Modelling Surface Mapping for Engineering Application

by

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17680

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Civil & Environmental Engineering

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CERTIFICATION APPROVAL

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Approved by,

____

(Associate Professor Dr. Nassir Bin Matori)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEPTEMBER 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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(Nur ‘Amirah Bt Abd Sukur)

ABSTRACT

Land surface or topography can helps us to identify proper and safe location for construction site that might affect the cost, time and besides creating the safety related problems. The more safe location of constructions site, the less waste of money and time they can make. Basically, architects or engineers used their basis of their knowledge and experience in making 2D contour maps for analysing the location of buildings. By using Geographic Information System (GIS) it can helps in analysing the land surface by modelling topography. GIS also provides 3D views of land surface of the region where the construction site is proposed and likely to be located. Besides GIS software also can identify the location of water catchment area and used as a planning for value of soil volume before start the construction works. This research explored the application of GIS in modelling the location of proposed area to determine either the location is safe or hazard area.

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CHAPTER 1

Introduction

1.1 Background

A map is basically defined as a graphic that represent of the certain area. Maps are used to display both cultural and physical characteristics of the environment. Usually, topography maps shows a various information and details including elevations, roads, rivers and water bodies, land use classification and identification the location of building and houses.

According to Pike (1995), the development in the characterization of land form has lagged behind those in understanding of process in the significant study of earth's surface. This is might surprising when there are strong substantive and methodological reason for study of topography in geomorphology, as well as a purely etymological one. The lag may reflect the way that developments in landform characteristics have often been driven by applications which have been come out outside geomorphology at unpredicted times, for example in terrain trafficability studies. With the elaboration of physically base and semi distributed modelling in land surface, different realistic requirement for geomorphological data have come out, whose intellectual aims are more closely allied to those of geomorphology.

For this research, the first stage of study is focuses on the land structure and physical characteristic of surface and water catchment area by using spatial analyst tool to determine safe zone location and suitable area to do any industry activities. For example in civil construction industries, foundation is one of the construction activities that are challenging especially when to determine accurate location for installation of pile since the engineer have to make sure that the location of it is suitable and the right. Thus, it is very important to identify the safe zone area of condition of land surface to minimize any damages caused by irregular terrain surface.

Geographic Information System (GIS) is been used entirely to emerged the modelling of land surface in this research. GIS have proved successful in handling, integration and analysis of spatial data and easily accessible technology. Beside that, the link between stimulation modelling and engineering has been longstanding and offer tremendous possibilities for improved surface modelling and engineering solution.

1.2 Problem Statement

One of the triggering factor of surveying and mapping at the beginning of construction works is usually because of the irregular surface of terrain. The irregular of land surface is one of the obstacles to know the safe zone area to construct any structural or construction works such as installation pipeline or foundation. For example, the low area is not suitable for any construction because there is the main location for flooding to be occurred. In order to learn more about the terrain surface mapping, this research is aim to study about the physically and analysed the surface of land and to determine the hazard and safe zone area for construction purpose by using GIS software for modelling on the study area. Besides, this research also study about the application of this software for making the shortest path and can optimize cost for making the road from one point to another point based on the surface of land. By doing so, there is minimal work done on the early warning system to predict the hazard area before do any construction works. It could warn the surveying engineers about the hazard. Griffiths.S. J (n.d) state that, zoning maps especially, can be effective geohazard studies where the magnitude of the hazard can be often represented by an interpretative map with an ordinal scaling for the degree of hazard. The mapping for zoning the area are made for civil engineering purpose and will normally be based on site plans that was made specifically for the location.

1.3 Objectives

The objectives of this research are:

- To identify the safest location for selecting construction site
- To determine the location of water catchment area to avoid from flooding.
- To optimize cost and increase precision and efficiency of early roadway selection in mountainous terrain using modern software, ArcGIS.

- To estimate the volume of soil needed for cut and fill works.

1.4 Scope of Study

The scope of study in this research focuses on making map and analysed the various aspect of physical surface of land floor by using GIS software. Besides, this research is aimed to identify and analyse the safe and hazard zone for choosing the construction sites. Using the data given, GIS software will be able to map out the area that safe zonation map, so that any structure or earlier constructions works such as surveying or installation of foundation can be performed safely on that area. Moreover, this research is conducted to study the aspect of safe site location to identify the important aspect in making the decision for safe area.

CHAPTER 2

Literature Review and/ or Theory

2.1 Introduction

This chapter present the literature review on landform monitoring, modelling and analysis by using Geographical Information System (GIS). Besides that, this chapter also present the literature review on the use for terrain mapping and monitoring. The last part explains the other method that can be used for mapping such as Radar Remote.

2.2 Technical Development in Terrain Monitoring

Both Chorley (1972) and Pike (1995) has mentioned that the complexity of terrain arising from its three dimensional spatial character, and therefore its four dimensional time dependent nature. The complexities indicate that improvement in capability to measure and monitor terrain in three spatial dimension are critical. Parameters and technology that use one or two dimensional is traditionally method that been used by geomorphologist to monitor some landform. Some methods reflect rapid dissemination of the three dimensional digit represent the topography using digital elevation models (DEM). Basically, DEM is a digital model or represent the terrain surface in three dimensional. A DEM can be representing as a raster or as a vector based triangular irregular network (TIN). Modern surveying methods are reliant to computerised method but vary widely in their degree of advancement and the intricacy of infrastructure need in their usage.

2.3 Method used in mapping studies

- **Micro scale studies: the Modern Total Station/Electronic Tachometer**

Theodolite and electromagnetic distance measurement (EDM) is the simplest way for three dimensional surveys for small areas. However, there are other sophistication instrument for surveying that is much better which is commonly known as total station and electronic tachometers (Schofield, 1994) . A lightweight EDM are capable to measure distance of greater than 2km accurately, in a variety of weather condition and using a minimum number of prisms as long as the sight are not limited. Significantly, EDM based on pulsed laser compared than the traditional phase difference measurement even offer the potential distance measurement without a prism (Lane, N. S et al, 1998). Although, this capability is restricted to certain surface and relatively short distance, it is offer the possibility of automated measurement of complex natural surfaces.

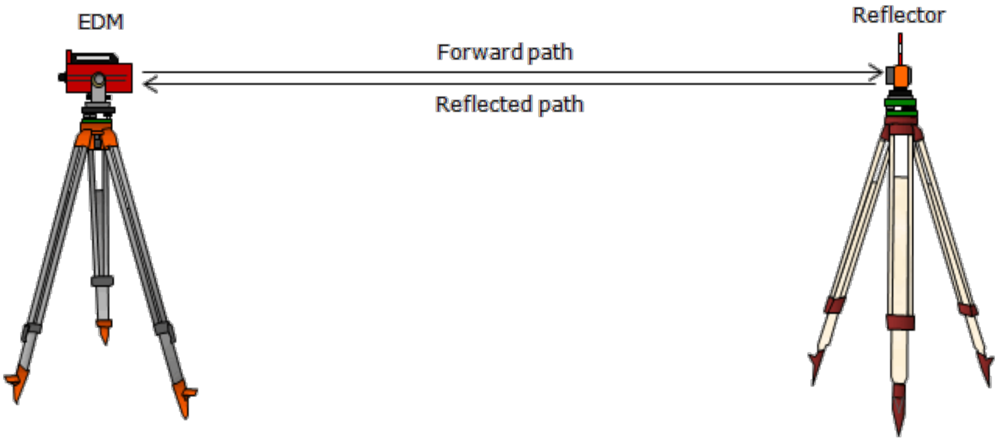


Figure 1: Electro-optical System

- **Meso-scale Studies and the Global Positioning System**

  Meso-scale is basically related with the weather condition which is scale of weather system. Total station equipment is not suitable for meso-scale studies due to the time needed to set up a control network over the study area. The most suitable advance in survey technology for this scale is the Global Positioning System (GPS) which has been spend the range of field-based survey at least on order of magnitude (Fix and Burt, 1995). In US Department of Defence, they produce the infrastructure for this system that consist of 24 operational satellite that orbiting around the earth. (Lane, N. S et al, 1998). The usage of GPS is to provide military navigational data for ship, aircraft and missile.

- **Macro-scale: Remote Sensing Methods and Continental DEMs**

  Global scale terrain data are widely available and regional, continental and global terrain analysis is now possibility even though the accuracy needed is vary. Previously, Thelin and Pike (1991) were developed a 0.8km resolution terrain model based on contour data to produce a basis for mapping of both structural and regions and specific landform. But today, global digital elevation data are even accessible through World Wide Web (WWW), for instance, the global 30 arc second DEM. This shows that the large scale terrain analysis can now be carry out easily and always occurs without accurate assessment of data quality. Besides, remote sensor methods make it feasible to collect the data at dangerous area. This method been used during Cold War by the military to detect the dangerous border area. Orbital stages gather and transmit information from various parts of the electromagnetic range, which in conjunction with larger scale aerial or ground-based sensing and analysis, give enough data to researcher to monitor.Analysis of terrain properties has been increasingly overlapped with the domain of Geographical Information System (GIS) and remote sensing. An extensive variety of remote sensor has been exploited in geomorphology. The geomorphology use aerial photography for landform qualitative analysis and recovery of quantitative information by conventional analogue photogrammetry. The research about landform at large spatial scales has tended to focus on qualitative attributes.

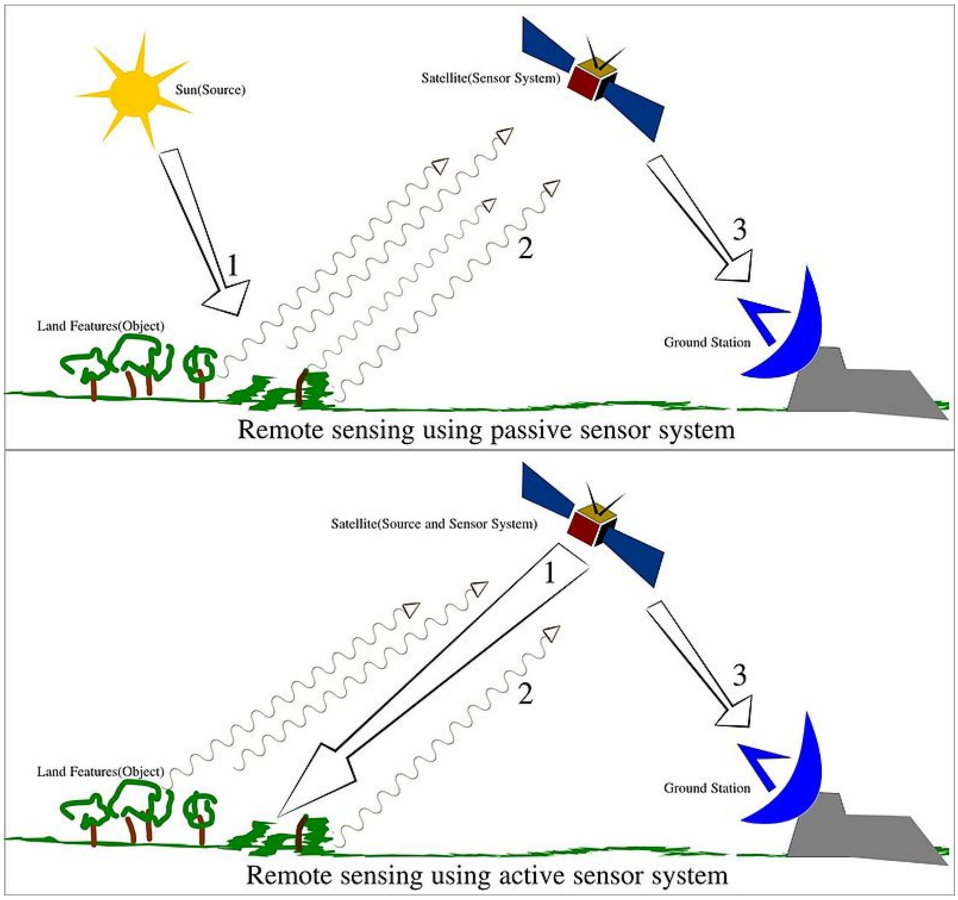


Figure 2: Illustration of remote sensing

- **Photogrammetry**

  Pike (1995) state that manually gathering data method may block the process in the study of land from, but it is possible to overcome this problem by using photogrammetry method. Photogrammetry is a method that can be applied over the range of spatial scales described above, provided consideration is given to the image resolution and scale. Photogrammetry is widely used as a dominant technique that required three dimensional topography data and most of the national map compile the maps from data acquired photogram metrically. During the late of 1980s, photogrammetry has been changed since analogue method were developed and analytical technique become applicable. This method are appropriate to monitor the object in a wide range of size or scale with comparable precision. According to Petrie and Price, (1966), geomorphologist has been use photogrammetric previously but the cost of the equipment is too expensive. Advancement in digital photogrammetry in which points are measured using scanned digital image showed on the computer screen are now redressing this circumstance. Basically, all equipment that required is access to a high resolution scanner and a powerful PC

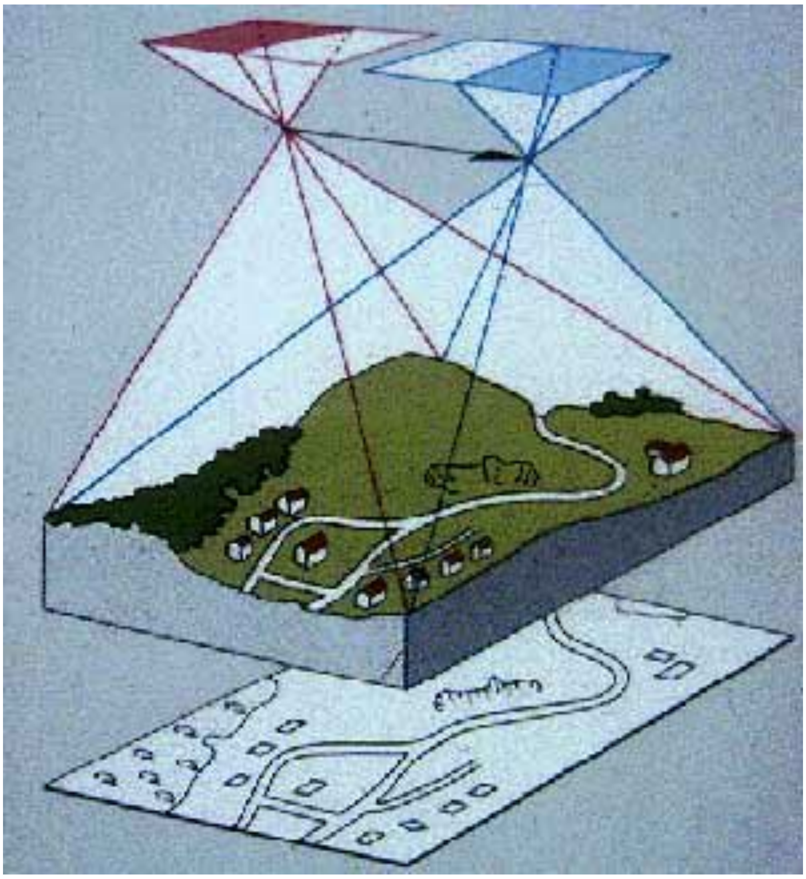


Figure 3: Aerial Stereo Photography

2.4 Conceptual Issues in Terrain Modelling

There is still remain many limitation to land surveying such as the technical development find that there have almost reversed the traditional geomorphological equation. Previously, to make a field area map required a monotonous and subjective application of method that resulted in only an estimation of surface, which from one dimensional and two dimensional data were extracted. Realistic monitoring of spatial patterns of terrain change was implausible and the process of monitoring seemed to offer most potential in the investigation of that change. Today, there is a new method that topography can be presented in four dimensional entity, the weak link is then spend of process monitoring at a single point or at very few points within this system.

- **Data and Terrain Surface Quality**

Fryer *et al.,* (1994) state that, most of the researchers encounter some problem by using digitised contour to generate DEMs and such matter are magnified where statics are used to represent DEMs. The correlation of landform surface achieved from two conservative time period may imply differences. Instead, they may be due to either inaccurate data or various errors occur during the original survey.

Surveyor and photogrammetrist recognised there different kind of error which are, random error, systemic error and blunders (avoidable mistakes made during measurement). The data quality can be related to these there type of error. To get the quality data, we must consider in terms of accuracy, precision and reliability element of precise and scientific geomorphology.

Accuracy is the main key component of quality but in most instance is hard to estimate. The DEMs accuracy were determine by compare the elevation in a DEM with a “true” values of elevation obtained by independent means and by computing root mean square error. It is recommended that the aspect derived from contour data is a best method for recognizing and measuring incorrect artefacts within DEMs. Terrain statistic are repeatable for altitude and gradient, but the third and fourth moment used to explain the higher order derivatives are variable and depends on grid size. (Lane, N., S. *et al*, 1998). The terrain surface used to define the boundary condition in environmental modelling application will contain error, and it is substantial that the effect of that error are evaluated together with the uncertainties in the process of making the model.

2.5 Type of GIS data

Basically, there is two type of data that most widely used in GIS software which are vector data and raster data. The vector and raster models for storing geographic data have respectively unique advantages and disadvantages. Both model can be practice by a full function of GIS. Below is the picture shows both model represent their data:

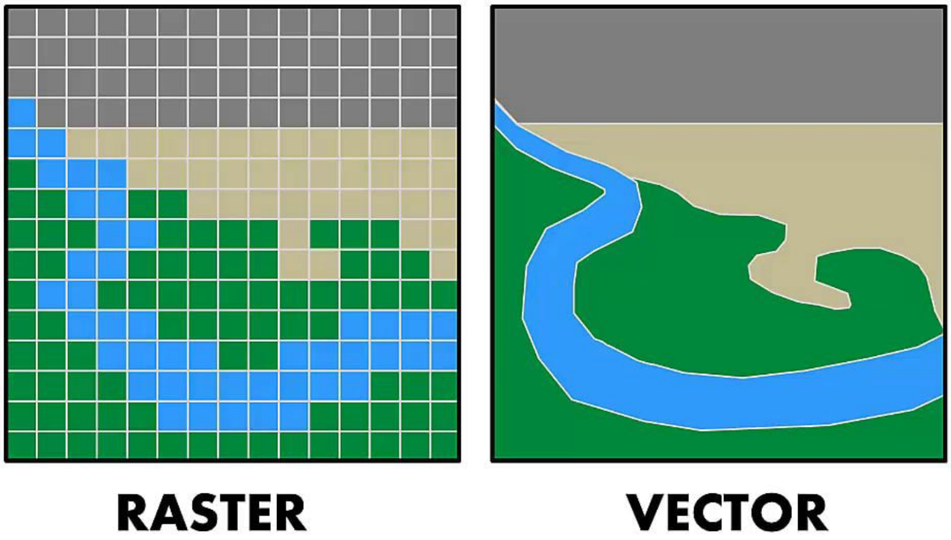


Figure 4: Type of GIS data

- **Vector Data**

  In general, vector data model is contain of three different features that known as specific point, lines (point coordinate), or areas (shape bounded by line). According to George, B (2001), vector data can be represent drawing and map feature in CAAD, AM/FM and GIS. In the vector model, the data about point, lines and polygon is stored as the location of x and y coordinate.

  The specific location of point feature such as schools or office building is described by a single x and y coordinate. Line feature such as road or drainage is stored as a string of point coordinate. Meanwhile, polygon feature such as lakes or residential area is located as a closed loop of coordinate. Basically, vector model is useful for describe discrete feature such as buildings, but less for describing continuously varying features such as type of soil or population of certain area.

- **Raster Data**

  Raster data consist of row and column of uniform cell coded according to the data value. The computer can manipulate raster da quickly but they are generally less detailed than vector data. As shown in the picture above, the raster cell approximately the area of river and land. The degree of approximation is related to the size of cells. The smaller the cells, the accurate data can be provided. Maps plotted from raster data may be less visually appealing than vector data. Due to that, raster model data is usually used to model the continuous map features.

2.6 Selection of Site area by GIS

In construction industries, safe site selection (SSS) of a building is one of important early stage to do and need to consider the evaluation of various aspects. SSS required measuring the needs of proposed facility for selected potential location (Vahidnia, 2008). It involves the selection of building area by followed the prevailing safety codes. Consider site safety from inception is the best way to make sure the sustainability of the building. In the previous decade, various methods to determine safe site area have been used. For instance, above point have been mentioned regarding this. Safe Site Selection in hilly region especially, need to consider various aspect such as landslides, slop stability and topography to ensure minimum impact on the weak area. (Kumar. S., & Bansal. V. K., 2015). These considerations also give a huge impact during early construction phase. The GIS is been used for viewing and analysing the effect of selected site location. In order to increase the accessibility of GIS, some of spatial information about neighbouring of a construction site need to be taken to know its dependence on facilities/utilities. GIS is also to encourage the spatial navigation of sustainability and infrastructure of some area or region (Chang et al., 2014). The relevance of building data displaying in the geospatial environment has additionally been explored to bolster the site determination process. GIS is a sufficient tool for safety assessment and for detect the hazard at construction sites. The review of GIS based multi criteria decision of evaluation shows that GIS based spatial decision are aim to determine the most suitable location for any constructions site. Besides, GIS based spatial decision helps spatial navigations in sustainable planning research. The utilization of GIS has as of now been investigated in site selection, however, SSS using GIS software has not been explored in profundity. Site selection of construction area in hilly where terrain is the most important role cannot be done without geospatial modelling and analysis that are available in GIS software.

2.6 Aspect of safe site selection

There are four aspects that need to be consider in safe site selection (SSS) especially in hilly region to ensure the construction safety, which are, topography, slope, elevation, and land use.

- Topography

Topography is basically known as physical shapes and features of the Earth. It is concerned with local detail in general, including natural and artificial features. A safe site is guaranteed by followed the safety codes and setting building with respect to topography.

- Slope

This feature can be measured by finding the ratio of rise/fall between two distinct points. It signified the steepness, incline or grade of the hilly. Usually, ecological damage and slope instability at the adjacent area are due to the cutting of hill slope. Therefore, engineers must not take easily and appropriate measure must be taken regarding this problem before cutting the hill to avoid any damages to ensure site safety. Ebisemiju, F. S., (1988) has suggested that no construction should be taken for slope that more than 30° or area in landslide hazard zone.

- Elevation

The elevation of a location is a height above a reference point (sea level). It is one of the crucial factor that related with site safety. For instance, a location of overhead tank is suitable for high elevation to flow the water by gravitation way, whereas a low elevation location is suitable for drainage system.

- Land use

This features refer to the human utilization of land, including management and modification of area to used to work to earn a living cost such as agricultural area, farming area and field. SSS should consider the land that been used in different activities on going at selected area.

2.8 Degree of Slopes

Slopes is the relationship of vertical rise to horizontal run, expressed as a percentage from the “toe” to “top”. There are various ways used to measure the slope. Some low-tech methods include using a compass or calculating by looking at topographic maps. For most subdivision and land development plans, licensed surveyors and engineers do the slope calculation as part of the survey of the site. According to Jabatan Kerja Raya Malaysia, they categorized the slope into for classes which is shown below.

Degree of Slopes	Development Potential
Less than 15°	Generally suitable for all development and uses
16° - 25°	Suitable for medium density residential development, agriculture, industrial and institutional uses.
26°- 35°	Only suitable for low-density residential, limited agricultural and recreational uses.
More than 35°	Only used for open space and certain recreational uses.

CHAPTER 3

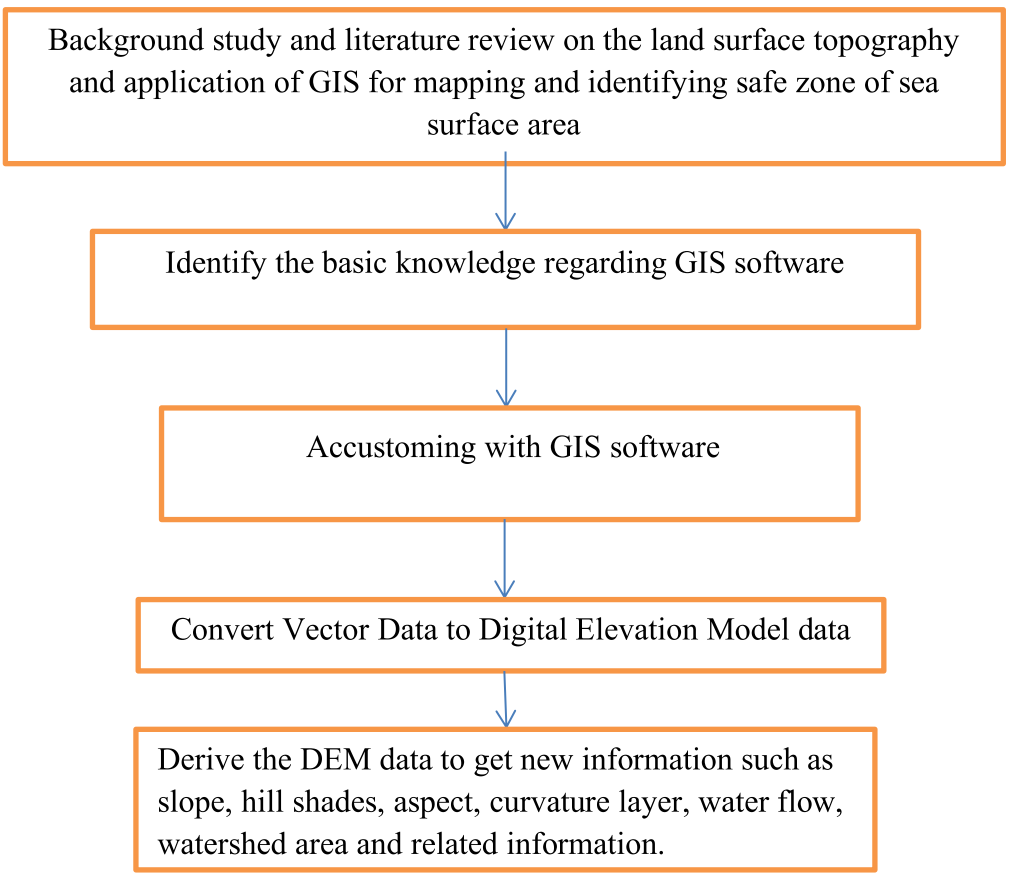
Methodology

The main objective of this chapter is to describe the methodology that used for this study within FYP1 period. As mention in Chapter 1 of this report, the main problem and objective were outline and will be elaborated further in this chapter. This chapter starts with research methodology used to understand more about the GIS software. Furthermore, this chapter also presents key milestone, Gantt chard and tools required.

3.1 Research Problem

This study basically to determine the safe zone of sea floor topography and mapping the area needed for safe site selection. Critical literature reviews are very crucial in order to identify what is other method that used for mapping and important aspect for site selection. Therefore, by using GIS application, we can identify the safe and hazard zone area of land surface topography to perform any constructions to encourage site safety. The data was been taken in Malaysia area and will be analysed and illustration presented by using GIS application.

3.2 Research Methodology



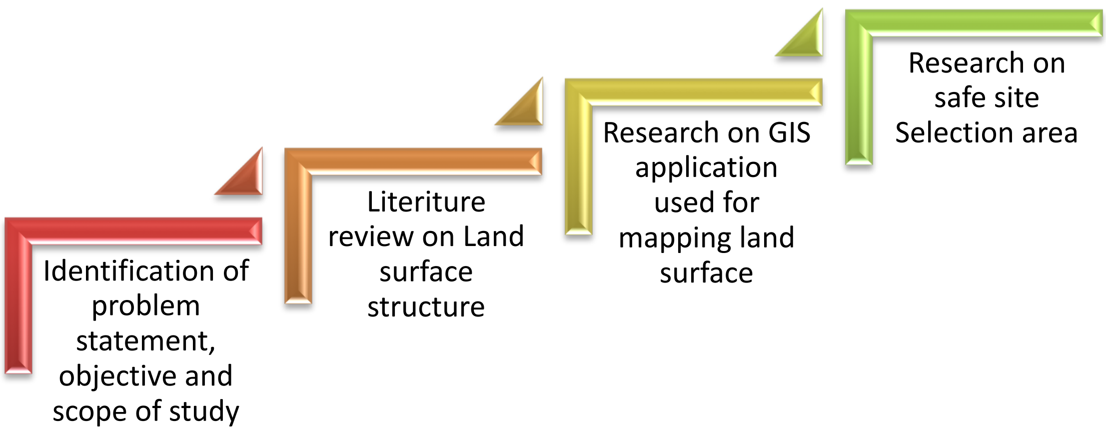
Reclassify the dataset to a common scale to get precise result

↓

Combine all the dataset to get the suitable location, path between two point and estimate soil volume for earthwork.

Flow Chart 1: Research methodology and project activities

3.3 Key Milestone for FYP 1



Flow Chart 2: Key Milestone within FYP 1 period

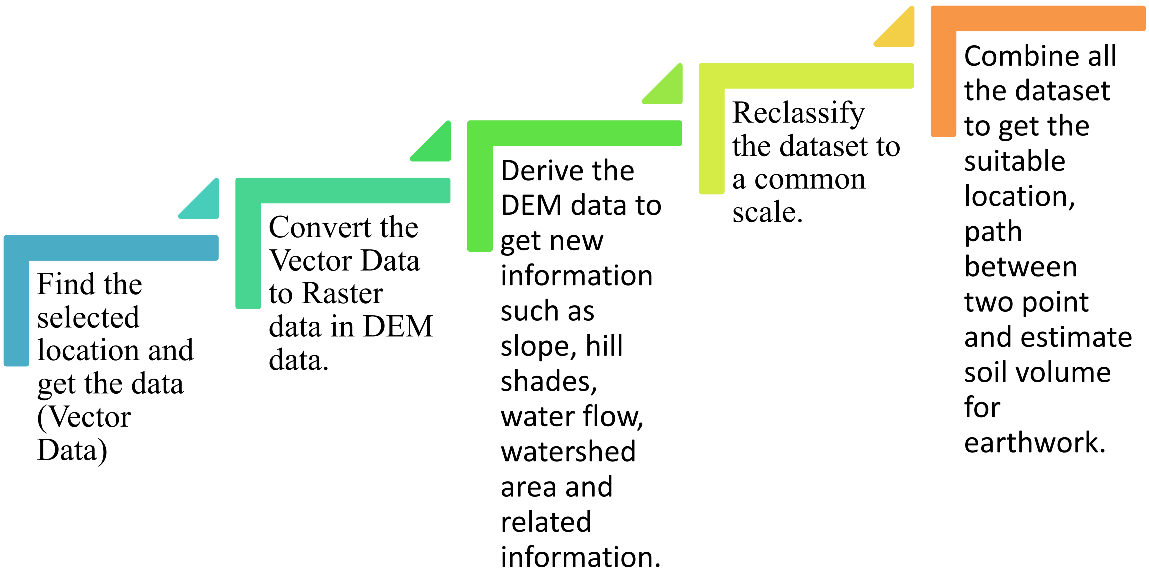


Figure 5: Key Milestone of FYP 2

Timelines for FYP 1

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic	■	■												
2	Preliminary Research Work		■	■	■	■									
3	Submission of Extended Proposal						●								
4	Proposal Defence								■	■					
5	Project work continues										■	■	■		
6	Submission of Interim Draft Report													●	
7	Submission of Interim Report														●

● Suggested milestone

■ Process

Table 1: Gantt Chart for FYP 1

Timelines for FYP 2

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■								
2	Submission of Progress Report							●								
3	Project Work Continues								■	■	■	■	■			
4	Pre-SEDEX										●					
5	Submission of Draft Final Report											●				
6	Submission of Dissertation (soft bound)												●			
7	Submission of Technical Paper												●			
8	Viva													●		
9	Submission of Project Dissertation (Hard Bound)															●

● Suggested milestone
■ Process

Table 2: Gantt Chart for FYP 2

3.4 Tools Required

Software Use
• Laptop pre-installed with Windows, AutoCAD software and ArcGIS 10.3 software

3.5 ESRI/ArcGIS 10.3

ArcGIS, created by ESRI, is currently most well-known GIS software available. According research by the ARC Advisory Research Group (ESRI, 2015), Esri hold 43% share of the GIS software in market and the next largest developer just hold it for 11%. ESRI was build up in 1969, and produce a various GIS software packages with its fundamental items offering are ArcGIS for Desktop, ArcGIS Online and ArcGIS for server.

3.6 GIS Data

There are two type of GIS data that can be used which are vector and raster. Vector data represent geographic features as line, points and polygon. Vector data are most suitable for represent the features that have distinct boundaries such as road network, country borders and land area. For raster data, it consists of matrix of cells that organised in column and row where each cell contains a value that representing information such as temperature. For instance of raster data are, aerial photography, satellite image and scanned maps. These data are stored in an attribute table.

CHAPTER 4

Result and Discussion

4.1 Introduction

In this chapter, the result from certain land data selected in Malaysia from AutoCAD are discussed. The data then will be converted to shape file format in ArcGIS software. In the last part of this chapter, the author will explain more about work that are to be done.

4.1 Data Preparation

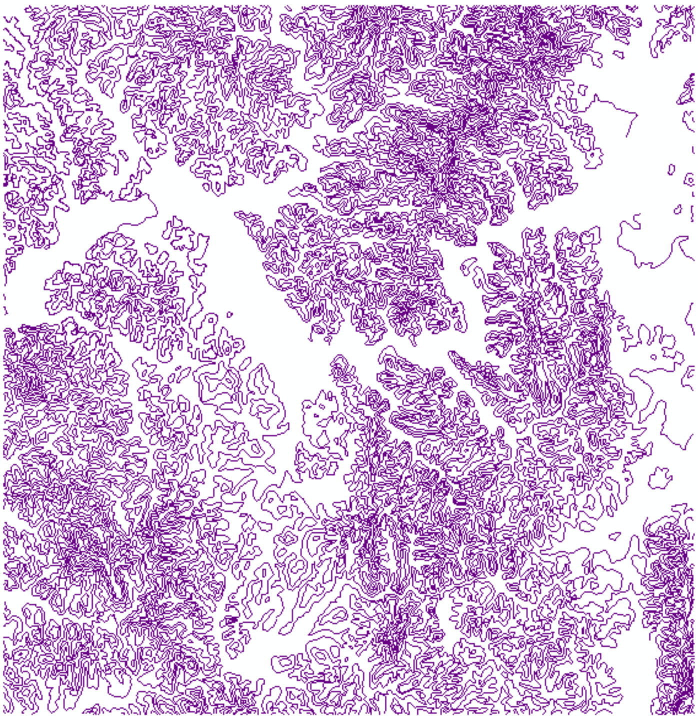


Figure 6: Contour data

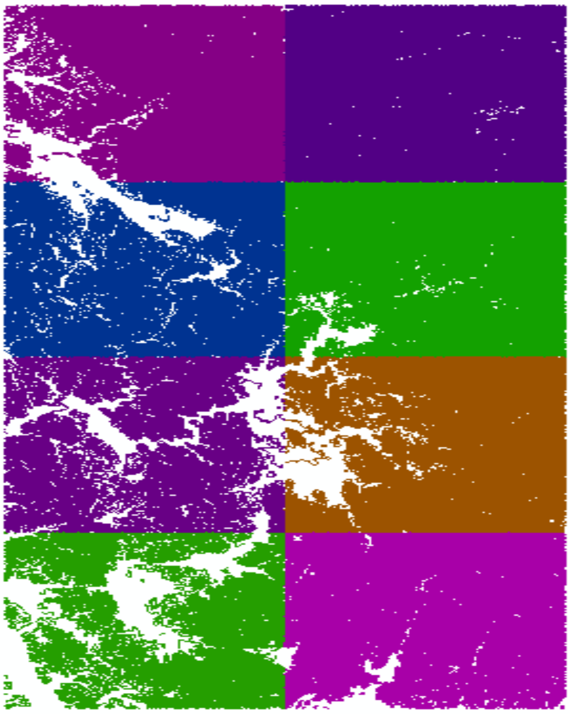


Figure 7: Eight of contour data will merge

Data that the author has been use is vector data since the data contains polyline, polygons and points features in the data. Figure 4 shows a data obtained for selected area and Figure 5 shows the data that be used after it merge together. The data given that be used shows the contour of selected area. Then, the merge of contour data will be converted to digital elevation model (DEM) data before proceed for analysis. Digital elevation model (DEM) is geospatial dataset that consist of elevation value sample according to spaced rectangular grid. It is most useful to be used in terrain analysis, spatial analyst, 3D visualizations and hydrological modelling. Figure 8 and Figure 9 below show the digital elevation model (DEM) in 2D view and 3D view data that have been converted from contour line data to DEM data.

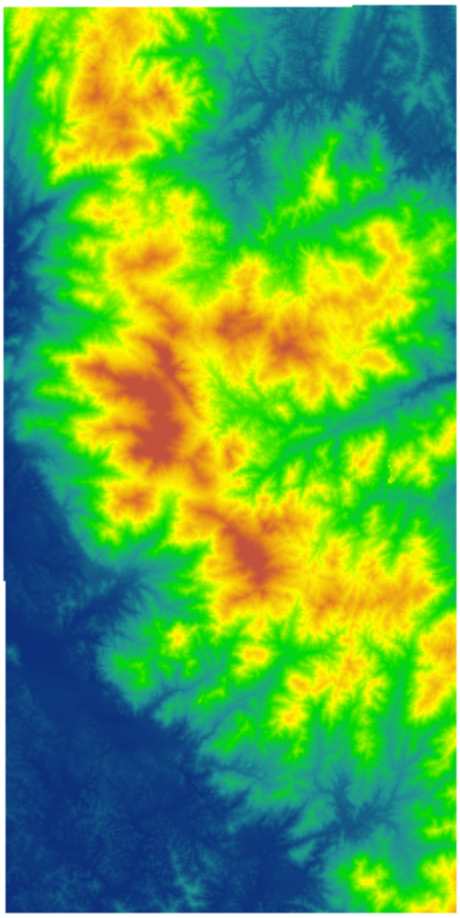


Figure 8: Digital Elevation Model (DEM) layer

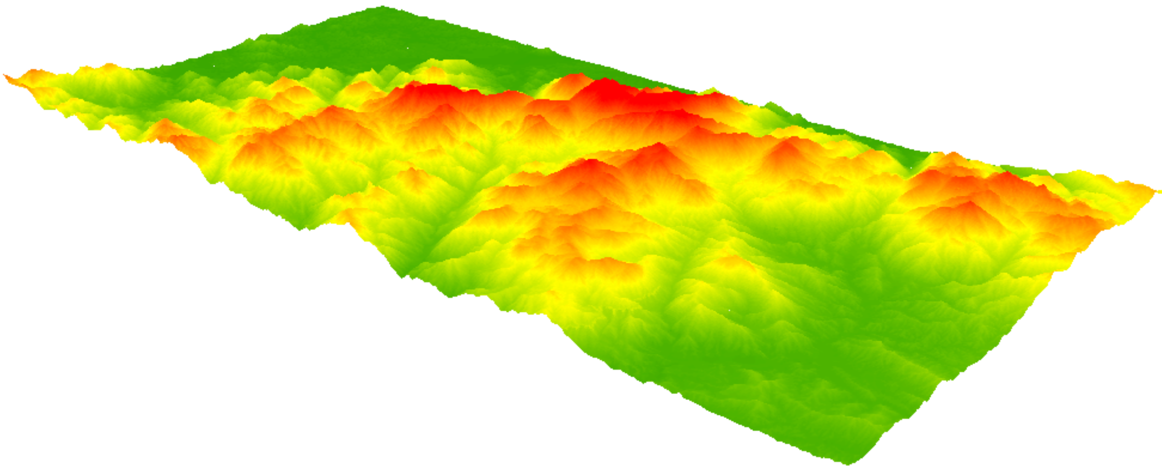


Figure 9: 3D view of Digital Elevation Model

Spatial Analyst was been used in ArcToolbox to proceed to the next step which are to determine the slope, hill shades, aspect and curvature to analysed the topography of the data.

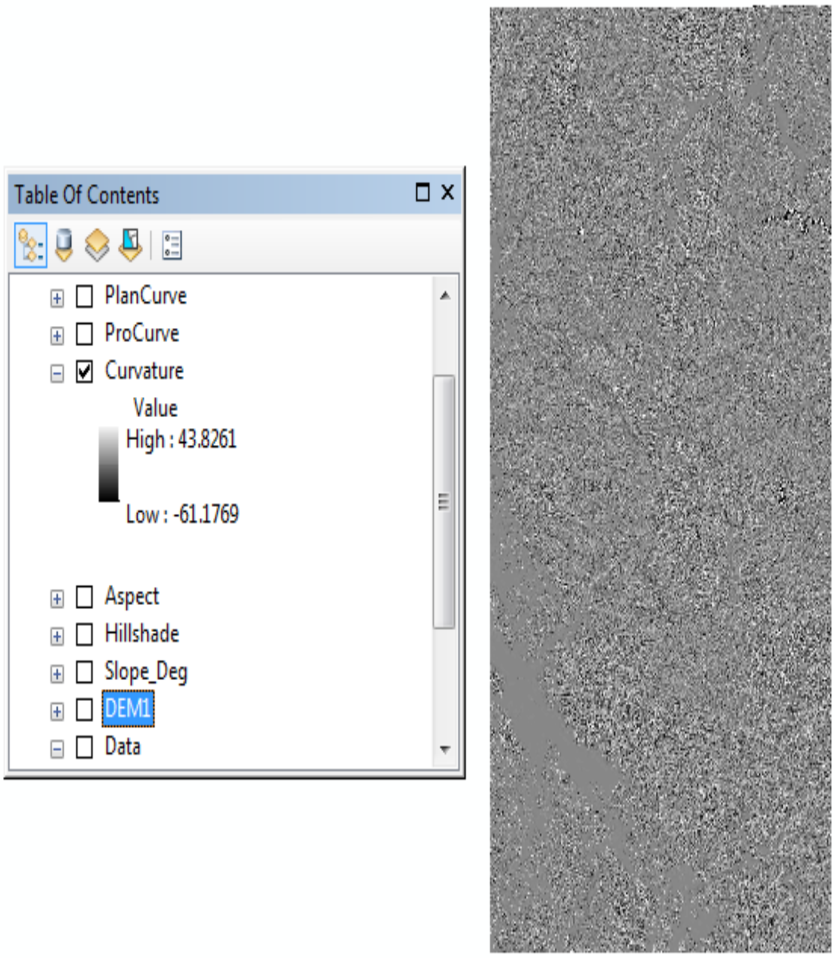


Figure 10: Curvature Layer

In figure 10 shows the curvature layer to identifying areas of rapid changes in slope or aspect. The curvature layer can show more detail in the high slope areas along the rim in the data.

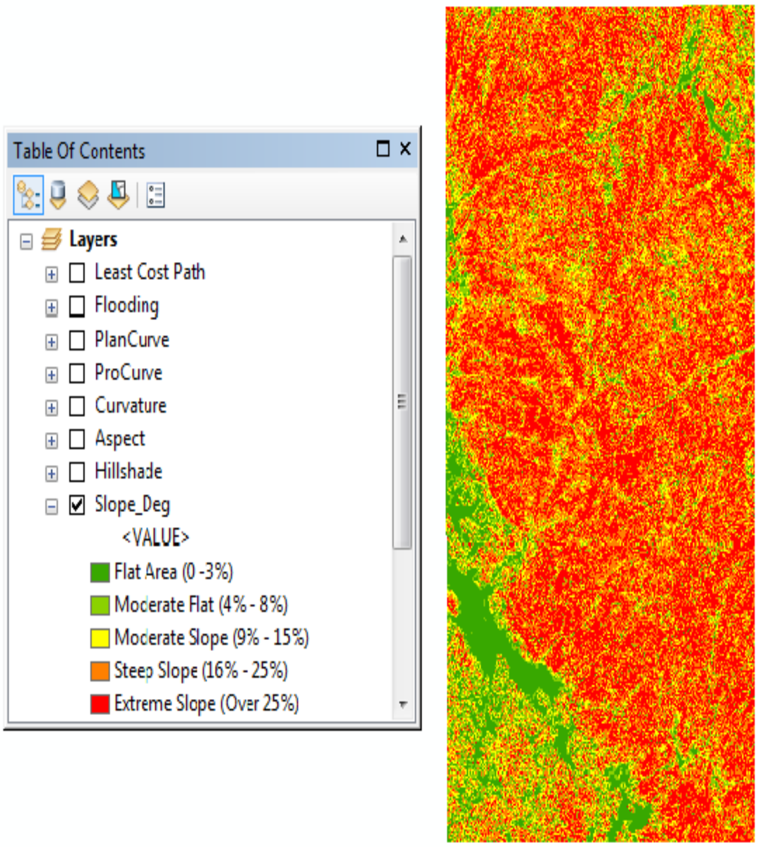


Figure 11: Slope Layer

In slope layer, the slope were been classify in four different category based on their percentage slope. By referring *Steep Slope Development Permit Area Guideline,* four different category of slope are Flat surface (0 – 10% slope), Moderate slope (10% - 20%), Steep slope (20% - 30%) and Extreme Slope (>30%). It shows that, the extreme slope is the most not suitable to do any construction on that particular area because it may cause high risk on that location while flat surface area is preferable and safest area to be as construction site. Besides, the location that has slope still can do any construction on that area but it will takes a lot of cost and time for cut and fill slope activity even may faces the risk on it.

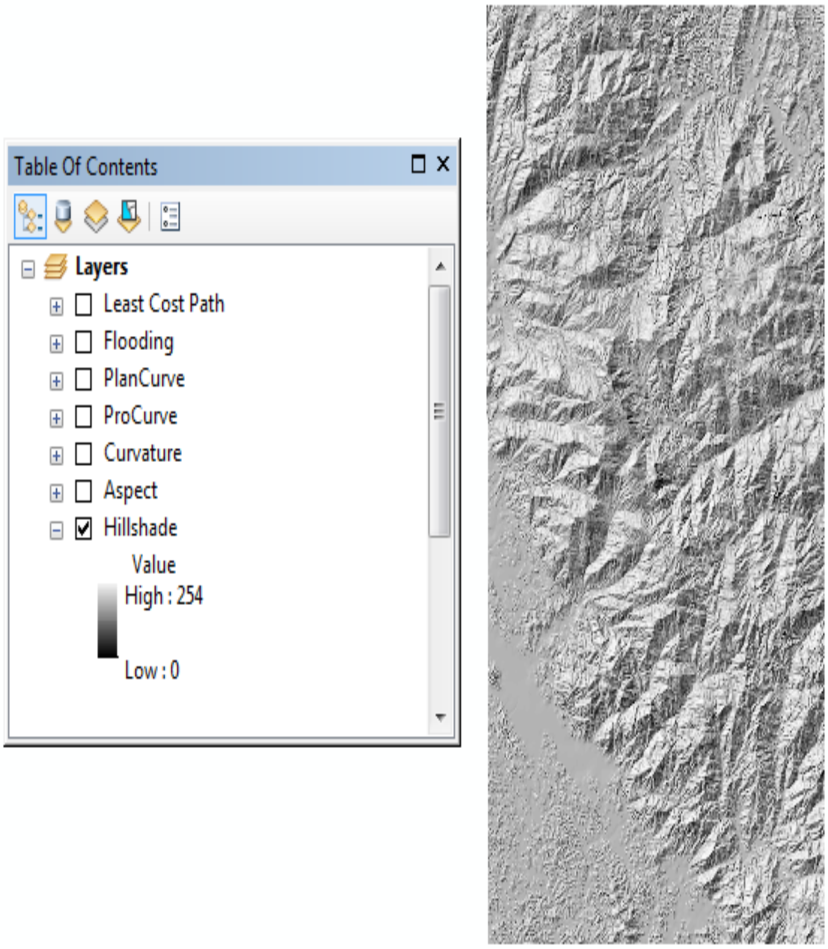


Figure 12: Hill Shade Layer

Construct a hill shade from digital elevation model data and adding transparency shows a good visual impression of the terrain and highly enhances the display of map.

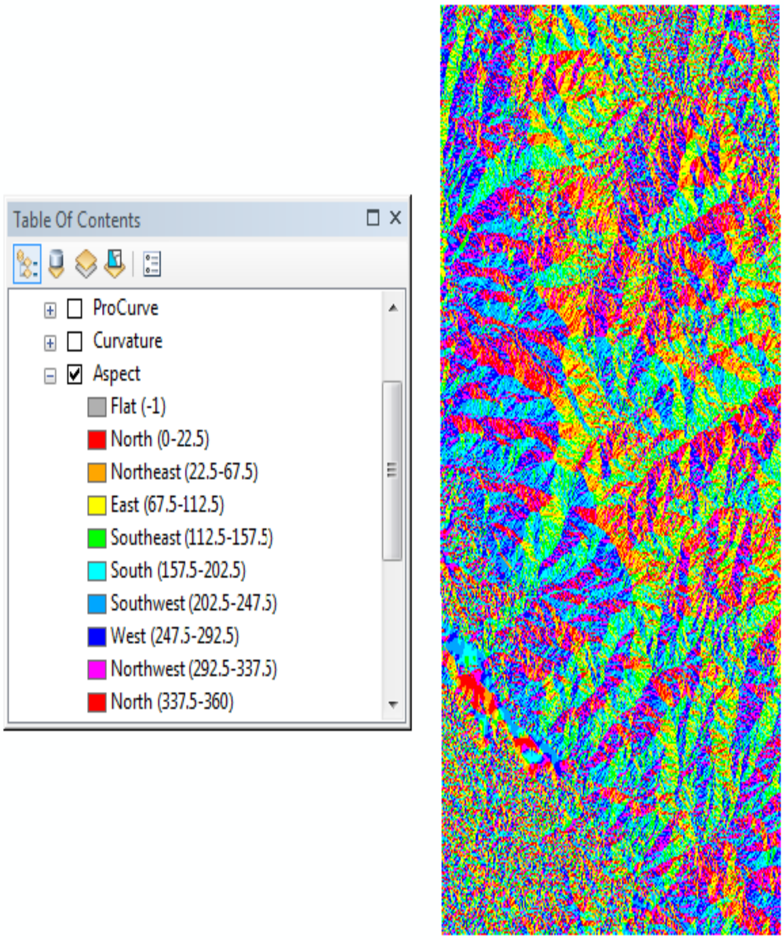


Figure 13: Aspect Layer

In aspect layer, it is been used to identify the steepest downslope direction from each cell to the neighbours. It can be considered as a slope direction or the compass direction of a hill faces. Grey colour represent flat area (0 – 5%) to encourage the interpretation these area had no aspect. According to Chang and Tsai (1991), "flat" area should be a part of an aspect class on terrain because the errors in automated aspect calculation are devoted in minor landform.

- **Shortest path between two point**

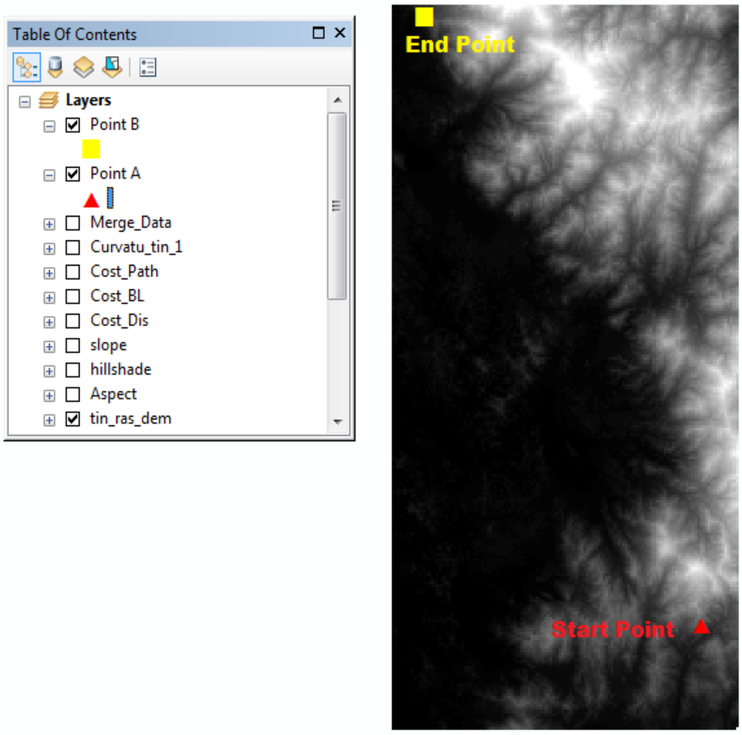


Figure 14: Two points are placed on DEM layer

Start and End Points are placed on the digital elevation model raster to assume the location of two places to analysed the shortest path from Start Point to End Point.

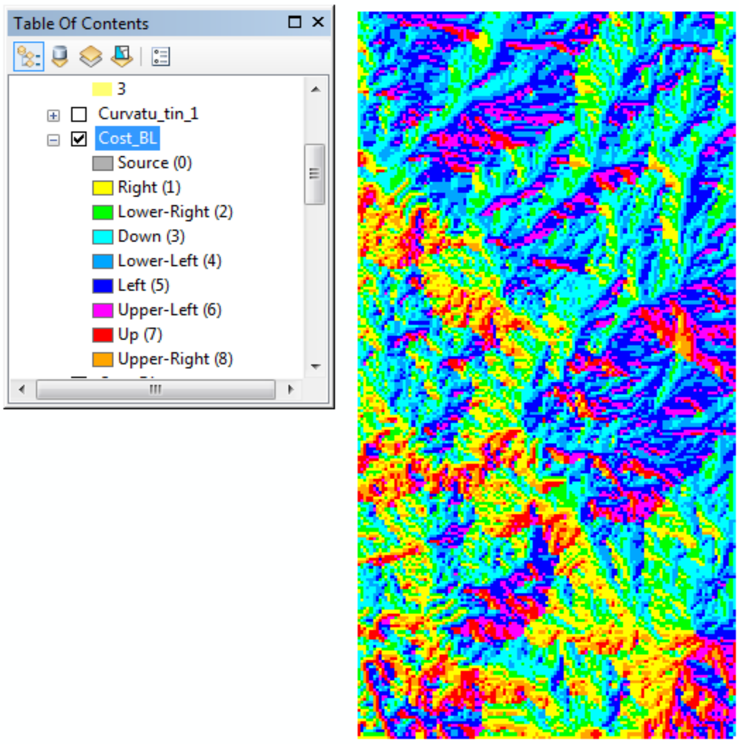


Figure 15: Cost Back Link Layer

Least cost method is used to find the shortest distance from Start Point to End Point. Least cost meaning that to find the path that avoiding the steep slope and least costly from Start Point to End Point. Five inputs are necessary for least cost method. The first input that required is Digital Elevation Model (DEM) data set, which each cell value is average elevation of the cell area. The DEM data (Figure 6) can be generated by contour map interpolation as seen in the Figure 4 or 5. The second and third inputs in least cost method are a single point representing start and end point as show in Figure 14.

Next process is to generate cost distance raster. A cost distance raster is another one of the input needed for creating least cost distance. Cost distance tool is available in the spatial analyst extension. The cost distance also can produce a back link raster that has cells with values between 0 to 8 that representing the direction along the least accumulative cost as shown in Figure 15.

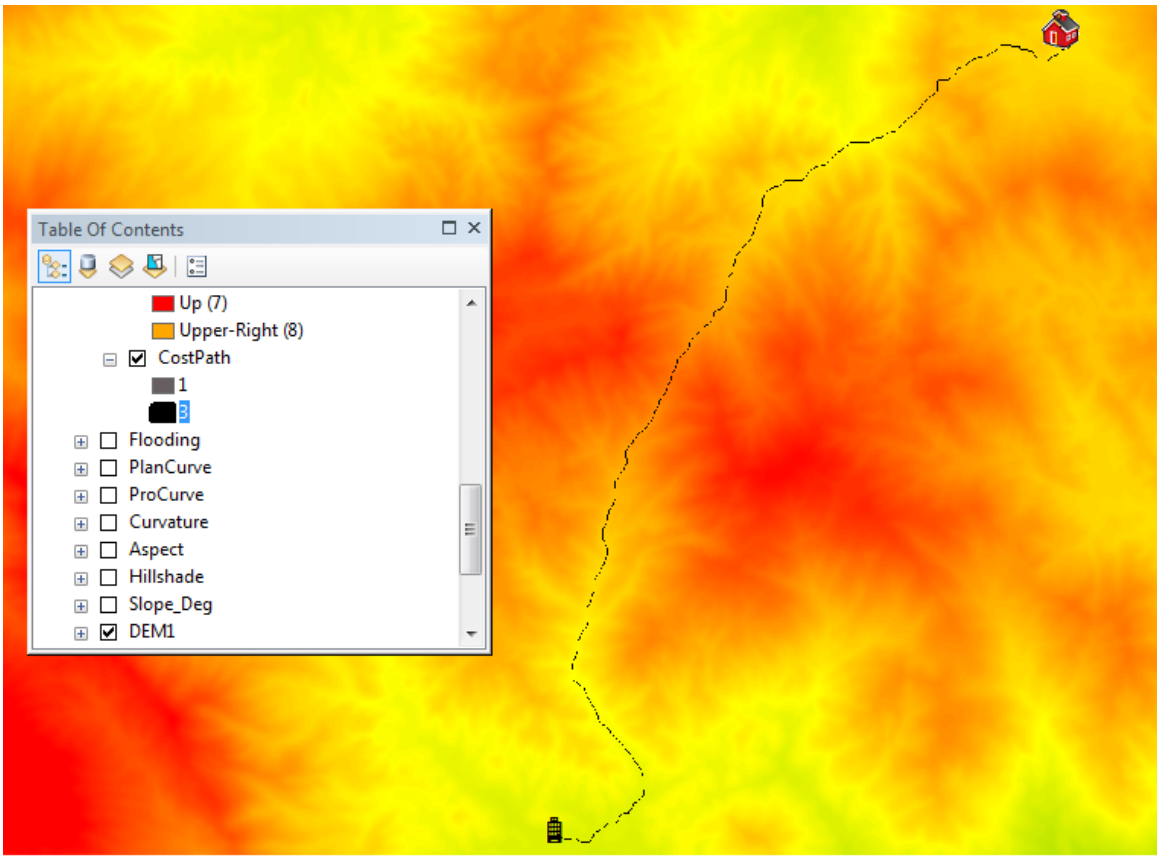


Figure 16: Shortest path from Start point to End point

The least cost analysis combined the starting point, the cost distance raster and cost back link raster to produce least cost raster. Next, the least cost raster will be converted to line feature class by using *raster to polyline* tool to create polyline feature class. The feature class is final output that can be used to plan the location of a road from start point to end point as shown in Figure 16.

- **Watershed area**

The first step to get watershed result is to get the Digital Elevation Model (DEM) data. From DEM data, a few steps are required by using hydrology tools in spatial analyst to obtain the final result which is watershed.

In general, watershed is the land area that drains down slope to the lowest point of the terrain. The water will move by gravity means in a network of drainage pathway that may be underground or on the surface into a specified body of water, river or stream. Even though, there are many ways for water to enter the stream, most of it will enter as a run off from the land surface. Then, the land will forms a stream watershed.

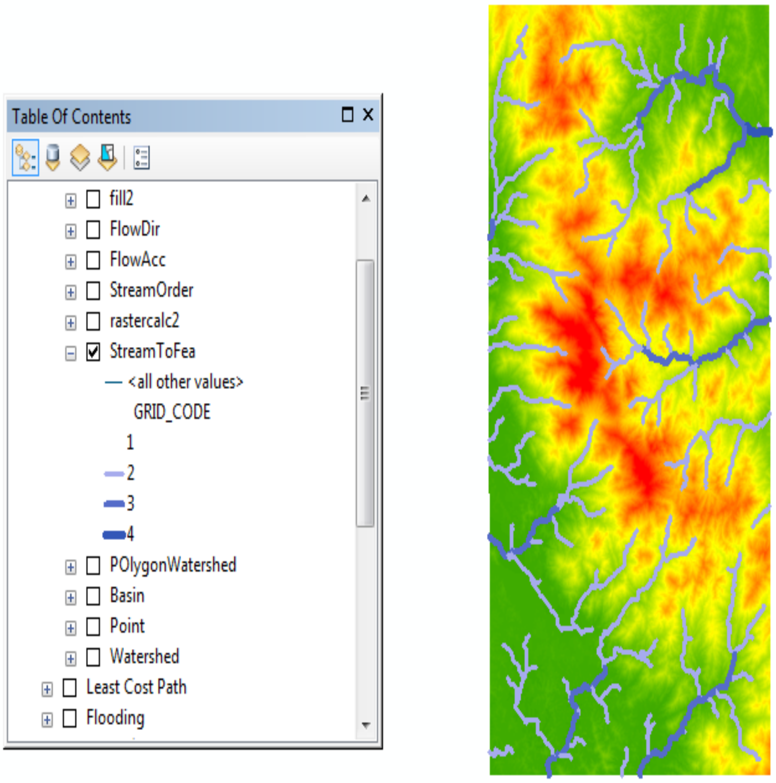


Figure 17: The stream links of the channel network are differentiated by colour

In figure 17 show the stream links of channel network from upstream to downstream. The darkest blue of stream shows the main river and others colour shows the link river.

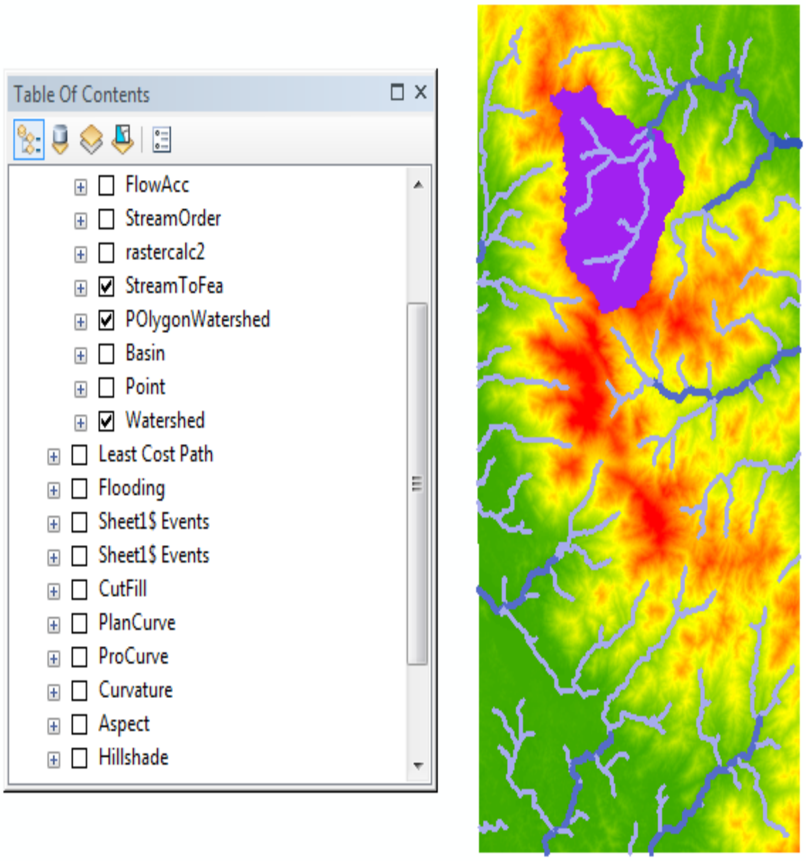


Figure 18: Watershed area

As seen in figure 18, water catchment or watershed area is located in purple area. From that image, it shows that, in purple area that representing watershed is not suitable for any residential development near that area because, this location is bear to face flooding during rainy season since the water from watershed might be spill out and causes flooding. Other construction works that suitable for this area is dam which generally used as irrigation, control water and hydropower.

- **Estimation of Soil Volume**

When planning and design construction site, engineers must consider the existing condition of soil at6 site. Frequently, the given site is not level and should be adjusted before any construction works can start. So, cut and fill stages is commonly one of the first construction procedures take place on site. By using ArcGIS software, the process is much easier and takes short time to estimate the volume of cut and fill of soil.

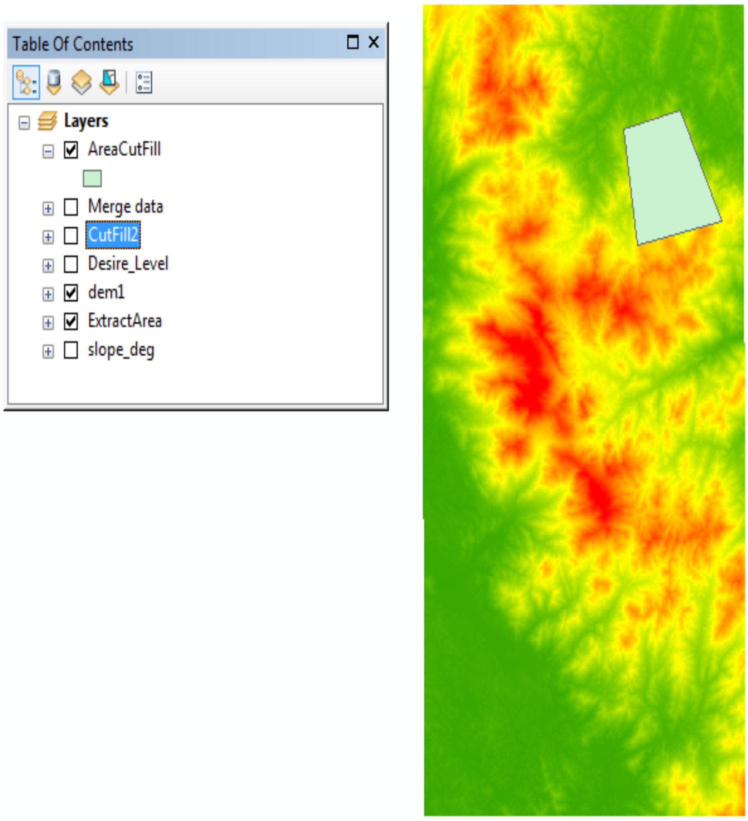


Figure 19: Selected area for cut & fill process

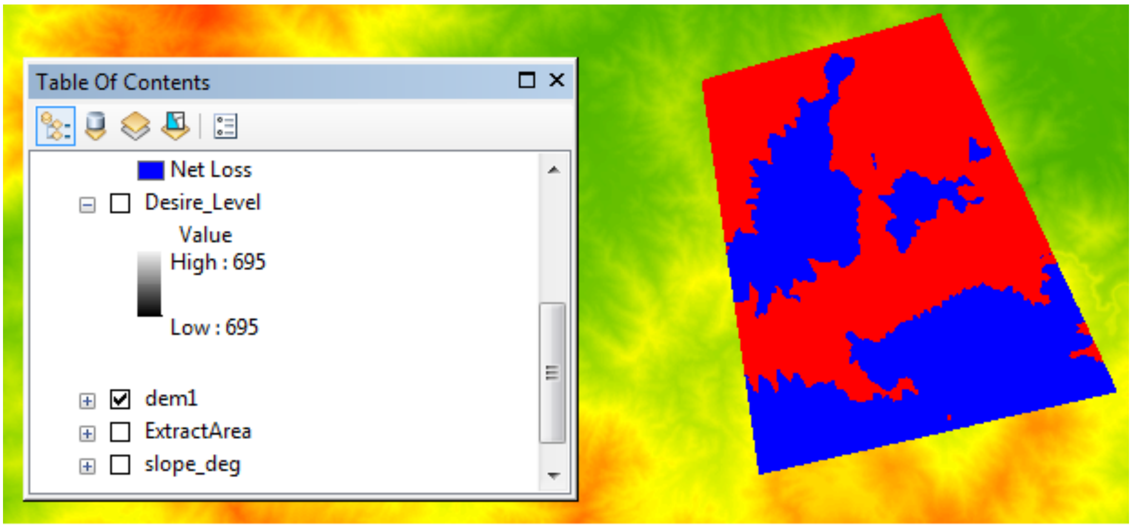


Figure 20: Cut & Fill area

As shown in Figure 19, light blue area is representing the selected location for cut and fills process. In figure 20, red colour is representing the area that need to be filled up with the soil while blue colour representing the area that need to be cut to achieved the elevation level of 695 meters.

Table

CutFill2

Rowid	VALUE	COUNT	VOLUME	AREA
0	1	316022	-5277704615.353394	3160220
12	13	1402	-3816568.463135	140200
10	11	538	-1037584.893799	53800
6	7	80	-105882.830811	8000
14	15	82	-15264.587402	8200
5	6	1	-201.098633	100
11	12	1	-30.236816	100
13	14	1	-8.862305	100
7	8	20	6268.579102	2000
8	9	35	9027.55127	3500
3	4	206	107018.139648	20600
2	3	1636	5816558.166504	163600
4	5	16526	94522885.36377	1652600
1	2	82844	1022178244.732666	8284400
9	10	174522	3030143714.300537	1745220

1 (0 out of 15 Selected)

CutFill2

Figure 21: Value Cut & Fill

The table above shows the value of soil volume that need to be cut and fill. The 'negative' value means that, the area that need to fill up with the soil while 'positive' value show that the value of soil that need to be cut or removed. From the table also, the engineer can estimate the total volume of volume required to fill up the soil.

Statistics of cutfill2.vat

Field

VOLUME

Statistics:

Count: 15
Minimum: -5277704615.353394
Maximum: 3030143714.300537
Sum: -1129896439.492798
Mean: -75326429.29952
Standard Deviation: 1591742406.08583
Nulls: 0

Figure 22: The sum of soil volume.

In Figure 22 shows the total volumes of soil for cut and fill works. If the sum of soil volume is ‘negative’ meaning that the earthworks required another extra volume of soil while ‘positive; value meaning that, got an excess soil for earthwork activity. From the table above shows that the for earthwork activity for this area need another 1130 m^3 of soil for 695 meter elevation level.

Summary

This chapter presented the result from spatial analyst and the result were discussed and clarified. The next chapter will contain conclusion and recommendation of this study.

CHAPTER 5

<u>Recommendation and Conclusion</u>

5.1 Introduction

This chapter presents conclusion and recommendation of this study that recap of problem statement, objective, methodology and result from the analysis in ArcGIS software. The last part of this chapter will discussed the recommendation proposed by the author.

5.2 Conclusion

ArcGIS software helps the user especially in Engineering Industry to analysed various spatial problems. This research focused on a identify suitable site location, creating the shortest path between two points and for earthworks. The analysis used a combination of vector and raster data to achieve the final results. The author also discussed and elaborates the aspect needed to produce the result such as generate the slope, hill shade, aspect and curvature layer. From the result that the author generates suitable safe location for construction site and determine water catchment area. Then it was followed by determined the shortest path from one point to another point by using least cost method. The least cost path method is the best method to use for placing the road feature along the side of slope in less steep slope area. These initial route selection phases can lead to better designed and more ecologically stable for road network. Finally, ArcGIS is also an efficient tools for the engineer to estimate the volume of soil for earthworks activity and cost needed for earthworks during planning stages of construction.

ArcGIS software is a power and efficient tool especially in engineering industry that engineers should utilized it in order to discover the safe area for construction site, determine the location of water catchment area, identify the safest path and optimize the coast and lastly, for earthworks activities. With the advancement of technology, GIS software made work done on paper in the past, possible to be done on computer and database could be kept for updating and control.

CHAPTER 6

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