determine factors that affect the hill slope in contribute to slope failure using GIS approach.

## 2. Methods and Materials

Since GIS techniques are applied in the study, several data are needed for analysis purposes like elevation data and contour maps, land used map data,

original map data, and vegetation map data. These data can be received from government department or agencies, height and topographic data maps, data from internet sources, and data from documentation includes publications. The selected area for this research study is Selangor State, which highlighted rapid development of land used for human activities. Accordingly, the first step will be entering all data into database, which involve with the physical and environment components; while the second step will be identification and preparation based on the data layers that required in the research study; and the third step are storing data into database for designed. The storage are refer to non-spatial data elements and geographical data.

### **3. Results and Discussion**

In analysis, the results indicated three main factors that affect slope failure in the Selangor districts. The factors can be described as below.

#### **(a) Steepness Factor**

Slope failure is caused by different angles (Wiezorek, 1987). His study stated that through experiments of a ball are rolled down a slope, which showed thickness of 0.2 to 0.5 meter have slope angle of 26° to 47°; while thickness of 0.3 to 1 meter will have slope angle of 24° to 40°; and thickness of 1 to 3 meter will have slope angle of 20° to 28°. Therefore, steepness define slope angles, where the land surface depend on the structure, process and stages are formed from high and low of geomorphological processes that happen on different levels.

Slope is influenced by its characteristics, e.g. slope steepness characterizes the region, which affect the processes occur on slopes like soil erosion and debris. Meanwhile, the steepness of the slope can have probability to be influence of water velocity and mass movement. For examples, erosion or landslide rate are high when the slopes are steep. Therefore, most cases of landslides occurred in areas with high gradient. However, according to Yu and Coates (1970) stating that the concave shape of the slope is more stable compared with the convex slope of the phenomenon of active landslide occurred in the area.

The slope steepness factor is identified as the most important factor in influencing the occurrence of mass movements or landslides. For example, most cases of landslides is happen at the high slope area, which often happen in Kuala Lumpur, Selangor, and several parts in Malaysia (Weng Chan, 1998). According to the Town and Country Planning Act

1976 (Act 172) has set some guidelines for the development of an area should follow the rule in a certain degree of steepness. The guidelines are designed based on various experiences and research done that shows a more viable mass movement occurred on slopes steeper hills. From the Act 172 has determined that the slope between 5° to 15° is considered moderate slope and it can be developed to implement measures to control the stability of the slope; while the slopes with 15° to 25° can be developed with debris control measures implemented; and the areas with the slope of more than 25° are not allowed for any development, because it is considered critical and unsafe for site development. Therefore, this shows the failure of the slope was very influenced by the steepness.

#### **(b) Land Used Activities**

People thinking and development activities are important for economic development in a country. In the mission and vision to achieve 2020, the development are continuously in fulfillment of human demand, which indirectly involve with the government and the private sector that having a great influence on the physical process changes in shape on the earth surface. For example, development activities have resulted in changes to the terrain slopes, such as the renovation of slopes, drainage modification, destruction cover, cutting the hill and so on, have created a variety of physical processes. This, has invited a high risk of occurrence of mass movements or landslides, when the slope of a hill natural suffered human intervention, which directly interferes with the slope of the hill.

Furthermore, in developing an area or spatial for development, natural features such as vegetation, soil and so on, had to be excluded as the development site. This modification will have an impact and influence on hill slopes processes. For example, as happened in Selangor, has experienced mass movements or landslides triggered by heavy volatility and high load by development activities in hilly terrain. In other words, human activity is a contributing factor to the occurrence of mass movements or landslides on slopes. Therefore, the preservation of Natural Topography in Physical Planning and Development under the Town and Country Planning Act 1976 (Act 172), has outlined a few guidelines slopes that can be developed based on the degree of steepness of the slope. Based on a tragedy that happen Hulu Klang, Selangor, which involve with the collapse of the Highland Towers in 1994, is an example that the development activity is one of the factor contributing to the landslide; in which through investigation and research conducted

by the Technical Investigation Committee expressed the main causes of this incident is due to the occurrence of landslides in exaggeration of the slope of a hill at the back of the condominium building. However, based on surveys, it appears that too much water has seeped into parts of the hills to cause mudslides during development was conducted in the Hill International that is located near to the condominium. This is due to the clearing of vegetation in the developed area which is located 150 meters above the Highland Towers condominium (Weng Chan, 1998). Therefore, development activities must be taken seriously in ensuring the safety and can avoid a lot of property damage.

#### (c) Vegetation Covers Factors

Plants are important to all living being on earth, due to the benefits of transforming solar energy into chemical energy through photosynthesis. In addition, plants cover becomes main features to influence other features on the slopes of the hill. As general information, vegetation or plant cover is multi-functional and distinctive role in providing advantages that exist in plants, which seeks to prevent rain falling directly, prevent and reduce runoff, compresses and binds the particles of soil and promote infiltration or infiltration water. This is because the plant cover in the hills naturally has an important role as a water catchment area and the spinal root system found in forest ecosystems play an important role and able to fix soil particles to remain firm in the structure. Generally, plants cover can be divided into two components, namely the top canopy and the litter zone (Heatwole and Higgins, 1993), which both are very important in influencing the processes that existed at the slope. Both categories have important function that is in its natural state, overflowing rain will fall on the canopy of trees; in advance, prior to arrival and is absorbed into the soil and runs through the normal hydrological cycle and soil acts like a sponge so that it will absorb excess rainwater and spinal root system of the trees that are deep in the soil also acts to hold this land span to enable it to store and release excess water little by little, to ensure the stability of the slope in natural conditions.

Usually the slope of the hill that has no cover is extremely risky and prone to various physical processes, because the region has no coverage will be more prone to mass movement or slope failure due to the surface area that is exposed to a variety of resources and processes. Therefore, no plant cover or highland hills bare and without roots stem from the plants, the abundance of rainfall throughout the year, will continue to fall in large quantities on hilly

terrain, the land had to absorb the sum plenty of water immediately or quickly, while the particles of soil has been loosened for the exposed area than soil that is rich in natural vegetation cover. This resulted in a quick span soil becomes saturated, thereby inviting the occurrence of landslide and so on; and the slope of a hill or high ground being excavated have a very high risk of collapse, due to the more vulnerable strata. In fact, in addition to control landslides, land span and support of the spinal root system also serves to control the overflow which may lead to the occurrence of flash floods.

#### 4. Conclusion

Lastly, rapid development is happen in Selangor State, especially surrounding the hill of slope. Although the GIS indicate three factors, namely steepness factors, land used activities, and vegetation cover factors, however, the slope failure will still continue to danger the human life and properties. Department of Town and Country Planning should control and prevent any development to carry out surrounding the hill of slope.

#### 5. References

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