MODELING AND SIMULATION OF HILL SIDE FEASIBILITY WITH GIS

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By

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CERTIFICATION OF APPROVAL

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Approved by,

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(A.P. Dr Abdul Nasir Matori)

Universiti Teknologi PETRONAS

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June 2010

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.

(JOSHUA LING ZHONG YIE)

Acknowledgement

First and foremost, thank you almighty for HIS blessings enabling me to have strength and intelligence to carry and complete this paper.

I am very grateful to my parents, who taught me the meaning of struggle in this life. Their loves becomes my power in my life and always make my life more meaningful.

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Abstract

Hill Side development has always been a sensitive issue to a development, especially when it involves the public. In Malaysia, the problems and solutions to a sustainable hill side development has been largely discussed over the years while in geotechnical aspect, it is a never ending discussion.

Engineering investigations is hard to be predicted and carried out especially at hilly area that is often hard to be reached. Thus, engineering feasibility studies are hard to be carried out and indirectly, it will certainly minimize its accuracy and most often, it is very much dependent on the engineers experience in making feasibility decision.

This paper presents an integrated system to improve Hill Side feasibility by modeling and simulation with GIS, the modeling involves, Land Elevation and Land gradients plotting for Hill Land identification and Hydrological mapping in Flow Directions Flow Length and flow accumulation to identify the hydrological effects on the development.

The transformation techniques of data into GIS base are Modeled and Simulated. A full and clearer development outlook has been presented. Data from different factors that affecting development is combined and of course in this project, we are focusing on few selected parameters mentioned.

Techniques and difficulties of modeling and simulation with a large database are discussed. A user-friendly interface is developed to support the planning, management and decision making in the development.

Contents

List of Tables and Figures

Chapter 1

Introduction

1.1 Preface - The Industry

By 2050, the global population is predicted to be over 9 billion people. Thus, the build or property development industry bears the responsibility of Designing and building the homes, workplaces, and playing grounds to accommodate this increasingly diverse population. Land development merges the science of city building with the art of place making through a collaborative, multidisciplinary approach to project delivery. Encompassing the fields of planning, engineering, surveying, architecture, landscape architecture, construction, marketing, finance and a host of other specialties, land development needs proper planning with technically skilled and creative personnel.

Design professionals must meet the challenges of today while not losing sight of yesterday's lessons and today's high standards. Professionals must have their finger on the pulse of the community – the political climate cultural and environmental priorities, infrastructure needs and desires – in order to reliably produce sound designs and contribute to the development of high quality places. However, all these are governed under a simple rule of thumb, the feasibility. Most often, the return on investment is what matter most.

Especially in the hilly zone, hill land, where sites are actually available for limited access during the planning part of a development. While Site accesses are quantified, it is pretty clear that site feasibility that is done is limited as well. Thus, these have made hill land development an interesting topic to look into.

In Malaysia, following the collapse of Highland Towers in 1993, the Federal Government has ordered for a thorough review of all development projects on hilly lands and temporarily suspended all new applications related to hill land development. The Parliament later in 1996 passed an Amendment Bill to Town & Country Planning Act 1976 containing new guidelines on hill land development. Hill land development has become a sensitive issue ever since.

1.2 Problem Statement

Most often not, in Technical analysis of a development, their parameters are roughly estimated judging from an Engineers' experiences and there was no appropriate modeling to help simulate the conditions of a site for overall development overview.

In hill land development, there are many factors that may affect its stability ie its natural existing geological properties, gradients of slope, cutting of slope, the natural water stream, treatment method (structures) to reinforce it and so on. Therefore, there has to be a tool to carry out a sound feasibility studies before all these modes of possible threats stated above can be identified.

Thus, through this FYP, we are trying to introduce, to model and to simulate a method of studies that involves both technical and non technical analysis. It is to help the industry or the professionals to determine feasibility of a proposed development.

1.3 Objectives

1. To model & simulate true site conditions with GIS in Elevation and Slope layering.
2. To model & simulate Hydrological effects on site with GIS.
3. To compare the feasibility between the Proposed Plan and GIS yielded.

1.4 Project Focus

In urban development, as land mass decrease gradually while the density of population increase rapidly, a development needs to become sound technically and non technically as the demand has increased overtime parallel to our complex macro economic growth.

The Land model that has been chosen for the scope of studies should include the following characteristic.

1. Consist at least not less than 20% of Hill Land area
2. Elevation of its surrounding lands varies from 10 meter until 100 from MSL.

Modeling and Simulation of Technical Factors (with GIS) in:-

a. Elevation effects on development
b. Slope Gradients/ contours effects on development
c. Hydrological effects on development
    i. Flow Direction
    ii. Flow Length/ Flow Pattern Prediction

Studies indicate that there are some numbers of similar modeling and simulation approaches towards accessing a rural and urban land behavior, in this case, we can relate it as 'the feasibility'. These need to be brought together as a whole for studying the impact of various factors affecting land feasibility.

Modeling and simulation in this paper refer to the use of computer based models and simulations. It is recognized that physical simulation such as site investigations play an important role in feasibility studies, but such activities are not the focus of the discussion in this paper.

To "model" means to draw and coming out with a 3d Visualization of the site.

To "simulate" means to yield the data based on the JKR Standard, Malaysia.

Chapter 2

Literature Review

The land development industry is the direct result of the ongoing need for housing and services as communities expand their borders and the population pursues for a better living conditions. Land development industry, its end product are the ones that we live by every day. Together with innovative Science and technology programs, these advancements have helped to boost development industry.

2.1 Towards a spatial decision support system

GIS is one such tool responsible for revolutionizing the era of spatial data management. A GIS can be considered as a tool for the integration and analysis of geological data (Shukla, Yadav, & Goel, 2006).

Basically, in order for development industry to move forward, a more aggressive and a higher technology approach should be taken for a more precise feasibility model that currently the industry is lack of, which is in spatial statistics and modeling language. This is required in applications in the field of land use planning, geology, geo technical, hydrology, soil science, forestry and many more.

Linear referencing systems have been developed to manage and maintain linear location reference data. It has been used for decades by state Department of Transportation (DOTs USA) to record and manage the location information associated with the characteristic and condition of transportation facilities. Recently, GIS have been proposed as a technology to facilitate, store, integration, management, and analysis of data used by DOTs (O'neil & Harper, 1999).

2.2 Why Integration, of analytical models with GIS?

GIS has become a prominent tool for development of city, country and infrastructure planning in general. In the disaster mitigation field, several uses in land management, response and reconstruction are reported (Lovett & Appleton, 2008). GIS has been charted for sustainable development. In Environmental issues, Engineering has adopted GIS as a medium of problems identifying and solutions. In more specific examples of usage, GIS is a tool in securing lifelines such as gas, water and electricity.

Land and property Advisors are beginning to recognize the opportunities that new technologies such as GIS can offer; increasingly, the potential of the digital property information system as a valuable decision support tool is being recognized. (Wyatt & Ralphs, 2003)

At the global level, it is important to realize that GIS is only a tool for overlaying maps, though it makes such overlay and integration easy (Brimicombe, 2003). The results of GIS processing are determined by the analyses carried out and the quality of data.

The most expensive part of the GIS use lies in the data preparation. It is important to note that more and more regional and global data of topography, land cover, soil characteristics, etc., prepared under various international and regional collaborative programs are becoming freely available (Lovett & Appleton, 2008).This makes it possible to start on GIS programs with base data sets that can be upgraded with more detailed data if the need arises (Herath, 2001).

The modeling system discussed is developed in a GIS environment to facilitate data capture, spatial analysis and visualization. The aim of the current system is to generate broader scenarios to direct planning at a broader level (Wyatt & Ralphs, 2003).

2.3 Existing Land Feasibility with GIS

Urban Planning Method

To forecast future activity within an area, it is necessary to know some basic land use attributes about the zone. For example, does the zone have any vacant and developable land? Is the developed land within the area mostly residential, mostly commercial, or a mix of uses? Is there significant open space or other constraints to development? In (Mulger & T.Quinn, 1999), it is clearly stated where the Denver Regional Council of Governments (DRCOG) has been utilizing GIS in its Town planning. Its developing program has interest in forecasting future development mode, future household trend, employment levels and its demographic features.

Transportation Planning Method

According to (Souleyrette & Strauss, 1999), GIS technology is being used to solve problems in urban transportation. The focus is on applications within transportation planning, such as transit planning, travel demand management, network models, freight transportation planning, safety analysis, traffic control and intelligent transportation systems. Transportation by all means affects a value of a land in development. Traffics acted as a medium of communication between places and it holds pulse of the community.

Storm water and Waste Management Method

Handling a community's waste streams can be one of the greatest challenges faced by urban planners and engineers (Campagna, 2005). Many urban areas are finding GIS to be an important tool to reduce costs of installation, expansion, and maintenance of storm water and waste management systems. A method of GIS has been utilized and applies for maintenance, hydrologic modeling, flood control, storm water quality as well as landfill management. (Herzog & W.Labadie, 1999).

Disasters Reduction

In the paper of (Herath, 2001), GIS has been put into use relating to disasters reduction. The strength of GIS lies in the ability to represent the real world situation closely with layers of information (maps) that can be combined in a predetermined manner to identify the impacts of a natural hazard through the introduction of hazard dimension. In the case of floods, the hazard information is represented as water height, velocity and the flood duration distribution over the catchment. Combining this information with population distribution helps identify people at risk, with road network shows available or passable roads for evacuation and relief, with hospitals and emergency facilities in planning response and relief and with the property distribution in estimating damage.

With GIS, information required for such purposes ranges from those pertaining to emergency response providers (location, capabilities, etc.) to spatial and temporal distribution of various group that could be potentially affected such as population sub groups (elderly, children, hospital bound, etc.) (Parentela & Nambisan, 1999)

Crime Patterns

A potential development will not be favorable if criminal rates are high. As metropolis and cities gain wider, bigger and denser, its population will definitely be suffering from morality sickness where it gives rise to the criminal rates. Same goes to a political climate and education level of a certain area which have very much influence on the crime patterns.

Department of Geography, Division of Criminal Justice of University of Cincinnati has been working on this research. This research developed a dynamic crime pattern simulation model from a static crime model and coupled it with Arcview GIS (Liang, Liu, & Eck, 2001).

Within the framework of this simulation system, customized GIS is serving as system interface while here it also saves efforts on spatial data organization, visualization, and analysis. In the research itself, the department has chosen commercial property robbery simulation as an example for integrating a spatial-temporal simulation model with GIS (Liang, Liu, & Eck, 2001); thus, it suits the purpose of this FYP and it gives us a strong link-relation to the land feasibility studies that we are studying at.

Economic optimization

Economic land evaluation is a method for predicting the micro-economic value of implementing a given land-use system on a given land area. GIS are a more useful prediction of land performance than a purely physical evaluation, since many land-use decisions are made on the basis of economic value. Measures of economic suitability include the gross margin, net present value, internal rate of return, benefit/cost ratio, and utility functions based on these.

The economic value of the *in-situ* resource quality of a land area may be inferred directly from land characteristics or from Land Qualities which, when less than optimum, result in decreased yields or increased costs (Rossiter, 1995).

The economic value of geographic land characteristics may be determined by spatial analysis. Single or multi criteria economic optimization and risk analysis can extend the economic land evaluation from a natural resource or managements unit to a production or planning unit. GIS is nonetheless a computerized tool that is used to assist in economic land evaluation (Mallawaarachchi, Morrison, & Ebert).

The aim of the optimization model is to find the socially optimal land allocation consistent with available land, site characteristics and the opportunity costs of using that land. Given the production objective of profit maximization, and the social benefit from preservation of natural land, the model should be able to derive maximum net returns. Optimal investment decisions incorporate both environmental and economic characteristics of land, which jointly determine the long-term profitability of land in production.

2.4 Hill Land Development in Hong Kong

Hong Kong is a concrete jungle; its skyscrapers were not built by days but years. Decades ago, Hong Kong has run out of flat land to sustain its ever increasing populations and development needs. Through years of experiences, reasonable enough to say that, they have become expert in hilly land development.

During 1972 and 1976, 2 major landslides had occurred and claimed a total of 138 fatalities in Hong Kong. It has then driven major media coverage and public concern of the citizens. After then on, Hong Kong government has taken dramatic changes and modification to its development regulations.

Subsequently, Geotechnical Control Office in 1977 (renamed Geotechnical Engineering Office or GEO in 1991) has been set up and since then, after many years of concerted efforts the risk of landslides in Hong Kong, the landslide has been reduced significantly to a manageable level through a slope safety system.

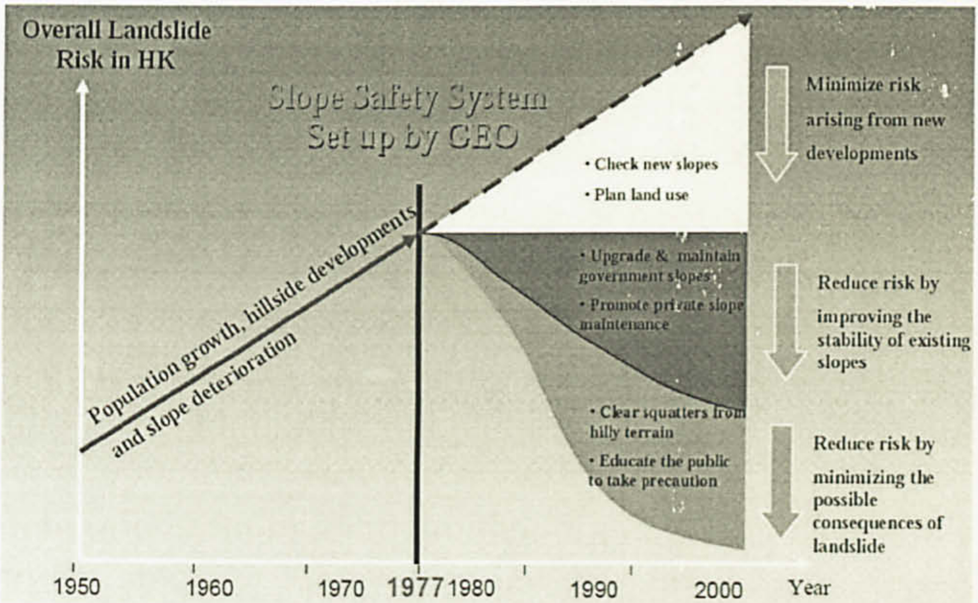


Figure 1: Land Slide Reduction Strategy

Source: (Chai, Ooi, & Krishnan, 2009)

Since the establishment of GEO, it has been undertaking geotechnical research and development projects with an aim to set the geotechnical standards for Hong Kong and prepare professional guidance documents for practitioners.

Today, Slope Safety System in Hong Kong had managed to reduce the overall landslide risk of old man-made slopes to less than 50% of that in 1977 while their GEO strives to reduce it further to less than 25% by 2010.

Although landslide fatalities have been greatly reduced, the public has become less tolerant of the occurrence of multi-fatality landslides and secondary impact of landslides such as road closure and building evacuation. The public is demanding a better and greener living environment.

GEO takes a leading role in making the man-made slopes look as natural as possible and blending them with their surroundings. For some ideas, let's take a look at the major contributories to the engineering soil cuts in the island.

Key contributory factors to failure of engineered soil cuts in Hong Kong

Contributory factor	All failures	Minor failures	Major failures
Adverse groundwater conditions	30%	38%	75%
Weak geological materials	46%	40%	67%
Inadequate slope maintenance	45%	55%	19%
Inadequate surface drainage provisions	5%	7.5%	Nil
Uncontrolled, concentrated surface water flow	2%	2.5%	Nil

Figure 2: Key Contributory Factors to Failure of Engineered Soil Cuts in Hong Kong

Source: (Chai, Ooi, & Krishnan, 2009)

2.5 Hill Land Development in Malaysia

By nature, Hill Land is an environment particularly prone to landslide due to its extremely hilly terrain. Following the collapse of Highland Towers in 1993, the Federal Government ordered for a thorough review of all development projects on hilly lands and temporarily suspended all new applications pending outcome of a review conducted by an ad-hoc technical committee appointed by the Federal Government.

The Parliament later in 1996 passed an Amendment Bill to Town & Country Planning Act 1976 containing new guidelines on hill land development. The new guidelines, among others, prohibit cutting of existing slopes of more than 35 degrees in gradient. These new guidelines were to be adopted by all State Governments and local authorities.

Place	Date	Consequence	Estimated loss (RM Millions)
Ringlet, Cameron Highlands	1961	16 deaths	35
Highland Tower, Selangor	1993	48 deaths	185
Genting Sempah jalan ke Genting Highlands, Selangor.	1995	20 deaths	48
Lebuh Raya Utara Selatan di GuaTempurung, Perak.	1996	1 death, expressway closed for 15 days	17
Aliran puing Pos Dipang, Perak.	1996	44 deaths	69
Aliran puing Keningau, Sabah.	1996	302 deaths	459
Simunjan, Sarawak.	2002	16 deaths	32
Km 44 Jalan Spg. Pulai Cameron Highlands	2000	Road opened in 2004 (4 yrs delay)	355
Bukit Lanjan, Lebuhraya NKVE	2003	Expressway closed for 6 months	860
Kg. Pasir, Ulu Kelang	2006	4 deaths	21
Bukit Antarabangsa, Selangor	2008	5 deaths	200

Figure 3: Major Landslides in Malaysia since 1961

Source: (Chai, Ooi, & Krishnan, 2009)

Basically, all development projects on hilly land will be referred to the Hill Land Committee for review and comments before clearances can be obtained for planning permission. In general, a development project will most likely be categorized under hill land development which will be referred to Hill Land Committee by JKR if the existing conditions of the land contain any or all of the fol'owing characteristics:

- Hilly land with existing Slope > 25°
- High land with Ground Levels > 250 ft (76m) above sea level
- Hill slope cutting > 6m height
- High retaining wall
- Any other land or development characteristics which are of concern to JKR in connection with environmental and development risks.

Land use suitability is generally classified according to the slope gradient of existing terrain, site geology, degree of erosion and terrain component into four (4) classes. The actual analysis is much more complicated but as a general guide, the following criteria are normally considered:

Land-use Suitability	**Slope Gradient**
Class I	< 15 degree
Class II	16 – 25 degree
Class III	26 – 35 degree
Class IV	> 35 degree

Table 1: Hill Land Classification by JKR Standard

Lands classified under Class IV are not allowed for any development. (Chan, 1998) Mentioned that in Malaysia, especially in Penang Island itself, is largely made up of steep topography and much of the lowland areas are already developed. Penang is one of the many rapidly industrializing states in Malaysia with a largely urban populace.

Thus, like Hong Kong, Penang is a state where Hill Land development plays a major part in their development. The Local Authorities have always paid serious attentions towards to any kind of land development in the state. Thus, the professional and the private entities in the field have always maintain a good relationship with the government to deliver a solution that suited best for the public.

In Penang state, after 1993 Highland Tower tragedy, the state government had temporarily frozen applications for development on lands located more than 250 ft. above sea level. This directive was later lifted. The local council then also made it mandatory that all hill land development project applications are to be supported by geotechnical study reports.

In 2001, JKR Pulau Pinang was entrusted with the responsibilities to impose requirements to comply with Guidelines on Hill Land Development in Penang. This led to the formation of the Hill Land Committee in Penang. The setting up of the Committee and adoption of Hill Land Development Guidelines have, to a large extend, made references to the similar guidelines drawn up by the Geotechnical Engineering Office (GEO) of Hong Kong Government in dealing with hill site development and slope safety systems.

(Chan, 1998) stated hill land needs to be protected, conserved and especially cared in all ecologically and environmentally sensitive areas. He also mentioned, "It is essential to the set up Hill Land Technical Committee (HLTC) to manage all developments pertaining to hill land and to gazette all hill land in the State, and the use of state-of-the-art remote sensing and Geographic Information System (GIS) technology to monitor and control development activities on hill land in Penang.

2.6 Engineering Feasibility

The engineering feasibility study should evaluate the technical and non-technical analysis that involved the physical, environmental, regulatory or other constraints and it must be overcame or accommodated in constructing the intended use.

The results of this study often affect the purchase price of the property which is frequently based on presumed development potential. Uneducated assumptions about development potential frequently prove to be in error because of physical, locational, or external characteristics not properly considered.

Land development is a very risky business. To help offset that risk, an engineering feasibility study is often required fairly in the development process in order to identify problems likely to be encountered during planning, design, government review, and construction, as well as to more resolutely determine potential uses for the land.

It is this engineering feasibility study that aids developers in answering their basic questions and minimizing the risk incurred in purchasing land with the intent to develop or redevelop.

The developer may study several alternative uses based on the information compiled during the assessment period. This helps determine the uses that are economically feasible or whether the land development project can be profitable.

The study must be well organized and is usually supported by maps, photographs, and other graphics. It is often but not always, presented in report form, although annotated base and topographic maps may suffice, depending on the client and the complexity of the project. The intent of the study is to identify development constraints or red flags along with options to minimize or alleviate those constraints. The study does not always specify preferred solution.

The feasibility study requires a comprehensive collection of all information that could affect the site and its development. The research and analysis associated with an engineering feasibility study can be categorized into few major types of information:-

1. **Physical condition** of the site such as topography; soils, utilities, sanitary sewer, hydrology and external influences created by neighboring properties and uses.

2. **Legal condition** of the site such as easements, land rights, and other property issues.

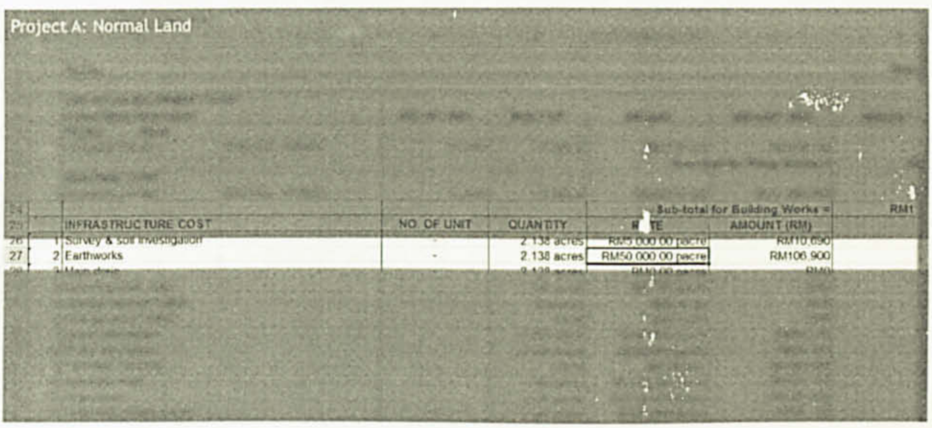
3. **Regulatory concerns** of the site such as applicable master plans, zoning and ordinance requirements, possible citizen opposition and governmental review considerations.

4. **Cost of Development** in this conscience usually depends on the outcome of the Physical condition analysis which then leads to Land premium, Materials cost and Construction cost. As always, the cost will play down the rest as the last prerequisite to a development.

2.7 Factors Affecting Hill Land Feasibility

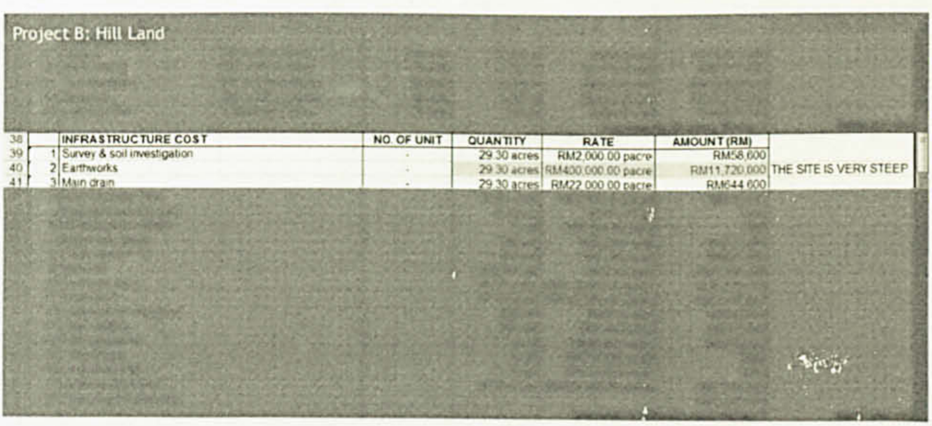
Like normal land studies, Hill Land development study consists and includes the same factors of consideration in evaluating land feasibility. In terms of non technical considerations and cost, it is about the same. As in technical considerations, we might see an increase in cost for its earthworks treatment resulted in concern of the Natural hill land stability as well as its hydrology affects.

As an Example, from the feasibility studies spreadsheet, comparison between both Hill Land and Normal Land development are shown:-



Project A: Normal Land

		INFRASTRUCTURE COST	NO. OF UNIT	QUANTITY	RATE	AMOUNT (RM)
26	1	Survey & soil investigation	-	2.138 acres	RM5,000.00 pacre	RM10,690
27	2	Earthworks	-	2.138 acres	RM50,000.00 pacre	RM106,900
28	3	Main drain	-	[illegible]	[illegible]	[illegible]



Project B: Hill Land

		INFRASTRUCTURE COST	NO. OF UNIT	QUANTITY	RATE	AMOUNT (RM)	
39	1	Survey & soil investigation	-	29.30 acres	RM2,000.00 pacre	RM58,600	
40	2	Earthworks	-	29.30 acres	RM400,000.00 pacre	RM11,720,000	THE SITE IS VERY STEEP
41	3	Main drain	-	29.30 acres	RM22,000.00 pacre	RM644,600	

Figure 4: Cost Comparison between Normal and Hill Land
Source: SP Setia Bhd

2.8 SOP for Sustainable Hill Side Development

After the wake of Landslide in Bukit Antarabangsa, (Gue & Chow) has suggested and created the Standard Operating Procedures (SOP) in the aim of centralizing institution for a sustainable hillside development.

The effectiveness of an institution compared to promises by political parties is described by Tim Harford in his book "the Logic of Life: Uncovering the new economics of everything". Tim Hardford argues that institutions are more effective simply because it is far more difficult to overthrow them while policies can easily be changed of political parties. This is the current dilemma facing hillside development.

The public has no confidence in the credibility of various stakeholders in ensuring safe and sustainable hill side development and therefore, demand a total ban on hill side development. As such, the way to move forward is for the creation of SOP and a centralized institution/agency for hill side development together with strict enforcement of the SOP to re-establish credibility in the eyes of the public. This is also advantageous to other stakeholders as protests against hill side development will definitely reduce if the competency of the centralized institution agency is demonstrated.

(Gue & Chow) Has observed that knee jerk reactions from political parties and they know that things easily revert to previous bad practices when time passes. This is why the establishment of a centralized institution/agency and SOP are important to ensure sustainable hill side development even after the issue is no longer 'hot'. Promises can easily be broken while institutions often last and are more difficult to overthrow.

They have addressed several key issues to be included in the SOP with both at high risk areas, which can be summarized as such

1. Classification of Slope
2. Submission Requirement
3. Approval Enforcement by Authorities
4. Qualifications of geotechnical engineers to undertake geotechnical design and checking hillside development.
5. Construction Supervision
6. Requirements of accredited Checkers

The procedures for Identifying High risk areas are generally as follows:

1. Carry out hazard mapping and risk assessment to identify areas with high risk-to-life and economic losses.
2. Upon Identification of areas with high risk. Carry out detailed stability assessment.
3. From the stability assessment, propose strengthening measures for unstable slopes. The land owner should carry out the necessary strengthening measures recommended. The approach will be similar to Hong Kong's Dangerous Hillside Order.

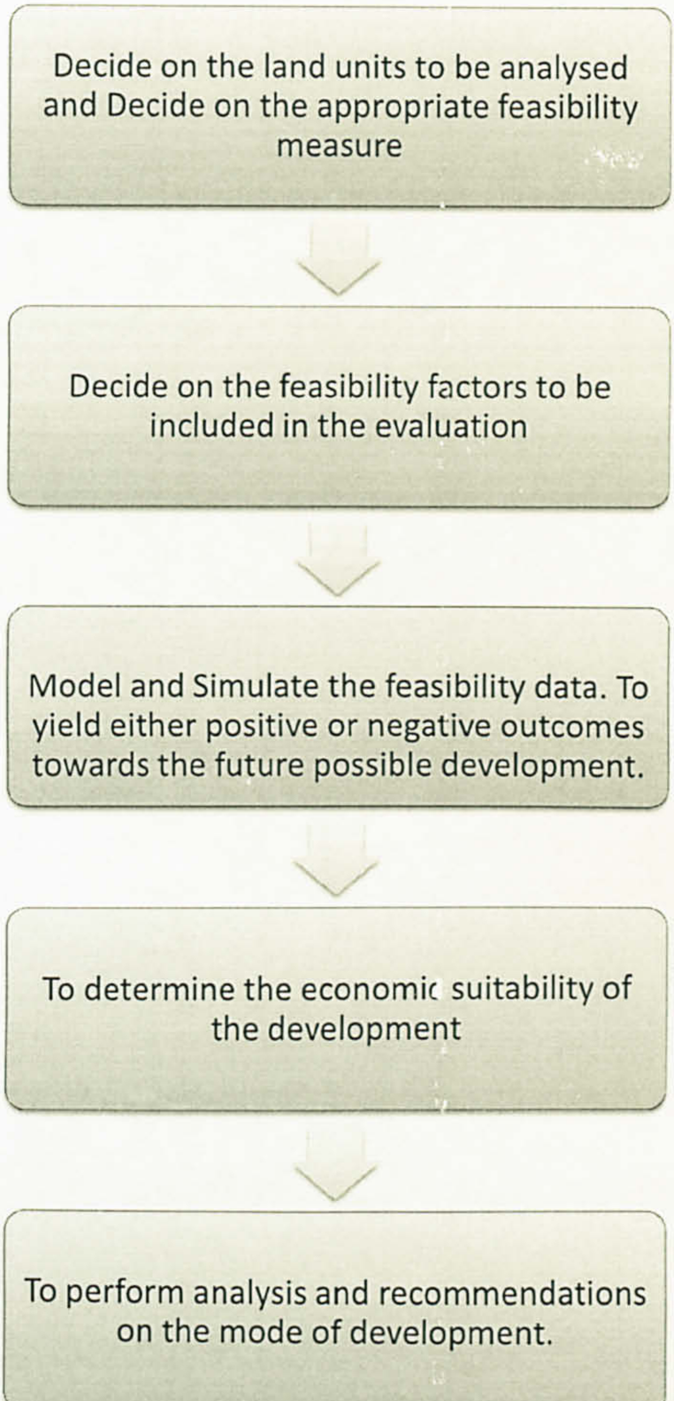
SOP aims to formulate a national guideline with centralized agency regulating geotechnical works on hillside that will ensure sustainable hillside development. For a sustainable hillside development, it is also important to carry out proper maintenance on slopes and existing drainage. As such, the centralized agency needs to carry out programs to educate the public, local authorities and private land owners on the importance of slope maintenance.

Chapter 3

Methodology

3.1 FYP Project Work Flow

3.2 Proposed Feasibility Procedures



Refer to Chapter 3.3 for details.

3.3 Studying Procedures

1. Identifying our target site - Cangkat Sungai Ara, Relau, Penang Island, Malaysia @ Latitude 5°20'4.72"N, Longitude 100°15'54.26"E

Figure 5: Google Earth Bayan Lepas Overview @ Interested Site

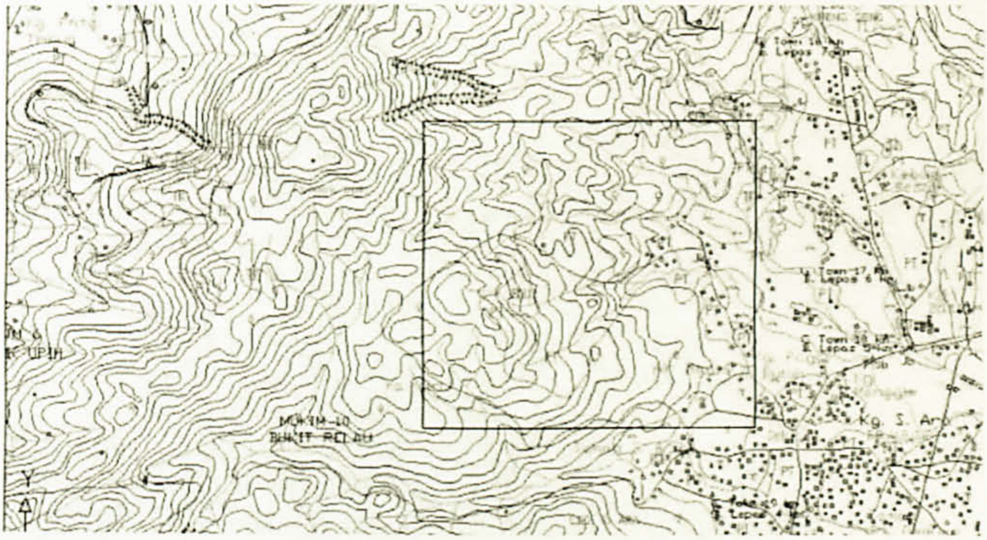


Figure 6: Surveyor Plans of Cangkat Sungai Ara Site

2. The land model chosen to be studied should fulfill the following characteristic.
    a. Consist at least not less than 20% of Hilly Side area which contains slopes and it is not of 100% flat land
    b. Elevation of its surrounding lands must at least vary between 10 meter MSL and 100 MSL (Mean Sea Level).
    c. Land model chosen should consist primary from forestry area where investigations and surveying works are hard to be carried out thus fulfilling the use of GIS in this matter.

3. For the results; with GIS, we will Model and Simulate the data of

    a. Elevation effects on development **(Chapter 3.5)**
    b. Slope Gradients/Contours effect on development **(Chapter 3.6)**
    c. Hydrological effects on development **(Chapter 3.7)**
        i. Flow Direction
        ii. Flow Length/ Flow Pattern Prediction

Figure 7: SP Setia Cangkat Sungai Ara Development Layout Plan

4. After deciding on which feasibility factors to be considered @ Item No.3 above, with reference to the study location @ Item No.1 and met the condition for investigation @ No.2; We will then Model and Simulate the

    a. Site conditions in Land Elevation of 3a to achieve **(Objectives No.1)**
    b. Site conditions in Slope layering of 3b in order to **(Objectives No.1)**
    c. Hydrological effects on site with GIS of 3c(i) and 3c(ii) to achieve **(Objective No. 2)**

5. Thus, with the outcome of the ArcGIS generated from Item No.4; the feasibility of the project can then be further determined by comparing the existing designed development layout plan and GIS yielded data.

6. **Objective No. 3** can then be proved from the outcome of the comparison.

7. To carry on, based on the data from Item No.4, if the development pass the bill of feasibility study, the project will be enhanced further.

8. Here, with the GIS development data yielded earlier, we will be able to make recommendations for improvements to the site's configurations; from the possible Safety features, slope treatment, geotechnical treatment and hydrological disaster prevention treatment.

3.4 CAD and GIS Integration

Figure 8: Plan View of Penang Island in AutoCAD DXF file format.

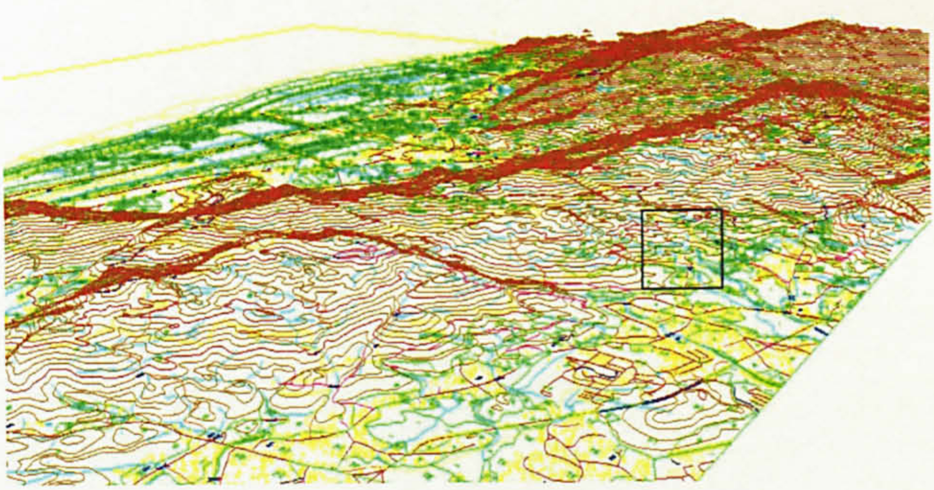


Figure 9: Integration of CAD into GIS Mapping with 2D and 3D Outcome.

Integration between CAD and GIS software (ArcGIS) will help aiding in retrieving the needed data more efficiently because GIS has the ability to model and simulate different data sets which were the plus point for a certain user.

3.5 Elevation Effects on Development

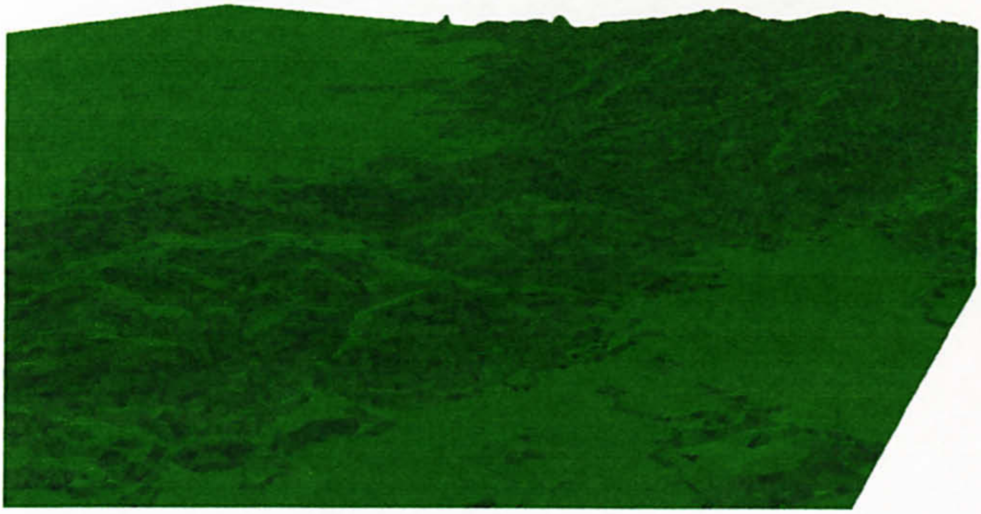


Figure 10: Elevation Modeling using GIS

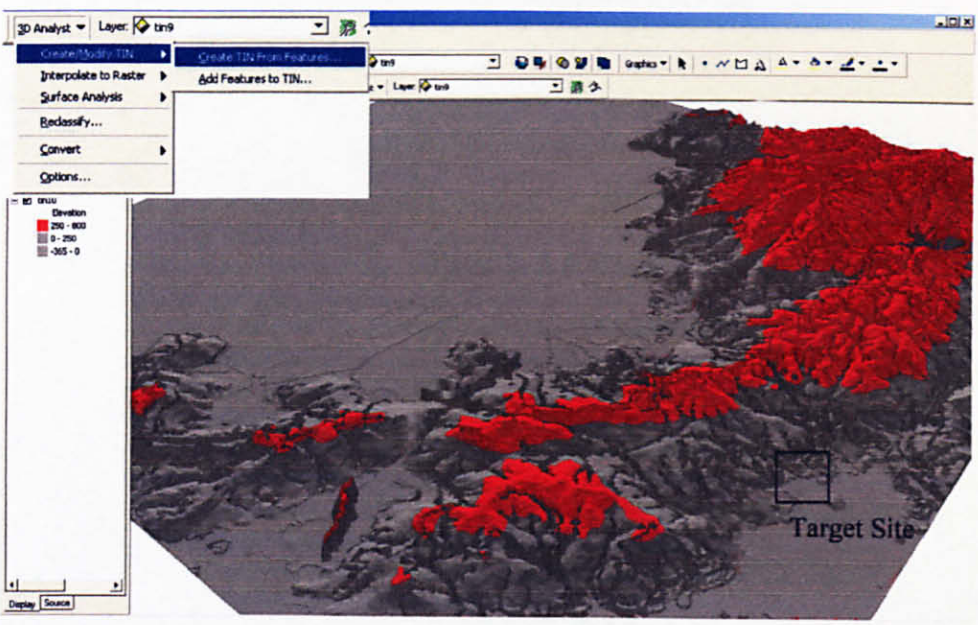


Figure 11: Elevation Modeling

As it is shown in the modeling above, Hill Land parameters can be set in order derive the required data.

3.6 Slope's Gradient and Contours Effects on Development

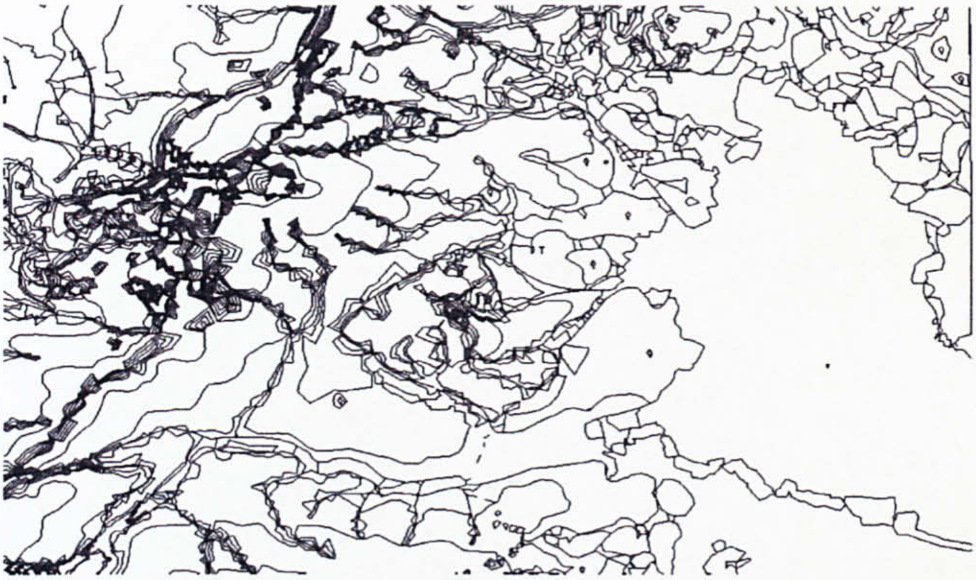


Figure 12: Contour Modeling with GIS

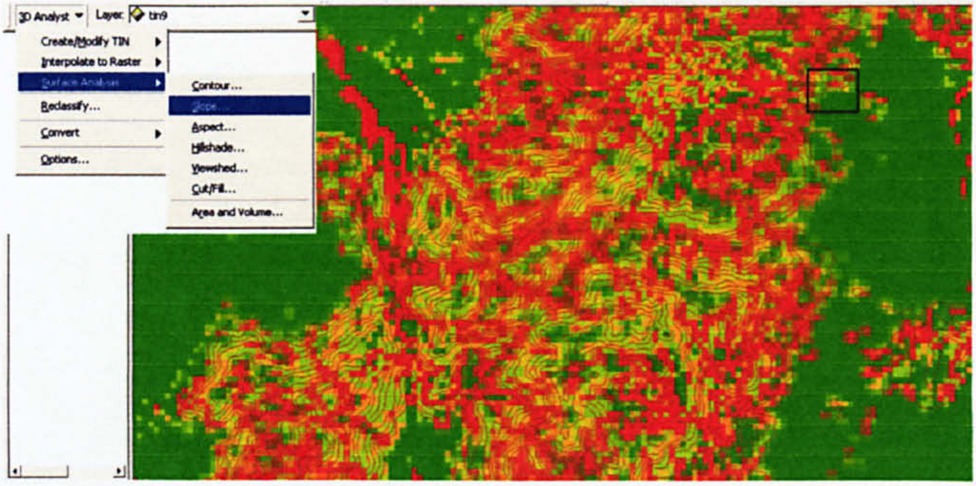


Figure 13: Slope's Gradient Modeling

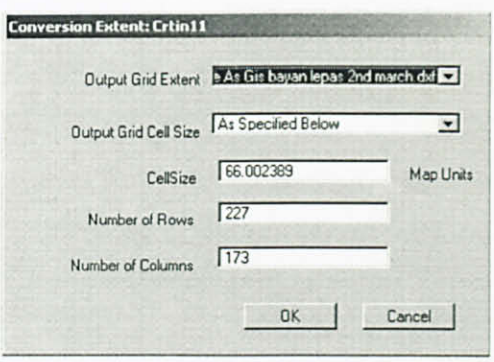
3.7 Hydrological Effects on Development

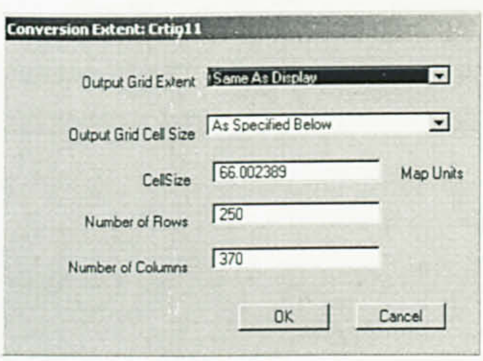
3.7.1 Flow Direction (Flow Path Prediction)

ArcGIS 3.x with the extension of Hydrotools 1.0 has the capability to predict the possible direction of flow path. These predictions have been able to take into accounts the rainfall and water runoff in the study area. For better and more accurate simulation of data, the data of the hydrology runoff data prediction has been taken from a wider perspective, whereby, the data input has covered the hilly land area along the southern part of Penang Island where our Target site, Changkat Sungai Ara, Relau are located.

In ArcGIS 3.x, under Hydrotools 1.0, there are 2 distinctive conversion of TIN to GRID layering. Therefore, due to uncertainty, we are converting and using both of the "Output Grid Extent" for our modeling and data simulation for comparison purposes.

1. Output Grid Extent: Same As "Display"
2. Output Grid Extent: Same As "GIS Bayan Lepas ..." (Source File in DXF format)





The 2 different type of Conversion of GRID as mentioned will then give 2 different Digital Elevation Model (DEM). As a result, there will be 2 Flow Direction output in the process.

Water Runoff or Flow Direction Pattern is important for project planning in a development, as it affects the geotechnical conditions. The prediction of flow path in GIS are denominated by Integer number,

Numeric Denomination	Directions of Flow
1	East
2	Southeast
4	South
8	Southwest
16	West
32	Northwest
64	North
128	Northeast

Figure 14: Flow Direction with Output Grid Extent of Source File AutoCAD DXF.

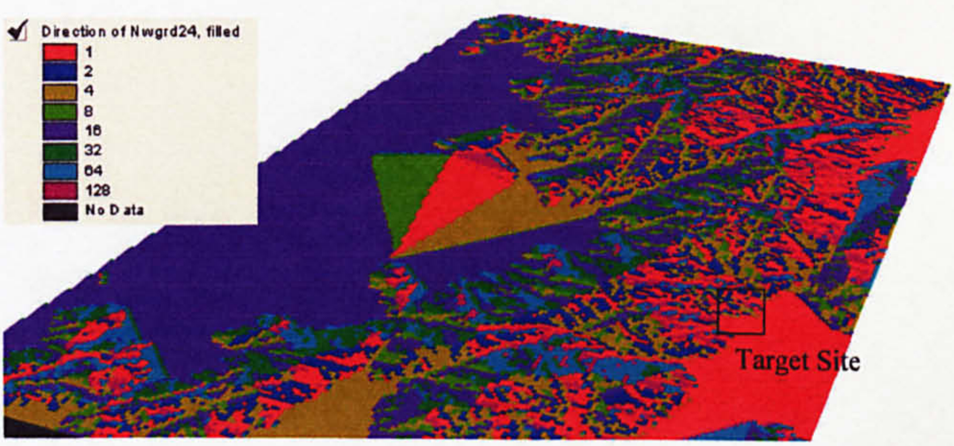


Figure 15: Flow Direction with Output Grid Extent of Same as "Display".

3.7.2 Flow Length/ Flow Pattern Prediction

Figure 16: Flow Length Prediction (from F. Direction Grid of Source file DXF AutoCAD).

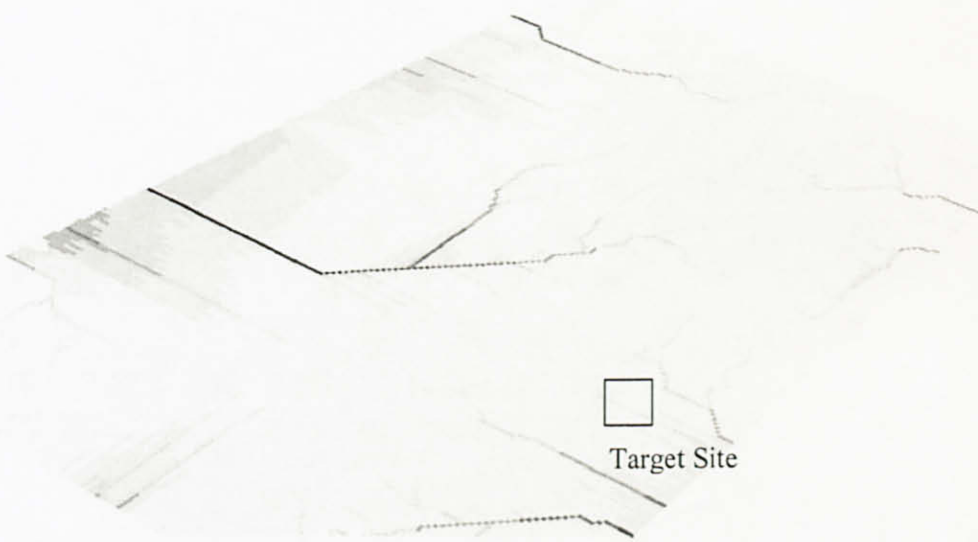


Figure 17: Flow Length Prediction (from F. Direction Grid of Same as "Display").

From simulation of flow direction of Figure 16 and Figure 17 above, it is clearly shown that the target site has minimal flow or water runoff accumulation. Thus, for the ease of analysis, we then adopt the latter layer of figure 17 for results and discussion.

Chapter 4

Results, Discussions & Recommendations

Comparison of the feasibility between the Proposed Plan and GIS yielded.

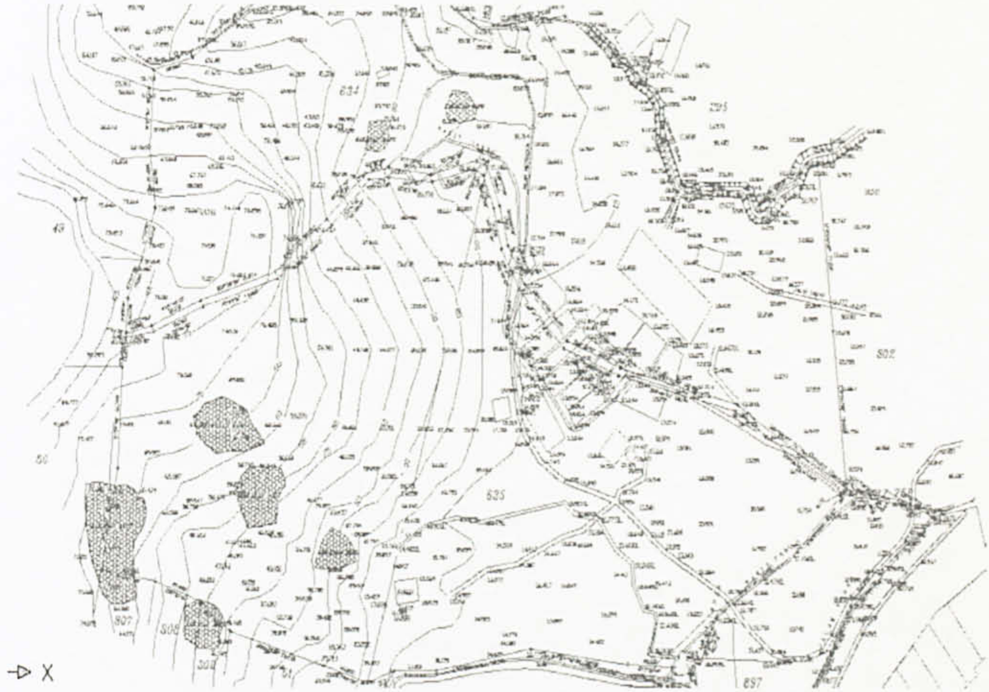


Figure 18: Project Layout Plan of SP Setia Bhd, Cangkat Sungai Ara, Relau, Penang.

To Achieve Objectives No.3, we need to apply GIS Yielded data to seek compliance with the existing proposed development for further Clarification.

4.1 Comparison with Elevation Layer

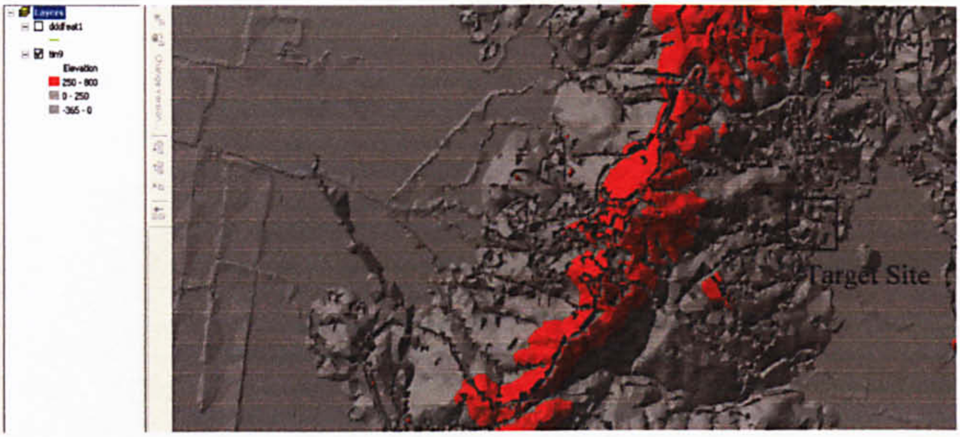


Figure 19: Elevation Modeling

Area colored with Red are > 250ft. Area covered with Grey are < 250ft or 76m. The modeling was done based on Hill Land committee classification where land above 250ft MSL are categorized as Hill land, which in any case, no development is allowed.

Recommendation: Pass. Target Site for Development is not categorized as Hill Land. **Objective 1 achieved.**

4.2 Comparison with Slope Layer

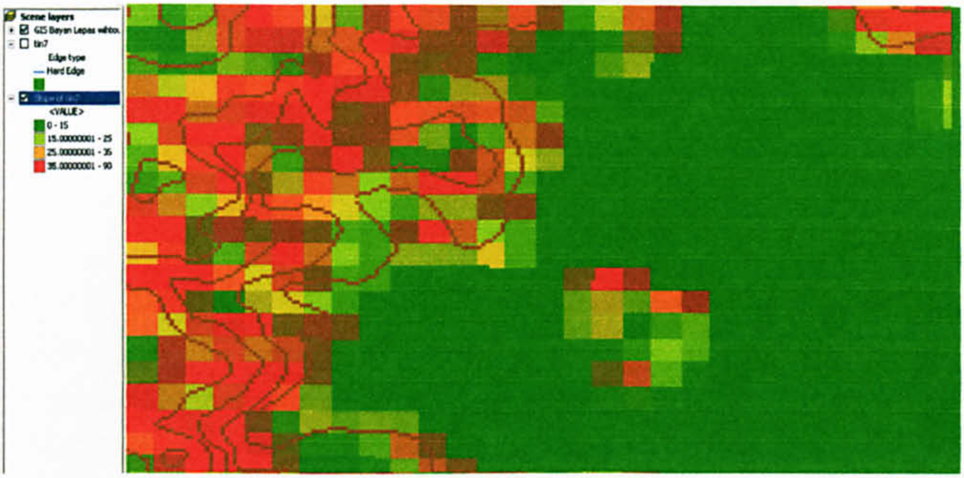


Figure 20: Site Slope Gradient Configuration.

Colors		Land Gradient	Development Status
Dark Green	Class I	< 15 Degree	Allow
Green	Class II	16 - 25 Degree	Allow
Orange	Class III	26 – 35 Degree	Upon Approval
Red	Class IV	> 35 Degree	Not Allowed

Recommendation: Upon Approval. On average, it's Class III land. Under JKR's guidelines, Environmental Impact Assessment (EIA) and Geotechnical Report is needed to further clarify and approve on the development. **Objective 2 achieved.**

4.2 Comparison with Slope Layer

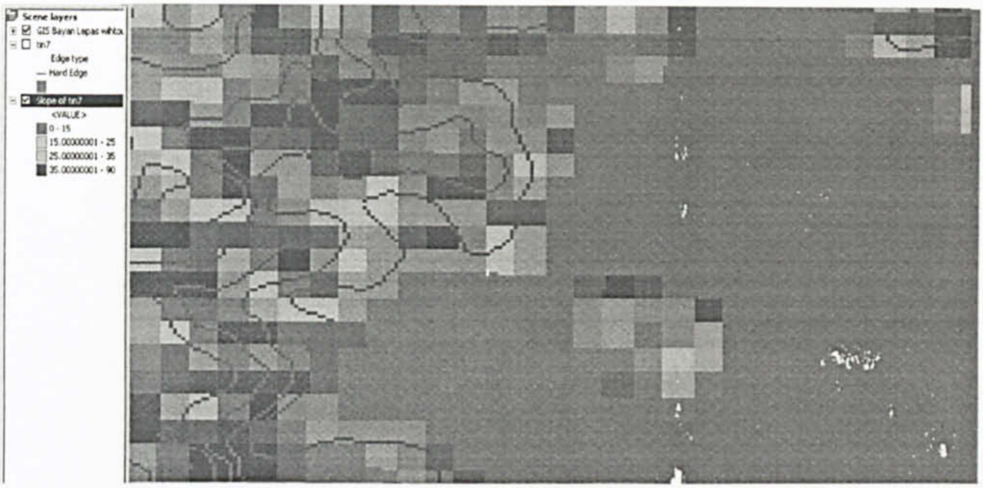


Figure 20: Site Slope Gradient Configuration.

Colors		Land Gradient	Development Status
Dark Green	Class I	< 15 Degree	Allow
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Red	Class IV	> 35 Degree	Not Allowed

Recommendation: Upon Approval. On average, it's Class III land. Under JKR's guidelines, Environmental Impact Assessment (EIA) and Geotechnical Report is needed to further clarify and approve on the development. **Objective 2 achieved.**

4.3 Comparison of Flow Length/ Flow Direction Pattern

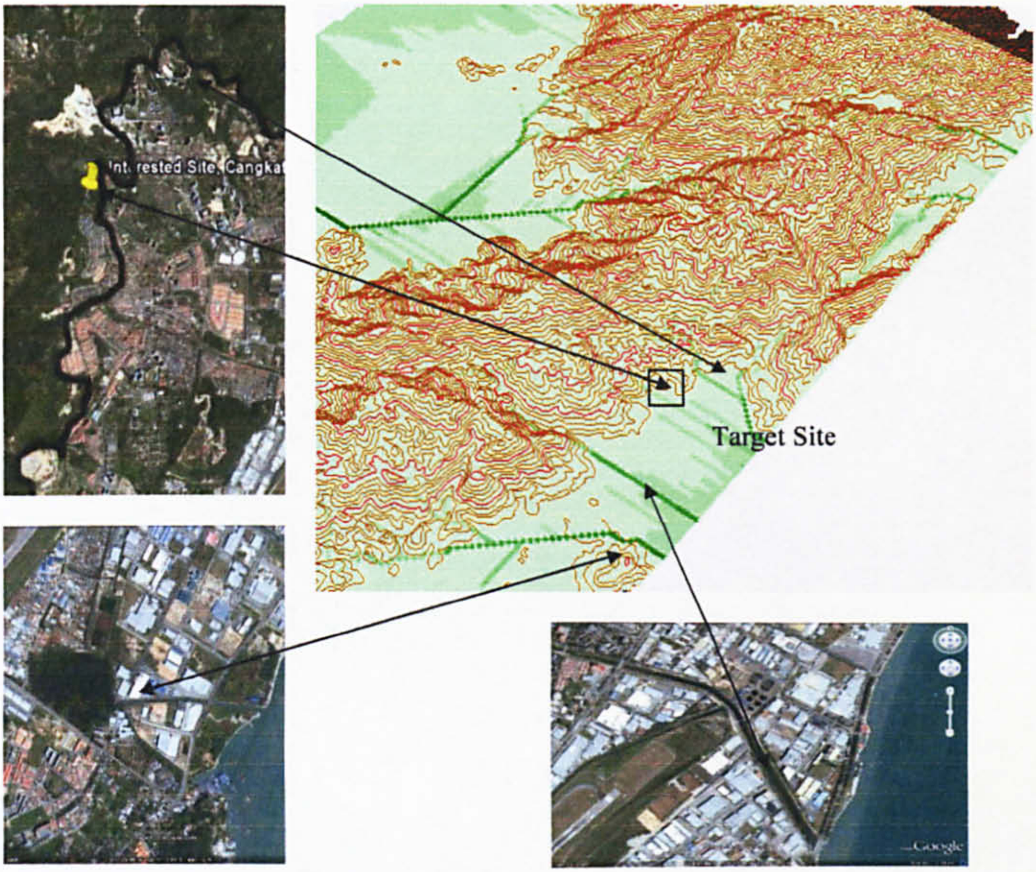

Figure 21: Comparison between Real Topography Terrain and GIS Flow Length Prediction Pattern.

As Figure 16 has shown, GIS has successfully mapped/yielded out comparatively the same outcome as to the real topography terrain. Referring back the Site (marked with a square), there is minimal or no predicted flow pattern shown/mapped from the GIS output.

Recommendation: Pass. The concerned site is to say free from any kind of hydrology impact in the long run. Though the nature of the site's land type, hill land that are not highly expose to hydrology effects is suitable for development. **Objective 3 achieved.**

4.4 Discussions

1. Though GIS application has been widely used in other studies as mentioned in Chapter 2, we have found out that, the intensity of usage of GIS in the development arena is not comprehensive.
2. More Customizations through GIS can be done to carry out a comprehensive, detail and organized information for a development.
3. Comparing the country to the other developed nation, in Malaysia, however, the usage of GIS in Engineering is still very rare and GIS databases are yet to be exploited. Its scale of usage is still minimal and it is on its development path.
4. GIS in land Feasibility helps gives an overview picture of a development which is better and clearer.
5. With GIS, we will manage to identify factors that may affect a land value, cost of development and last, the overall feasibility.
6. GIS has successfully mapped/yielded out comparatively the same outcome as to real topography terrain.

4.5 Recommendations

Therefore, the country as well as the industry should adopt GIS system into their practice during any kind of planning and development. It may not be as appealing in the beginning but this paper believes that it is definitely a good step forward both for the country and the industry.

Chapter 5

Conclusion

The objective of this project of land feasibility has been able to depict that GIS is a valuable tool for modeling and simulating land feasibility using ArcGIS. It provides objective criteria for the different land type, land use and factors of affection where different modes of developments are being considered. The integrated modeling system presented in this paper has combine spatially distributed resource technically, it is as such like Land Elevation, Land gradients, Hydrological mapping in Flow Directions and Flow Length.

Finally, perhaps most imaginatively, GIS has become a favored technology on which to base design and visualization applications. The advantages that GIS can offer over CAD in feasibility are clear. GIS has the ability to store and link attributes data to geographical or spatial features. In short, the impact of a design can be analyzed and projected rather than merely visualized.

Chapter 6

Economics Benefits

The research carried out in this paper has been able to achieve a solution providing a platform for Engineers to evaluate parameters in Land Elevation, Land Gradients, Flow Direction, Flow Length/ Flow Pattern Prediction.

With GIS Computational Modeling and Simulation method, we believe that the research has been able if not aimed to reduce the Time needed and increase the Accuracy of conducting the feasibility studies on a Hill Side development. Therefore, it will be able to reduce the overall cost carrying out these different kinds of studies.

6.1 Cost

Maps are provided by the JUPEM, Jabatan Ukur dan Pemetaan Malaysia while the Software required for Modeling and Simulation in this research paper are

1. AutoCAD 2007
2. ArcVIEW GIS 3.2
3. ArcMAP GIS 9.2
4. ArcSCENE GIS 9.2

With reducible Time, we foresee a significant amount of Man/hour wages reduction. Based on 22 days work a month, 8 hours a day, we have roughly calculated a cost comparison schedule.

	Average Wages/hour	Conventional Assessment	GIS Method	Savings
Fresh Graduates	14.20	4 days	2 days	50% (16 hours)
Engineers	18.75	2 days	2 hours	88% (14 hours)
Senior Engineers	25.57	1 day	Less than 1 hour	88% (7 hours)
Total (MYR)		959.09 (56 hours)	290.34 (19 hours)	69% (MYR 669)

Figure 22: Forecasted Cost Savings for a Developer/Client/Owner of a project

According to (Idrus, Sulaman, & Khamidi, 2010) in their latest publication of Engineers in Society book, the accuracy of "Expert Opinions" in cost estimation can be differed/off by as much as 90%. The Stats are staggering thus; there must be a need for proper feasibility studies.

With GIS method, though it is not proven thus far, we believed that it can yield a better accuracy in conducting feasibility studies and thus, directly affecting the result of costing and budget.

Comparing both Conventional and GIS method, average amount of time that is saved is significant. At each skill level, the usage of GIS can help yield as much as at least 50% of savings in time. While time is saved at this part of the work, there would be an opportunity for other Resource Allocation chances; hence, operating cost would be lowered while efficiency would be raised.

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