SLOPE STABILITY STUDIES FOR DEVELOPMENT OF HILLSITE AREA IN PENANG

By

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ABSTRAK

Pulau Pinang merupakan salah satu tempat yang mempunyai topografi beralun dan berbukit. Pembangunan aktiviti di sekitar kawasan berbukit semakin hari semakin bertambah. Aktiviti yang sering menjadi tumpuan ialah aktiviti pembangunan perumahan dan rekreasi. Keadaan kawasan berbukit ini sekiranya tidak diambil perhatian khusus akan menyebabkan masalah di kemudian hari. Maka penyelesaian yang terbaik untuk mengatasi masalah ini ialah dengan membuat kajian khas berkenaan kestabilan cerun di kawasan berbukit di Pulau Pinang. Proses kajian ini boleh dilakukan dengan menggunakan analisis melalui sistem maklumat geografi dengan adanya perisian Erdas Imagine. Melaluinya ia akan membantu dalam menganalisis kawasan-kawasan kritikal di Pulau Pinang sebelum sebarang aktiviti pembangunan di kawasan bukit dilakukan. Secara keseluruhannya, dengan perisian sistem maklumat geografi ini dapat menghasilkan keputusan yang tepat dan cepat dan amat berguna sekali.

ABSTRACT

Penang is a country that has billowy topographic hillside area and there are lots of development activities being held nowadays. Most activities are from housing and recreational development. The situation now can be dangerous to the hillside if no preventive measures be taken care; it would be disastrous for hillside development in near future. Therefore, it is important to study the slope stability for Penang hillside development.

The process for this study is carried out with the help of Geography Information System (GIS) analysis software that is Erdas Imagine. With the help of this software, analysis for the critical area for hillside development in Penang can be determined.

As a result, from this Geography Information System software, the result can be determined in fast and very useful to.

TABLE OF CONTENTS

ABSTRACT ii

ABSTRAK iii

TABLE OF CONTENT iv

LIST OF TABLES vi

LIST OF FIGURES vii

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION 1

1.2 PROBLEM STATEMENT 1

1.3 OBJECTIVE OF STUDY 2

1.4 SCOPE OF STUDY 2

CHAPTER 2: LITERATURE REVIEW

2.1 GENERAL 4

2.2 THE CONCEPTUAL FRAMEWORK OF THE PROPOSED MODEL 5

2.3 GEOGRAPHIC INFORMATION SYSTEM 5

2.4 FACTORS INFLUENCING HILLSIDE DEVELOPMENT 6

2.5 CAUSE OF INSTABILITY 7

2.6 FACTOR OF SAFETY 9

2.7 PROPOSED MODEL 11

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION 13

3.2 DATA COLLECTION 14

3.3 SOFTWARE 16

3.4 IMAGE PROCESSING 17

3.5 DIGITIZE 24

3.6 DIGITAL ELEVATION MODEL (DEM) 25

3.7 CREATING PARAMETERS 27

3.8 TOPOGRAHY ANALYSIS FOR SLOPE 29

3.9 MODEL MAKER 30

CHAPTER 4: ANALYSIS AND RESULT

4.1 INTRODUCTION 35

4.2 ANALYSIS WITH THE USED OF ERDAS IMAGINE 36

4.3 RESULT 36

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 DISCUSSION 49

5.2 ANALYSIS USING ERDAS IMAGINE 50

5.3 THE PROS AND CONS USING GIS 54

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION 55

6.2 RECOMMENDATION 56

REFERENCE

APPENDIX

LIST OF TABLE AND GRAPH

Table 5.1: Results from Model Maker Analysis

Graph 5.1: % of the area for Jalan Kenari

Graph 5.2: % of the area for MK 13 D.T.L

Graph 5.3: % of the area for Tanjung Bungah

Graph 5.4: % of the area for Mount Plesure

Graph 5.5: % of the area for Jalan Permatang Damar Laut

Graph 5.6: % of the area for Bayan Lepas

LIST OF FIGURES

Figure 2.1: GIS Programme

Figure 2.2: Alternative Methods of Interfacing Models with GIS.

Figure 2.3: Integration of a Simulation Model with A GIS

Figure 2.4: A 3D Slope Failure and One Grid Column. (Xie, Esaki and Cai, 2004)

Figure 3.1: Topography Map of Penang

Figure 3.2: ERDAS Imagine Version 8.3.1

Figure 3.3: Step of Modelling

Figure 3.4: Open File

Figure 3.5: Set Geometrical Model

Figure 3.6: Polynomial Model Properties

Figure 3.7: Projection Chooser

Figure 3.8: GCP Tool Reference Setup

Figure 3.9: Reference Map Information and View

Figure 3.10: GCP#3 at the Intersection Grid

Figure 3.11: GCP Tool: Input

Figure 3.12: Resample

Figure 3.13: Inquire Box

Figure 3.14: Subset Dialog

Figure 3.15: Annotation Tool Bar Dialog

Figure 3.16: Polygon/Polyline Properties

Figure 3.17: Create Surface/ Read Points

Figure 3.18: Surfacing

Figure 3.19: Image after Surfacing

Figure 3.20: Annotation Tool

Figure 3.21: Polygon / Polyline Properties

Figure 3.22: Insert Value for Parameter

Figure 3.23: Slope Image Process

Figure 3.24: Slope Image

Figure 3.25: Model Program

Figure 3.26: Model Maker Sample and Tool Palate

Figure 3.27: Input Raster File

Figure 3.28: Function Definition Dialog

Figure 4.1: Model Programmed For Mount Pleasure

Figure 4.2: The Location of Mount Pleasure on Topography Map

Figure 4.3: Image Factor of Safety for Mount Pleasure

Figure 4.4: Model Programmed For Tanjung Bungah

Figure 4.5: The Location of Tanjung Bungah on Topography Map

Figure 4.6: Image Factor of Safety for Tanjung Bungah

Figure 4.7: Model Programmed For Jalan Kenari

Figure 4.8: The Location of Jalan Kenari on Topography Map

Figure 4.9: Image Factor of Safety for Jalan Kenari

Figure 4.10: Model Programmed For MK 13 D.T.L

Figure 4.11: The Location of MK 13 D.T.L on Topography Map

Figure 4.12: Image Factor of Safety for MK 13 D.T.L

Figure 4.13: Model Programmed For Jalan Permatang Damar Laut

Figure 4.14: The Location of Jalan Permatang Damar Laut on Topography Map

Figure 4.15: Image Factor of Safety for Jalan Permatang Damar Laut

Figure 4.16: Model Programmed for Bayan Lepas

Figure 4.17: The Location of on Bayan Lepas Topography Map

Figure 4.18: Image Factor of Safety for Bayan Lepas

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The studies for this slope are carried out with special reference to Penang Island. Actual review is based on hillside development. Where is to find out the geotechnical characteristics in the area. This will help to know the soil characteristic in the critical area. The purposed of this report is to analyze and interpretate a model slope stability and also to develop a data base about slope stability for Penang Island.

The concept of slope stability can also be determined by using latest geography information system (GIS) software which can help to provide input data in order to perform slope stability analysis for various possible slope profiles in hillside area.

1.2 PROBLEM STATEMENT

This study is about to produce a model to get in sight into the process of slope development through mass movement. Presently, a relational data model and diverse structures, methods and tools to handle analyze the data are used. This practice complicates the exchange of data, methods and research results.

The results shows, that object oriented data modeling can facilitate user access to multiple data sets, support integrated used of different analysis technologies and could aid in the development of standards for exchanging data in multi displinary environment.

The demand for land for any development will always be the primary requirement and to establish utility oriented information system about such land must be important criteria in community.

The general land used map may be available for planning but the concept of carrying capacity base land use plan is still a dream for any planner. To obtain sustainability for any development plan such carrying capacity plays a vital role.

1.3 OBJECTIVE OF STUDY

The objectives of this study are:

- To find out the geotechnical characteristic in the area
- To interpretate a model for slope area.
- To develop a data base about slope stability for Penang Island.

1.4 SCOPE OF STUDY

This study consists of hillside area in Penang Island. The selected areas are Tanjung Bungah, MK 13 D.T.L, Bayan Lepas, Permatang Damar Laut, Jalan Kenari, and Mount Pleasure.

This project will used Erdas as the main software. In Erdas, the analysis which can generate a modeler that can calculate the factor of safety on the rectified area. The process will include the parameter that had been given in the SI report such as cohesion, angle of friction, unit weight of soil so on and so for. In addition with the Penang topography map given this analysis can be done thoroughly to determine the factor of safety for the 6 location in Penang.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

"Knowing the forces that shape the Earth, allows you to better control and utilize the 'forces' that affect construction and building."

Dr. Alan Scott – University of Wisconsin

The studies for this slope stability are carried out with special reference to Penang Island. Actual review is based on hillside development. To find out the geotechnical characteristic in the area. This will help to know the soil characteristic in the critical area. The purposed of this review is to analyze and interpretate a model slope stability model and also to develop a database about slope stability for Penang Island.

Firstly, the concept of slope stability is known as exposed ground surface that stands at the horizontal. Nowadays, slope stability also can be determined by using latest methodology which can help to provide input data in order to perform slope stability analysis for various possible slope profiles in hillside area.

2.2 THE CONCEPTUAL FRAMEWORK OF THE PROPOSED MODEL

The present study attempts to develop the modeling of slope stability or hillside area. The chosen of this activity because the development of hill side area become dynamic phenomenon, changing with space and time.

For the slope stability analysis model the approaches used are by using Erdas application. Erdas imagine are being used to generate digital elevation models (DEMs) for a variety of earth science studies at various scales. For this study, the proposed model was develop based on the geographic model (Tobler, 1979)

2.3 GEOGRAPHIC INFORMATION SYSTEM (GIS)

Geography Information System is a system that can be used to store, manage, analysis, manipulate and shows geography information data. Practically, GIS is the combination of software, hardware, data and user to solve such problems, corroborate a decision and to help in organize planning.

The unique capability of GIS to work (to capture, store and manage the data) with data referenced by geographic coordinates and its ability to incorporate appropriate engineering models, have caused its proliferating application across the wide sections of engineering, especially in the analyze slope stability (Mukesh et al. 2001). In particular, the ability to present the data and analysis results in maps forms for the critical area of the hill side for Penang.

The 3D visualization of the study area is created and digitized by Erdas imagine analysis. Here various map or image can be generated such as contour, land use, river, water table, road net, geology profile, soil profile rock profile, fault joint veins etc.

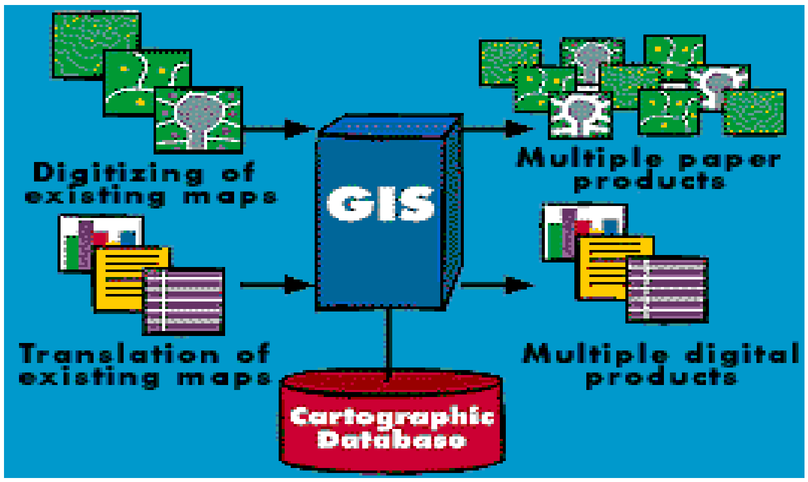


Figure 2.1: GIS Programmed

2.4 FACTORS INFLUENCING HILL SIDE DEVELOPMENT

The development of hillside area is influenced by numerous factors. These factors can be classified into two categories namely based on physical characteristic and spatial characteristic (Landis and Zhang, 1997; Landis, 1994; MPSP Structure Plan, 1993). Among the physical factors are topography, geology and soils. Topographic features hillside area, surface shape, drainage, local depressions and areas of distinctive vegetation (Walker and Fell, 1987). Strong geologic foundation will make sure that the selected areas are not susceptible to the danger of landslides and others.

The spatial characteristic has been determined hillside development included neighborhood, site suitability, good economic status, very high population densities, infrastructure availability and accessibility. The hillside development in Penang has grown rapidly since 1970s and is expected to continue growing in the near future. The northern region of Peninsular Malaysia has the potential to become an important centre in the region. So it is understood why the development process on hillside were taken by most developers.

2.5 CAUSE OF INSTABILITY

Instability in hillside area may be considered under the headings of 'natural' and 'developed' instability. Natural instability refers to naturally occurring instability which takes place without direct intervention of man. Develop instability occurs when inappropriate construction techniques are used, causing natural slopes which are on the limit of stability to start moving down slope (Walker and Fell, 1987).

Those critical areas or instability areas are cause by this movement:

i. Falls
ii. Slides
iii. Translational
iv. Flows
v. Rotational

2.5.1 Falls

A fall of material, soil or rock, is characteristic of extremely steep slopes. The material which moves can break away from the parent rock by an initial sliding movement: some shear surfaces may develop in response to gravity stresses and in moving, the material is projected out from the face of the slope.

2.5.2 Slides

A rock block may slide down intersecting joint planes which daylight in the face of a cutting, or a block may move down a steeply inclined joint or bedding plane.

2.5.3 Translational

This kind of slides often involves the movement along marked discontinuities or planes of weakness.

2.5.4 Flows

A flow is a mass movement which involves a much greater internal deformation than a slide. Thus, a flow could be obtained through movements taking place on a large number of discrete shear surfaces, or by the water content of the moving mass being so high that it behaved as a fluid, the latter being the case in clay soils at water contents above the liquid limit.

2.5.5 Rotational

Rotational slips have a failure surface which is concave upwards and occur in both soil and rock formations.

2.6 FACTOR OF SAFETY

In the stability analysis of slopes, many design factors cannot be determined with certainly. Therefore, a degree of risk should be assessed in an adopted design. The factor of safety fulfills this requirement. The factor should take into account not only the uncertainties in design parameters but also the consequences of failure. Where the consequences of failure are slight, a greater risk of failure or a lower factor of safety may be acceptable.

Slopes must be protected from failure that will cause disaster. Basically, slope that are slanting are most wanted by an engineer but the cost are high to do the process. Due to that, an engineer has to produce optimum slope from the appropriate factor of safety. That means slope stability is measured from the value of its factor of safety. The objective of slope stability analysis is to find the value of factor of safety.

Guidelines for slope stability by Connolly H. (1997) World Wide Web pages for slope design:

Factor Of Safety	Slope Detail
< 1.0	Unsafe
1.0 – 1.25	Questionable safety
1.25 – 1.5	Satisfactory for routine cuts and fills
> 1.5	Satisfactory for dams

The potential seriousness of failure is related to many factors other than the size of project. Often, the most potentially dangerous types of failure involve soils that undergo a sudden release of energy without much warning (Huang, 1983).

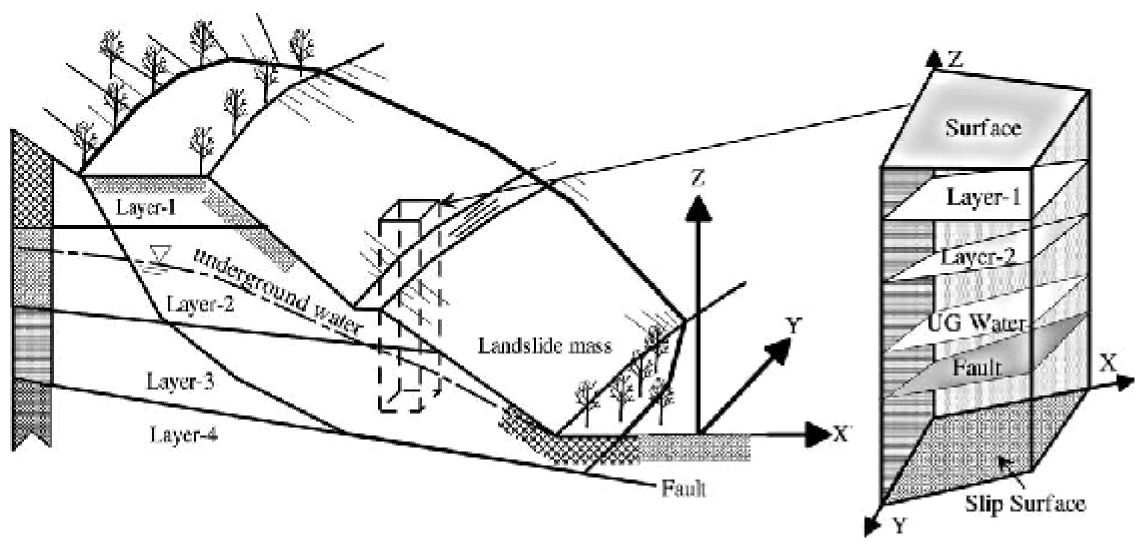


Figure 2.2: A 3D Slope Failure and One Grid Column. (Xie, Esaki and Cai, 2004)

2.7 PROPOSED MODEL

There are several types of model can be produce by using GIS application they are model may be a representation of data such as a Digital Elevation Model (DEM), conceptual model is an idea of how something functions (often described with a flow chart) and rule base modeling uses rules and numerical thresholds to interpret information represented in multiple data themes.

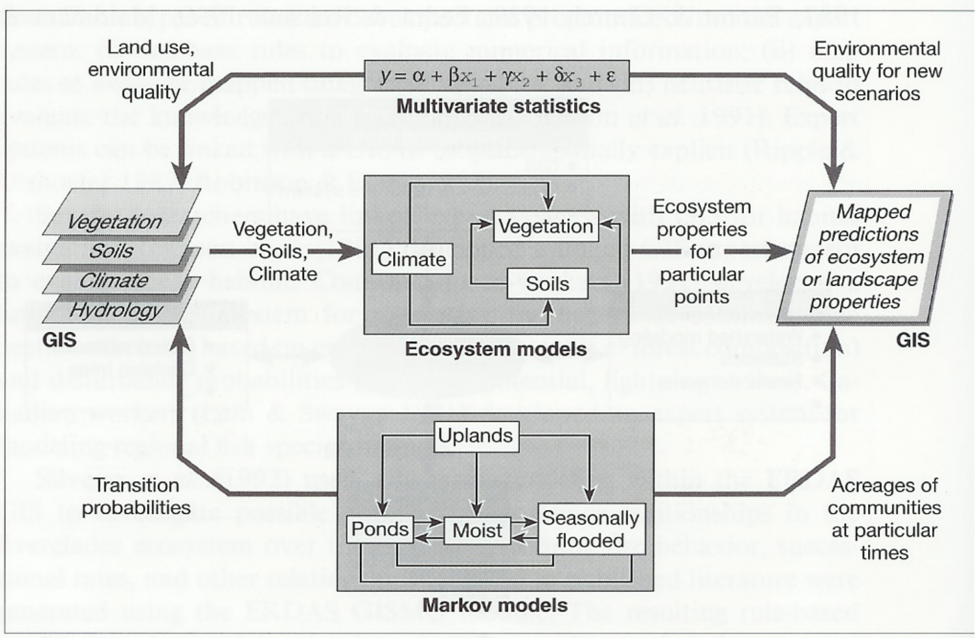


Fig. 10.4 Alternative methods of interfacing models with GIS. From Pastor & Johnston 1992.

Figure 2.3: Alternative Methods of Interfacing Models with GIS.

(Pastor And Johnson, 1992)

The development of hillside area in Penang have arises rapidly. That's why with the proposed model it will produce a benchmark for Penang hillside area development. Improper development will cause serious civil and environmental problem (Tapas Ghatak, 2000). This model will prepare comprehensive development to control the uses of such development that is improper so that such development can be properly implemented. In particular with this model it might present the data and analysis result in maps forms plays a key role in identifying the critical areas.

The need of this model is for the information for local authorities and agencies that's responsible for operation and maintenance of the infrastructure facilities created to ensure sustainability of the developments efforts.

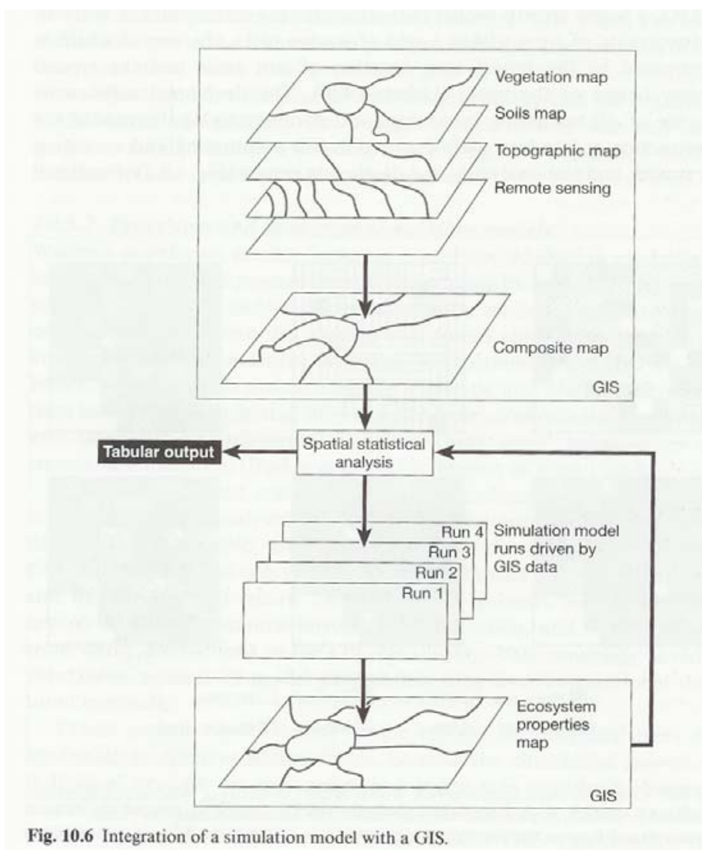


Fig. 10.6 Integration of a simulation model with a GIS.

Figure 2.4: Integration of a Simulation Model with A GIS (Pastor and Johnson, 1992)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The methodology for the report was carried out with the following site investigation (SI) report which had been given from Dr. Fauziah b. Ahmad. There were 6 of them which include location all around Pulau Pinang. The location that had been analyzed was as follows:

a. Jalan Permatang Damar Laut
b. Bayan Lepas
c. Mount Pleasure
d. Jalan Kenari
e. Tanjung Bungah
f. MK 13, DTL

In terms of analysis, there were two kinds of software were used, that is Erdas Imagine. Both of them were used to digitize Penang map with the reference from the SI report given.

3.2 DATA COLLECTION

The most important value that was taken from the SI report was the cohesion value, c, angle of friction, Ø, unit weight, γ, soil profile, soil shear strength and water level. These were taken during the analysis of slope stability to find the factor of safety to the studied area.

From the SI report, the parameters of soil strength were taken from the borehole that was stated in it. We can see from the reference the soil characteristic of every location that being studied.

In the SI report, there are maps that showed the contour of the proposed project area. From that, we can possibly take the height of the contour to determine the soil properties of the proposed location. In addition to that, borehole data and parameters were taken out such as reduce level height, description of strata and the SPT values.

Other than the SI report, the Penang topography map, contour of Penang and the road network were given data to process the analysis slope stability in this project. From the topography map, the information that were used during analysis are the height from contour line pattern, map grid, location name, administration limit, height point so on and so for.

Figure 3.1: Topography Map of Penang

Figure 3.2: ERDAS Imagine Version 8.3.1

3.3 SOFTWARE

This study was carried out using with the help of GIS. It is a tool to perform modeling to find factor of safety in slope stability. In this analysis, there were two software used. It is ERDAS Imagine Version 8.3.1.

To develop modeler, in brief these steps had been done:

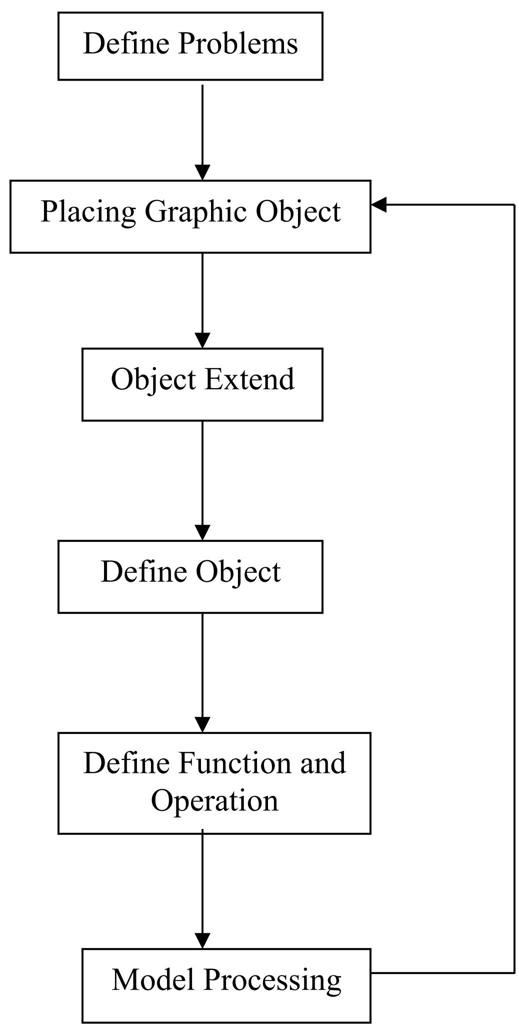


Figure 3.3: Step of Modeling

3.4 IMAGE PROCESSING

3.4.1 Image viewer

To start the process, first we have to open file.

The procedure was as follows:

Viewer / File / Open / Raster Layer/File Name/ OK

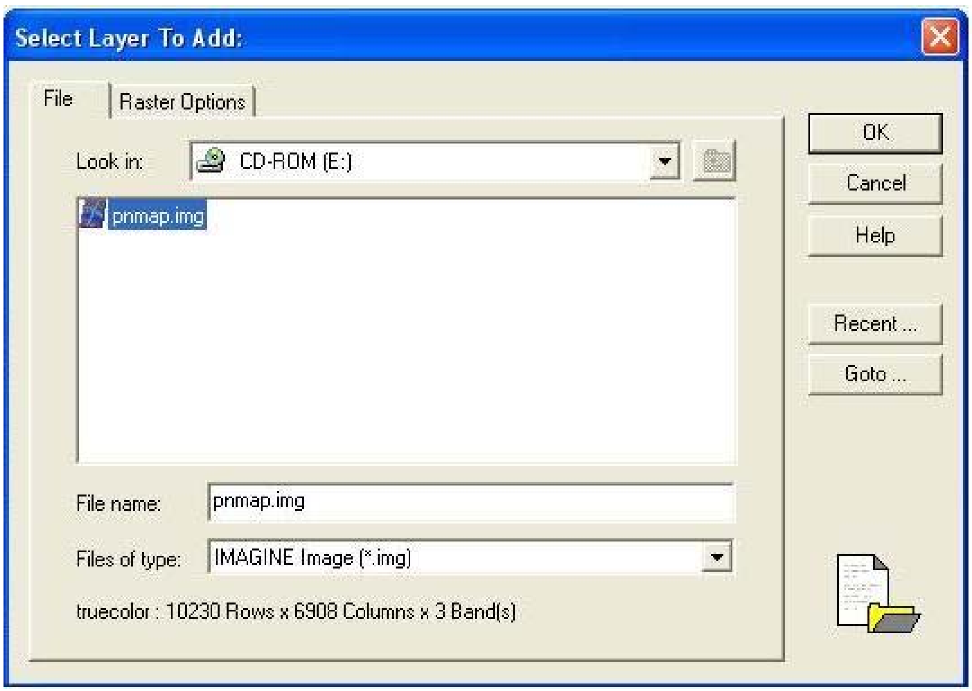


Figure 3.4: Open File

3.4.2 Rectification

Raster image rectification can record ground control point (GCP), compute a transformation matrix and use the transformation matrix and a resampling method to rectify the image.

Procedure:

Viewer /Open / Raster / Geometric Correction /Polynomial Model Properties /

Add/Change Projection/ Custom / Set Projection from GCP Tool

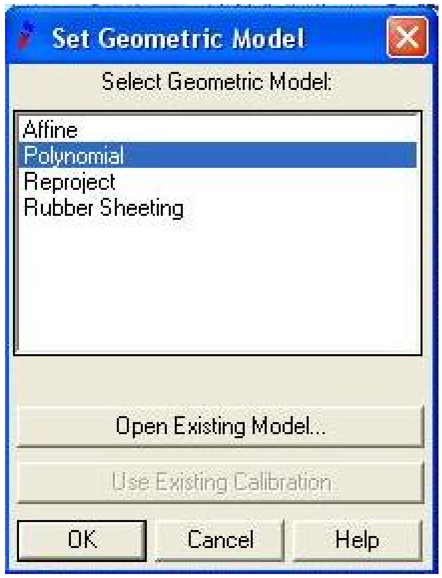


Figure 3.5: Set Geometrical Model

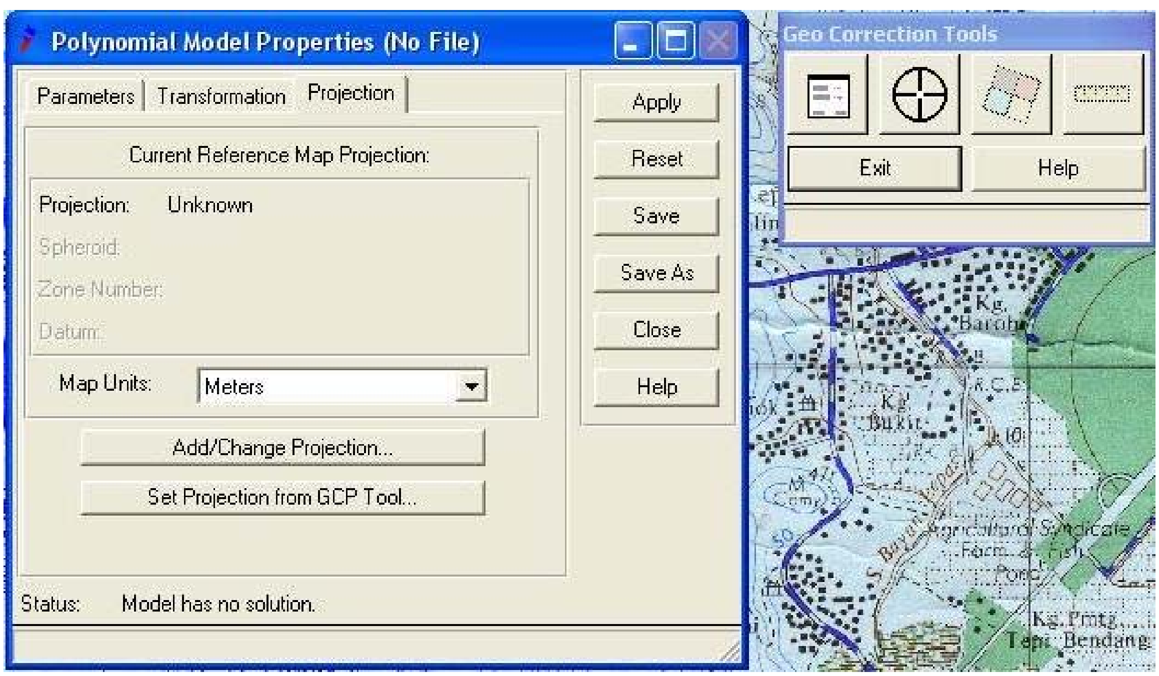


Figure 3.6: Polynomial Model Properties

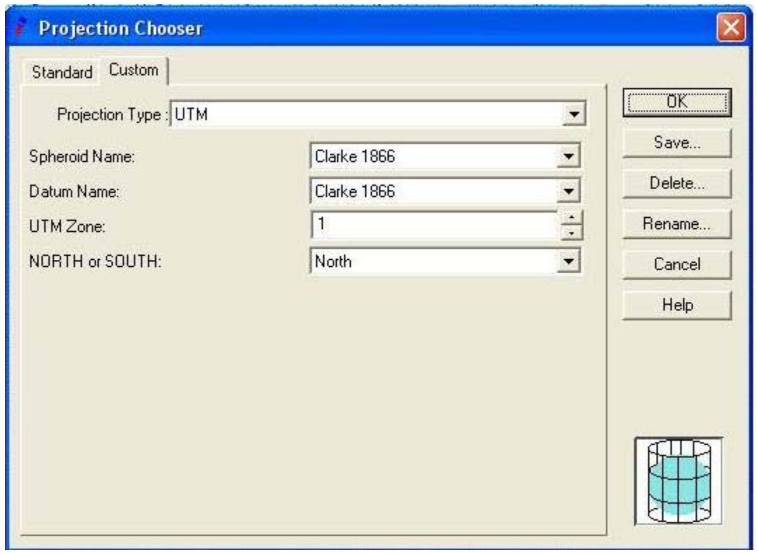


Figure 3.7: Projection Chooser

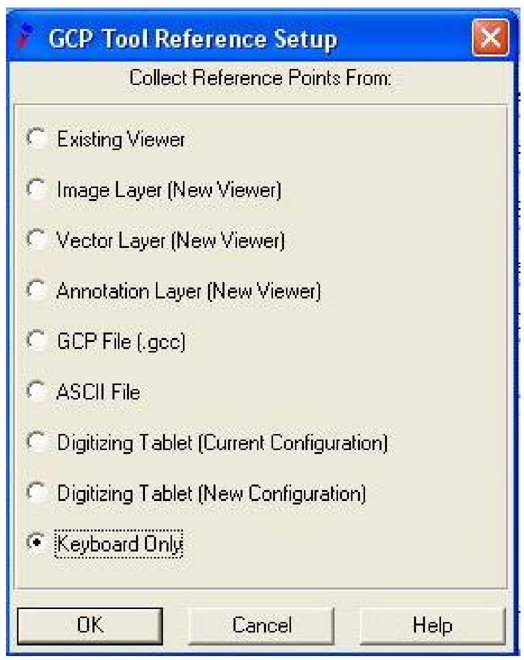


Figure 3.8: GCP Tool Reference Setup

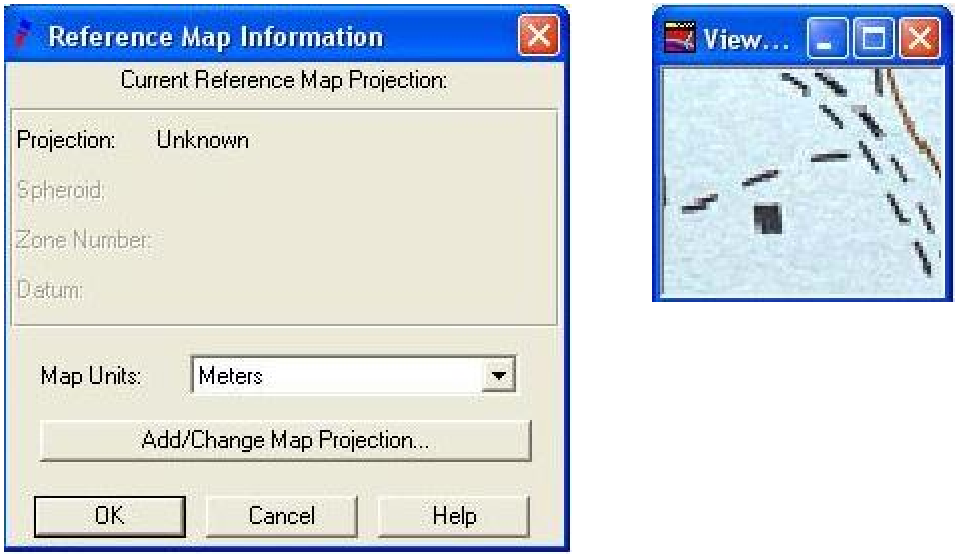


Figure 3.9: Reference Map Information and View

Ground Control Point (GCP)

Ground Control Point is the location in image where is it the coordinate that should be knowed. In ratification, the GCP coordinate is a must to know in system for the data that going to be processed.

The procedures are as follows:

GCP tool / icon create GCP / set 4 point GCP on every corner at the image that we want to ratificated / in every GCP point, the coordinate should be in the intersection grid of the map / it is easy for us to find the reference coordinate in topography map and those value were put into X Ref. and Y Ref. (figure 3.11).

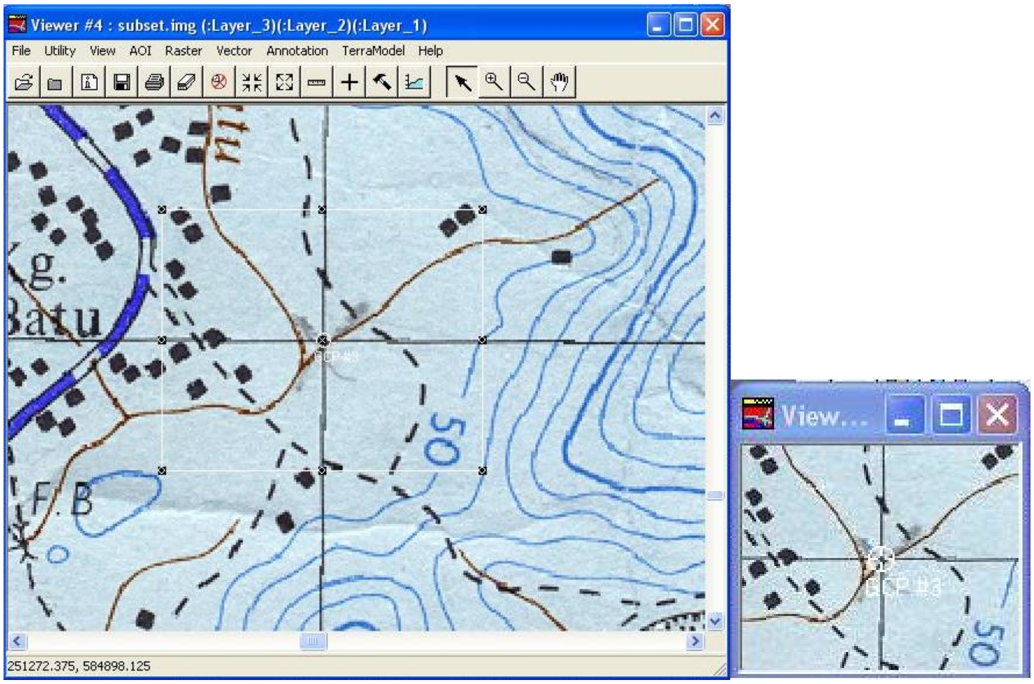
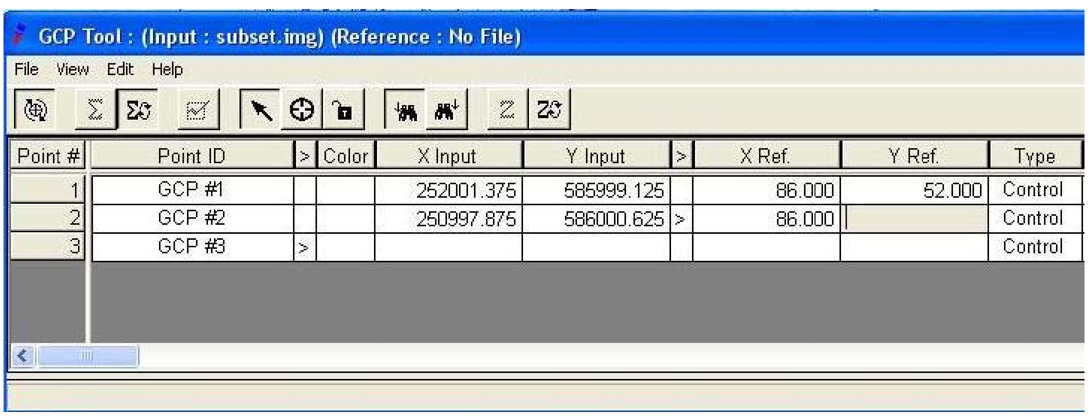


Figure 3.10: GCP#3 at the Intersection Grid


GCP Tool : (Input : subset.img) (Reference : No File)

File View Edit Help

Point #	Point ID	>	Color	X Input	Y Input	>	X Ref.	Y Ref.	Type
1	GCP #1			252001.375	585999.125		86.000	52.000	Control
2	GCP #2			250997.875	586000.625	>	86.000		Control
3	GCP #3	>							Control

Figure 3.11: GCP Tool: Input

After all four GCP point is set, resample were the next step. Here, the value for ULX (upper left X) and ULY (upper right Y) were the coordinate value for X and Y in GCP#1. Furthermore, the LRX (lower Right X) and LRY (lower left Y) value were the coordinate value X and Y in GCP#3. The next step was putting the output size cell with X: 10 and Y: 10. Finally click OK and ratification process will do its job.

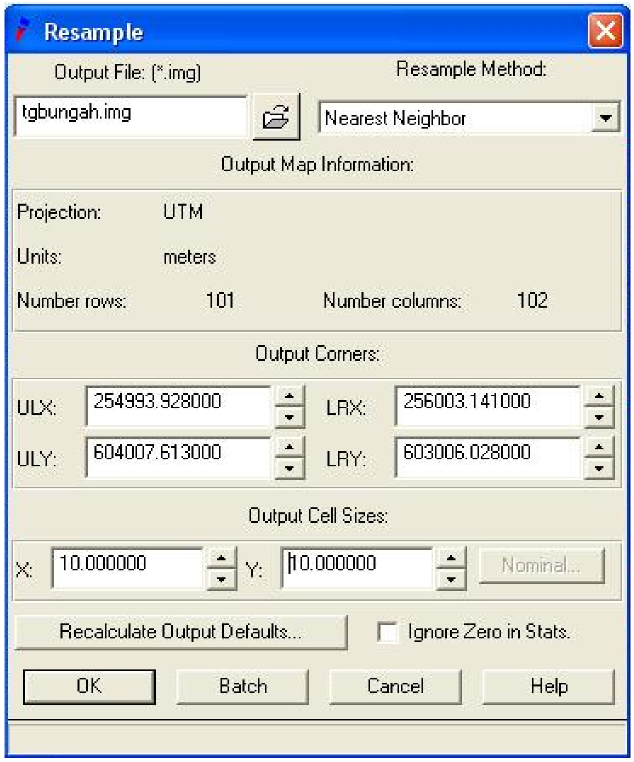


Figure 3.12: Resample

3.4.3 Image Subset

The purposed of this process was to develop a new image only on the selected area after it had been rectified. The process divided into two parts.

Firstly, put the file that need to view in viewer. Next, just click the **utility / inquire box** and a box will appeared on the image. The box then, dragged until it will covers the location of the site project i.e. Tanjung Bungah. Then click **apply.** Then a box stated coordinates ULX, ULY, LRX and LRY will appeared. This value will be used in surfacing process.

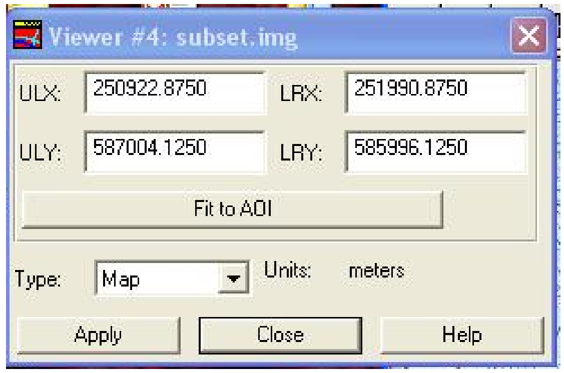


Figure 3.13: Inquire Box

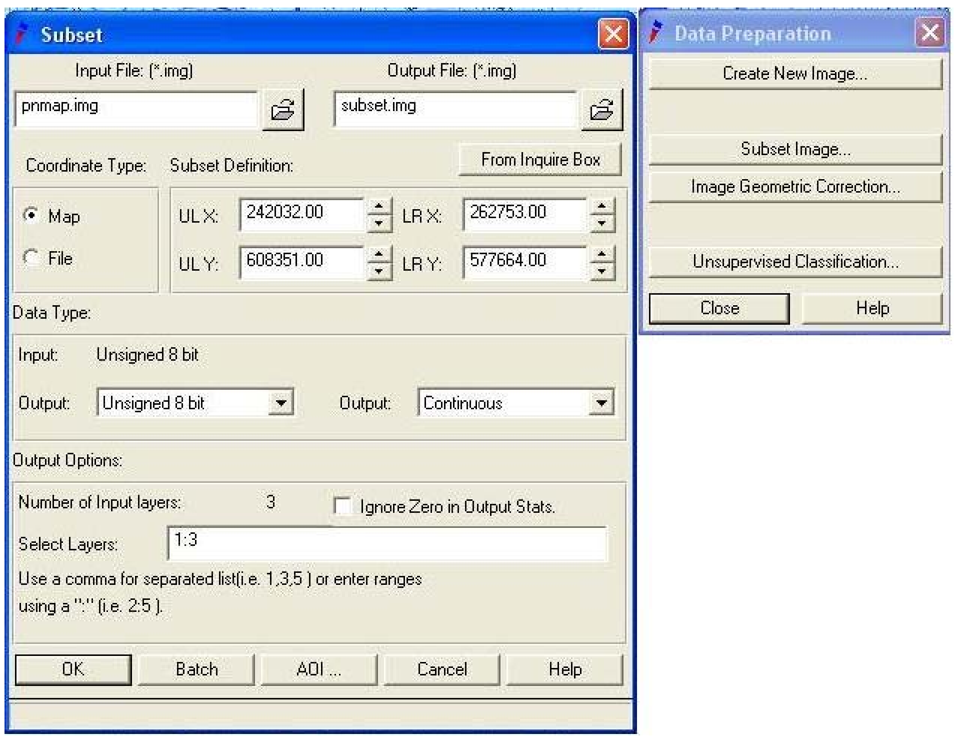


Figure 3.14: Subset Dialog

The second part; go to data preparation / subset image and a subset dialog will appear. Then these procedures were taken (figure 3.14).

Procedure: Data Preparation / Subset Image / Input File: / Output File: / OK

3.5 DIGITIZE

Digitize is a process to get the information from the topography map into digital. In ERDAS, digitize can be done easily. Firstly, open file that we want to digitized. Next in viewer, go to file/ new / annotation layer and a annotation dialog will appeared. Put new name of input*.ovr and press OK. After that, a tool bar will come out and digitized can be done will the help of polyline lines.

Next, draw the contour with the reference of the contour on the topography map it self. If necessary, to end the lines just double-click the computer mouse. Then to input the value of the contour we need to click twice the computer mouse and a polyline properties dialog will appeared. After all contours and its value had been inputted, finally press the safe button.

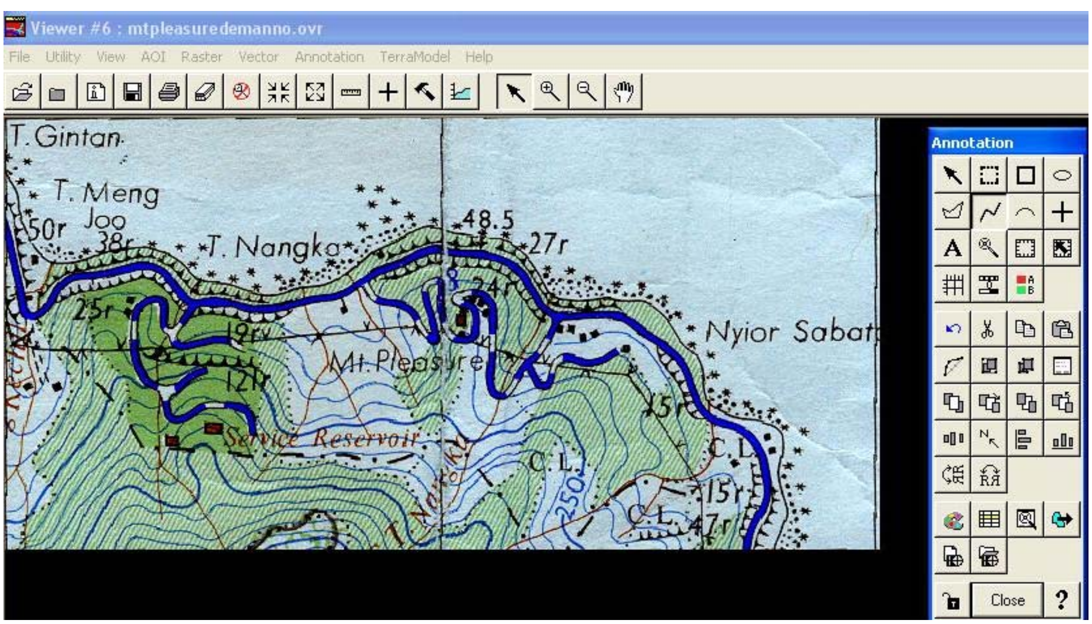


Figure 3.15: Annotation Tool Bar Dialog