GEOLOGY AND GEOMORPHOLOGICAL CONSTRAINS OF RURAL DEVELOPMENT IN KUALA BETIS, KELANTAN.

by

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DECLARATION

I declare that this thesis entitled "Geology and Geomorphological Constrains of Rural Development in Kuala Betis, Kelantan" 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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APPROVAL

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

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Geology and Geomorphological Constrain of Rural Development in Kuala Betis, Kelantan.

ABSTRACT

Kuala Betis is located in Kelantan State under district of Gua Musang. As Gua Musang undergoes urbanization, Kuala Betis get affected to the urbanization processes as it its located near to the Gua Musang town. Kuala Betis connected to the Gua Musang and Lojing town by Jalan Gua Musang-Kuala Betis. There are two main rivers of Kelantan in this study area which are Sungai Betis and Sungai Berok, making it prone to flood and landslide. The purposes of this research study are to produce updated geological map of study area, to identify geomorphological constrain of study area and to suggest suitable area for development in the future. Various methods used to complete this research study including geological mapping and geomorphological mapping. Overall, Kuala Betis consist of sedimentary rocks and metasedimentary rocks which topography ranging from low hill to hilly area. Several areas in Kuala Betis have been identified which suitable for development as it is low to moderate geotechnical limitation.

Geologi dan Halangan Geomorfologi untuk Pembangunan Luar Bandar di Kuala Betis, Kelantan

ABSTRAK

Kuala Betis terletak di negeri Kelantan di bawah jajahan Gua Musang. Apabila Gua Musang mengalami pembandaran, Kuala Betis turut menerima kesan kepada proses pembandaran kerana ia terletak berhampiran Bandar Gua Musang. Kuala Betis dihubungkan dengan bandar Gua Musang dan Lojing oleh Jalan Gua Musang-Kuala Betis. Terdapat dua sungai utama bagi negeri Kelantan di Kawasan kajian iaitu Sungai Betis dan Sungai Berok, menjadikan Kuala Betis terdedah kepada bahaya banjir dan tanah runtuh. Tujuan kajian ini dijalankan adalah untuk menghasilkan peta kawasan geologi yang dikemas kini, untuk mengenal pasti halangan geomorfologi untuk pembangunan Kuala Betis dan bagi mencadangkan kawasan yang sesuai untuk pembangunan di Kuala Betis pada masa akan datang. Beberapa kaedah geologi digunakan untuk sepanjang menjalankan kajian ini termasuk pemetaan geologi dan pemetaan geomorfologi. Secara keseluruhannya, Kuala Betis terdiri daripada batuan sedimen dan batuan metasedimen yang mana topografi Kuala Betis berkisar dari Kawasan bukit rendah ke kawasan berbukit. Beberapa kawasan di Kuala Betis telah dikenalpasti yang sesuai untuk pembangunan kerana ia mempunyai halangan geoteknik yang sederhana.

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CHAPTER 1

INTRODUCTION

1.1 General Background

Kuala Betis is located at the southern of Kelantan state. Kuala Betis is a settlement of *Orang Asli Temiar* in Kelantan. As Kuala Betis is located in between Gua Musang and Lojing, the *Orang Asli* settlement is now undergo development processes which transform it from traditional settlement area into developing rural area. Many basic living facilities have been developed in Kuala Betis due to its growth impact such as living facilities, educational and economic.

The geology of Kuala Betis is consist of the Permo-Triassic metasedimentary rock sequence that later renamed as Gua Musang Formation by Kamal Roslan Mohamed et al. (1993). Gua Musang Formation overlies unconfirmibily over olistrom unit of Bentong-Raub Suture Zone. Gua Musang consist several facies including argillite, carbonate and pyroclastic facies. General lithology of Gua Musang Formation is consisting of sedimentary rocks such as limestone, shale, volcanic rocks and siltstone.

In Malaysia, rural development is the changes that occurs in rural area that involves change in living, education and economy of an area. Compared to urban area like Kuala Lumpur, rural environment such as Kuala Betis often show lack in achievement. This widening gap in term of education, income, skills and development is worrisome issues in our country. To resolve this problem, many actions have been taken by the government in order to achieve the same context in rural development. In Malaysia, Rural Transformation Development was first introduced in 1957 by Tun Abdul Razak to develop rural residency in term of physical infrastructure and providing extensive basic facilities. It provides a solid track for rural areas to become active and advanced.

This research is conducted to analyse the suitable area for future development in Kuala Betis. Findings from this research bring beneficial directly toward the community, researchers and government in developing Kuala Betis. Early planning in rural development can lower the risk that will jeopardized the sprawl rate in Kuala Betis.

1.2 Study Area

The area of the study for this research will be focused on the rural settlement area in Kuala Betis within box of 5×5 km^2. Kuala Betis is located in sub-district of Ulu Nenggiri under district of Bertam. Ulu Nenggiri is mainly consists of forestry, plantation and residential area.

Figure 1.1 below shows the map of Gua Musang and its district, including Kuala Betis which is under Ulu Nenggiri district. Gua Musang consist of four subdistricts which are Paloh, Galas, Lojing and Nenggiri.

Figure 2.1: Map of Gua Musang and its sub-districts.

1.2.1. Location

Kuala Betis is located in the southwest Kelantan, about 30 km from Gua Musang Town via Jalan Gua Musang- Kuala Betis. The study area cover box of 25 km^2. The coordinates of study area are, N 04° 54’ 53” E 101° 46’ 3”, N 04° 54’ 53” E 101° 48’ 48”, N 04° 52’ 12” E 101° 48’ 48” and N 04° 52’ 12” E 101° 46’ 3”. Figure 1.2 shows the topographical map of study area in Kuala Betis.

Generally, the topographical unit of Kuala Betis within the study area range from rolling, undulating to hilly with highest elevation about 220 m. There are two main rivers of Kelantan in this study area which are Sungai Berok and Sungai Betis. Settlement area in this study area are concentrated in the center of the box as most of the basic living facilities in Kuala Betis such as school, this area is suitable for rural development research as it is in the centre of settlement of orang asli in Kuala Betis that have high potential for urban sprawl.

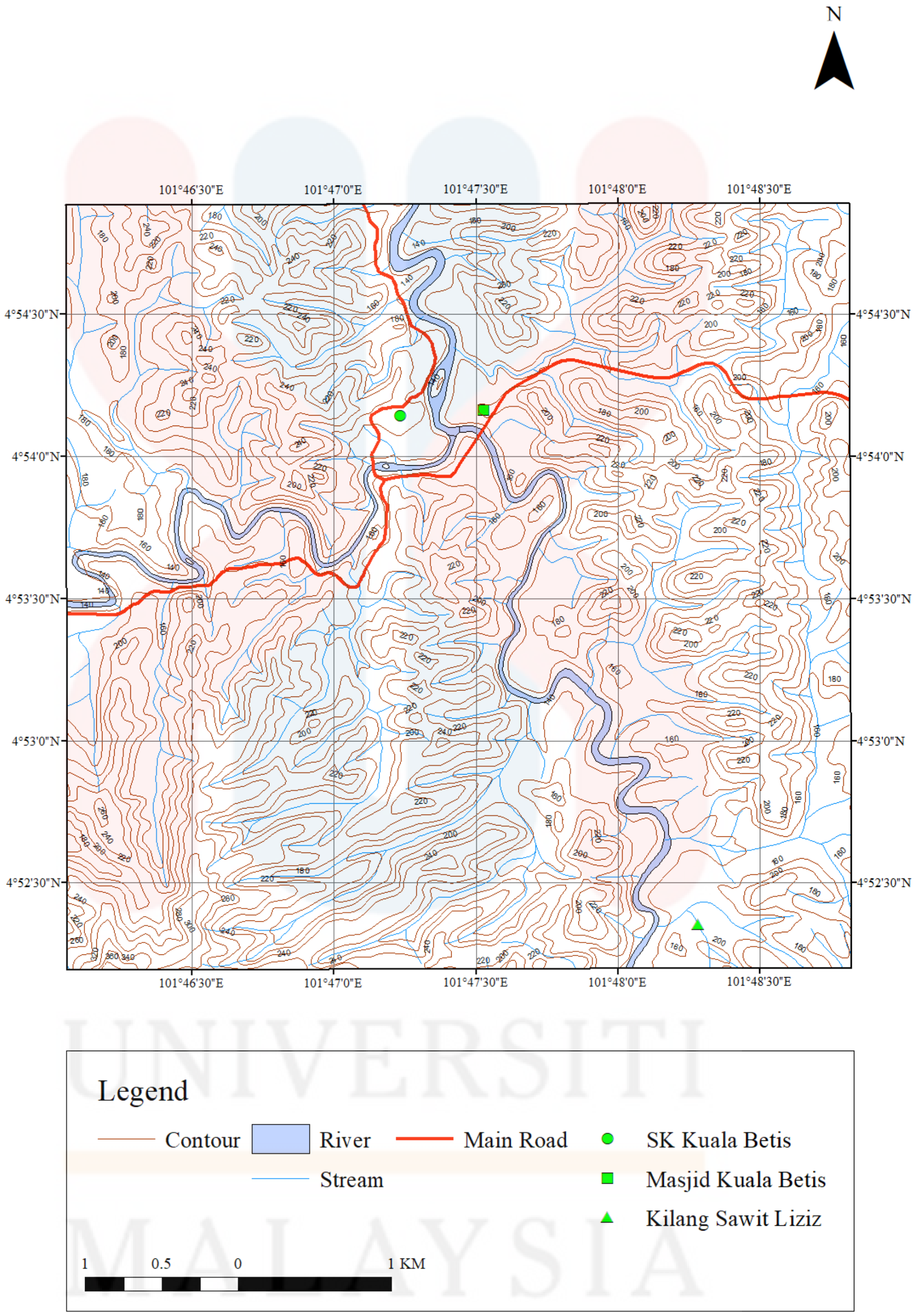


Figure 1.3: Topographical map of Kuala Betis

1.2.2. Road Connection & Accessibility

Kuala Betis is located as hub center that connected between two main town in Kelantan which area, Gua Musang and Lojing. Kuala Betis can be access in two way from Gua Musang and Lojing. It can be access from Gua Musang via Jalan Gua Musang – Kg Kuala Betis and Lebuhraya Kuala Lumpur – Gua Musang or known as Federal route 8, a highway that connected Bentong, Pahang and Kota Bharu, Kelantan (Figure 1.3). From Lojing, Kuala Betis can be access through Jalan Gua Musang Cameron Highland or known as Second East–West Highway/ Federal Route 185. It is a highway in Peninsular Malaysia which connects Simpang Pulai in Perak to Kuala Jeneris in Terengganu. It overlaps with Federal Route 8 Federal Route 8 between Gua Musang and Sungai Relau (Figure 1.4).

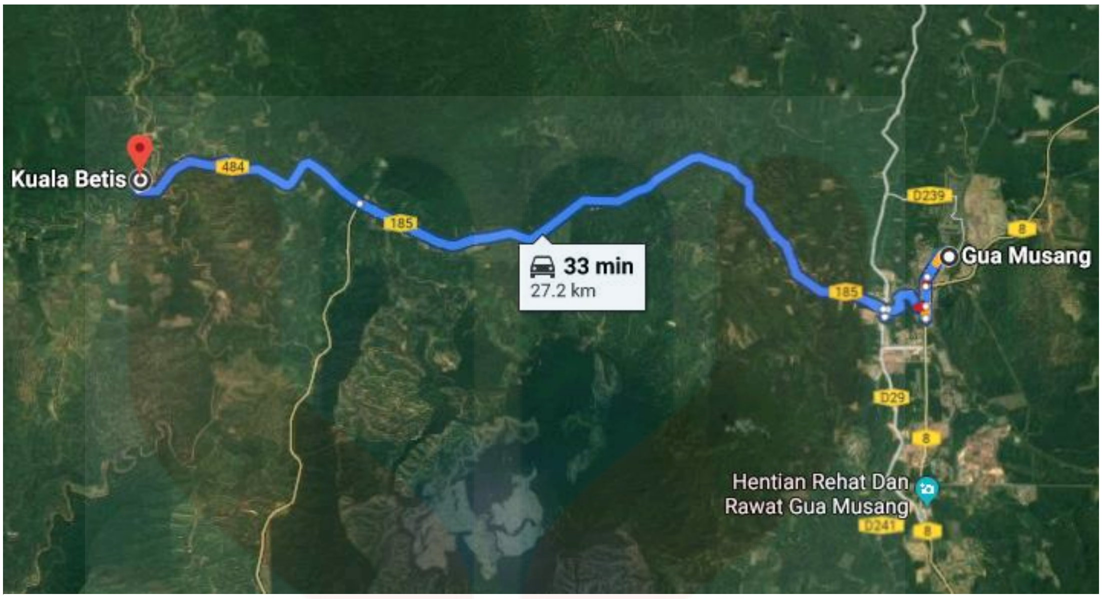


Figure 1.3: Kuala Betis from Gua Musang

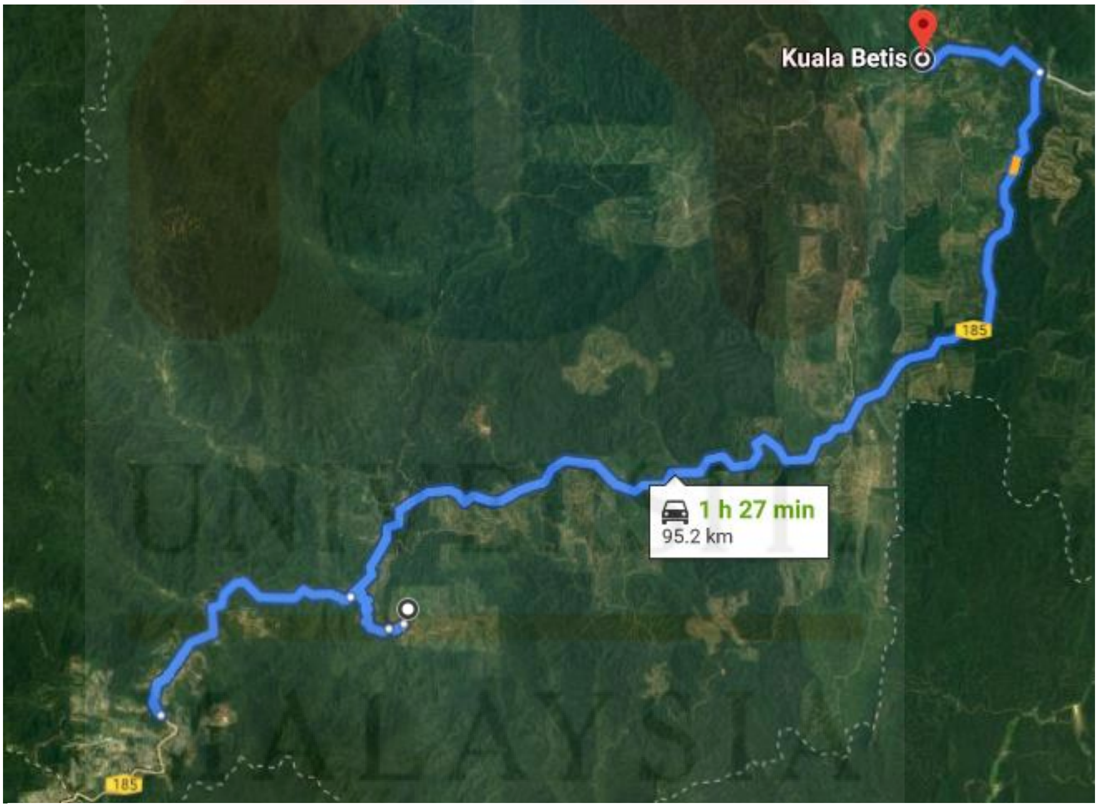


Figure 1.4: Kuala Betis from Lojing

1.2.3. Demography

Demography of Kuala Betis consists mostly of indigenous population. Based on the statistic by Local Authority Area and State, Malaysia, 2010, Ulu Nenggiri population which include Kuala Betis is 20 256 people. 19 832 of total population in Ulu Nenggiri is citizenship while only 424 is non-citizen. Among 19 832 of citizen, 11 969 of it is indigenous population which is *Orang Asli Temiar*, 7 814 is Malay, 16 of it is Chinese and only 7 Indian.

Table 1.1 and Chart 1.1 shows the demographic of Ulu Nenggiri according to their citizenship which consist of Malay, Chinese, Indian, non-citizenship and others while Table 1.2 show total population in Ulu Nenggiri by sex, household and living quarters.

Table 1.1: Table of Ulu Nenggiri demography according their citizenship.

District /	Citizenship				Non-citizen	Total
	Malay	Chinese	Indian	Others		
Ulu Nenggiri	7 814	16	7	11 969	424	20 256

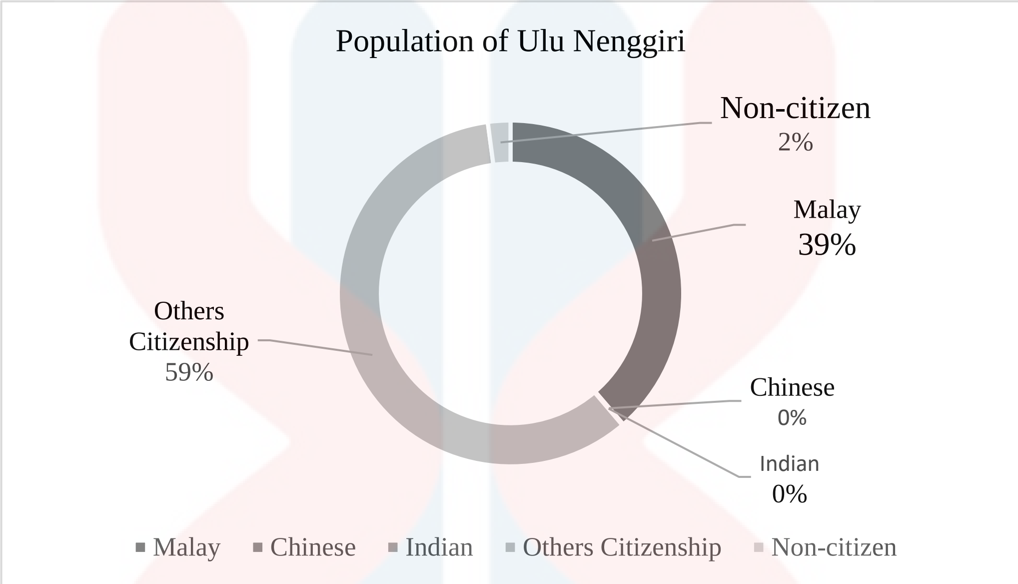
(Source: Local Authority Area and State, Malaysia, 2010.)

Table 1.2: Table of population in Ulu Nenggiri by sex, households and living quarters.

District / Sub-district	Population		Households	Living quarters
	Male	Female		
Ulu Nenggiri	10 464	9 792	3 702	4 313

(Source: Local Authority Area and State, Malaysia, 2010.)

Chart 1.1: Population of Ulu Nenggiri.

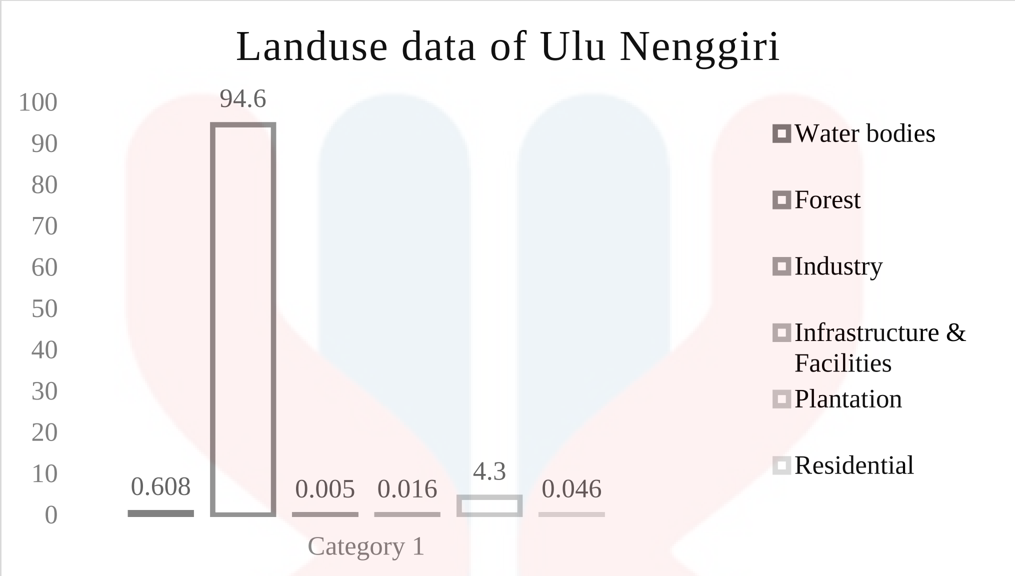


(Source: Local Authority Area and State, Malaysia, 2010.)

1.2.4. Land use

Kuala Betis land use is consist of forestry, plantation, residential and infrastructure & facilities. Kuala Betis is sub-district Ulu Nenggiri. In Chart 1.2 below, data shown that Ulu Nenggiri land use is mainly consist of forestry which make up 94% of the area which equal to 345 134 hectares. Plantation area compromised 4.5% of it of Ulu Nenggiri, approximately 16 555 hectares of total area of Ulu Nenggiri. Residential housing area in Ulu Nenggiri is only 0.04%, approximately 169 hectares.

Chart 1.2: Land use data of Ulu Nenggiri, Gua Musang, Kelantan.



(Source: Local Authority Area and State, Malaysia, 2010.)

Table 1.3: Table of land use in Ulu Nenggiri.

Land use	Area (Hectare)	Percentage (%)
Water bodies	2 217	0.608
Forest	345 134	94.60
Industry	19	0.005
Infrastructure & Policies	58	0.016
Plantation	16 555	4.300
Residential	169	0.046

(Source: Local Authority Area and State, Malaysia, 2010.)

1.2.5. Socioeconomic

Socioeconomic of Kuala Betis is fully depends on traditional activities and plantation as the land use of Kuala Betis is mainly dominated by forest and plantation area. In addition, the population of Kuala Betis is consist of indigenous racial which restrict the socioeconomic of Kuala Betis.

1.2.6. Rainfall Distribution

Malaysia is a country with tropical climate. In general, the Peninsula experiences a warm and humid tropical climate all year round, with uniform temperatures. Rainfall in Malaysia is characterized by two rainy seasons associated with the southwest monsoon from May to September and the northeast monsoon from November to March. (Suhaila, 2016, 2009). Data in Table 1.4 and chart 1.3 below shows the average rainfall distribution in Gua Musang in 2017.

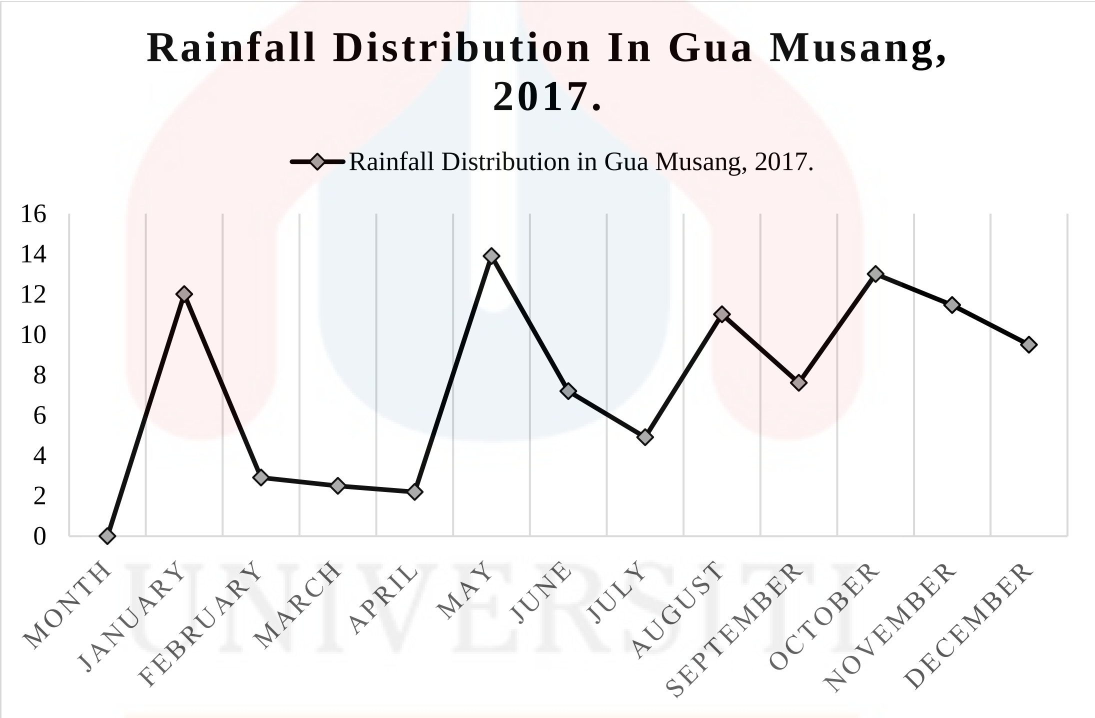
Table 1.4: The average rainfall distribution in Gua Musang.

Month	Rainfall distribution average (mm)
January	12.0
February	2.9
March	2.5
April	2.2
May	13.9
June	7.2
July	4.9

August	11.0
September	7.6
October	13.0
November	11.5
December	9.5

(Source: Department of Irrigation and Drainage, Kelantan, 2017.)

Chart 1.3: Rainfall distribution in Gua Musang, 2017.



(Source: Department of Irrigation and Drainage, Kelantan, 2017.)

1.3 Problem Statement

This study will be focused on the geological of Kuala Betis and geomorphological constrains of rural settlement area of Kuala Betis. Kuala Betis have high potential in rural development. However, Kuala Betis has been faced several geological hazards such as flood and landslide due to its geomorphological feature. Low slope area in rolling topography make it prone to flood hazard while high slope in hilly topography triggered it with landslide hazard. In order to developing an area, a geomorphological constrain analysis should be done first to avoid any problem in the future.

Besides, the population of Kuala Betis that increasing from times to times triggered Kuala Betis to grow into developed rural area. Thus, more area will be explored and discover for new building. The finding from this research will bring benefits towards the government and developers in finding new area to be developed in Kuala Betis. In addition, data provided through this research will be a help for future researcher in conducting more detailed research in Kuala Betis.

Thus, geomorphological constrains analysis is important to be conducted in Kuala Betis to find the suitable area of rural development.

1.4 Research Objectives

a) To update the geological map of study area in 1:25 000.

b) To identify the geomorphological constrain toward rural development of Kuala Betis.

c) To suggest the suitable area for rural development of Kuala Betis.

1.5 Scope of Study

This study focused in the geological mapping and geomorphological constrains of Kuala Betis. Geological mapping is done to gathered geological data that later be compiled as geological map of study area. Geological mapping includes the observation and data sampling collection.

Geomorphological constrain analysis conducted towards rural development in Kuala Betis to identify the potential rural development zone in Kuala Betis. Specifically, geomorphological constrain will be analysed based on several parameter, geology of Kuala Betis, soil characteristic, physical morphology and geological of study area. Geographic Information System (GIS) software will be use in collecting and analysing data.

After analysing the geomorphological constrain of Kuala Betis, this study proceeds with analysis of land suitability for rural development to identify and suggest the suitable area for rural development in Kuala Betis.

1.6 Significant of Study

At the end of this study, this research provided the analysis of suitable area for rural development in Kuala Betis area. The finding directly brings benefits to the community, government and private sector such in developing Kuala Betis as urban in the future. Any risk that will jeopardized the development sprawl in Kuala Betis can be avoided in the early planning. The drainage characteristic and slope classification map also help in identifying the location of geohazard in Kuala Betis such as landslide and flood that can be used to create awareness among the community about geological hazard.

In addition, data gathered from this research are compiled as series of maps and spatial data that can be used in the researchers in the future for detailed study in Kuala Betis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is focused on the preliminary study that is conducted before proceeding to data collection and data analysis. The aim of this chapter is to get better understanding of general geology in Kuala Betis through previous studies by researchers such as journals, articles and thesis. The specification of this research, geomorphological constrains towards rural development in Kuala Betis also being studied in this chapter to get better understanding of the topic.

2.2 Regional Geology & Tectonic Setting

According to Metcalfe (2013a, b), the Peninsular of Malaysia is part of continent of Southeast Asia that consist of Sibumasu plate in the east and Sukhothai that located in the west of the continent. This continent was assembled in the Late Triassic. The basal part of Malay-Thai continent was intruded several times with Mesozoic granitoids from Southeast Asia Tin Belt that formed during the subduction processes.

In Kelantan, the regional geology is consisting of sedimentary and meta-sedimentary rock in the centre zone and is bordered on the west and east by Main Range and Boundary Range. In the central zone of sedimentary and metasedimentary rock, the are bodies of granitic intrusion which are Seting Batholith, Stong Igneous Complex and Kemahang Pluton (MacDonald, 1967).

The state of Kelantan is located in the north-eastern corner of Peninsular Malaysia. Kelantan River is the major river in the region. It appears at the convergence of the Galas River and Lebir River near Kuala Kari and meanders over the coastal plain until it finally degrades into the South China Sea. Kelantan River basin covers 923 km2, which is about 85% of the Kelantan state's surface area. It is composed of the flat slope to moderately sloping areas in the northern part and steep scraps and high slopes in the southern part of the river basin (Pradhan et al., 2009). The geological map of Kelantan can be observed as in Figure 2.1 below.

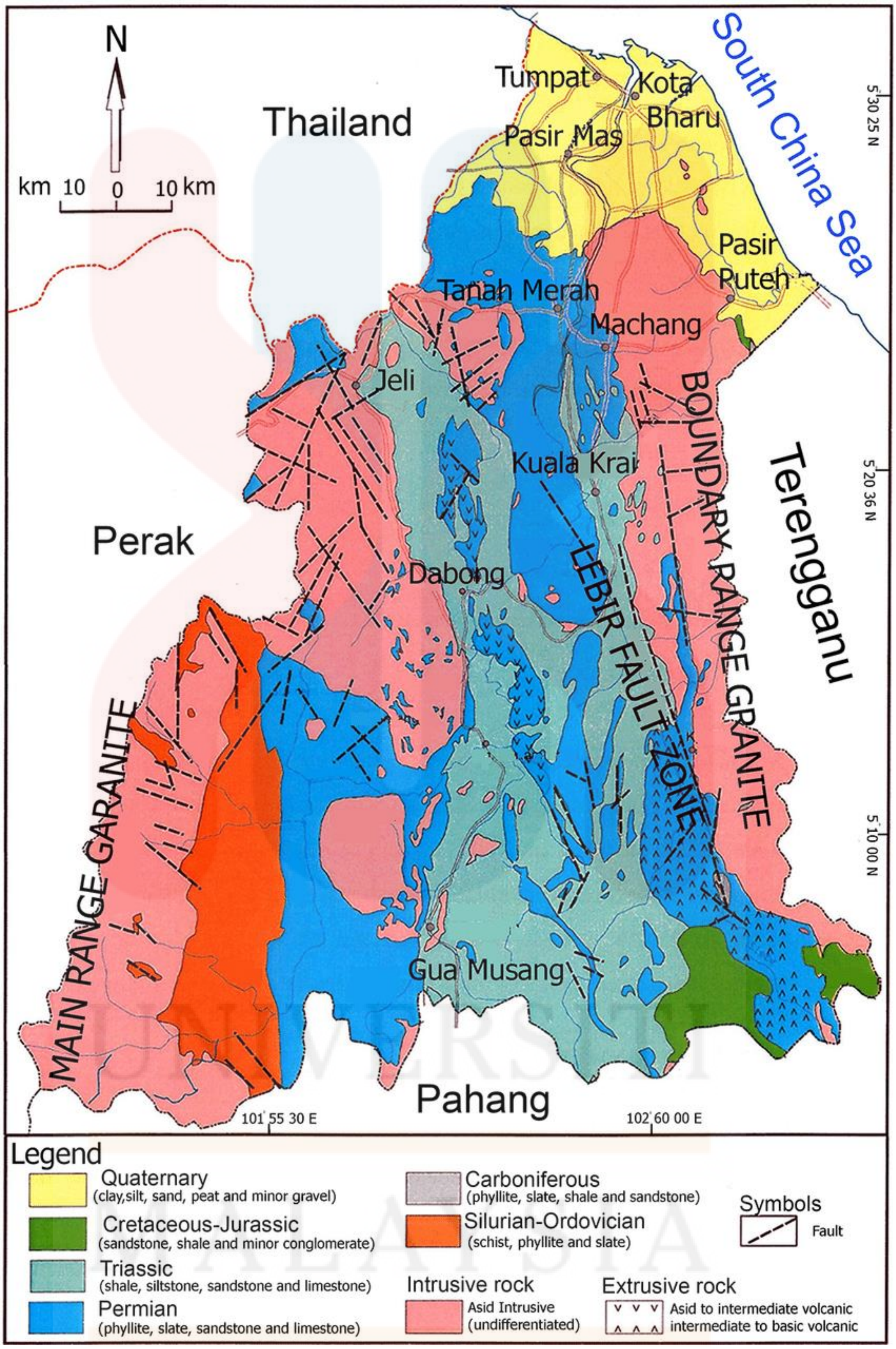


Figure 2.1: Geological Map of Kelantan.

2.3 Stratigraphy

The Peninsular of Malaysia can be divided into three belt that can be characterised by their difference in stratigraphy.

Kuala Betis is belong to Gua Musang Formation under Gua Musang Group. Gua Musang Formation located in the southern part of Kelantan until the northern of Pahang. Yin (1965), describe that Gua Musang Formation is consists of argillite, carbonate and pyroclastic or volcanic facies that formed during Middle Permian to Late Triassic. Later, all Permo-Triassic carbonate argillite volcanic facies in the north part of Central Belt is called as Gua Musang Group due to widespread distribution of argillite-carbonate-volcanic across northern Central Belt of Peninsular Malaysia. For example, similar lithologies to the Gua Musang Formation in Aring is called as Aring Formation and Sungai Telong is named as Telong Formation (Aw, 1990). Later, Muhammad (1995) gathered the same lithology formations as same group as long as these sediments were deposited in shallow marine environment of Gua Musang Platform in Permian-Triassic period.

Figure 2.2 shows the distribution of Gua Musang Group which are consist of Aring Formation, Telong Formation, Nilam Formation and Gua Musang Formation.

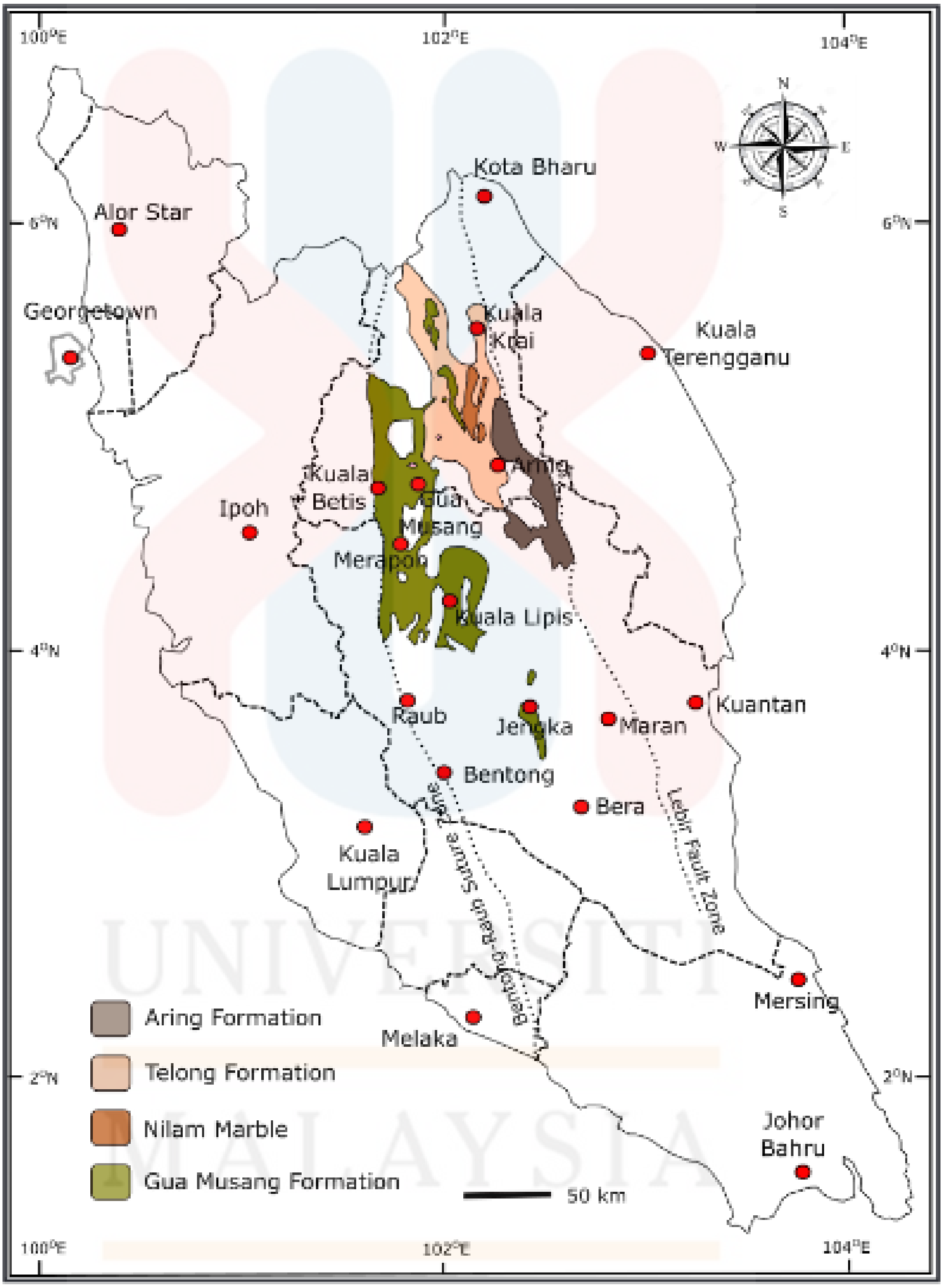


Figure 2.2: Map of distribution of Gua Musang Group.

Source: Mohamed (1995)

2.4 Structural Geology

According Tjia (1985), the structural geology in Peninsular Malaysia is divided into four main belt, Eastern Belt, Central Belt, West Belt and Northwest Belt. Eastern and Central Belt is boarded by Lebir Fault while Central Belt and Western Belt is boarded Bentong-Raub Suture.

According to Tjia and Zaiton (1985), Lebir Fault is the lineament that divided the Central Belt and Eastern Belt of Peninsular Malaysia. The fault zone ranges along the Lebir Valley for about 200 km. Bentong-Raub Suture is the segment that formed during Devonian to Middle Triassic. It is formed as the boundary between Sibumasu Plate and Indochina Plate that collide each other. Bedded chert from the Paleo-Tethyan oceanic ribbon are preserved in the suture zone area that aged in range of Middle Devonian until Middle Permian. A melange of limestone and chert aged from Lower Carboniferous to Lower Permian also included in this suture zone. The suture zone in formed as the Paleo-Tethys ocean under Indochina is subducted in the collision with Sibumasu Plate in the Late Palaeozoic and the Triassic. The suture zone is later covered by sediments from Triassic, Jurassic and Cretaceous, that formed red bed sequence.

According to Shuib (2009), major faults in Peninsular Malaysia strike N–S, NNW–SSE, NW–SE, WNW–ESE, E–W, ENE–WSW and NE–SW and have undergone complex repeated movements, including microstructure evidence for both sinistral and dextral movements along many strike-slip faults.

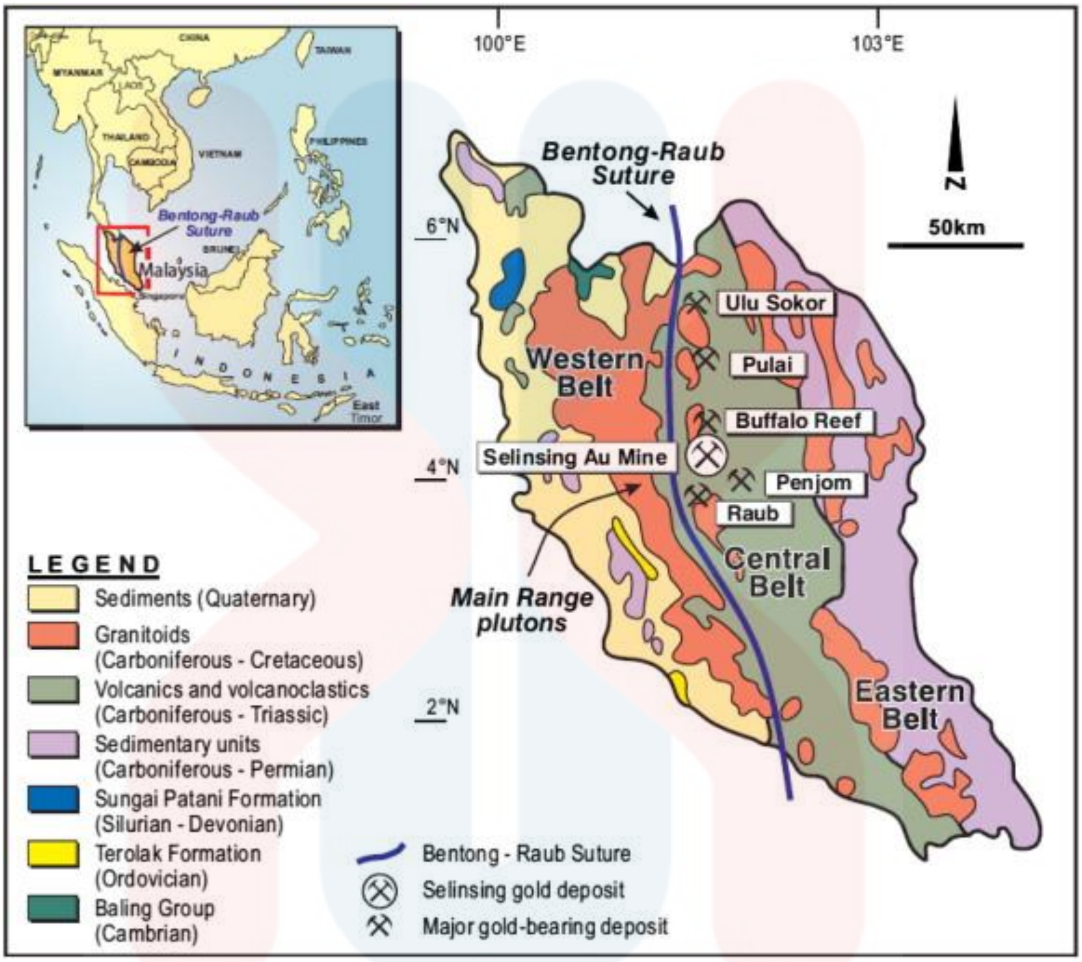


Figure 2.3: The structural geology of Peninsular Malaysia.

2.5 Historical Geology

The geology of south Kelantan can be divided into four formation, which are Gua Musang, Kuala Betis, Aring and Gunung Gagau. In Gua Musang, the general lithology of the area is argillite unit that change into phyllite during metamorphism process, limestone that change into marble, sandstone and conglomerate. The argillite and sandstone are origin from volcanic and tuffaceous. Limestone that was mainly exposed and formed karst topographic is known as Gua Musang Formation. At the eastern part of Gua Musang Formation, the rock exposed aged in Triassic is known as Gunung Rabong Formation. The lithology of Gua Musang Formation based on their period are as table below (Yin, 1965). The Gua Musang Formation is aged from Early Permian to Late Triassic and located at the top of bedrock in central belt of Peninsular Malaysia. The upper boundary of Gua Musang Formation us comformable with Semantan Formation.

Table 2.1: The lithology of Gua Musang Formation based on Period.

Period		Lithology
Triassic	Middle	Limestone with shale and volcanic rocks.
	Early	Argillite limestone, shale and volcanic rocks.
Permian	Late	Shale and siltstone.
	Middle	Limestone with shale.

According to Yin (1965), Gunung Rabong Formation is consist of shale, mudstone, siltstone, sandstone and conglomerate. Gunung Rabong Formation sequence is from flysch type which are onshore turbidite sediment and containing volcanic materials.

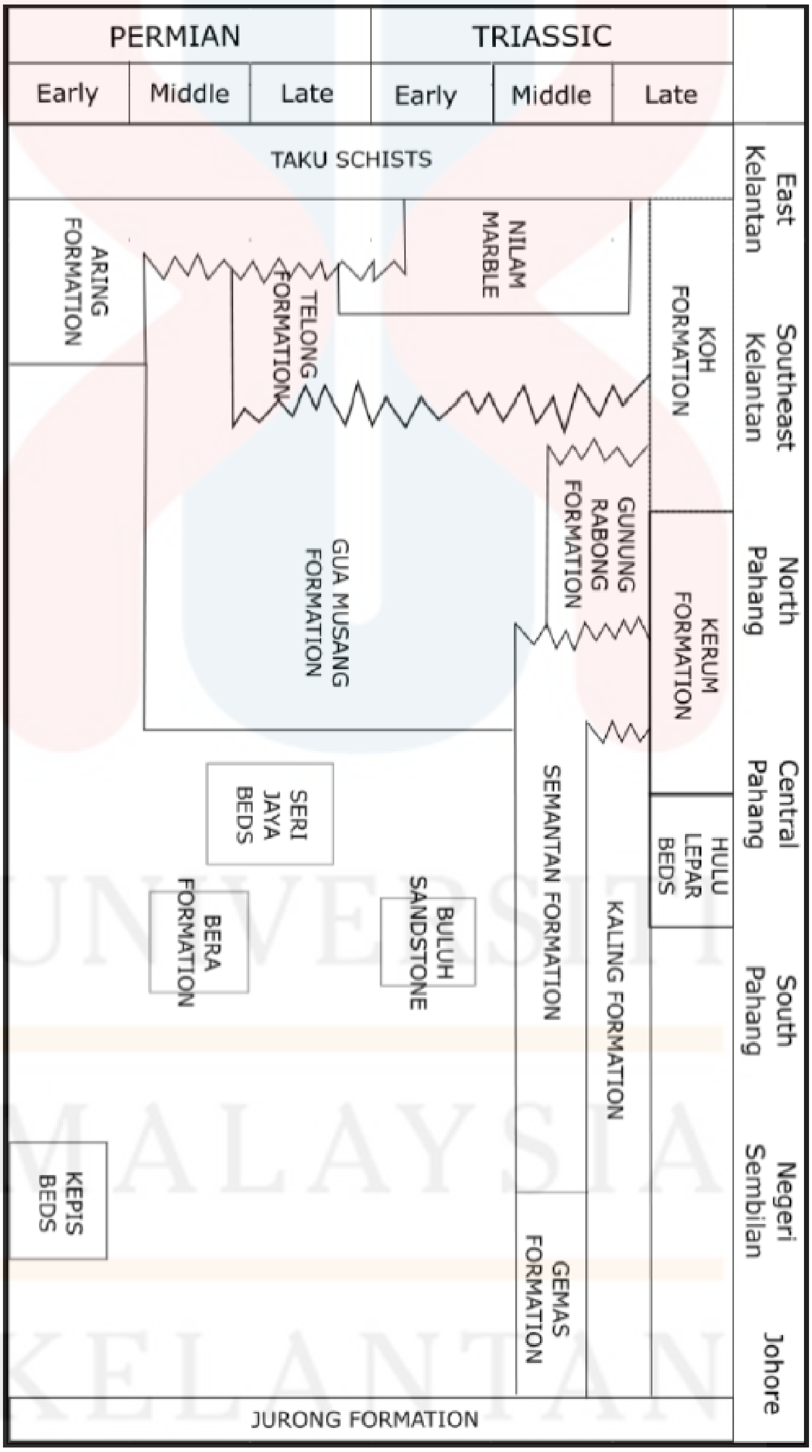


Figure 2.4: Chronostratigraphy of Gua Musang Formation.

2.6 Geomorphological Constrain Analysis

Geomorphology words is derived from Greek words which are gew (the Earth), morfh (form), and logo (discourse). Geomorphology is generally a study of the Earth formation. According to Magerie (1886), geomorphology is the study of the morphology of the Earth surface. Today, the word geomorphology describes the Earth land surface features and its landform while, the geomorphological constrains refer to the limitation and conflict faced in developing an area by landform of morphological issue. This restriction will later the limitation and restriction will later affect the urban sprawl rate and town development. If there are many complicated landforms, then it will be less potential to have a well developing area. Geomorphological analysis can be conducted using ArcGIS software, a geological informatic system (GIS) software that designed to capture, store, manipulate, analyse, manage and present spatial data or geographic knowledge. In general, GIS allowed users to make interactive queries that enable user to analyse spatial data, edit information and share the result of the operation.

2.7 Rural Planning & Development

Generally, the application of geology in rural planning and development is the application of the study of earth sciences toward the problems that arrive within rural and developing area related to the Earth sphere such as lithosphere, hydrosphere, biosphere and atmosphere. Rural planning and development include various field of geology, ranging from stratigraphy to geochemistry and hydrogeology to geophysical exploration techniques and environmental aspect.

Rural development has traditionally centred on the exploitation of land-intensive natural resources such as agriculture and forestry. However, changes in global production networks and increased urbanization have changed the character of rural areas. Increasingly tourism, niche manufacturers, and recreation have replaced resource extraction and agriculture as dominant economic drivers. The need for rural communities to approach development from a wider perspective has created more focus on a broad range of development goals rather than merely creating incentive for agricultural or resource-based businesses. Education, entrepreneurship, physical infrastructure, and social infrastructure all play an important role in developing rural regions. Rural development aims at finding ways to improve rural lives with participation of rural people themselves, so as to meet the required needs of rural communities. In developing countries like Nepal, Pakistan, India, Bangladesh, China, integrated development approaches are being followed up. Many approaches and ideas have been developed and implemented, for instance, bottom-up approach, PRA- Participatory Rural Appraisal, RRA- Rapid Rural Appraisal, etc. The New Rural Reconstruction Movement in China has been actively promoting rural development through their ecological farming projects.

CHAPTER 3

MATERIALS & METHODS

3.1. Introduction

In this chapter, all the materials and methodology used in this research will be discussed for the general geology part and the specification, geomorphological constrain of rural development in study area, Kuala Betis. This study aimed to conduct the geomorphological constrains analysis of Kuala Betis. This chapter will explain five methodology that used in archiving the objectives of this research.

3.2 Materials

For geological mapping part, the essential tools need in order to complete the fieldwork are hammer, global positioning system (GPS), geological compass, hydrochloric acid, hand lens, geological map, tapes and stationery such as clipboard and pen. Later, software such ArcGIS and Google Earth will be used in collecting, analysing and create and updated geological map.

For geomorphological constrains part, ArcGIS software will be used in collecting, analysing and interpretation stage. Several parameters will be layered to produce several maps to analyse the geomorphological constrains analysis of rural development in Kuala Betis. The restriction and limitation of Kuala Betis toward rural development will be analysed using several factors that will be integrated in this research such as soil characteristics, geological hazards, geology, physical morphology, river conditions and others.

3.3 Methodology

In completing this research, firstly the preliminary study needed to be done before proceeding to mapping of study area tin order to gathered data collection. Information is gathered from previous research including the general geology of study area, stratigraphy, structural geology and geomorphology. Preliminary study importance in identifying the problem statement and suitable methodology for the research.

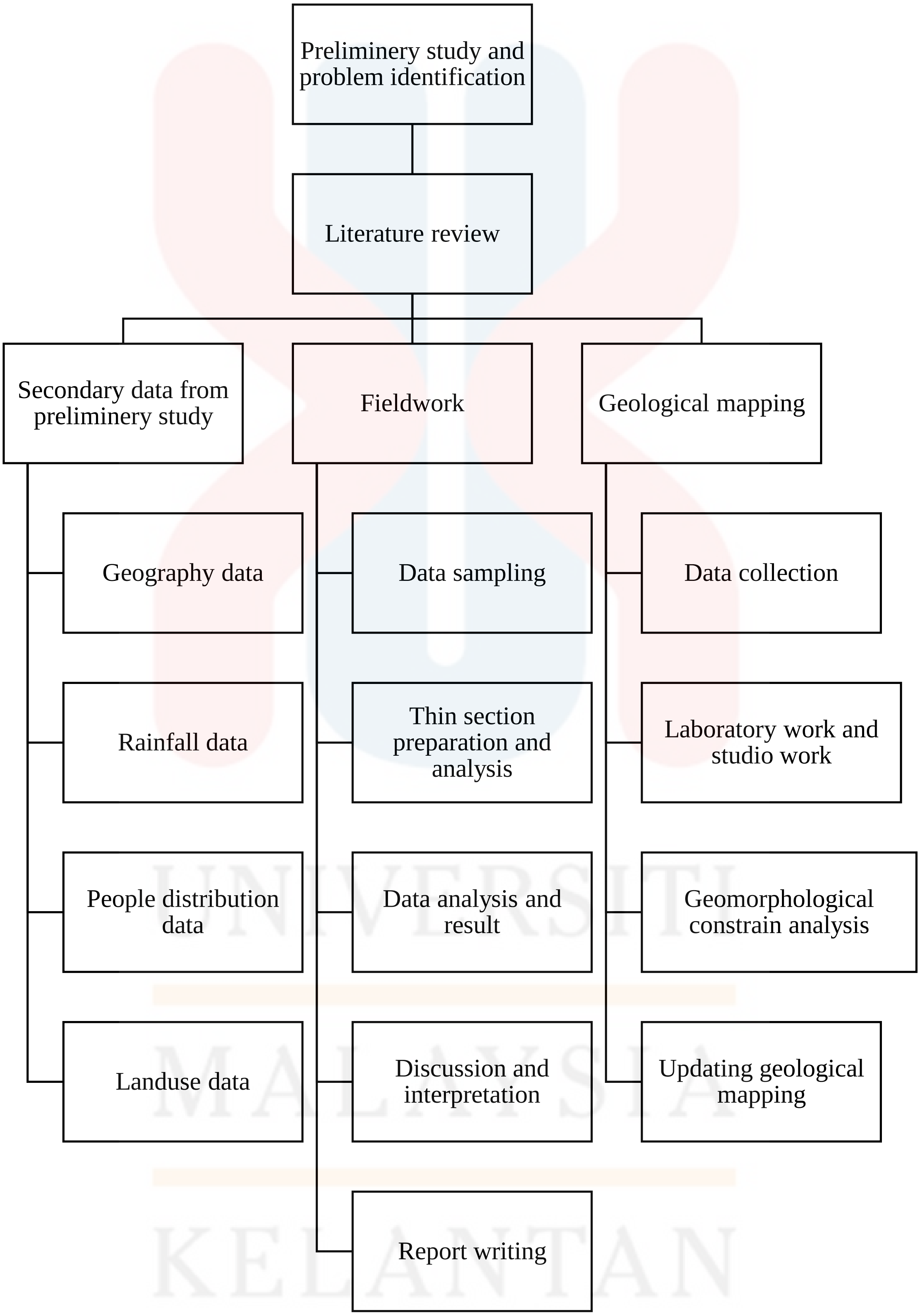
Next, the data collection stage continues with geological mapping which will determine the geological features of the area. Geological mapping is including field observation and taking fresh sample from the study area for the sampling and thin section analysis. The geological mapping aspect of the current project will be mainly based on fieldwork inputs including collection of samples from fresh outcrops, recording structural trends in rocks, and other field observations such as geomorphological features, drainage pattern Data gathered from this fieldwork will be gathered and analysis to produced geological map of study area and other map series.

For the geomorphological analysis part, spatial data from satellite imageries procured from National Remote Sensing Agency, demographic details from the

Census of Kelantan and the village maps from the Directorate Department of Survey and Mapping Malaysia and Department of Mineral and Geoscience Malaysia.

The data gathered from preliminary study, geological mapping and secondary data is then analysed using Geographic Information System (GIS) software to produces series of map that will be use in analysing the geomorphological constrain analysis toward rural development in Kuala Betis.

Chart 3.1: Flowchart of the research study.



3.4 Preliminary Study

The aim of the preliminary studies of this research is to gather the geological data of Kuala Betis. The topography and geomorphology of Kuala Betis is interpreted using data provided from previous research and Google Earth. The changes and modification in land morphology over years can be observed using Google Earth and can be correlated with existing data from previous study. The study is proceed with including information that gathered from the previous research in Kuala Betis area to get an overview of the geology of Kuala Betis before going to site. Data that obtained from preliminary study also importance in planning research.

3.5 Geological Mapping

Geological mapping in including analytical data collection in study area by observation and sampling. The primary data that obtained from geological observation is then recorded into field book. Some of the primary data is road, village name and people distribution in an area.

Sampling part including sample that taken during conducting geological map. Data sampling will be taken from the outcrop and will be described according to its characteristics. Data sampling also include the measurement such as strike and dip measurement and slope angle.

The geomorphological mapping will consist of observation in the study area for structural trends in rocks, geomorphological features, drainage pattern, lineament and slope.

3.6 Laboratory Work

For this research, laboratory work involves the thin section preparation and analysis. Thin section analysis is laboratory work that include the preparation of rock sample to be analysed using microscope. Thin sections are prepared to investigate the optical properties of the minerals in the rock. This work is a part of petrology and helps to reveal the origin and evolution of the parent rock.

A thin sliver of rock is cut from the sample with a diamond saw and ground optically flat. It is then mounted on a glass slide and then ground smooth using progressively finer abrasive grit until the sample is only 30 μm thick.

3.7 Data Processing

In processing data, studio work will get involved. Studio work is main consist of the process of producing map. Map that will be produced in this research are geological map, geomorphological constrain map, topography map, landslide susceptibility map, land use map, building distribution, lithology map, terrain slope map, buffer zone map and flood prone area map. The table below shows the function of each map.

3.8 Data Analysis & Interpretation

The constructed map that produced from data obtained through geological mapping and secondary data is the analysed and interpreted to determine the constrains and the chances of Kuala Betis in development. For interpretation process, it is entirely involves Geographic Information System (GIS) software.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discussed on the geology of this study area and other features in this study area including accessibility, settlement, land use, settlement area, traverse and observation point.

In this chapter, accessibility of this study area is presented by the map of road connection of Kuala Betis. Settlement is represented by map of settlement of Kuala Betis. Land use is described using map of land use of Kuala Betis. The traverse and observation point also presented in map of traverse.

Geomorphological aspect in this study area also discussed in this chapter through topographic classification, weathering and drainage pattern. For lithology, stratigraphic and unit description is discussed further in this chapter. Structural geology of the study area also discussed in this chapter.

4.1.1. Accessibility

Generally, this study area is accessible by car and motorcycle. Kuala Betis connected with Gua Musang via Jalan Gua Musang – Kg Kuala Betis (Figure 4.1) and Lebuhraya Kuala Lumpur – Gua Musang a highway that connected Bentong, Pahang and Kota Bharu, Kelantan. From Lojing, Kuala Betis can be access through Jalan Gua Musang Cameron Highland or known as Second East–West Highway as shown in Figure 4.4.

Unpaved road can be found in the study area which connected settlement area with plantation and forestry. However, unpaved area in plantation area is restricted by seasonal condition of weather.

Figure 4.1: Jalan Gua Musang-Kuala Betis that connected Kuala Betis with Gua Musang and Lojing.

Figure 4.2: Sungai Betis Bridge.

Figure 4.3 Unpaved road in Kuala Betis.

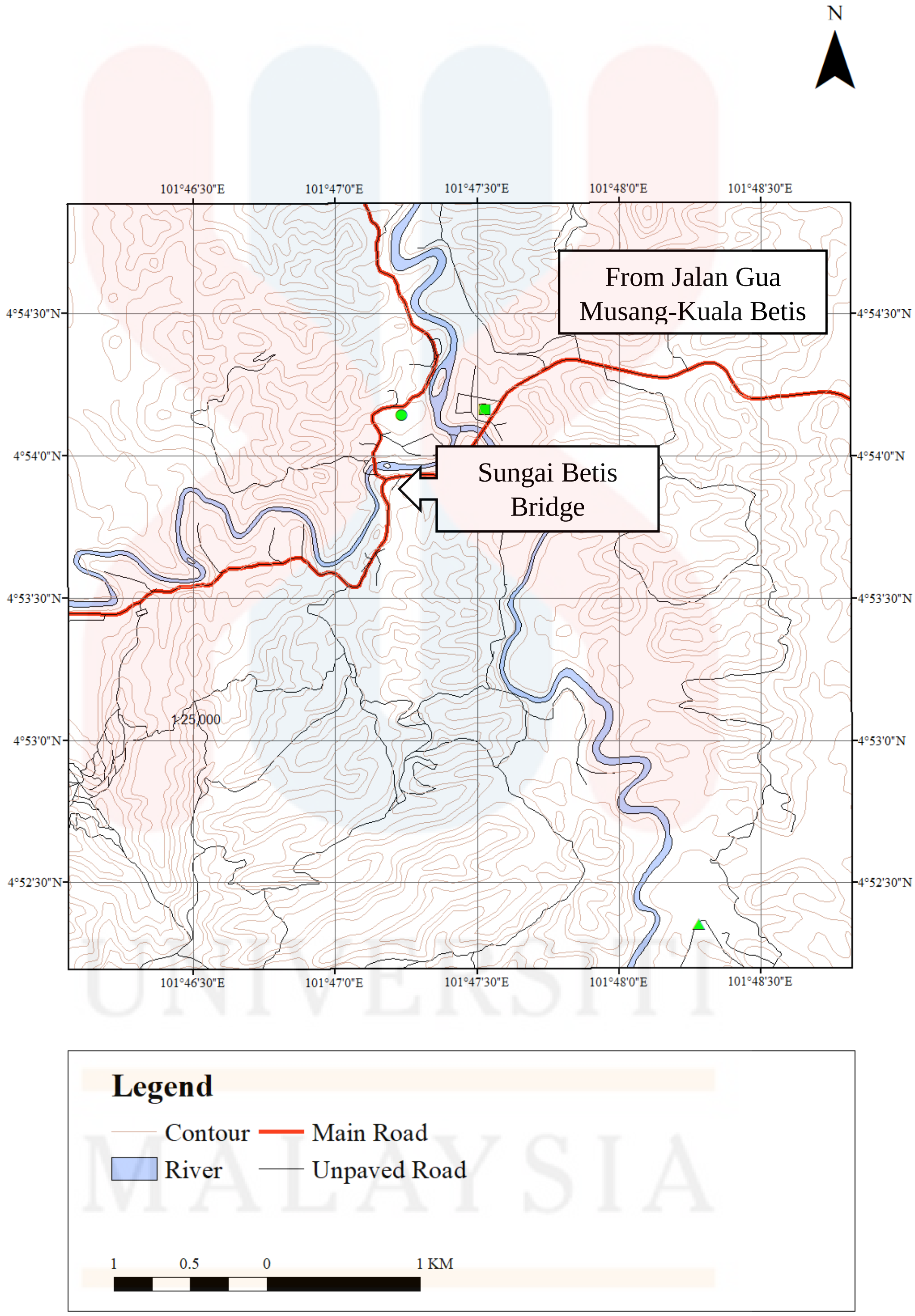


Figure 4.4: Map of road connection in the study area.

4.1.2. Settlement

Settlement at Kuala Betis is mainly focused along the main river, Sungai Betis. The residents are mainly from *Orang Asli Temia*r estimated to be 1400 people from 20 villages. Figure 4.5 and Figure 4.6 shows the residential area in Kg. Kuala Betis. Table 4.1 shows total population of Kuala Betis according the villages with total population of 1491 people.

Figure 4.5: Residential area in Kg. Kuala Betis.

Figure 4.6: Kampung Mangsok, Kuala Betis.

Table 4.1: Population of Kg. Kuala Betis.

Village	Population
Kampung Orang Asli Setawar	31
Kampung Orang Asli Bawik	56
Kampung Orang Asli Jias	52
Kampung Orang Asli Langsat	91
Kampung Orang Asli Depak	49
Kampung Orang Asli Pasir Rot	86
Kampung Orang Asli Guling	43
Kampung Orang Asli Tinjang	117
Kampung Orang Asli Terenek	46
Kampung Orang Asli Jenut	133
Kampung Orang Asli Merlong	90
Kampung Orang Asli Mangsok	68
Kampung Orang Asli Chengkelik	155
Kampung Orang Asli Lambok	47
Kampung Orang Asli Limau	97
Kampung Orang Asli Teluk Untung	87
Kampung Orang Asli Taman Sri Galas	127
Kampung Orang Asli	70
Kampung Orang Asli Angkek	55
Kampung Orang Asli Podek	78
Total	1491

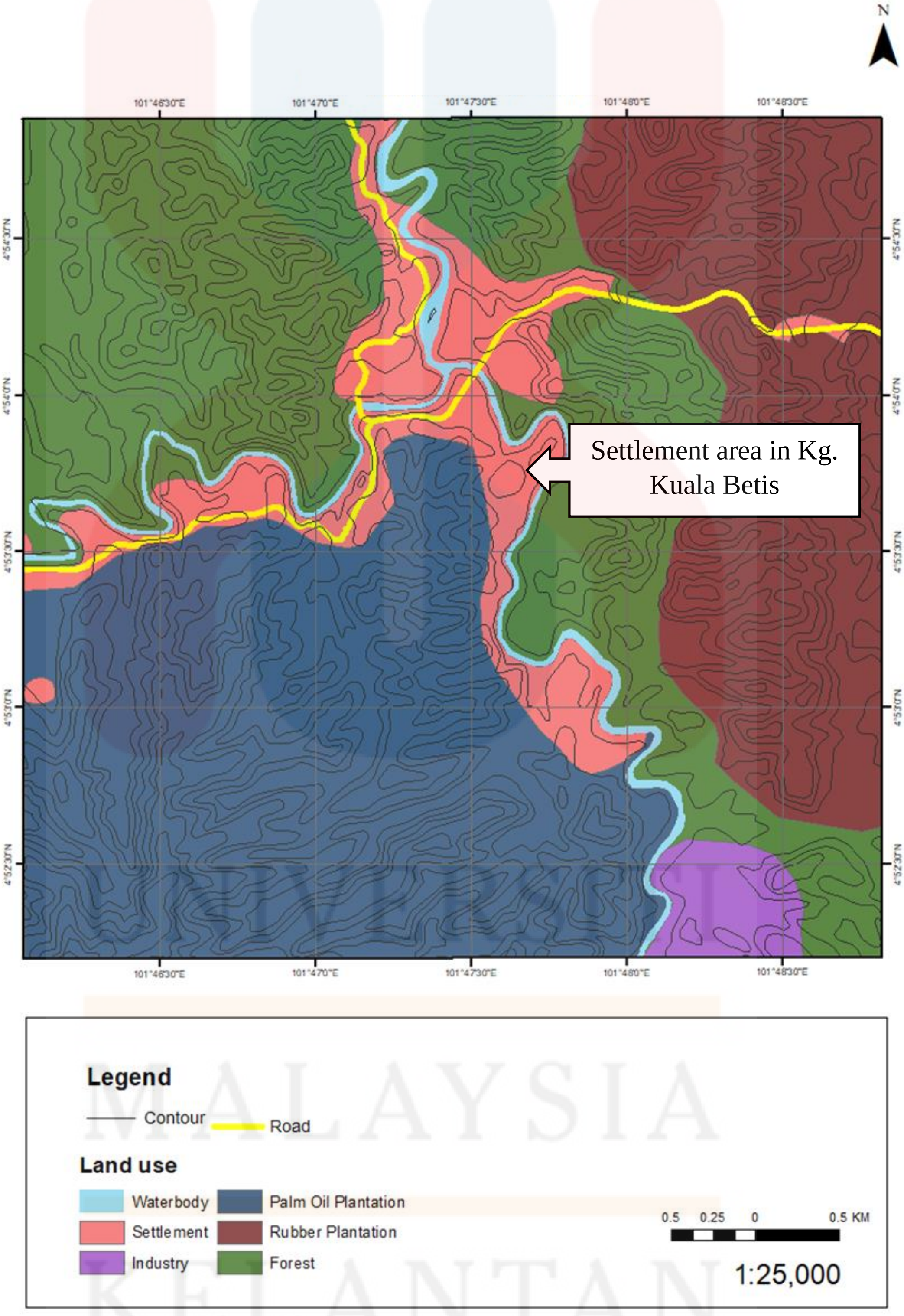


Figure 4.7: Figure above shows settlement area in the study area as shown in pink colour.

Figure 4.8: Satellite imagery of settlement area in Kg. Kuala Betis.

4.1.3. Land use

Kuala Betis land use is consist of forestry, plantation, residential and infrastructure & facilities. In Kuala Betis, forestry land use covered in the northwest and southeast of this study area. Forestry in Kuala Betis consist of Nenggiri Reserve Forest. In the southwest of this study area, the land use is focused on agriculture purpose which consist of economic purpose plantation such as palm oil plantation which managed by Liziz Plantation and Factory. Residential area is in the center of this study area, along Sungai Betis and Sungai Berok. Government infrastructure such as Rancangan Pengumpulan Semula (RPS) Kuala Betis and Sekolah Kebangsaan Kuala Betis also located at the center of this study area.

Figure 4.12 shows the land use map of Kg. Kuala Betis which consist of forest, plantation, settlement and waterbody.

Figure 4.9: One of the infrastructures provided to the residents of Kg Kuala Betis.

Figure 4.10: Sekolah Kebangsaan Kuala Betis.

Figure 4.11: Rancangan Pengumpulan Semula (RPS) Kuala Betis.

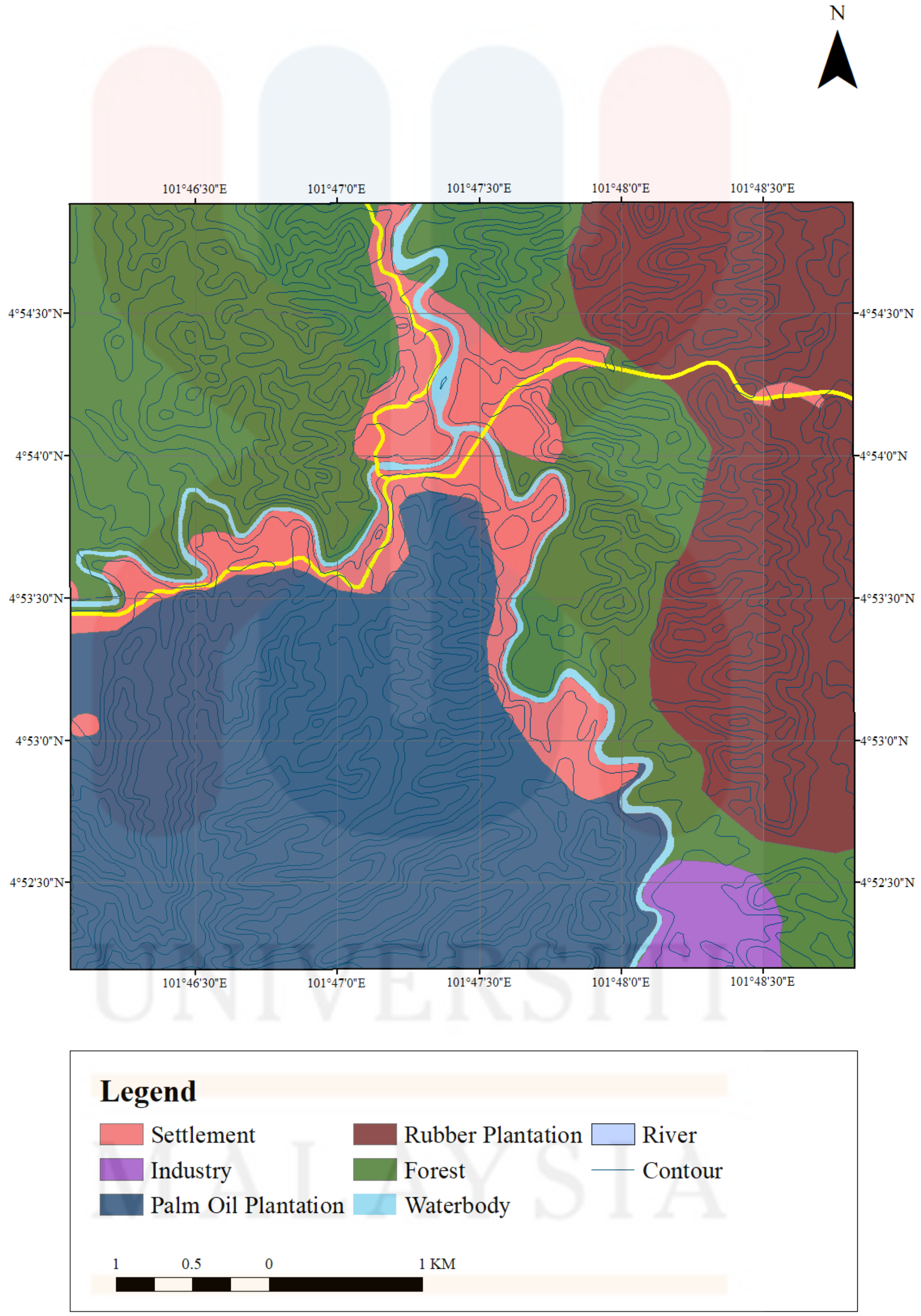


Figure 4.12: Map of land use in study area.

4.1.4. Socioeconomic

Socioeconomic of Kuala Betis is fully depends on traditional activities and plantation as the land use of Kuala Betis is mainly dominated by forest and plantation area. In addition, the population of Kuala Betis is consist of indigenous racial which restrict the socioeconomic of Kuala Betis.

Main economic activity in this study area are in farming sector. Oil palm plantation is focused in the southern part of this study area while rubber plantation area covered the eastern part of this study area.

Figure 4.13: Shop lot at the center of the study area.

Figure 4.14: Rubber Plantation at Kg. Kuala

Figure 4.15: Liziz Plantation that covered the southern part of this study area.

Figure 4.16: Complex of Liziz Plantation that include the plantation area and factory.

4.1.5. Traverse and observation point.

Traversing is importance aspect in geological mapping. Traversing is required to survey and gather information including lithology, geomorphology and structural geology. Traversing is part of geological mapping that included data collection by observation and sampling. Data sampling will be taken from the outcrop and will be described according to its characteristics. Data sampling also include the measurement such as strike and dip measurement and slope angle.

For this research project, traversing and surveying has been done in five days, two days for map reconnaissance and three days for data collection. Geomorphological survey is done during two day of map reconnaissance while data collection for lithology, stratigraphy and structural geology is done in three days of data collection. Most of the observation point in this study area are accessible with car and motorcycle.

Traverse and observation point map below show the traverse data that collected in 5 days including traversing and observation point.

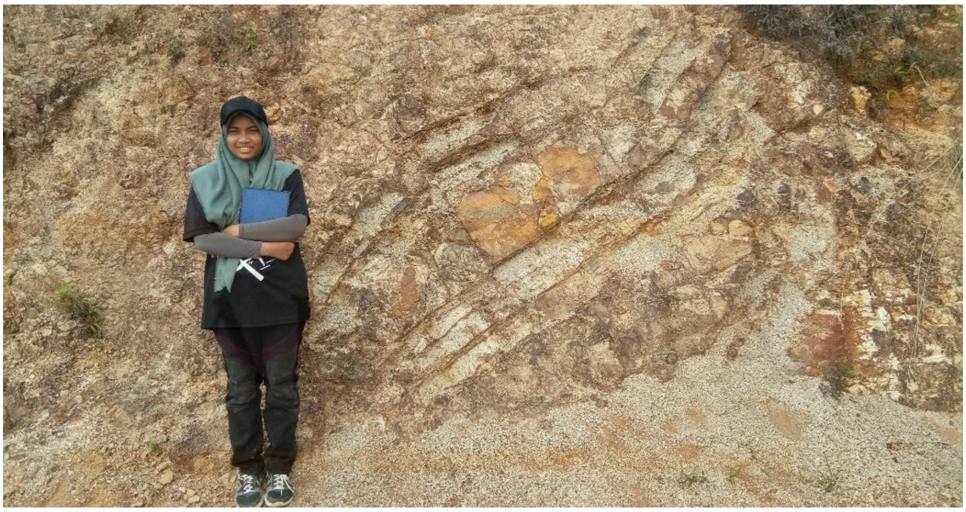


Figure 4.17: Data collection at checkpoint 1.

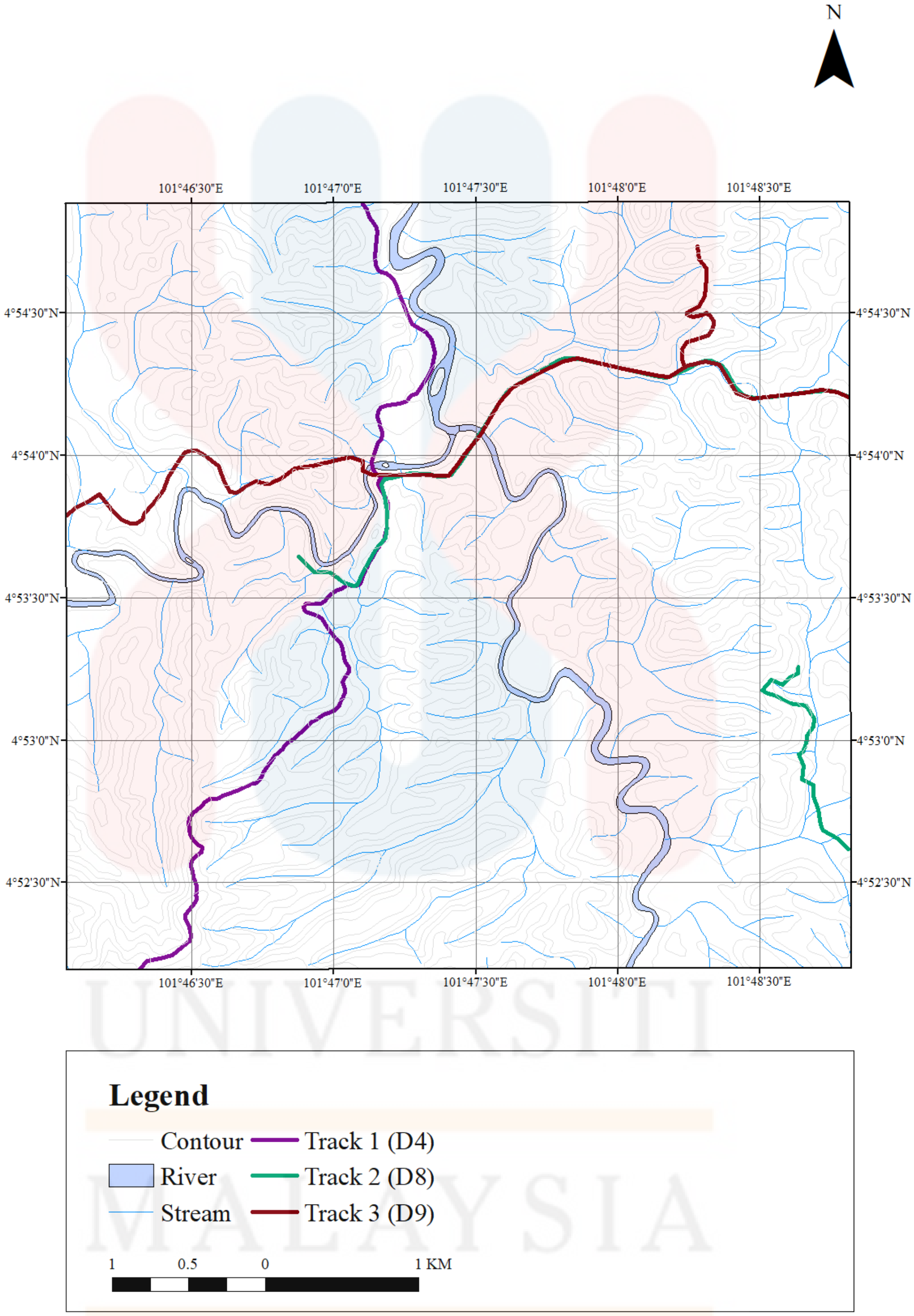


Figure 4.18: Map of traverse during three days of data collecting.

4.2 Geomorphology

This part discusses further about the geomorphology of the study area start from topographical classification, weathering and drainage pattern that gathered from geomorphological mapping and GIS analysis.

Geomorphology words is derived from Greek words which are gew (the Earth), morfh (form), and logo (discourse). Geomorphology is generally a study of the Earth formation. According to Magerie (1886), geomorphology is the study of the morphology of the Earth surface. Today, the word geomorphology describes the Earth land surface features and its landform.

4.2.1. Topography classification

Generally, the study area consists of several topography unit which varies from low to hilly area with the highest elevation 340 m. Geomorphological landscape in this study area is plain area which consist fluvial landscape and karst landscape.

According to Hutchison (2009), basic topographical unit based on mean elevation above sea level can be classified into five main unit: low lying (less than 15 m); rolling (16-30 m); undulating (31-75 m); hilly (76-301 m) and mountainous (more than 500 m). Basic topographical unit in Kuala Betis range from low lying to hilly topographical unit. Table 4.2 shows the topographical unit based on elevation according to Hutchison (2009) and topographical classification based on elevation and slope according to Van Zuidam (1985). Figure 4.18 is the map of topographical classification based on elevation.

Table 4.2: Topographical unit classification based on elevation.

Topographical unit	Mean elevation (m above sea level)
Low lying	< 15
Rolling	16-30
Undulating	31-75
Hilly	76-301
Mountainous	>500

(Source: Hutchison, 2009)

Table 4.3: Topographical classification by Van Zuidam (1985).

Class	Elevation-relative height (m)		Slope (°)	Characteristic
1	<50	Low lands	0-2	Flat to almost flat. No meaningful denudation processes.
2	50-200	Low hills	2-4	Gentle slope. Low speed ground motion, sheet erosion and soil erosion (sheet and rill erosion).
3	200-500	Hills	4-8	More gentle slope with higher magnitude.
4	500-1000	High hills	8-16	Slightly steep. A lot of ground movement and erosion, especially landslide that are flat.

5	>1000	Mountains	16-35	Steep, intensive denudation processes and ground movement are common
6			35-55	Very steep, rock generally begin to unfold, a very intensive denudation process, have begun to produce rework material.
7			>55	Extremely steep, exposed rock, extremely process of denudation, prone to failure.

(Source: Van Zuidam, 1985.)

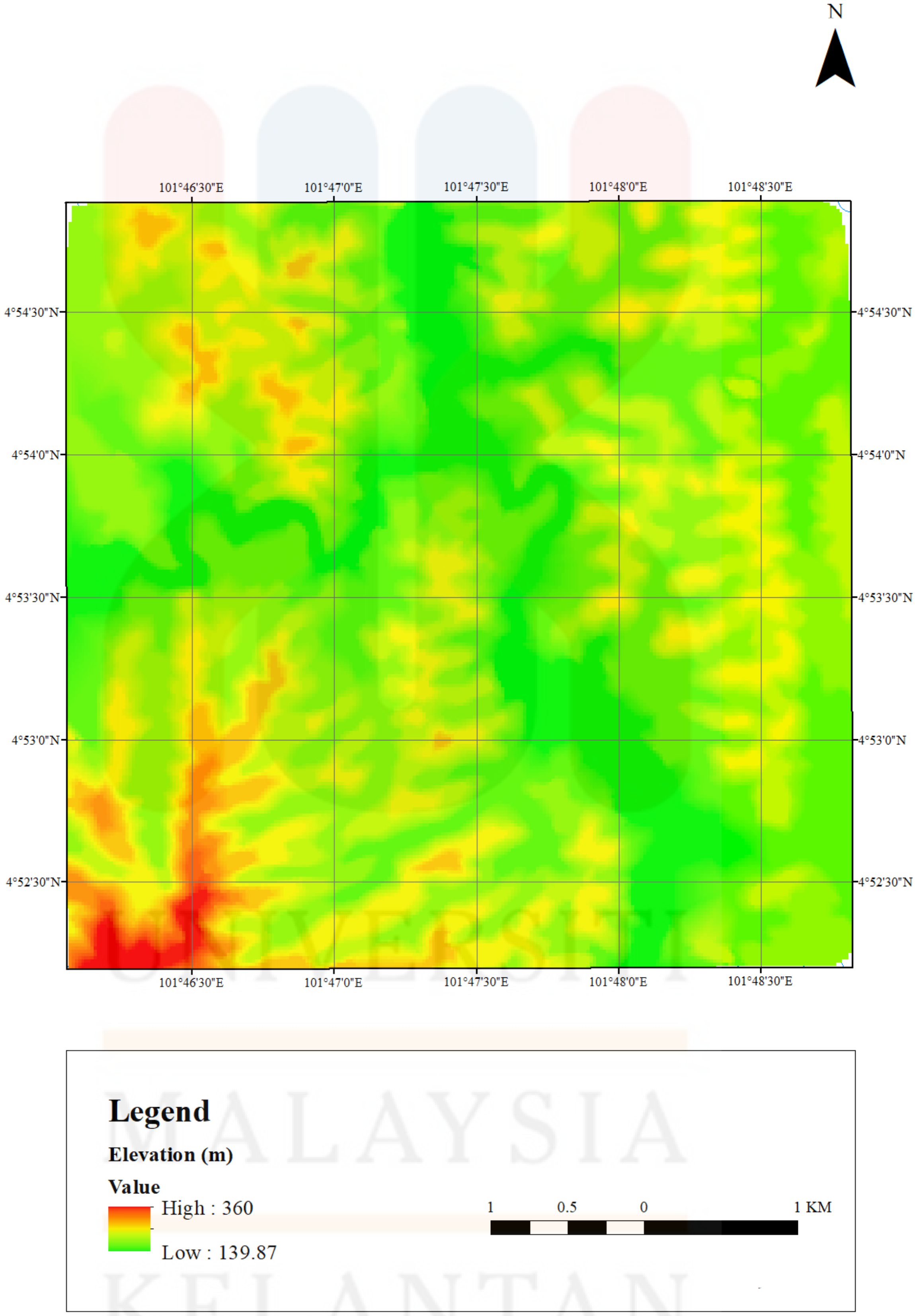


Figure 4.19: Topographical map of study area based on elevation.

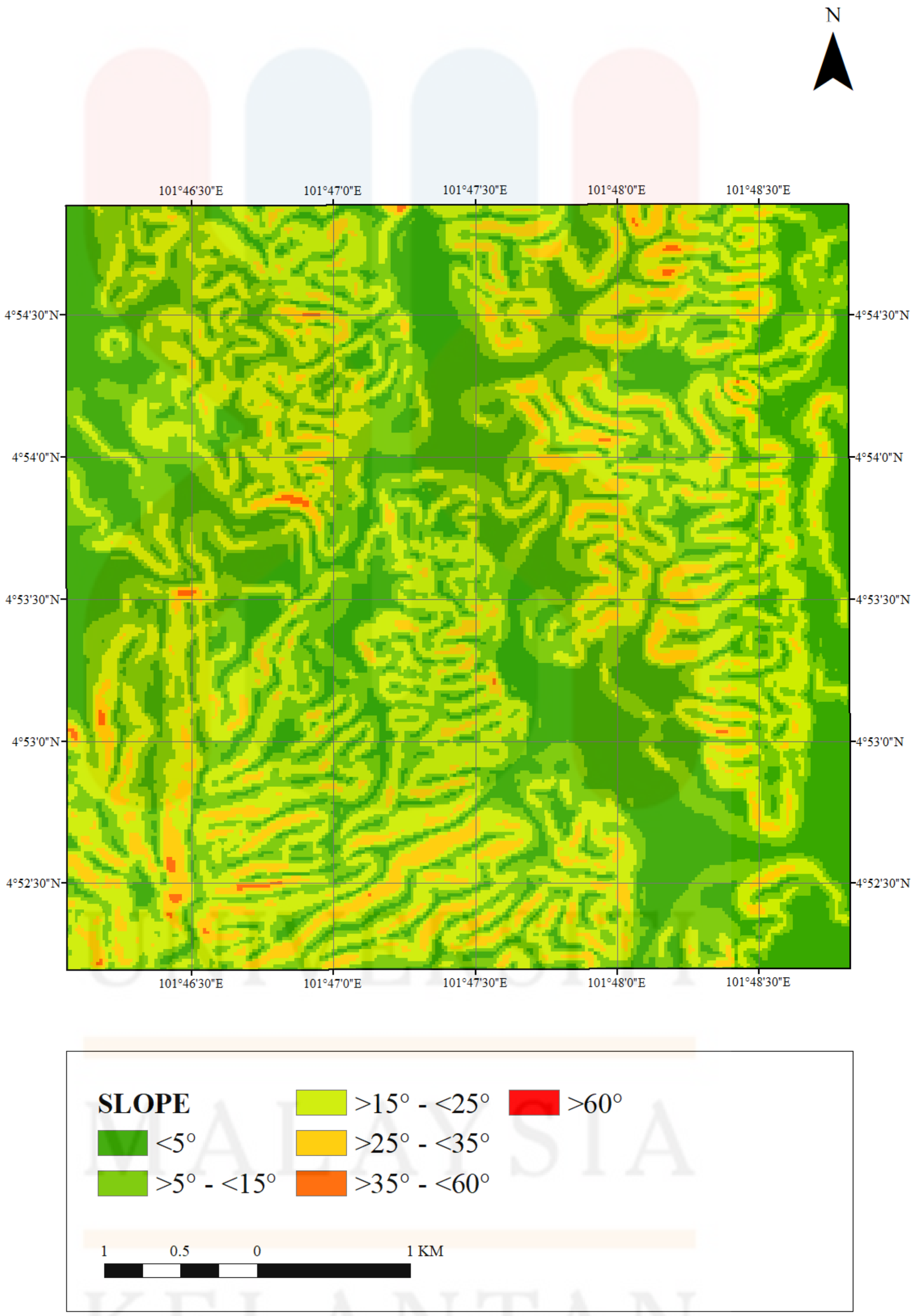


Figure 4.20: Slope gradient map of study area.

4.2.2. Weathering

Weathering is a process involved alteration and disintegration of mineral from bedrock as it exposed to the atmosphere. Weathering process can be classified into three main categories: (1) physical weathering; (2) chemical weathering and (3) biological weathering.

Physical weathering occurs when rock breakdown slowly by environmental effects such as temperature and pressure. This type of weathering will cause mechanical disruption such as granular disintegration, exfoliation and shattering. Example of physical weathering is ice wedge. Figure 4.21 is example of physical weathering in study area. Chemical weathering is alteration of mineral in the rock that mainly cause by water, temperature and oxygen. Example of chemical weathering is solution, oxidation and hydration. Example of chemical weathering in the study area is shown in Figure 4.23. Biological weathering is breakdown of rock which cause by natural effect such as animal and vegetation. Biological weathering includes both physical and chemical weathering process. Example of biological weathering are mosses, plant roots and burrow. Example of biological weathering in the study area is show in Figure 4.22.

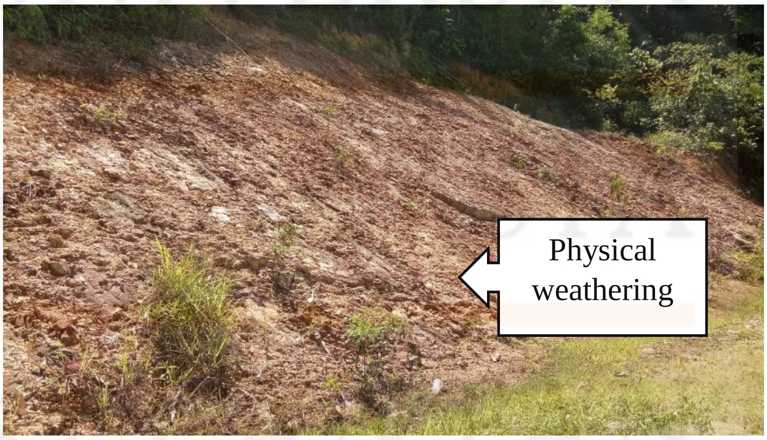


Figure 4.21: Example of physical weathering in study area.

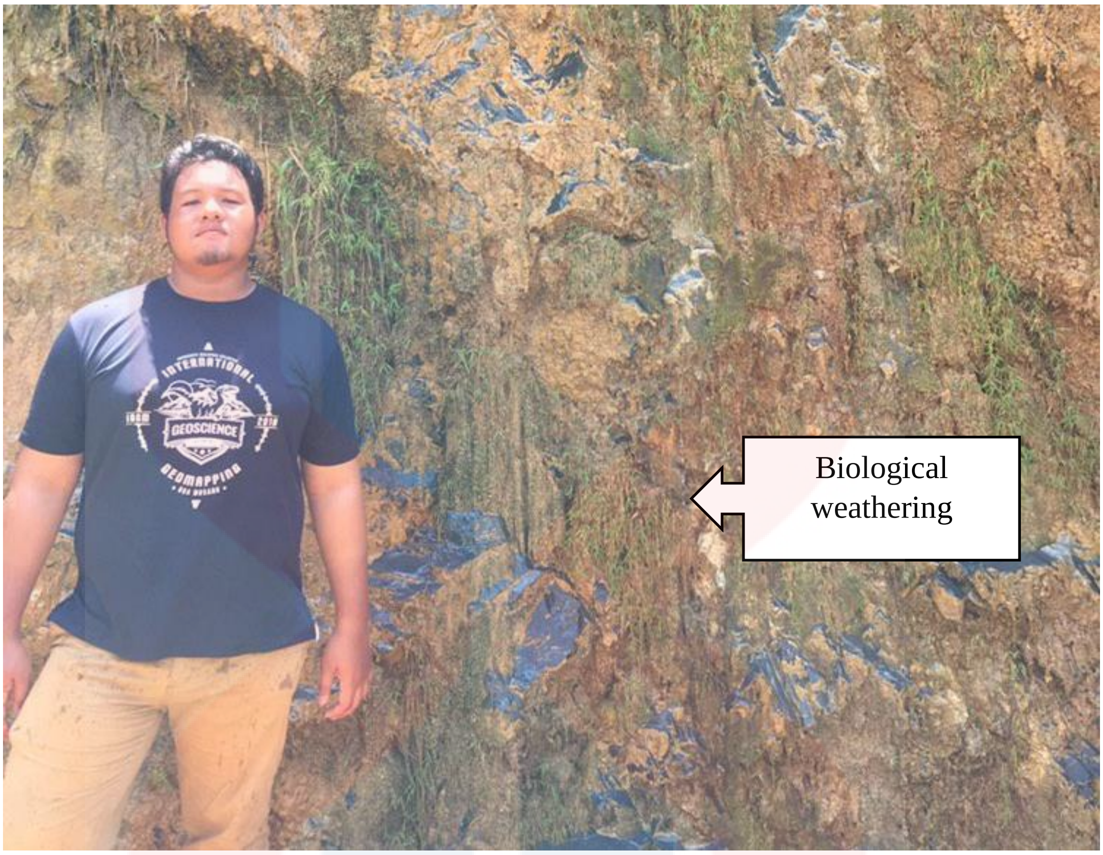


Figure 4.22: Example of biological weathering in study area.

Figure 4.23: Example of chemical weathering in study area.

4.2.3. Drainage pattern

In geomorphology, drainage pattern is pattern formed by water bodies such as river, stream and lake in particular drainage basin. Drainage pattern are mainly affected by topography and rock unit in the area. For study area, drainage pattern that can be identified is dendritic, trellis and sub-parallel pattern.

Dendritic drainage pattern is the most common drainage pattern. Dendritic refers to shape of tree, where few rivers or streams joined into one main river. Dendritic drainage pattern follows the slope gradient of terrain. Trellis drainage pattern is when the rivers or streams feed into main river in approximately 90° angle. Trellis pattern indicate that the rock sequence is hard rock and soft rock alternately. Trellis pattern also one of the indicators for fold mountain topography. Parallel drainage pattern is river system that formed by steep slope with some relief. In this drainage pattern the rivers or streams feed into one main river in the same direction. Parallel pattern indicates constant elevation. Different types of drainage pattern can be observed in Figure 4.25 which shown six main type of drainage pattern. Drainage pattern of river in study area are shown in Figure 4.26.

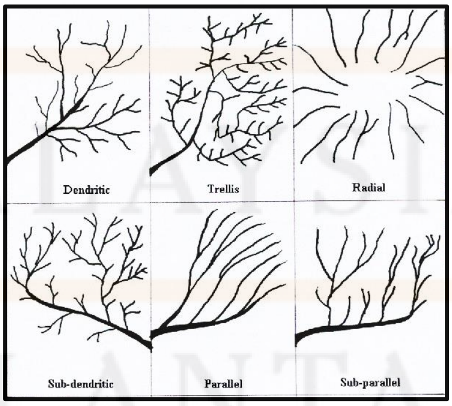


Figure 4.24: Type of drainage pattern.

(Source: Ramachandra, 2006).

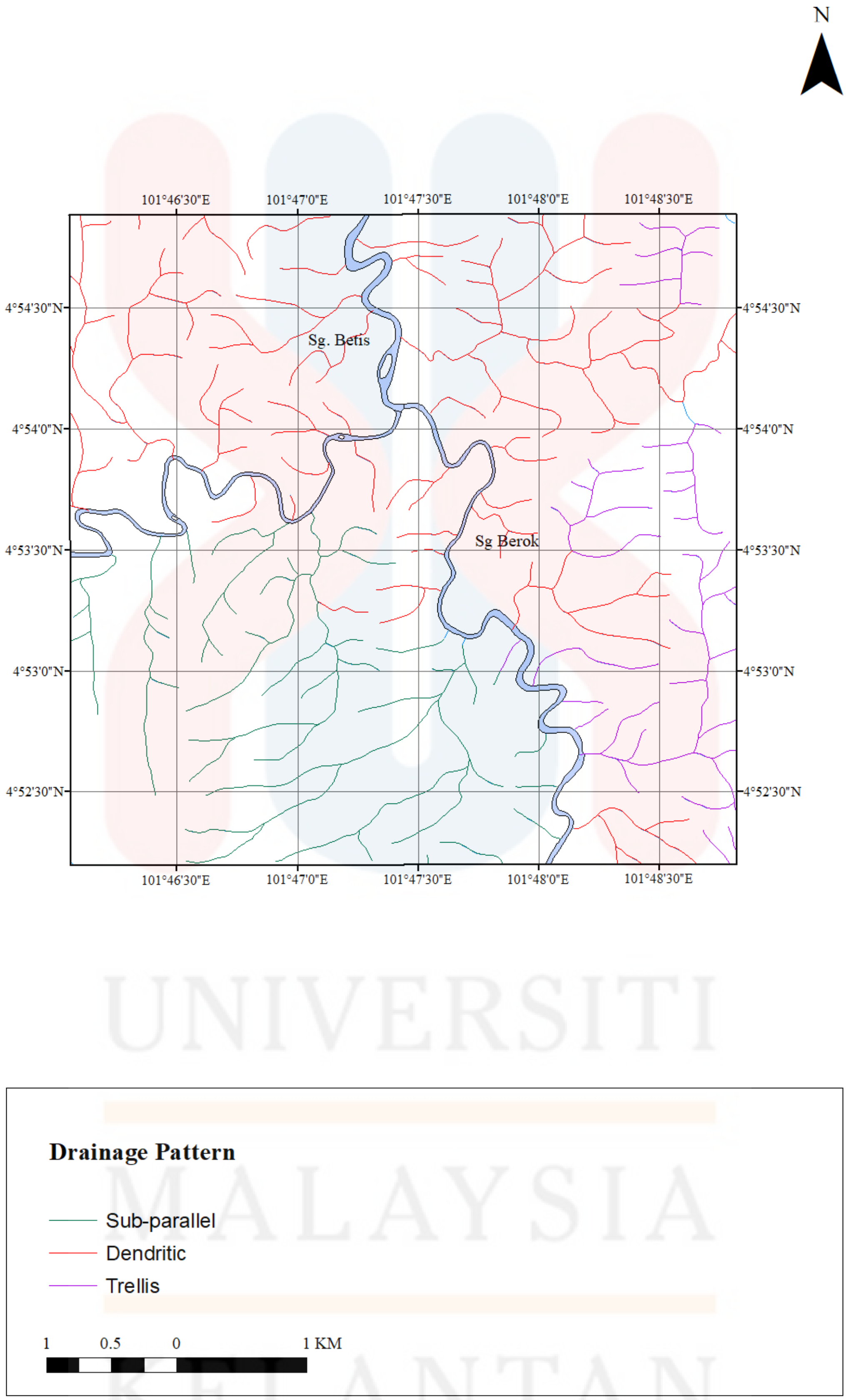


Figure 4.25: Map of drainage pattern of study area.

4.3 Stratigraphy

This part discussed about the lithology and stratigraphy of this study area. Four unit in this study area, alluvium unit, thick bedded limestone unit, fine grained sediment unit and Metasediment unit are discussed further.

4.3.1. Lithostratigraphy

Generally, Kuala Betis consist of igneous, sedimentary and metamorphic rock unit. In this study area of 25 km^2, the lithology identified are mainly sedimentary rock with some metamorphosed sedimentary rock. Sedimentary rock that can be found in this study area are mudstone, sandstone, limestone with alluvium that can be found along the main river, Sungai Betis and Sungai Berok. Metamorphic rock that found in this study area are metamudstone and marble.

The lithologic sequence in this study area is from the youngest which is alluvium unit, thick bedded limestone unit, fine grained sediment unit and metasediment unit. Table 4.4 shows lithostratigraphy of study area which started to deposit in Early Triassic to Quartenery Period and Figure 4.26 shows the geological map of Kg. Kuala Betis.

Table 4.4: Lithostratigraphy of study area.

Eon	Era	Period	Unit	Lithology	Symbology
Phanerozoic	Cenozoic	Quartenery	Alluvium	Alluvium	
	Mesozoic	Late Triassic	Thick Bedded Limestone	Limestone with marble	
		Middle Triassic	Fine grained sediment	Mudstone, sandstone and tuffaceous sandstone.	
		Early Triassic	Metasediment	Metamudstone with interbedded of sandstone and mudstone	

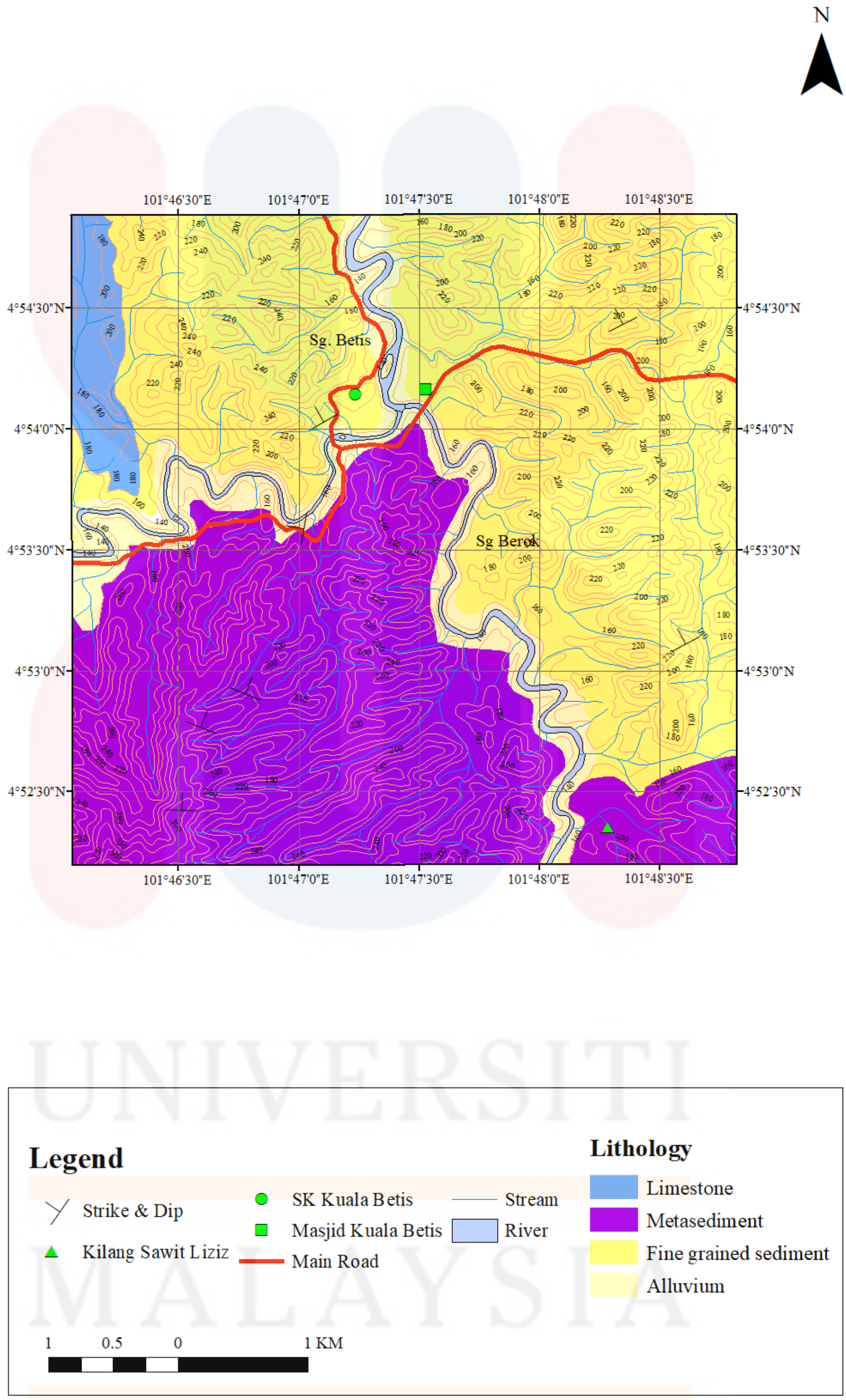


Figure 4.26: Geological map of study area.

4.3.2. Rock unit

Lithologic unit in this study area is explain further in this section by distinguish their characteristic according to their rock type. The lithologic unit sequence explained from the oldest to youngest which is alluvium unit, thick bedded limestone unit, fine grained sediment unit and metasediment unit.

a. Metasediment unit

This unit consist of metamudstone with interbedded of sandstone and mudstone. This lithologic unit covers lower southern part of the study area. The colour of outcrop is yellowish due to highly weathered condition. Figure 4.28 shows the outcrop and hand sample of metamudstone rock in study area.

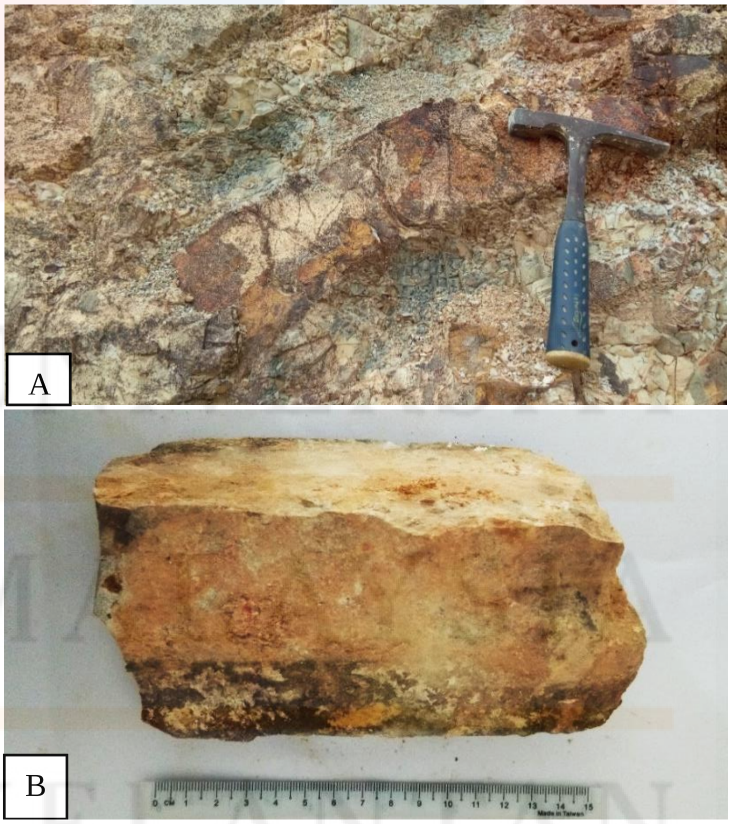


Figure 4.27: Outcrop (A) and hand sample (B) of metamudstone in study area.

Figure 4.28 below is thin section sample of metamudstone. On microscopic observation of 10x ocular magnification and 5x objective magnification, the texture of metamudstone sample is massive structure, good sortation, closed packing with grain size range from 1/256 - 1/16 mm. It is considered as meta-sedimentary rock because of the characteristic on microscopical appearance which the mineral begins to show mineral foliation. The thin section sample composed of quartz, silica clay mineral and opaque mineral.

Quartz mineral under PPL appears to be white while in XPL, quartz mineral appears to be blackish grey. The mineral showed low relief without cleavage and low pleochroism with 5% abundance in the thin section.

Silica clay mineral under PPL observation appear to be brown and brown blackish under XPL observation. It shows relief and pleochroism. There is no visible cleavage are present in this thin section. Percentage of silica clay mineral in this thin section is up to 89%. Opaque mineral showed to be dark colour in PPL and XPL observation. Abundance percentage of opaque mineral in this thin section is 6%.

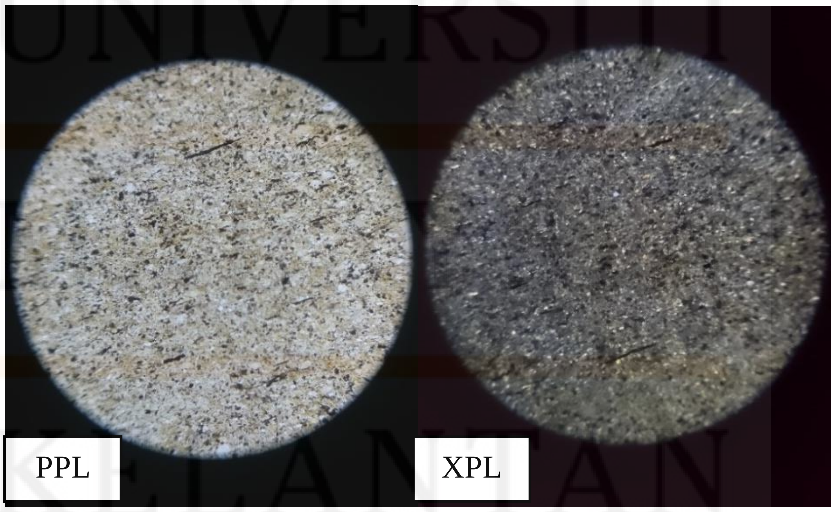


Figure 4.28: Metamudstone under PPL and XPL observation.

B. Fine Grained Sediment unit

Fine grain sediment unit in the study area consist of sandstone, mudstone and tuffaceous sandstone. This unit cover almost 50% of the study area. Figure 4.29 is the outcrop of tuffaceous sandstone under fine grained sediment unit. Figure 4.30 (A) shows the hand sample of tuffaceous sandstone and Figure 4.29 (B) shows hand sample of sandstone under fine grained sediment unit.

Figure 4.29: Outcrop of tuffaceous sandstone and sandstone.

Figure 4.30: Hand sample of tuffaceous sandstone (A) and sandstone (B).

Tuffaceous sandstone and sandstone are then observed under microscopic view as shown in Figure 4.31. The tuffaceous sandstone thin section was observed under 10x ocular magnification and 5x objective magnification. The thin section sample observation shows that the structure is massive structure with grain size ranging from <1/256 to 0.7 mm. The mineral is medium sortation and closely pack. The thin section sample composed of lithic fragment, quartz, silica clay mineral, volcanic glass and opaque mineral.

Lithic fragment appears brown under PPL observation and dark brown under XPL observation. Lithic fragment present spotted in thin section sample with abundance of 15%. Quartz mineral appears white under PPL observation and greyish white under XPL observation. The thin section sample shows low relief without cleavage, low pleochroism, anhedral crystalline form with 20% abundance. For silica clay mineral, the mineral appears white under PPL observation and dark grey under XPL observation. The mineral shows relief and pleochroism with no visible cleavage. The percentage of abundance of silica clay mineral is 55%. Volcanic glass, under PPL observation appears to be white color while under XPL observation, the mineral appears dark grey color. The mineral shows relief and pleochroism with no visible cleavage. The percentage for abundance of volcanic glass is 8%. Opaque mineral appears dark under both PPL and XPL observation with abundance of 2%.

For sandstone sample, after observed under thin section analysis of 10x ocular magnification and 5x observation magnification as shown in Figure 4.32, the thin section sample is massive structure with grain size ranging from <1/256 – 1/6 mm with closely packed medium sortation. Minerals that can be observed in the thin section sample are quartz, feldspar, silica clay mineral, oxide clay mineral and opaque mineral.

Under thin section analysis, quartz mineral appears white under PPL observation and dark grey under XPL observation. The mineral shows low relief with no visible cleavage, low pleochroism, anhedral crystalline form. The percentage of abundance of quartz mineral in the thin section sample is 25%. Feldspar mineral appears light color under PPL observation and greyish red under XPL observation. The mineral exhibit moderate pleochroism with visible cleavage. The percentage of abundance of feldspar mineral in the thin section sample is 10%. For silica clay mineral, the mineral appears white under PPL observation and dark grey under XPL observation. The mineral shows relief and pleochroism with no visible cleavage. The percentage of abundance of silica clay mineral is 56%. Oxide clay mineral appears brown under PPL observation and dark grey under XPL observation. There is no visible shape and cleavage observed in the thin section sample. The percentage of abundance of oxide clay mineral is 6%. Opaque mineral appears dark under both PPL and XPL observation with abundance of 2%.

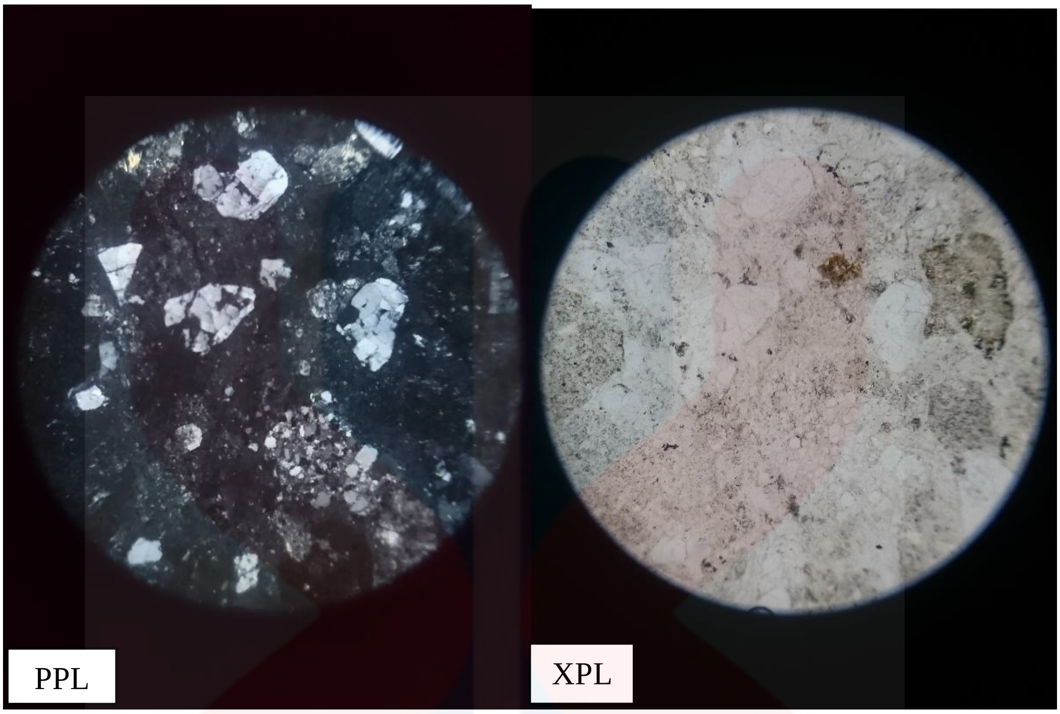


Figure 4.31: Tuffaceous sandstone under PPL and XPL observation.

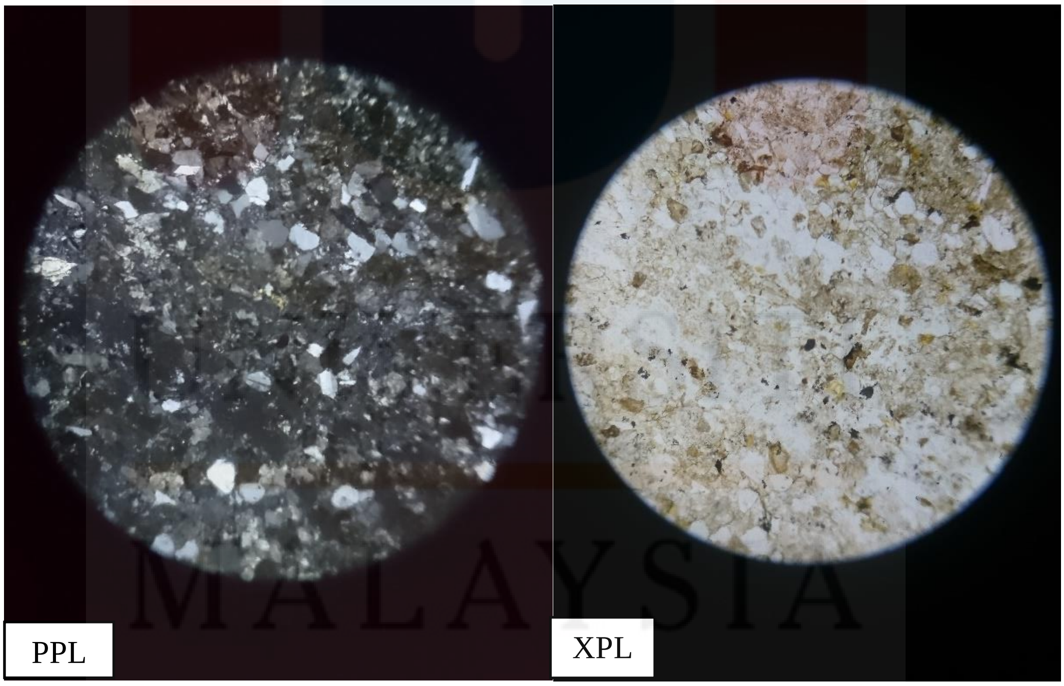


Figure 4.32: Sandstone under PPL and XPL observation.

B. Thick Bedded Limestone unit

This lithologic unit cover the least in this study area which only cover in the northwest of the study area. Thick bedded limestone unit consist of limestone, marble and sandstone. The outcrop is embedded in highly weathered sandstone. Figure 4.33 shows the embedded limestone outcrop.

Figure 4.33: Embedded limestone in weathered sandstone.

Limestone hand specimen (Figure 4.34) is dark grey colour, very fine-grained texture and react when tested with hydrochloric acid (HCl), which shows calcium carbonate mineral in limestone react with HCl and produces carbon dioxide (CO_2). For marble hand specimen, it is light grey colour with some visible mineral and quartz vein. Marble sample (Figure 4.35) was tested with HCl but did not react with acid.

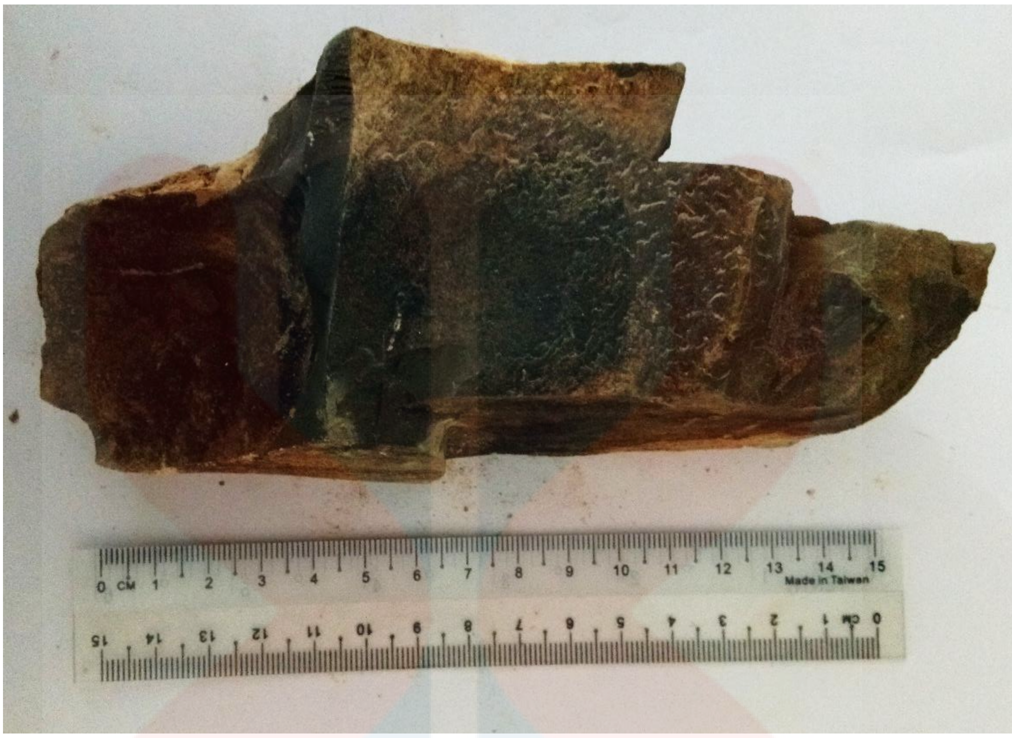


Figure 4.34: Limestone hand sample.

Figure 4.35: Marble hand specimen.

Limestone sample is then observed under microscopic view at 10x ocular magnification and 5x objective magnification as in Figure 4.36. The observation shows that the thin section sample is nonfoliating structures (granulose) with palimset textures which the grain size range from 1/256 - 1/2 mm with medium sortation. The sample composed of calcite, carbonate mineral and opaque mineral.

Calcite mineral under PPL observation, appear bright white colour while, in XPL observation, appear to be greenish pink whith very low relief, strong pleocroism. The percentage of calcite in this thin section is 24%. Carbonate mineral appear brown under PPL observation and pink brownish under XPL observation. Carbonate mineral do not possessed any relief, pleochroism and there is no visible cleavage present in this thin section sample. Carbonate mineral is the most abundance in the sample with 75%. Opaque mineral appears dark under both PPL and XPL observation with percentage of 1%.

For marble thin section sample, the observations made at 10x ocular magnification and 5x objective magnification as in Figure 4.37. The observations show that the thin section sample is non-foliating structures with crystalloblastic (granoblastic) textures which grain size ranging from 1/256 to 2 mm with poor sortation. The thin section sample composed 100% of calcite mineral. Calcite mineral under observations of PPL, appears bright white while under XPL appears pink-greenish colour. The mineral shows low relief (double reflection) with strong pleochroism.

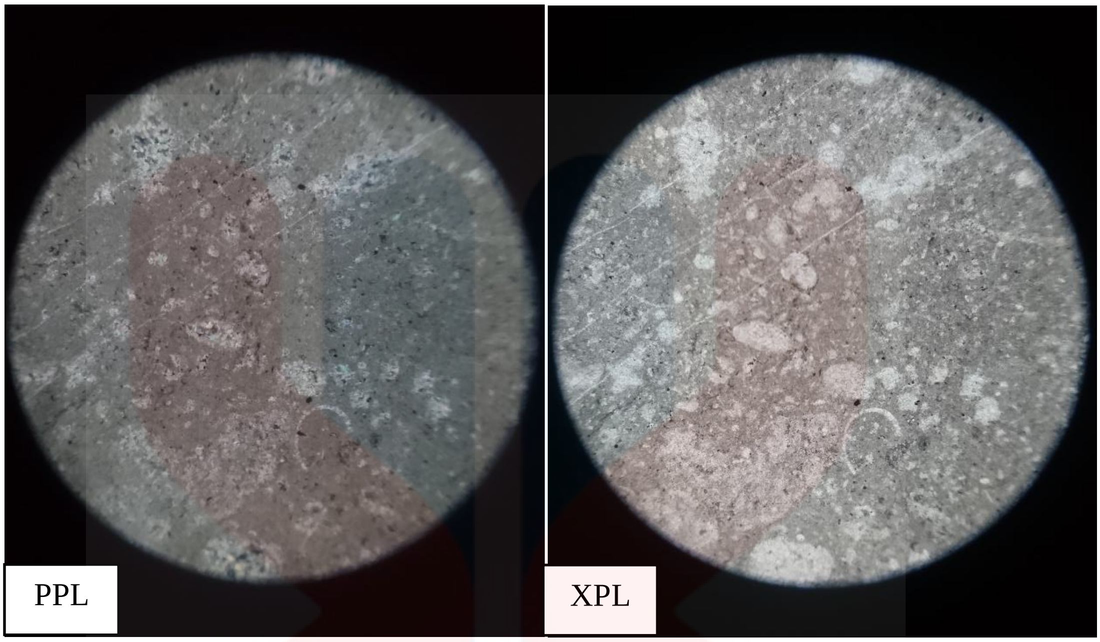


Figure 4.36: Limestone under PPL and XPL observation.

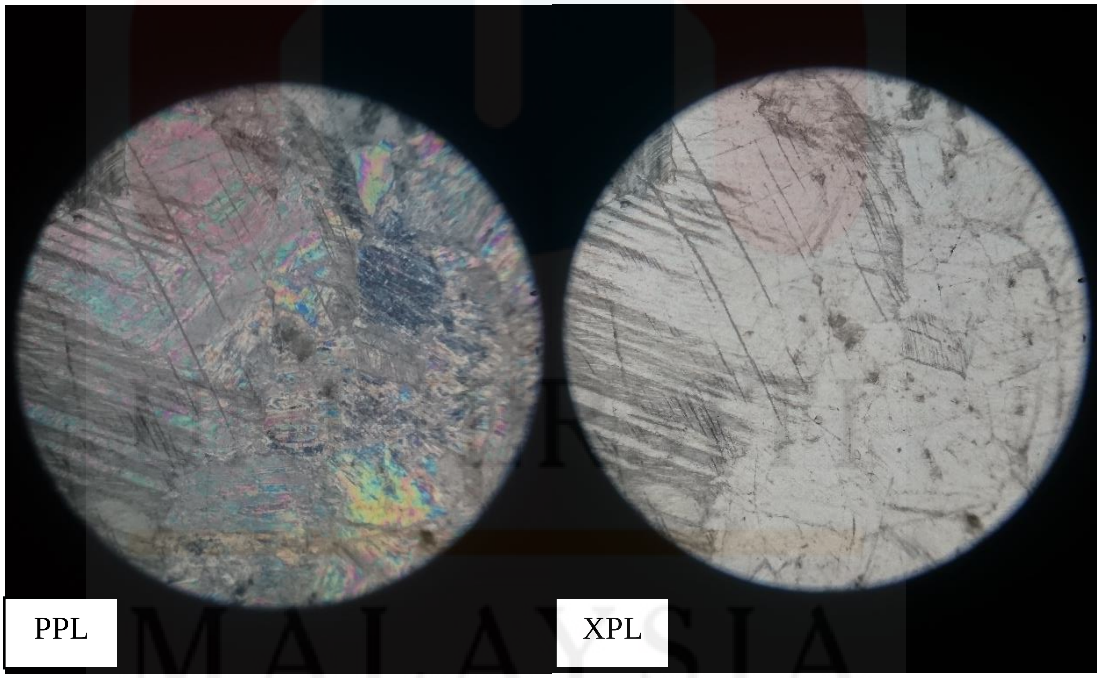


Figure 4.37: Marble thin section analysis under PPL and XPL observation.

4.4 Structural geology

Structural geology refers to the deformation that formed by action of forces within the Earth crust. Form and orientation of structure that formed by the deformation reflect the interaction between it an existing rock. Deformation is a process that transformed pre-existing rock.

Common structure that can be found in the study area are fracture, joint, vein, faulting and folding. This part discussed more detail about the structural geology aspect of study area including lineament analysis, joint analysis, folding and faulting.

4.4.1. Lineament analysis

Lineament is a geological feature with provide underlying geological structure by using application of remote sensing. Lineament is a pattern that can be observed in aerial photograph or map that must be linear and continuous. Lineament is usually indicator for geological structure such as faulting and fold axis. Accurate lineament analysis that can be done using satellite imagery is important for structural and tectonic interpretation of an area or regional.

Figure 4.38 is regional lineament analysis using satellite imagery around study area and Figure 4.39 is lineament map of study area. Joint analysis was done in the study area and data shown that δ_1 is in 45° direction as shown in Figure 4.40.

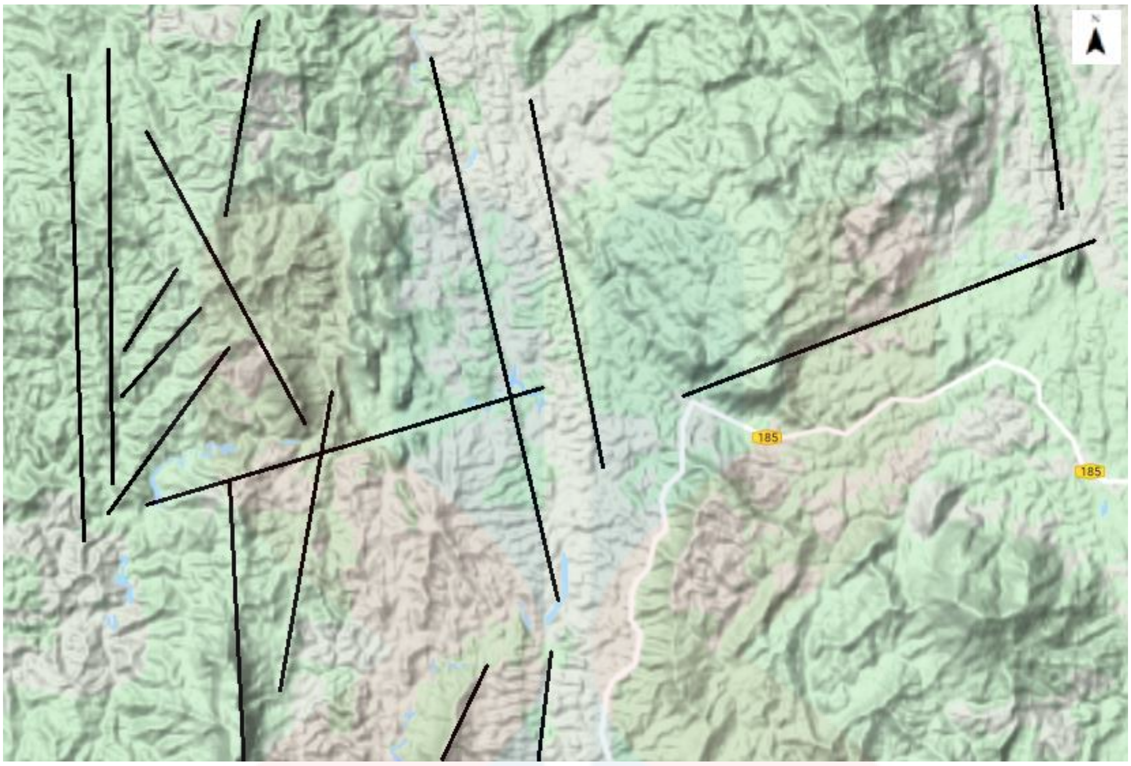


Figure 4.38: Regional lineament analysis using satellite imagery.

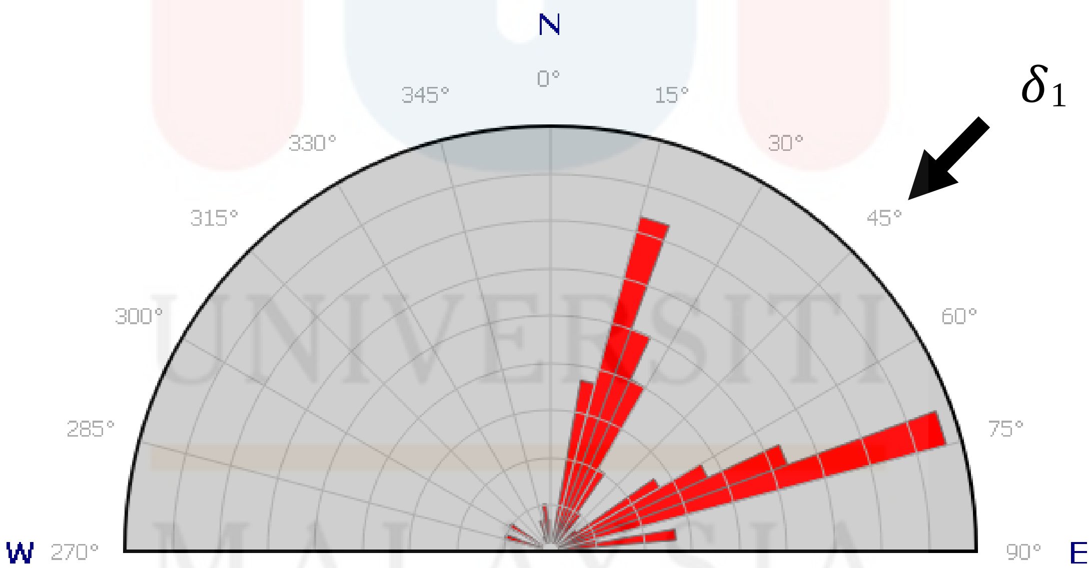


Figure 4.40: Rose Diagram for Outcrop 2.

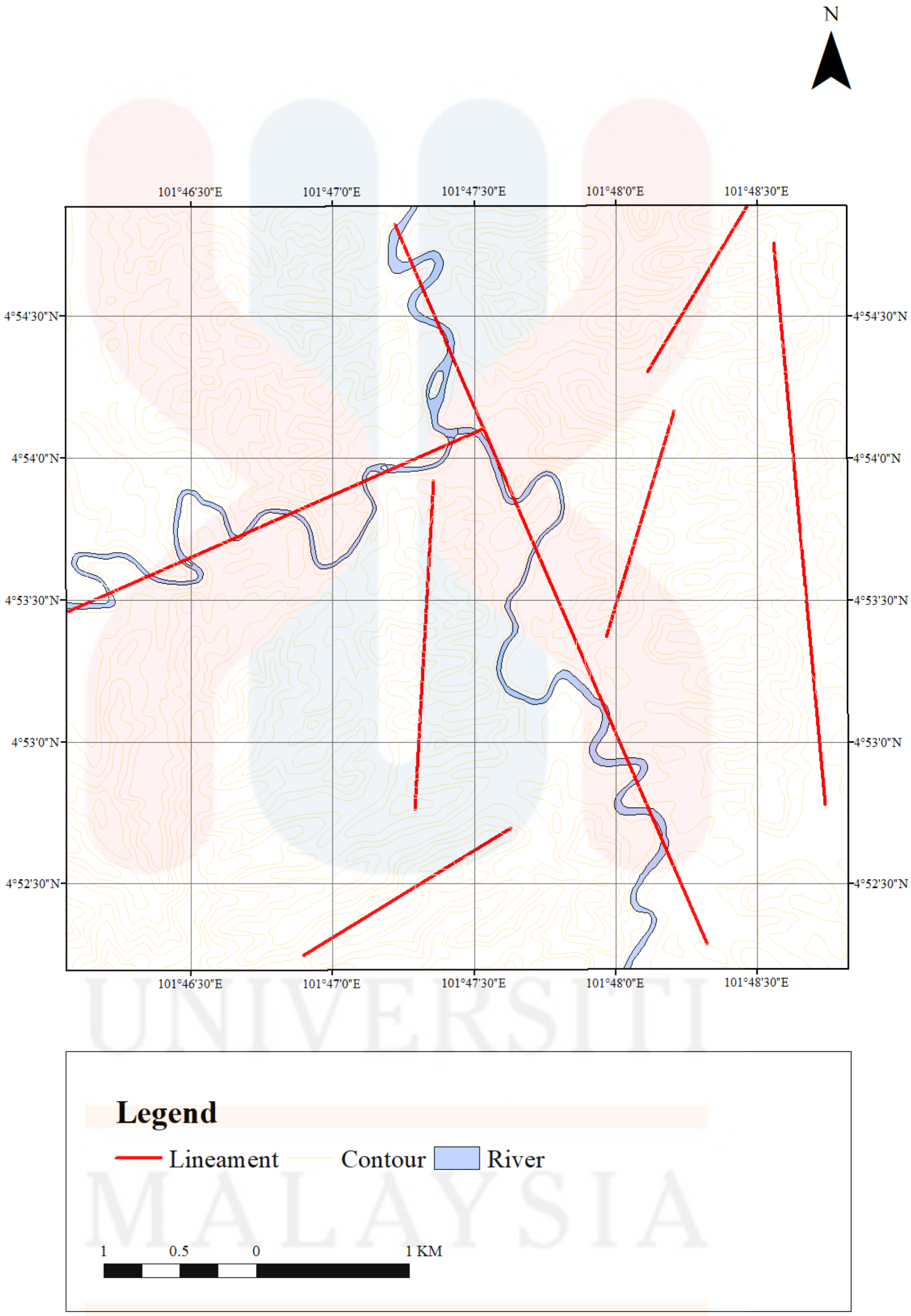


Figure 4.39: Lineament analysis map of Kg. Kuala Betis.

4.4.2. Fault

In checkpoint 1, a metamudstone outcrop with interbedded of sandstone and mudstone can be observed clearly. The coordinate for the outcrop is N 4° 52’ 23.98”, E 101° 46’ 28.76”. There are quartz veins present along the outcrop. Based on observation on field, the structure found is a series of minor normal fault as shown in Figure 4.41.

Figure 4.41: Normal fault at N 4° 52’ 23.98”, E 101° 46’ 28.76”.

4.5 Historical Geology

Generally, the rock unit in Kuala Betis starts to deposit from Period Permian to Quarternary which deposition starts with meta sediment unit to Alluvium. Meta sediment unit consist of metamudstone rock with interbedded of sandstone and mudstone. From observation of stratigraphic and structure distribution, lithologic unit contain minor faulting. For fine grained sediment unit, the lithologic of the unit consist of sandstone, mudstone and tuffaceous sandstone and thick bedded limestone unit consist of limestone and marble.

From joint analysis that have been made, the principal stress in this study area is 40° which similar to principle stress of Bentong-Raub Suture zone. The observation also shows that the depositional environment for this study area is shallow marine,

CHAPTER 5

GEOMORPHOLOGICAL CONSTRAIN OF RURAL DEVELOPMENT IN KG. KUALA BETIS.

5.1 Introduction

Kuala Betis is located at the southern of Kelantan state. Kuala Betis is famous for the settlement of *Orang Asli* Kelantan, mainly Suku Temiar. As Gua Musang undergoing urbanization process, Kuala Betis also get the effect of urbanization as it is located between two main town Gua Musang and Lojing, Kuala Betis is now undergo development processes which transform it from traditional settlement area of Orang Asli into developing rural area. Many basic living facilities have been developed in Kuala Betis due to its growth impact such as living facilities, educational and economic.

There are few factors contributing to development of an area such as population growth, economic need, increasing in social activity and many more. For a well design development in an area, a geomorphological constraint analysis must be understood to avoid any problem in the future.

Urban or rural planning is important to achieve sustainable development as planning will helps the investor and developer reduce their unnecessarily budget and helps to balance between growth and the environment.

5.2 Geomorphological Constrain and Its Relationship with Rural Planning and Development

Geomorphology is one of the main aspects in planning and development of an area. It is including the geology of an area, landform and geomorphological processes with their impact evaluation towards the development itself (Gupta and Ahmad, 1999). It is major factor that need to be considered for future development as it will help in reducing probability of geological hazard that can jeopardized the sprawl rate of an area.

Aspect in geomorphology that should be considered in development are lithology of the area, soil type, rainfall distribution, slope degree, relief and natural hazard such as flood/buffer zone area and landslide susceptibility area. All parameter will be considered to determined suitable and non-suitable area for development.

The geomorphological constraint that has been made is the will be useful for town planner and developer to choose suitable area for further development. It will be important in reducing potential risk of geological hazard in the area that not suitable for development and safety measure that should be taken by the developer they want to proceed development in highly risk area such as foundation and piling.

5.3 Lithology (rock type)

Rock type is importance aspect for planning and development of an area. Lithology of an area can be determine by conducting geological mapping. Understanding of lithology is important in determining the rate of weathering of the rock. In this study area, the main lithological unit are meta-sediment, fine grained sediment, limestone and alluvium unit.

According to Department of Mineral and Geoscience Malaysia (2002), Type of rock play important role in weathering as the composition of mineral in rock affect the rate of weathering. Rock with harder mineral have higher resistance while softer mineral less resistance and tent to erosion. Higher rate of weathering will cause lose in mineral content and become loose. As this process happen, it will lead to soil movement especially with heavy rainfall.

Table 5.1: Development Suitability Rating for Lithology.

Category	**Rock Types**	**Rating**
Type I	Basalt, Quartzite and Massive Limestone and Dolomite	**0.2**
	Granite, Gabbro and Dolerite	**0.3**
	Granite, Gneiss and Metavolcanics	**0.4**
Type II	Well cemented terrigenous sedimentary rock (dominantly sandstone) with minor beds of stone and gneiss rocks	**1.3**
	Poorly cemented terrigenous sedimentary rock (dominantly sandstone) with intercalations of clay or shale beds	**1.0**
Type III	Well cemented gneiss	**1.0**
	Shale, Slate or other argillaceous rocks like Siltstone, Mudstone and Claystone	**1.2**

	Schistose rocks	**1.4**
	Shale with interbedded clayey rocks (Siltstone, Mudstone)	**1.8**
	Weathered shale or other argillaceous rock, Phyllite, Schistose.	**2.0**

Source: Department of Mineral and Geoscience Malaysia (2002)

Table 5.1 above shows development suitability rating for lithology by Department of Mineral and Geoscience (2002). Higher rate shows more risky type of lithology for development. For this study area, type of rock observed are in Type III which is argillaceous rock and weathered argillaceous rock with rating 1.2 and 2.0. Type III is highest rating for development suitability due to high rate of weathering.

5.4 Land use

Kuala Betis mainly consist of forestry and plantation with some residential and infrastructure area. In Kuala Betis, forestry land use covered in the northwest and southeast of this study area. Forestry in Kuala Betis consist of Nenggiri Forest Reserve. In the southwest of this study area, the land use is focused on agriculture purpose which consist of economic purpose plantation such as palm oil plantation which managed by Liziz Plantation and Factory.

Residential area is in the center of this study area, along Sungai Betis and Sungai Berok. Government infrastructure such as Rancangan Pengumpulan Semula (RPS) Kuala Betis and Sekolah Kebangsaan Kuala Betis also located at the center of this study area.

5.5 Topography (Elevation)

Topography is one of important aspect to be considered in development suitability rating. Flat area with low elevation is suitable for further development compared to hilly area with higher elevation. In this study area, the elevation ranging from 140 m to 360 m. Table 5.2 below shows the development suitability rating based on elevation and morphological element according to Department of Mineral and Geoscience Malaysia (2002). Meanwhile Figure 5.3 shows the elevation map of study area.

Table 5.2: Development Suitability Rating based on Elevation and Morphological Element.

Elevation (m)	**Morphology Element**	**Rating**
1-60	Flat Area Inland	**0.1**
60-100	Lowland Inland	**0.3**
100-200	Low Hills	**0.6**
200-440	Hills	**0.9**

Source: Department of Mineral and Geoscience Malaysia (2002)

5.6 Slope gradient

Slope is the degree of inclination of horizontal plane. Study of slope of an area is important to determine the development suitability of an area. Higher slope is not suitable for further development, while area with slope less than 15° is suitable for development. For higher slope gradient, strong foundation is needed. Table 5.3 below shows the slope classification according to slope gradient and terrain code with their rating by Department of Mineral and Geoscience Malaysia (2002).

Table 5.3: Slope Classification Table.

Slope Gradient	**Rating**	**Terrain Code**		
<5°	1	Hillcrest/Ridge		A
>5° - <15°	2	Side Slope	Straight	B
			Concave	C
>15° - <25°	3		Convex	D
>25° - <35°	4	Foot Slope	Straight	E
			Concave	F
> 35° - <60°	5		Convex	G
>60°	6	Drainage Valley		H
		Flood Plain		I
		Coastal Plain		K
		Littoral Zone		L
		Marshy/Swampy		S
		Wave Cut Platform		W
		Alluvial Plane		X
		Undulating Hills		Y

Source: Department of Mineral and Geoscience (2002)

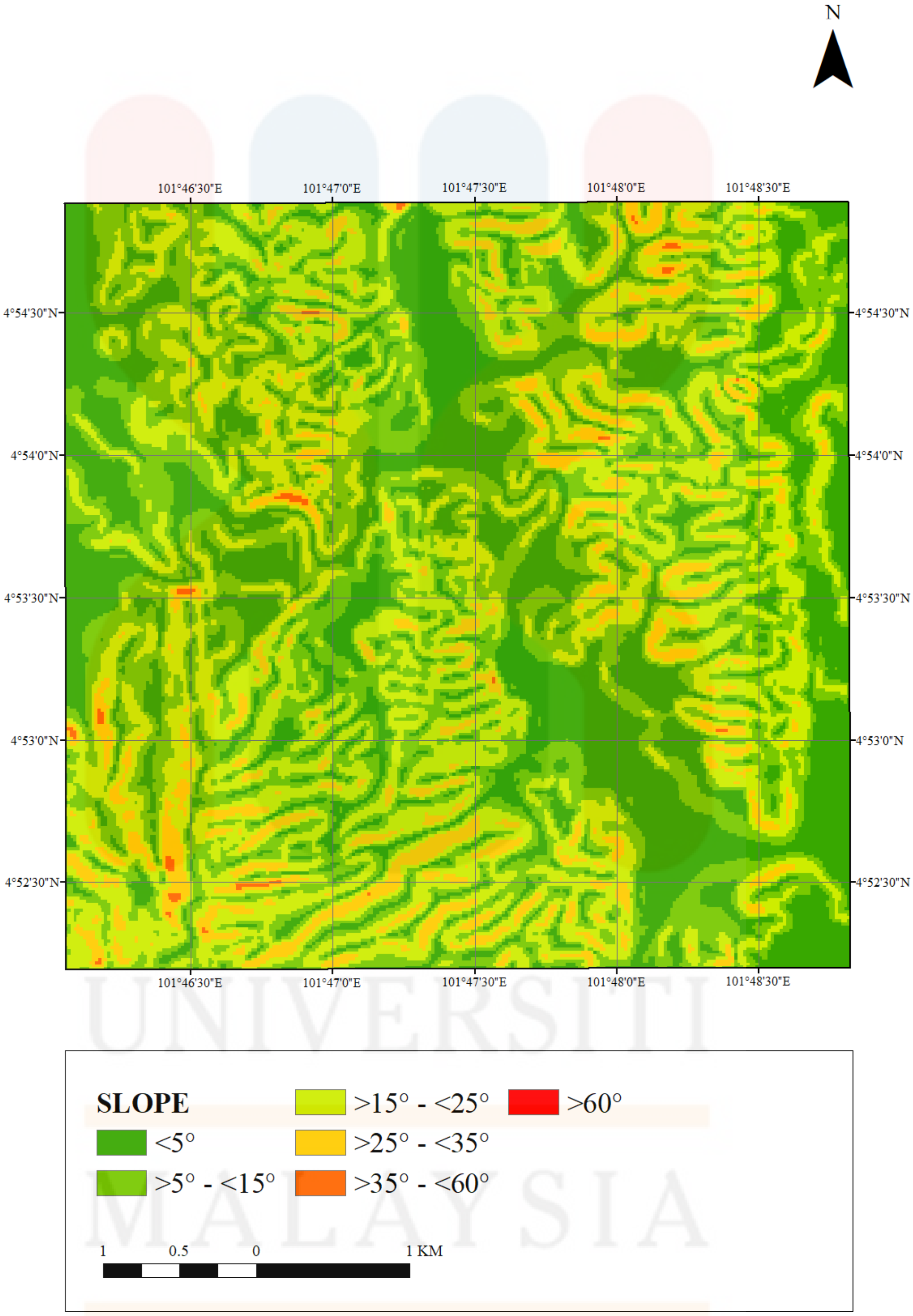


Figure 5.1: Slope gradient analysis map.

5.7 Flood/Buffer zone

Buffer zone or flood plain refers to the maximum area of land near the river which will experience flooding during high discharge. Flood plain area usually consist of alluvium layer such as clay, silt and sand deposit that transported along the river. Flood plain formed as water travel downstream eroded the river bank along it.

According to Department of Irrigation and Drainage, buffer zone area is determined by previous record of flood in the area. In the study area, previous record of flood happen is in 2014, when heavy flood hits Kelantan state when three main rivers in Kelantan water level rise above the water level that considered as dangerous. Highest record is in Sungai Galas, Dabong which water rose to 46.47 m. In the study area, heavy flood affects the settlement area which it reaches to the elevation of 160m. Most of settlement were drifted and landslide occurs along main river, Sungai Betis. Study of buffer zone is important for determination of suitable further development.

Figure 5.2 show buffer zone area in study area which classified into two type, buffer zone for main river and buffer zone for stream.

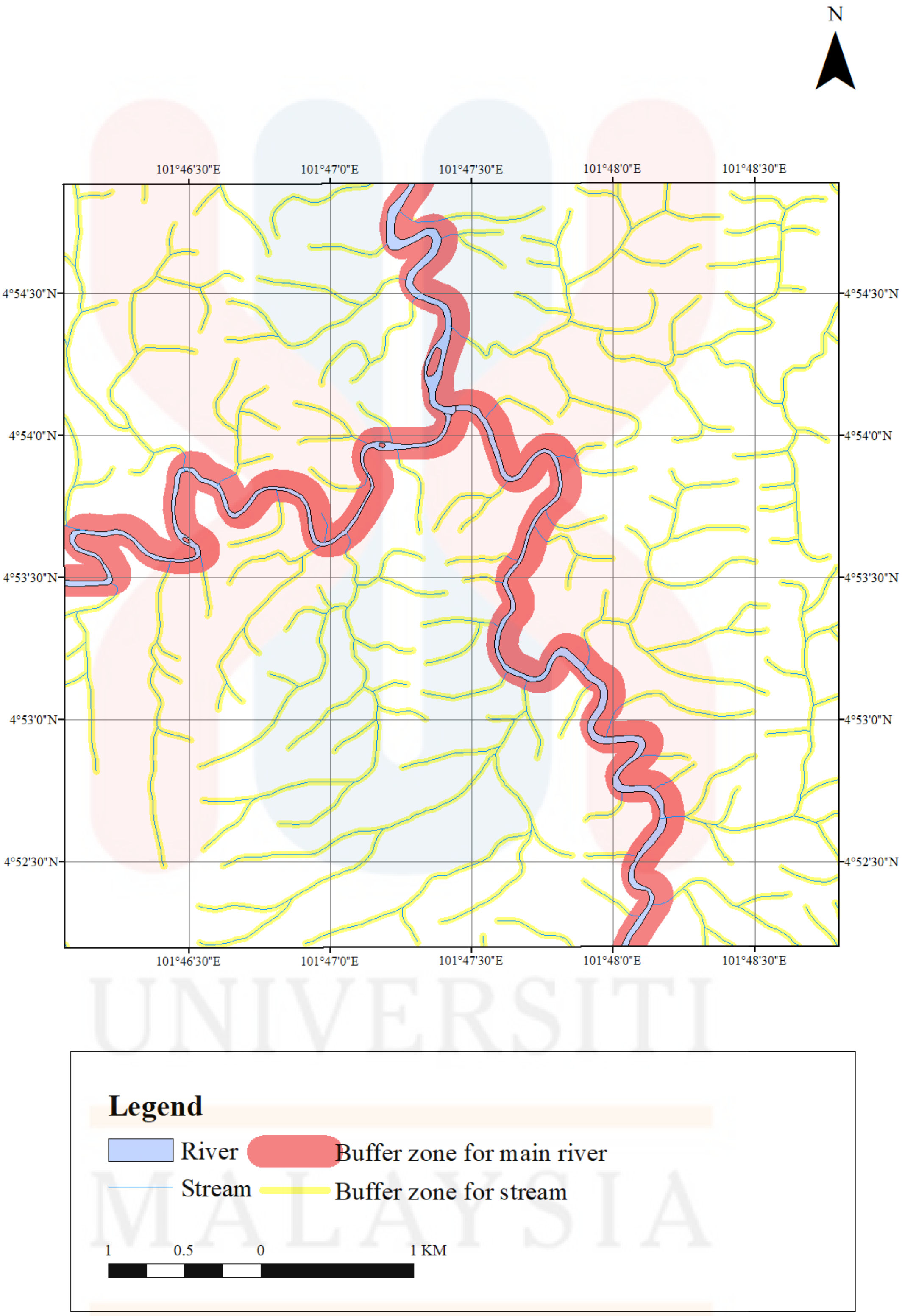


Figure 5.2: Buffer zone area in study area.

5.7 Landslide susceptibility

According to Cruden (1991), landslide is the movement of earth material down slope. Landslide is downward movement of land masses such as rock and debris along steep surface. Unconsolidated and loose material tend to be landslide. Landslide susceptibility is the tendency or likelihood of landslide to occurs in an area. Landslide can be affected by soil type and slope gradient.

Table 5.4 below shows soil classification for landslide susceptibility as guidance for future developer in planning for base and foundation in study area. Higher rating indicates higher chances of landslide to occurs. Meanwhile, Figure 5.3 shows map of landslide susceptibility in study area which categorized into three classes, no landslide possibility, low landslide possibility and high landslide possibility.

Table 5.4: Table of Soil Classification.

	Rating	**Classification**
Soil Type	1	Clayey soil with naturally formed surface
	2	Sandy soil with naturally formed surface
	3	Debris comprising rock pieces mixed colluvial
	4	Older well compacted alluvial fill material
	5	Highly weathered shale, phyllite and schist
	6	Younger loose material

Source: Department of Mineral and Geoscience (2002)

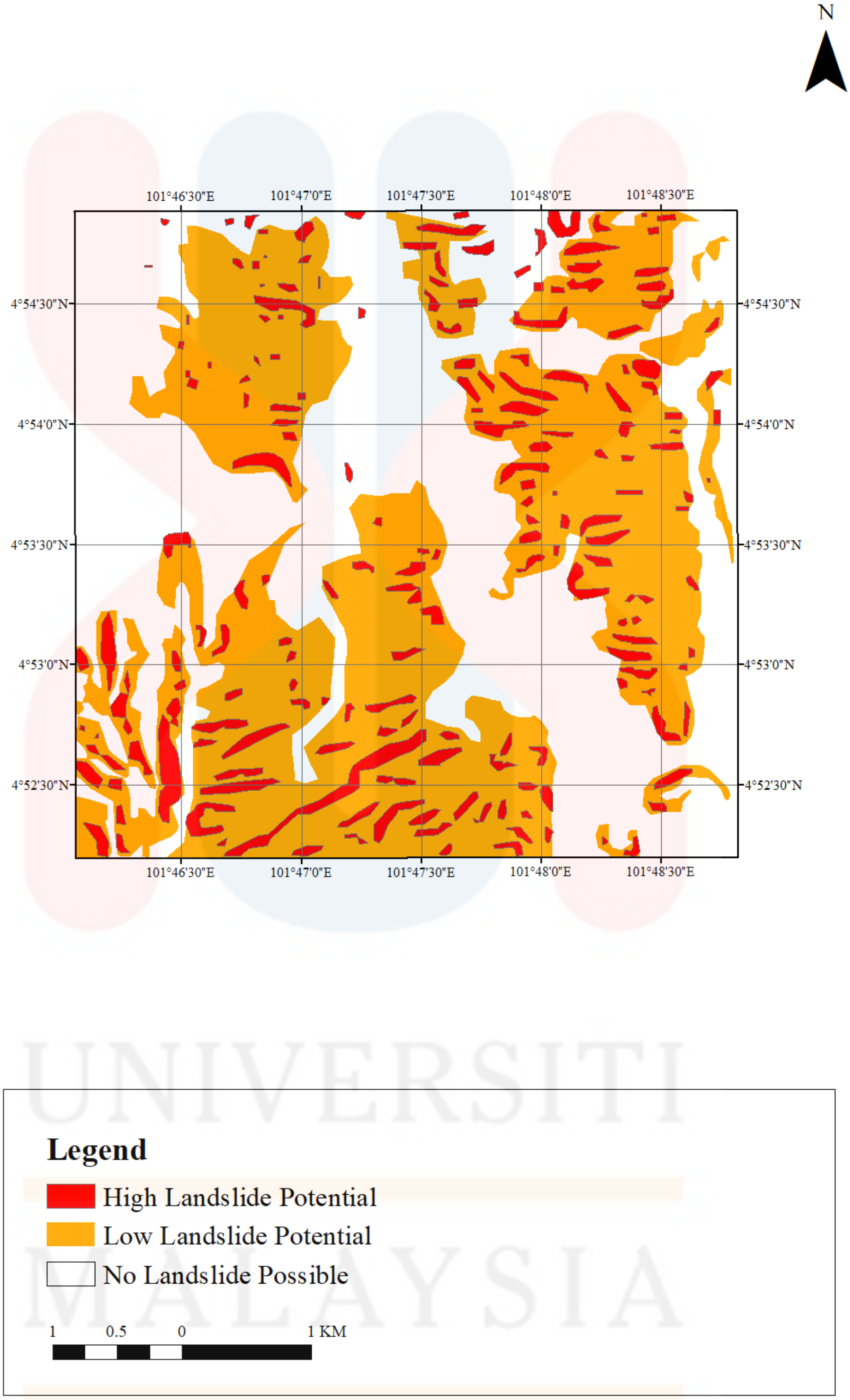


Figure 5.3: Landslide susceptibility area in study area.

5.8 Discussion

After compilation of geomorphological data such as lithology, soil type, slope gradient, buffer zone and landslide susceptibility, the final result for this research is geomorphological constrain map of Kg. Kuala Betis. These aspects are important to be considered before proceeding to planning and development. Geomorphological constraint map shows suitable and nonsuitable area for rural planning and development in for classes, Class I, Class II, Class III and Class IV as in Figure 5.7 and Figure 5.8.

From the map produced, the geomorphological constrain of study area is classified into four classes according to their condition. Class I with colour light yellow indicates that the area is low geomorphological constrain which is suitable for development with slope gradient generally below than 15°. Class I covered most of the study area.

Next, Class II with yellow colour on map. Class II indicates moderate geomorphological constrain with slope gradient generally ranging from 15° to 25°, colluvium or sensitive geological material and flood prone area. In the study area, Class II covers along the main rivers, Sungai Betis and Sungai Berok, along buffer zone area. Class III geomorphological constrain show in the map with orange colour which indicates high geomorphological constrain area with slope gradient ranging from 15° to 35°. Class III normally covered limestone, swamp, peat and mined out area. Class IV geomorphological constrain show in the map with red colour which indicates very high geomorphological constrain area with slope gradient exceeding 35° with severe erosion and instability. Class IV is not suitable for development and highly require site investigation for future development. Table 5.6 show the data construction suitability and type of site investigation required according to their classes.

Table 5.5: Construction stability classification system.

Class characteristic	Class I	Class II	Class III	Class IV
Geotechnical limitation	Low	Moderate	High	Extreme
Suitability for development	High	Moderate	Low	Not Suitable
Engineering cost for development	Low	Normal	High	Very high
Intensity of site investigation	Normal	Normal	Intensive	Very intensive
Condition	• In situ terrain <15° slope gradient • Cut slope <15°	• Hillcrest or ridges • In situ terrain >15° $to < 25°$ slope gradient with no erosion and instability • In situ terrain <15° slope gradient, comprises colluvium or sensitive geological material • Flood prone area.	• In situ terrain >25° to 35° slope gradient with no evidence and instability • In situ terrain >15° to <25° slope gradient with evidence of moderate to severe gully erosion and instability • In situ terrain <15° slope gradient comprises colluvium or sensitive geological material • Limestone, swamp, peat and mined out area.	• In situ terrain >35° to 35° slope gradient with no evidence and instability • In situ terrain >25° to <35° slope gradient with evidence of moderate to severe gully erosion and instability • In situ terrain >25° to <35° slope gradient comprises colluvium or sensitive geological material • In situ terrain >15° to <25°

Source: Department of Mineral and Geoscience (2002), after GLUM Classification System; GCO 1989.

Table 5.6: Construction Suitability Classes and Types of Site Investigation Required.

<table>
<tr><th rowspan="2">Risk Category</th><th colspan="3">Construction Suitability Class Equivalent in Geological Terrain Mapping</th></tr>
<tr><th>Class I</th><th>Class II and III</th><th>Class IV</th></tr>
<tr><td>Negligible
a) Non expected (no occupied premises
b) Minimal structural damage. Loss of access to the road</td><td>Assessment of surrounding geology and topography for indication of instability. Visual examination of soil and rock forming the site or to be used for embarkment.

Specialist advice-Requirement (A)</td><td>More detailed geology and topographical survey such as:
• Steeper slope information on soil and rock joint strength
• Survey of hydrological features

Specialist advice-Requirement (B)</td><td>Area outside confines of site to be examined for instability of soil, rock, boulder above the site.

Specialist advice-Requirement (B)</td></tr>
<tr><td>Low
a) Only small are threatened
b) Appreciable structural damage. Loss of access to the road</td><td>Geological and topological survey of site and surrounding area. Soil and rock joint strength parameters for foundation and cut slopes. For embarkment steeper than 1 on 3, recompacted strength parameter or fill

For cut slopes, information on groundwater is required.</td><td>Survey of hydrological features affecting the site</td><td>Extended investigation outside of the limits to permit analyses of slopes above and below site.</td></tr>
</table>

	Specialist advice-Requirement (B)	Specialist advice-Requirement (B)	Specialist advice-Requirement (C)
High a) More than a few b) Excessive structural damage to residential and industrial structures. Loss of access on regional trunk route.	Geological and topological survey of site and surrounding area. Soil and rock joint strength parameters for foundation and cut slopes. For embarkment steeper than 1 on 3, recompacted strength parameter or fill For cut slopes, information on groundwater is required. Specialist advice-Requirement (B)	Survey of hydrological features affecting the site. Extended investigation outside of the limits to permit analyses of slopes above and below site. Specialist advice-Requirement (C)	Extended investigation outside of the limits to permit analyses of slopes above and below site. Specialist advice-Requirement (C)
Note: Risk category a) For loss of life	Note: Requirement for specialist advice		

b) For economic loss	(A) Services for an experienced geotechnical engineer or engineering geologist are not necessary. (B) Services for an experienced geotechnical engineer or engineering geologist are depend in occasion relative to developed or developable land. (C) Services for an experienced geotechnical engineer or engineering geologist is essential.

Source: Department of Mineral and Geoscience (2002), after GLUM Classification System; GCO 1989.

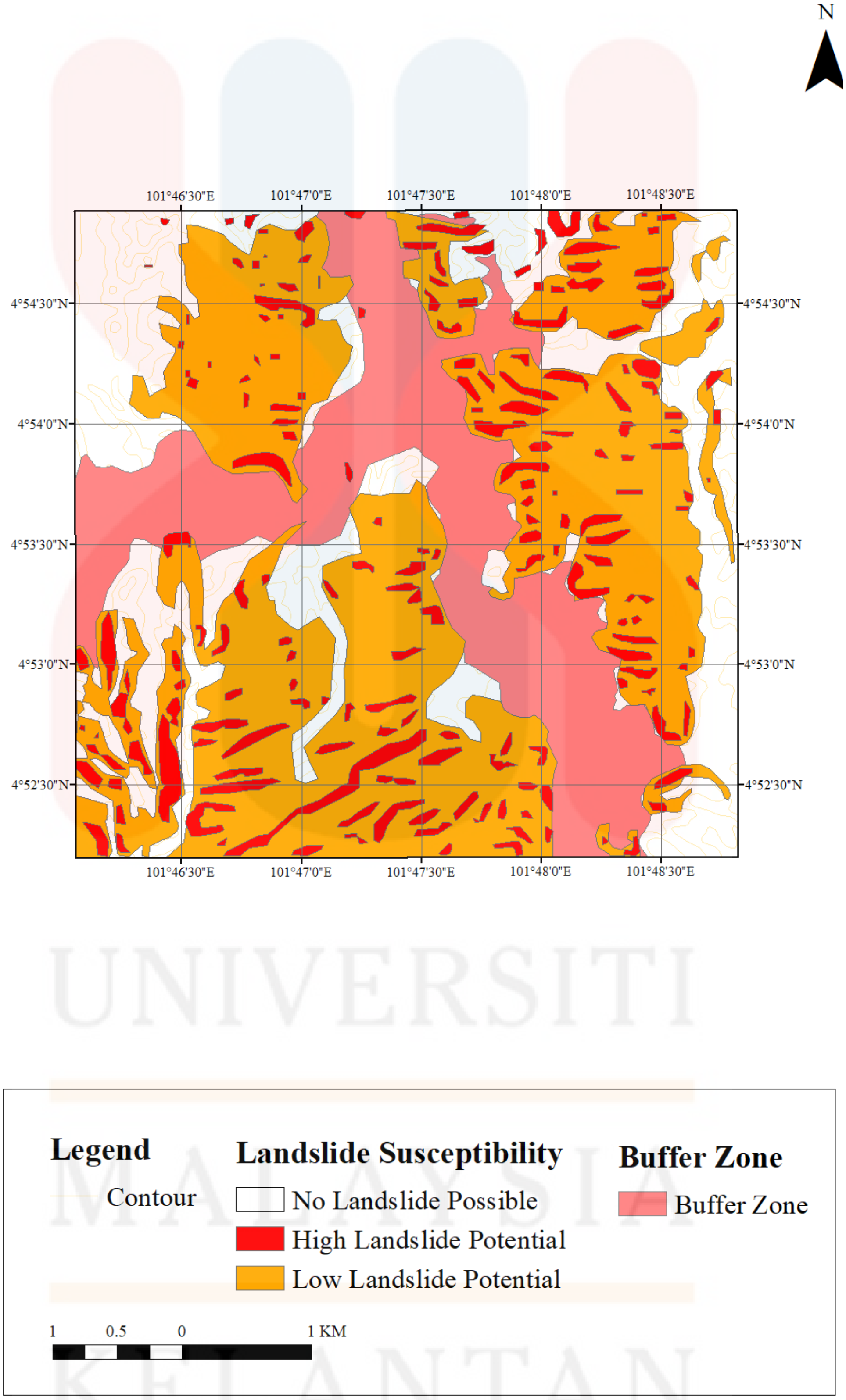


Figure 5.4: Geomorphological constrain analysis of Kuala Betis according to geological hazard possibility.

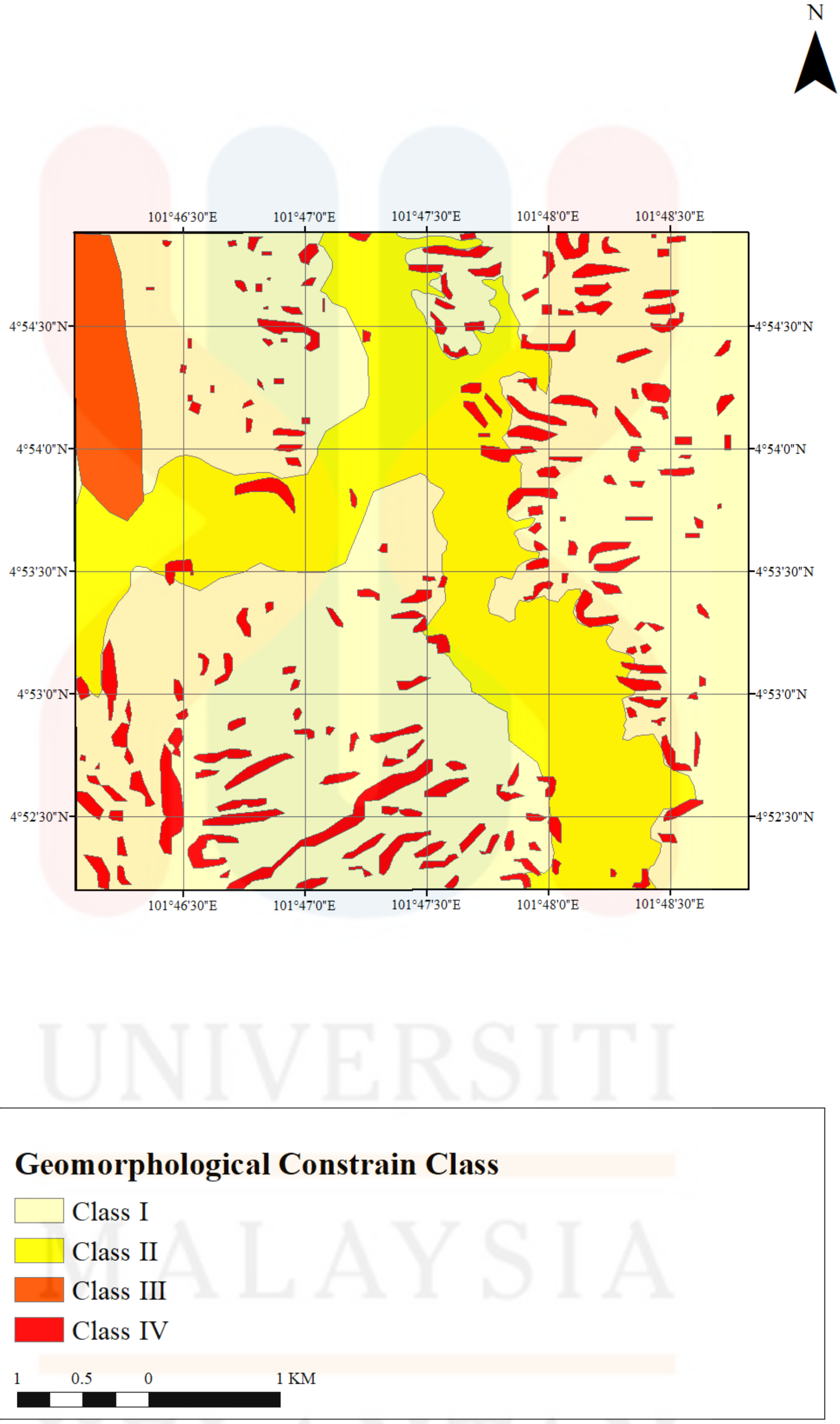


Figure 5.5: Geomorphological constrain analysis of Kuala Betis by classes according to Mineral and Geoscience Department.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Kuala Betis is suitable area for rural development research as it has high potential to be developed in the future. Geomorphological constrain analysis for rural development that have been gathered from this research study in this area are important especially for the government and developer. Early planning in rural development can lower the risk that will jeopardized the sprawl rate in Kuala Betis.

The first objective of this research study which is to update the geological map of Kg. Kuala Betis in 1:25 000 have been archive throughout two weeks of geological mapping. The identification of geomorphological constrain toward rural development of Kuala Betis, second objective of this research study such as lithology type, soil type, rainfall distribution, slope gradient, buffer zone and landslide susceptibility have been archive too. The identification of geomorphological constrain is transformed into map of geomorphological constrain analysis of Kg. Kuala Betis.

By identifying the geomorphological constrain of the study area, the third objective of this research study which is suggestion of suitable area for rural development of Kg. Kuala Betis also have been fulfil.

By completing this research, the limitation and geomorphological constrain of study area towards development and suggestion of site investigation required have been list.

6.2 Recommendation

Study of geomorphological constrain of an area is important to predict the limitation toward development. This research study will contribute to the community and government especially in development sector. Government sector and private sector can use this data produced as a reference in planning Kuala Betis in the future. This data can be useful for civil engineering field too as a guide for site investigation and foundation. This is very important as to decrease the risk of geological hazard and preserve sustainable life.

For the next researcher, the geologist should take notes on all aspect contributing to geomorphological constrain which affecting the suitability of development in an area. To conclude, this research should be continue and specified for better sustainability in the future.

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