GEOLOGY AND SOIL EROSION ASSESSMENT USING GEOGRAPHIC INFORMATION SYSTEM AT DABONG, KUALA KRAI, KELANTAN

By

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DECLARATION

I declare that this thesis entitled "General Geology and Soil Erosion Assessment using Geographic Information System at Dabong" 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.

Signature : ______________________________

Name   : ______________________________

Date   : ______________________________

ACKNOWLEDGEMENT

بسم أالله الرحمن الرحيم

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Geology and Soil Erosion Assessment using Geographic Information System at Dabong, Kuala Krai, Kelantan.

ABSTRACT

The study area is located at Kg. Kuala Geris aligned between longtitude of 5°25'20.22"N to 5°22'37.00"N and latitude of 102° 2'50.00"E to 102° 5'33.07"E with the total area covers about 25km .This study area generally situated in Dabong area under Kuala Krai district. Unmodified and outdated of geological map in the study area become the main problem for this research study. Another reason is to obtain and score overall soil erosion in the study area by using Geographic Information System (GIS), since there is a lack of details and information about soil erosion in the study area. Rapid development and various kind of human activities have make significant environment impacts due to some factors.The main objective of this research study is to update and produce the geological map of the study area in scale of 1 :25,000. The interpretation and analysis is based on previous studies and also satellite imageries in order to produce and improvise a geological map. Interpretation shows that the study area comprised of two different lithostratigraphic units which are meta-sediment and schist including also with alluvium unit. Other than that, this research study is to quantify the total loss of soil in the study area by using Geographic Information System (GIS). Revised Universal Soil Loss Equation (RUSLE) become the effective erosion modelling for soil management. A soil risk map was produced through computation of required data by using specific equation that needed in RUSLE method in ArcGIS. The results shows that the study area has a moderate rate of soil erosion which can be dangerous and threatening if unsustainable development and practices keep going on without appropriate control and preventive steps taken.The estimation of soil loss in the study area can be done as it helps to identify whether it tends to pose a threat to other environments such as floods and in turn provide mitigation measures to overcome those threats

GEOLOGI DAN PENILAIAN HAKISAN TANAH MELALUI SISTEM MAKLUMAT GEOGRAFI DI DABONG, KUALA KRAI, KELANTAN

ABSTRAK

Kawasan kajian terletak di Kg. Kuala Geris diselaraskan antara latitud 5 ° 25'20.22 "N hingga 5 ° 22'37.00" N dan longtitud 102 ° 2'50.00 "E hingga 102 ° 5'33.07" E dengan jumlah luas kawasan merangkumi dalam 25km. Kawasan kajian ini umumnya terletak di kawasan Dabong di bawah daerah Kuala Krai. Peta geologi yang tidak dikemas kini di kawasan kajian menjadi masalah utama kajian penyelidikan ini. Sebab lain adalah untuk mendapatkan dan menilai hakisan tanah secara keseluruhan di kawasan kajian dengan menggunakan Sistem Maklumat Geografi (GIS), kerana terdapat kekurangan perincian dan maklumat mengenai hakisan tanah di kawasan kajian. Pembangunan pesat dan pelbagai jenis aktiviti manusia seperti pertanian, penebangan hutan dan pembinaan telah memberi kesan persekitaran yang ketara kerana beberapa faktor Objektif utama untuk kajian penyelidikan ini adalah untuk menghasilkan dan mengemas kini peta geologi kawasan kajian pada skala 1: 25,000. Tafsiran dan analisis berdasarkan kajian sebelumnya dan juga data satelit adalah satu-satunya cara untuk menghasilkan dan memperbaiki peta geologi kerana kerja lapangan tidak dapat dilakukan kerana wabak pandemik Covid-19.Selain daripada itu, kajian penyelidikan ini adalah untuk mengetahui jumlah kehilangan tanah di kawasan kajian dengan menggunakan Sistem Maklumat Geografi (GIS). Universal Soil Loss Equation (RUSLE) yang model bersepadu hakisan yang berkesan untuk pengurusan tanah. Peta risiko tanah dihasilkan melalui pengiraan data yang diperlukan dengan menggunakan persamaan spesifik yang diperlukan dalam kaedah RUSLE di ArcGIS. Hasil dapatan menunjukkan kawasan kajian mempunyai kadar hakisan tanah yang sederhana dimana ia boleh menjadi lebih teruk dan berbahaya jika pembangunan dan amalan yang tidak sekata dan berkekalan terus dilakukan tanpa kawalan dan langkah pencegahan yang sesuai diambil kira.Anggaran kehilangan tanah di kawasan kajian dapat dikenalpasti dimana ia dapat membantu mengenali kaitan dia antara ancaman persekitaran lain iaitu banjir dan juga dapat membantu menyelesaikan ancaman ini melalui langkah-langkah mitigasi.

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LIST OF ABBREVIATIONS

N	North
E	East
Km	Kilometer
m	Meter
Mm	Milimeter
Ms^{-1}	Meter per second
DID	Department Of Drainage and Irrigation, Malaysia
DOA	Department of Agriculture, Malaysia
FELDA	Federal Land Development Authority
FELCRA	Federal Land Consolidation and Rehabilitation Authority
GIS	Geographic Information System
JUPEM	Department of Survey and Mapping, Malaysia
KESEDAR	Lembaga Kemajuan Kelantan Selatan
KTMB	Keretapi Tanah Melayu
MJ	Mega-joule
ha	Hectare

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The title of this study is "Geology and Soil Erosion Assessment Using Geographic Information System (GIS) at Dabong, Kuala Krai, Kelantan". Kuala Krai is the second largest region in Kelantan after Gua Musang. Based on geographical location, Kuala Krai have 2,239 km2 or 910 miles with the borders of Machang at the North, Gua Musang at the south, Terengganu state at the West and Jeli at the east of the Kelantan (Krai, 2008).

This research focused on the study of geology comprised geological aspects such as lithology, stratigraphy, structural geology, petrology, and others. Otherwise, it is to update those geological aspects in order to get a new precise and exact geological data of the study area. Moreover, this research of study also comprised about environmental problem that is soil erosion of the study area.

Geological field mapping cannot be conducted due to the critical unexpected situation that world facing in 2020 which is COVID-19 pandemic. Thus, the main task of geological mapping was accomplished by conducting various methods that does not involved any outdoor activities such as laboratory interpretation which using satellite imageries associated with geographic information system and also remote sensing. This might be the only suited method in order to carry out and produce geological map of the study area.

Soil erosion has become one of the main and crucial environmental issues facing the world (Rahman et al, 2009). Soil erosion caused by water that initiates the detachment process of soil particles via raindrops and flowing water and then transports soil particles downslope (Yusof et al, 2011).

Generally, there are some erosion agents such as water, wind, gravity and even ice. .Human activities such as deforestation, agriculture, industrialization, mining and construction contribute most to this environmental issue .All of these activities are relatively interrupt the condition of environment where it increase the rate of erosion which then disturb the ground and causing another hazards.

1.2 Study Area

The study area of this study research is located at Dabong, Kuala Krai, Kelantan. Dabong is one of the main towns located in Kuala Krai district of Kelantan. It is located at the north-west part of Kelantan which is in between Jeli on the north part, Gua Musang on the south part and Kuala Krai on the east part of it. This research area is at Kampung Kuala Geris, Dabong and its surrounding areas.

This small village is accessible with two network, small road and railway road. Besides, 10-15% of the study area is covered with–water bodies of Galas River and with the small river.

1.2.1 Location

The location of the study area is located near at Dabong, Kuala Krai, Kelantan which aligned between 5°25'20.22"N to 5°22'37.00"N and 102° 2'50.00"E to 102° 5'33.07"E. The total extent covered for the whole study area is 25 km^2 with various elevation throughout the map. The highest elevation of the study area is around 262 meter from sea level while the lowest elevation of the study area is around 24 meter from the sea level. As for geomorphology of the study area, most part is categorized as denudational hills which for the moderate and high elevation. As for low elevation, most part is peneplain or floodplain. Figure 1.1 shows the base map of the study area at Dabong, Kuala Krai, Kelantan.

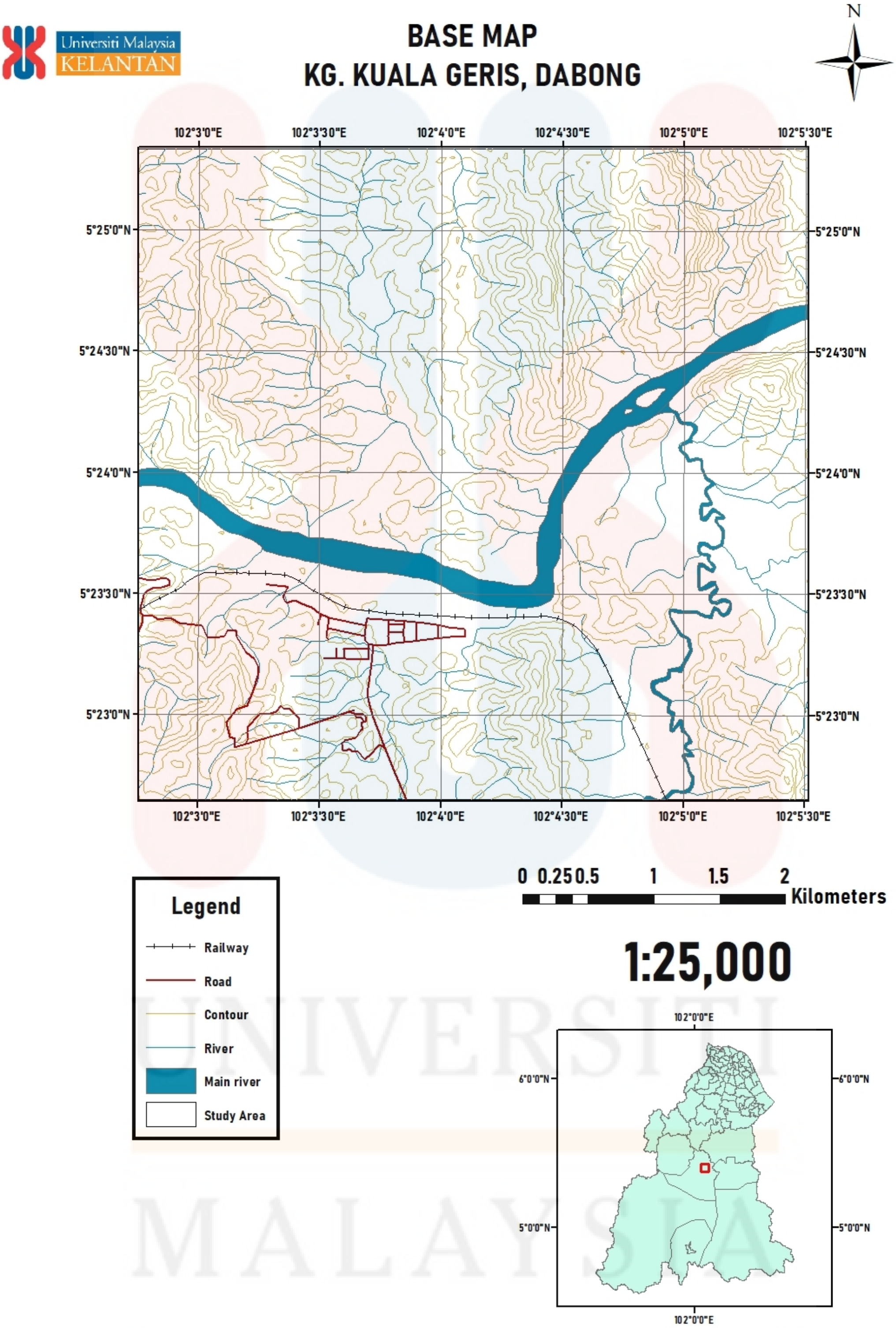

Figure 1.1 : Map of the study area at Dabong, Kuala Krai

1.2.2 Accessibility

There are some ways to reach and access this place. First road is using Federal Route 66 linking between Jeli and Kuala Krai. Then, begin to access with the small route to Kampung Kuala Geris. Another main network that can be accessed from the south part through the Jelawang- Gua Musang D29 state route and Dabong- Kemubu D231 state route .Another alternative network is by taking a train of KTMB East Coast Railway to the railway station of Dabong.

There are small roads or roads in the northern part of the study area that is commonly used for farmers or rubber tappers. Besides, there might be a new roads on the study area since the satellite imagery doesn't update the new view of the study area. In addition, there might be also another alternative transportation that can be used which is by river transportation that can be used in the study area since the study area was splitted by the main river, Galas River into two parts, the north part and the south part.

1.2.3 Demographic

People distribution in Kuala Krai has diverse ethnicities and races. The total population of Kuala Krai's people based on the statistics of UPEN (Unit Perancang Ekonomi Negeri Kelantan) 2010 is about 104,234 people. At Kuala Krai, most of the majority ethnics and races were predominated with Malay race with total percentage, 95.32%. Chinese races become the second races that predominated in Kuala Krai with the total percentage about 4.01 % followed by Indian races at third places with the percentage about 0.8% with others for the remaining with the total percentage 0.2%. The numbers might increase more since the data is outdated and unupdated about a decade. The migration process might influence these numbers. Table 1.1 refers to the population by district in Gua Musang, Kelantan in year 2010.

Table 1.1 Population by district in Gua Musang, Kelantan in year 2010

Ethnic	**Total percentage of population (%)**
Malay	95.32
Chinese	4.01
Indian	0.81
Others	0.2

(Sources: Lembaga Kemajuan Kelantan Selatan (KESEDAR))

1.2.4 Land Use

Land uses in Dabong, Kuala Krai covered from the rural to urban development activities. Dabong become one of the small town in Kelantan that undergone progressive development due to social economics itself nowadays. At Dabong, most of the area are covered with hills range with forest areas surrounds from any direction.

Specifically for the study area, most of the area predominated with rubber plantation area. It shows that most of the people at here might be rubber tappers. Based on the recent satellite imagery of Landsat-8, this area undergone some re-plantation of rubber plantation at certain location. Other than that, forest area becomes the second largest coverage which can be found at certain location especially at northeast and northwest with some part at east and southeast of the study area. The remaining areas covered by mangrove forest and small villages. Figure 1.2 refers to the landuse map of the study area at Dabong, Kuala Krai, Kelantan.

1.2.5 Social Economic

As for social economic in the study area, like stated before, most of people works as farmers or rubber tappers. It shows that this place is dominated with rubber plantation sector. This might be affected and influenced by land development authority such as FELDA, FELCRA, KESEDAR and so on. Development and expansion of new plantation sector and area might boost up more the economy at here. Other than plantation sectors, the remaining might works in various sectors such as teachers, local guiders and self-employment.

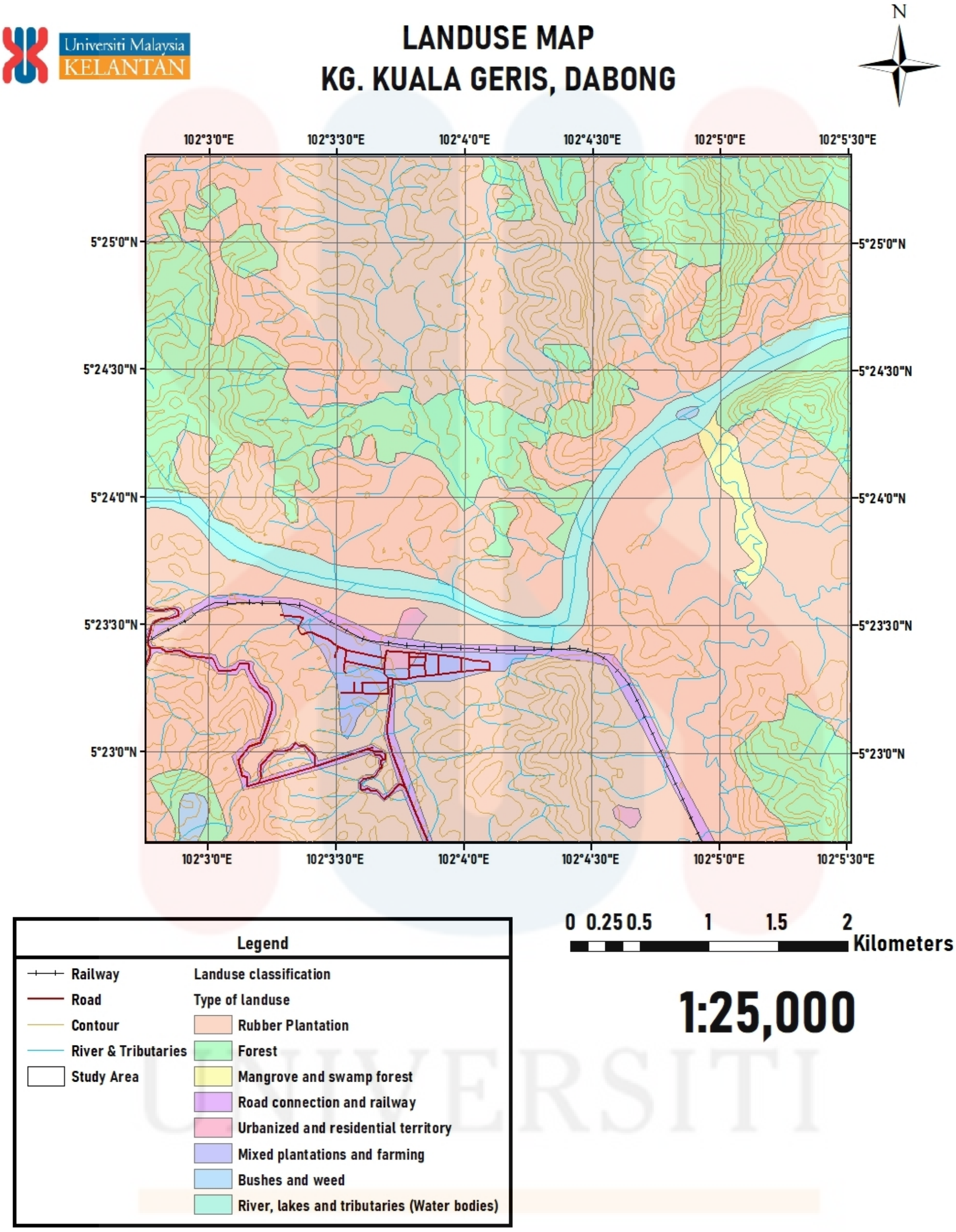

Figure 1.2: Landuse map of the study area

1.3 Problem Statement

This study is focused on geology and the soil erosion assessment in Dabong, Kuala Krai, Kelantan. The main purposes are to update and improve the geological map of study area with the scale of 1: 25000. Reason for this is that due to unupdated and unmodified of geological map in the study area which may outdated and totally different with recent. This problem might lead to inaccurate and imprecise results especially in geological mapping. This update will comprises into new information of geological from the lithology and stratigraphy of study area, its geomorphology and structural geology analysis.

Next, the research was conducted to acquire and rate the total soil erosion in the study area by using GIS as there is lack of information or data that focused on the soil erosion in the study area.. It is necessary to have this data where all of this data are essential to related party such as development authorities, urban planner and researchers for particular study and research.

Another reason is since the study area has undergone development and human activities such as agriculture, farming and re-plantation, deforestation and construction. Hence, there is high possibility of this study area to have environment impacts such as flood, landslide and the loss of soil fertility. High intensity of sedimentation process in rivers might increase the possibilities of flood occurrences in the study area. Besides, it also affect by interrupt aquatic ecosystems. As stated before, natural factors also play role in this situation. With the total average of rainfall in Kelantan 3017 mm and mean circadian yearly wind speed is 1.50 ms^{-1}, Dabong are one of the affected area during monsoon season as this place become extremely flooded.

1.4 Objectives

This research contains several objectives as follows:

I. To update the geological map of the study area at Dabong, Kuala Krai, Kelantan in scale of 1 :25,000

II. To quantify the total loss of soil in the study area at Dabong, Kelantan.

III. To produce soil erosion risk maps of the study area in Dabong, Kelantan.

1.5 Scope of Study

This research scope is focused on some aspects. First are interpretation works or data analysis and processing sessions to generate geological map. In order to carry out the study of geological mapping, the basic needs such as base topographic map and also with some geological interpretation need to be done. By then in the field, the geological mapping needs to be completed by combining all of geological information from the lithology, geomorphology to structural analysis of the study area. For data analysis and processing sessions, Revised Universal Soil Loss Equation (RUSLE) method is among practicable and widespread method which define specifically soil erosion model. RUSLE method is used where the risk of soil erosion is calculated by following the formula of this method where considering some important parameters involved such as rainfall precipitation, soil erodibility, land uses and land cover and slope. After that, by following and completing important steps and formula in RUSLE method, the risk thematic maps of soil erosion was produced.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed on findings and past study research in related fields. All of references describe more about scope of this research.

2.2 Regional Geology

In general terms of geology, Malaysia can be categorized into three parts of geological belts which are Western Belt, Main Central Belt and Eastern Belt. All of these belts began from the north and extensively end up at south part of Peninsular Malaysia. Otherwise, there are two blocks that comprised in our region which are Bentong-Raub suture zone, the western part belongs to Sibumasu blocks, meanwhile the eastern parts belongs to Indochina block (Metcalfe, 2000). Both Sibumasu and Indochina originated from gigantic plate of Gondwanaland.

The Bentong-Raub suture zone is the final product from the process subduction of the Palaeo-Tethys ocean beneath Indochina plate, and the collision of the Sibumasu block with Indochina block that occured in Triassic period. This major collision of Sibumasu block and Indochina block have resulted in orogenic deformation throughout the whole region.

Kelantan is one of the states that located at the northeast of peninsular Malaysia bordered with Perak on the west side, Terengganu on the east side, Pahang on the south side and Thailand on the north side. Kelantan can be categorized into 10 administrative districts which are Kota Bharu (Capital state) , Pasir Mas, Tumpat, Bachok, Pasir Puteh, Tanah Merah, Jeli, Machang, Kuala Krai and Gua Musang. Figure 2.1 shows the geological map of Kelantan.

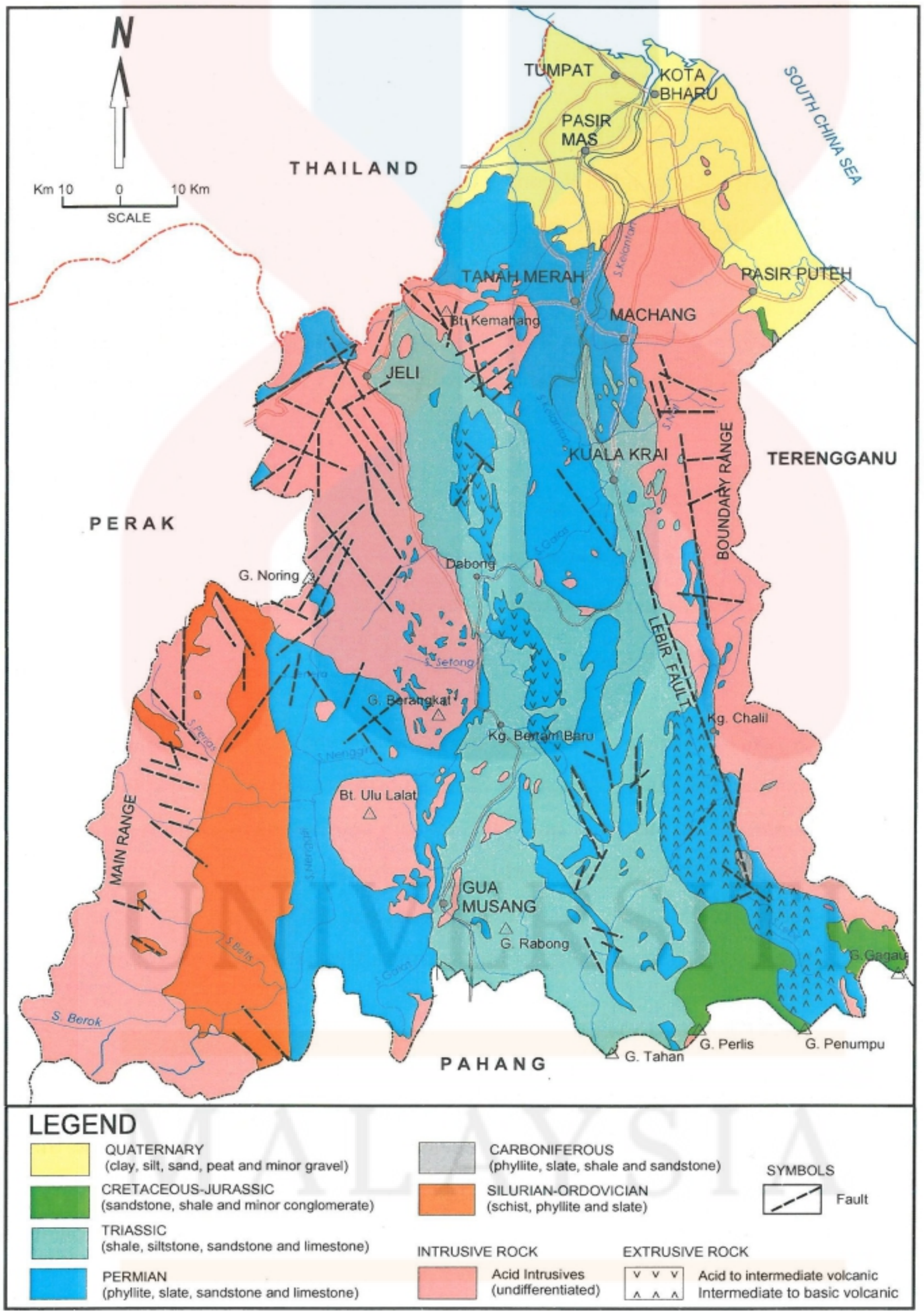

Figure 2.1: The geological map of Kelantan (Department of Minerals and Geoscience Malaysia, 2006)

2.3 Stratigraphy

Kelantan can be categorized into some formation of lithology which is Gua Musang Formation, Taku Schist and also East Kelantan Olistrotrome. However, there are less supported evidences that shows for East Kelantan Olistrotrome to be explained. The rocks in Kelantan are distributed in a north-south trend (Nazaruddin,D.A 2014). There are also some intrusions of igneous rocks such as granite, porphry diorite, dolerite and ignimbrite. Igneous distribution in Kelantan can be observed at west and east part of it. Generally, it can be divided into two main bodies part. The first is the igenous bodies within the main range and the second one is within the boundary range. The Main range granite is generally of a Middle Triassic age, between 200 and 230 m.y (Nazaruddin,D.A 2014).

2.3.1 Gua Musang Formation

As for Gua Musang formation, it is the dominant formation that predominate the state. Gua Musang formation has been introduced by Yin (1968). The ages of this formation varies from the Carboniferous until late Triassic. Eventually in Gua Musang Formation, there are other formation under it which are Telong formation, Aring formation and Nilam Marble formation. Some researcher especially geologists have proposed to combine all of these formation under the same group which is Gua Musang group but since there is a lack of studies and argument about this formation, it is still remain as Gua Musang formation. There is also new kind of lithological units under Gua Musang formation which is Gunung Ayam Conglomerate. Gunung Ayam Conglomerate which was named as the basal conglomerate of the Gua Musang formation (Aw, 1974) is now regarded as the Bentong Raub Suture Zone (Tjia & Almashoor, 1996) and thus need to be excluded.

a) Gua Musang Formation.

The age for this formation varies from middle Permian until Middle Triassic. Lithological units for Gua Musang Formation dominated with argillaceous rocks with carbonate rocks and also pyroclastic or volcanic rocks. Based on the lithological units, it is believed that the depositional environment for this formation is shallow marine environments with some kind of volcanic activities.

b) Telong Formation

Telong Formation is another formation that aged between Permian until Triassic. This formation consisted with argillaceous rocks also associated with meta-sedimentary rocks with some pyroclastics facies.The lithology unit of sediment have strong similarities to the argillaceous rocks of the Gua Musang Formation (Nuraiteng ,2009).

c) Aring Formation

Aring formation was named after the location of Sungai Aring, Gua Musang.This formation is mainly deposited with pyroclastic facies which is tuff and minor of agglomerate with thin argillite and interbedded of carbonate rock which is dolomitic marble. The pyroclastics facies can be categorized as coarse grained-tuff and volcanic breccia. Fine to coarse pyritiferous tuffs with subordinate amounts of interbedded lavas of composition also rhyolite to andesite existing in Aring formation (Lee, 2004). It is believed that the age of Aring Formation was from Late Carboniferous until Early

Triassic. It was supported based on the fossils evidence such as brachiopod and foraminifera that aged around that period. . The depositional environment was suggested by Lee (2004), is neritic with volcanic input.

d) Nilam Marble Formation

Nilam Marble Formation consisted with dominant in massive carbonate rocks, interbedded with some pyroclastics facies such as tuff and some argillite according to Aw (1990). It has suggested that Nilam Marble Formation was from Permian until Late Triassic. Based on previous research, it suggested that carbonate rocks at here that undergone metamorphism process to form marble may consists more than one separate bodies of rock. Besides, this rock bodies have formed the lenses shape structure of carbonate rocks in forms of argillitic unit or tuff unit of Aring Formation or maybe Telong Formation.

2.3.2 Taku Schist

Taku schist is the evidence of highly regional metamorphism that occurred during the collision of Sibumasu plate with the Indochina plate. This metamorphic unit was dominant with garnet-mica schist and quartz-mica schist with assemblages of quartz, muscovite, feldspar and almandine minerals (MacDonald, 1968, Hutchinson, 1973). Taku schist can be found within the main range of Central belt. There are reports suggesting that the Taku Schists are the metamorphic equivalent of the surrounding Triassic sediments (Sankoth Singh, 1963, and Chung and Yin, 1980, in Khoo and Lim, 1983). Khoo and Lim (1983) suggest that the Taku Schists were deposited in Permian and Triassic times as shales, fine arenites, acid to intermediate pyroclastics and limestone.

2.4 Structural Geology

As for structural geology, there are some major geology structure can be found around the state. The Lebir Fault, one of the major fault in Malaysia, can be traced and outlined on the RADARSAT imagery with zone of NNW-SSE trending curvilinear lineaments along Sungai Lebir that located at area of Manek Urai in Kelantan (Hutchison and Tan, 2009)

The Stong Igneous Complex is one of the biggest intrusive plutonic complexes in Kelantan. This complex consisted three lithodemic unit under it which are Berangkat Tonalite, Kenerong Leucogranite and also Noring Granite. Berangkat Tonalite and Kenerong Leucogranite are highly deformed and strong foliated of their rock unit. This huge intrusive bodies might affected and influenced the regional scale of deformation around it's region.

2.5 Historical Geology

For historical geology, Peninsular Malaysia is one of the part from the gigantic plate of Eurasian known as Sundaland, and it has divided by the north to south of Palaeo-Tethys Bentong-Raub suture into Sibumasu block on the west and East Malay block on the east. Most of the various continental pieces that now formed Southeast Asia were derived from the southern hemisphere supercontinent Gondwana (Metcalfe, 1988) (Metcalfe, 2013).

Raub-Bentong suture divide into two blocks of Peninsular Malaysia. Sibumasu located at Western part and East Malaya block located at eastern part or it called Indochina block (Metcalfe, 2013). Sunda Shelf from part of two-tectono-stratigraphic terrane branched by Malay Peninsular, there are divided east malay there is Eurasian plate-Indochina and Sibumasu terrane respectively (Yeap,E.B 1993). Figure 2.2 indicates the evolutionary of collision between Sibumasu block and Indochina block

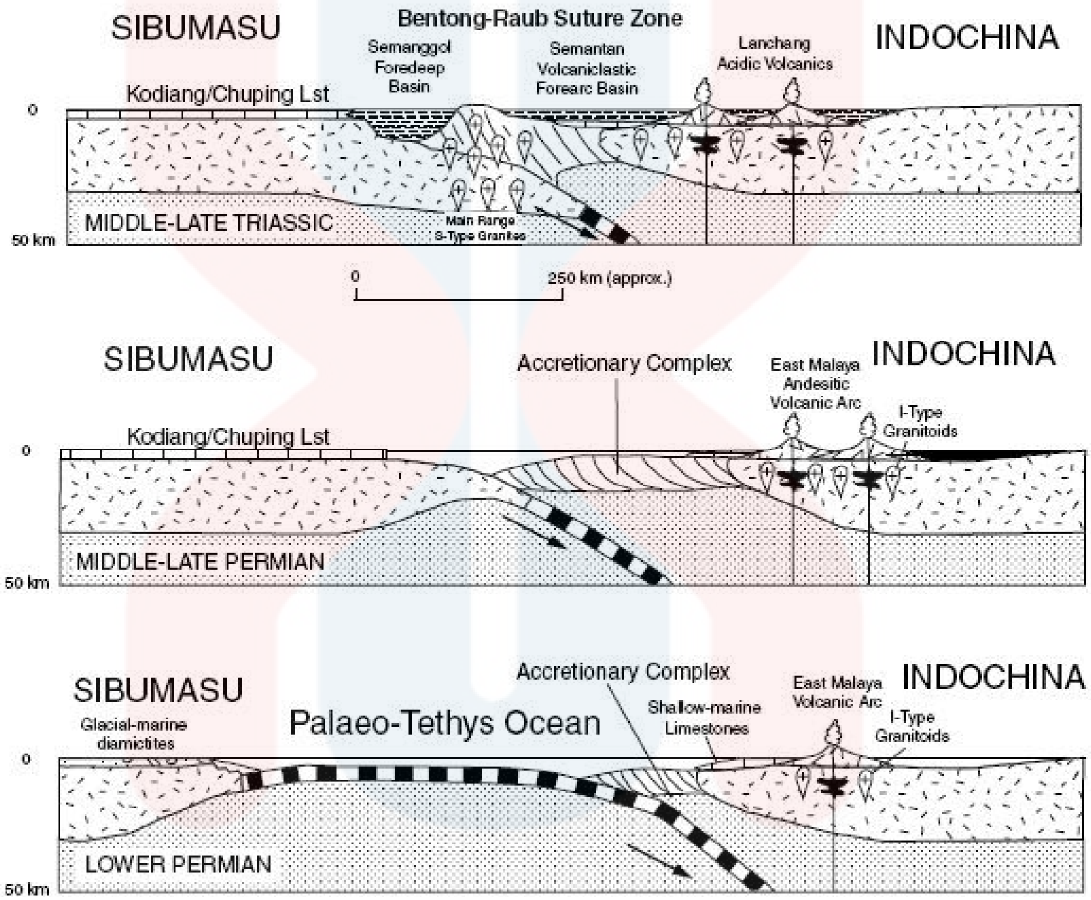

Figure 2.2: The evolutionary of collision between Sibumasu block and Indochina block.

(Metcalfe, 2000)

2.6 Soil Erosion

Soil erosion can be described as a mechanism for detaching and moving soil particles from its origin to another (Singer and Munns, 1999). Works by Ouyang et al (2010) have shown that soil erosion is primarily caused by human activity and land use change, making this one of the principal factors in the occurrence and intensity of soil erosion. Human-induced land use or soil cover change has a significant impact on soil degradation, including soil erosion, soil acidification and reduction of organic matter (Sharma et al, 2011). Soil erosion accelerated by human activities such as land clearing, agricultural activities, development and urbanization has been the source of serious environmental problems.

The consequences from this threat might be worst enough not only for human but also for the environment. Its might beyond under expectation as could increase pollution especially soil and water, increased in sediments yield in rivers, which might interrupt another ecosystem such as the aquatic ecosystem. Soil erosion specifically affects soil quality and fertility (Gao et al. 2011; Khan et al. 2015), water quality and the deposition of sediments in river beds (Walsh et al. 2011), which reduces the depth of river and results in channel overflow during high precipitation. Environmental and soil conservation efforts have increased globally, particularly for the need for ecologically sustainable improvement choices in watersheds with different objectives and the capacity to predict erosion and reduce its natural effects (Cunha et al. 2016).

2.7 Application of Geographic Information System in Soil Erosion Assessment

Geographic Information System (GIS) is one of the important applications that widely used of the selection, storage, recovery, transformation, manipulation and display of spatially distributed data and is most also used in distributed deterministic modeling (De Roo, 1993). It is proven as many specific studies and research have been done such as morphometric analysis, land use changes analysis, estimation of soil loss and many more. With the advent of remote sensing and GIS technology, a variety of spatial data such as geology, structure, surface cover, slope characteristics and others can be efficiently obtained, manipulated and incorporated in an environment that can be used for landslide hazard zoning (van Westen 1994, Gupta and Joshi 1990, Gupta 1991, Nagarajan et al. 1998, Sabins 1999).

2.8 Revised Universal Soil Loss Equation (RUSLE) Method

RUSLE method is a model that widely used in the world especially when it comes to estimate and analyze the total rate of soil loss. The Revised Universal Soil Loss Equation (RUSLE), a revised version of USLE (Wischmeier and Smith 1978), is a widely used model to predict the long-term average annual soil loss carried by runoff from particular field slopes in specified cropping and administration frameworks, and additionally from rangeland (Renard et al. 1997). It has been proven effective in estimating soil loss in different parts of the world (Rozos et al. 2013; Ganasri and Ramesh 2016; Zhao et al. 2017). It also can predict erosion potential on a cell-by-cell basis (Shinde et al. 2010), which is effective when attempting to determine the spatial pattern of the soil loss present within a large scale. In USLE / RUSLE, there are five main factors, which are rainfall pattern (R), soil, type (K), topography (LS), crop structure (C) and management practices (P)] are used to measure the predicted annual average erosion by the following equation: (Renard et al. 1997):

$$A = R \times K \times LS \times C \times P$$

Where A = mean annual soil loss (in ton / ha / year), R = factor for rainfall and runoff erosivity (in MJ / ha / mm / yr), K = factor for soil erodibility (in ton / MJ / mm), LS = slope and slope factor frequency, C = factor for crop management, P = factor for erosion control.

CHAPTER 3

MATERIALS AND METHOD

3.1 Introduction

This chapter explains and discuss about each of material and method that was used to run this study research within the given duration. Each of material and methods used is based on needs that required in every specific step in order to accomplish the research's goals.

3.2 Materials

Some materials used in this study are as follows:

1. Base or Topographical map.

Base or topographical map is an important tool especially for geological interpretation and analysis. General ideas can be obtained trough specific geological analysis with the aid of previous studies.

2. ArcGIS Software.

ArcGIS software developed by ESRI, was designed specifically for GIS user in order to create or using maps, gathering and analyzing geographical or geological data and managing the geographical data in the database. It also important as it helps to produce geological map and the soil loss zone map.

3. Google Earth Pro.

Google Earth Pro is important software in order to visualize the detailed imagery of the study area. Developed by Google, this software originally displays 3D visuals of Earth. Besides, Google Earth Pro can be used in any device from small one, handphone, to tablet and also laptop.

4. Secondary Data.

Secondary data is another main thing that important for this study research. It support and assist more about the chosen methods especially for geology and specification part. Each secondary data can come across from various agencies. For example, terrain data was acquired from Department of Survey and Mapping of Malaysia (DSSM) and United States Geological Survey (USGS), soil data from soil map and type of soil with rainfall precipitation data from Department of Agriculture of Malaysia (DOA) and others related bodies or agencies.

3.3 Methodology

Methodology must be well-organized and efficient enough to carry out each steps in order fulfill this research appropriately. For methodology, it separates into some parts, which are preliminary studies, imagery interpretation and data analysis and interpretation. Fieldwork cannot be carrying out due to COVID-19 pandemic. The only way to solve this problem is by carry out imagery interpretation and data analysis and interpretation by using geographic information system (GIS) medium with some kind of aid from remote sensing medium.

3.3 .1 Preliminary Studies

Before conducting research on the study area, it is better to know and figure out the studies of any geological interpretation of the study area. Interpretative knowledge basically come out as soon studying and researching on the previous research, studies, journals and investigation in order to get the a general idea. Interpretation of geological can be applied by recognized based on the geographical view in topographical base map or even in Google Earth Pro.

3.3.2 Imagery Interpretation

Morphological characteristics and the resulting of various landform can be analyzed through fieldwork and from remote sensed data. Interpretation of geological features from remote sensed data is intended to collect geological knowledge for additional applications. Specific computer software has been used with digital image processing capabilities, modelling, 3D visualization, hydro enforcement.

3.3.3 Data Analysis & Processing

As for data analysis and processing, it more focused on the data interpretation based on the outcomes that obtained during the field or the previous research. In this research, the first data interpretation focused on the geological update on the study area while the second data interpretation focused on the prediction of soil loss in the research area by producing the probability risking zone maps.

1) RUSLE method

For data analysis and processing, RUSLE method was applied in GIS. Some important data sources need to be taken to fulfill the criterion that needed in RUSLE method. Those data are such as soil physical and chemical values data plus with soil map, terrain map which DEM data, land use changes data and rainfall precipitation data. All of these data represents each of the factors in the formula:

$$A = R \times K \times LS \times C \times P \qquad \text{(Equation 3.1)}$$

Where:

A= total soil loss factor

R = rainfall erosivity factor,

K = soil erodobility factor

LS = steepness of slope factor

C =land cover management factor

P = aided practices factors.

Final outcome for RUSLE method comes by multiplying all the processed factor's data by using Equation 3.1 before compute using map algebra tool in ArcGIS. The results was concluded in terms of soil erosion mapping where the intensity or probability of risking zone map was produced. This map was graded into five zonations of soil erosion in visual clarification from very low, low, moderate, high and very high.

The factor (R) represents erosivity of rainfall evaluating the effect of rainfall and runoff appears to be correlated with precipitation. The factor (K) that reflects soil erodibility places importance on measuring soil type characteristics and their resistance to dislodging and flooding due to rainfall.

$$R_{ann}\left[4.17 \times \sum_{i=1}^{12} (\frac{p2i}{p})\right]$$

(Equation 3.2)

Where;

π = total mean of rainfall intensity in (mm) for a given month i,

P = the total annually mean of rainfall intensity in (mm)

Rann = the total annually mean of rainfall erosivity, R in the study area.

As for R, rainfall erosivity factor, the rainfall intensity and precipitation data within a year was acquired from Department of Irrigation and Drainage (DID), The next step is by computing it specified formula or method which is by implementing the spline interpolation method in ArcGIS software. This specific method was then processed each of grid cells into precise final data for rainfall erosivity.

The K factor of each soil type was determined to identify its chemical and physical characteristics which play an essential key in contributing to the erosion potential. Morgan claimed that the color of the soil could be observe based on the values of K. It acts as a indication of the soil's capacity for eroding and can help to produce estimates of the possible soil loss level.

Table 3.1 shows the soil types for 26 Malaysian Soil Series. Table 3.2 shows the soil layer series in Malaysia. Table 3.3 shows some of soil types with their K factor values.

Table 3.1 . Types of soil for 26 Malaysian Soil Series

Soil Group	**Soil Series**
1	Batu Lapan, Marang, Mat Daling, Serdang
2	Muchong, Kuah, Mat Jempul Durian
3	Tangga, Terap
4	Kemahang, Merapoh, Baling, Kuala Nerang
5	Laka, Nami, Jitra
6	Bongor, Jeragau, Beserah, Renggam, Lanchang, Ketak, Pulau Besar
7	Holyrood, Batang Merbau

(Sources : Department of Agriculture, DOA (1995))

Table 3.2. Layer of soil for soil series in Malaysia

Texture Layer	**Soil Layer Depth (m)**
A (Surface soil)	0.00 - 0.50
B (Subsoil)	0.51- 1.00
C (Substratum)	1.01 - 1.50

(Sources : Department of Irrigation and Drainage, DID)

Table 3.3. Types of soil with their K factor values

Soil Series	K factor
Serong	0.1144
Selangor kangkong association	0.07
Renggam	0.09
Kuala Kedah permatang association	0.1125
Steep land	0.1100
Renggam Bukit temiang association	0.1159
Local alluvium- colluvium association	0.1137
Urban land	0.1102

(Sources : Agricultural Handbook (Shamshad et al.2008))

Soil erodibility factor (K) was calculated in SI units according to (Renard et al. 1997) which is given as:

$$K = 0.277 \times 10^{-6}(12 - OM)M^{1.14} + 0.0043(s - 2) + 0.0033(p - 3) \qquad \text{(Equation 3.3)}$$

Where;

M = (silt percentage + very fine sand percentage) x (100 – clay percentage)

OM = organic matter percentage, s is a structural parameter of the soil sample

p = permeability parameter.

However, equation 3.3 can't be apply in this study since this equation involving sampling in field and analysis in laboratory. The only way to obtain the soil erodibility factor value is from the standardized soil erobility factor that have been established from Department of Agriculture (DOA).

For soil erodibilty factor, K, the soil map for study area was gathered from Malaysian Department of Agriculture (DOA). The data was then compute under statistical model or formula in GIS where the original soil map obtained in vector format was transformed into grid format. After that, it was reclassified for each soil class based on the K factor value.

Slope Length-Steepness (LS) factor is the factor that modify and affect the impact of local topography on the rate of soil erosion, cumulative impacts of slope length (L) and slope steepness (S) as a function of the assumed soil loss ratio for each region. Slope (L) is determined from the point of origin of the overland flow to the point at which the deposition begins and/or the water enters.

As for the slope length-steepness factor, LS, this data which are slope map and topographical map will obtained either from Malaysian Mapping and Surveying department (JUPEM) or maybe from United States Geological Survey (USGS). LS factor then was calculated by using equation that have been introduced by Wischemeier and Smith (1978):

$$LS = \left(\text{Flow accumulation} * \text{Cell}\frac{\text{value}}{22.1}\right)^{m}(0.065 + 0.045S + 0.0065S^{2})$$

(Equation 3.4)

Where;

S = mean gradient of slope in (%)

m = m value based on the table in (Table 3.4)

Table 3.4. m value with slope gradient (%) for LS factor

m value	Slope Gradient, (%)
0.2	< 1
0.3	$1 \leq s < 3$
0.4	$3 \leq s < 5$
0.5	< 5

(Source: Ministry of Natural Resources and Environment Malaysia, 2010)

The value of m value differs from 0.2 until 0.5 based on the slope gradient (%) which can be shown in Table 3.4. The next step is for the calculation of this formula in ArcGIS by multiplying pixel value to standard or specific value and compute it using Raster calculator function in ArcGIS.

The Cropping and land cover management (C) factor reflects the soil loss ratio in a crop field to the soil loss in an open region (Ranya, et al,2015). It is the ratio of land-cropped soil loss to the corresponding loss from clean-tilled, continuous fallow under defined conditions. The P-factor supporting activity explains the impact of such activities as contouring, strip cropping, concave slopes, terraces, sediment basins, grass hedges, silt walls, straw bales, and underfloor drainage. The value for P is taken using analogy of practices, as the data is not readily available for the study area.

For the C factor, cropping and land cover management factor, it is also same like slope factor to obtained the data which are from JUPEM and USGS. The data from JUPEM might completely perfect for land cover management. If the data from USGS, the data which is Landsat-8 OLI/TRS isn't completely perfect since it covers only at certain distance which is in a big scale . However, it can be done completely by taking some steps of supervised classification method for that data before transformed into vector grids format.

As for the last factor which is support practices factor, P factor, the data for this factor will be acquired from updated land use map from related bodies or agencies like Malaysian Mapping and Surveying Department (JUPEM) and Malaysian Drainage and Irrigation Department (DID). P value is obtained by allocate on each different type of land use and land cover.

Land use land cover (LULC) for 2015 was prepared by visual interpretation of Landsat 8 data in a GIS environment (Anees et al. 2017). The C and P factor values were taken from the Guidelines for Soil Erosion and Sediment Control in Malaysia (DID 2010) and these values were assigned for each LULC class polygon.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discussed about general geology which comprised of geomorphology, lithostratigraphy, structural geology and also historical geology of the study area. These entire field and others necessary point that related to this research is explained based on the analysis and interpretation of previous studies and either aerial or satellite imagery.

Accessibility to the study area as well as settlement also become as part of discussion in order to get an idea on how to reach that place and to know the community and their necessities at there. Vegetation is also important to determine information about the attribution of the study area.

Branches of earth science like geomorphology, lithostratigraphy, structural geology and historical geology information are necessary to figure out since all of those studies have their relation to each another in order to generate more understanding about the geology of the study area. In addition, it helps to overcome the environmental issues and sustain the environment interactions

4.1.1 Accessibility

The study area is located at Dabong, Kuala Krai, Kelantan specifically at Kg. Kuala Geris, one of the small village near Dabong town. This location can be accessed by using Federal Route 66 that linking between Jeli and Kuala Krai. There are also several options to link the residents at this small village to get their needs at Dabong town by using Jelawang- Gua Musang D29 state route , Dabong- Kemubu D231 state route or maybe by taking a train of KTMB East Coast Railway to the railway station of Dabong. In the northern part of the study area, there are also small roads or off-roads used by farmers. This study area might get modernized after all since there are existences of new roads.

4.1.2 Settlement

The total extent area of Kampung Kuala Geris is about 0.8 kilometer per square. This village have essential facilities either social or economic such schools, grocery store, small workshop, mosque, restaurants and even railway station. Sekolah Kebangsaan Kuala Geris (Figure 4.1) become the main educational institution for the community at here, especially the young generation receives the early education just same like all another young generation receives that lived in urban area. .

There are also mini marts where communities at here can get all basic groceries necessities. To get more additional groceries or commodities, they might get at Dabong town or maybe even further at Kuala Krai town. Kg. Kuala Geris mosque (Figure 4.2) is the only worshiping place for muslims that can be found at here. Kuala Geris railway station (Figure 4.3) is one of the important accessibility ways for communities at here to stay connect with another places.

Figure 4.1 : Sekolah Kebangsaan Kuala Geris, Kuala Krai, Kelantan. (Google Earth)

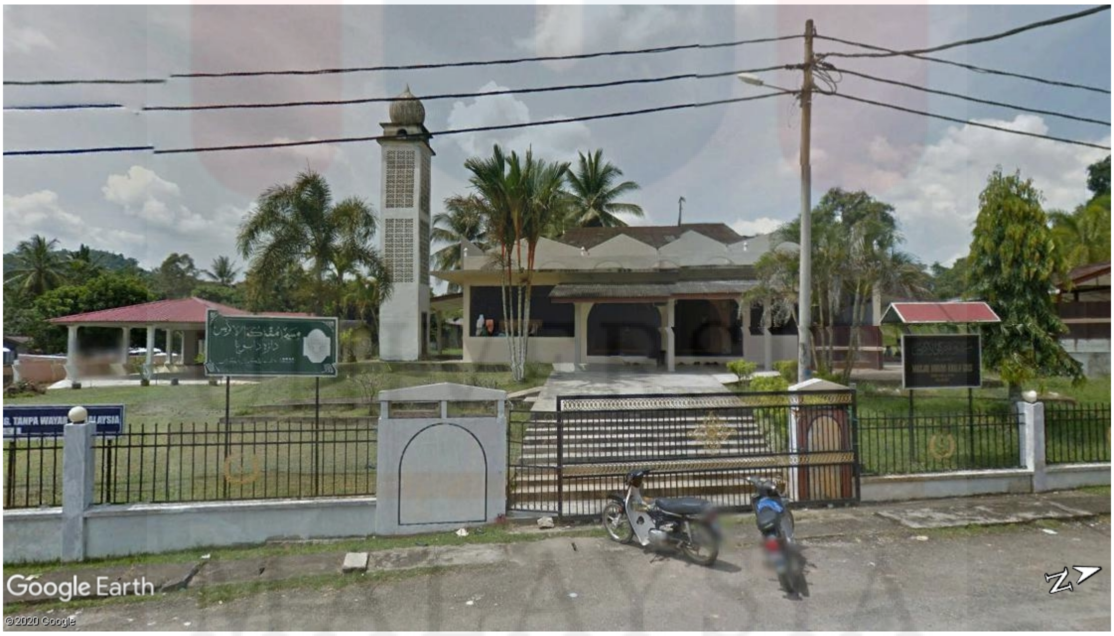

Figure 4.2 : Kuala Geris Mosque, Kuala Krai, Kelantan. (Google Earth)

Figure 4.3 :Kuala Geris Railway Station

4.1.3 Vegetation

The study area comprised widely of agriculture area which is rubber plantation (Figure 4.5). About 70% area in the study area is rubber plantation while 27% of it is forest area comprised of wild forest, swamp and grass weeds area. The remaining percent consists of settlement area, Kg Kuala Geris itself. Generally, most of residents at Kg. Kuala Geris work as rubber tapper and farmers.

Figure 4.4 :Rubber plantation along the road to Kg. Kuala Geris. (Google Earth)

4.2 Geomorphology

Geomorphology is the study of earth landforms with associated process that makeup the large evolutionary landscape on earth. Changes in land form patterns influenced by some factors such as weathering process, tectonic movement , drainage pattern and so on. Dynamic process make landforms classified based on their genesis and evolution. This process occured in such a long period.

4.2.1 Geomorphology Classification

For geomorphology classification, it can be categorized into four classes in the study area which are low land, low lying hill, low hill and hill. Based on the Figure 4.1, the study area was low lying land that focused especially at the center part of the study area. Low hill become the following class that dominant in the study area which focused at each of ordinal directions in the study area. For low land, it predominated mostly at Kg. Kuala Geris and at the mouth of Teku River and the south part of Teku River.

Low lying land class covered about 55 percent of the study area, which has elevation range from 50 m to 100 m. Low hill become the second dominant class that covered the study area which has elevation range from about 100 m to 200 m. Low hill class covered about 25 percent of the study area with the mean elevation range about from 33 m to 50 m. The remaining of 5 percent is hill class ranged from 200 m to 260 m that focused at the north east part of study area. Figure 4.5 represents the geomorphology map of the study area while Table 4.1 indicated the classification between the morphology elements with the absolute elevation range. (Raj, 2009)

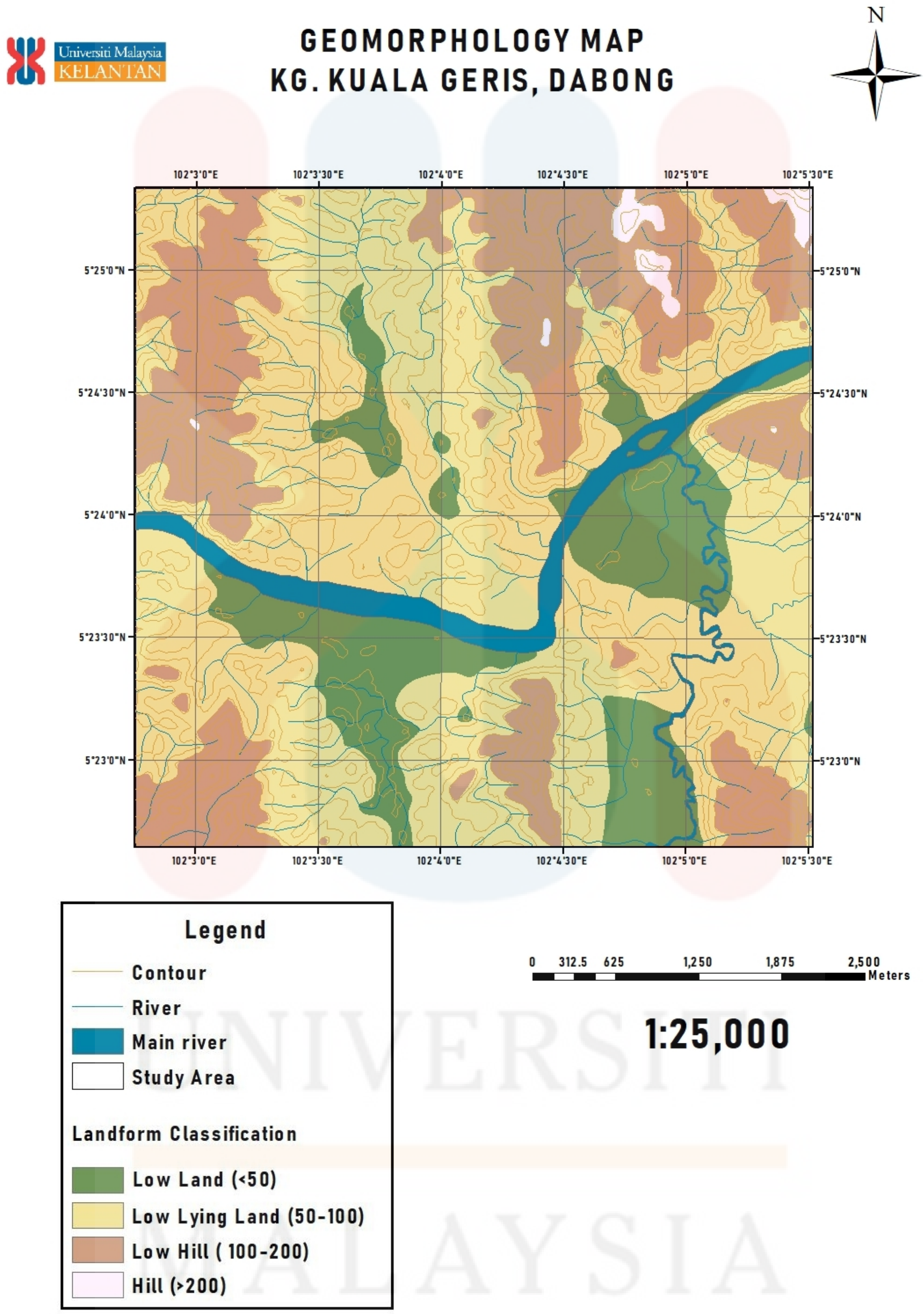

Figure 4.5 : Geomorphology map of the study area

Table 4.1 : Relationship between the morphology elements with the absolute elevation range.

Morphology elements	Absolute Elevation Range
Low Land	<50 metres
Low Lying Land	50 - 100 metres
Low Hill	100 - 200 metres
Hill	200 - 500 metres
High Hill	500 - 1500 metres
Mountain	1500 - 3000 metres
High Mountain	> 3000 metres

(Raj, 2009)

4.2.2 Drainage Pattern

Drainage pattern is the pattern that created by rivers, tributaries, or lakes in a particular drainage complex. These drainage pattern categorized into some types based on different kinds of characteristics. The characteristics come from it's specific size, shape, and pattern of drainage system. All of these characteristics were influenced by some factors such as the topography of land, lithology, vegetation, type of bedrocks, structural geology and climate.

In drainage pattern, there are six major types that can be classified which are dendritic, parallel, rectangular, radial ,trellis and centripetal. There are also other types like annular, angular, discordant, pinnate, braided, sub-dendritic and sub-parallel.

For different sub-networks corresponding to sub-catchments of the main river catchment, drainage patterns were defined and can be determined for various orders.

Based on observations on the study area, there are three types of drainage pattern consist of dendritic, parallel and sub-parallel (Figure 4.6). Besides, Sungai Galas that flow from west to east of study area become the main river body instead of Teku River that becomes the main tributaries in the study area.

Drainage patterns of stream network from the study area have been observed as mainly dendritic type. This pattern is characterized by a tree like or fern-like pattern with branches that intersect primarily at acute angles. In a dendritic river system, there are many contributing streams (analogous to the twigs of a tree), which join together and are the tributaries of a main river (Lambert, 1998). Dendritic pattern were identified based on the pattern of tributaries where they have same style of acute angle. Drainage pattern usually formed at gentle slope regions. This regions are usually can be classified in horizontal and uniform rock types region such as in sediments regions and rarely also can be in crystalline rocks regions. Based on the observation, this pattern can be identified at the northern part of the study area where this part comprised of sedimentary rocks like shale, siltstone and sandstone.

Parallel pattern is the parallel like drainage pattern where formed due to steep angle of slopes with quite regularly spaced and more or less parallel main tributaries joining together. Parallel pattern tend to have average to steep slopes. This pattern has small value of acute angle compared to dendritic angle. Besides, this type of pattern somehow shows the existence of geological structure in that area like faults and folds. This pattern type can be observed at eastern part of study area near at Taku River.

Other than that, sub-parallel pattern is the pattern's type that similar under its main type, parallel. However, both of it different where sub parallel pattern have much less parallel rather than parallel pattern. About 180 streams were identified in the study area where about 135 are first (1^{st}) order stream segments, 34 are second (2^{nd}) order segments. Third (3^{rd}) order segments was defined as 9,while for the highest order, forth (4^{th}) order segments are only 2.

Other than that, low plain of the study area specifically can be classified as floodplain. The other high plain around the floodplain can be termed as upland area. Along the main river channel, some deposition features such as sand bars and river islands or ait can be observed.

River island is nearly seen at the middle of Galas river and another main river body which is Teku river. River island is determined as any exposed land surrounded by river water. For the sand bars, there are some sandy bars that deposited along the Galas River.

In the study area, describing a channel as a straight channel seems pretty obvious, though rarely is a channel perfectly straight in nature. Galas River is easy to classify it as straight channel. Along the main river channel, deposition features can be observed in the study area such as sand bars and river islands or ait based on Figure 4.7, 4.8 and 4.9. River island can be seen near at the middle of Galas river and another main river body which is Teku river. River island is any uncovered land formed by the accumulation of sediments enclosed by river water associated with fluvial interactions. For the sand bars, there are some sandy bars that deposited along the Galas river. Sand bar in a river is an elevated region of sediment such as sand or gravel that has been deposited by the flow. Sandbar is the region depositional materials or sediments like gravel and sand accumulated by the intensity of water flow. The formation of this linear minor landform are determined by the pattern and types of river and it's flow and also the rate of transportation process.

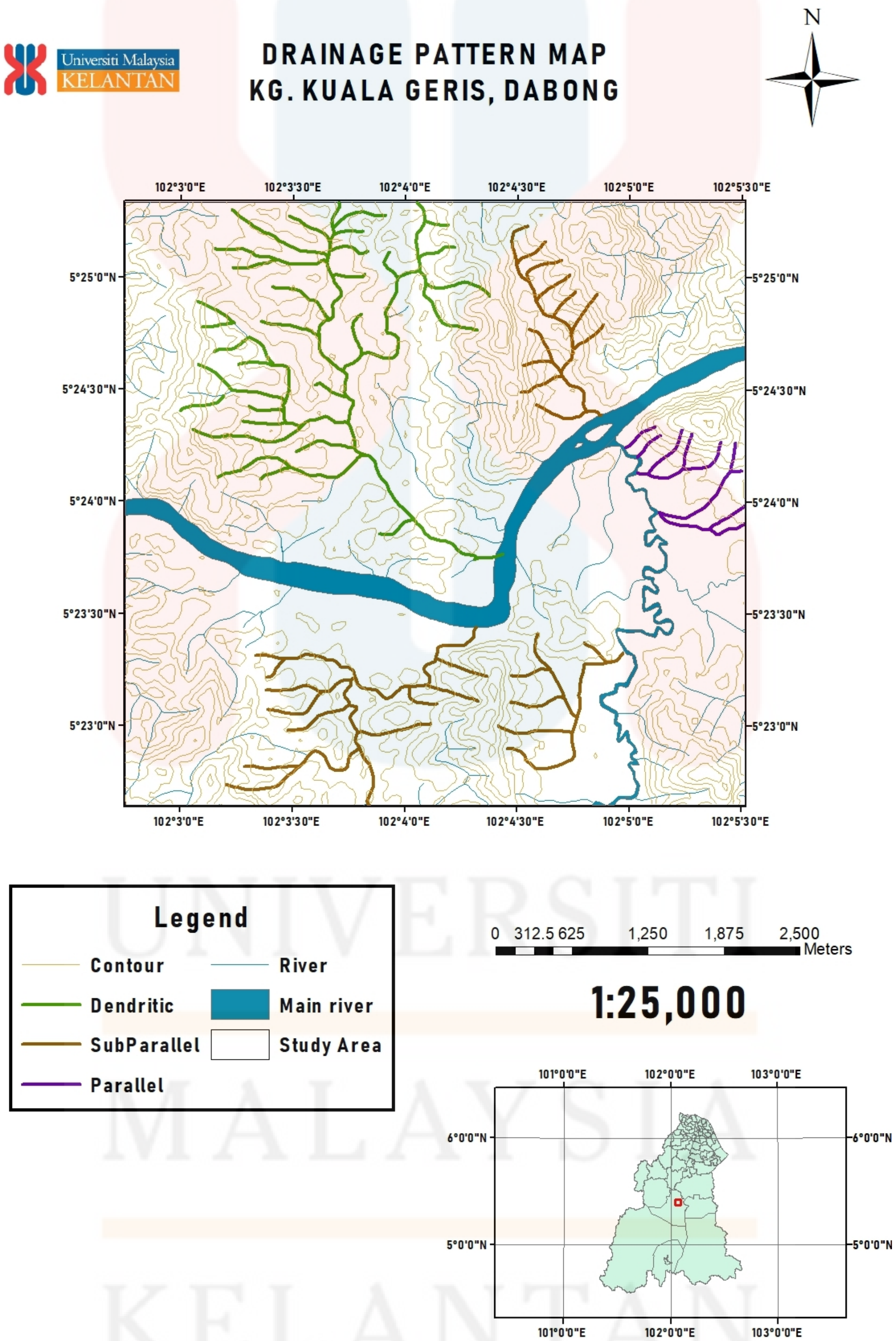

Figure 4.6 : Drainage pattern map of the study area

Figure 4.7: the river island or ait near between Galas river and Teku river

Figure 4.8 : the presence of sand bar near at the bending part of Galas river.

Figure 4.9: the presence of another sand bars formed at Galas river near at Kg. Kuala Geris, Dabong.

4.3 Lithostratigraphy

Stratigraphy is one of the geology branches that significant in the studies of rock's strata with the relation of geological time scale. The time relationships involved are calculated and units of the sequence or the whole sequence are associated with rock strata elsewhere.

Since Covid-19 struck all over places including our country, field mapping can't be carried out. Due to that, there is no much outcomes obtained especially from field mapping. Data for this part obtained particularly by satellite imagery and previous research and data.

Meta-sedimentary rocks and schist become the major type of rocks that constituted in the study area. Meta-sedimentary rocks become the prime one of lithological unit with about 70% covers the study area followed by schist with the percentage of 25% and the remaining 5% that covers the study area particularly along Galas river and Teku river is alluvium. This can be shown by the geological map of the study area (Figure 4.10)

The oldest unit lithological unit in the study area is meta-sedimentary rocks unit with aged of Permian era. Schist unit represented by Taku Schist were believed to be aged between Permian to Triassic period. The alluvium unit become the youngest unit since most of alluvium formed during quarternary period.

4.3.1 Stratigraphy Position

ERA	PERIOD	LITHOLOGICAL COLUMN	ROCK UNITS	DESCRIPTION
Cenozoic	Quarternary		Alluvium	Alluvial deposits, comprised of silt, clay and sand
Mesozoic	Triassic		Meta-sediments	Phyllite / Shale/ Slate / Sandstone / Mudstone
Paleozoic	Permian		Schist	Medium grade of metamorphic rock with rich quartz and mica content

4.3.2 Unit explanation

(a) Meta-sedimentary units

Meta-sedimentary units represent one rock unit under it such as phyllite, shale and slate. It also include un-metamorphosed sediments such mudstone and sandstone. Those un-metamorphosed sediments were the protoliths before undergoes metamorphism processes that changed into recent rock units either meta-sedimentary rocks or metamorphic rocks. These protoliths somehow signify the Gua Musang Formation since they surround the Stong Complex, Taku Schist and some part of Eastern Boundary Range.

- Phyllite unit

Phyllite is the medium grade of metamorphic rock that has foliation which undergoes metamorphism process from slate. The color of this rock usually gray to black. The appearance of this rock is quite wavy and crinkled. Besides, it also has high foliation texture with strong sheen surface. Generally, the mineral compositions of phyllite are such as graphite, quartz, muscovite, biotite and mica minerals.

- Shale unit

Shale is the origin of metamorphic rocks or called as protolith. Shale is fine-clastic sedimentary rock composed of mineral composition such as quartz, feldspar, clay minerals and also mica minerals. This rock formed typically under the environment like deep ocean water, lagoons, lakes and swamps where the water sufficient enough to ensure the extremely fine clay and silt particles to settle down to the seafloor.

- Slate

Slate is the low grade of foliated metamorphic rock which metamorphosed from shale. This rock has slaty cleavage that makes it easily break or splits into thin and flat pieces. The foliation of this rock displays the perpendicular planes to the direction of compression. The mineral composition in slate composed of quartz, mica and muscovite.

(b) Schist unit

Schist, medium grade of metamorphic rock, can be seen dominantly at the east part of study area. This metamorphic rock comes with high mineral composition of quartz and mica and low mineral content of feldspars, tourmaline and garnets. Due to certain condition of regional and contact metamorphism processes occurred during the collision of Sibumasu plate and Indochina plate, the origin of protolith which represents by Permo-Triassic sediments of Gua Musang Formation transformed into metamorphic rock unit.

(c) Alluvium unit

Alluvium unit comprised of unconsolidated sediments like silt, clay, pebble and sand that deposited along the main river and also at floodplain. Due to that, it comprised of variation in grain size from boulder to coarse grain (sand). These grain size of alluvium material influenced by some factors such as the intensity of water flow, the pattern and types of river and also the rate of transportation process.

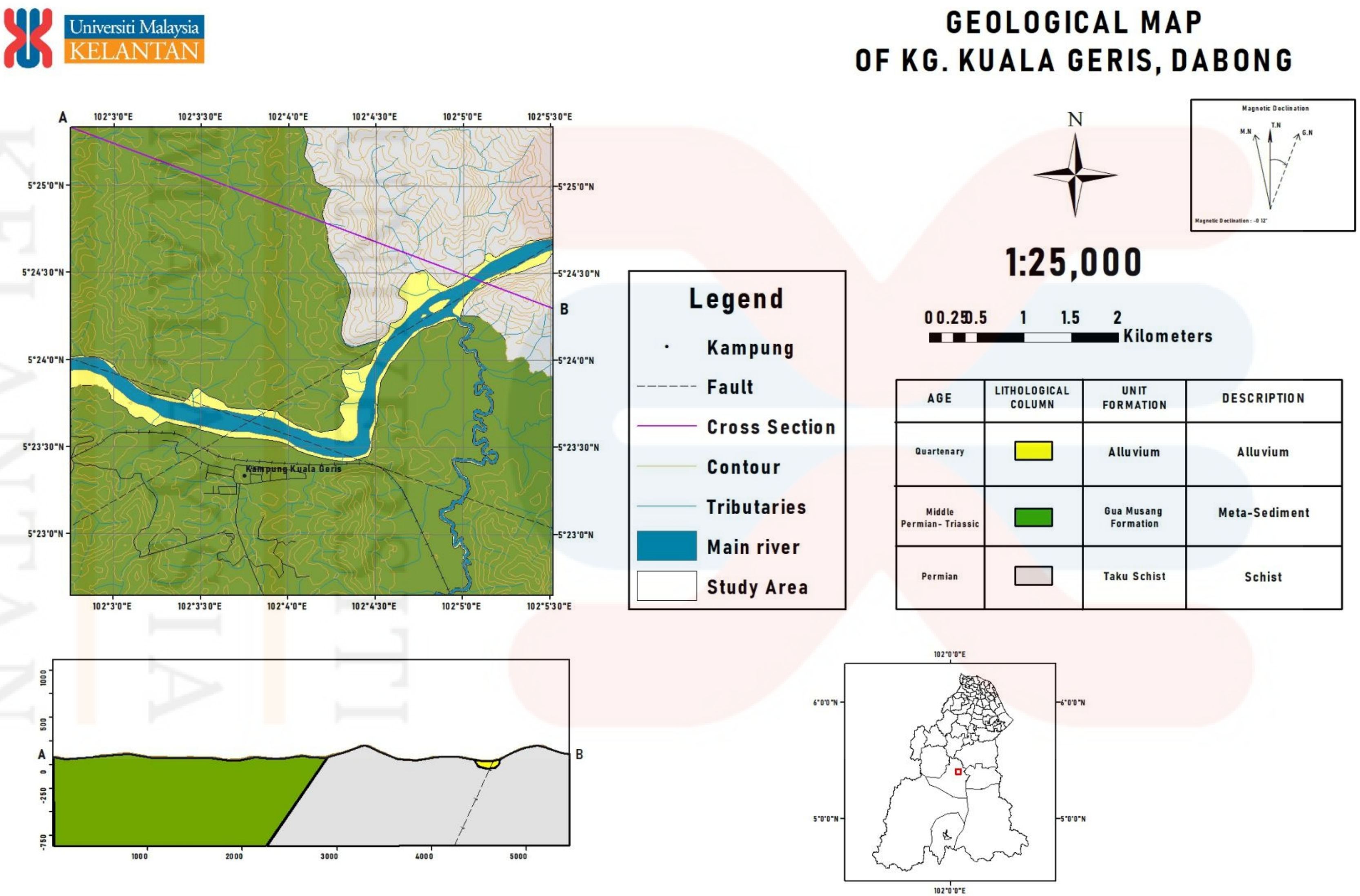

Figure 4.10 : Geological Map of Kg. Kuala Geris, Dabong

4.4 Structural Geology

Geological structures are the geological features that formed by endogenic processes which revolutionize the earth's landscapes. Endogenic processes are the internal processes occur and initiate beneath the earth's crust such as tectonic activities, volcanism and Aeolian process. All of these endogenic processes create differing type of principal stresses. Generally, stresses can be categorized into three kind; tensional, compressional and shear.

By then, the results come in various effects on earth's landscape and also in terms of geological structures. Effects by these kinds of endogenic processes contribute into the rise of orogenic, epeirogenic and isostatic processes. At the same time, it also influences the deformation of rocks. The deformation of rocks caused the genesis of geological structures. Geological structures that commonly observed are such as faults, folds, joints, fractures, dikes and veins.

4.4.1 Fault

Faults are the geological features in the forms of fracture in which displacement has taken place due to the force of stress. The orientation of respective displacement becomes the main factor in the occurrence of faults instead of the magnitude of forces and also rock's type.

Lineament is any geological features in the form of linear that can be observed and analyzed on the earth's surface by satellite imagery. Lineament can be categorized into two types which are positive lineament and negative lineament. This can be displayed by Figure 4.11 and 4.12

. Positive lineament usually indicated by the ridges and ranges of mountain or hills while negative lineament usually indicated by the existence of rivers, valleys and also fractures.

By doing and analyzing through lineament analysis, the outcomes which specified on the presence of geological features like faults and fractures can be determined. There are relationships between negative lineaments with the presence faults. With the aid of rose diagram that have been calculated by using Georose, the orientation of principal stresses that acts throughout rock bodies in the study area can be determined.

Sigma 1 shows the direction of significant principle stress while sigma 2 shows the direction of intermediate principle stress. Sigma 3 shows the direction of least principle stress. Sigma 1 usually represents the compressional stress.

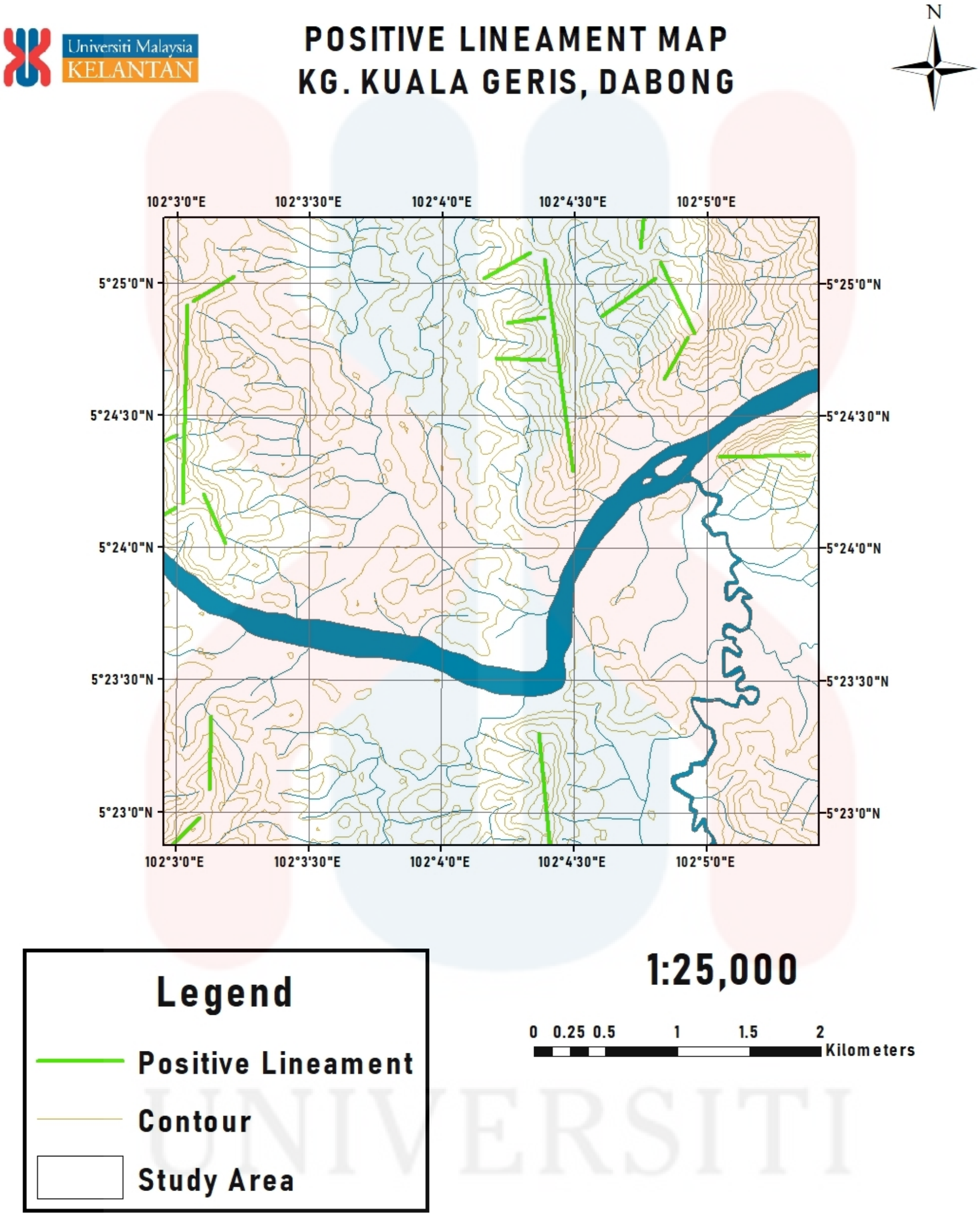

Figure 4.11 : Positive lineament map of the study area

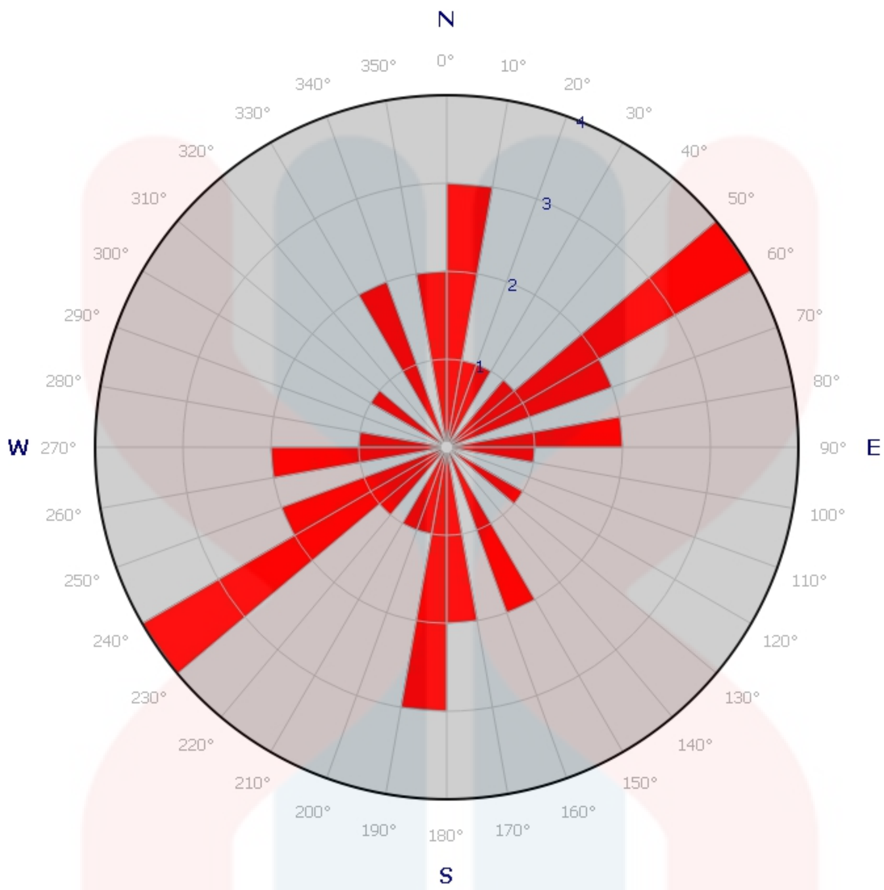

Figure 4.12: The orientation of principal force for positive lineament

The outcomes for the geological structure interpretation were displayed in the form of lineament map and rose diagram. About 20 positive lineaments identified in the study area based the existence of ridges on that location. This shows at the figure 4.13.

The trend of force direction for positive lineaments shows comprised mostly from north-south directions, north-east to south-west directions, east to west directions and north-west to south-east directions.

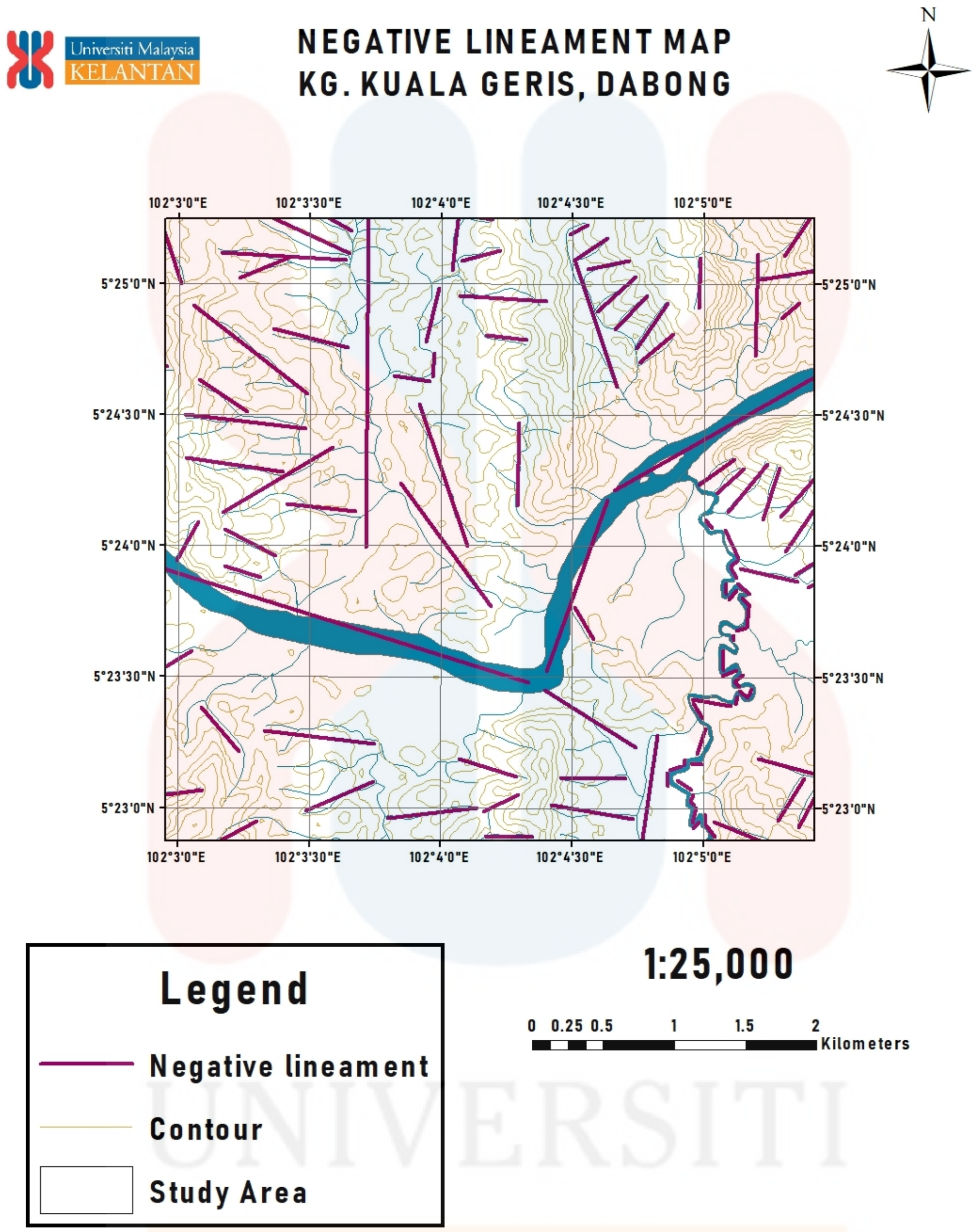

Figure 4.13: Negative lineament map of the study area

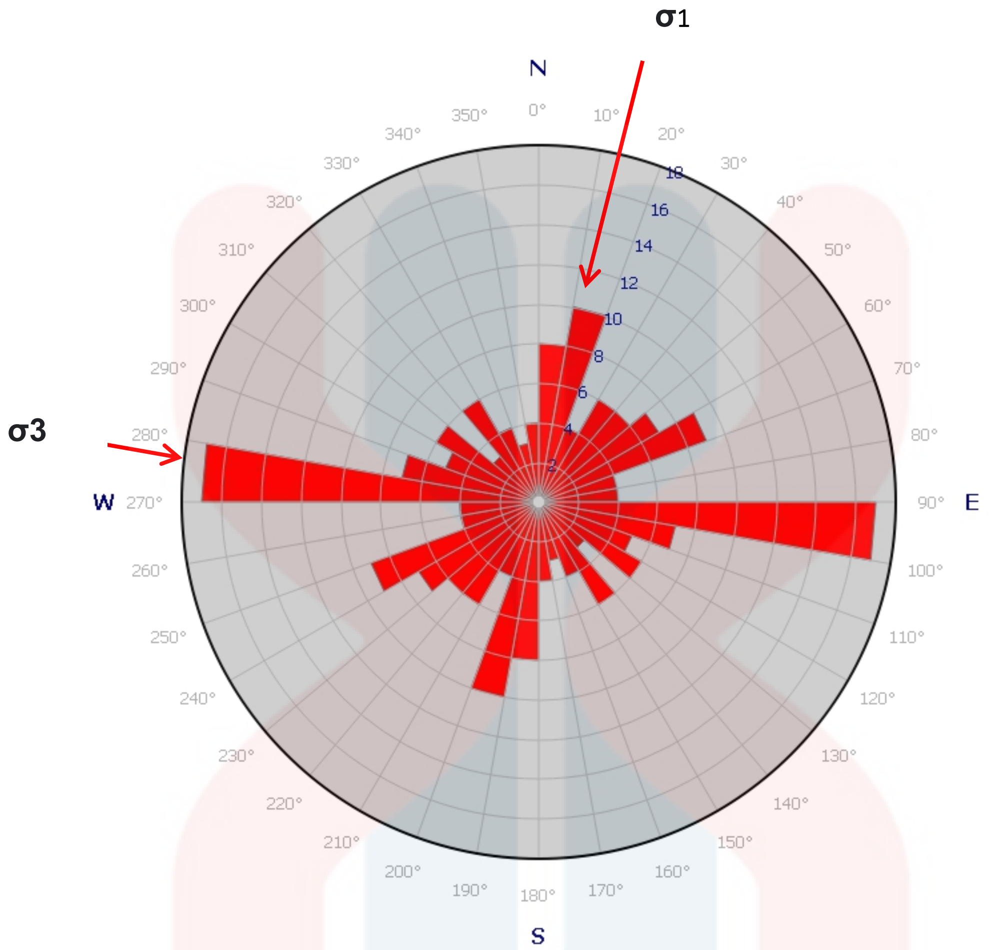

Figure 4.14: The orientation of principal force for negative lineament

About 129 negative lineaments recognized in the study area based on the existence of valleys including with rivers or tributaries. Based on the figure 4.15,the results mostly show the dominant direction of the geological structure in the study area. The direction of principal stress represents by Sigma 1(σ1) , is mainly from the north to south by reason of the direction of structures in the study area perpendicular to the direction of principal stress represents by sigma 3 (σ3) which is from east to west.

4.4.2 Fold

Fold structures occurs when the layer of rock (strata) was bend or curve because of the permanent force. The flat and planar surfaces of sedimentary rock are easily to bent or curved. Fold can be classifying based on two principle mechanisms of rock that are plasticity and brittle.

Fold is the geological feature that formed due high intensity of compressional force acts on rock bodies until they got curved or bend. Fold generally classified and related to deformation of ductile materials. As the rate of strain is low, rocks that are typically considered brittle may behave ductile behaviour which leading to such folds.

4.4.3 Mechanism of structure

The origin and formation of fault and fold are likely influenced by several factors such as the major principal forces and its orientation, frictional behaviour, temperature and pressure. In other words, it can be related into orogenesis process. Orogenesis can be defined as the genesis of mountains and ranges due to the collision of tectonic plates or can be termed as convergent plate boundary. This involved the uplifting processes and massive deformation.

This reason can be strengthened more by the evidences of collision between Sibumasu plates with Indochina plate that happened in Late Triassic period. This collision has formed the Main Range or in another term is Central Belt of Peninsular Malaysia. Evidence that associate to previous occurrences is by the presence of Bentong-Raub Suture zone.

4.5 Historical Geology

Historical geology is one of the branches in geology that emphasized the evolutionary of earth's life and forms over time. The principle of Uniformtarianism that highlight about "The present is the key to the past" by some means shows that the geological process or event that might happened recent or in the future is just the same things like before in the past. By knowing the past, incoming of unexpected events like climate changes, volcanic eruptions and tectonic activities will be able predicted and at the same time able to make preparation and prevention measures.

Based on the observation of the study area, a lot of changes occurred in that place by the geomorphological process. Desertification becomes the main effect behind all of these changes through all over the study area. Deforestation, agricultural activities like re-plantation and overgrazing are fairly obvious of human activities can be observed in the study area that changes the landscape.

CHAPTER 5

SOIL EROSION ASSESSMENT

5.1 Introduction

This chapter focused more on specification of the research study. Soil erosion assessment is the evaluation of natural hazard. Some factors caused soil erosion such as rainfall intensity, soil erodibility, slope length and steepness and anthropogenic activities. Revised Universal Soil Loss Equation (RUSLE) method is one of the standard and effective approaches to evaluate and measure the rate of soil loss based on the several factors such as rainfall intensity, soil erodobility, steepness of slope, land cover management and practices.

5.2 Revised Universal Soil Loss Equation (RUSLE) method

Revised Universal Soil Loss Equation (RUSLE) is the improvised and computerized version of USLE method that considers in the interrelationships between various factors. The incorporation of RUSLE with aid of GIS can likewise be utilized as a mechanization medium to aid the normalization of the utilization of the RUSLE to large scale area or regions.

5.3 Rainfall Erosivity (R) Factor

Rainfall erosivity (R) factor is the factor that related to the distribution and intensity of rainfall in the study area. In Dabong area, the average of annual precipitation for previous five years is within the range about 2828.22 to 2876.57 mm recorded by five rainfall stations which are Dabong ,Ladang Kuala Gris, Stn Pertanian Dabong, Stn. Keretapi Bukit Abu and Ldg. Kuala Gris. Meanwhile, as for the R factor recorded within previous five years is about in the range of 1041.57 MJ.mm/(ha.hr.year) to 1058.13 MJ.mm/(ha.hr.year). More details of rainfall's distribution and R factor shown in Table 5.1.

Due to small scale of the study area, there is insufficient data to be processed for this factor since there is only two rainfall stations in the study area which make less coverage to get the value of rainfall erosivity. By then, the processing of new method start by computed all rainfall data from all rainfall stations that available in Kelantan which suit to get the value of R factor.

Based on the figure 5.1, the value of rainfall distribution in the study area varies from 2851.91mm until 2879.44mm. The total average of rainfall distribution in the study area is about 2865.68 mm. Based on the figure 5.2 , the high intensity of rainfall's distribution focused on the eastern part of the study area while the low intensity of rainfall's distribution are more focused on the western part of the study area.

Relate with rainfall's distribution, R factor links with the intensity of rainfall. The high intensity of rainfall's distribution have K factor of 1046.3 MJ mm ha-1 h-1 y-1 and the lowest intensity of rainfall's distribution have K factor of 1036.67 MJ mm ha-1 h-1 y-1. The value of rainfall erosivity factor varies from 1036.67 MJ mm ha-1 h-1 y-1 until 1046.3 MJ mm ha-1 h-1 y-1.

Particularly most of the study areas have the average values of annual rainfall erosivity because there are not big differences between the values obtained.. All of these rainfall stations shows the same trend of rainfall's distribution data which approximately more than 2800 mm.

R factor was computed by using standard equation that used by Bols (1978). This equation are widely used in tropical regions and moderate developed countries such as Indonesia and our country, Malaysia.

It is known that east coast part of Peninsular Malaysia faced the high intensity of rainfall during northeast monsoon season from November until December by the year. Kelantan, Terengganu and Pahang are among the states that receive high distribution of rainfall during this period. In facts, the study area, Dabong, is one of location that affected a lot by this natural phenomenon which contributes another natural disaster such as flood.

Table 5.1 Annual Rainfall's Distribution with rainfall erosivity (R) factor from 2015 until 2019 in Dabong.

Rainfall Stations	Average Annual (2015-2019) (mm)	R Factor
Stn. Pertanian Dabong	2828.22	1041.57
Stn. Keretapi Bukit Abu	2871.77	1056.48
Ldg. Kuala Pergau	2836.30	1044.33
Dabong	2857.25	1051.51
Ldg. Kuala Gris	2876.57	1058.13

(Source : Department of Drainage and Irrigation, DID)

5.4 Soil Erodibility (K) Factor

Soil erodibility (K) factor displays the properties of soil and it's profile which contribute to the soil loss. It displays the quantity of soil loss per unit of erosive mechanisms by precipitation. Increased of K factors shows that prone to less resistant to erosion mechanisms while decreased of K factors indicate that prone to more resistant to erosion mechanisms.

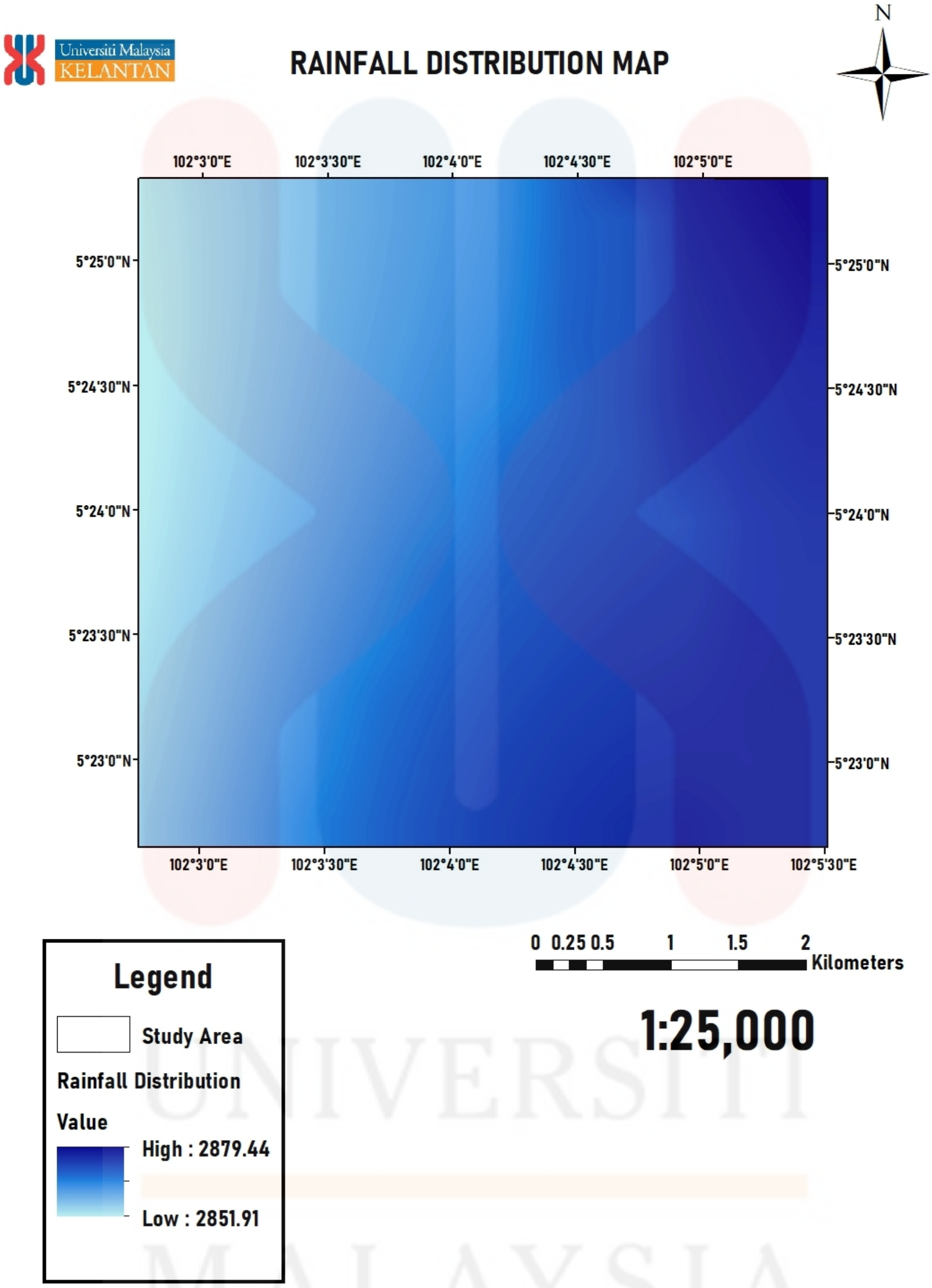

Figure 5.1 Rainfall's distribution map of study area

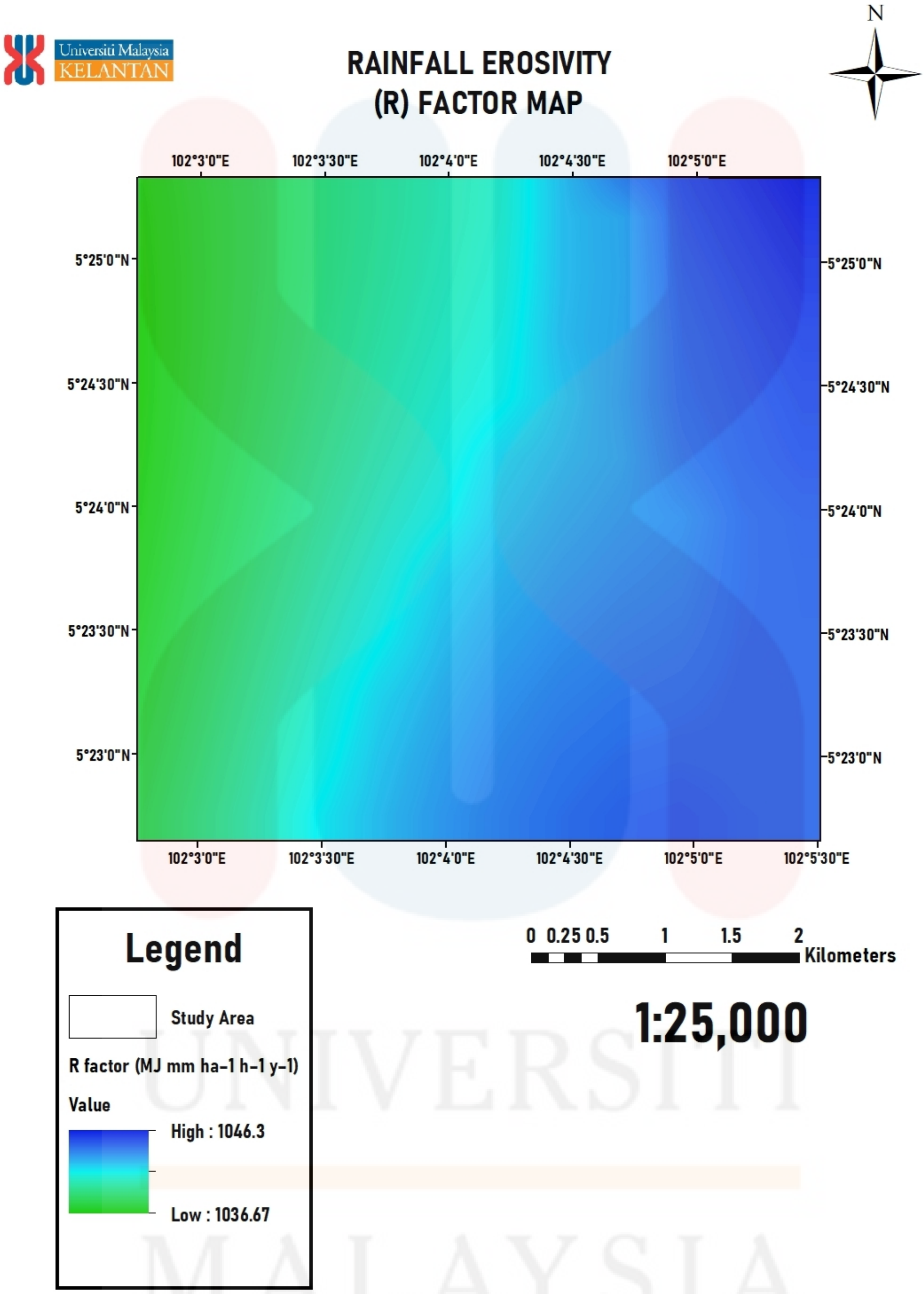

Figure 5.2 Rainfall erosivitty (R) map of study area

The composition and structure of sediment materials in the soil determine the value of K factor. The composition of sediment and organic materials determined the water holding capacity which results in the potential of detachment. Another distinct component that influenced the rate of soil loss in mechanism of surface runoff are such as the potential of infiltration. Blocky and platy soil structure helps to obstruct the movement of water into soil itself. As a result, it creates overflow of water through runoff and ultimately eroding away the soil. Soil erodibility (K) factor can be reduced or increased by the composition and structure of sediment and organic materials.

K value in the study were determined by the data that has been obtained from the Department of Agriculture (DOA). The most updated in 2010 values were determined by DOA composed about 289 type of soil series and each of their respective K factor values. The type of soil series in the study area comprised of two major soil series type which are Durian-Munchong-Bungor and Steepland which can be shown in Figure 5.3.

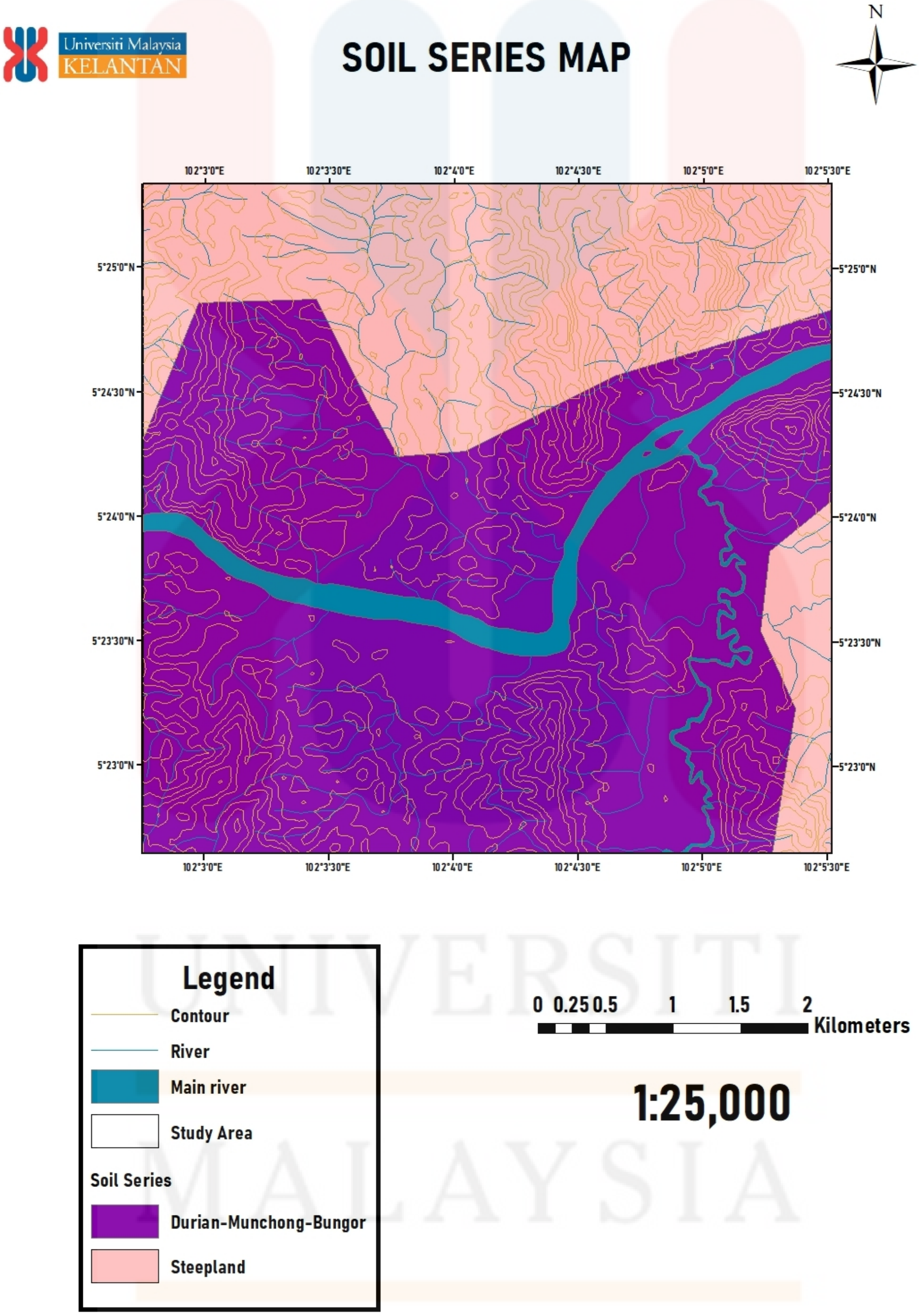

Figure 5.3 Soil Series map in the study area.

Table 5.2 : Soil series (types) with the soil erodibility (K) factor

Soil Series	K Factor	Texture
Durian- Muchong-Bungor	0.043	Clay and Sandy clay
Steepland	0.042	Clay

(Source: Department of Agriculture, DOA)

Based on the Figure 5.3, it is shown that the study area was predominated with Durian-Munchong-Bungor with the percentage of 59.4% followed by Steepland with the percentage of 40.4%. The value of K factor for Durian-Munchong-Bungor is about 0.043 Mg h MJ^{-1} while the value of K factor for Steepland is about 0.042 Mg h MJ^{-1}. Table 5.2 shows the types of soil series with their soil erodibility (K) factor.

Durian-Muchong-Bungor type definitely have less potential to cause the rate of soil loss due to composition and texture of organic materials in this type are likely dominant in clay and sandy clay. Generally, this type of soil series has low support of structure system. Besides, Durian-Muchong-Bungor type also has well drained properties where sediments are easily transport but in the moderate rate that not quickly. Steepland type in the study area is one of the reasons that contribute to the high rate of soil loss. Due to this, high sedimentation occurred along downstream of Sungai Galas and its tributaries.

5.5 Slope Length and Steepness (LS) Factor

Slope length and steepness (LS) factor displays the gradient of slope that lead and influence the rate of soil erosion. It aided by previous factors such as erodibility factors and precipitation factors. LS factor increased if slope length and steepness also increase and vice verse.

Slope in the study area varies from 0 until 45.2° which can be shown in Figure 5.4. Those value of slope were produced from raster data, DEM before computed it in slope tool under Spatial Analyst function. After that, those value were classified based on Table 3.4 which represents the m value with slope gradient for LS factor. These values indicates that the study area have various conditions of slope either from gentle to very steep. Result for this factor was displayed by Figure 5.5.

LS factor were determined where the m value of 0.5 m from Table 3.4 was set in the equation 3.4 since the study area predominated with more than 5% of slope gradient which can be shown by Figure 5.4. Table 5.3 shows the each class of slope gradient with the total area covered in (km^2) and its percentage.

Table 5.3 Slope gradient with the total area covered and percentage in the study area

Slope Gradient (%)	Area (km^2)	Percentage (%)
0 - 1	2.35	9.4
1 - 3	2.30	9.2
3 - 5	2.13	8.5
5 - 45.2	18.24	72.9

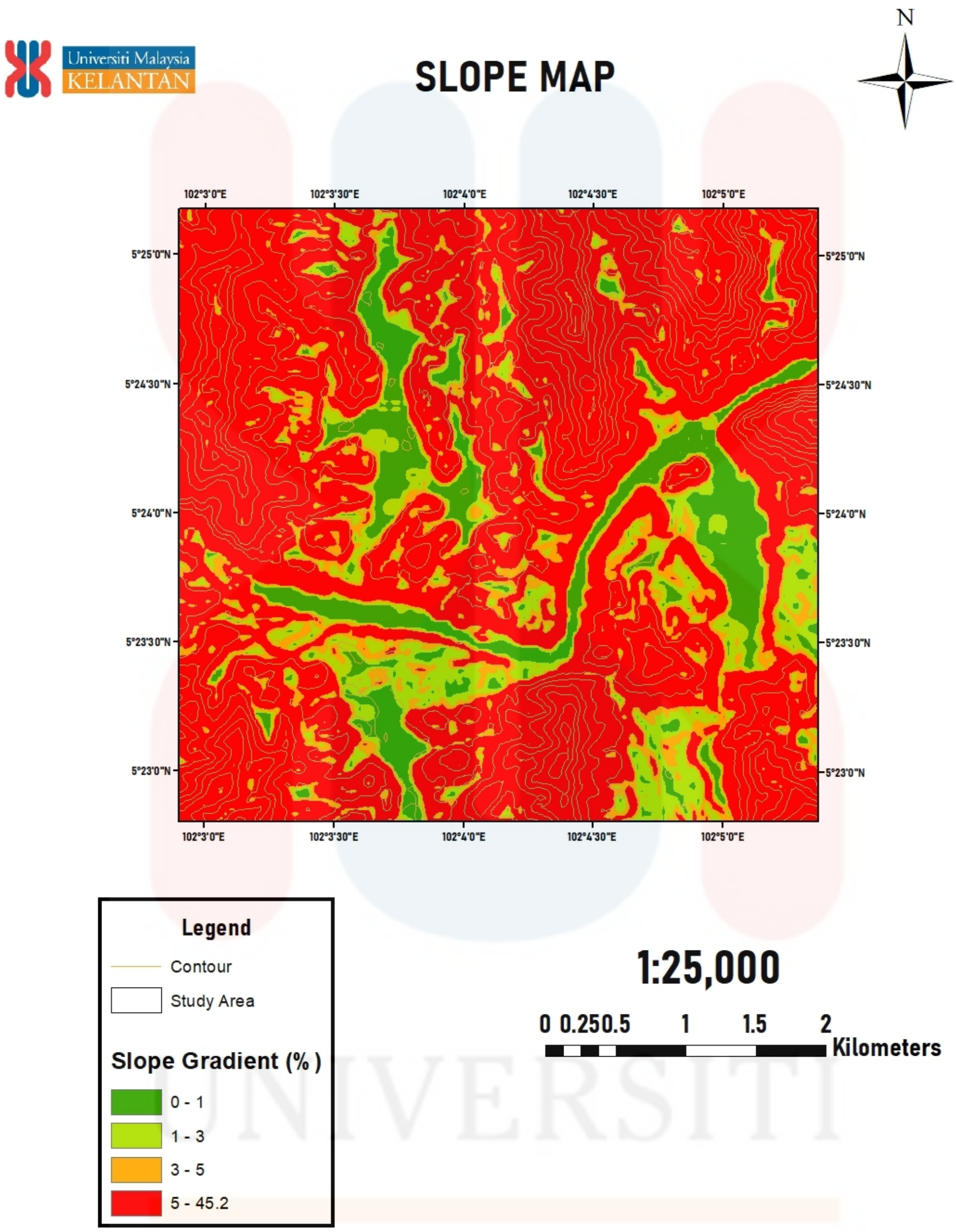

Figure 5.4 Slope map of the study area

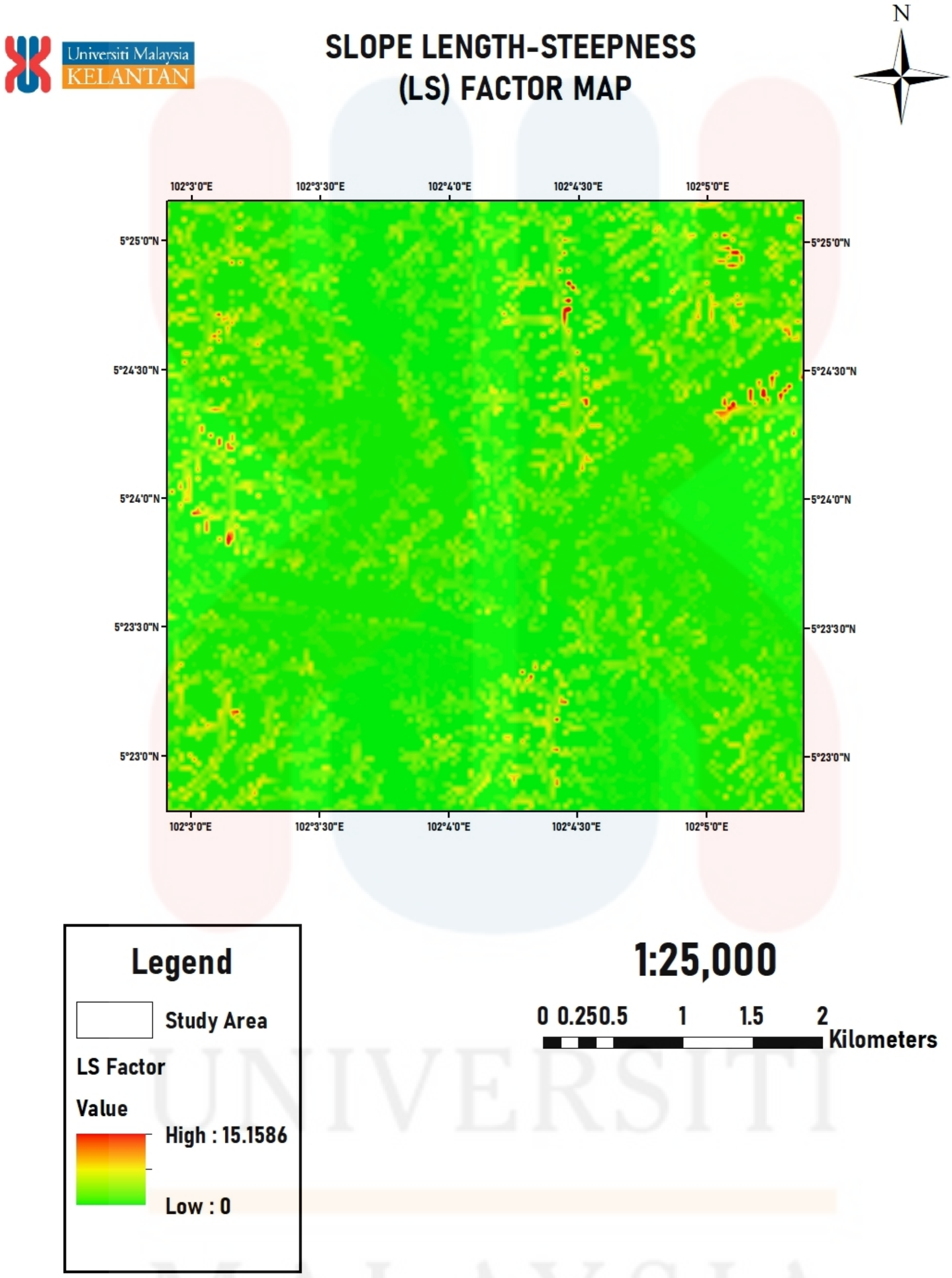

Figure 5.5 Slope length-steepness (LS) factor map

5..6 Land Cover Management (C) Factor and Support Practices (P) Factor

Land cover management (C) factor can be defined as the factor that influenced the rate of soil loss due to management of land cover. Support practices (P) factor is the factor that contributed by the influence of aided practices.

For C factor, when the land got covered by vegetation in a large percentage, the value of C factor shows lower values. It means that the lower value of C factor displays the less soil loss. Basically, C factor can be determined by the classification of landuse generated by Department of Agriculture. In this classification, it can be categorized into three components which are the first one is vegetation covered and undisturbed areas, the second is agricultural and development areas and the lastly is construction sites based on Department of Agriculture Malaysia (DOA).

For this research study, C factor can be categorized into two groups, undisturbed areas and development areas. Most part in the study predominated with forest covered and undisturbed area. Forest is the most extensive coverage area for this group with the total hectare covers about 532.3 ha. Other than that, water bodies become the third dominant land use type in the study area which covers around 116.2 ha followed swamp and mangrove areas with 21.5 ha and bushes area with the total area around 7.4 ha.

For agricultural and development areas, rubber plantations is the most dominant one in the study area which covers about 1881.9 ha. Residential area covers about 50 ha in the study area and road connection include railway track covers around 51 ha. Mixed plantations become the least part in the study which covers about 43.6 ha. Figure 5.5 shows the cropping and land cover management (C) factor map of the study area while Table 5.4 shows land use types with their C factor values.

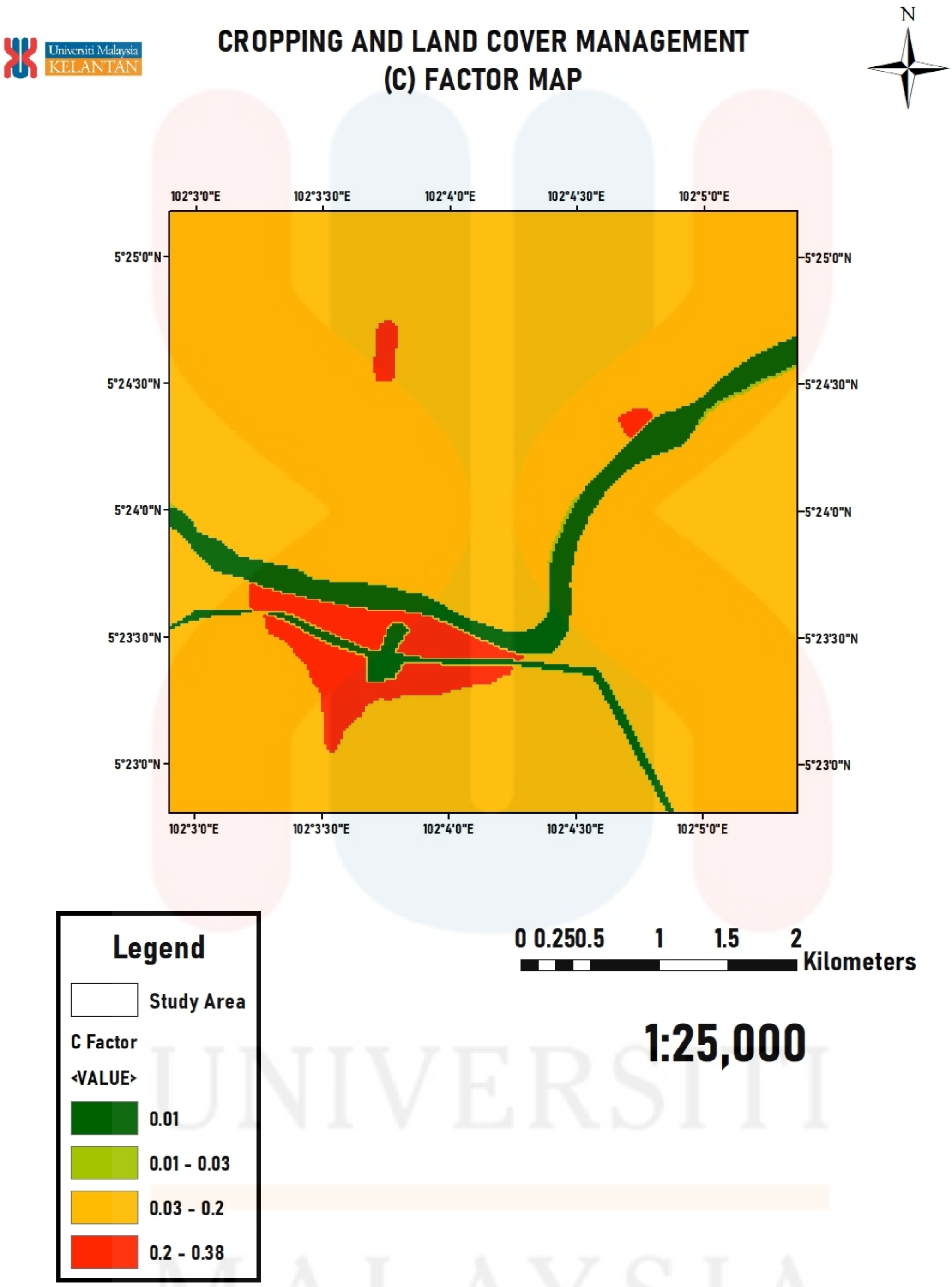

Figure 5.6 Cropping and land management (C) factor map

Table 5.4 Land use types with their C factor

Type of landuse	C factor
River, lakes and tributaries (Water bodies)	0.01
Road connection	0.01
Urbanized and residential territory	0.01
Mixed plantations and farming	0.38
Rubber plantation	0.2
Forest	0.3
Mangrove and swamp forest	0.01
Bushes and weed	0.3

(Source : Department of Agriculture, DOA (2010))

Support practices (P) factor is the factor that controlled by the practices or any conservation activities. This factor considers the control rehearses which lessen the dissolving strength of spillover and precipitation through their impact on the examples of seepage, the grouping of overflow and its speed.Table 5.5 shows the P factor with it's land use types that used in our country (Troeh et al, 1999).

Forest and rubber plantations share the same value of P factor which become the main factor in the study area. The value of P factor between 0.5 until 1 which comprises of water bodies, road connection, residential area, swamp and mangrove forest plus with bushes. The value between 0.4 until 0.5 is represented by rubber plantations and mixed plantations and farming. The last class of value between 0.1 and 0.4 represented by forest area only in the study area. The final result of this factor established with support practices map based on Figure 5.6.

Table 5.5 Various Land use's type and it's P factor

Type of landuse	**P factor**
River, lakes and tributaries (Water bodies)	0.5
Road connection	1
Urbanized and residential territory	1
Mixed plantations and farming	0.45
Rubber plantation	0.4
Forest	0.1
Mangrove and swamp forest	0.5
Bushes and weed	0.6

(Troeh, Hobbs, & Donahue, 1999)

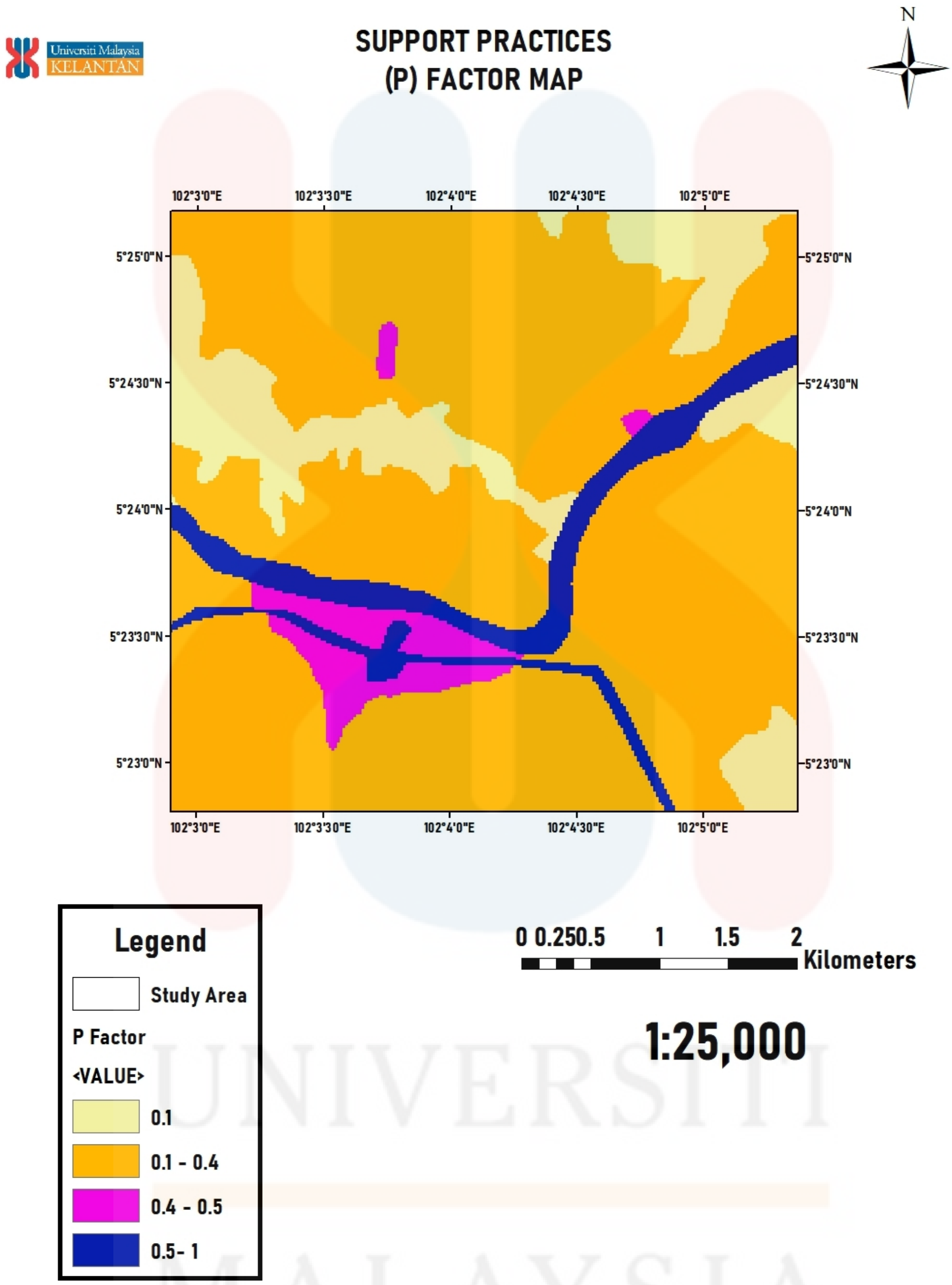

Figure 5.7 Support Practices (P) factor map

5.7 RUSLE Outcomes

The total estimation of annual soil loss in the study area is approximately about 13.3 ton/ ha/ year. Based erosion risk classes introduced by Wischmeier and Smith (Table 5.6), the value for the total estimation of soil loss can be classified under erosion class of three where the level and potential of erosion is moderate.

Table 5.6 Soil erosion risk classification (ERC)

Erosion class	Amount of soil loss (t/ha/year)	Erosion classification
1	0-5	Very low
2	5-10	Low
3	10-20	Moderate
4	20-40	High
5	40>	Severe

(Wischmeier and Smith, 1978)

However, since the classification of soil erosion reached only by moderate level, another map for more erosion class were produced comprised from very low until severe class. By then, the high and severe class in this map shows that the value is same to moderate class in exact classification of soil erosion risk.

Based on the observation of the map and Table 5.6, the severe and high erosion risk class comprise only in a very small scale of the study area which is about only 2.7 sq km. About 4 sq km of part in the study area was represented by moderate erosion risk class. Most of the study area was covered by very low to low erosion risk class within 18.3 sq km.

With the low total value of soil loss estimation and most of coverage area in the study area have low to moderate erosion risk classes, the rate of soil loss in the study area have a very low probability value based on the final results obtained. However, conservation and sustainability measures need to be taken even though the rate is low for precaution steps.

Table 5.7 Erosion risk class in the study area with the total area covers

Erosion risk class	Area (sq km)
Very low	14
Low	4.3
Moderate	4
High	2.6
Severe	0.1

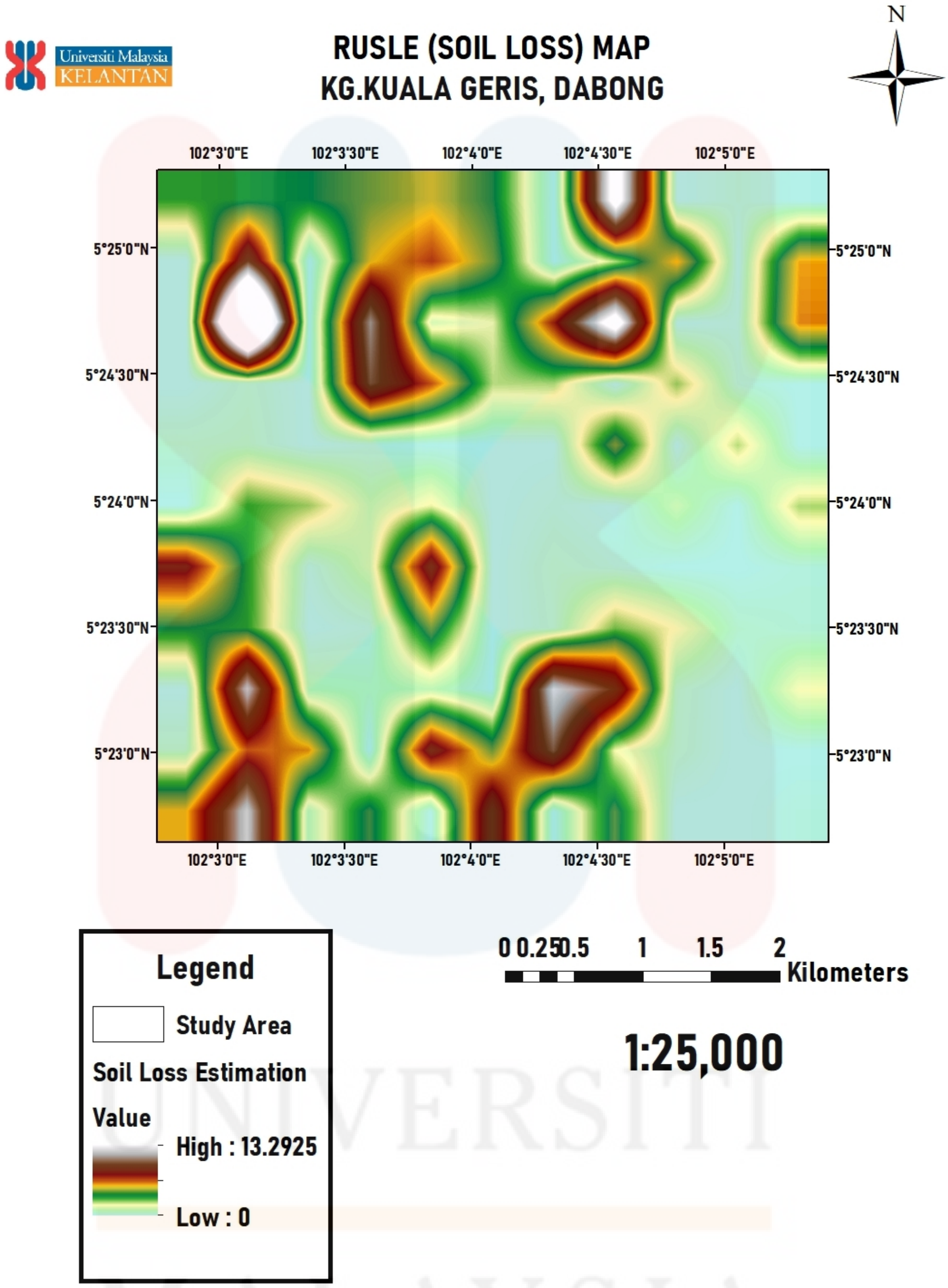

Figure 5.8 RUSLE (Soil loss estimation) map

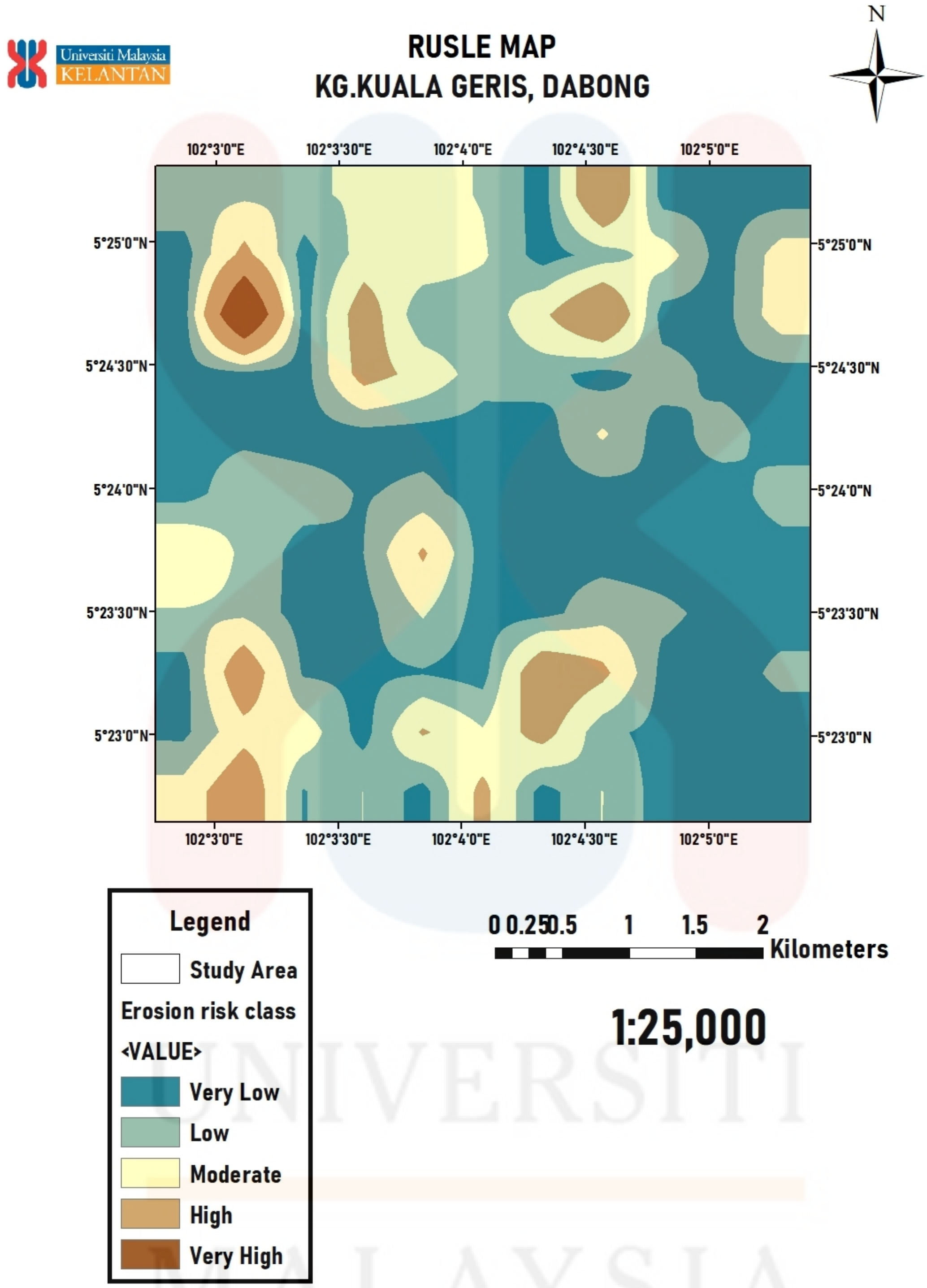

Figure 5.9 RUSLE (classification) map

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Objectives and aims for this research study are well-achieved. First of all is about producing a geological map of the study area in Dabong, Kelantan. By combining and interpreting of various geology aspects and information such as geomorphology, lithostratigraphy, structural geology and historical geology, detailed and comprehensive geological map of the study area was produced.

The study area which located at Kg. Kuala Geris, Dabong were predominated with two lithological unit which are meta-sediments unit, schist unit and alluvium unit. These lithological units represented by Gua Musang Formation and Taku Schist.

As for second objective in this research study, it is to quantify the rate of soil loss in the study area by carry out soil erosion assessment. RUSLE method becomes the chosen approach to manage the soil erosion assessment in the study area. Kg. Kuala Geris have undergoes rapid development recently. Interconnection between natural factors such as soil properties, rainfall's distribution with slope's gradient and human-made factors like land management and support practices contributes into this under threat that are not given much attention.

Establishing a soil loss risk map become the last objectives of this research study. By combining through some factors or parameters needed in RUSLE method, the final of soil loss risk map was able to be produced. The purpose of this objective is shows that this environment threats would be a big complication not only for human but also to environment. Other than that, this threat could rise and initiate another environmental disaster whish flood. Final outcome of this modelling are favorable and able to aid in policy development of soil erosion management. Dabong is one of effected area due by heavy flood every years due to heavy rainfall especially during the northeast monsoon season that struck the eastern states of Peninsular Malaysia.

6.2 Recommendations

For recommendations of this research study, it highlight on some aspects that need to be improvise more. The best options to get accurate and precised results of this research study are by conducting through physical activity which is field mapping. Eventhough field mapping can't be done due to unexpected Covid-19 pandemic that hit all over the world including our country, it might be the best way to prevent any possibilities to get this serious disease thus reducing and stopping the spread of this Covid-19.

Combination of RUSLE and other tools like spectral index or NDVI and the sediment delivery ratio (SDR) can be another necessary alternative way especially for soil loss risk management, particularly with the point of view to assess and produce soil risk map.

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