MODELING SLOPE STABILITY IN FRASER HILL CATCHMENT

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1.0 Introduction

Natural disasters are one of the world's greatest socioeconomic problems and one of the significant incidents is landslides which is a natural phenomenon that could change the relief and cause damage to mankind (Carrara *et al.*, 1999; Huabin *et al.*, 2005). Most of the landslides accidents happen in unstable slope area especially during high intensity of rain pour that can cause the reduction of the factor of safety due to soil saturation (Van Asch *et al.*, 1999). Most of the highland areas generally get more rain compared with the other zone. Therefore, because of the long saturation, the strength of slope masses gradually decreasing as well as for rock mass the scale of joints or fractures extending until failure happens. Evaluating the stability of slopes is an important and challenging. Concerns with slope stability have driven some of the most important advances in our understanding of the complex behavior of soils. Shallow landslides are one type of landslides that often occur in steep area in different climate zone (Van Asch *et al.*, 1999; Claessens *et al.*, 2007). In tropical country like Malaysia, the most triggering factor that cause slope instability is rainfall. Therefore, it is important to assess the stability of an area before development can be done and to do this, tool such as GIS can be very effective in order to produce slope stability map. One of the major advantages of GIS in evaluating slope stability is it possible to incorporate hydrological data such as rainfall, runoff, accumulation area and infiltration in the slope stability calculation on spatial basis.

The study area is Fraser's Hill catchment which is situated in Pahang and it is one of the popular highland resorts in Malaysia. The size of the catchment is 9 km^2 and the main river is Sg. Teras. The original geomorphology of the Fraser Hill catchment characterized by hilly terrain and most of the natural slopes are steep with more than 50° gradients (IKRAM, 2007). The relief of the catchment ranges from 400 to 1300 m above mean sea level. Since it is situated in high area, Fraser Hill catchment receives more rain compared to other areas and due to the long saturation, the strength of slope gradually decreasing. The mean annual rainfall is about 2624 mm with average of 208 rain- days in a year

(Gassim *et al.* 2001). Fraser Hill catchment is underlain by granitic rock as its parent body which is composed of clayey sand or sandy clay that has moderate friction angles and cohesion values. Base on the geological map, the catchment and its surrounding is mainly composed by Main Range Granite

Figure 1: Location of the Fraser Hill Catchment in Pahang

2.0 Objective

The main objective of this study is to model slope stability condition in Fraser Hill Catchment

The specific objectives are:

1. To produce landslide susceptibility map for Fraser Hill Catchment based on return period of 5-100 years.
2. To determine which spatial resolution (grid size) that give optimal result (5m to 100m DEM)
3. To study the influence of different input data (geotechnical and hydrological parameters) to the model.

3.0 Research Methodology

Basically, there are several steps and procedure that had to be followed in order to achieve the objective of this study. Figure 2 shows the chart that explains in graphically the methodology for the whole study.

In order to study the slope stability condition in Fraser Hill on a catchment wide basis, a deterministic slope stability model called Stability Index Mapping (SINMAP) was utilized (Pack et al, 1998). SINMAP are based on raster format which able to predict slope stability by coupling hydrological and infinite slope stability models. Producing stability index grid map in SINMAP require several parameter from geotechnical and hydrological data. Geotechnical inputs are such as such as bulk density, angle of internal friction angle, soil cohesion and soil depth. Internal angle of friction is a component of a material's shearing resistance. Internal friction is the friction between individual grains within a mass of material and failure occurs when internal friction is overcome along a given shearing angle. Hydrological inputs are such as hydraulic conductivity and rainfall data. Hydrological data were input into the model in the form of a wetness index (T/R) parameter. When multiplied by the sine of the slope, the T/R value can be interpreted as the length of the hillslope (in meters) required to develop saturation (Pack et al,. 1998)To gather the geotechnical and hydrological inputs, in situ and lab analysis were had to be done to find parameter as listed below:

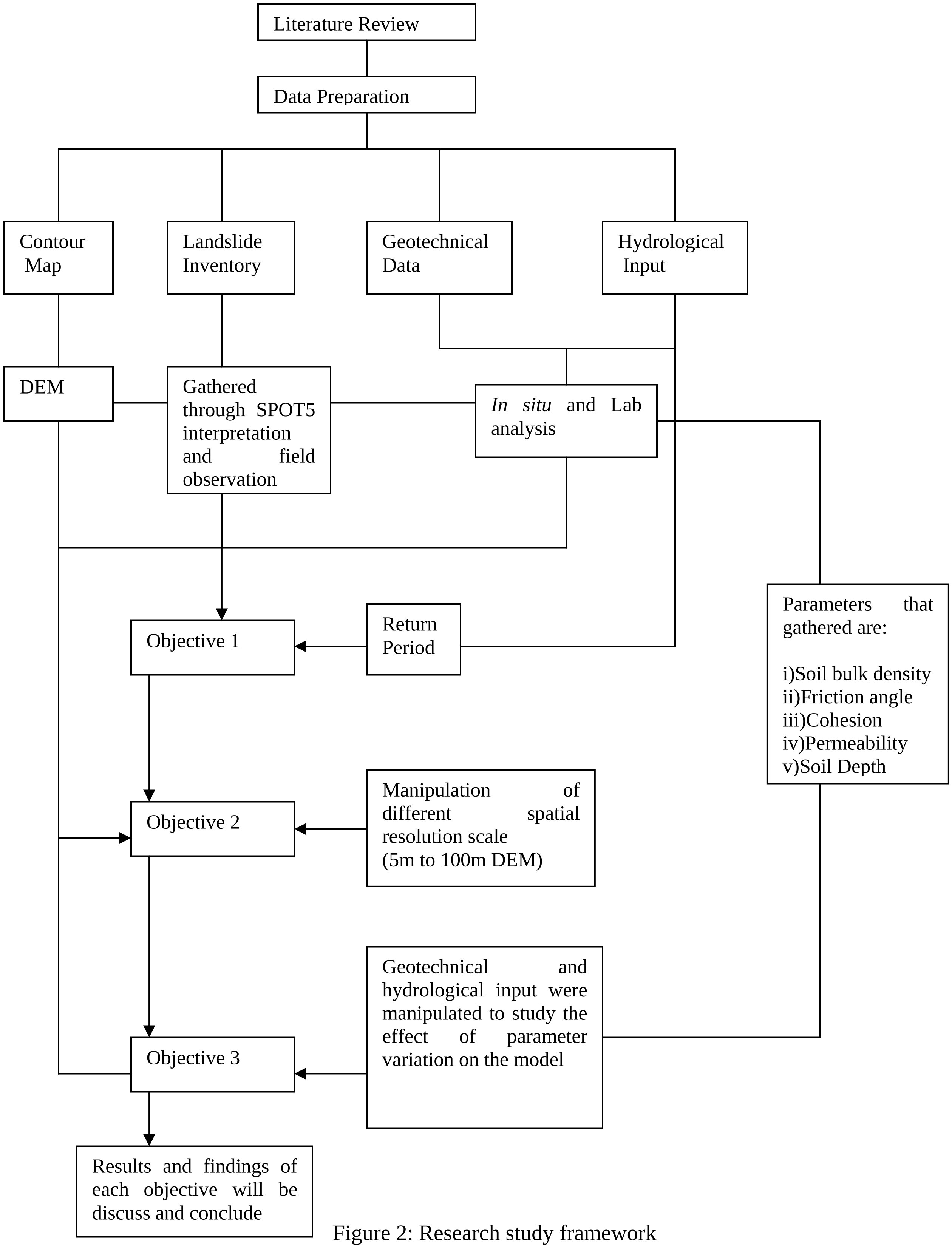

Figure 2: Research study framework

1. Soil bulk density
2. Angle of internal friction

3. Soil cohesion
4. Hydraulic conductivity
5. Soil depth

Besides that, historical landslide inventory for the study area is required to run the model. SPOT 5 satellite images were used to identify the landslide locations and field study also had been done to confirm the locations. During *in situ* visit, the coordinate of the landslide location had been taken using GPS.

4.0 Result & Discussion

The result will be put accordingly to the specific objectives.

Objectives 1
To produce landslide susceptibility map for Fraser Hill Catchment

Based on model input as well explain in methodology part, the model able to produce landslide susceptibility model by combining factor of safety and hydrologic model. As the summary, it can be concluding that for the first objective, the outputs of this model are Stability Index Grid and Slope - Area Plot (SA Plot).

Stability Index Grid Theme

The prime output of SINMAP is a stability index (SI) which used to classify the terrain stability for each grid cell of the study area. The SI is defined as the probability that a location is stable assuming uniform distribution of the model inputs over their uncertainty ranges. The range of the SI value is between 0 (most unstable) and 1(least unstable).

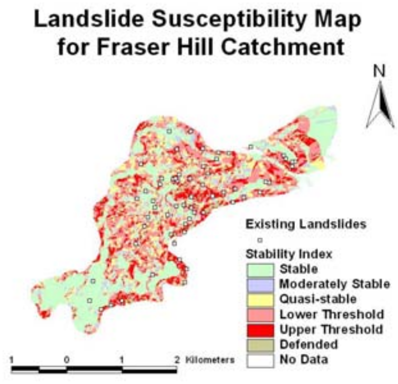

Figure 3: Stability Index Grid for Fraser Hill Catchment

SA- Plot

There is also a statistical summary given for the study area in order to help aiding in the data interpretation and calibration. SA Plot as shown in Figure 4 provides an overview of the study area in slope-area space. From the SA Plot, most of the landslide occurs on slope more than 20° although there are some of the landslides occur on slope less than 10°.

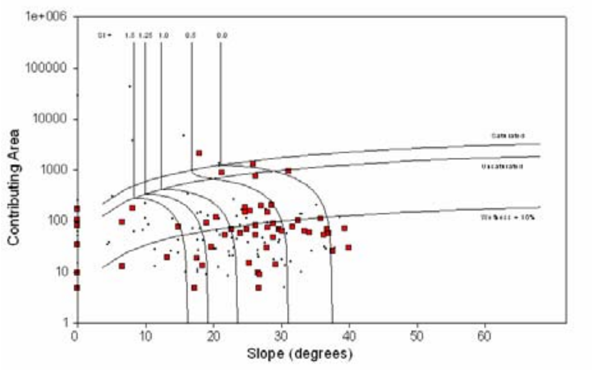

Figure 4: SA Plot for Fraser Hill Catchment

Objective 2
To determine which spatial resolution (grid size) that give optimal result (5m to 100m DEM)

This objective tends to find suitable DEM size that captures most of the landslide inventory with quickest processing time. Of course the smaller the DEM resolution (i.e: 1m DEM) can capture more topographic detail but does worth it with time frame. But, we have to bear in mind that these DEM are generated from height sources (topographic map (i.e: 1 :250,000, 1 : 50,000), LiDAR, tachymetry survey and etc), thus in this study, we used 1 : 250 000 topographic map scale.

From the analysis, it was found out that DEM with 5-10m spatial resolution gave the most optimal result compared to others.

Objective 3
To study the influence of different input data (geotechnical and hydrological parameters) to the result

To study the effects of each tested parameter, we calculated the mean value and the standard deviation value to capture the true uncertainty (Zaitchik et al., 2003).

Deterministic SINMAP simulations for all combinations of input parameter values were performed to identify model sensitivity. The analysis found out that FS calculation was most sensitive to permeability and friction angle. The least affected input to the FS calculation is T/R.

5.0 Significance of Finding

So far, the first objective has been achieved by producing a landslide susceptible map for Fraser Hill Catcment. Furthermore, by combining a theoretical model of slope instability with actual slope failure locations, landslide hazard areas may be efficiently identified and mapped for regulatory purposes. Identifying areas already at risk for slope failure could prevent loss of property and lives. This is very helpful to identify the prone landslide area so it can help the policy makers and planners to avoid or minimize the infrastructure development in the landslide prone area. Considering SINMAP is a freeware, readily available for download from World Wide Web at no cost, it is very economical for both government and business.

6.0 References

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