GEOLOGY AND FOREST COVER MAPPING USING SATELLITE DATA IN KUALA BETIS, GUA MUSANG

by

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APPROVAL

"I/ We hereby declare that I/ we 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 Honors"

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DECLARATION

I declare that this thesis entitled "Geology and Forest Cover Mapping Using Satellite Data in Kuala Betis, Gua Musang" 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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Date :

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GEOLOGY AND FOREST COVER MAPPING USING SATELLITE DATA IN KUALA BETIS, GUA MUSANG

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Abstract: Deforestation is the destruction of forest for other purposes such as agriculture and urbanization. Malaysia used to have a large area of forest, but the high demand for agriculture and urbanization resulted in a high rate of deforestation in Malaysia. The objectives of this research are to produce a geological map in a scale of 1:37,000 and evaluate forest cover changes using remote sensing in Kuala Betis, Gua Musang. The study includes the identifying of geological characteristics and forest cover mapping using satellite data to detect forest cover changes in the study area. In order to produce a geological map, data and information are obtained by on-site mapping activity while to produce a forest cover map, satellite data of two different years of 2010 and 2018 are processed using remote sensing software (ENVI 5.1). At the end of the study, a geological map including a topographic map, traverse map, and drainage map was produced. A list of geological structures and rock unit in the study area also was recognized. For forest cover mapping, the results of two the different years of 2010 and 2018 show the decreasing in the area of forest cover in the study area. Besides of forest area, the other types of parameters such as water body, agriculture, and bare soil area were also been identified. As the conclusion, all the objectives of the research were successfully achieved as the map that is required are produced and analyzed.

Keyword: Forest cover; Satellite data; Kuala Betis; Remote Sensing; Deforestation

GEOLOGI DAN PEMETAAN LITUPAN HUTAN MENGGUNAKAN DATA SATELIT DI KUALA BETIS, GUA MUSANG

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Abstrak: Penebangan hutan adalah pemusnahan hutan untuk tujuan lain seperti pertanian dan urbanisasi. Malaysia pernah mempunyai kawasan hutan yang besar, tetapi permintaan yang tinggi untuk pertanian dan urbanisasi menyebabkan kadar penebangan hutan yang tinggi di Malaysia. Objektif kajian ini adalah untuk menghasilkan peta geologi pada skala 1:37,000, menghasilkan dan menilai perubahan litupan hutan menggunakan penderiaan jauh Kajian ini merangkumi pengenalan ciri geologi dan pemetaan litupan hutan menggunakan data satelit untuk mengesan perubahan kawasan hutan di kawasan kajian.. Untuk menghasilkan peta geologi, data dan maklumat diperoleh dengan aktiviti pemetaan di tapak sementara untuk menghasilkan peta litupan hutan, data satelit dua tahun yang berbeza iaitu tahun 2010 dan 2018 diproses menggunakan perisian penderiaan jarak jauh (ENVI 5.1). Pada akhir kajian, peta geologi termasuk peta topografi, peta tinjauan, dan peta saliran telah dihasilkan. Senarai struktur geologi dan unit batu di kawasan kajian juga dikenali. Untuk pemetaan litupan hutan, hasil dua tahun yang berbeza iaitu tahun 2010 dan 2018 menunjukkan penurunan di kawasan litupan hutan di kawasan kajian. Di samping kawasan hutan, jenis lain parameter seperti badan air, pertanian, dan kawasan tanah yang terdedah juga dikenalpasti. Sebagai kesimpulan, semua objektif penyelidikan berjaya dicapai kerana peta yang diperlukan dapat dihasilkan dan dianalisis.

Kata kunci: Litupan hutan, Data satelit, Kuala Betis, Penderiaan jarak jauh, Penebangan hutan

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LIST OF ABBRECIATION

km^2	kilometer per square
GPS	Global Positioning System
m	meter
USGS	United States Geological Survey
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
ENVI	Environment for Visualizing Images
UTM	Universal Transverse Mercator
WGS	World Geodetic System
ETM	Enhanced Thematic Mapper
GIS	Geographic Information System
ETM+	Enhanced Thematic Mapper Plus
OLI	Operational Land Imager
TIRS	Thermal Infrared Sensor
HCl	Hydrochloric acid
PPL	Plane polarized light
XPL	Cross polarized light
N	North
LULC	Land use land cover

LIST OF SYMBOLS

%	Percentage
°	Degree
‘	Minutes
“	Seconds
+	Plus

CHAPTER 1

INTRODUCTION

1.1 General Background

The research project entitled Geology and Forest Cover Mapping using Satellite Data in Kuala Betis, Gua Musang, Kelantan. The main reason to conduct the geology is to know the geological characteristics in the research area. Structural geology and characteristics of Kuala Betis can be detected and studied to understand the geological process that has been occurred. Geology classification consists of geomorphology, stratigraphy, structures, and deformation. Geomorphology states about the landscapes and landforms such as topography, drainage, and terrain. Stratigraphy is more to concern with the order and relative position of strata and their relationship to the geological timescale, while structures and deformation are involving the formation and occurrence of basins.

Deforestation is the permanent destruction of forest in order to make the land available for other uses (Bradford, 2018). Forests give a lot of supply and income to human also act as a primary home for flora and fauna. Malaysia consists large area of forest but now, Malaysia is known as the country with the highest rate of deforestation in the world which the rate keeps increasing every year. Deforestation can give big impact and effect on land and living things. Deforestation also can be caused by the extinction of flora and fauna.

The main reason to conduct forest cover mapping using remote sensing is to detect changes in forest cover. With the mapping of forest cover, the remaining forest resources can be managed in a suitable manner. Most of the deforestation in Malaysia is caused by urbanization, commercial supply, and agriculture. People cut down trees to make space for new building construction and for income supply. Impact of deforestation can cause loss of species, soil erosion, damage the water cycle and disturbing the life quality.

There are various methods in the mapping of forest cover using the remote sensing technique. Various types of remote sensing data can be used to determine the deforestation activities and produce the new forest cover map. Using remote sensing application can be beneficial because it is low-cost production, also saves time and energy especially at the inaccessible area.

1.2 Study Area

1.2.1 Location

Figure 1.1 refers to a map of Gua Musang and Kuala Betis. Gua Musang is a town and the largest district in Kelantan. Gua Musang is surrounded by the state of Pahang (in the south), Terengganu (in the east), Perak (in the west) and other Kelantanese districts of Jeli and Kuala Krai (in the north). Gua Musang also located close to the Taman Negara (National Park) in the northern gateway at Sg. Relau near Merapoh, Pahang.

Figure 1.1: Map of Gua Musang and Kuala Betis

The study area is located in Kuala Betis, Gua Musang, Kelantan. Kuala Betis is located about 40 km south from Gua Musang. Figure 1.2 indicates the base map of Kuala Betis. The base map covered about 25 km^2 of area coverage.

1.2.2 Accessibility

Gua Musang can be accessed by car and public transport. There are two federal routes that can be used to reach Gua Musang which is Kota Bharu northwards that leads to the state administrative center, and another route that connect Simpang Pulai near Ipoh, Perak in the west to Kuala Jenderis in Hulu Terengganu in Terengganu in the east. Kuala Betis can be accessed by car, motorcycle and by boat. But, to enter the village road and the hill road, only motorcycle and trucks are recommended because of the rough surface of the hilly road.

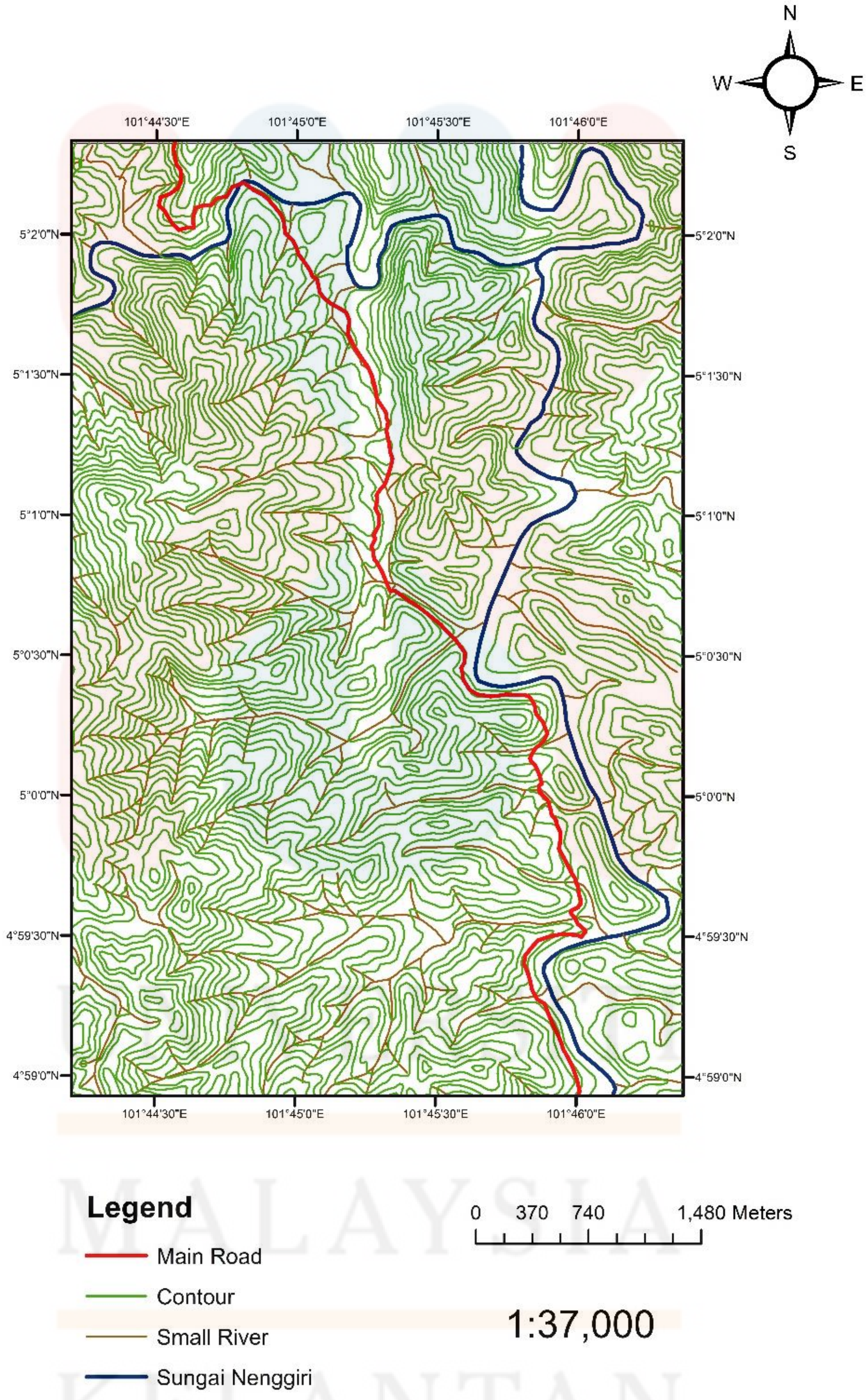

Figure 1.2: Base map of the study area in Kuala Betis

1.2.3 Demography

The total population of 2010 in Kelantan district are shown in Table 1.1 below. The total population data were obtained from the Department of Statistics Malaysia. It shows that the total population of Gua Musang was about 90,057, from a total of 1,539,601 of overall Kelantan population.

Table 1.2 shows the total population by nationality and ethnic group of 2010 in Kelantan. Kelantan population mainly consists of Malaysian citizens which are Bumiputra, Chinese, Indians, and others, also Non-Malaysian citizens.

Table 1.1: The total population of Kelantan district in 2010

District	Population
Kota Bharu	491,237
Pasir Mas	189,292
Tumpat	153,976
Pasir Putih	117,383
Bachok	133,152
Kuala Krai	109,461
Machang	93,087
Tanah Merah	121,319
Jeli	40,637
Gua Musang	90,057
Total	**1,539,601**

Table 1.2: The total population of nationality and ethnic group of Kelantan in 2010

Malaysian	**1,439,640**
Bumiputera	1,378,352
Chinese	48,787
Indian	3,658
Other group	8,843
Non-Malaysian	**31,056**

1.2.4 Land use

In Gua Musang, there is an effort to eliminate poverty in the rural population by project implementation by the government to bring forth growth center based on agriculture in a rural area, known as agropolitan development. Most of the lands are used as farming area (usually by the villagers in these rural areas) and plantation. Two types of the plantation which are oil palm and rubber trees were handled by Federal Land Development Authority (FELDA) and South Kelantan Development Authority (KESEDAR).

1.2.5 Social Economic

Gua Musang became popular with cavers and rock climbers because it was totally surrounded by limestone hills. There are few archaeological sites can be found in caves such as Gua Cha, Chawan and Jaya. Also, a Buddhist temple that was reportedly aged about 400 years old in Pulai, and Perias River that is popular with river rafting activities. Gua Musang has a high potential as a tourism and a heritage site. Residents in Gua Musang work in various sectors, because of Gua Musang locality in a city area.

While in Kuala Betis, most of the Orang Asli still living as a nomadic; which their main economic are agricultural activities, collecting forest products, hunting, and some of them already works as government staff such as a teacher, in business, employees of Jabatan Hal Ehwal Orang Asli (JHEOA) and others.

1.3 Problem Statement

In the research area, there is less information on geological aspects such as structures, geomorphologies, and stratigraphic data. The lacked data was due to the lack of research and the difficulties of accessibility in the study area. Also, existed a geological map of Kuala Betis need to be updated so that new information can be added. New land use planning and natural disaster can change the characteristics of the geological structure of the study area.

Forest resources are being poorly managed and lead to geological hazard because of the high level of living that tend people to deforestation for oil palm plantations, logging and mining, forest fires, and tourism (J. Melanie, 2013). Therefore, this research was conducted in order to map and detect changes of forest cover in Kuala Betis, Gua Musang because of timely information on forest cover is required to help the government to ensure that the remaining forest resource is managed in a sustainable manner.

1.4 Objectives

1. To produce a geological map of the study area in scale of 1:37,000
2. To produce the forest cover map in Kuala Betis
3. To evaluate land cover changes and vegetation using remote sensing technique

1.5 Scope of Study

Geology mapping was required to know the geological characteristics of the study area and update the geological map including new information collected. Fieldwork is the main activity needed to do the general geological mapping. Various mapping equipment (i.e. GPS, hammer, compass, and measuring tape) and ArcGIS software for map production are needed. Data such as traversing and sampling were analyzed to produce a new geological map.

In the research of forest cover using satellite data, remote sensing data from Landsat images and remote sensing software which is ENVI 5.1 are used to ease the progress of new forest cover map production. It is also used to detect the rate of deforestation activities in the study area in Malaysia. The data about the research area is collected and then processes using the remote sensing software. Secondary data such as data from Global Forest Watch website (www.globalforestwatch.org) is required to detect the accuracy assessment of the produced map. The complete forest cover maps of the research area can be done without the need to go to the site.

1.6 Significance of Study

Data collection recorded give new information of the study area in the term of geological structure, geomorphology, and other geological classification. Production of the new geological map provides other people new information of geological characteristics, thus updating the existing map of the study area.

The data of the research area that are obtained are processed using suitable remote sensing data and software. Remote sensing data and software is the most suitable instrument as the researcher did not need to go to the site, so it is basically cost-effective, time-saving and environmentally friendly. The expected results of deforestation and disturbance provides information such as forest resources, and percentage of land cover changes and vegetation; that can be used to protect the forest being logged and can also help the responsible authorities to preserve and conserve the forest against loss, which can be used in making replantation plans to regain the forest area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the regional Geology and tectonic setting, stratigraphy, structural and historical geology of the study area based on previous research. Gua Musang Group consists of Gua Musang Formation, Aring Formation, and Nilam Formation. Each formation was grouped and divided based on their lithologic unit. Gua Musang also located in the Central Belt. The general geology in Kuala Betis, Gua Musang acquires fieldwork for data collection and then analyzed to produce a new geological map.

Besides, these sections also discussed various techniques that have been used to detect forest cover and monitor the changes over a period of time. Forest cover loss that occurred was due to urbanization, deforestation and vegetation activities. Loss of forest cover can lead to geological hazard and biodiversity disruption. The use of remote sensing data and software in forest cover mapping contributes to the better conservation and management of forest resources in Malaysia.

2.2 Regional Geology and Tectonic Setting

The fossil assemblages in the northern area of Central Belt are correlated with other regional warm Paleo-Tethys fauna such as Lengwu fauna in South China (Liang, 1990) and Kitakami Mountains in Japan (Tazawa et al., 2000). The deposition of pyroclastic and volcanic caused by regional volcanism in the area build up marine topographic highs by its deposition within the Seaway (Lim and Abdullah, 1994; Leman, 1995). As the suturing of Peninsular Malaysia was in progress at the midst of the Indosinian Orogeny, the Paleo-Tethys Ocean and Sibumasu terrane were being subducted under the Indochina volcanic arc (Tija and Almashoor, 1996; Metcalfe, 2000). The subsidence and basin segmentation that occurred within the forearc basin during Middle Triassic opened the deep marine setting of Semantan - Gemas Basin, which similar to the Aceh/Simulue/Nias basins of West Sumatra.

The forearc basin subsidence and segmentation of Permo-Triassic Indosinian Orogeny are based on four differences geologic time. In Early Permian, deposited thick argillite and volcanic are in adjacent with Indochina volcanic arc, as in the current Aring and Telong Formation. Singa Formation pebbly mudstone and Kubang Pasu Formation argillite were deposited in the west. As the Paleo-Tethys Ocean subducted, the accretionary complex build up.

In Middle-Late Permian, Gua Musang platform with shallow marine was created by thick argillites and volcanic and suitable for the development of carbonate and benthic fauna. While forearc basin starts to terminate, volcanism peaks up. In Early

Triassic, increased forearc subsidence in Gua Musang platform creates more accommodation space for deposition of carbonate-argillite-volcanic. At this time, Paleo-Tethys Ocean is subducted completely as Sibumasu was docked into Indochina.

In the last stage, which in Middle-Late Triassic, the process of basin segmentation on the subsiding Gua Musang platform was assisted by oblique subduction of Sibumasu. The process also creates deep marine Semantan - Gemas basin. The basin was surrounded by shallow marine platform as illustrated by the Central Belt geometry that was observed today.

2.3 Stratigraphy

Works by Mohamed et al (2016) have shown that a map by Yin (1965) describes that Gua Musang Formation which located in south Kelantan – North Pahang are from Middle Permian to Late Triassic argillite, carbonate and pyroclastic/volcanic facies within Gua Musang area. Gua Musang Formation also has the same lithology with Felda Aring called Aring Formation. Lateral facies in Aring Formation and Telong Formation based with their similar lithologies explained that these lateral facies changes of sediments are in the same group as Gua Musang platform.

Aw (1990) states that Aring Formation is dominant for its pyroclastic unit, Telong Formation for its dominant argillite unit, and Nilam marble for its metamorphosed limestone. While Gua Musang platform in northern boundary concluded to be surrounded by low to medium grade metamorphic rocks of the Carbo-Permian Mangga Formation (The Malaysian-Thai Working Group, 2006) and Taku Schists (MacDonald, 1967) in the north.

The sedimentological assessment of Gua Musang Group is categories in three facies, which are, argillaceous facies, carbonate facies, and volcanic/pyroclastic facies. Argillaceous facies area consists of siltstone, shale, slate, mudstone, and phyllite. In Gua Musang and Telong Formation, argillaceous facies present as dominant facies but in Aring Formation and Nilam Marble, its presence as interbeds or lenses. Exposed road roadcuts along the Merapoh-Kuala Lipis shows the argillite-carbonate interbeds from hundreds of meters of light-medium grey fissile shale that interbedded with thick-bedded medium gray carbonate bodies. Thin argillite which interbeds with thick-bedded calcitic marble is found in the Nilam Marble.

Carbonate facies that are exposed usually created karst topography such as trending limestone hills and pavement. Carbonate facies in Nilam Marble are dominant, extensive in Gua Musang Formation, and forming beds/lenses in Telong and Aring Formation. In Gua Panjang, there were Carbonate-volcanic interbeds observed. The presence of thin and localized carbonate beds/lenses within thick volcanic and pyroclastic sections in Aring shows that Aring location is close to the volcanic source compared to Gua Musang during Permian.

In Aring Formation, the volcanic facies are dominant and are interlayered with carbonate and argillite. In Kuala Betis-Lambok roadcuts, tuffaceous shale and tuffaceous sandstone can be seen. The volcanism activities in this area are more rhyolitic composition near to the Gua Musang area. The instant level of volcanic activity shows the bulk volume of volcanic/pyroclastic deposits.

Kuala Betis village located about 40 km west of Gua Musang town. According to Leman (1995) shows that Kuala Betis geology is mainly from Permo-Triassic metasedimentary-pyroclastic sequence (Aw, 1974) which later considered as the Gua Musang Formation by Kamal Roslan Mohamed et al. (1993). Many fossiliferous localities from Kuala Betis area were discovered. Some of it consists of Permian flora and fauna including ammonoids, while others consist of Triassic fauna. The Permian ammonoid faunas found are from two different locations, from Sungai Peralong and Sungai Berok.

The crop out along the Sungai Peralong timber track shows several exposures of sedimentary rocks from steep dipping to vertical. These rocks consist of thin to thick bedded tuffaceous mudstone, siltstone, and sandstone; with some of it are thin to moderate bedded tuffaceous siltstone and mudstone within a distance of 50 m from the log bridge. Some cephalopod remains are found in both on the northwest and southeastern area, where the collection comes from nearby river exposure.

In Sungai Berok, the cephalopod fauna is found in a road cut exposure about 200 m Southwest of Belau Bridge. The exposed road cut also shows some thin bedded of chert and cherty mudstone interbedded with laminae, or a very thin layer of tuffaceous shale. In this thin layer of tuffaceous shale is where the fauna is preserved commonly.

2.4 Structural Geology

There are several geological structures has been identified during basin subsidence and segmentation. The structures occurred are first, relative motion between the volcanic arc and accretionary complex; second, extensional faulting (Izart et al., 1994); third, pre-existing fault zones reactivation in overriding plate (Dorobek, 2008); fourth, tectonic rotation caused by accretionary complex growth, loading, and underplating and basin widening (Coulbourn & Moberly, 1977); fifth, magmatic arc cooling that cause thermal contraction (Moxon & Graham, 1987); sixth, separated strain by oblique subduction (Izart et al., 1994); seventh, crustal thinning that occurred by basal erosion from subducting plate (Cliff & MacLeod, 1999); and lastly, isostatic adjustment on the overlying plate of subducting slab (Moxon & Graham, 1987; Kobayashi, 1995).

2.5 Historical Geology

The formations of Gua Musang were deposited during the Permo-Triassic time within the Paleo-Tethys Seaway of Central Belt, in a warm and shallow marine environment, based on its evidence on sedimentology and paleontology. Argillite-carbonate interbeds presence shows the depositional interaction during the time of high-low supply of detrital from neighboring landmass.

Presence of volcanic in all types and sizes such as tuff, lapilli, and agglomerates demonstrate a depositional environment that closes with the volcanic source. Deposition of volcanic and pyroclastic caused by regional volcanism accumulates marine topographic highs on its deposition inside the Seaway. Then, the topographic highs formed by shallow environment were beneficial for the deposition of limestone and for various shallow water fauna to flourish.

2.6 Forest Cover in Malaysia

Forest cover refers to all lands more than one hectare in area, with a tree canopy density of more than 10 percent irrespective of ownership and legal status (data.gov.in). Most forest cover losses are caused by deforestation, urbanization, and vegetation. Deforestation and urbanization activities can give effects to the surrounding forest cover area and also to the flora and fauna of the affected area. While severe vegetation degradation results in biodiversity loss and land degradation.

2.6.1 Remote Sensing in Forest Cover Mapping

Geospatial technologies such as remote sensing nowadays act as the best efficient tool for analyzing the forest cover area. Many researchers choose geospatial technology to conduct their research to ease them monitoring any changes by using satellite images. Remote sensing data with sufficient spatial and high temporal resolution datasets are effective for forest cover mapping and monitoring (Lu et al., 2004). Using remote sensing in forest cover mapping are mainly to map and detect changes recording to forest cover area in terms of deforestation activities or any disturbance. By monitoring the changes of forest cover area, information regarding the affected area can be studied, thus further proper planning for sustainable management can be conducted.

Satellite images such as Landsat provide high-quality, multi-spectral imagery of the surface of the Earth. Satellite images of few different years are obtained to detect the forest cover changes throughout the years. The satellite images obtain then will be processed using remote sensing software to detect the change of the forest cover area. Secondary data such as existing forest cover map of the study area from government agencies such as Forestry Department Peninsular Malaysia (FDPM) is needed to assess the accuracy of the forest map of the study area with the forest cover statistics produced by the agencies.

2.6.2 Data Sources of Forest Cover Mapping

Forest cover mapping and monitoring using remote sensing are effective with sufficient spatial and high temporal resolution of datasets (Lu et al., 2004). Variety of digital image processing techniques and remote sensing data from aerial photography to high and medium resolution optical imagery and from hyperspectral data to active microwave (SAR) satellite data have been applied to monitor forest cover changes.

Works by Kanniah et al., (2016) have shown that remote sensing data used are Landsat 8 (2010) and Landsat 5 (1990). One Landsat scenes for 1990 and 2010 respectively are downloaded from the USGS Global Visualization Viewer (GloVis) website (http://glovis.usgs.gov) with < 20% cloud cover coverage. The Landsat images downloaded were georeferenced with UTM, Zone 47 North projection and WGS 84 datum. Other data used was the Johor state Land use maps in the year 1990 and 2010 obtained from the Peninsular Malaysia Agricultural Department with a scale of 1:75 000.

While works by Aliero et al., (2017) have shown that satellite images of Landsat of 1986, 1996, 2006 and 2016 were downloaded from United States Geological Survey (USGS) website with Path and row 191/51 and 191/52. To determine human influences on land cover change (LCC) and vegetation dynamics (VD), field and other secondary data were collected. Also, some simple random sampling survey technique was conducted by interviewing the respondent using a structured questionnaire.

2.6.3 Data Analysis of Land Cover

Basically, forest cover loss within the field of view of a satellite sensor is defined as tree canopy that is totally removed at the pixel scale (i.e. 30 m for Landsat sensor) (Hansen et al., 2013). To detect and monitor forest cover loss over a period of time, various techniques have been used such as multi-date classification (Desclée et al., 2006), object-based classification (Berberoglu and Akin, 2009), visual interpretation (Sakthivel et al., 2010), support vector machine (SVM) (Huang et al., 2008), maximum likelihood classification (Sire'n and Brondizio, 2009; Valožić, and Cvitanović, 2011; Forkuo and Frimpong, 2012) and artificial neural networks (ANN) (Sugumaran, 2001).

Forest cover mapping and change information extraction from satellite data can be automatically done with the help of current software development.

Works by Kanniah et al., (2016) have shown that Landsat data in time between 1990 and 2010 were observed to detect forest cover change due to economic development in Iskandar Malaysia (IM) during the period and the availability of Landsat data. For radiometric correction, the Digital Numbers (DN) of each pixel are converted into radiance using conversion factors (gains and offsets) from the satellite sensors provider (i.e. Landsat) (CLASlite, 2013).

CLASlite steps for the image processing including i) Image calibration, ii) Map fractional cover, iii) Map forest cover, and iv) Map forest change (deforestation & disturbance). Lastly, forest cover statistics produced by Iskandar Regional Development Authority (IRDA) were used to validate the accuracy of forest cover that is extracted from the Landsat images.

While works by Aliero et al., (2017) have shown that the remote sensing data were processed in three main steps; first is preprocessing that include image enhancement, radiometric calibration, ETM fills gap and image rectification carried out mainly to standardize the imagery prepared for processing. Second, processing that includes classification of the thematic classes of land cover such as dense vegetation, shrubs/build area, farmland, bare/grassland and water body using ENVI 5.1 software. Third, posts processing that includes classification accuracy assessment and change detection (CD) by map the area using some random sampling technique.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter discusses the materials used for data collection and other information to comply with all the objectives stated in Chapter 1. Production of geological map and forest cover map including several different kinds of maps for a different purpose, different scales and different types of terrain. Therefore, various materials and methods are used and sometimes it was different with each type of map. Data collection should be taken as much as possible based on the objectives of the study. Geological profiles of the study area location were predetermined in order to describe the basic units, their boundaries and possibly take a sample.

3.2 Materials

3.2.1 Materials for Geological Mapping

Materials used for geology research is Global Positioning System (GPS), measuring tape, compass, hammer, and base map. GPS is used to determine the geological information such as location, coordinate and tracks of the study area. The measuring tape is used to measure the size or length of outcrop, river or road. Compass is used to take a dip and strike reading, also to know the direction of the wanted location. Hammer used in geological mapping is mostly to take rock sample from large outcrops.

The base map is important because it is used in identifying the overall map of the study area. Base map can show what type of geological structure and geomorphology of the study area.

3.2.2 Materials for Forest Cover Changes

For evaluation of forest cover mapping, materials used are satellite image, GIS software, remote sensing software, and secondary data such as existing forest cover map. GIS software used is ArcGIS 10.2, mainly to produce the base map of the study area. Another map such as traverse map and geological map also was produced using ArcGIS 10.2 software. While remote sensing software used is ENVI 5.1, mainly to process, analyze, and produced the forest cover map from the satellite image. Satellite images are downloaded from USGS Earth Explorer website.

a) Satellite image

Satellite images of the year 2010 and 2018 were downloaded from the USGS Earth Explorer website. LANDSAT satellite images were chosen because it offers critical and irreplaceable capability to observe land use and land use change across those scales (Landsat Science). Landsat satellite images used in this research are Landsat 7 Enhanced Thematic Mapper Plus (ETM+) C1 Level-1 (2010) and Landsat 8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) C1 Level-1 (2018). The image of Landsat 7 was taken at Path 127, Row 57 on February 1, 2010, with a cloud cover of 5.00 (Figure 3.1), while the image of Landsat 8 was taken at Path 127, Row 56 on February 15, 2018, with a cloud cover of 14.02 (Figure 3.2)

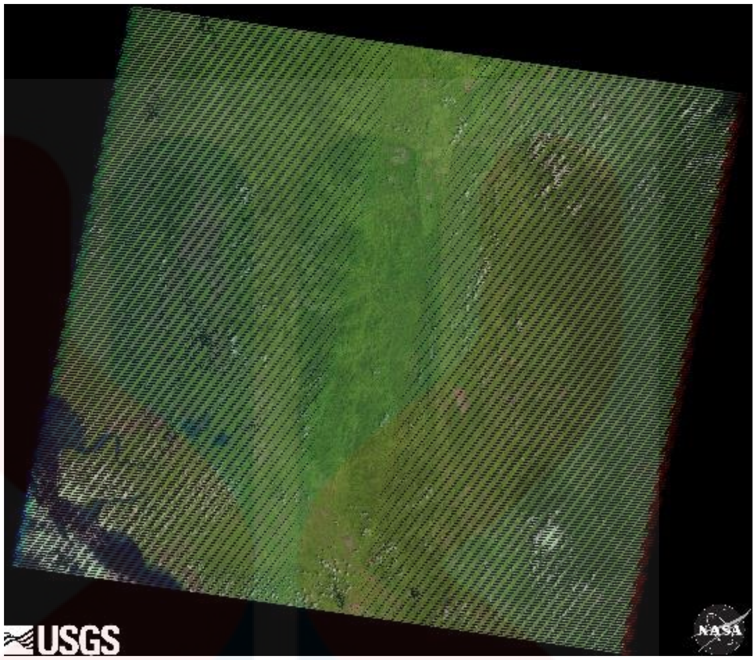

Figure 3.1: Satellite image of Landsat 7 on 1 February 2010

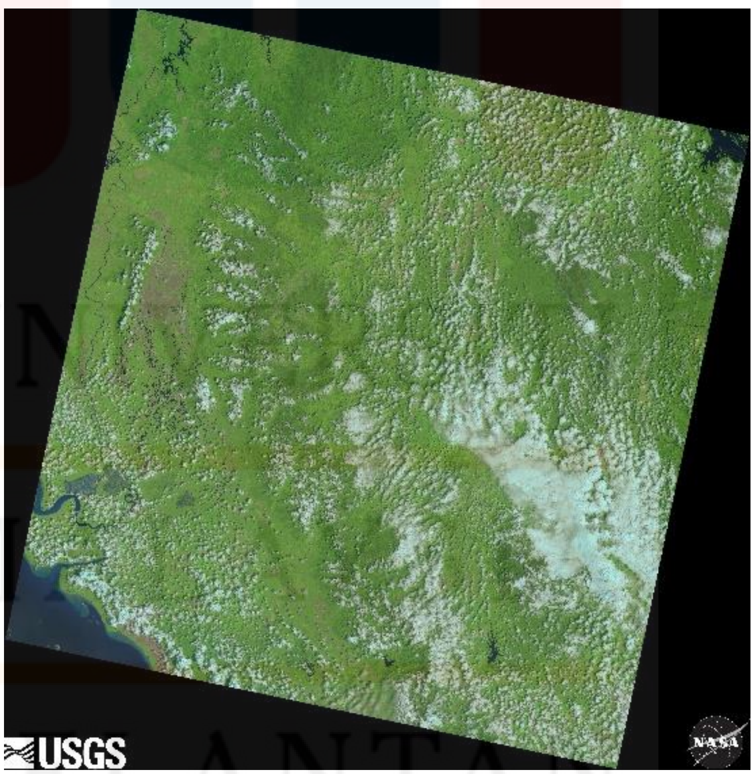

Figure 3.2: Satellite image of Landsat 8 on 15 February 2018

b) ENVI 5.1 and GIS Software

ENVI 5.1 remote sensing software was used to maximize the processing and results of the forest cover map into different classes. ArcGIS was used to generate the other map such as base map, geological map and topography map of the study area.

c) Data and Information

Other data and information such as land use of the study area were obtained. Secondary data such as existing forest cover mapping by Global Forest Watch website (www.globalforestwatch.org), is required to detect the accuracy assessment of the new forest cover map produced.

3.3 Methodology

3.3.1 Preliminary Studies

Before starting the field mapping, some preparations were done to simulate a field site. The preparations are desktop studies, site characterization, and geoprocessing techniques. Desktop studies were begun by learning about the rock characteristics of the study area using available geological maps and reports.

In site characterization, the study area hydrological aspects such as river were studied. The river plays an important role to know the basic geologic of the study area and its geomorphology. Availability of underground water in the study area was studied to know the rock porosity, granular and fractures according to the lithological characteristics. Meteorological and rainfall data were obtained to know the forecast data for hydrological aspects. While geological data also are studied to know the geology of the study area such as their ages, geological structures, and stratigraphic units.

Geoprocessing techniques such as software are needed for base map production of the study area. The scope, locations, geological characteristics and accessibility of the study area were carried out. The socio-demographic of the study area also were studied to know better about the area.

3.3.2 Field Studies

During the field, mapping skills such as compass use, walking contacts, outcrop descriptions, and others were used. Detailed outcrop mapping was studied to understand the bedrock geology of the study area. Structural characteristics of the bedrock such as size, type, and fractures location, also physical characteristics of rock such as color and texture were observed. These field observations were used to construct geologic maps, cross-sections, and stratigraphic columns. Also, the field observations were used to interpret the geologic history of the field area and to integrate it with regional and global geology.

3.3.3 Laboratory Processing

The rock sample obtained were processed using laboratory equipment to detect their types and its mineral contribution. Hand lens was used to observe roughly of the mineral present by the naked eye to know the possible name of the rock sample. Then, a thin section of the rock sample was observed using microscopes to detect the rock sample mineral composition in details to know the precise name of the rock sample based with the presence of its mineral composition.

3.3.4 Data Processing

For geology, the data collection, traversing and sampling recorded obtained such as lithostratigraphy, the occurrence of structural geology, rock description, and total tracks were processed. Coordinates by the GPS also were processes to know the location of every detail in the data collection obtained. ArcGIS software was used to process these locations and tracks traversed to see which location in the study area undergoes certain geological characteristics. ArcGIS also are used in processing, analyzing and producing of geographic map of the study area. The rock sample obtained were processed using laboratory equipment to get precise details of the rock.

For evaluation of forest cover mapping using remote sensing, ENVI 5.1 were used to produce the forest cover map. Land cover and forest cover area were detected from the satellite image. The satellite image of the study area was chosen to form the metadata and was clipped. The image then undergoes the pre-processing process.

The pre-processing process includes radiometric correction and calibration to achieve the actual surface values. Both radiometric correction and calibration were done to correct and reduce errors in the image digital number, also increase the quality of the remotely sensed data. Then, the atmospheric correction was conducted to remove the scattering and absorption effects, and to produce reflectance value of the surface. Dark object subtraction (DOS) were also conducted to improve the process for classification and change detection application.

Supervised classification was used to produce different classes of land and forest cover map. The data and information from the field surveys and satellite imagery from Google Maps were collected to identify and classify the type of land cover, and the area of forest cover. The classes were differentiate using supervised classification by labeling the different classes based on the pixel values or spectral signatures that related to each class. All the pixel values or spectral signatures were classified using maximum likelihood classification (MLC) method which it can describe each spectral class by a multivariate normal distribution.

3.3.5 Data Analysis and Interpretation

Data analysis was done after the field work. The data collected throughout the fieldwork are collected together and analyze. The analyzation of data collected including age, structural geology, and accessibility, stratigraphic and other characteristics. After all the data collection was complete, new geological maps (i.e. topography, vegetation, drainage pattern, etc.) are produced based on the data required during the fieldwork. The rock sample obtained and field data such as strike and dip reading, joint reading and lithology also was analyzed and the geological interpretation of the study area was made.

This interpretation of the data analysis is discussed with lecturers and followed by report writing.

While in forest cover mapping using remote sensing, the images that underwent pre-processing and produced land and forest cover map were analyzed to see the area of the land that has been classified. There are four main classes that can be classified which are agriculture, bare soil, forest, and water body. The total area of each class was calculated and recorded. The next post-processing includes classification and change detection (CD). Secondary data such as existing forest cover mapping by Global Forest Watch website (www.globalforestwatch.org), were obtained to detect the accuracy assessment of the new forest cover map produced. All the methodologies are shown in Figure 3.3.

3.3.6 Report Writing

After all the data and maps required was obtained, the last step was to document all the data in a report writing. The report writing includes all the data obtained, results of the processes data, recommendation and conclusion of the research study.

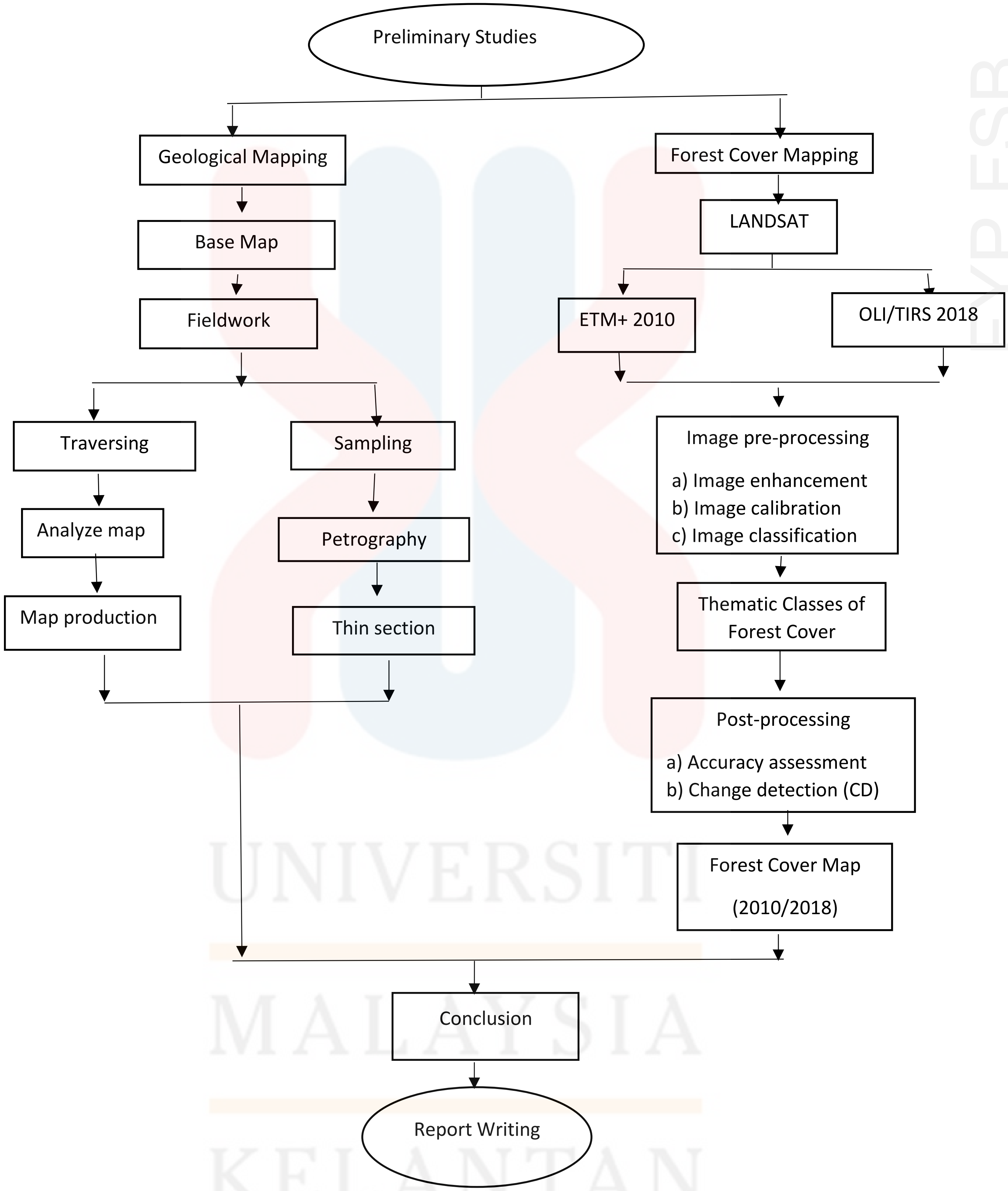

Figure 3.3: Flowchart of overall research methodology

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is important to understand the formation of the earth and its processes. In this chapter, the general geology of the study area is covered and explained. General geology conducted are mainly for analysis and to interpret the geological information of the study area. It also shows how students applying their knowledge in the field during fieldwork. This chapter cover structural geology, geomorphology, stratigraphy and historical geology. Several maps such as topographic map, drainage pattern map, geomorphological map, geological map, and the cross-section were also produced.

4.1.1 Accessibility

The road connection in the study area mainly is a trail road (Figure 4.1). This road is the only road in the study area that connects the main road to the study area. This road also was the only road that connecting the village and the plantation area. The road was used by the local villagers and outsider especially by plantation workers and government officials.

Figure 4.1: Trail road in the study area

The other accessibility in the study area is a river (Figure 4.2), which can be accessed by boat. The river was the Nenggiri River, which is the main river in the study area. Nenggiri River is connected with Betis River and Perias River. Only some villagers used the boat, only to find fishes and for research purpose by professors or students.

Figure 4.2: River accessibility by boat

4.1.2 Settlement

There are mostly Orang Asli settlements in Kuala Betis. In the study area, there is an Orang Asli settlement known as Pos Tohoi. Pos Tohoi settlement is well equipped with enough clean water and food supply, also with electricity for the entire village. There also school, court and community hall are built by the government for the local people.

4.1.3 Forestry

The study area located near the forest (Figure 4.3) and are mostly rubber plant vegetated (Figure 4.4). Forest in the research area are mostly being abused by logging activities but nowadays the logging activities are slowly decreasing. Rubber plants vegetation can be seen mainly in the research area, as rubber become one of the main income among villagers. Some of the forests are being cut down for the rubber plant planting, making the size of the forest become decreasing. The plantation was run by Orang Asli villagers and plantation agencies workers.

Figure 4.3: Forests in the study area

Figure 4.4: Rubber plant vegetation in the study area

4.1.4 Traverses and observation

Traverse is a method mainly measured in geological mapping. Basically, the traverse method involved surveying and observing along the path or line of the travel. Traverse helps in to identify the surveyed points. Traverse can be either in a closed traverse or open traverse. Closed traverse is the traverse which starts from a point and returns to the same point, and open traverse is the traverse which either returns to its starting point or closes on any other knowing point.

While traversing, rock sample and data are collected. Base map of the study area (Figure 4.5) was used as references to determine the surveying points and GPS are used to record the point where the geological features and rock sample are taken in the study area.

The rock samples are collected in a random location in the study area such as at rivers, plantation and near the residential area. The location of the rock sample and its observation were named as T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13, T14 and T15 (Table 4.1). There are three rock types that can be found in the study area which are limestone, tuff, and phyllite.

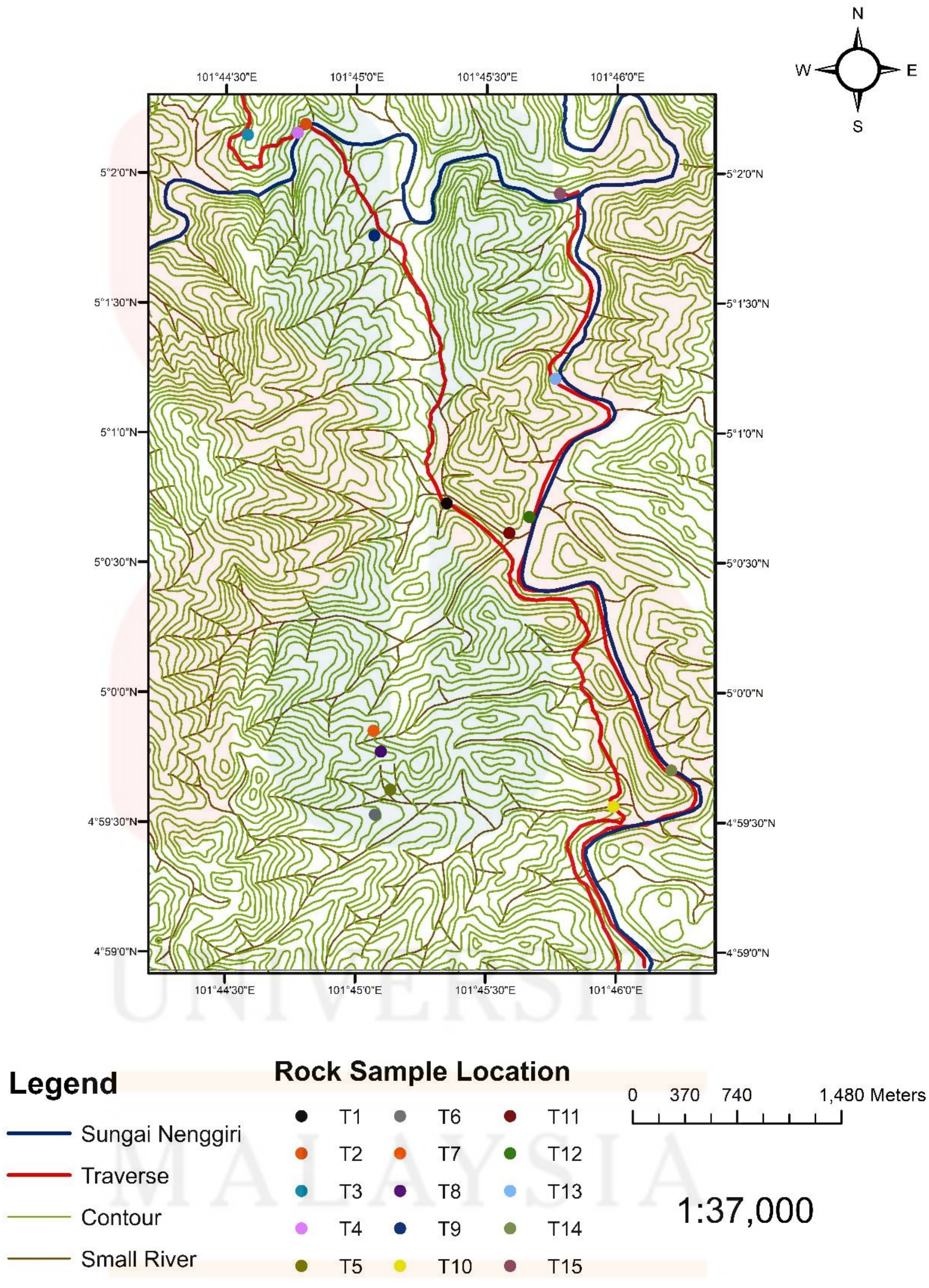

Figure 4.5: Traverse map in the study area

Table 4.1: Location for rock sampling

Location	N	E
T1	05° 0’ 43.4”	101° 45’ 20.2”
T2	05° 02’ 11.3”	101° 44’ 48.2”
T3	05° 02’ 08.7”	101° 44’ 34.8”
T4	05° 02’ 09.2”	101° 44’ 46.4”
T5	04° 59’ 37.5”	101° 45’ 08.0”
T6	04° 59’ 31.7”	101° 45’ 04.5”
T7	04° 59’ 51.1”	101° 45’ 04.1”
T8	04° 59’ 46.3”	101° 45’ 05.8”
T9	05° 01’ 45.5”	101° 45’ 04.0”
T10	04° 59’ 33.7”	101° 45’ 59.4”
T11	05° 0’ 36.9”	101° 45’ 35.3”
T12	05° 0’ 40.5”	101° 45’ 39.9”
T13	05° 01’ 12.5”	101° 45’ 45.8”
T14	04° 59’ 42.0”	101° 46’ 12.7”
T15	05° 01’ 55.3”	101° 45’ 46.7”

4.2 Geomorphology

Geomorphology is defined as the science of landforms with its processes from their origins, evolution, form, and distribution across the physical landscape. The Earth surface can change through the period of time. Geomorphology also concerned with the shaping of landforms, by natural processes such as subsidence uplift, and with the classification and study of landforms such as mountains, volcanoes, and islands. The geomorphology process is influenced by topography, drainage system and also weathering and erosion.

4.2.1 Geomorphologic classification (with geomorphologic unit map)

Topography is the arrangement of physical features of an area in both natural and artificial aspect. Topography also shows detailed characteristics and study of the Earth's surface, including changes such as mountains and valleys; and features such as rivers and roads, on the Earth's surface. Topography is related to the surveying practices and recording in positions of points and generally concerned with the measurement and recording of elevation contours, producing a three-dimensional contour, which later produced a three-dimensional representation of the Earth's surface.

Based on the topography map (Figure 4.6), the study area is a mostly hilly area which is the fourth class in the topographic unit. Based on Raj (2009), the topographic unit is divided into five major units by its mean elevation (Table 4.2). The morphology in the study area shows a smooth and hilly topography with gradients and slope.

Table 4.2: Topographic unit based on elevation (Raj, 2009)

Class	Topographic unit	Mean elevation (above sea level, m)
1	Low lying	<15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	>301

The highest peak recorded in the study area is 540 meters located in the west and the lowest peak is 140 meters in the North-West and in the east area. The residential area in the study area located in the North-West area, which has a low elevation point. The houses are built near the main road for easier accessibility, and the main river for an easier housework.

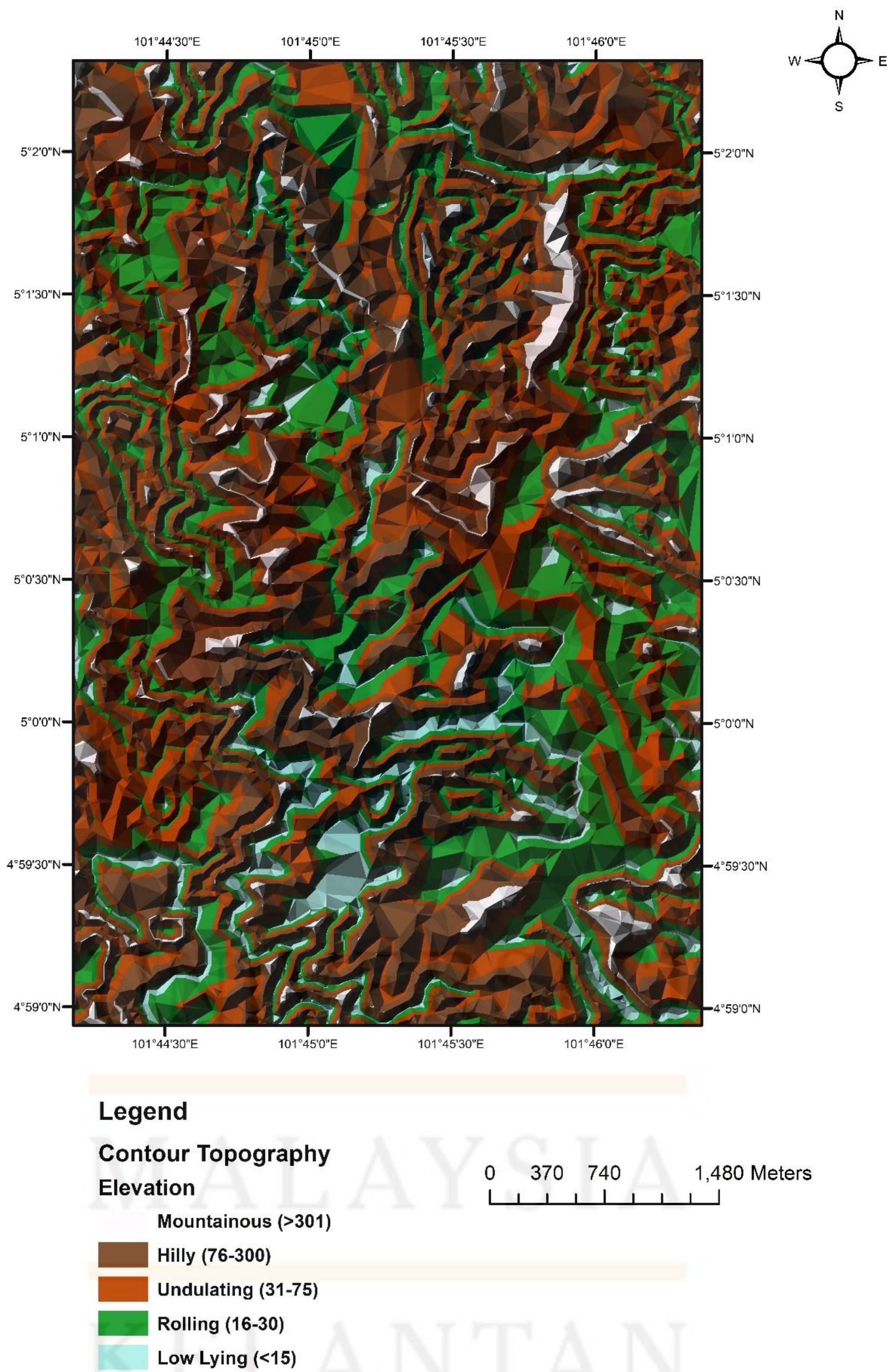

Figure 4.6: Topography map of the study area

4.2.2 Weathering and erosion

Weathering is defined as the change of appearance or texture of rocks by long exposure to the atmosphere. Weathering can basically change the state of the rock but does not involve the removal of the rock material. Weathering also breaks down and loosen the surface minerals of rocks, cause the disintegration of rock near the Earth surface, and later transported away by agents of erosion such as ice, wind, and water. Weathering is divided into three major types of weathering, which are mechanical or physical weathering, chemical weathering, and biological weathering.

Physical weathering defined as the geological process of rocks breaking apart without changing its chemical composition. The rate of physical weathering process can depend on the temperature and climate, also can occur due to pressure, frost, and others. The rate of physical weathering in Malaysia is high due to the tropical condition of Malaysian weather. In the study area, physical weathering is common because of the hot weather during the day and cold weather during the night. It increases the thermal stress and pressure of the rock and initiates the physical weathering. Figure 4.7 shows the physical weathering in the study area.

Figure 4.7: Physical weathering in the study area

Chemical weathering defined as the erosion or disintegration of rocks, building materials, and others, caused by chemical reactions rather than by mechanical processes. Chemical weathering also can occur when the rocks undergo chemical reactions by forming new minerals. Chemicals such as water, acids, and oxygen can lead to this geological change. The chemical weathering can produce dramatic results of rock weathering through time. In the study area, the chemical weathering occurred, caused by the presence of chemical and change the rock chemical composition as in Figure 4.8.

Figure 4.8: Chemical weathering in the study area

Biological weathering defined as the weakening of rock and followed by disintegration of rock by plants, animals, and microbes. Example of biological weathering is such as growing plant roots can exert stress or pressure on a rock, therefore breaking the rock. Biological weathering also was known as organic weathering. Biological weathering process is slow, but may strongly influence the rock condition. Figure 4.9 shows the biological weathering in the study area, which happened mostly among the rock outcrops in the study area.

Figure 4.9: Biological weathering at the study area

Erosion is defined as the process of eroding or being eroded, mostly by wind, water, or other natural agents. Erosion is the opposition of deposition, in which the geological process involving deposition of Earth materials, or built up, on a landform. In the study area, erosion occurred due to the action of running water to the exposed and unprotected soil material caused by a natural occurrence. Most of the erosion process in the study area occur at the riverbank, which as the stream flows through the river, it erodes the riverbank thus makes the stream becomes wider (Figure 4.10). Factors such as the type of soil, amount of rain and the degree of slope also contributed to the main rate of erosion activities.

Figure 4.10: The erosion along the main river

4.2.3 Drainage pattern

Drainage pattern is one of the important aspects of geological characteristics. Drainage patterns are patterns that formed by the streams, rivers, and lakes in a particular drainage basin. A drainage basin is defined as the topographic region which a stream receives runoff, throughflow, and groundwater flow. Drainage patterns are also known as river systems. Drainage patterns are based on the topography of the land, whether the region is dominated by hard or soft rocks and the gradient land. Drainage pattern is classified into several classes, which are classified by its topography and the geology of the land. The classes are dendritic, parallel, trellis, rectangular, radial, centripetal, deranged, annular, and angular drainage pattern.

In the study area, Nenggiri River is the main river, which linked with Betis River and Perias River. These main rivers contribute to the network of small rivers and stream in the surrounding area. The main river is important for the daily life of the local community and as accessibility, with Perias River as the attraction of kayak activities among the tourists. Figure 4.11 shows the drainage pattern in the study area.

The type of drainage pattern that can be found in the study area is first, dendritic drainage system. The dendritic drainage system is one of the most common forms of a drainage system which involved streams joined together into the branch of the main river. Dendritic drainage system usually not in a straight pattern and they forms in V-shaped valleys, where the river channel following the terrain slope. The rock types in the dendritic drainage systems must be non-porous and impermeable.

The second type of drainage pattern that can be found in the study area is parallel drainage system. Parallel drainage system involved streams and their branches are parallel or subparallel with each other. These parallel streams then approximately at the same angle, joined the mainstream over the significant area. Usually, parallel drainage system located at the region which has a recognizable and uniform slope, also in homogeneous lithologies. Rock structure exists in parallel drainage system are young coastal plains and large basalt flows.

Another drainage pattern can be found in the study area are trellis drainage system. Trellis drainage pattern forms in two main landscape; young and mature landscape. In a young landscape, the drainage system occurs in a folded-mountain region, while in the mature landscape, it occurs in the dissected belted coastal plain of tilted strata. Most of trellis involved streams from the steep slopes on the mountain sides. The stream branches later joined the main river in its correct angle by erodes the soft rock, making it resulted in an alternate pattern of hard and soft rock. Trellis drainage pattern mostly developed in the area that undergoes simple folds characterized by parallel anticlinal ridges which alternated with parallel synclinal valleys.

4.3 Lithostratigraphy

Figure 4.12 below shows the geological map with its geological features of the study area in Kuala Betis, Gua Musang. There is three main rocks unit that can be found in the study area, which is tuff, limestone, and phyllite. The rock units in the study area can are differentiating by colors; as tuff in orange color, phyllite in purple color and limestone in blue color. Also, there is cross-section with line A to B that shows the detailed profile of lithology unit in the study area.

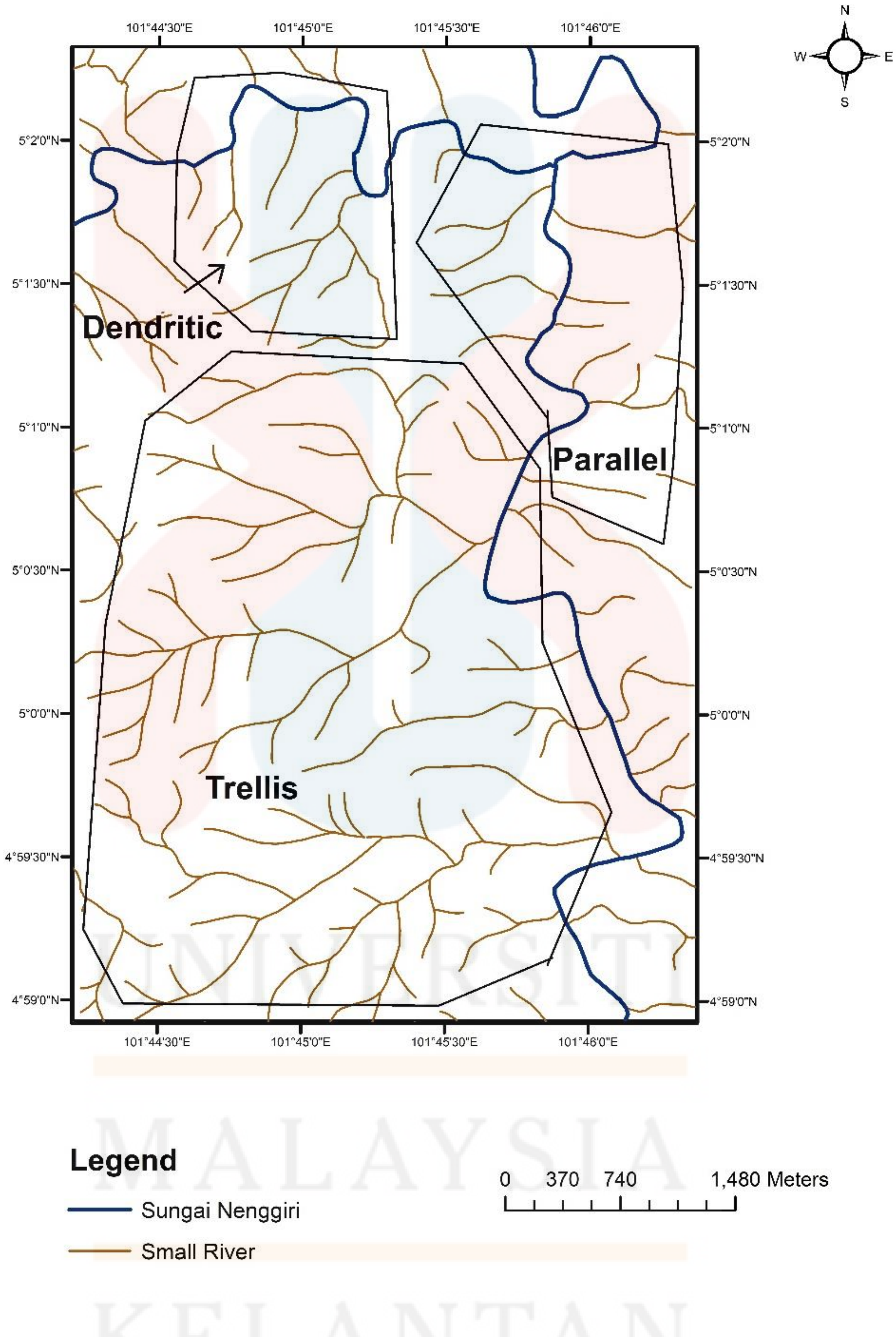

Figure 4.11: Drainage pattern in the study area

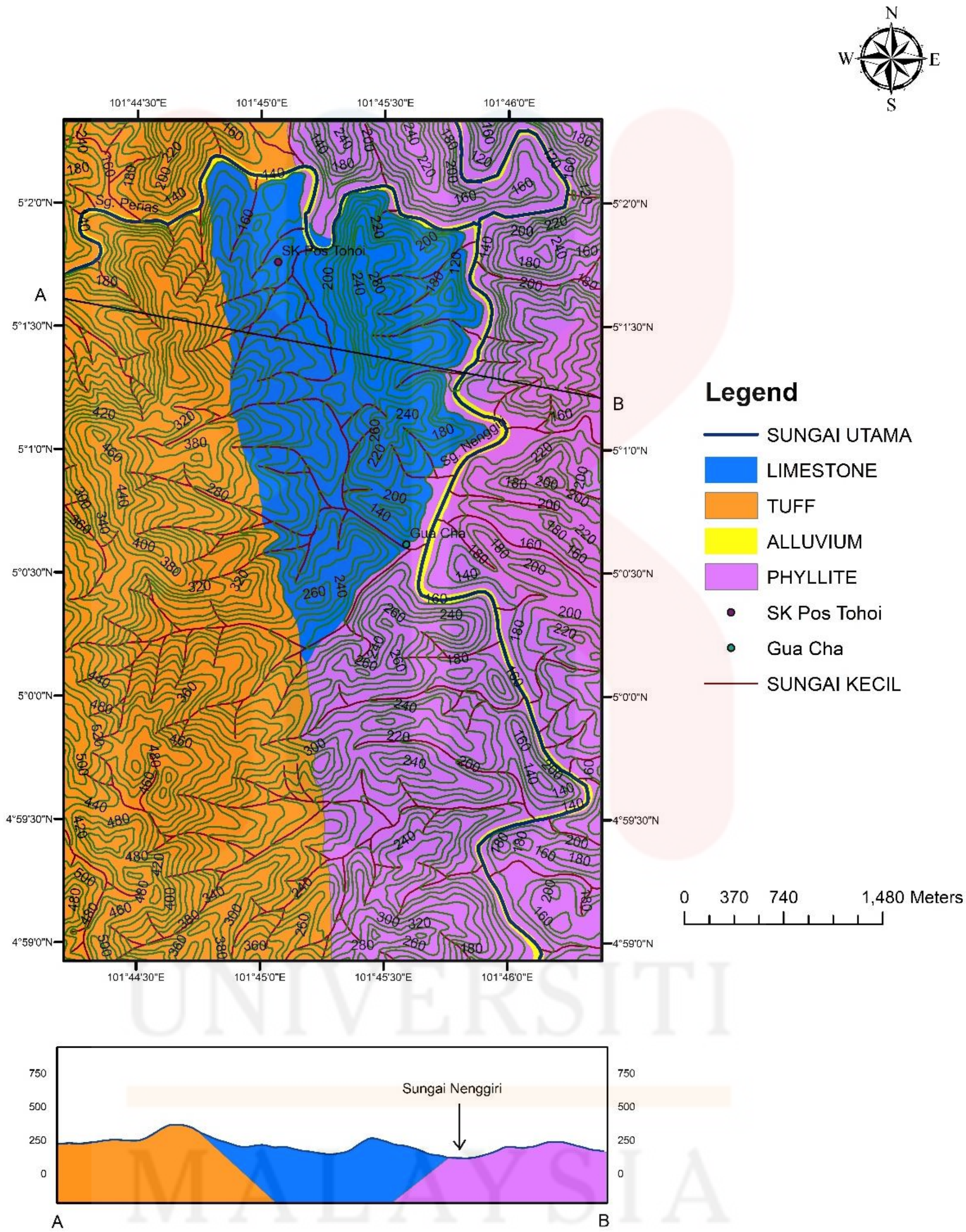

Figure 4.12: Geological map of the study area

4.3.1 Stratigraphic Position

There are three main rock units that can be found in the study area, which are tuff, limestone, and phyllite. These type of rock units are formed from Pre-Mesozoic to Quarternary age. These rocks units formed according to their respective depositional environment that correlates with the age of formation. Table 4.3 below shows the stratigraphic column of the study area.

Table 4.3: A stratigraphic column of the study area

Age	Lithology unit	Description
Quaternary		Alluvial along the river
Middle Triassic		Well-bedded limestone, as same with limestone in Pulai
Early Triassic		Bedded tuff and lapilli tuff, intercalated by fine-grained clastic sediments
Pre-Mesozoic		Well-bedded phyllite unit with slate and shale

Based on the stratigraphic column, it can be concluded that phyllite is the oldest rock in the study area, which formed during Pre-Mesozoic age. The second oldest rock is tuff, which formed during early Triassic age. The youngest rock in the study area is limestone, which formed during middle Triassic age. There are also alluvial deposits along the main river in the study area which formed from Quarternary age.

4.3.2 Unit Explanation

- Limestone Unit

Limestone is a hard sedimentary rock, mainly composed of calcium carbonate or dolomite. In the study area, limestone is found in Gua Cha and in the Pos Tohoi area. The limestone in both areas is well-bedded limestone. Limestone in Gua Cha undergoes biological weathering from the plants while limestone in Pos Tohoi area undergoes physical weathering where a big block of limestone cracked into small pieces of limestone.

Based on the observation on rock sample (Figure 4.13), the color of limestone is grey in color. To prove the presence of calcite carbonite in limestone, hydrochloric acid (HCl) is used. Limestone is originally formed commonly in a clear, warm and shallow marine water. The organisms that live in that type of environment produced calcite from their shells. Limestone also contains small particles of feldspar, quartz, pyrite, siderite and clay minerals. Figure 4.14 and Figure 4.15 shows the thin section of limestone under the microscope based on plane polarized (PPL) and cross-polarized (XPL) respectively.

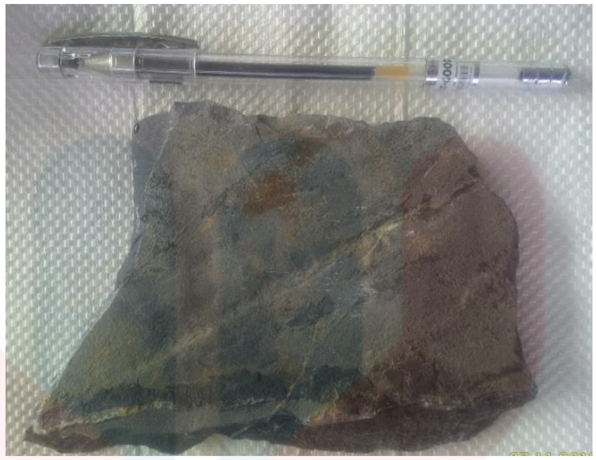

Figure 4.13: Rock sample of limestone

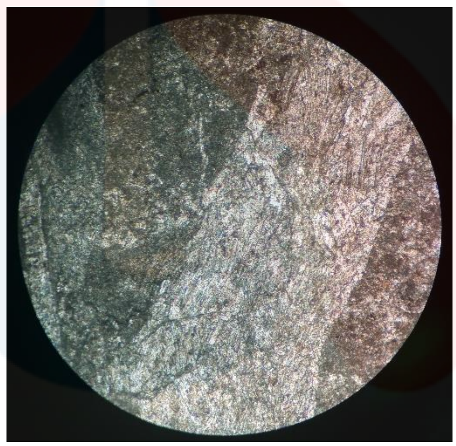

Figure 4.14: View of limestone under PPL view

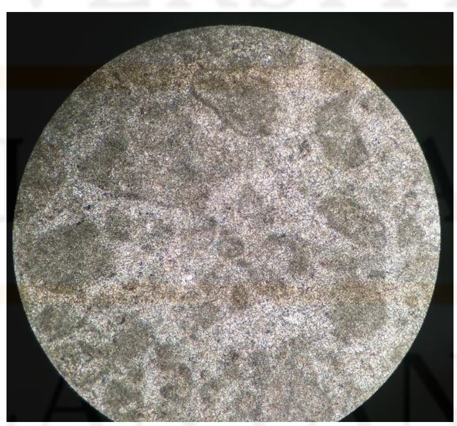

Figure 4.15: View of limestone under XPL view

- Tuff Unit

Tuff is a light, porous rocks that are formed by the consolidation of volcanic ash. Tuff also are known as volcanic tuff. In the study area, tuff is mostly found near the rubber plant plantation and near the west area of the forests. Mostly of the tuff in the study area is highly weathered and undergoes several types of weathering such as biological weathering and physical weathering. The color of the tuff found varies from white, brown, orange, or reddish depends on its mineral content, the rate of weathering and it is relatively soft rock. Tuff rock can be classified as either sedimentary rock or igneous rock because its rock properties that match both types of rock.

Rock sample in Figure 4.16 shows the tuff contains fine grain size of the texture. There is sub lithology that can be found in this tuff unit which is lapilli tuff. In some points, such as in the plantation are, both tuff and lapilli tuff can be found interbedded with each other.

Figure 4.16: Rock sample of tuff

- Phyllite Unit

Phyllite is known as a foliated metamorphic rock that has been exposed to low levels of heat, pressure and chemical activity. Phyllite also formed when the sedimentary rocks are buried and altered by the heat and direct pressure of regional metamorphism. In the study area, phyllite rocks are found mostly in the rubber plant plantation and near the main road, also along the main river of Nenggiri River. Most of the phyllite rocks found are highly weathered because of the exposure by weather and by river stream. Phyllite rocks found in the study area also are greenish, greyish and brownish in color.

The rock sample (Figure 4.17) shows that phyllite rocks contain the fine-grained size of texture and foliated structure of metamorphic rocks. In the study area, phyllite rocks can be found in a well-bedded condition, although it was highly weathered, with a constant bedding dipping. Figure 4.18 and Figure 4.19 shows the thin section of phyllite under the microscope based on plane polarized (PPL) and cross-polarized (XPL) respectively.

Phyllite consists majority of flake-shaped mica minerals in a parallel alignment. The tiny grains of mica minerals such as muscovite or sericite can be found in phyllite. Some fine-grained minerals such as quartz, feldspar, andalusite, biotite, cordierite, garnet and staurolite also can be found in phyllite rocks.

Figure 4.17: Rock sample of phyllite

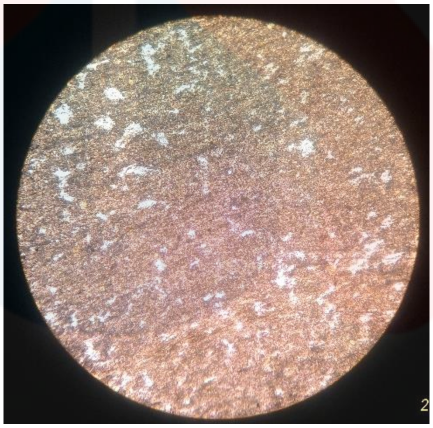

Figure 4.18: View of phyllite under PPL view

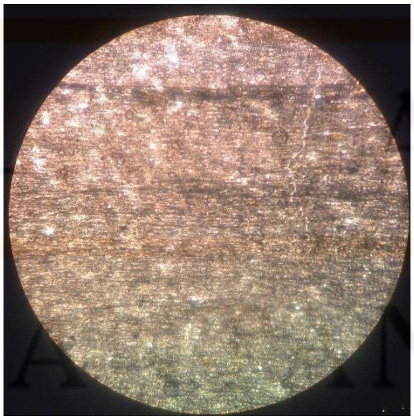

Figure 4.19: View of phyllite under XPL view

4.4 Structural Geology

Structural geology is the study of rock deformation in both small and large scale. Rock deformation can occur below and upper the Earth crust, and changing the shape of the Earth surface. Studying structural geology can give information about the type of rock deformation occurs in the study area, thus got to know the type of deformation that occurs in the study area and their geological history.

4.4.1 Lineament

Lineament is defined as a linear feature on the landscape of the Earth's surface. Lineament can express the geological structures underlying such as fracture zones, shear zones, and igneous intrusions. Lineaments can be seen obviously in geological or topographic maps, also can be seen obviously on aerial or satellite photographs. Figure 4.20 shows the lineament map of the study area.

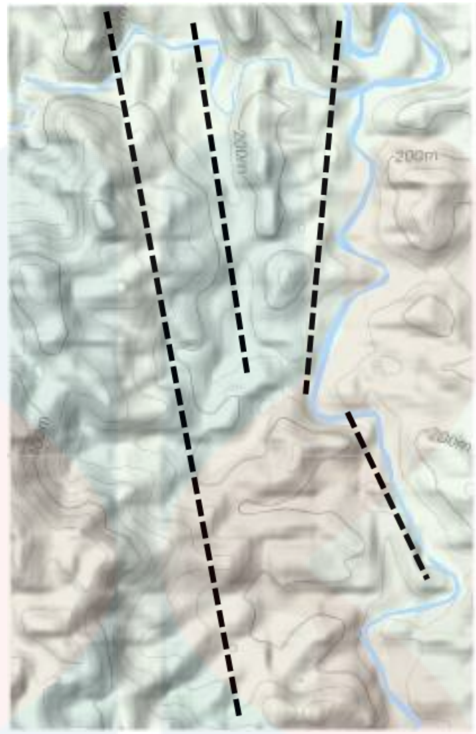

Figure 4.20: The lineament map of the study area

4.4.2 Vein

The vein is defined as a fracture in a rock that contains mineral deposits or ore and usually has an extensive course underground. The minerals that carried by the aqueous solution within the rock mass, becomes deposited through precipitation process, forming veins. Usually, the type of hydraulic flow involved is due to the hydrothermal circulation.

The vein that has been found in the study area is located in near the rubber plan plantation, between the phyllite rocks (Figure 4.21), and between the cracks in rocks in

Kuala Sungai Perias (Figure 4.22). The type of vein that is found in the study area are quartz vein because it did not reacts when tested with hydrochloric acid (HCl).

Figure 4.21: Quartz vein in phyllite rocks

Figure 4.22: Quartz vein in rocks in Kuala Sungai Perias

4.4.3 Bedding

Bedding is known as the series of geologic formation and stratigraphic rock that are marked by a well-defined divisional plane, or known as bedding planes, separates between the above and below rock layer. Bedding can varies in thickness from a centimeter to several meters. Other terms used for bedding are sedimentary strata.

Figure 4.23 above shows the bedding that can be seen clearly. The bedding structures are thickening upwards and easy to fracture. The strike and dipping of the bedding are measured and recorded.

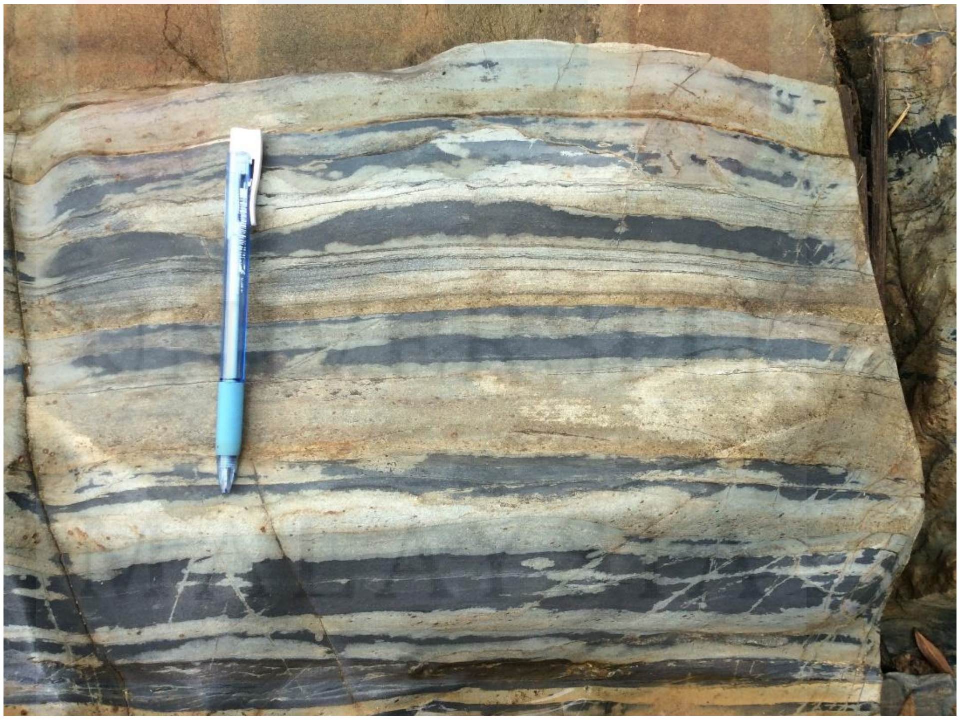

Figure 4.23: Bedding structure of a rock

4.4.4 Fold

Fold defined as a layered rock that bends and then folded due to the compressive stress and tectonic pressure. Folding is a result of a permanent formation where rather than fracture when the rock received huge stress, they fold instead. When tectonic forces acting on the sedimentary rock, the pressure makes the rock folded like a piece of paper, because the way sedimentary rock is more flexible than metamorphic rock. Folds can vary in size, form a few centimeters or less, to several kilometers or even hundreds of kilometers. Figure 4.24 shows the anticline that can be found in the study area.

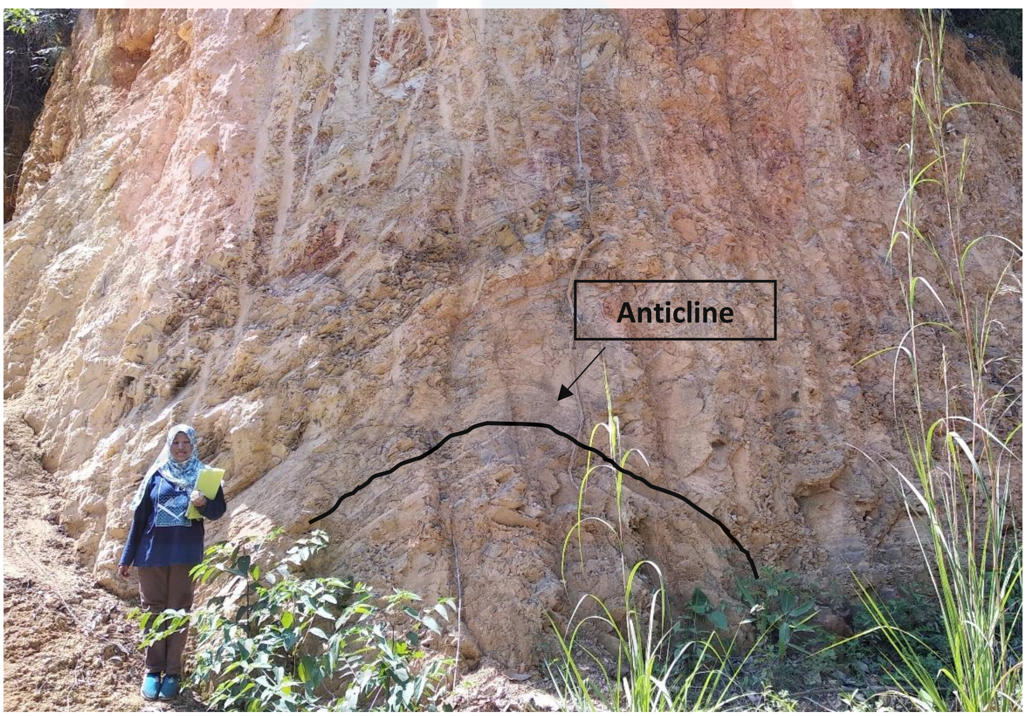

Figure 4.24: Anticline in the study area

4.4.5 Fault

The fault is a fracture or discontinuity occurs when a rock undergoes significant displacement due to the forces acting on them. Fault can occur from a few centimeters to a few meters or even kilometers. A fault usually caused by brittle deformation mechanism, where it involved a discontinuity with wall-parallel displacement. The type of force acting on rocks can show the direction of movement on a fault.

In the study area, the type of fault that can be found area micro fault, which also known as a secondary fault. The micro fault occurred by a set of displacement that opposite to its associated major and synthetic faults. The antithetic-synthetic faults sets are typical in an area that undergoes normal faulting. Figure 4.25 shows the micro fault in the study area.

Figure 4.25: Micro fault in the study area

4.5 Historical geology

Historical geology is one of the most important in knowing the structure of the Earth's surface. Historical geology defined as the method of using principles and techniques of the geology to reconstruct and understand the history of the Earth geology. Historical geology can produce a detailed knowledge of geologic timescale, involved with the stratigraphy, structural geology and paleontology of the Earth. All the events that occurred are being related by its sequence to know the Earth evolution from its origin state.

Kuala Betis is a part of Gua Musang Formation which formed from the collision of Sibu Masu and Indochina plate. The collision resulted in the formation of Bentung-Raub Suture, which where the Kuala Betis are located. The age of Kuala Betis is identified around Pre-Mesozoic to Quarternary age, in a warm and shallow marine environment, also close with the volcanic source by the presence of tuff rocks. It shows that the area experienced volcanic activity because of the presence of volcanic ash. The tuff rock unit is formed from the deposit of these volcanic ash. The appearance of alluvial deposits along the main river occurs because of the water activity stream that flows.

CHAPTER 5

FOREST COVER MAPPING USING SATELLITE DATA

5.1 Introduction

This chapter explained the results that were produced and obtained based on forest and land cover classification of the year 2010 and 2018. The objective of the forest cover mapping using satellite data is to differentiate the forest cover coverage in the study area between the eight-year interval of 2010 and 2018. Both of this data was produced using a supervised classification method. The data were classified into a different class to differentiate their features. Table 5.1 shows the land cover classification with its interpretation.

Table 5.1: Land cover classification

Class	Description
Agricultural	Land that is cleared to be used for agriculture
Bare Soil	Uncovered vegetation of soil surface area and highly vulnerable to erosion
Forest	Large, inaccessible and dense growth of area dominated by trees
Water Body	Earth surface which contains any significant accumulation of water

5.2 Results and Discussion

5.2.1 Land Use and Land Cover in 2010

The satellite data for the year 2010 was downloaded from Glovis USGS website using Landsat 7 ETM+ with datum WGS84 and spatial reference UTM 47N. Figure 5.1 shows the land use and land cover (LULC) in 2010. The area and percentage of every class in land use and land cover map (LULC) are presented in Table 5.2. Based with the table 5.2, it can be seen that the study area consists of mainly forests area which about 22.94 km^2 (87.75%), followed by water body area about 1.46 km^2 (5.57%), then agriculture area about 1.08 km^2 (4.14%), and lastly bare soil area which about 0.66 km^2 (2.54%).

Table 5.2: Statistics of classification of Landsat 7 ETM+ for 2010

Class	Area (km^2)	Percentage (%)
Agriculture	1.08	4.14
Bare Soil	0.66	2.54
Forest	22.94	87.75
Water Body	1.46	5.57
Total	**26.14**	**100.00**

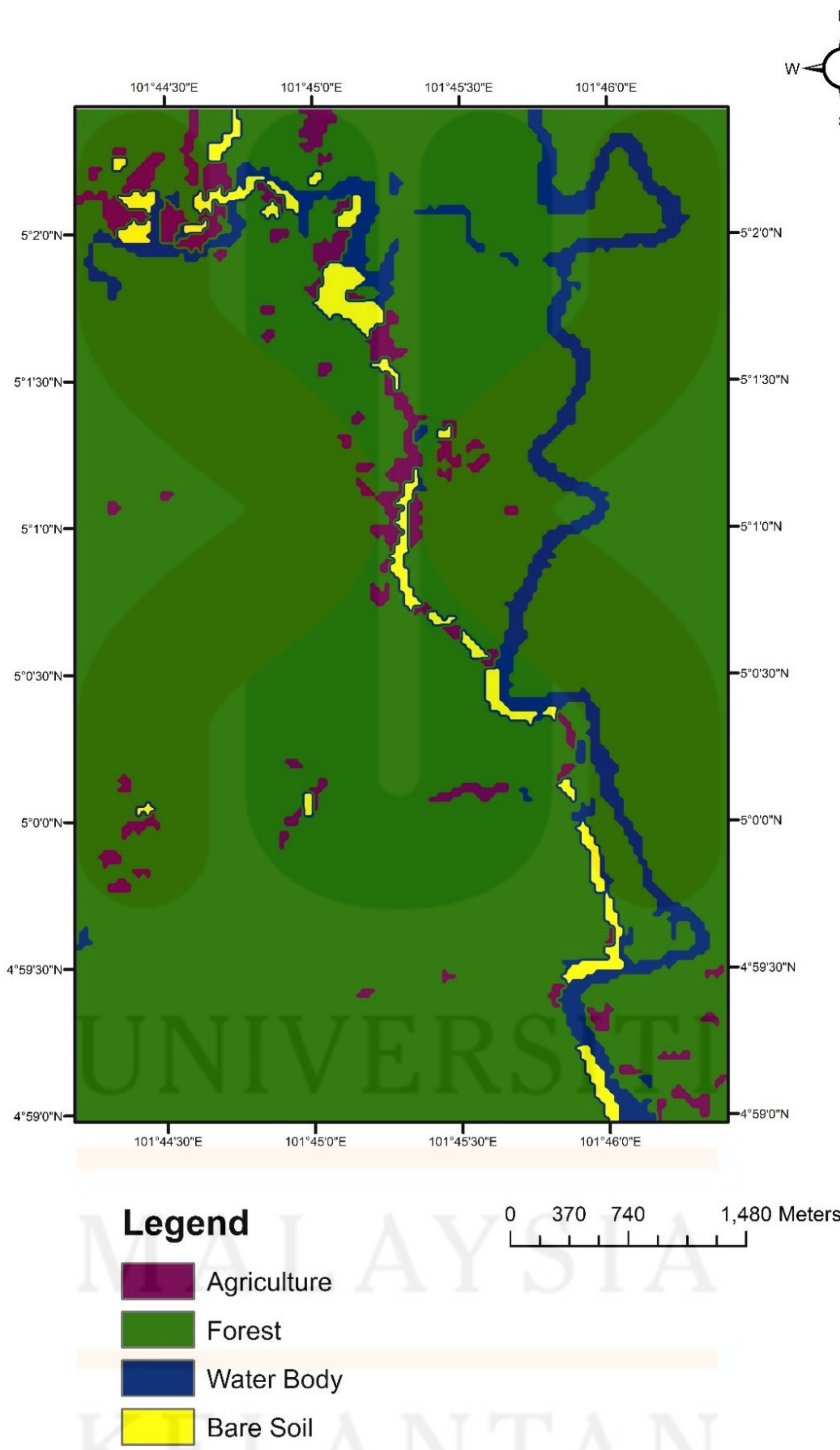

Figure 5.1: Map of supervised LULC of the study area in 2010

5.2.2 Land Use and Land Cover in 2018

The satellite data for 2018 also was downloaded from Glovis USGS using Landsat 8 OLI/TIRS with datum WGS84 and spatial reference UTM 47N. Figure 5.2 shows the land use and land (LULC) cover map in 2018. The area and percentage of every class in land use and land cover map (LULC) in 2018 are presented in Table 5.3.

Based with the Table 5.3, the study area consists mainly of forest area which about 18.16 km^2 (68.97%), followed by agriculture area about 4.63 km^2 (17.57%), then bare soil about 2.01 km^2 (7.63%), and lastly water body about 1.54 km^2 (5.83%).

Table 5.3: Statistics of classification of Landsat 8 OLI/TIRS for 2018

Class	**Area (km^2)**	**Percentage (%)**
Agriculture	4.63	17.57
Bare Soil	2.01	7.63
Forest	18.16	68.97
Water Body	1.54	5.83
Total	**26.34**	**100.00**

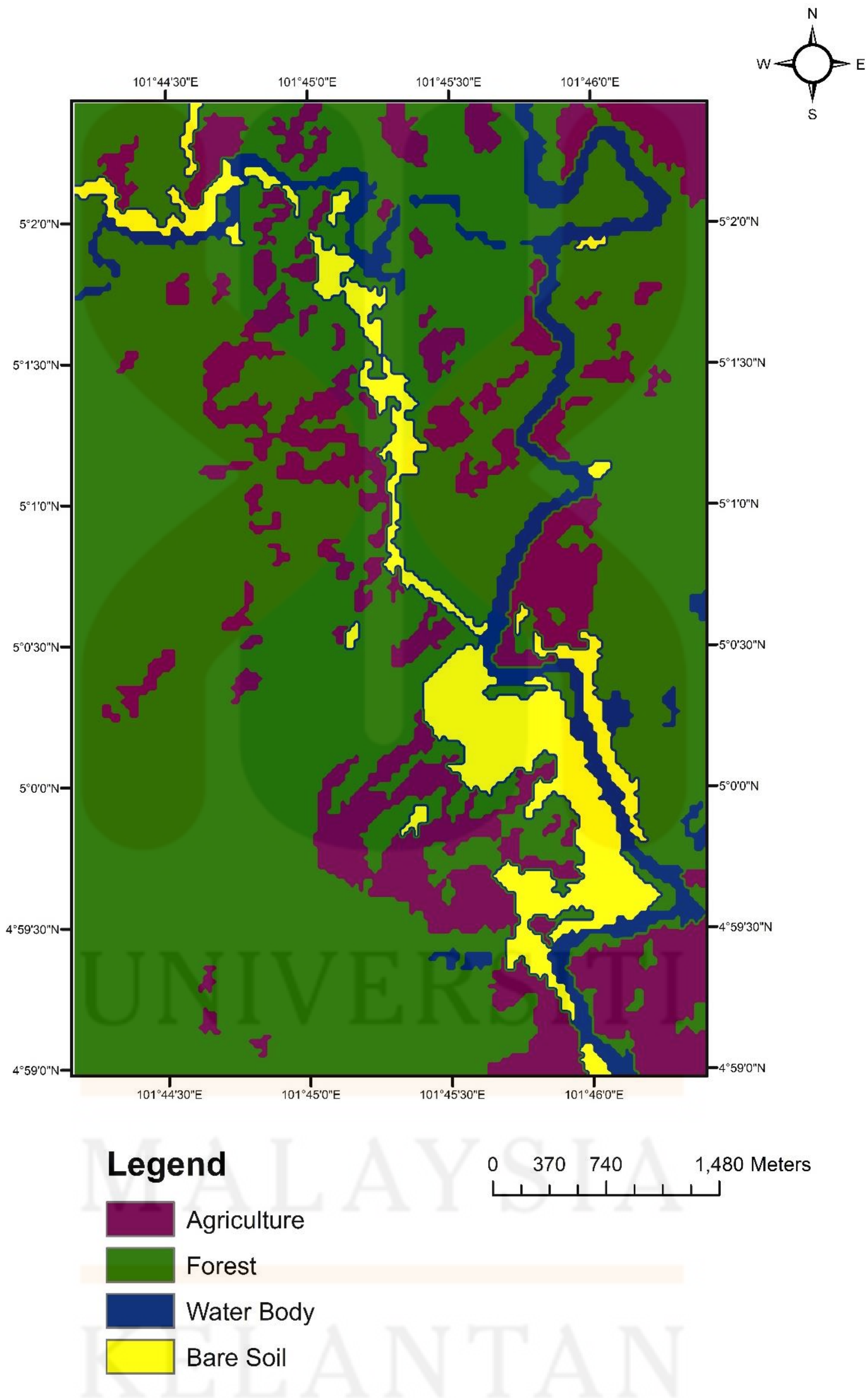

Figure 5.2: Map of supervised LULC of the study area in 2018

5.3 Change Detection Analyses

The change detection analysis was conducted using the post-classification comparison. Both Land use and cover classification results for 2010 and 2018 was presented in Table 5.4, while Figure 5.3 shows the chart statistics of image classification on the percentage of 2010 and 2018 respectively. The land use and land cover in the study area shows an increase and decrease in value in term of both land and forest cover.

From 2010 to 2018, agriculture has seemed to increase about 13.43%, from the area of 1.08 km^2 to 4.63 km^2. Bare soil also increased in term of the area about 5.09%, from 0.66 km^2 to 2.01 km^2. Waterbody only undergoes a slight increase of 0.26% of the area, from 1.46 km^2 to 1.54 km^2. While the forest shows a great decrease in the area which about 18.78%, from the total area of 22.94 km^2 to 18.16 km^2.

Based on these changes in the term of land use and land cover, it can be concluded that the decreasing of forest area are related to the demand of agriculture sector which can seem increasing by years. The appearance of rubber plantation also shows the cause of deforestation in the study area. The increase of bare soil area also causes by the increasing total of Orang Asli villagers and the effect of clean up forest to open a new place for vegetation project.

Table 5.4: Classification statistic in the study area for both 2010 and 2018

Class	**2010**		**2018**		**Relative Change**	
	Area (km^2)	**Percentage (%)**	**Area (km^2)**	**Percentage (%)**	**Area (km^2)**	**Percentage (%)**
Agriculture	1.08	4.14	4.63	17.57	3.55	13.43
Bare Soil	0.66	2.54	2.01	7.63	1.35	5.09
Forest	22.94	87.75	18.16	68.97	-4.78	-18.78
Water Body	1.46	5.57	1.54	5.83	0.08	0.26
Total	26.14	100.00	26.32	100.00	-	-

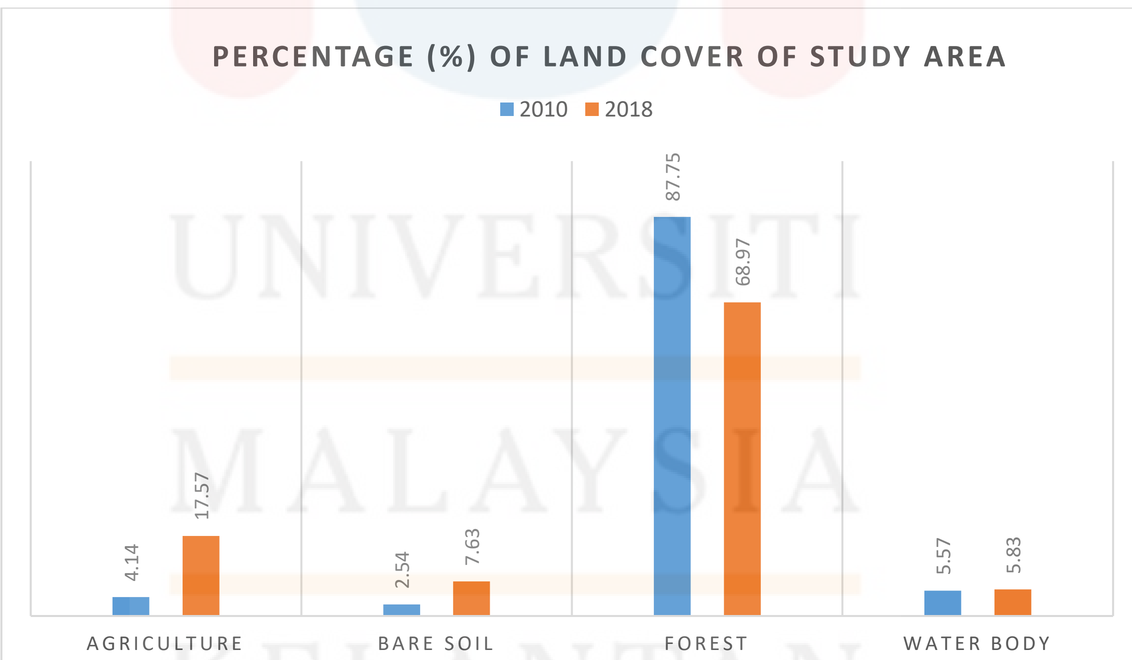

Figure 5.3: Chart statistic of image classification of the study area in 2010 and 2018 on percentage

5.4 Forest Changes Analyses

From the summary of both land use and land cover data, it can be concluded that the main cause of deforestation is for agriculture activity. The information gained from the land use and land cover data also are important to monitor the changes of forest cover for the past eight years from 2010 and 2018, which is the time where most of the deforestation for agriculture activity occurred, also from the local people activity.

Figure 5.4 and Figure 5.5 shows the total of forest cover for both 2010 and 2018. Based on the figures, it can be seen clearly that the area of forest cover in the study area is decreasing over these eight years. Figure 5.6 shows the overlying map of 2010 and 2018 to highlight the zone which undergoes deforestation in the study area.

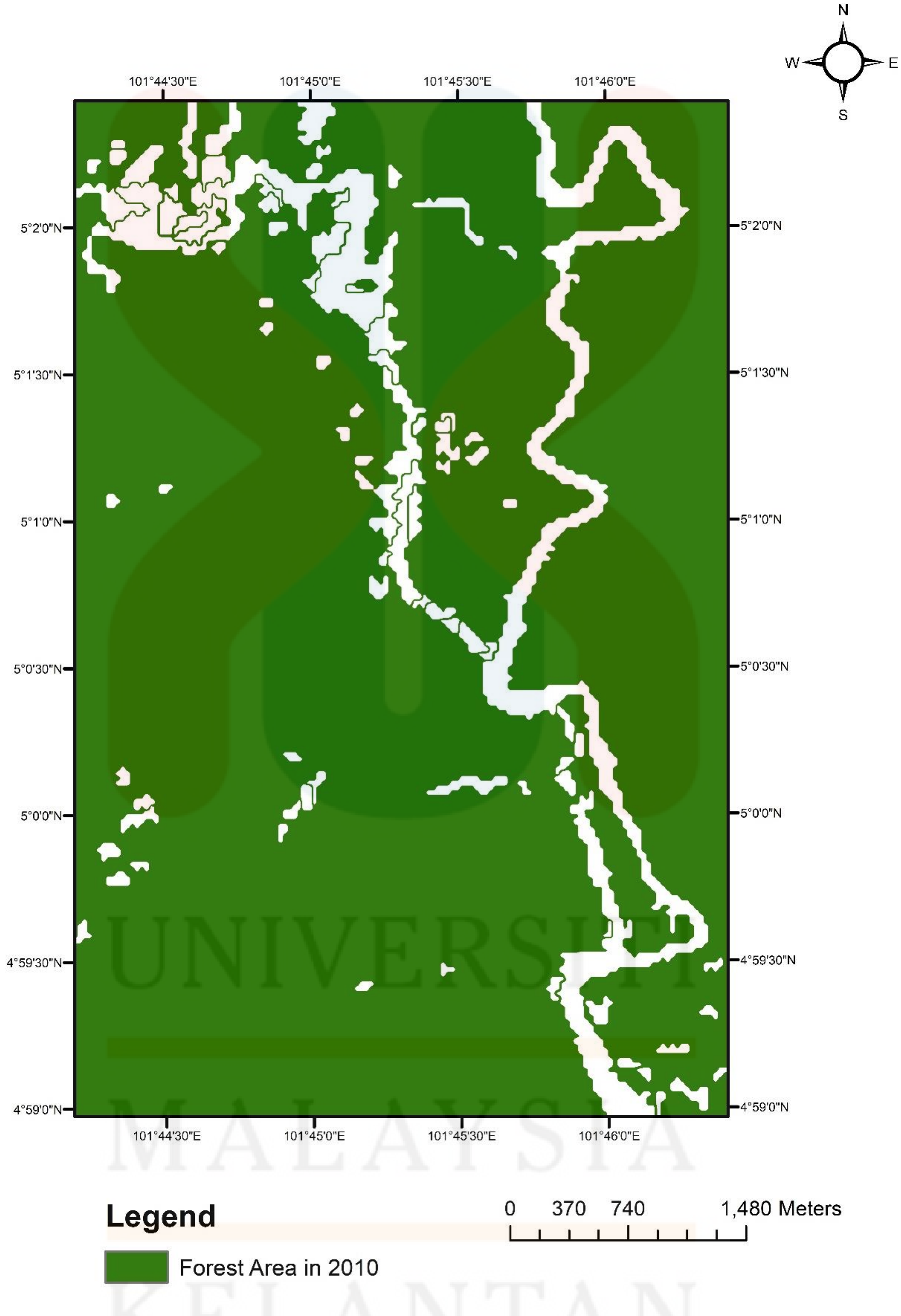

Figure 5.4: The forest cover of 2010 in the study area

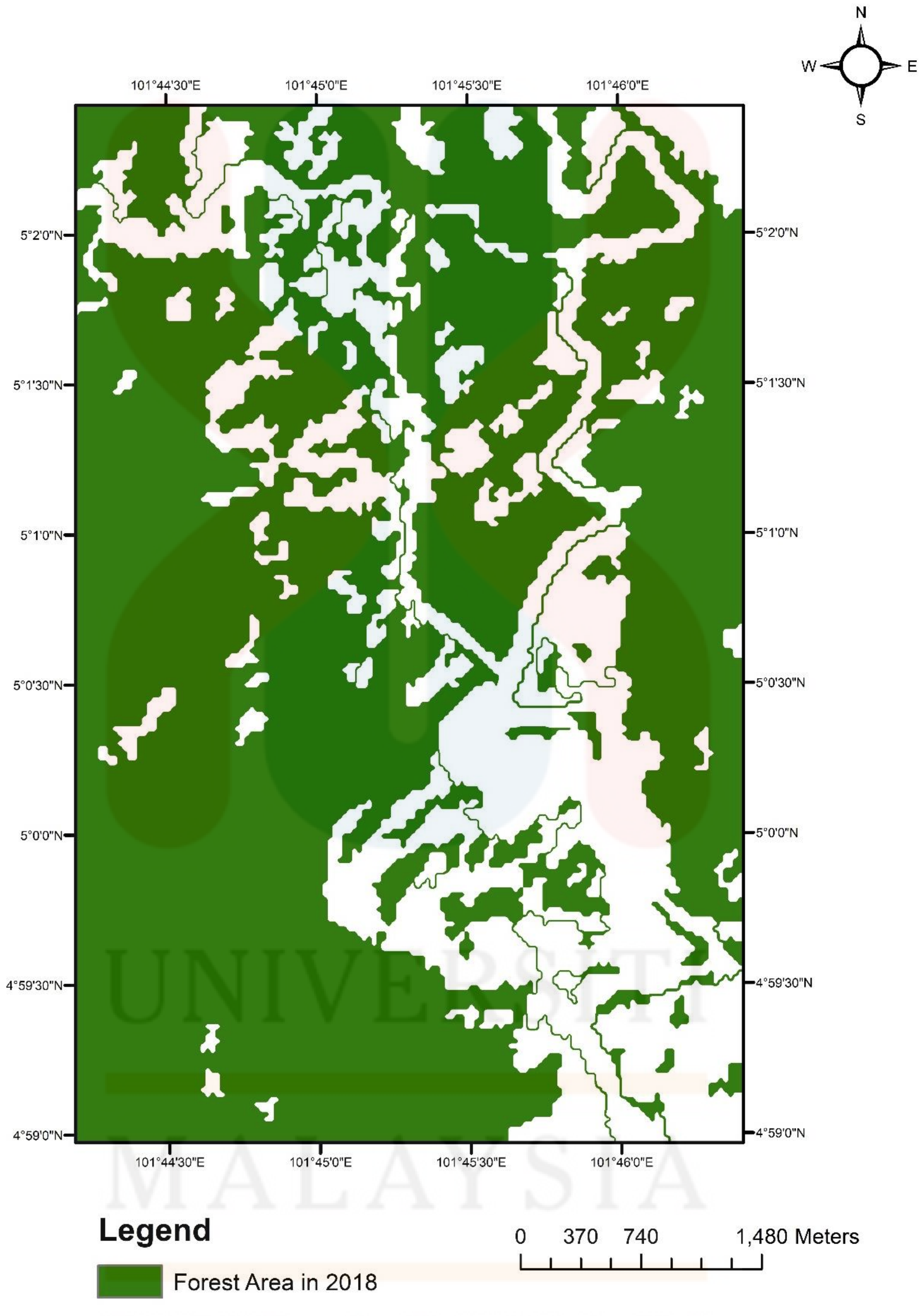

Figure 5.5: The forest cover of 2018 in the study area

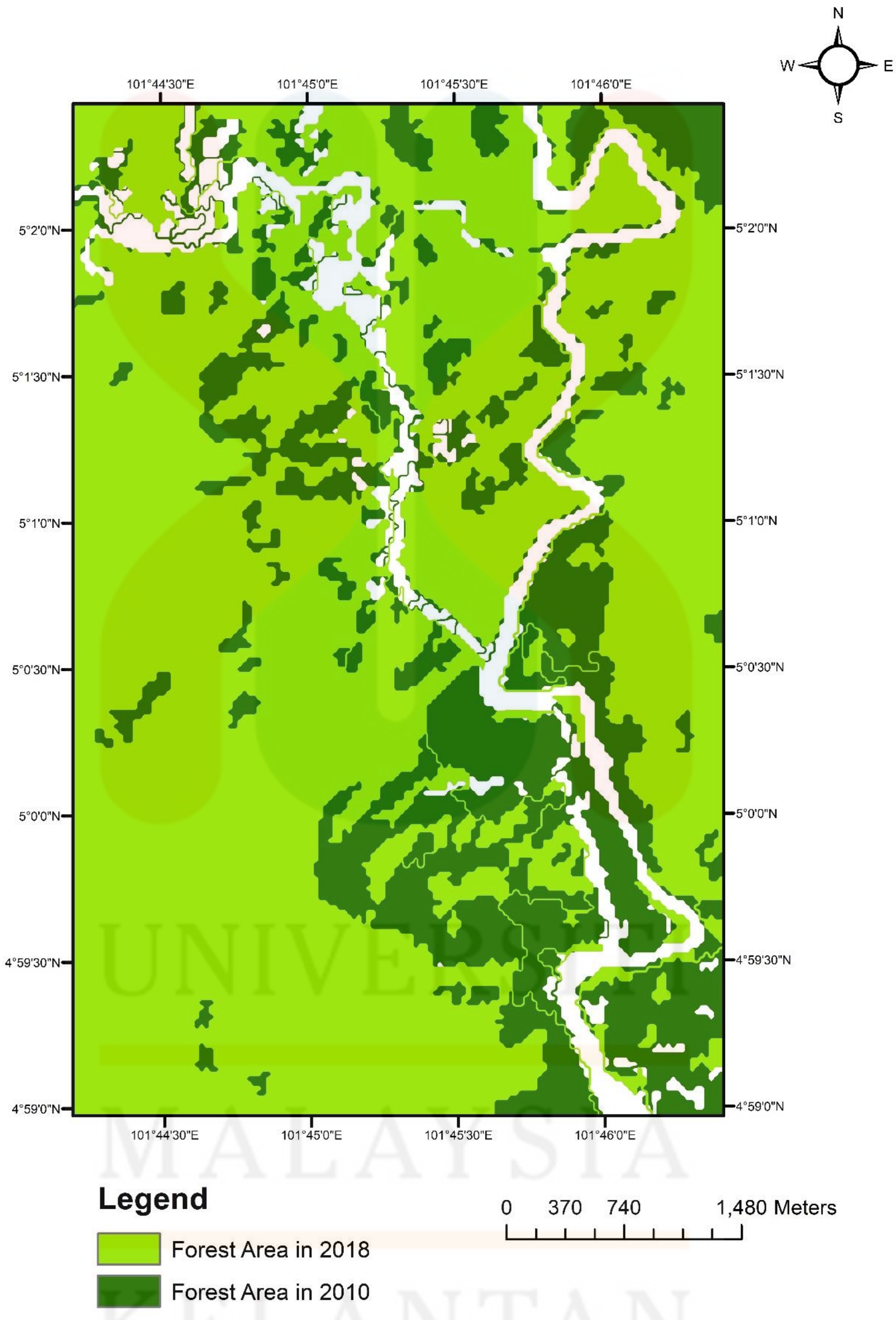

Figure 5.6: The forest cover for both 2010 and 2018 in the study area

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

As the conclusion, the research that is conducted in the study area yields two type of main research which are the geological study and the land use and land cover study. At the end of the research, a complete geological map in the scale of 1:37,000 was produced. Another map such as topographic map, drainage pattern map, and traverse map also was produced. All geological structures that can be found in the study area such as fold, fault, and veins are identified and recorded. There are three types of main rock unit can be identified at the study area which is phyllite, limestone and tuff unit. All the geological data and information collected are recorded and a writing report was made.

Another map produced at the end of the research was a forest cover map in the study area, which located in Kuala Betis, Gua Musang. The forest cover map produced including a map of land use and land cover (LULC) in 2010 and another map in 2018. The area of each land and forest cover was calculated to detect the total area of the changes. The change of land and forest cover of both 2010 and 2018 shows that the area of forest covers decreasing about 18.78%, from 22.94 km^2 to 18.16 km^2. While agriculture, bare soil and water body undergo increasing in the area about 13.43%, 5.09%, and 0.26% respectively. All the objectives of the research were successfully achieved.

6.2 Recommendation

In term of the geology of the study area, some of the places are inaccessible because of no other road except the main road, so not much geology structures can be found. To obtain more data of geological structure of the study area, more area need to access, by motorcycle or by foot to ease the accessibility to the dense area of the land cover. The rock outcrop that is found in the study area are mostly along the main road and was highly weathered because it was exposed to the surrounding. To obtain a more fresh rock outcrop, more places that are not too exposed need to be accessed.

For the production of forest cover map, a good resolution of satellite image need to be processed. Some of the satellite image from Landsat have poor resolution, and to overcome the problem, other types of images such as aerial photo can be used. The satellite image process for this research has some disturbance in the term of cloud coverage. To hinder from this disturbance, a good satellite data with less cloud coverage can be used. In ENVI 5.1 software, there are some tools in the ENVI 5.1 that was used in this research was not complete, and a perfect forest cover map are not produced. There is other remote sensing software that can be used to execute the forest cover map such as ERDAS IMAGINE or another version of updated ENVI to produce a more perfect map so that it can produce a better resolution map and better interpretation.

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