GEOLOGY AND LAND SUITABILITY ANALYSIS FOR URBAN DEVELOPMENT USING GIS IN INDUSTRIAL AREA OF GUA MUSANG TOWN

by

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

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APPROVAL

"I hereby declare that I have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honours"

Signature	:	…….....
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DECLARATION

I declare that this thesis entitled "Geology and Land Suitability Analysis for Urban Development using GIS in Industrial Area of Gua Musang Town" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Geology and Land Suitability Analysis for Urban Development using GIS in Industrial Area of Gua Musang Town

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Abstract: Land use suitability analysis is a key factor in determining the urbanisation plan on the certain places especially in city or town. The assessment of the suitability is determined by series of criteria including the geological and environmental aspect. This research focussed on the geology and land suitability analysis for urban development. The aim of the study is to evaluate the trend and growth of the research area and to produce potential land suitability analysis map for further development. Besides geological map of the research area with scale 1: 25 000 was also updated using GIS method. The research area is around the industrial area of Gua Musang town (E E101°57'58.8'', N 04°51'48.0''), which is categorized as growing area that receive positive impact of urbanisation. For geological study, all geological characteristic that associated within the area is identified and analysed, it is including the rock unit, geological structures and morphology of the area. Next, six parameters were selected for suitability analysis study, there are existing land use, water body, road accessibility, slope and elevation of the research area. All parameters were defined based on literature review, available data and expert's opinion and the weighted overlay category are ranked into five suitability classification, (mostly suitable, suitable, moderate, less suitable and not suitable). As the result, geological map of the research area is produced and for land suitability analysis, there are about 40% of area can be classify as suitable area for urban development and the 60% area is less and not suitable for urban development since the area is plantation and high elevation and slope area.

Key words: Urbanisation, Geology, Land Suitability Analysis, Industrial Area, Gua Musang Town

Geologi dan Analisa Kesesuaian Tanah untuk Pembangunan Bandar menggunakan GIS di sekitar Kawasan Perindustrian Bandar Gua Musang

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Abstrak: Analisis kesesuaian penggunaan tanah adalah faktor utama dalam menentukan rancangan urbanisasi di tempat-tempat tertentu terutama di bandar. Penilaian kesesuaian ditentukan oleh beberapa kriteria termasuk aspek geologi dan persekitaran. Kajian ini, ia memberi tumpuan kepada analisis geologi dan kesesuaian tanah untuk pembangunan bandar. Tujuan kajian ini adalah untuk menilai corak dan pertumbuhan kawasan penyelidikan dan menghasilkan peta analisis kesesuaian tanah untuk pembangunan. Selain itu, peta geologi kawasan penyelidikan dengan skala 1: 25 000 juga diperbaharui menggunakan kaedah GIS. Kawasan penyelidikan ini terletak di sekitar kawasan perindustrian bandar Gua Musang (E E101 ° 57'58.8 ", N 04 ° 51'48.0 "), yang dikategorikan sebagai kawasan pertumbuhan yang mendapat kesan positif dari urbanisasi. Untuk kajian geologi, semua ciri geologi yang berkaitan di dalam kawasan itu dikenal pasti dan dianalisis, termasuk unit batu, struktur geologi dan morfologi kawasan. Seterusnya, enam parameter dipilih untuk kajian analisis kesesuaian, antaranya adalah penggunaan tanah sedia ada, badan air, akses jalan, cerun dan ketinggian kawasan penyelidikan. Semua parameter yang ditakrifkan adalah berdasarkan tinjauan literatur, data sedia ada dan pendapat pakar. Seterusnya, hasil lapisan enam parameter tersebut di ketegorikan kepada lima peringkat klasifikasi kesesuaian (paling sesuai, sesuai, sederhana, kurang sesuai dan tidak sesuai). Hasilnya,, peta geologi kawasan penyelidikan dan analisis kesesuaian tanah telah dihasilkan. Terdapat sekitar 40% kawasan yang boleh diklasifikasikan sebagai kawasan yang sesuai untuk pembangunan bandar dan 60% kawasan kurang dan tidak sesuai untuk pembangunan bandar sejak kawasan itu adalah ladang dan kawasan tinggi dan cerun yang tinggi.

Kata kunci: Urbanisasi, Geologi, Analisis Kesesuaian Tanah, Kawasan Industri, Bandar Gua Musang

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATION

USGS	United States Geological Surver
KTM	KeretaApi Tanah Melayu
KESEDAR	Lembaga Kemajuan Kelantan Selatan
MDGM	Majlis Daerah Gua Musang
JMG	Jabatan Mineral dan Geosains
GIS	Geographic Information System
GPS	Global Positioning System
UAV	Unmanned Aerial Vechicle
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
JPS	Jabatan Pengairan dan Saliram
JKR	Jabatan Kerja Raya
LULC	Land Use Land Cover

CHAPTER 1

INTRODUCTION

1.1 General Background

Kelantan is one of the states in Malaysia and divided into ten districts which are Gua Musang, Kuala Krai, Jeli, Tanah Merah, Machang, Pasir Puteh, Bachok, Pasir Mas and Kota Bharu as shown Figure 1.1. Among of those districts, Gua Musang is the biggest district in Kelantan. It was located in the southern part of the Kelantan and it covers about 7979.77 km of the total area. The district also bordered by some part of Terengganu, Pahang, and Perak. Three sub-districts in Gua Musang are Galas, Chiku and Bertam.

Next, Gua Musang geology was divided into 4 different localities which consist of Kuala Betis, Gua Musang, Aring and Gunung Gagau. The west part of Gua Musang districts mainly composed of rocks in Lower Palaeozoic age. Meanwhile, in the middle part scattered the sedimentary rocks in Permian until Triassic age. In the east part, there are carbonate rocks in Jurassic age. The town of Gua Musang is located at the Gua Musang Formation. Gua Musang town has much evidence of rocks from the argillaceous unit of rocks that have been exposed to the low grade of metamorphism and become slate or phyllite rocks. It also consists of limestone, marbles sandstone and a little composition of the conglomerate.

Most of the argillaceous unit and sandstone unit Gua Musang formation is tuff type and having the characteristic of volcanic origin rocks. Basically, the argillaceous unit is more widely covered the Gua Musang Formation, but the limestone outcrop is more exposed and forms karst topography and it can easily be recognized. This research is

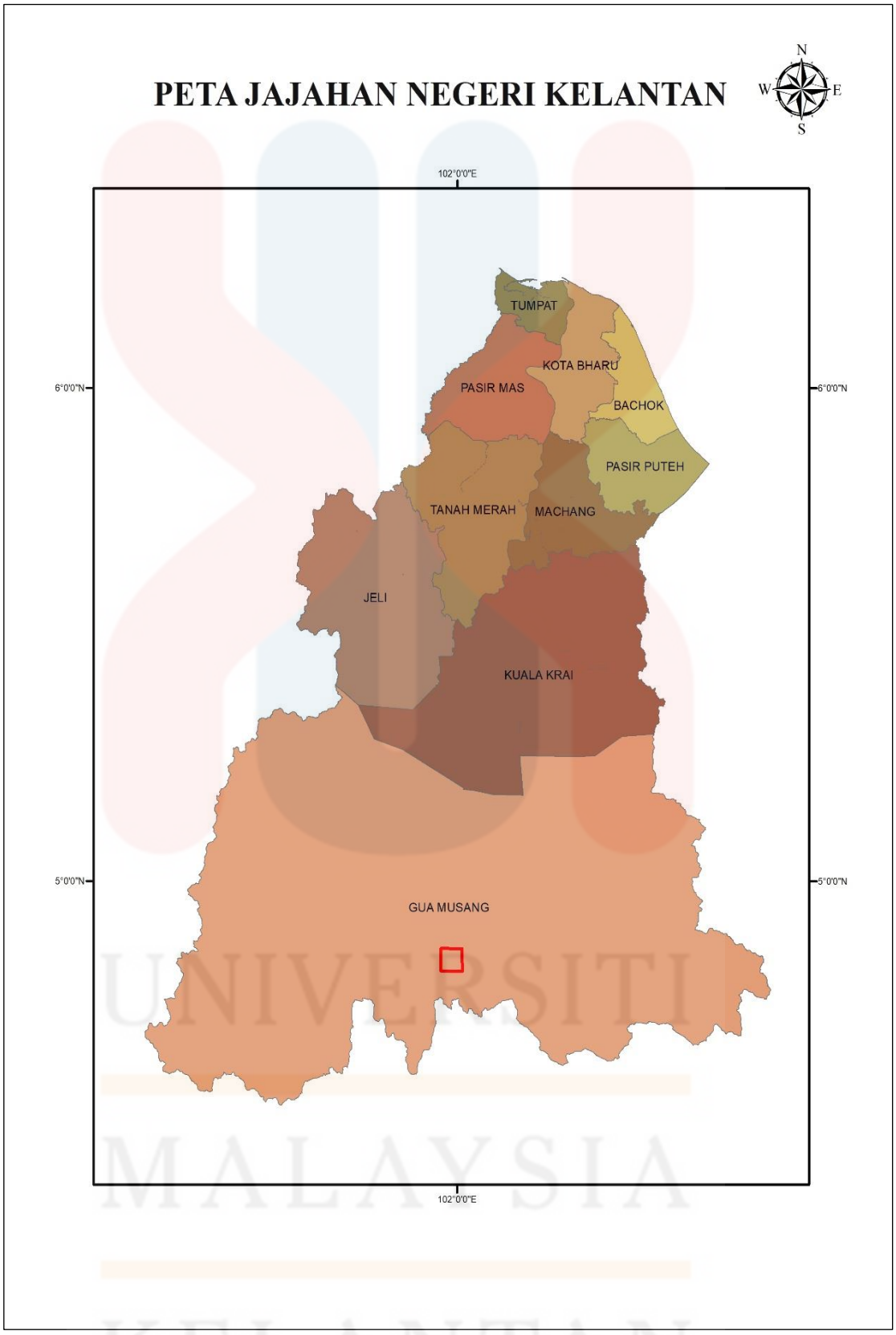


Figure 1.1 District Map of Kelantan

focusing in Gua Musang town. Gua Musang Town is the main city of Gua Musang district. It categorized under sub-district of Galas. According to Besar et. al (2012), even though this area is not categorized as an industrial zone but this area is well known as a transit city and it is in well develop phase. Thus, Gua Musang town receives the positive impact of urbanization on many aspects. In the scope of this research area, many developments occur in this area such as basic education centre, living style, basic health facilities, plantation area, industrial area, and transportation. This is known as urbanization of a place. So, Gua Musang town has developed in terms of economic and basic facilities.

Gua Musang Town seems to be develop an enlarged, build more building, empower the manpower, provided more hospitality and facilities for the resident and outsider. Those things can impress the area and location that builds the patterns or shape in Gua Musang town by using spatial process. Gua Musang town is cover with some mountainous area, flat area, karst landform and few main rivers that connected to Galas River.

According to Jusoof (2013), the urban analysis is referring to the process of urban planning rationalization and the investigation of the urban areas, that including the geographical, economic and sociological investigation studies. For this analysis method, the researchers may apply some methods to gather information. For instances, land use and geological mapping, data gathering survey methods, Geographic Information System (GIS) or journal sources. By applying GIS and geological mapping method into this urban analysis research, it is easier and helpful in terms of visualizing the spatial data and also find the process of spatial distribution. In addition, the geologic mapping can contribute to the important data sources of the actual

scenarios of the location or research study and help in understanding the geological problem at Gua Musang town. The map included the landform, stratigraphy and structural geology of the area. Urbanization process should be studied from various factors or parameters including the socio-economic criteria, utilities, physical area, and environment.

Nowadays, the town enlarging and spread out in more in the new area of town development and also included the rural areas and then become the urban sprawl itself. In another hand, the sprawling of Gua Musang town has its own constraint based on its physical and environmental factor, for an instant, slope, elevation, hydrological, land use and flood possibilities of the area. Gua Musang needs a suitable place to accommodate its rapidly growing population. Therefore, the pattern of town development needs to consider both factor of the area and the only suitable area will development process.

1.2 Study Area

1.2.1 Location

This research is conducted in industrial area of Gua Musang town. It covers from the residential area in Taman Wangi and extended to the Chin Tek Plantation in the north and Gua Musang Rest and Relax (RNR) pit stop in the south of the study area. In addition, for this research, 25 km^2 areas are covered as the requirement for research mapping. Next, for this area, it was actually lies on Gua Musang Formation. The formation is a part of Gua Musang-Semantan depocentre within Central Belt of Peninsular Malaysia.The coordinates of the area are marked by four different points, which aligned from E101°57’58.8’’ to E 102° 0’ 43, and N 04°51’48.0’’ to N 04

49’7.0’’. Figure 1.2 shows the base map of the research area including the road connection, the topography and the basic landform of the area.

1.2.2 Road Accessibility

Road is the main element in a residential area because the road can connect one place to another place. There are few types of road connection such as railways and highways. The driving route also can reachable from the main road of Kuala Lipis to Merapoh if the driven from the south of peninsular or through the Dabong road if from Kelantan. The category of road is federal road and residence road. For the train route, the train travels from the southern of Peninsular Malaysia until the last station in centre of Gua Musang town. Many facilities and accommodation are provided to help the residence from all over the area. Figure 1.3 shows road connection to the study area which is around the area of Gua Musang to Industrial area.

1.2.3 Demography

The demography of Gua Musang is categorized by ethnic and the age of the people within the area. In Gua Musang area, the residents live with different type of ethnic or races, which are Malay, Chinese and Indian. Table 1.1 shows the total numbers of people distribution according to their ethic in 2010. According to the Local authority and State Malaysia, the total resident in Gua Musang are about 86 189 people and Malay ethic serve as the highest ethnic population. These totals are increasing from year to year as the town are in developing phases.

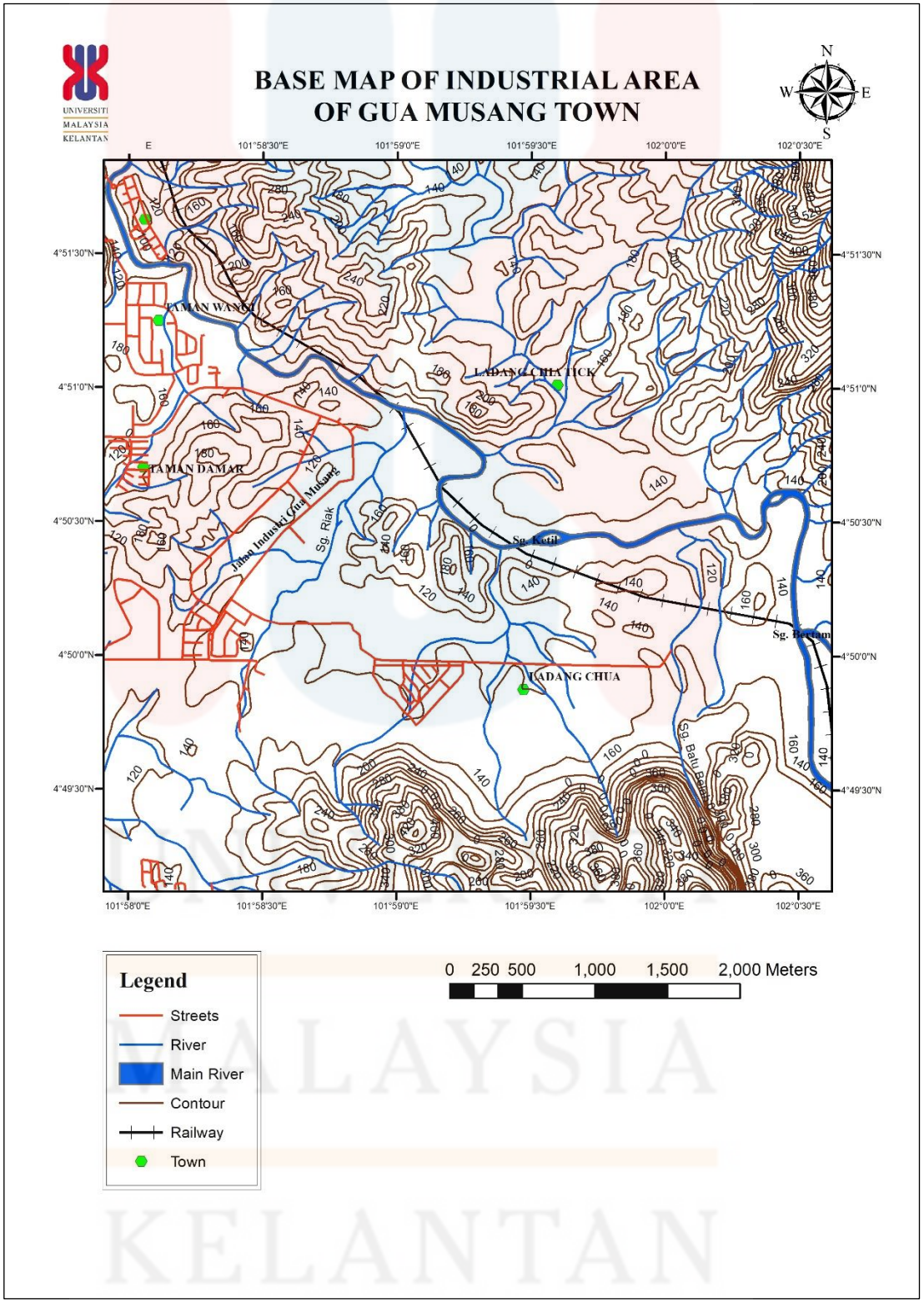


Figure 1.2 Base Map of study area

Figure 1.3: Road connection of the study area

Table 1.1: People distribution in Gua Musang

Jajahan/ Kawasan Pihak Berkuasa Tempatan *Jajahan/ Local Authority Area*	Jumlah *Total*	Warganegara Malaysia *Malaysian citizens*							Bukan Warganegara Malaysia *Non-Malaysian citizens*
		Jumlah *Total*	Bumiputera			Cina *Chinese*	India *Indians*	Lain-lain *Others*	
			Jumlah *Total*	Melayu *Malay*	Bumiputera lain *Other Bumiputera*				
GUA MUSANG									
M.D. Gua Musang	**86,189**	**81,204**	**76,823**	**64,253**	**12,570**	**3,870**	**350**	**161**	**4,985**
Batu Papan	2,594	2,543	1,520	1,512	8	883	132	8	51
Bertam	1,142	1,133	1,131	1,131	-	1	1	-	9
Chegar Bongor	494	426	398	398	-	24	-	4	68
Gua Musang	18,420	17,775	15,373	15,285	88	2,217	155	30	645
Kerinting	157	144	128	128	-	1	15	-	13
Limau Kasturi	975	905	893	893	-	5	-	7	70
Paya Tupai	337	325	325	325	-	-	-	-	12
Kawasan selebih M.D. *Remainder of M.D.*	62,070	57,953	57,055	44,581	12,474	739	47	112	4,117

Next, Table 1.2 shows the numbers of people distribution according to their age. The dominant age of people in this area are ranging from 10 to 14 years old. Besides, people in this area work in different places. But, roughly, it can be divided into two sector which are work with government or doing own business. For example, mostly the residents who live in Taman Wangi are the worker or staff of KESEDAR or in MDGM. Meanwhile, in industry area, mostly people in this area work as labour in wood factories. Not less than that, some of them also work as rubber tapper, work at the oil palm and self-employed

Table 1.2: People distribution in Gua Musang based on age

Jajahan/ Kawasan Pihak Berkuasa Tempatan / *Jajahan/ Local Authority Area*	Jumlah / *Total*	Kumpulan umur / *Age group* 0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29	30 - 34	35 - 39
GUA MUSANG									
M.D. Gua Musang	**86,189**	**9,758**	**10,146**	**10,485**	**9,990**	**7,379**	**7,246**	**5,854**	**5,017**
Batu Papan	2,594	203	304	250	285	152	199	253	259
Bertam	1,142	100	130	177	138	93	80	65	54
Chegar Bongor	494	63	73	47	41	45	37	35	37
Gua Musang	18,420	2,205	2,386	2,047	1,856	1,356	1,737	1,270	1,268
Kerinting	157	19	17	24	22	14	10	5	13
Limau Kasturi	975	86	96	119	107	82	72	73	84
Paya Tupai	337	30	35	48	49	33	32	26	25
Kawasan selebih M.D. / *Remainder of M.D.*	62,070	7,052	7,105	7,773	7,492	5,604	5,079	4,127	3,277

Jajahan/ Kawasan Pihak Berkuasa Tempatan / *Jajahan/ Local Authority Area*	Kumpulan umur / *Age group* 40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	75 +
GUA MUSANG								
M.D. Gua Musang	**4,214**	**4,663**	**4,059**	**3,030**	**2,006**	**1,071**	**659**	**612**
Batu Papan	176	184	118	102	56	22	13	18
Bertam	58	62	50	38	29	25	24	19
Chegar Bongor	31	20	20	11	10	6	9	9
Gua Musang	1,097	1,160	834	488	266	218	117	115
Kerinting	6	10	7	1	2	1	1	5
Limau Kasturi	52	48	41	33	23	17	18	24
Paya Tupai	15	16	10	6	2	6	2	2
Kawasan selebih M.D. / *Remainder of M.D.*	2,779	3,163	2,979	2,351	1,618	776	475	420

1.2.4 Land use

Land use can be obtained from District Council of Gua Musang and any software, for example USGS, Google Earth and Glovis. This land use is being planned as it affects the effectiveness of the town development. According to the Gua Musang Local Authority Plan for 2020, this town will be equipped with more facilities to improve or enhance the development of economic and industrial. Besides, land use in this research area has few categories such as residential area, plantation area, transportation area, infrastructure and forest area.

The residential areas are dominated in southern part of Gua Musang town, which is in Taman Wangi and some part of Taman Damar. Next, the public transport also can be found in this research area. For instance, Kereta Api Tanah Melayu (KTM) train station and main bus transit station. Other than that, industrial and plantation area also

dominated in this area. For industrial area, it is located within the area of Taman Wangi and on the way to the Chin Tek Oil Palm Plantation, the main activity or operation in this area is related to timber industry.

1.2.5 Social Economic

Mostly in this study area, the social economic can be classified into three, which area government staff, self-employment and labour. The resident in Taman Wangi mostly worked as a staff at KESEDAR or MDGM. Meanwhile, in the industrial area, most of the residents work as labour at the factory or open a small shop. In addition, some of them also work in the plantation area in Ladang Chua and Ladang Chin Tek. Since Gua Musang town is still in development phase, it can open more job or work opportunities for the resident in this district.

1.3 Problem Statement

As for the geological mapping, there are no recent maps for the specific area in Gua Musang. In more specific, there is no map of this study area with scale 1:25000. The data also need to be updated and in order to detect any changes in many aspects such as natural terrain or land use changes in the area. Thus, for this research, there is significant geological information being provided according to the sign of an area. The map provides the more detail about the geology condition of the area. In addition, from the geological map, better understanding and information can be known.

Gua Musang Town is surrounded by karst geomorphology. It clearly sees as the rounded slope of the limestone hill from the rural area to urban area. Since the population of Gua Musang is increasing from time to time, there must be a step forward planning for the upcoming issues, especially issues related to their basic needs such as

food, clean water, daily supply, home and the proper area for socialization. All these matters lead to the seeking of a new area or places to overcome the current and future issues. Thus, by looking into the lithology unit of Gua Musang, many safety aspects need to be considered before developing the town, it is including the flood hazard observation and producing slope angle map of the study area.

1.4 Objectives

1. To update the geological map of industrial area of Gua Musang town with scale 1:25000
2. To evaluate the growth and trend of urbanization around Gua Musang Town.
3. To produce land suitability analysis map for further development of the research area.

1.5 Scope of study

This research is focus on the growth study and trend of urbanization in Gua Musang town based on two parameters, which are environmental and physical or topographical of the research area. Next, this research is applying GIS or remote sensing method and weighting system for land suitability scoring in other to produce the final result. This research covers the small part in Gua Musang districts which is only in the new town of Bandar Gua Musang, due to the time limitation of this research. Basically, this research could be done in all places as the research is about the land development analysis.

1.6 Significance of study

This research is significance to the student or researcher which can help them to ease the understanding about urban development and parameter need to be considered before choosing a suitable places or site for any development. This research also can provide and gather information or data regarding this area for further research purposes. Secondly, through this research, it can create awareness to the society about the safety and cause effect hazard about karstic limestone area. Since, some of them seem build their house near the karst area, so there must be a precaution steps that need to be taken in other to prevent any incidents. For example, this research can be likely small informative template that can be used for the responsible authorities in other to give some information about risk of building development near or at the karst and steep slope area to the society.

Lastly, this research hopefully can give benefits to the government sector. For instance, geological data from this research can contribute information about geological setting at the area especially for Department of Surveying and Mapping Malaysia (DSSM) and Mineral and Geoscience Department in Kelantan (JMG). While, the study of urban planning in this research can be benefit for Majlis Daerah Gua Musang (MDGM) for further city planning and it is important in other to overcome the problem with limit land availability against the drastic growth of urbanization.

CHAPTER 2

LITREATURE REVIEW

2.1 Introduction

The chapter provides a review on the literature study from previous research in order to obtain an understanding on various component of analysing urban development and geological mapping studies. It also reviews the different literature providing the definitions related to the urban planning and its selected parameter. The literature review is very important to know the formation, age of rock, plate boundaries and past history study on the research area. All of the information can be obtained through electronic or non-electronic research media, such as book, paper, journal, scientific reports, and online sources. As a concern through this research, only some part in southern Gua Musang town was highlighted.

2.2 Regional Geology and Tectonic Setting

According to the Bemmelan V et al, (1949), Peninsular Malaysia covers a total land area of 130 268 km^2 which is part of the Sundaland that include Borneo, Jawa and Sumatra as well as the shallows seas that emerge a few number of islands too. The state of Kelantan is located at the north-eastern corner of Peninsular Malaysia. It shares boundaries with Perak to the west, Pahang in the south and Terengganu in the east. It also borders Thailand to the north-west with coastline of 71 km fronting the South China Sea.

For regional geology, it is the link between global continental geology and local geology. Sibumasu and Indochina terranes plate boundaries are joined or collide each other and then form the Bentong Raub Suture ath the end of Permian age. Thus, the uplifted landmass of Peninsular Malaysia which remained sub aerially exposed. In the Cental Belt, there are two areas of marine sedimentation, which are Kodiang Semanggol Depocenter and Gua Musang Semantan Depocenter. The Gua Musang Depocentre is developed on the shelf deposits of the Eastern Province. According to the Gobbett and Hutchinson (1973a), during Triassic time, the occurrences of tuffs and associated lava, tuffaceous siliciclastic and conglomerate in Gua Musang Semantan Depocentre indicate the active volcano activity and basinal instability. In the deeper part of Gua Musang Semantan Depocentre, thick accumulations of turbidites deposit are founded (Peng and Abdullah et al, 2008). The tectonic setting of Peninsular Malaysia shows that it is divided into two tectonic blocks and has a few major faults across it from north to south and west to east.

2.3 Stratigraphy

Stratigraphy is concerned with the description and the deposition of the rock layer with the interpretation of time scale. According to Chai Peng et al, (2004), Kelantan are categorized under Palaeozoic-Mesozoic Formation. It is founded in the central belt of Peninsular Malaysia. The Upper Palaeozoic rock are divided into two formations, which are Gua Musang Formation and Aring Formation, both of the formations are located in the south of Kelantan as shows in Figure 2.1. In addition, these formations are dominated by argillaceous and volcanic facies while the rest of the rocks are calcareous and arenaceous facies. The depositional environment is shallow marine with intermittent active submarine active submarine volcanism (Lee, 2004).

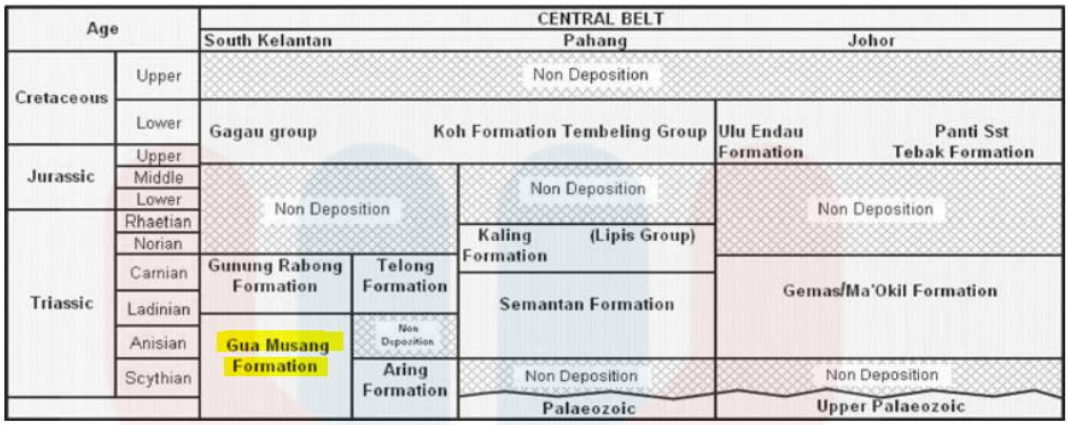


Figure 2.1 Mesozoic stratigraphic column in Central Belt (Khoo, 1983)

Next, the formation is the lateral equivalent of the pyroclastic Aring Formation and is synonymous with Telong Formation. In other hand, by Yin (1965), rocks around Gua Musang town indicate its formation, which is Gua Musang Formation. Through previous study and research, there are no specific information or exact understanding of its development during Permian-Triassic transition remains problem. Table 2.1 shows Gua Musang Formation consists from several units of different limestone facies.

Table 2.1 Sequence stratigraphic of Gua Musang Formation (Yin,1965)

Time / Age	**Type of lithology/rock**
Middle Triassic	Limestone, shale, volcanic rock
Early Triassic	Argillaceous limestone, shale, volcanic rock
Late Permian	Shale, siltstone
Middle Permian	Limestone and shale

2.4 Structural Geology

According to Hutchinson (1993), Peninsular Malaysia form as the resulted of the collision between two plates which is between Sibumasu and Indochina plate boundaries. The collision zone is representing by Bentong Raub Suture zone. This collision accompanied by the major tectonic event, and causes the rock deformation in the Malay-Thai Peninsular. Pre orogeny sedimentary successions are folded in the series of syncline and anticlines. Figure 2.2 shows the major faults and various formations in Central Belt.

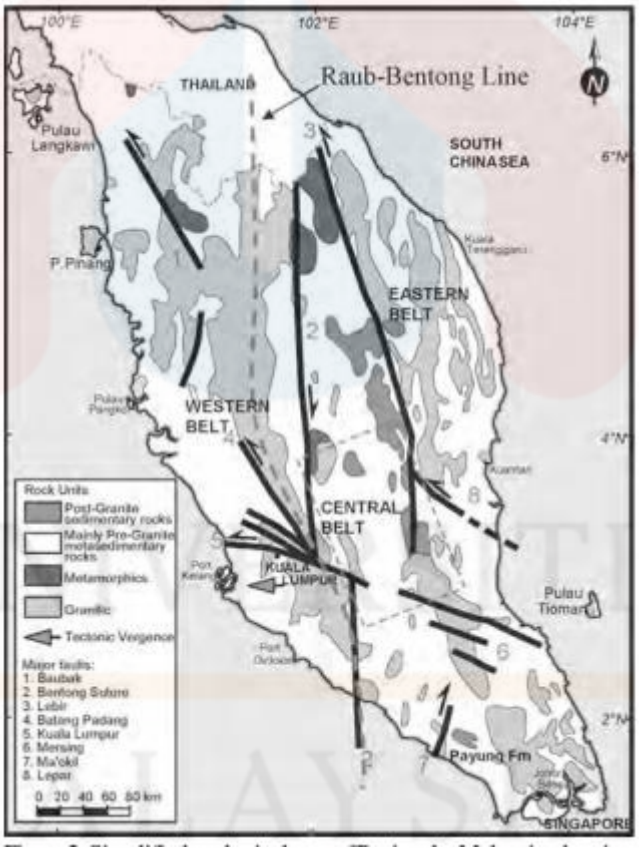


Figure 2.2 Major fault in Centre Belt of Peninsular Malaysia (Hutchinson,1989)

2.5 Historical Geology

Gua Musang is an in progress developed town located in the southern province in the Kelantan. This area composed of dominantly limestone rock, but there are some map able rocks of granite and meta sediment in industrial area. Most of the rock type found there are influences by lineament or fault. The oldest rock is believed composed of limestone with different facies. The Triassic period donated the start of real changes that happen to all through the Mesozoic Era especially in the appropriation of landmasses. Physical atmosphere is predominantly warm and dry.

2.6 Land Suitability Analysis for Urban Development using GIS in Industrial area of Gua Musang Town

This section discussed the geological mapping and the land suitability analysis for urban development. The land analysis takes two main consideration of parameter, which is the topographical and environmental study of the research area.

2.6.1 Geological Mapping

According to Njue (2010), the geological mapping is the process of area selection of interest and identifying all geological aspects of the area with the aim of preparing detail geology report and map to summarize the report. The geological mapping look into few aspects, including the variety of rock type, soil texture or colour changes, the geological structural involved, example like fault or fold, slope and elevation and the formation of the place itself. Nowadays, the advanced technology in mapping field will produce a quality map that depends on the accuracy and the precision of the work. Example of technology is GIS, accurate satellite imagery, aerial photograph, and UAV. The geological mapping will take into three phase which is planning, data

collection, and final report writing. Geological mapping was carried out in order to cover part of the new town of Gua Musang and some part of plantation field. Based on Rashid (2017), this area is classified as the industrial area and still under development phases.

2.6.2 Topographical Area

In the urban analysis, the physical or topographical factor is an important parameter that needs to be considered. In this research, these factors cover the slope and elevation of the area. Since this area is surrounded with some limestone rock and high elevation hill, Mineral and Geosciences Department (JMG) in Malaysia have proposed a demarcation of safety zone and construction classification for slope shown in Figure 2.3, Figure 2.4 and Table 2.2. It is special for vicinity of limestone hills and terrain geomorphology of an area in term of construction suitability class. The zones are divided into three different rating which is low, high or very high and four classes. Under this factor, two parameters need to be discussed such as which area land use and the flood hazard of the area.

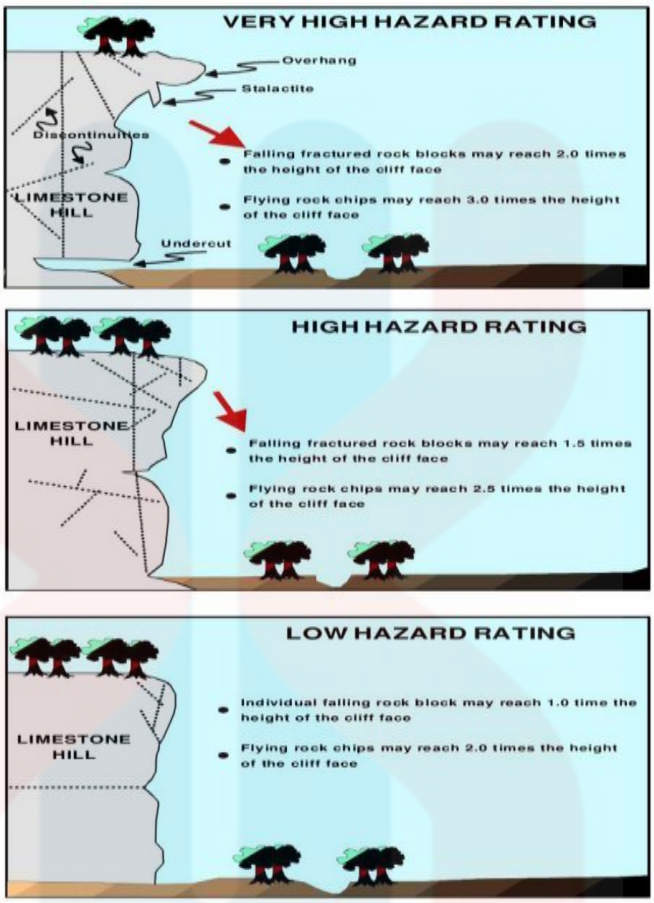


Figure 2.3: Classification of cliff faces in limestone hill (Source: JMG Kelantan, 2013)

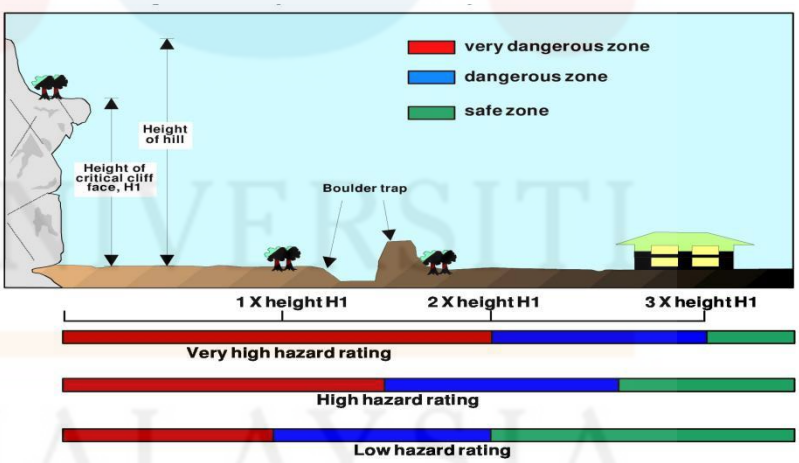


Figure 2.4: Demarcation of limestone safety zone (Source: JMG Kelantan,2013)

Table 2.2: Construction Suitability Analysis

CLASS	DESCRIPTION
I	● Low geotechnical limitation a) Insitu Terrain < 15° slope gradient b) Cut Slope < 15° slope gradient
II	● Moderate geotechnical limitation a) Hillcrest or ridges b) Insitu terrain≥15°-25° slope gradient with no erosion and instability. c) Insitu terrain < 15 slope gradient comprises colluvium or sensitive geological material d) Flood-prone area
III	● High geotechnical limitations a) Insitu terrain≥25°-<35° slope gradient with no evidence erosion and instability b) Insitu terrain ≥15°-<25° slope gradient with no evidence of moderate to severe gully erosion and instability. c) Limestone, swamp, peat, and mine-out area.
IV	● Extreme geotechnical limitations a) Insitu terrain ≥ 35° slope gradient with no erosion and instability b) Insitu terrain ≥25°-<35° slope gradient with evidence of moderate to severe gully erosion and instability.

2.6.3 Land Use

This study refers to the land use map produced by Majlis Daerah Gua Musang in 2009. These map extracted from satellite data obtain from USGS, and then turn it into the thematic layers for purpose of processing. The accuracy assessment method applied to the land use map of 2009 to ensure that classification accuracy is acceptable. According to Anderson scheme, the acceptable index must be above 8.5 scales. Table 2.3 shows the data extracted from factors for urban analysis.

Table 2.3: Data used in the analysis

Material	Sources	Type of data	Scale
Land use maps of 2009 & 2018	Glovis/USGS	Raster	10
Population	Department of Statistic Malaysia	Statistics	2010
Topographic map	JUPEM/USGS	Map	1:25000
Digital Elevation Model (DEM)	JUPEM/USGS	Grid	10
River and Flood Regulation	Drainage and Irrigation Department	Report	2010

(Source: Maher M Amburas,2016)

2.6.4 Water Body

Next important parameter is water body. This parameter also needs to be considered as a safety precautions and to avoid damage. In addition, urban development is said to be in the higher at the vicinity of the area that far from river and channel.

2.6.5 Land Suitability Analysis using GIS

Since, the land use planning is a process based on the analysis combined spatial resources; use of effective tools for spatial analysis can be helpful. One of these tools is GIS which are widely used in land use planning process at national and global level (Miryaghoobzadeh & Shahed, 2012). One of the most useful applications of GIS for planning and management is land use suitability and analysis (Collins et.al, 2001).

GIS which incorporate database system for spatial data, design and develop enabling the acquisition, compilations analysing and displaying topological interrelations of different spatial information. Moreover, the surface and overlay analysis capabilities in GIS can effectively facilitate in handling vast amount of spatial information. Next, GIS application used in planning agencies in the developed countries (Yeh, 1991). Many planning departments used GIS application to acquire mapping in the past (Wiggins & French, 1990). GIS is now an operational and affordable information system for planning urbanization system.

The main function of GIS in urban development is not only the technical issues but the availability of data, organizational changes and staffing. GIS is used for the storage of land use maps and plans, socioeconomic data, physical data and environmental data can be digitized by using GIS. The researcher can extract useful information from the data base through spatial query. GIS mostly used to improve map currency, more effective thematic map and reduced storage cost. GIS and remote sensing can be used to analysis land suitability for urban development in the study area, and it helpful to improve analysis of the result.

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

In other to accomplish this research, a material and method are examined and selected so that the data needed for this research can be obtained and analysed. There are several different phases included the method for the geology and specification of this research. Preliminary research is focus on the studies of base map such as types of rock, the elevation of contour, existing town or village, the drainage pattern and road connection in the study area.

Next, reading the literature and previous research papers, books, journal or project as reference and extra information related with this research. For geology part, the base map is a way of beginning to understand about to understand the geomorphology of the area and then make a classification according to its landform. Besides, for research specification review can get through the publish book or get an opinion from the expertise instead of using or get information from electronic or non-electronic reading medium.

Next step is data collection. Data collection are defining as the systematic approach to gather and measure information from variety sources in other to get at least a rough visualize picture or scope of an interest research or area. Besides, data collection also enables person to evaluate outcomes and make predictions about future probabilities and trends. There are few methods can be applying to gather or collect data. For

instance, mapping or surveys, interview, web and analytics tools, mobile devices, website traffic, server activity, experimental project and any relevant sources that suit for the research or project. Data collection also can be divided into quantitative and qualitative data. In geological survey and study, all data are collected during the mapping process at the research area, including the rock samples are also collected during mapping time, because it can save and reduce cost. The total of people distribution, rain distribution, road connection and land use data are collected from many government department as stated in Table 2.3.

The next following step is data processing which involves manipulation of data to produce meaningful information. The data processing often used software to process the data and visualize it into more easily readable result, for example in form of table, graph or picture. In this research, the data processing involved is the processing of rock sample through the thin section to determine the types of existing mineral in the sample. It can be observed by using the microscope. For specification part, the data collected were focusing on five parameters that need to be observed along this research. All of the data need to rasterize, and scoring method are applied by using ArcGIS software. Then, after all data are process, it need to be analyse to prove or valid the data collection.

From data processing and analysis, the land use map, land suitability and geological map can be produce. Last but not least, after get all the result wanted, there must be discussion and suggestion to ease the researcher understanding about overall research project and for other researcher use in the future time. Report or thesis writing is also needed. Figure 3.1 refers to flowchart of overall research methodology.

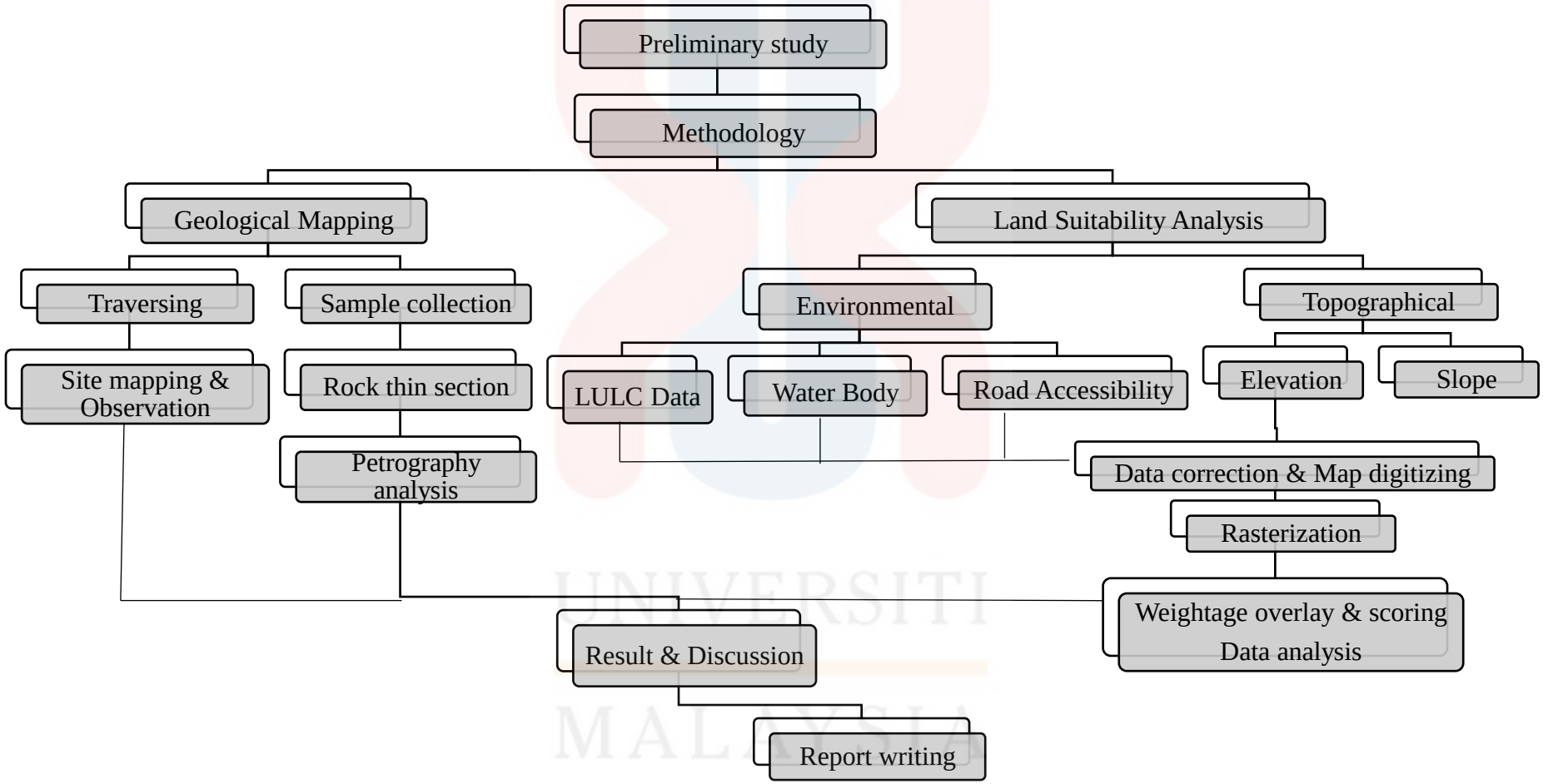


Figure 3.1 Flowchart of methodology

3.2 Materials

The suitable material is important during this research and suitable methodology must be determined in order to analyse the result. The listed materials are used at the site to collect and record the data before doing the laboratories test. There are few materials that related with general geology method that applied at the field.

3.2.1 Base map

Base map of study area during this research is very important because it aid as reference. Base map are can be produced using Coral Drawl or ArcGIS software. The base map must contain little basic information such as contour, river, elevation, road and town or village. It also helps to visualize the topographic of the research area.

3.2.2 Hydrochloric acid solution (HCL)

These acid solutions are used to detect the presence of carbonate in mineral or rock. HCL used to differentiate limestone, dolomite and marble rock. If the dropping of this solution produced like a bubble effect, then it can be concluding that rock are limestone or the rock contain calcite mineral.

3.3.3 Compass

Compass used to measure the orientation of any geological planes and the lineation with respect to north, calculate the strike and dip of geological features and use to mark for azimuth reading. The compass also can be used to determine accuracy of location based on topographic map. There are two types of compass, which are Brunton and Sunto compass.

3.2.4 Geological Hammer

Hammer is the basic material needed while doing geological mapping. It used to collect sample and for remove weathered rock surface to obtain the fresh sample. The common type of geological hammer is a chisel head and tip point head.

3.2.5 Global Positioning System (GPS)

GPS was used to produce valuable information to the geologist during the field work. GPS can record waypoint, tract, location where the sample are collected, elevation and mark the current location where we stand.

3.2.6 Measuring tape

Measuring tape used to measure the diameter or size of the outcrop. It also can use to measure joint, fault line or any thickness of layer in sedimentary rock.

3.2.7 Hand lens

The main function of hand lens is to make a first observation and analysis of the rock sample in the field before doing the analysis in the laboratories. A good hand lens with moderate magnification is absolutely needed for examine the rock sample taken, especially to observe the grain size and shape or is there any fossil embedded on the rock sample.

3.2.8 Materials used in Land Suitability Analysis for Urban Development

a) Topographical map

b) Satellite data

c) Land use of urban, agriculture, forest and river

3.2.9 Software

The software used in interpreting, analyzing geological features of the study area and producing the geological maps is ArcGIS version 10.2, DNR GPS and Corel Draw. Besides, it used in order to make the cross-section for the lithology in the study area.

3.3 Methodology

3.3.1 Preliminary Studies

Preliminary research is the important step before starting the research. Usually, preliminary research includes a few aspects. There are about study area, know the geomorphology of the area, the type and distribution of rock, geological condition of the area and the formation. This is the basic information before doing the research. This information was obtained from a few types of sources such as journal, thesis, test book and private sector of geology. The geomorphology is a major part and the urban area is a main objective in this research.

This research need to accomplish with a mapping method. The geomorphology map was produced based on the data collection from the field observation and it was produced by using the ArcGIS software or remote sensing application. For the first observation, these areas are covering by flat and some part of mountainous area and have a connection with a few main river of Kelantan such as Ketil River and Bertam River. This area has a railway road that starting from the Kuala Lumpur Centre. The main public transport of this area is car or bus or motorcycle because it faster, but there are also a train. Gua Musang area was upgrade to become an urban area because at the

area has a new development according to ‘Rancangan Tempatan Jajahan Gua Musang 2020’.

3.3.2 Field studies

a. Mapping

Field study is one crucial element in this method of research. The purpose of the study is to study the general geology of the study area and lastly produce the geological map. The field studies are severally taken a few weeks and many aspects must be prepared. The purpose of the field mapping is determined and produced the latest data in study area. For the pre-field study, many preparations are needed to be done before go to site. It involved the traverse planning, money planning and basic thing need during the field work.

Firstly, the literature review surveys are done on the research area. This is crucial as it can provide the overview of the area and what is specialize of the area. From the literature review, many kinds of plan and method were constructed. Then, study the remote sensing or any type of digitize information about the study area. The GPS is important material to record the traverse and mark the location of the outcrop. It also can act as a compass to shows the coordinate and direction at field. Next, at the end of mapping activity all equipment and material need to be checked to avoid any problem. In addition, the basic method after reach at the study area is found the outcrop as an indicator to know the type and distribution of rock around the area and detail observations are made onto the outcrop by figures sketching that has been analyses at the field site. For the geological structure, tectonic setting and sedimentary structure part, it also need to be identified during the field mapping as well as orientation, dip

and strike reading. Based on the previous literature review, the formation of the areas is known. All the information was recorded for fully analysis and data interpretation.

b. Sampling

For the rock samples sampling, the samples are collected from the field for microscopic analysis. Samples were then processed in thin section form and it is examined under the microscope. The rock sample must be fresh and good condition.

3.3.3 Laboratory studies

a. **Thin section preparation**

The collected samples were then undergone laboratory investigation. Step one is prepare the glass slide. The glass was glue the rock and must be flat in order for the rock section to end up with a constant thickness and being 'frost'. The second wheel is turned on from the left and some water was spray on the wheel until it completely wet. The wheel was sprinkled by abrasive. The wheel should be prepared considerably to prevent it from rusting. After that, area is marked by permanent marker.

Second step is cut the slab. The samples are clamped in the holder parallel to the saw blade. The cover is closed in order to make sure the sides and bottom tucked inside the lip. The rods are cut off. The crank handles are removed and the cover will be close. The cutting processes were repeated for 8 times. Next, cut the chip. The slab must be reduced in size and slightly smaller that thin section. These steps involved a trim saw and carefully decide at wish part that will be cut. The rock is cut by using a special rock-cutting blade which it made of metal with diamond embedded in it. The size of rock becomes smaller than slide.

After that, the slides are polished to remove the mark on the surface. Then, grind the slide to the correct thickness. The black place is placed on the grinder to block the vacuum. The water was turn on to the cut-off saw and the vacuum need to turn on. The handle was used to move the chip into the blade carefully and slowly. After that, turn off the vacuum and saw. When the blade is stopped, the chip was removed from the saw and the slide rinse to remove any particle. Last step is added a cover slip. The section should be clean from dirt or grit. The section was dropped by a small of epoxy and the cover will be expelling from bubble and fully coat the section. Let it dry and the thin section is done.

3.3.4 Data Processing

This research needs land use map of 2009 and 2018 the data was extracted from satellite imageries, Landsat 7 and Landsat 8 from USGS respectively. Then selected Landsat images were corrected with using ArcGIS software. Geological mapping data were collected using GPS and accuracy classification assessment is made by comparing the classified image with GPS from the field data. Using the high resolution of Google Map, the accuracy assessment is made based on previous land use map in year 2009. This method creates random point using ArcGIS 10.2.

3.3.5 Method use in Land Suitability Analysis for Urban Development

For any suitability analysis, appropriate base data is required generally from satellite data, topographic maps, thematic maps and field data. The different land qualities, which can be consider for suitability modelling are present land use or land cover, slope, elevation, proximity of transportation network and water body. To assess the overall suitability a scoring and weighting system is applied to the various aspects of suitability. Suitable sites are found out by adding all layers which affecting site

suitability. In this research there five selection of different parameter for suitability, which are:

a. Existing land use:

Land use or land cover map is a comprehensive expression of land use or land cover classification. This map has been prepared by using data from Majlis Daerah Gua Musang or from Department of Surveying and Mapping (JUPEM). The main classes which affect the planning aspect vacant, agriculture land, reserve forest, karst area and residential are considered.

b. Water Body:

Major rivers were digitized from the topographical map. To identify the river prone areas, various buffer zones need to be created by taking different distance values from both sides of the river banks. Information and guideline about the river or stream channel are obtained from Jabatan Pengaliran & Saliran (JPS).

c. Road Accessibility:

In this study, in order to find out the accessibility of the area, major roads, which are connecting to the different areas, need to be digitized. The topographical map of Gua Musang Town and buffer zones was created by taking different distances from the road to generate road accessibility nap.

d. Slope and elevation:

Next, in this study method, the main layer that need to be digitize is contour layer, where the contour map must be in complete line. Then, using contour map, the layers were converted into raster form, where result will be show in small pixel form with

different colour that according to the level of the slope and elevation. The output of this method is terrain map.

3.3.6 Data analysis and interpretation

To assess the accuracy and overall land suitability for the urban development, the data need to be analyse, in other to reach the final result such as suitability scoring and ranking. For suitability analysis, it is necessary to give some score to each category as per their suitability for urban development since each category will not have the same weightage or usefulness for urban development. The suitability scoring used in this study for each of the map and their category at an eight-point scale. Then, in this case the suitability rank is classified into five important ratings, which area most suitable, suitable, moderate, less suitable and not suitable as stated in the final result in Figure 5.5.

3.3.7 Raster and Reclassifying

All the selected parameter layers need to be convert into the raster form before it can be reclassifying. The layer can be either in polyline or polygon shape file, but for the data obtain from satellite image, such as from Landsat 8 or Landsat 7 can be directly reclassify since the format is already in the raster form. In this study, all vector data need to be calculate in the "Euclion Distance" before can be reclassify in the Spatial Analysis Tool'. The purpose of converting all layer into raster is to calculate the pixel size and to calculate the area of each layer.

3.3.8 Suitability Score

For each layer, a score need to be put while reclassify each of the layer. The score given is between one to eight, in which eight is the most suitable or good and the least

score given are not suitable or poor. In addition, in this study three important parameter or the most higher percentage given in the reclassifying table are land cover, road accessibility and elevation as stated in the Table 3.1.

3.3.9 Weighted Overlay

Next assessment need to be taken is suitability map with weighted in the overlay tool. All layers that has be given score are overlay and weight in the tools before the final result can be projected. The main criteria that influence the land suitability shown in the result projected in the Figure 5.4, is resolve the rating on the Table 3.1 above. For further discussion about suitability will be discuss in the chapter five.

Table 3.1 Weighted Overlay Criteria

WEIGHTED INFLUENCE (%)	CRITERIA	RANK	WEIGHTED INFLUENCE (%)	CRITERIA	RANK
LAND USE/LAND COVER CLASSIFICATION			**MAIN RIVER**		
40	TRANSPORTATION	9	**10**	2619 - >3000	8
	BUILT-UP LAND	8		2245 - 2619	7
	RESIDENTIAL AREA	7		1870 - 2245	6
	BARREN LAND	6		1496 - 1870	5
	INDUSTRIAL AREA	5		1122 - 1496	4
	WATER BODY	4		748 - 1122	3
	PLANTATION AREA	3		374 - 748	2
	KARST LIMESTONE	2		0 - 374	1
	RESERVE FOREST	1			
SLOPE CLASSIFICATION			**RIVER**		
10	0- 8	8	**5**	832 - >950	8
	8 - 13	7		713- 832	7
	13-21	6		594 - 713	6
	21-28	5		475 - 594	5
	28-35	4		356 - 475	4
	35-42	3		238 - 356	3
	42-49	2		119 - 238	2
	49- >56	1		0 - 119	1
STREET CLASSIFICATION (m)			**ELEVATION**		
20	0 - 339	8	**10**	0 - 74	8
	339 - 679	7		74 - 159	7
	679 - 1018	6		159 - 245	6
	1018 - 1357	5		245 - 331	5
	1357 - 1696	4		331 - 416	4
	1696 - 2036	3		416 - 502	3
	2036 - 2375	2		502 - 588	2
	2375 - >2714	1		588 - 673	1

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discussed on the geology aspect that related specifically in the research or study area. The general geology covers all aspect such as study area, geomorphology, lithostratigraphy, structural geology and historical geology of the study area. The general geology provides geological information supported with related maps to complete this research.

The general geology part of study area should cover all information about this research area, which are the accessibility, settlement or demography, forestry and field observation information. The accessibility to the study area can be classified into two ways, which by main and small road or by railways road. The accessibility in the study area are shown in the Figure 1.2. The red line indicates the highways and small roads which is the road that interconnect Merapoh - Gua Musang road to others road in the research area. As for the black line, it refers to the railways road the lies in the most centre part of the study box or study area, this train road carried the passengers from others train stations, for instance train station in Tanah Merah.

Next, demography is the study of human population in a certain area and including the size, composition and distribution across space and the process that happen through their population changes. The latest data get from Majlis Daerah Gua Musang is shown in Table 4.1. The population of Gua Musang peoples shows an increasing trend for the

past eight years, where the most percentage present by Malay race and least percentage present by others ethnic, that may be present by foreign peoples that work as a labour, either in plantation field or in factory. Next, for the land cover aspect, almost sixty percent of the area are cover with oil palm plantation and forest, while the remaining area are classified as develop urban area as shown on land cover map in Figure 5.2. This aspect will be further discussing on the next chapter.

Table 4.1 Population of Gua Musang

Population by races	Total Number (%)
Malay	75
Chinese	10
Indian	10
Others	5

(Source: Majlis Daerah Gua Musang, MDGM)

Traversing mapping is an important step before continue with writing. During this method, all geologic data are collected, observe and used in the research writing. Then, a few maps will be provided for better understanding about the area. For instance, traverse and observation map and drainage pattern map as shown in Figure 4.1 and Figure 4.2 respectively. Along this method, all coordinate of each location are marked and recorded by using GPS, and all rock samples are taken using hammer for further investigation.

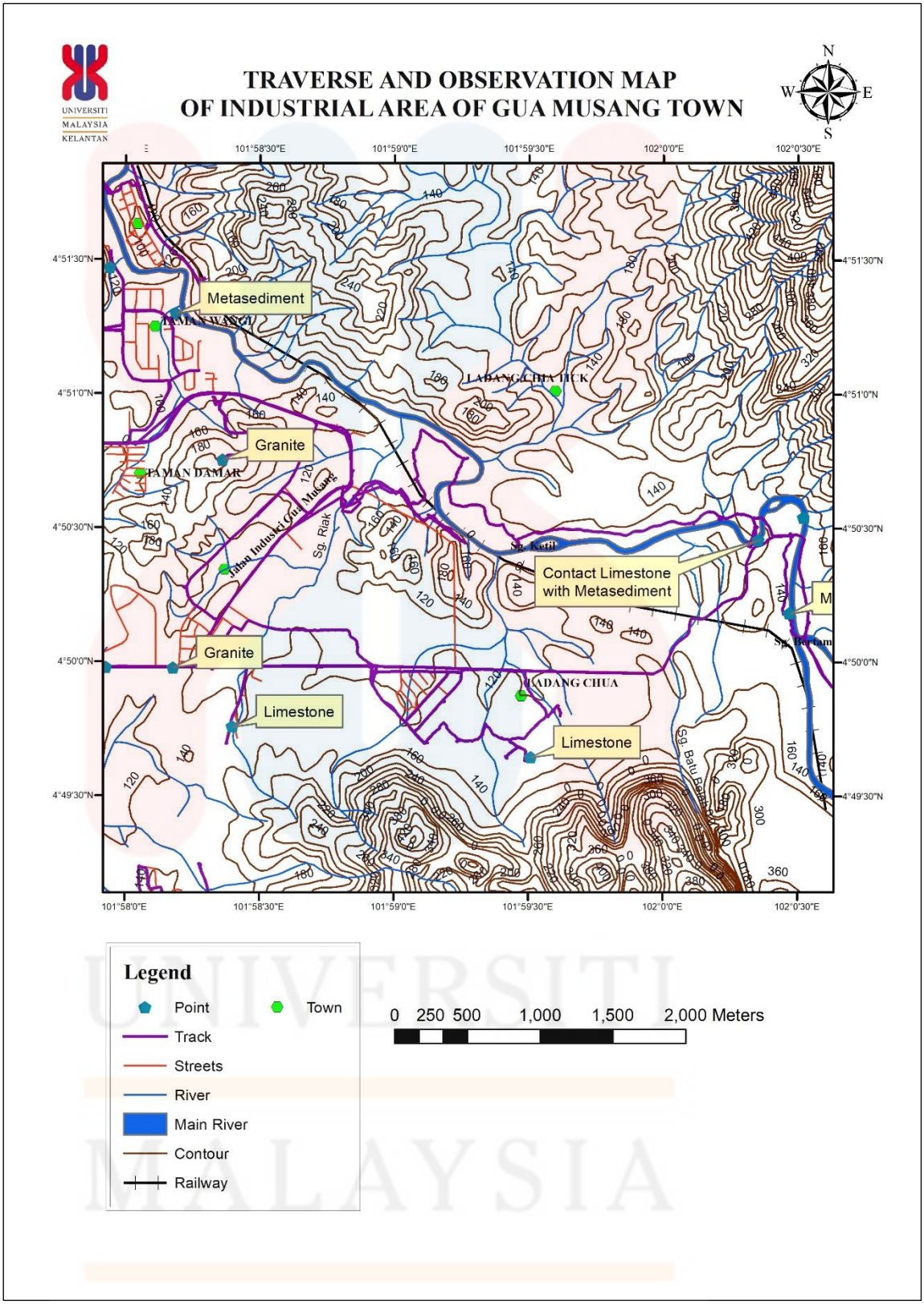


Figure 4.1 Traverse and Observation Map

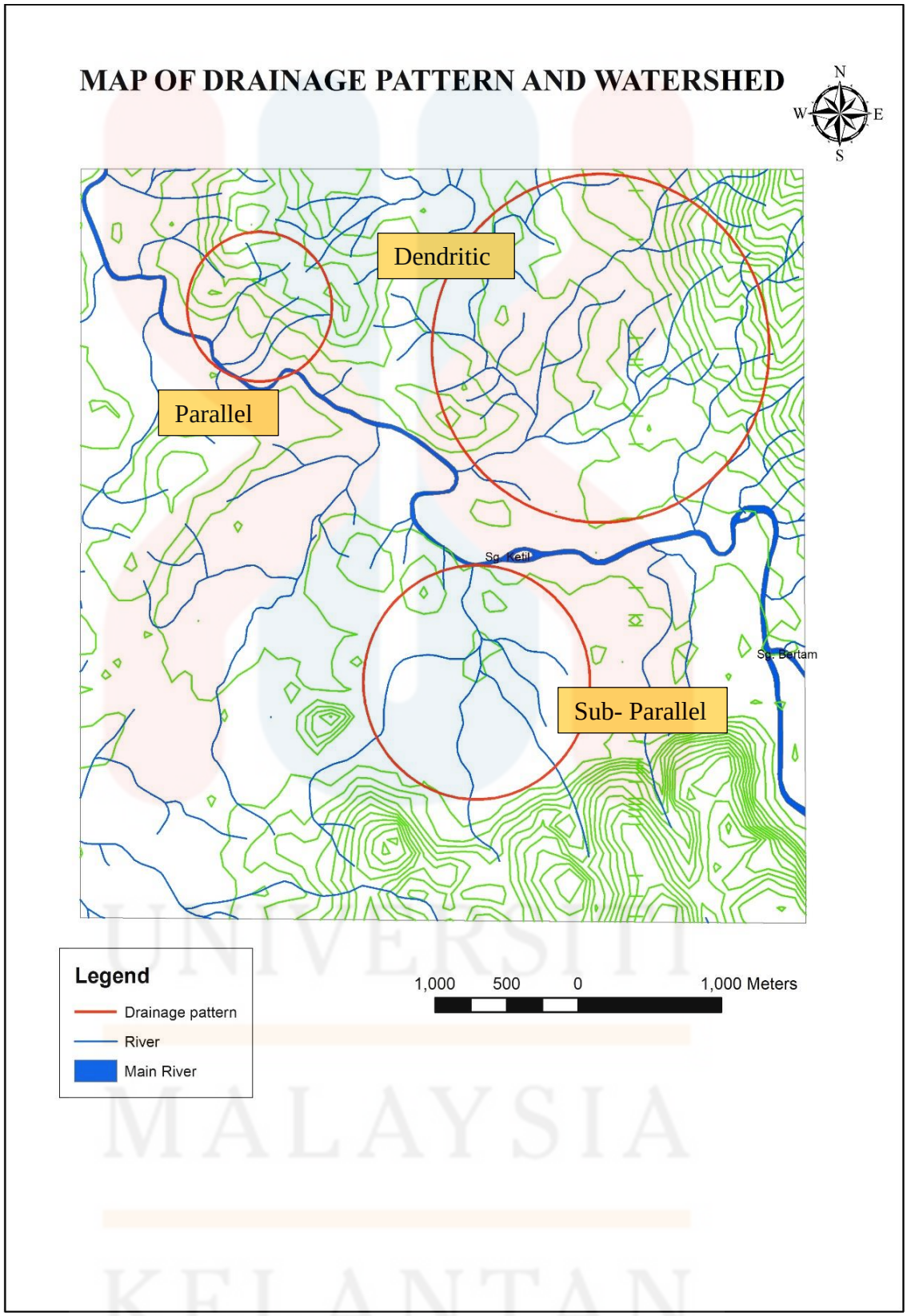


Figure 4.2 Map of drainage pattern

4.2 Geomorphology

Geomorphology part covers the related information about the study area according to its classification. The geomorphology is a study about the earth form, by describing the existing landform and investigate the process that influences the building up of the landform. There are four component need to consider in order to put the geomorphology into its own classification, it is including geomorphic process, landform, morphometry and geomorphic generation. For geomorphic process, it can be divided into types of fluvial, glacial, periglacial, lacustrine, mass wasting, tectonic and volcanic. Next, types of landform can be determined after the process involved are identified, landform are mountains, valley, plateaus, glaciers, karst, plain and hill. In this study, it takes value of an elevation as a part of guidance to classify the type of landform as shown in Table 4.2. Geomorphology can be used to explain the factors that create the surrounding landform.

Table 4.2 The topographic unit based in mean elevation (Raj,2009)

Description	Mean Elevation
Low lying	< 15 meter above sea level
Rolling	16-30 meter
Undulating	31-75 meter
Hilly	76-300 meter
Mountainous	>301 meter

In addition, some landform is created effect from the process of equilibrium, different climatic environment, weathering and erosion. Different factor or mechanism of geomorphology process create different types of landform. Weathering process are divided into three types, which are physical, chemical and biological process. The physical process creates and modify the earth surface into landform through endogenic or exogenic process. In some cases, the age or time of the landform can be determined or predicted using morphochronology method, where in this method, all related fossils evidence are find and collected before it can be used as indicator of the age of the landform type. Usually, the age of the fossils can be same with age of the landform.

Next, drainage pattern also can be determined based on the elevation because the water flowy from high to low area. The type of drainage pattern is influence by the geomorphology system of the area. Besides, drainage pattern also can determine the type of rock that build up the landform type. The urban area is developed on the lower elevation area. The area of the highly elevation is mostly being plantation or karst landform that does not have any development at the study area. As a conclusion, mostly settlement area is located in low relief area and near to the water resources.

Geomorphology is important to understand why landscape look on that it way build, to understand landform history, to predict changes through the combination of field mapping and observation. For the geomorphology within the study area is shows in Figure 4.3.

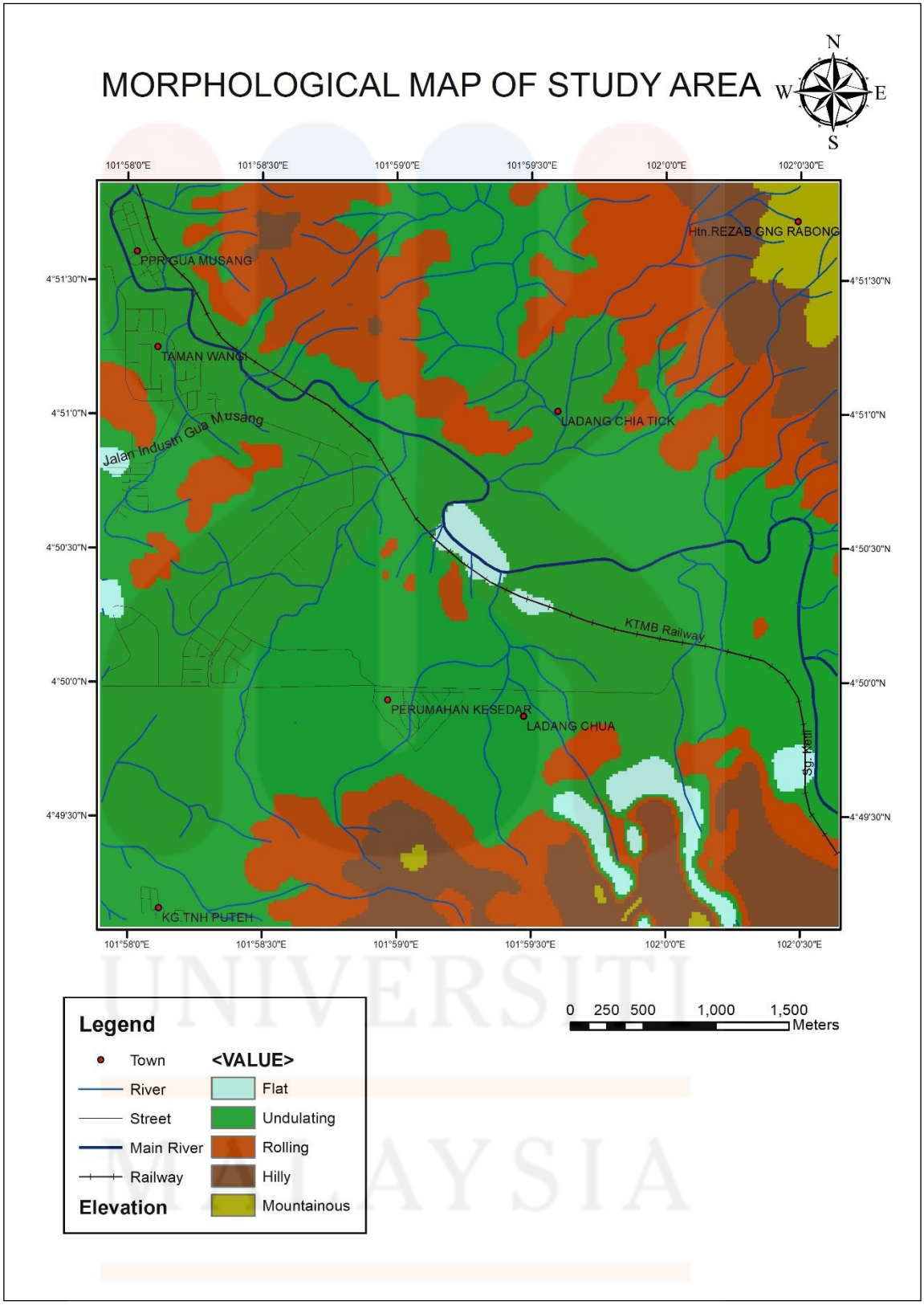


Figure 4.3 Geomorphological Map of study area

4.2.1 Morphology classification

Morphology or landform in this study is classify according to the elevation. Thus, from Figure 4.3, it can be see the study area can be classifying into five morphological class. It is flat, undulating, rolling, hilly and mountainous. All morphology classification is formed by various landform process, for example:

a. Fluvial Landform

Fluvial landform can be determined in the study area. This process that build up the landform are associate with the river and the streams. It happens when the river and stream are deposit either in the corner of the river or in the mid or centre of the river. The deposit can be composed of sand, silt or pebbles. Fluvial process form by erosion process, where the loose sediment and suspended are moving by water and becoming smaller and more rounded.

The fluvial deposits form by process of erosion, transportation and then deposit. The breakdown or deposition of rock and soil are caused by few erosion mechanisms. For instance, water, wind or ealion. The type of sediment transport can be in form of bed load or suspended load. The process start when the flow of river flow on faster rate, more particle is being carried out than dropped at any area as the flow rate decrease. In other hand, when the river flow slowly, more particle or sediment deposit into the ground. If the area has more particle or sediment are call fluvial or flood plain and the sediment deposits are called as alluvial.

b. Karst Landform

Karst is a type of landform that form because of reaction of dissolution of the soluble rock such as limestone, dolomite and gypsum. Karst features are stalactites, stalagmites, rock pillar, and cave as shown in Figure 4.4. In some karst landform,

reappearing stream or disappearing stream can be found. The karst landform is cockpit karst, cone karst, tower karst, moggote and pinnacles karst. In the study area, mostly the area is surround with the karst that obviously seen on the road side.

Based on the field observation during mapping, limestone rock has undergone chemical and physical weathering. Especially, in the area of Chin Tek Plantation, most of the limestone rock that found scattered in the ground has turn into the marble rock. This is because of the pressure and the chemical that react in the rock.

Figure 4.4 Kart features in study area

In addition, one of the limestone cave in the study area are have been observe has a river flow into it. It can be an indicator of groundwater present. Next, the deposition environment. Each of landform has its own history of deposition environment. It can be either in the deep sea, swamp or land. The deposition environment of limestone is known in the deep ocean. Then, because of tectonic activity, it undergoes the uplift process from deep marine or ocean into the earth surface, as we can see now. It composed by marine life such as shell. Thus, fossil content can be found in limestone rock. For instance, gastropod or bivalve fossils.

4.2.2 Weathering and Erosion process

Weathering is a process of disintegration, break down or changing the colour of the rock. Weathering can be divided into three main types, that are physical, chemical and biological. Mostly weathering occurs in in-situ process, whereby there is no movement of rock or soil. It is differing than erosion process. Inversely from weathering, erosion process involves transportation or movement of rock, mineral or sediment. Process of erosion and weathering can happen both in one time.

Physical weathering also known as mechanical weathering is process that breaks down the rock in small pieces without changing the mineral and chemical composition. The agent of this weathering can be water, gravity, humidity or pressure. The reaction of this weathering make the rock broke into smaller pieces or produce cracking in the wall of the rock surface.

Next, chemical weathering. This type of weathering can alter the mineral composition affect from the chemical reaction in certain rock. It occurs more in the mafic rock. The type of reaction that allow this process can be oxidation, reduction, carbonation, dissolution and hydrolysis process. the agent of chemical weathering are water or rainfall.

Biological weathering is disintegration or decay of rock and minerals caused by chemical or physical agents of organism. For example, organic activity of root, lichen, burrow and algae. Weathering and erosion are one of important aspect need to be observe in geomorphology system. In this study area, the weathering effect can be easily observing by naked eyes because it happens on the surface of rock. The rate of weathering also can be grade into six grades according to its condition as shown in Table 4.3.

Table 4.3 Weathering grade by ISRM (1978)

Term	Description	Grade
Fresh	No visible of rock material weathering, perhaps slightly discoloration on major discontinuity surfaces,	I
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock materials may be discoloured by weathering and may be weaker than its fresh condition.	II
Moderately weathered	Less than half of the rock material is decomposed or disintegrated to a soil. Fresh or discoloured rock is present either as a core stones.	III
Highly weathered	More than half of the rock material is decomposed into a soil. Fresh or discoloured rock is present either as a continuous framework or as core stones.	IV
Completely weathered	All rock material is decomposed and disintegrated into soil. The original mass structure is largely intact.	V
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume but the soil not been significantly transport.	VI

(Sources: International Society for Rock Mechanic, 1978)

a. Physical weathering

Physical weathering can be identified easily during field work. Both physical and chemical weathering can happen on an outcrop or rock in one time. Usually, physical weathering can cause mass wasting landform, such as landslide or soil slide. It happens when the rock break into small size or crush. Factor of physical weathering is compressional force, brittle force, expand and contract process that act at the rock. Meanwhile, the strength of soil will become weak and easily to slide down together, especially during rain. The area has a high physical weathering can be classified as a hazard area and less suitable to construct as urban area. In addition, the targeted area

is mark as a hazard probe area or landslide susceptibility area. In some places, the geotechnical engineer will advise to make a slope cutting then cover with grass or cement to prevent the landslide, as shown in the Figure 4.5 below. In the study area, the physical weathering is found in the Taman Wangi and with weathering grade of IV, because more than half rock at the area is decomposed into soil and discolored.

Figure 4.5 Physical weathering process

b. Chemical weathering

The chemical weathering mostly reacts with limestone or karst landform. It also can react with marble rock. This is because marble or limestone rock contain calcite mineral and it will react when acid water act on the surface of the rock. The mineral will dissolve and cause the features of rock change. For example, cave, sinkhole and pothole on the surface. Thus, chemical weathering process will act on any limestone hill or karst landform occurrence. Chemical weathering is common happen in the area that exposed to watery area like river or stream, because the main agent to allow the chemical process is water. Figure 4.5 show the formation of stalactites effect from this type of weathering.

Figure 4.6 Chemical weathering process

c. Biological weathering

Biological process can be identifying when the rock has a crack or joint at the surface. Biological weathering can be occurring at any type of rock such as on igneous, sedimentary or metamorphic rock. But, usually it occurs more on sedimentary rock such as sandstone, shale or phyllite, where the living thing can live on it or between the crack and joint. The strength of outcrop become reduces because the organism activity that live between the structures. The precipitation process can cause the organism easily to growth within the crack. The plant roots become big and this factor caused the rock to crack and then broken into smaller pieces or crash. For example, in the study area, the plant roots live in the block sandstone rock.

Figure 4.7 Biological weathering process

4.2.3 Drainage pattern

Drainage system is a pattern is form by streams, river and lakes in a particular drainage system. A drainage system also important in the development of urban area as it control the management of industries disposal if related. This system also usually receives infiltration, run-off, sub-surface and groundwater flow during rainfall. Drainage system can be classified into different size, pattern and shape of the drainage basin that found in the area

Next, drainage pattern also said to be depend on the topography and type of rock over the which stream flow. It can be divided into nine type according to its shape and pattern. There are, dendritic, trellis, rectangular, angular, annular and radial. Each of the pattern and shape also own their special geometric and topography characteristic as shows in Figure 4.8. According to Gibson U.C and Singer R.D (1971) in the manual of water well stated that drainage pattern can help in identify the rock type or formation in the area, recharge and potential area of groundwater present. In addition, by this system, ones can make in interpretation of the condition of the area by observing the drainage structures. In hydrologist aspect, the volume of groundwater is usually high at the lower area compare in the high elevation area, because the recharges and infiltration water occur at the basin area or lower elevation area.

There are about three type of drainage pattern has been observed along Ketil and Bertam River as shown in Figure 4.2. It is dendritic, parallel and sub parallel. Dendritic drainage pattern is tree look like pattern, that composed of branching tributaries and a main stream. This type of pattern is developing where the stream channel follows the slope terrain and form in V- valley shape It is common drainage pattern and relatively cause the rock type homogeneous rocks and impervious soils. Next, parallel drainage

pattern. It occurs affect from steep slopes and relief, where in the steep slope area the stream is swift then straight. It consists of few tributaries and flow into same point of direction. In addition, it develops in the resistant rock bands landform. Then, sub parallel, like parallel drainage pattern it has elongated catchment with small tributaries joining at small acute angle

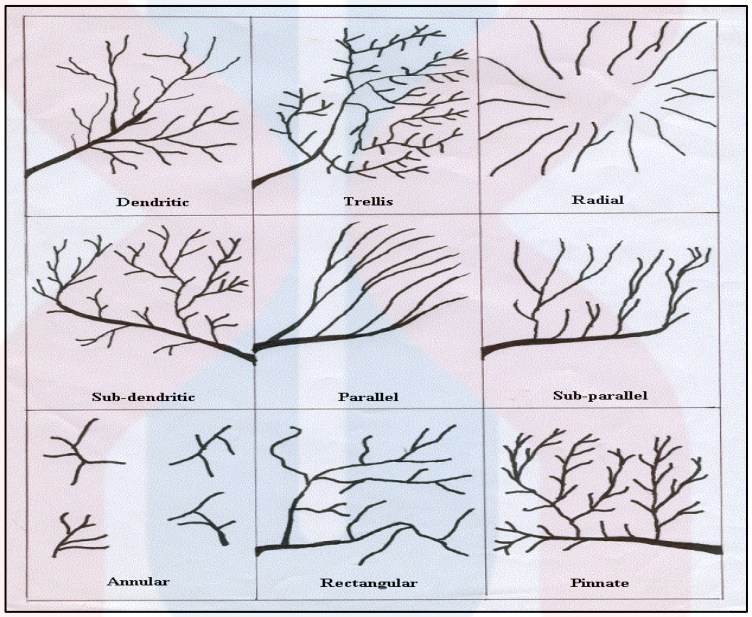


Figure 4.8 Types of drainage pattern

4.3 Stratigraphy

4.3.1 Lithology

The field observation should have been done to accomplish this observation. This field observation including all the method that use in the mapping to discover the study area. The outcome from field mapping is much information can extract through the mapping method. The traverse method also uses in this mapping to point the location of any structures and the rock that found at the study area. Thus, along the field mapping., there are four distinctive rock unit in the study area, there are sandstone, granite, limestone and meta-sediment rock unit.

a. Sandstone

Sandstone is categorized as sedimentary rock that have size grain of 0.0625 to two millimeter. Sandstone also contain cementing material that cemented together in the rock, the matrix of the rock may contain silt or clay contain. The mineral composition in sandstone are usually quartz or calcite mineral. It is high porosity rock and easily to weathered and erode.

In this study area, sandstone rock found along the left side of railways track and part of the Ketil River in the urban area. The color of sandstone is greyish, but the dominant color is orange in color as shown in figure below. The grain size and medium grain. It also may contain some silt and clay mineral composition since it still feels like sticky to gritty texture. The common deposition environment of sandstone rock is at river, stream and channel. Besides, there is some structure can be found on this outcrop, which is bedding.

Figure 4.9 Sandstone outcrop sample

b. Granite unit

Granite is intrusive rock. Granite is familiar with pink and grey granite. The specification name of granite is depending on their percentage of mineral and using IUGS triangle as shown in Figure 4.10. The common mineral associated with granite are is quartz, alkali feldspar and plagioclase. The mineral can be seen by using naked eye because the size is larger than 1 millimeter (phenocryst).

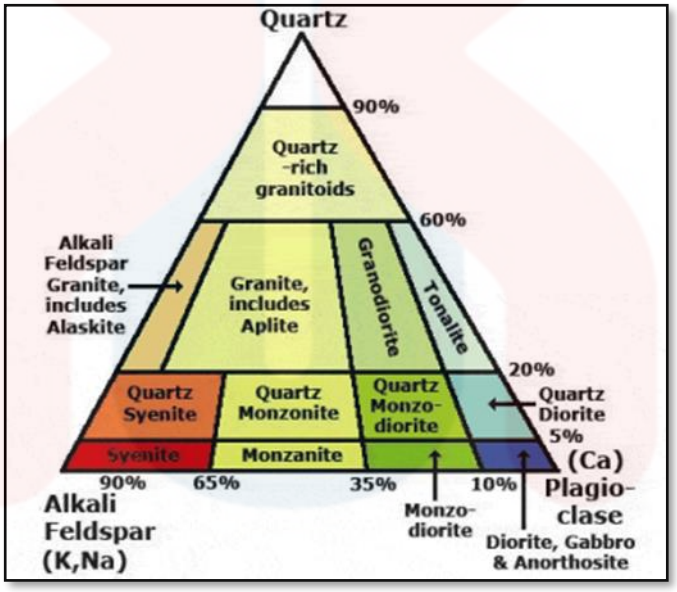


Figure 4.10 IUGS Igneous Classification name

Granite rock is located in the west part of the study area and in industrial area. Generally, mineral composition that can be seen in the outcrop are feldspar, quartz, mica and biotite. The age of this rock unit in the study area on literature review is about cretaceous. Therefore, this granite unit is the youngest unit in the study area.

Figure 4.11 Granite rock sample

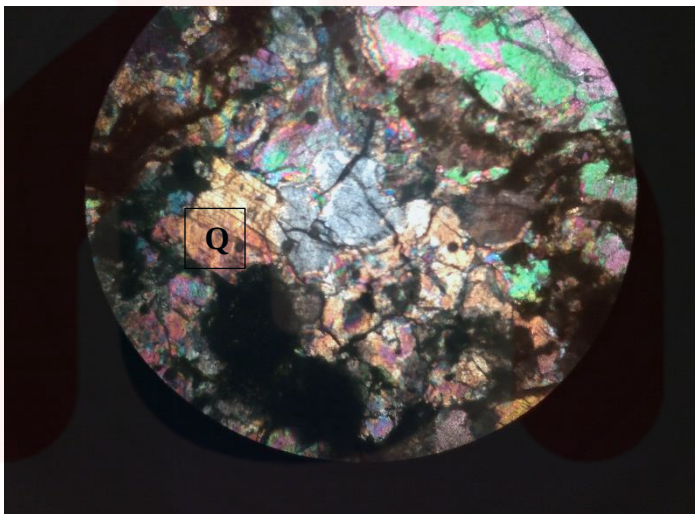


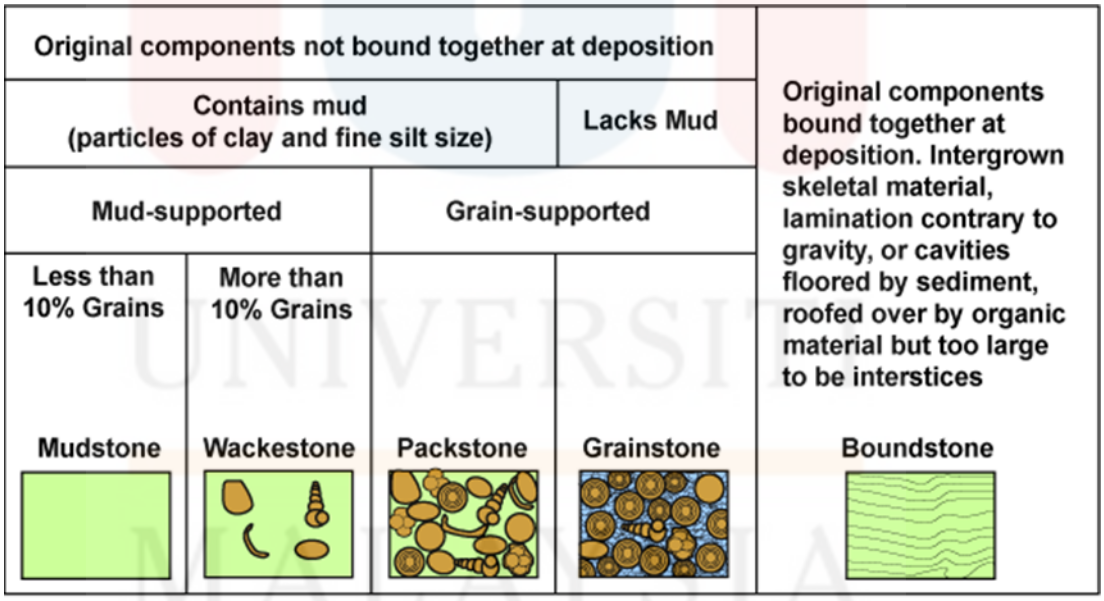
Figure 4.12 Cross polarization image of granite under 0.1 magnification

c. Limestone unit

The limestone rock is found scattered in the area of Chin Tek Plantation area and along half of the Ketil River. The limestone is a part of sedimentary rock and has a fined grain and dominated mineral, which is calcium carbonate. This limestone has undergone chemical weathering because it exposed with the river water and at the surface has a small crack because of the chemical weathering as shown in Figure 4.13. In some area, the limestone rock has turn into marble rock affect from the heat and pressure of the surrounding. Limestone rock also can classify according to the grain

size of the mineral in the rock as in Dunham's Classification in Table 4.13 below. For the karst landform in the study area shows a bedding unit either in thick or well bedded. The color of limestone mostly milky white and grey depend on the rate of the chemical weathering. The grain size of rock sample is medium grain to coarse grain. Thus, it can be simply recognized by the naked eyes that limestone is type of lime-mudstone. As for the petrography analysis shown in Figure 4.14, it is hard to identify the mineral contain, since the grain is very fine, the whitish color may be considered as calcite mineral. Generally, the dolomite and calcite mineral also can be found during meta-sediment process. The deposition environment of the rock may be in marine environment either in reef, slope or rise area. The age of limestone based on the literature review is in Triassic age.

Table 4.4 Dunham Classification



C. G. St. C. Kendall, 2005 (after Dunham, 1962, AAPG Memoir 1)

Figure 4.13 Limestone rock sample

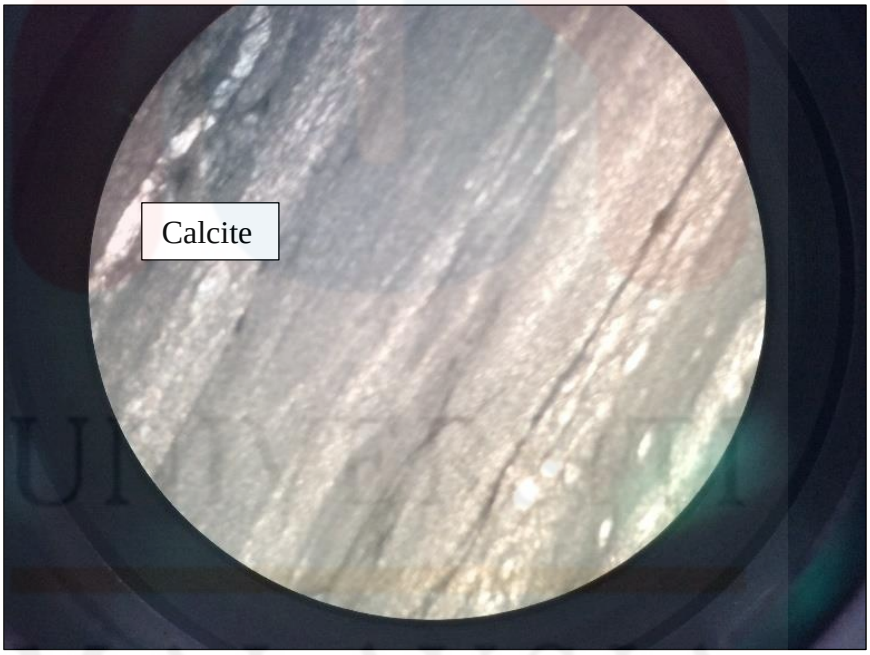


Figure 4.14 Fined grain image of limestone under 0.1 magnification

d. Meta-sediment unit

Meta-sediment rock is also said as metamorphic rock. But, the primary rock formed is a sedimentary rock, then rock is buried underneath the surface and face high pressures and temperatures. In the study area, meta-sediment rock recognizes as slate and phyllite. The rock found in the Chin Tek Plantation area is phyllite contact with marble rock, while slate is found in the small river in Taman Wangi. The colour of both rock is dark colour and has sheet-like structure. It is deposit in the stream channel. Past study of the Gua Musang formation stated that the age of the formation is in Mesozoic age.

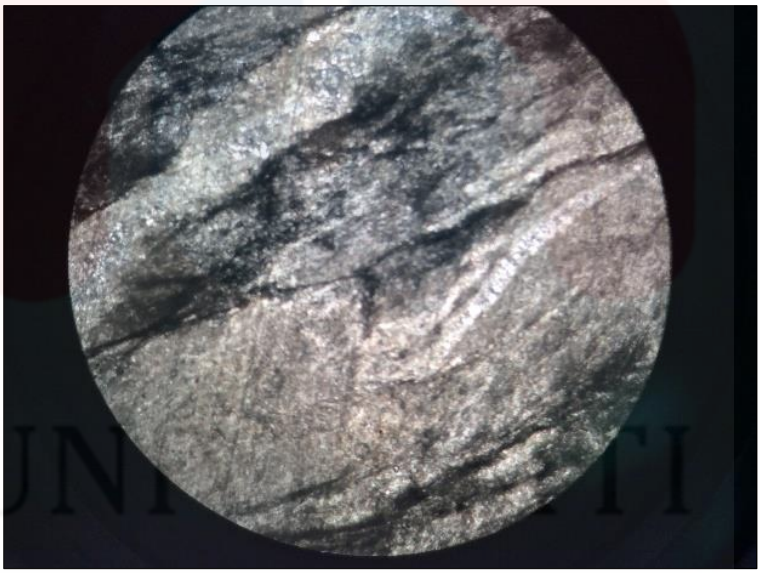


Figure 4.15 Image of meta-sediment under cross polarization with magnification 0.1

4.3.1 Lithostratigraphy

Lithostratigraphy can be used to interpret the origin of rocks and predict the extent of their age and rock character. This is also uses to describe the stratigraphic term of the rock based on their characteristic, naming, classification and features as well as

their correlation. Stratigraphy also can use to relate the rock unit formation with the age with the help of observation in lithology, mineralogy, petrology, geochemistry, fossil content and relationship between stratigraphy study. Each of the different rock unit is marked in GPS is needed before ones can correlate the formation of the area.

For the field observation, the stratigraphic unit can be found is igneous rock (granite), sedimentary rock (sandstone and limestone) and meta-sediment rock (slate, phyllite and some of schist). Stratigraphy is a study of geology that describe, interpret and correlate rock layer or strata on the Earth. It also studies the relative and absolute age and the process that related between the stratified rock. The stratigraphy of the study area rearranges the rock unit from the oldest in the bottom to the youngest in upper. The age of the formation is from Pre-Mesozoic up to the Cretaceous ages.

The oldest rock is meta-sediment (rock dominated with slate and shale, some phyllite) which in period of Middle Permian, then limestone with part of marble rock and the youngest in strata is sandstone with present of some mudstone and siltstone in period of Late Permian. As for the granite rock, it put on the upper strata in the stratigraphic column because from field mapping, the observations show that rock intrudes the other rock, make it as the younger one in this study area formation. Figure 4.16 and Figure 4.17 below shows the stratigraphy column and geological map of the study area respectively. Thus, from the stratigraphy analysis, it is match with the sequence stratigraphic stated by Yin (1965) in Table 2.1.

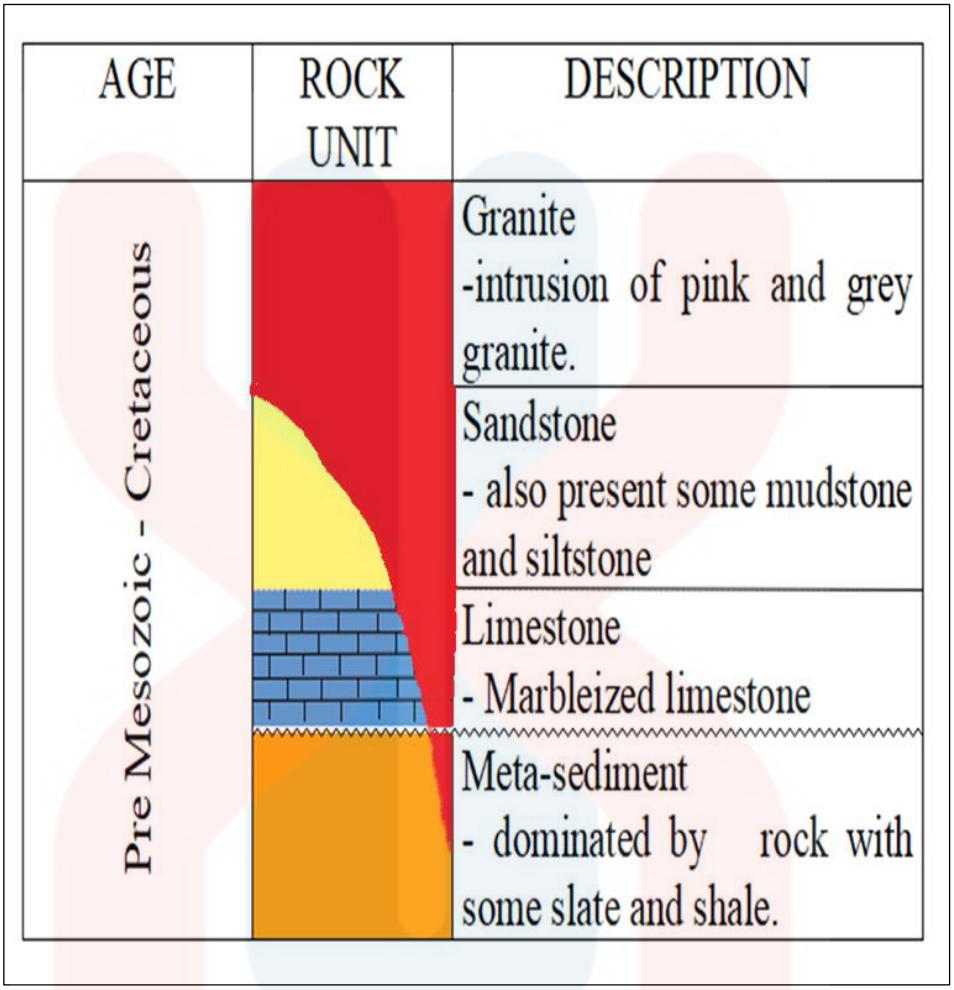


Figure 4.16 Stratigraphy column

4.4 Structural Geology

Structural geology can be identified by study the lineament analysis lined in the study area. Lineament indicate the line of straight line of the landform, for example river, stream, valley peak of hill or mountain. Lineament analysis helps geologist to make rough interpretation and observation about the geological structure present at the area that rise from the lineament analysis such as fault, fold, fractures zone or shear zone form by the geological process.

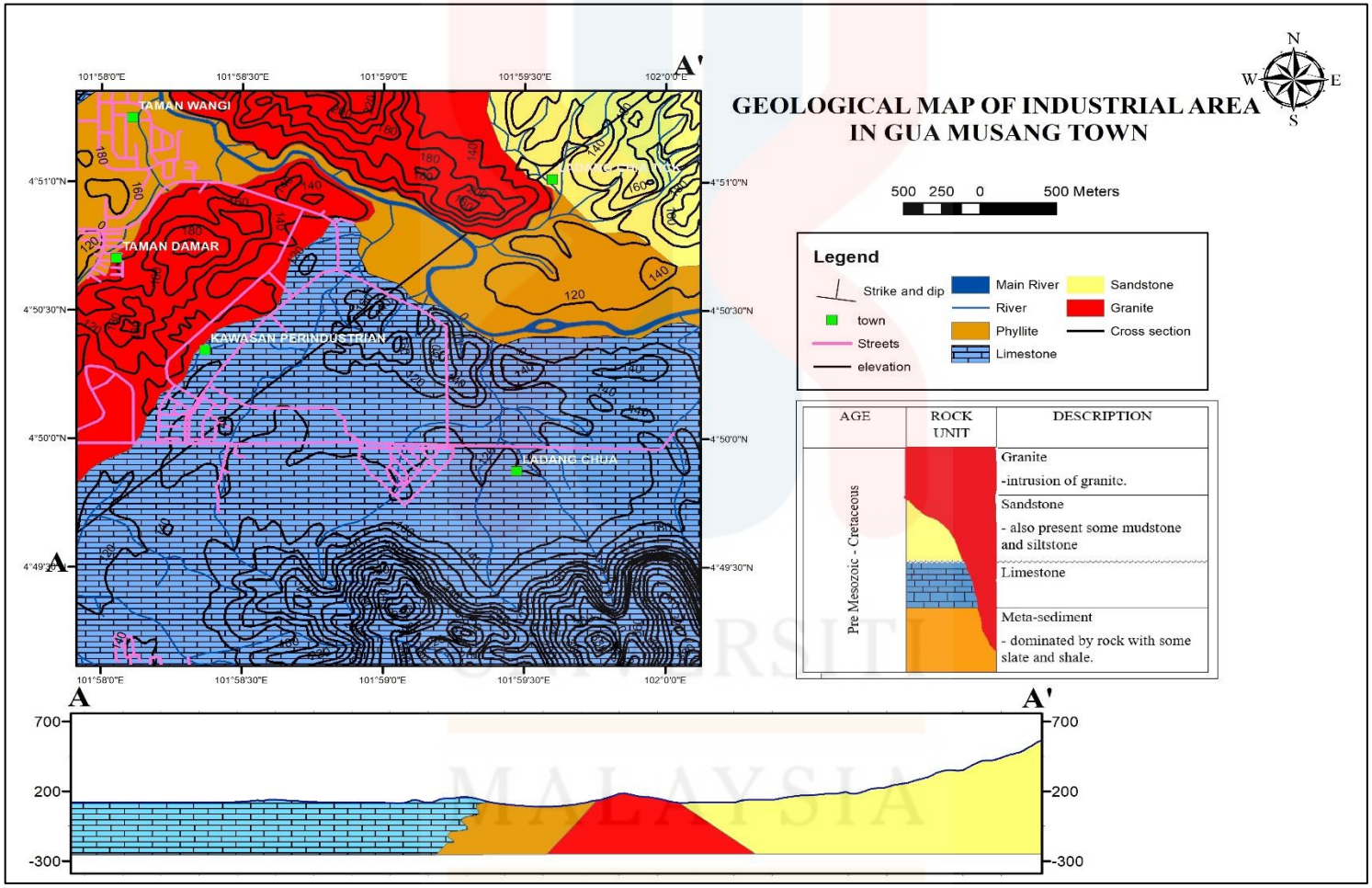


Figure 4.17 Geological of the study area

Software that usually used for analyzing geological structures data obtain from the field mapping are 'Georose Software'. From this software, it can generate rose diagram that displays the directional data and the frequency of each class of force based on the joint data obtain in the field. Besides, it is also used to determine the direction of principal stress, sigma one. This principal stress indicates the direction of the main force that act on the rock, before the rock deform into any structures or landform.

a. Joint analysis

Joint is the common structure that can be found in the field site. It found on the rock surface when the rock experienced any compression and then break or crush into smaller pieces. Joint can occur at any type of rock, whether it is igneous, sedimentary or metamorphic rock. It can be divided into two types, which is shear joint and extensional joint. It can be intercalating in various direction either horizontal or vertical or both direction.

Joint set can be identified through mapping and analysis on the study area. the joint type in this study area are shear joint in industrial area and systematic joint in Taman Wangi. Both joint reading collected are in 100 frequencies. Joint obtain in industrial area is expose on a granite outcrop. From the rose diagram analysis below, the principal stress (sigma one) is in the direction of north east of the outcrop area.

b. Fault

Fault is one of the geological structures that can be found in any field site. It can be major or minor fault and usually fault can be interpret from previous study of lineament line. There can be categorized into few type, which is normal, reverse and strike-slip fault. In addition, the indication of fault in the field can be recognized through its process effect, such as slicken line on the rock side (slicken side). Fault structures also

important in describing the formation of an area, because the process of mechanism deform the actual or original stratified rock.

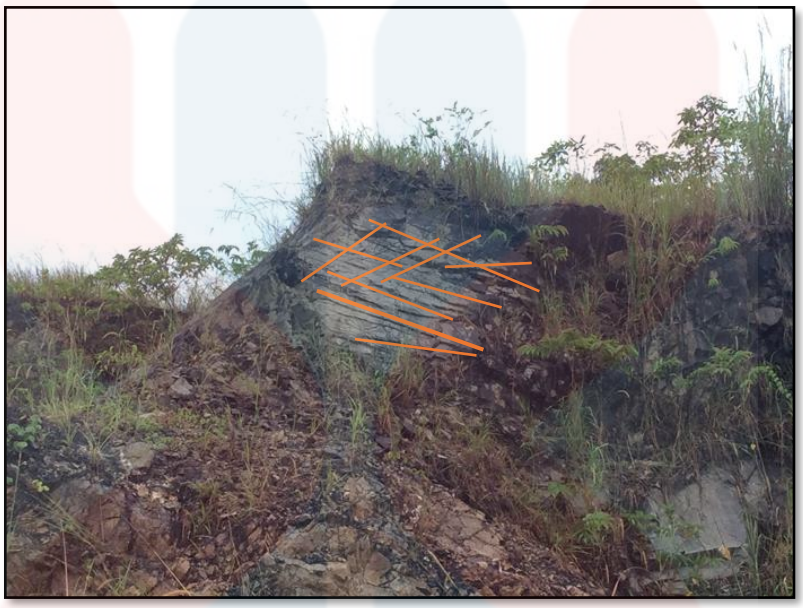


Figure 4.18 Joint set on granite rock

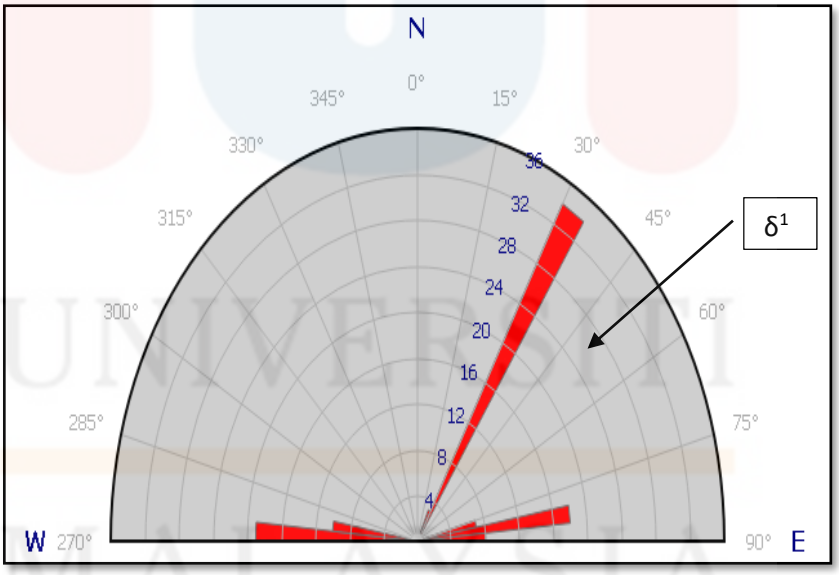


Figure 4.19 Joint analysis for granite rock

In the study area, some and major minor fault can be recognizing. This structure supports the lithostratigraphy of the area as discussed in previous section. Major fault can be found in industrial area, where from the road side, there are obviously seen the fault block of granite rock with slicken line traces on the surface of rock, as shown in Figure below. Then, minor fault found on the surface rock in small river of Taman Wangi. This minor fault may affect from the compressional pressure that act in rock. This is shown in Figure

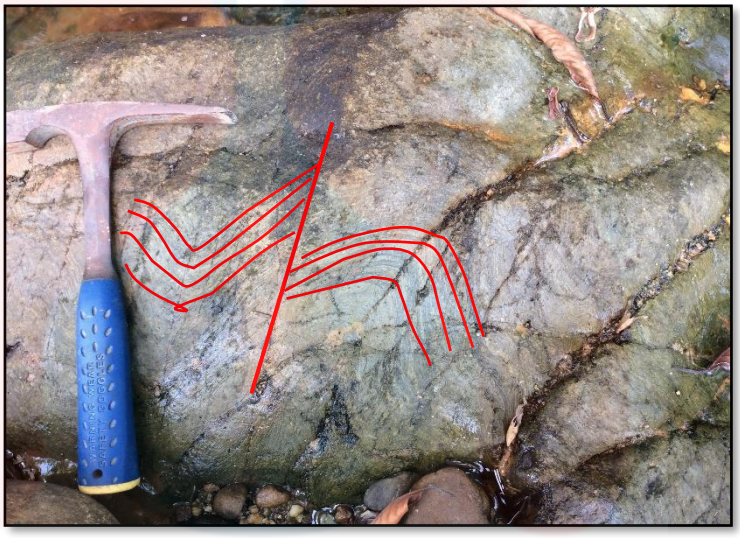


Figure 4.20 Fault and fold structure

Figure 4.21 Fault block on granite wall

c. Fold

Fold is also one of the geological structures that can be found in any field site. There can be categorized into two type of classification, which is syncline and anti-cline shape. The indication of fold in the field can be recognized through its process effect, such as compressional force from any directions. Fold structures also important in describing the formation of an area, because the process of mechanism deform the actual or original stratified rock.

In the study area, some minor fold can be recognizing. This structure supports the lithostratigraphy of the area as discussed in previous section. The minor fault found on the surface rock in small river of Taman Wangi as shown in Figure .

CHAPTER 5

RESULT AND DISCUSSION

5.1 Introduction

Urbanization is one of the important parts in the process of the growth in any city or country. The addition of populations in certain places is affected by the rapid growth of urbanization. Besides, the social and behaviour characteristics of the urban living style need to be considered from the urbanization (Pacione, 2001). According to Bunting and Filion (2000), city as an intensive space for social interaction, communication and the places where different opinion are voiced out.

In this chapter, the main objectives for this research was discussed in terms of the growth and trend of the urbanisation of the study area and to produce land suitability analysis map for further development of the research area. All method and analysis had been discussed in the Chapter 3. Next, there are about six parameters are chosen in producing the results which categorized as land use or land cover (LULC) layers, elevation, slope, water body and road accessibility. The classification of the land suitability may vary and different as different experts gives different opinion. For this research, there are few expert opinion has been taken, for example from JPS for the exact buffer zone classification for river, from JKR for the buffer zone of the road accessibility and from MDGM for the city planning and demography data.

5.2 Growth and Trend of Urbanisation in Study Area

Gua Musang is undergoing the urbanization process compare with past years based on the factors above. Nowadays, Gua Musang can be classify as growing urban area because of the increasing population data on the people and built up area. Figure 5.1 shows the land cover map of the recent years (2018) and Figure 5.2 indicates the past nine years' land cover map that shows a lot of land cover changes as stated in Table 5.1. Two type of land used to compare the changes between the selected years which is agriculture and built up land.

As a result, the trend of the urbanisation may indicate the urbanization growing process of Gua Musang town. It is about 13 percent loss of the agriculture and forest land through this past nine year. While there are about 3 percent increasing or addition area for the built up land. Next the map shows the clearer result of the changes by the colour that portrays the type of lands. The area that show the big changes of land use is on west part of the map, which is in industrial area. There is also an addition of residential area and the better road connection in the study area. Thus, by comparing this years, it can be seen that Gua Musang town is facing the process of urbanisation years by years.

Table 5.1 Land cover changes between years 2009 & 2018

Land Type	Year			
	2009		2018	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Agriculture & Forest Land	18	73	15	60
Built-Up Land	7	27	10	40
TOTAL	**25**	**100**	**25**	**100**

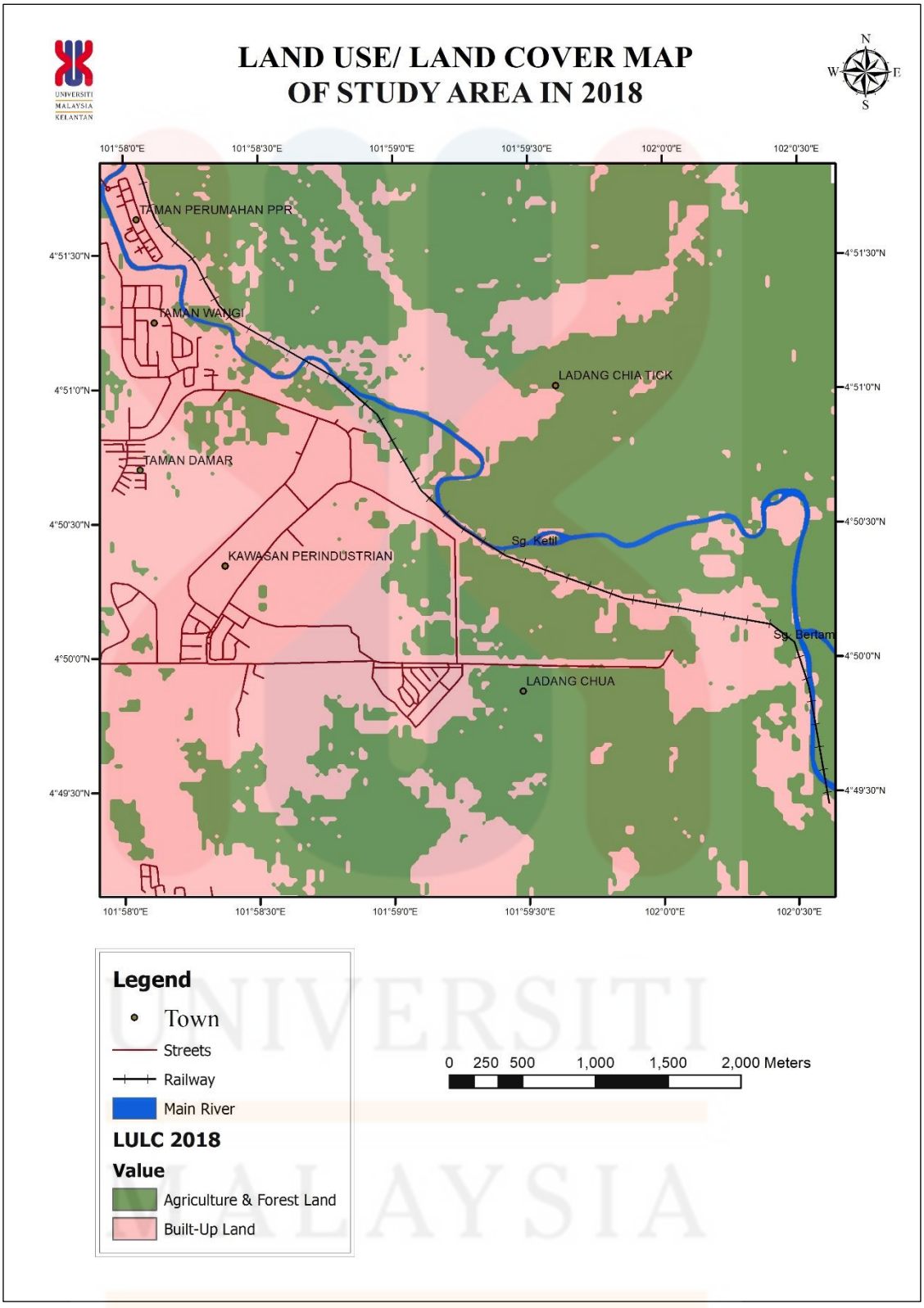


Figure 5.1 Land Cover Map of study area in 2018

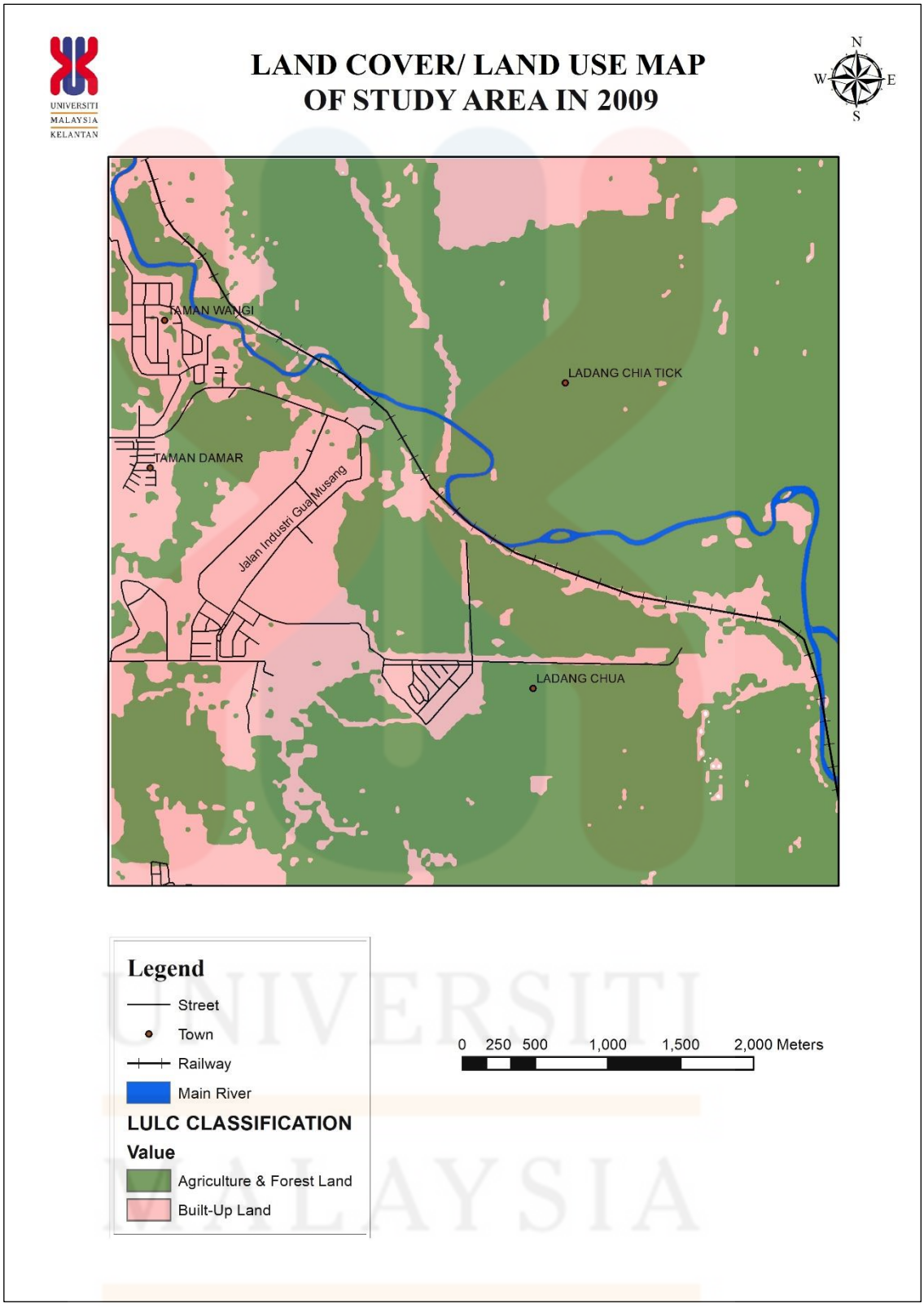


Figure 5.2 Land Cover Map of study area in 2009

5.3 Land Suitability Analysis for Urban Development

The location of suitability area was determined during field mapping. Then, the suitability map for urban development in the research area is produced using GIS method. In other to produce the map, six layers are being classify and overlay to give the raster result. Each layers or parameter plays an are needed in determining the potential or suitable location for the urban development. The produce result in Table 3.1 from the weighted overlay result is produced, and then being ranked into five classes, which is most suitable, suitable, moderate, less suitable and not suitable as shows in Figure 5.5. The protected areas like reserve forest and karst area are excluded from the final map as it is the most unsuitable area for the urban development in which to prevent from any risk and hazard.

Three important layers or parameters that has being weight among of higher percentage. The parameters are:

1. Land cover or land use:

There are about eight type of land has being classify as shown in Figure 5.3 and the area of each land are calculated in kilometre square. The data for this layers is obtaining from USGS Earth Explorer dated on September 2018 and in the weighted table, 40 percent of the overall is distributed to the LULC classification. The reason on choosing land cover as the main parameter is in other to build an urban development, a strategic place is needed. Table 5.2 shows the higher percentage cover area is on the plantation area (36%) then follow by built-up area (20%) but the most scoring given on built-up land as it is the suitable places for urban development based on expert opinion.

2. Road Accessibility:

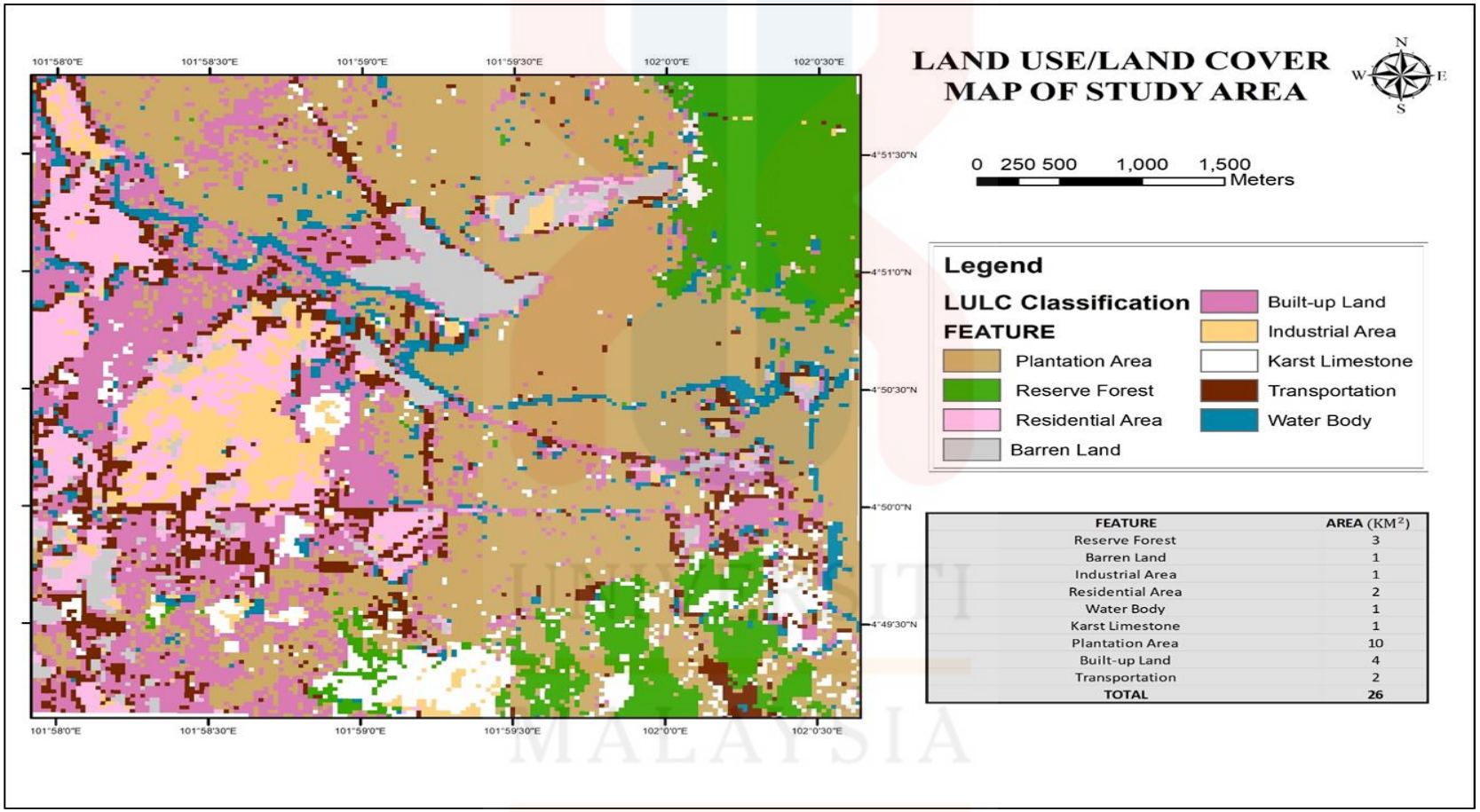
Road accessibility is also important in classifying land suitability analysis which need to be consider as it involved road connection to reach all over the places. All highly suitable areas are within 100 meters to 1 kilometre, whereas the less suitable is when the distance is more than 2.5 kilometres as shown in Table 5.3. So it can be concluding that the area near the road, like industrial, built-up and residential is suitable for urban development purposes as it eases the migration process within the area that may increase the population of the places.

3. Elevation & Slope Classification:

Figure 5.4 and Table 5.4 shows that most suitable area is from low lying and low slope degree unit and it is also far from the water body. The correct and suitable criteria chosen also can reduce risk from hazard and next can increase the commercial value of the land for investment purposes. The risk and hazard that may affected one's places is including flood, landslide and even earthquake. That is important reason to make an urbanisation process in stable land conditions.

Table 5.2 Land Cover Classification

LAND COVER TYPE	AREA (KM^2)	AREA (%)
Reserve Forest	3	12
Barren Land	1	4
Industrial Area	1	4
Residential Area	2	8
Water Body	1	4
Karst Limestone	1	4
Plantation Area	9	36
Built-Up Land	5	20
Transportation	2	8
TOTAL	**25**	**100**



FEATURE	AREA (KM^2)
Reserve Forest	3
Barren Land	1
Industrial Area	1
Residential Area	2
Water Body	1
Karst Limestone	1
Plantation Area	10
Built-up Land	4
Transportation	2
TOTAL	**26**

Figure 5.3 LULC map of study area

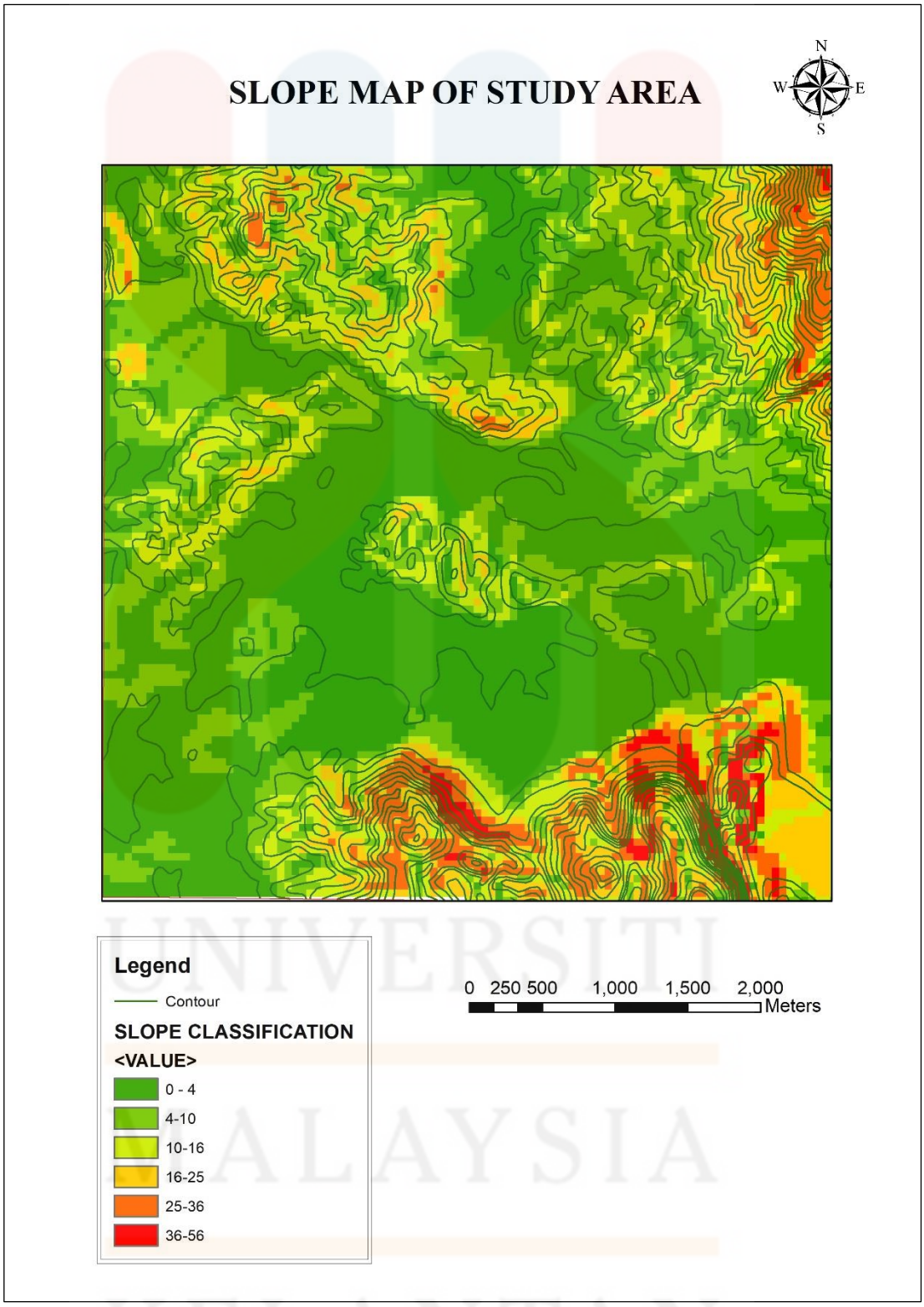


Figure 5.4 Slope Classification map of study area

Table 5.3 Road Accessibility

STREET BUFFER DISTANCE (KM)	SCORE RANKING
0.1-1.0	Very Suitable
1.0-1.5	Suitable
1.5-2.0	Moderate
2.0 - > 2.5	Less Suitable

Table 5.4 Elevation Classification

ELEVATION DISTANCE (m)	SCORE RANKING
0-100	Very Suitable
100-150	Suitable
150-250	Moderate
>250	Less Suitable

5.3.1 Result

The result of this study cover all the parameter enlisted in the Chapter 3. The result of land suitability analysis for an urban area are been classified or ranked into five zones or area, which is land with the most suitable area, land with suitable area, land with moderate suitable area, land with less suitable area and not suitable land or area for urban development. In addition, the classification are including the area in kilometres squares shown in the Figure 5.5, infer that about 40 % of the study area that rank from high suitability to moderate is suitable for urban development, meanwhile the another 60 % is less or not suitable because the land is consist of plantation area, forest, and limestone structures. These three area are not suitable because it may cause hazard to the environment, especially for forest and karst limestone area. Further descriptions about the rank of classification of the land suitability map are as follow

a. Land with high suitable areas:

The areas lie in flat and less degree of slope and vary in long distance within the water body. It is including the built-up area, part of plantation, industrial and residential area. In addition, this area consists much road accessibility that connects one place to another.

b. Land with suitable areas:

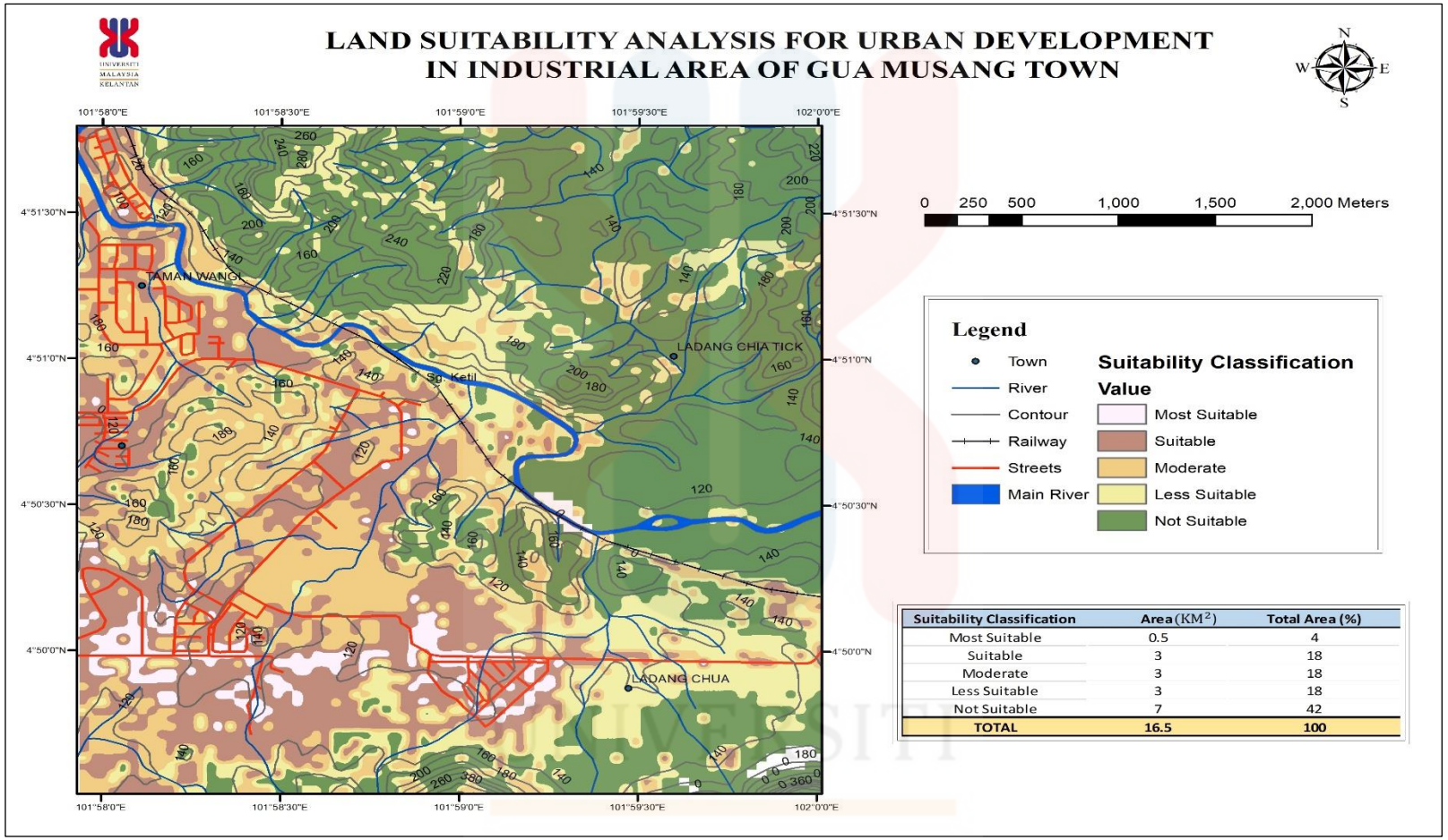
The areas that represent about 18% of the study area is lies in low elevation and slope area. The area covers all vacant land, residential and industrial development area.

c. Land with moderate suitable areas:

Share the same percentage value with suitable rank classification, the different between these two rank is the moderate suitable area is cover up all the barren land including in high relief area. Besides, some of the cover part in this area are in rural area with lack of road network accessibility.

d. Land with less and not suitable areas:

This rank of suitability classification represents about 60% over the total area of the study area. The area cover including the reserve forest, plantation area and limestone and is not suitable for urban development because there is too much step in other to plan the opening of the land for urbanisation development. It is also will involve high cost in planning it and some of area may create a hazard risk since the area within the hazard prone area especially in north and south part of the study area.



Suitability Classification	Area (KM^2)	Total Area (%)
Most Suitable	0.5	4
Suitable	3	18
Moderate	3	18
Less Suitable	3	18
Not Suitable	7	42
TOTAL	**16.5**	**100**

Figure 5.5 Land suitability classification for urban development

5.4 Comparison between the urbanisation growth trends with the land suitability analysis for urban development of the study area

These two objectives have been discussed before and it can be analyse and observe that the trend and growth of the area is match to the potential land suitability for urban development in the study area. Figure 5.1 refer that the west part of study area had faced big increasing changes of urbanisation especially in both residential and industrial area. Then, for the land suitability analysis, the area classified as suitable for urban development also lies on the same area as discussed in the comparison years of land cover before. The suitable area mostly in the western part of the study area since it meets all the selected requirement parameter for the analysis. Thus, it can have said that this area is still in the process of growing into the better urbanisation system mainly in geographical, economic and social aspects.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This research is conducted around the industrial area in Gua Musang Town to analysis the potential or suitable area for the urban development using GIS method. The method prove that GIS software is one of the best software in producing or planning the city since it can overlay all desire layers and produced into the desire results. Thus, it can be classified that there are about 6.5 km^2 of the area is suitable for urbanisation process and the not suitable area present because of the restricted area of the study area. It also shows the positive growing of demography including population and infrastructures within the study area. Next, for geological mapping, all type of rock has been observed and analysis and there four rock unit found in the study area. The area also geographically forms in various form of relief. As an end result, the updated geological is being produced.

6.2 Recommendation

The suggested opinion for future study and research is to including and relate the geological aspect in determining the suitable area. For example, data from type of soil and rocks, hydrology and stream analysis can be use in the land suitability analysis for a better result. It also may help in strengthen the result. In addition, the environmental parameters also can be added as a precaution step and for the waste management for the better city planning. Next, for future research, the other software can be used for this research are ENVI and ERDAS. These software is more user friendly and easy to learn and understand for analysing data purposes. In addition, in this research the result is restricted to the secure area, such as part of reserve forest and karst limestone, thus it is suggesting to next researcher to use better satellite image to produce overall projection result.

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