



**GEOLOGY AND FLOOD HAZARD ASSESSMENT USING
GEOGRAPHIC INFORMATION SYSTEM (GIS) IN
DABONG, KELANTAN**

By

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2023

DECLARATION

I hereby this thesis comprises of chapter 1 until 6 entitled “**Geology and Flood Hazard Assessment using Geographic Information System (GIS) in Dabong, Kelantan**” submitted based on my own research except as cited in the references. This thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree. I further declare this thesis done under guidance of my supervisor.

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GEOLOGY AND FLOOD HAZARD ASSESSMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS) IN DABONG, KELANTAN

ABSTRACT

Dabong is part of the Gua Musang Group formation, Taku Schist and granite Stong Complex in the western part, which is made up of rocks from the Permian to the Triassic. Extreme flooding has struck Kelantan on multiple occasions, wreaking havoc and costing millions in property damage. It is generally accepted that the heavy monsoon rains are the root cause of those floods. This study has chosen Kampung Dabong, Kelantan to study about flood hazard. The coordinate of the study area is in between 5°24'34.77"N to 5°22'3.60"N latitude and 101°58'34.87"E to 101°58'36.74"E longitude and it covers a region of 25km². The objective of this study is to update the geological map of Kampung Dabong with scale of 1:25,000, to determine the parameters of the flood hazard and to produce a flood hazard map of the study area. From the result of petrography analysis, this study area consists of metamorphic rock which is schist and phyllite. There are seven parameters of thematic maps for flood hazard map have been identified such as slope map, elevation map, drainage density map, land use map, rainfall map, river density map and flow length map. Weighted Overlay Method (WOM) being applied in ModelBuilder using ArcGIS software to overlay all parameters in order to create flood hazard maps from year 2017 to 2020. The result of flood hazard maps was classified into three classes which is low, moderate and high. From 2017 to 2020, it can be concluded that 81% of the study area falls within the high hazard zone, 10% falls within the moderate hazard zone, and 8% falls within the low hazard zone. In conclusion, the geological map of this study area has been updated and a final flood hazard map has been produced.

Keywords: Geographic Information System (GIS), Weighted Overlay Method (WOM), Parameter, Flood Hazard, Geological map, ModelBuilder

GEOLOGY AND FLOOD HAZARD ASSESSMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS) IN DABONG, KELANTAN

ABSTRAK

Dabong adalah sebahagian dari formasi Gua Musang Group, Taku Schist dan granit Stong Complex di bahagian barat, yang terdiri dari batu dari Permian hingga Triassic. Banjir melampau telah melanda Kelantan dalam beberapa kesempatan, menimbulkan kekacauan dan mengakibatkan berjuta-juta kerosakan harta benda. Umumnya diterima bahawa hujan monsun lebat adalah punca banjir tersebut. Kajian ini telah memilih Kampung Dabong, Kelantan untuk mengkaji bahaya banjir. Koordinat kawasan kajian berada di antara $5^{\circ}24'34.77''$ N hingga $5^{\circ}22'3.60''$ N garis lintang dan $101^{\circ}58'34.87''$ E hingga $101^{\circ}58'36.74''$ E garis bujur dan ia meliputi wilayah 25km². Objektif kajian ini adalah untuk mengemas kini peta geologi Kampung Dabong dengan skala 1: 25,000, untuk menentukan parameter bahaya banjir dan menghasilkan peta bahaya banjir di kawasan kajian. Dari hasil analisis petrografi, kawasan kajian ini terdiri daripada batuan metamorf iaitu schist dan phyllite. Terdapat tujuh parameter peta tematik untuk peta bahaya banjir telah dikenal pasti seperti peta cerun, peta ketinggian, peta kepadatan saliran, peta penggunaan tanah, peta curah hujan, peta kepadatan sungai dan peta panjang aliran. Kaedah Hampan Berat (WOM) diterapkan di ModelBuilder menggunakan perisian ArcGIS untuk melapisi semua parameter untuk membuat peta bahaya banjir dari tahun 2017 hingga 2020. Hasil peta bahaya banjir diklasifikasikan kepada tiga kelas yang rendah, sederhana dan tinggi. Dari tahun 2017 hingga 2020, dapat disimpulkan bahawa 81% kawasan kajian berada dalam zon bahaya tinggi, 10% berada dalam zon bahaya sederhana, dan 8% dalam zon bahaya rendah. Kesimpulannya, peta geologi kawasan kajian ini telah dikemas kini dan peta bahaya banjir terakhir telah dihasilkan.

Keywords: Weighted Overlay (WOM), Sistem Maklumat Geografi (GIS), peta geologi, peta bahaya banjir, ModelBuilder

TABLE OF CONTENT

DECLARATION	i
APPROVAL	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
ABSTRAK	v
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATION	xiii
LIST OF SYMBOLS	xiiiv
CHAPTER 1 INTRODUCTION	
1.1 General Background	1
1.2 Study Area	2
1.2.1 Location	2
1.2.2 Accessibility	4
1.2.3 Demography	5
1.2.4 Land use	6
1.2.5 Rainfall	7
1.2.6 Social Economic	8
1.3 Problem Statement	8
1.4 Research Objectives	9
1.5 Scope of study	10
1.6 Significance of study	10

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction	11
2.2 Regional Geology and Tectonic Setting	11
2.3 Stratigraphy	13
2.4 Structural Geology	14
2.5 Historical Geology	15
2.6 Research Specification	15
2.6.1 Flood Hazard	15
2.6.2 ModelBuilder Tool	17
2.6.3 Weighted Overlay Method in Model builder	18

CHAPTER 3 MATERIALS AND METHODOLOGIES

3.1 Introduction	19
3.2 Material	19
3.2.1 Geological Mapping	19
3.2.2 Flood Hazard Mapping	21
3.3 Methodology	22
3.3.1 Preliminary studies	22
3.3.2 Field Studies	22
a) Geological Mapping	23
b) Flood Hazard Mapping	23
3.3.3 Laboratory work	24
3.3.4 Data collection	24
a) Rainfall	24
3.3.5 Data Preparation & Processing	25
3.3.6 Data Analysis and Interpretation	25

CHAPTER 4 GENERAL GEOLOGY

4.1 Introduction	28
4.1.1 Accessibility	28
4.1.2 Settlement	30
4.1.3 Traverse and observation	32

4.1.4 Forestry (or vegetation)	34
4.2 Geomorphology	36
4.2.1 Geomorphology classification	36
4.2.2 Weathering	39
4.2.3 Drainage	40
4.3 Lithostratigraphy	42
4.3.1 Stratigraphy	42
4.3.2 Unit Explanation	45
a) Phyllite	45
b) Schist	47
c) Alluvium	49
4.4 Structural Geology	49
4.4.1 Lineament Analysis	49
4.4.2 Joint	51
4.4.3 Bedding	52
4.5 Historical Geology	53
CHAPTER 5 FLOOD HAZARD ASSESSMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS)	
5.1 Introduction	55
5.2 Parameter of Flood Hazard Assessment	55
5.2.1 Slope	56
5.2.2 Elevation	58
5.2.3 Drainage density	60
5.2.4 Land use	62
5.2.5 Rainfall	64
5.2.6 River Distance	73
5.2.7 Flow Length	75
5.3 Flood Hazard Map	77
5.4 Flood Hazard Assessment	86
CHAPTER 6 CONCLUSION AND RECOMMENDATION	
6.1 Conclusion	90
6.2 Recommendation	91

REFERENCE 92

APPENDIX 94

LIST OF TABLES

No	TITLE	PAGE
1.1	Population at Dabong in 2020.	6
1.2	Average monthly rainfall distribution in 2020.	7
3.1	Material for geological mapping.	19
3.2	Material for flood hazard mapping.	21
4.1	The location of observation.	31
4.2	Geomorphological unit of study area.	37
4.3	Stratigraphic column.	43
5.1	Weightage for each parameter.	56
5.2	Weightage for slope parameter.	57
5.3	Weightage for elevation parameter.	58
5.4	Weightage for drainage density parameter.	60
5.5	Weightage for land use.	62
5.6	Weightage for rainfall parameter.	64
5.7	Rainfall distribution in 2017.	65
5.8	Rainfall distribution in 2018.	66
5.9	Rainfall distribution in 2019.	66
5.10	Rainfall distribution in 2020.	67
5.11	Weightage for river distance parameter.	73
5.12	Weightage for flow length parameter.	75

5.13	Weightage overlay and influence for each parameter.	78
5.14	Classify zone in percentage (%) from 2017 to 2020.	86

LIST OF FIGURES

No	TITLE	PAGE
1.1	Base map of Dabong, Kelantan.	3
1.2	Galas River at Dabong.	4
1.3	KTM Dabong railway station.	5
1.4	Road connection of Dabong. Main road (Black line) and Railway (White line).	5
1.5	Graph of average monthly rainfall distribution in 2020.	8
2.1	Geological map of the peninsular Malaysia.	13
2.2	Formations included within Gua Musang Group.	14
2.3	AHP fundamental scale.	17
3.1	Research flow chart of study area.	22
3.2	Flood hazard area determination.	27
4.1	Road connection of study area	29
4.2	Railway track of Dabong.	30
4.3	Path road of the study area.	30
4.4	Traverse map of Dabong.	33
4.5	(a) Palm Oil plantation and (b) rubber plantation of study area.	34
4.6	Land use map of Dabong.	35
4.7	Hilly landscapes in the study area.	36
4.8	Topography map of study area.	38
4.9	Physical and biological weathering of study area.	39

4.10	Drainage pattern map of study area.	41
4.11	(a) main river and (b) stream of study area.	42
4.12	Geological map of Dabong.	44
4.13	Outcrop of phyllite in the study area.	45
4.14	Hand specimen of phyllite.	46
4.15	The photomicrograph of phyllite under (a) cross polarized light (XPL) and (b) plain polarized light (PPL).	46
4.16	Outcrop of schist in the study area.	47
4.17	Hand specimen of schist.	48
4.18	The photomicrograph of schist under (a) cross polarized light (XPL) and (b) plain polarized light (PPL).	48
4.19	Lineament map of Dabong.	50
4.20	Positive lineament of study area.	51
4.21	Negative lineament of study area.	51
4.22	The joint	52
4.23	Rose diagram of the region area.	52
4.24	Bedding outcrop in the study area.	53
4.25	Stereonet of bedding.	53
5.1	Slope Map of Dabong.	57
5.2	Elevation Map of Dabong.	59
5.3	Drainage Density Map of Dabong.	61
5.4	Land Use Map of Dabong.	63
5.5	Graph of rainfall distribution from 2017 to 2020.	68
5.6	Rainfall Map of Dabong in 2017.	69

5.7	Rainfall Map of Dabong in 2018.	70
5.8	Rainfall Map of Dabong in 2019.	71
5.9	Rainfall Map of Dabong in 2020.	72
5.10	River Distance Map of Dabong.	74
5.11	Flow Length Map of Dabong.	76
5.12	ModelBuilder representing of flood hazard parameters in 2017.	78
5.13	Flood Hazard Map of Dabong in 2017.	79
5.14	ModelBuilder representing of flood hazard parameters in 2018.	80
5.15	Flood Hazard Map of Dabong in 2018.	81
5.16	ModelBuilder representing of flood hazard parameters in 2019	82
5.17	Flood Hazard Map of Dabong in 2019.	83
5.18	ModelBuilder representing of flood hazard parameters in 2020.	84
5.19	Flood Hazard Map of Dabong in 2020.	85
5.20	Trend changes of flood in Dabong from 2017 to 2020.	88

LIST OF ABBREVIATION

ABBREVIATION	EXPLANATION
GIS	Geographic Information Systems
KTM	Keretapi Tanah Melayu
MM	Milimetres
WOM	Weighted Overlay Method
AHP	Analytic Hierarchy Process
JMG	Mineral and Geoscience Department Malaysia
DEM	Digital Elevation Model
GPS	Global Positioning System
USGS	United States Geological Survey
JPS	Jabatan Pengaliran dan Saliran
M	Meter
KM	Kilometer

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LIST OF SYMBOLS

°	Degree
%	Percentage



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CHAPTER 1

INTRODUCTION

1.1 General Background

This study is about the general geology of Dabong and flood hazard assessment in Dabong, Kuala Krai, Kelantan. For the geology part, the study focusing on the lithology, geomorphology, structural geology, mineralogy, and petrology. It is necessary to do a field survey, preparatory study, and observations to extract the information and data pertaining to the region's geology. Therefore, this study was conducted to understand general geology of the study area, factors of flood hazard that cause the impact of disaster to the community and the area.

Flood hazards are classified based on characteristics such as flood likelihood, flood depth flow velocity, water level increase rate and others. Hazard dimensions may be defined by where, when how long they last and how much adjustment happens. Flood managers working in such areas should be aware of the location, probability, persistence and scale of potential hazards. Management alternatives was examined in addition to estimates on the dimensions changes that will occur because of implementing these options (Downs & Gregory, 2004).

Flood Hazard Mapping is an essential part of flood-prone region land use planning. It includes easy-to-read maps and charts to find flood-prone areas and calculate prevention and response actions (Bapulu & Sinha, 2005). The dynamic character of flood threats must be considered when assessing the consequences of climate change.

Geographic Information Systems (GIS) was used successfully to show the analyzed flood maps to create flood hazard map. Data entry, data management, modification and analysis and output are all functions of a computerized system known as a Geographic Information System (GIS) (Aronoff, S. 2008). Many different GIS methods are available for evaluating flood-prone zones and assessing the impact of rising river water levels. Flood study relies heavily on Geographic Information Systems (GIS).

1.2 Study area

1.2.1 Location

The location of study area is marked with four points in the edge of the box which is between $5^{\circ}24'34.77''\text{N}$ to $5^{\circ}22'3.60''\text{N}$ latitude and $101^{\circ}58'34.87''\text{E}$ to $101^{\circ}58'36.74''\text{E}$ longitude. The area location is 25 km² wide. This study area is very suitable for conducting study on general geology and flood hazards because this area has flood potential. This area is also close to the main river of Kelantan and a lot of housing is also one of the causes of floods. **Figure 1.1** shows the base map of the study area located in Dabong, Kelantan.

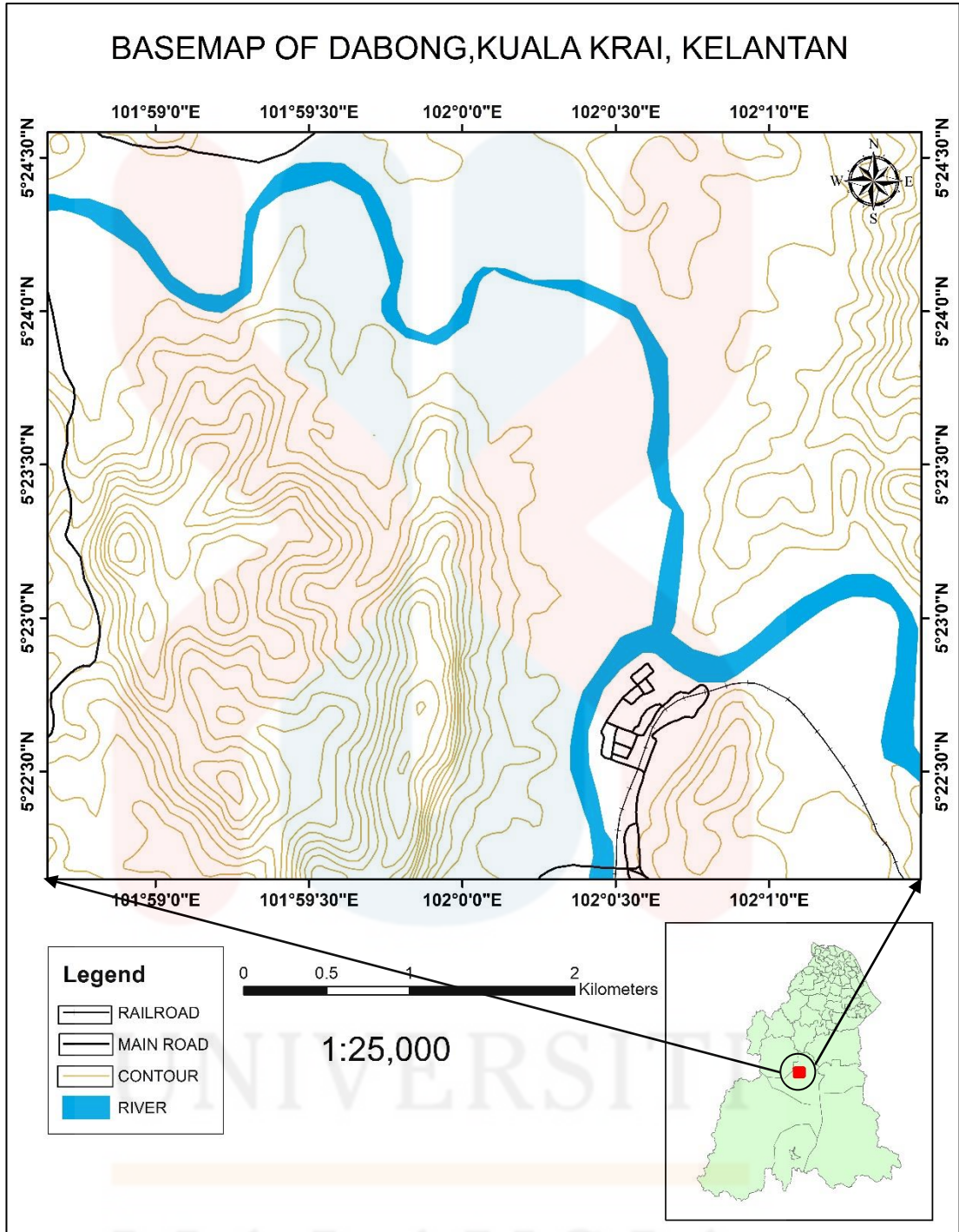


Figure 1.1: Base map of Dabong, Kelantan

1.2.2 Accessibility

For road connection, Kuala Krai is expanding rapidly after the Kuala Krai-Gua Musang highway, which is opened in August 1983 making route to Kuala Lumpur from Kota Bharu. The two main rivers are the Galas River and the Lebir River met on the Kelantan River in Kuala Krai town. The Keretapi Tanah Melayu (KTM) Dabong railway station is an important stop in the state of Kelantan on the Malaysia East Coast Line, which is also referred to as the Jungle Line. It is also the gateway to the Gunung Stong State Park, which is located just a few miles outside of town. As the study area is located near to the city of Dabong, therefore, it is easier to access this area because there are many transportations can be used by taking cars, bus and train. Besides, there is also a boat service that can help to cross the Kelantan River as it is deep river. There are 3 routes to Dabong town, namely Jalan Dabong - Jeli, Jalan Dabong - Kemubu and Federal route 66. Federal Route 66 connects Jeli, to Kampung Bukit Tebok and Manek Urai. There are also infrastructures like bridges that connected the surrounding villages.



Figure 1.2: Galas River at Dabong.



Figure 1.3: KTM Dabong railway station.

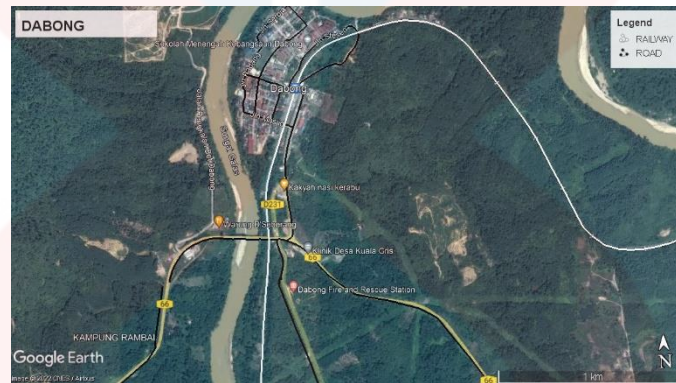


Figure 1.4: Road connection of Dabong. Main road (Black line) and Railway (White line).

1.2.3 Demography

Dabong is a highly important town that might be selected as the future capital of Kelantan due to its central position in the state and its accessibility from all areas of Kelantan. Years of failed governmental development plans have left Kelantan with an unbalanced population and a pattern of dispersed major cities. This may be remedied by relocating the capital from congested Kota Bharu to Dabong to further stimulate population development.

Table 1.1: Population at Dabong in 2020.

Mukim	MALAYSIA CITIZENS					Non-Malaysian citizens	TOTAL
	Bumiputera		Chinese	Indian	Others		
	Malay	Other Bumiputera					
Dabong	16,583	-	-	35	35	828	17,411

(Source: Department of Statistic, Malaysia, 2020)

From the **Table 1.1**, the total people in and surrounding Dabong District is 17,411. The number is including the Malaysian citizens and non- Malaysian citizens. The population in Dabong is made up of Malays who are grouped in villages along the river and tributaries. Total population for Dabong is 17,411 which is Malay (16,583), Indian (35), Others (35) and non – Malaysian citizens (828).

1.2.4 Land use

Rural development in Dabong as an accommodation provided to improve the living standard of the rural population. There are various urban based developments planning program carried out in rural area. As Dabong can be categorized as rural area and therefore the rural development is crucial there.

Dabong is dominated by agricultural land use and at the same time, there is also small city in the area. For land use it is highly focused on plantation and vegetation such as palm oil, rubber tree and so on because of its people cultivating plantations among them.

1.2.5 Rainfall

As Malaysia lies near the Equator and surrounded by water, there is no dry season. As in other tropical nations, the rains are irregular. March and April are the driest months for travel and has the least precipitation.

Table 1.2 and **Figure 1.5** shows average monthly rainfall distribution in 2020 in Dabong fluctuates greatly throughout the seasons. Dabong has constant precipitation. August is the wettest month in Dabong, with an average rainfall of 1306.5mm. Due to the heavy rainfall in that month, flood has struck Kelantan state and Dabong is affected too. January is the driest month in Dabong, with an average rainfall of 57mm.

Table 1.2: Average monthly rainfall distribution in 2020

MONTH	RAIN(MM)
January	57
February	191.5
March	94
April	74.5
May	321
June	225.5
July	205.5
August	1306.5
September	288
October	381.5
November	474
December	340

(Source: Department of Irrigation and Drainage,2020)

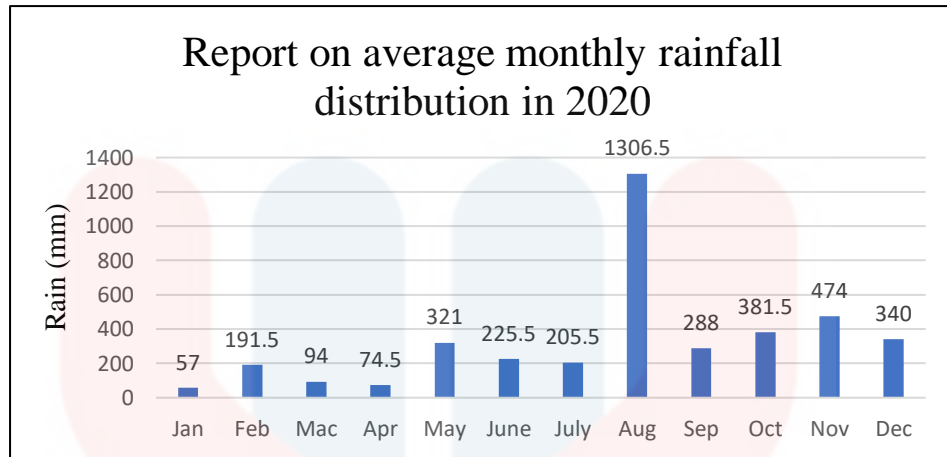


Figure 1.5: Graph of average monthly rainfall distribution in 2020.

1.2.6 Social Economic

The foremost social economic generate income in the location of study area is most from agricultural activities and from government servant or self-employed. Government sector is a large and consist of several residents such as state or local government and all units of central which it can provide many facilities to people. Furthermore, most people in the area working as contractor or laborer due to the study area that near to the palm oil in the north area and rubber tree plantation in the northeast and southeast area in the location.

1.3 Problem Statement

The previous study of geological mapping around Dabong was conducted by student but in different area. So, geological mapping required to updated lithology distribution on small scale 1:25 000. For that period, the geological aspect of the study area may change a bit. So, a geological map of study area can be produced.

In this research, the location needs to be study is in Dabong, Kuala Krai, Kelantan as the flood that occurred in this country is experienced flooding annually due to the main factor which is rainfall during rainy season and during the northeast

monsoon seasons occurring from November to March. This research will conduct to know the factors that cause the impact of disaster to the community and the area.

In 2014, the flood level at Kampung Tualang Bridge, which is near the Dabong train station, was as high as a four-story school building. The Galas is a branch of the Kelantan River that flows through Kuala Krai and Gua Musang. It has a lot of water and moves quickly. After the flood, the river got bigger, which caused the riverbank to erode and plants to die. Land clearing has been named as one of the things that led to the level of erosion and sedimentation that has never been seen before. On the hillside upstream of the Galas River, land was being cleared, and during the recent flood, sediments built up to make a long point bar (Yahaya et al., 2015).

This research aims to create updated geological map and generate flood hazard assessment mapping of the study area. Also, this research is also important to identify the parameters triggering the flood hazard.

1.4 Research Objective

The following are the objective of this study:

- i. To update the geological map of the study area in 1:25,000 scale measurement.
- ii. To determine the parameters of flood hazard assessment.
- iii. To produce a flood hazard map using GIS in Dabong, Kelantan.

1.5 Scope of study

This research will focus on the geology of Dabong, Kuala Krai. GIS method is suitable because it speeds up the modelling process by using a data-driven approach and making it easy to collect data by only using secondary data. By using ModelBuilder, the amount of time spent on processes can be cut down without calculate Weighted Overlay Method (WOM) and can be easily fixed. Each parameter was inserted into the ModelBuilder has calculated WOM and eventually produce the flood hazard map. The level for the classes of the parameter also were examined through flood hazard mapping in the GIS tool with three levels of relative hazard classes which are low, moderate, and high.

1.6 Significance of study

The significance of the study is to improve the previous research of the study area especially for the geological part and to produce the latest geological map of Dabong in scale 1: 25 000. This is important especially, to solve the geological problems such as floods in the present and future.

This research has focused on the flood hazard assessment of Dabong, Kuala Krai, Kelantan since the area annually experienced flooding. Flood hazard map that was produced is able to inform the further researcher about the flooding in the study area. Furthermore, this map also can be used as a reference for people, flood management or government in the present or future to reduce or improve the problems that relate with the flood hazard. This research can help for further researchers to figure out how likely it is that a flood will happen based on information from the ground and show how floodplains were set up in the past.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, all previous research will comprise with details to relate with the research study that were carried out. The important contents must be including in the literature review such are objective, problems and method that have been used previously. It introduces the framework for case studies, which is the major emphasis of the study. To carry out the study, it is necessary to review previous work done by other researchers. Therefore, the examination of the relevant literature may be of significant assistance in carrying out and enhancing this research.

The aim of this research is to study about geology and flood hazard assessment using GIS of Dabong, Kelantan. Therefore, the geological study is important as an indicator to identify the type of rock, rock distribution, lithology, geomorphology, structural geology, mineralogy and petrology in the study area. These data help in produce geological map on the study area.

2.2 Regional Geology and Tectonic Setting

Dabong is located at Central Belt. In the middle belt, which runs north to south, the Mesozoic formation predominates. Kelantan's Gua Musang, Gunong Rabong, and Aring formations date from the Permian-Triassic era and are composed of shallow marine clastics and carbonates interbedded with volcanic rocks (Mohd Shafeaa Leman, 2004).

There are many windows of granite intrusion, the most prominent is the batholith of Ulu Lalat (Senting Granite), the Stong Igneous Complex and the Kemahang pluton which extend to the north of Pahang. The belts in the central and west continue northward into the south of Thailand while the east belt, the Boundary Range Granite, is overlain by the coastal alluvial flat of Kelantan River.

In terms of the geological conditions, the intermediate stream reaches are composed mostly of rocks that date back to the Permian and Triassic epochs. These rocks include phyllite, slate, shale, limestone, tuff, as well as volcanic and metamorphic rock formations. It is difficult to pin down exactly where Permian and Triassic rocks may be found. On the other hand, these strata nearly all trend in the same direction, either north to south or northwest to southeast. The rocks that were formed during the Permian period may be broken down into four categories: arenaceous, argillaceous, volcanic, and metamorphic rocks. Mica-garnet schist, quartz mica schist, and amphibole schist are all examples of the kind of metamorphic rocks that are mostly composed of schist and have formed foliations.

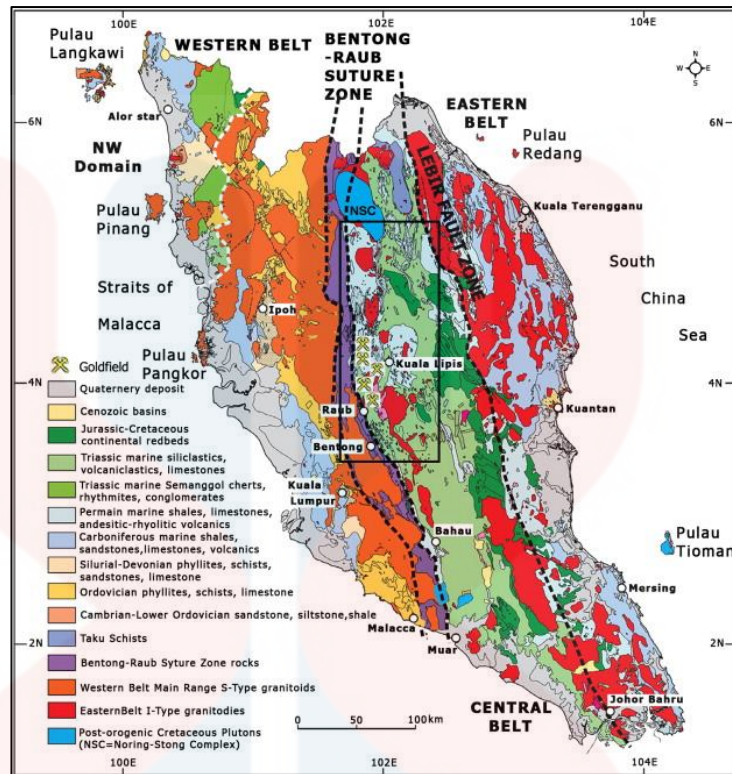


Figure 2.1: Geological map of the Peninsular Malaysia.

(Source: Modified from Metcalfe, 2013)

2.3 Stratigraphy

The Taku schist outcrops occupy a wide strip in the centre north of Kelantan State in Malaysia. This belt extends from the railway line south of Sungai Galas to Tanah Merah in the southeast corner of the Transect area. The western boundary is moving northward from Sungai Galas, through Sungai Kenik, crossing Ulu Sungai Taku and then Sungai Sokor at Kuala Bertam to the Kemahang granite pile. While the eastern edge followed the way in which Sungai Lebir and a portion of Sungai Kelantan flowed downstream from their confluence.

The town of Dabong may be found in the southeastern region of the state of Kelantan. The Dabong people are indigenous to the Gua Musang Group, which is composed of rocks that were formed during the Permian and Triassic time periods.

Gua Musang Group is a new stratigraphic unit that has been proposed in Peninsular Malaysia. It is in the central part of the country.

Under this group, it was said that the formation was mostly made up of calcareous and argillaceous rocks, as well as arenite, pyroclastic, and lava flow. The upper boundary of the Gua Musang Formation is covered by the Koh Formation, but the lower boundary of the Gua Musang Formation is still unknown. Another two formations make up the Gua Musang Group: The Gua Musang Formation and the Gunung Rabong Formation, which are the two parts of the group (Sulaiman et al., 2020).

Name	Gua Musang formation	Telong formation	Nilam marble	Aring Formation
Origin of Name	Gua Musang, South Kelantan	Sungai Telong, South Kelantan	Sungai Nilam (of Sungai Chiku)	Sungai Aring, south Kelantan
Age	Middle Permian to Late Triassic	?Permian to Late Triassic	?Permian to Late Triassic	Carboniferous to Early Triassic
Boundary	Unknown lower boundary; Upper boundary overlain by Koh Formation	Lower boundary overlies Gua Musang formation; top boundary overlain by Koh Formation	Unexposed bottom and top boundary	Lower boundary unexposed. Tectonized upper contact with Telong formation and Koh Formation.
Correlation	Upper part of Gua Musang formation interfingers with Semantan Formation, Telong formation, and Gunung Rabong formation	Lateral equivalent to Gunung Rabong formation and Semantan Formation	Lower part coeval with Aring Formation, upper part coeval with Telong formation	Lateral equivalent to Gua Musang formation in Kelantan, metasediments in SE Pahang, Volcanic Series in NW Pahang
Lithology	Argillaceous and calcareous rocks interbedded with volcanic. Minor presence of arenaceous rocks	Sequence of predominantly argillite associated with some tuff, turbidites	Calcareous marble interbedded with tuff and argillites	Basal dolomite marble, tuff, calcareous argillite, pyritiferous tuffs, subordinate lavas, argillo-tuffaceous limestone
Type Area	Gua Musang area (extended to north Kelantan and Pahang)	Sungai Telong, the upper reaches of Sungai Aring in south Kelantan	Upper reaches of Sungai Nilam	Sungai Aring, south Kelantan
Depositional Setting	Shallow marine shelf deposit, with active volcanic activity	Shallow marine environment with occasional pyroclastic	Open marine for growth of shelly fauna	Neritic with volcanic input

Figure 2.2: Formations included within Gua Musang Group.

(Source: Lee, 2004)

2.4 Structural Geology

Many structural investigations have been conducted in Dabong for structural geology, and the findings suggest that the studied region has undergone significant deformation. Sinkholes, stalactites, and stalagmites are some of the karst characteristics discovered in the research region, along with slate, sandstone,

limestone, and andesite from the Paleozoic and Mesozoic eras. Dabong's crowning geological achievement is the Stong Igneous Complex, made up of the Berangkat Tonalite, Noring Granite, and Kenerong Leucogranite lithodemic units. Type granite rocks have mafic to intermediate igneous origins, as indicated by their classification. Therefore, the Stong Complex has crustal melting and extensive migmatization with a geochemistry high in potassium and platinum.

2.5 Historical Geology

The Gua Musang Group, which includes rocks from the Permian and Triassic eras, is the homeland of the Dabong people. The Permian Taku Schist was metamorphosed into medium-grade metamorphic rocks and is conformably overlain by the Triassic Telong Formation. Near the margin, where limestone bodies, possibly like the Gua Musang Formation carbonates, are found, the age of the non-fossiliferous Taku Schist is unknown but is thought to be the Permo-triassic. Complex high-grade metamorphic, the process by which uplift and profound erosion occur, characterizes the northern half of the Peninsula, whereas tilting down characterizes the southern section. Mounts Stong, Dabong, and Gunung Stong together contribute to the Stong Migmatite Complex, which is a mountainous region located 8 km west of the Kemubu railway town.

2.6 Research Specification

2.6.1 Flood Hazard

In many nations, flooding is one of the most common natural disasters. A town in Kelantan's southern Kuala Krai area, Dabong Town, served as the focus of this study. While field investigations were being undertaken in the inundated region,

secondary data was collected from the Department of Irrigation and Drainage (Udin et al., 2018).

Natural disasters and human activities are the two most common sources of flooding in Kelantan. On flood plains, farming and other agricultural activities are becoming more common. Due to the high intensity of rainfall in a short period of time, flash floods are the result of flooding produced by natural forces. The land that drains into this river has been rapidly changing and has been cleared for farming, industrial and urban development.

Stable structure and a continuous network of pores at the soil's surface indicate a healthy soil. Rainwater can enter freely during a rainstorm because of this. Surface seals that are compromised or have blocked or discontinuous pores might result in a low rate of infiltration. Soils with less infiltration produce more runoff water overall. As a result of the heavy rain, several areas were left with stagnant floodwaters which might lead to flooding. As a result of development, land clearing and other human activities there has been a rise in the number of impermeable surfaces and obstructions in rivers. Heavy rains might create flooding therefore the public must be watchful about economic output, victim compensation and rebuilding.

According to Saaty, T.L (1980), who created the Analytic Hierarchy Process (AHP) in the early 1970s as a mathematical model to streamline and enhance the decision-making process. The six main steps are as follows: defining the problem, breaking it down into subproblems, comparing subproblems head-to-head, finding the largest eigenvalue and eigenvector, determining whether the matrix is consistent by determining its consistency ratio, and finally, aggregating the relative importance weights of a choice to arrive at a final weighting for decision alternatives.

Using a pairwise comparison approach grounded on measurement theory, the analytic hierarchy process (AHP). Numerous research has focused on the effectiveness of AHP in evaluating the risks posed by natural hazards like earthquakes and floods, with a greater emphasis on flood control. These publications demonstrate the usefulness of AHP in accurately assessing and mapping flood risk. (Pourghasemi et al., 2014).

Rating Scale	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
2	Weak	Between equal and moderate
3	Moderate importance	Experience and judgment slightly favor one element over another
4	Moderate plus	Between moderate and strong
5	Strong importance	Experience and judgment strongly favor one element over another
6	Strong plus	Between strong and very strong
7	Very strong or demonstrated importance	An element is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	Between very strong and extreme
9	Extreme importance	The evidence favoring one element over another is one of the highest possible order or affirmation

Figure 2.3: AHP fundamental scale.

(Source: Saaty, T.L, 1980)

2.6.2 ModelBuilder Tool

ModelBuilder is a modelling application. Models integrate the result of one geoprocessing tool into another. ModelBuilder is a visual programming language for workflows. ModelBuilder is handy for building and executing simple workflows, but it also offers complex methods for extending ArcGIS capabilities by allow to develop and share models as tools. ModelBuilder were used to connect ArcGIS to other software (Nuwanka & Withanage, 2021). It is important to construct geoprocessing processes alongside data processing. Models of the potential for flooding in the research region will be created using ModelBuilder.

To complete a model, ModelBuilder requires geoprocessing tools, map layers, datasets, or other data types, which it then combines into a process by either executing the model in its whole or in discrete steps. Six questions about the

detection of occurrences, locations, trends, optimum pathways, patterns, and models must be answered by this model. The floodplain land value is calculated using this specific model. This finding has important implications for urban planning and the evaluation of flood risk.

2.6.3 Weighted Overlay Method in ModelBuilder

Weighted Overlay Method (WOM) is utilized when weighing many aspects of varying relevance. Along with significant of use, using a ModelBuilder was ensure that Geographic Information System (GIS) databases conform to the rules of processes the process sequence were fixed and constant would be particularly declared, would allow making changes to each component of a segment of the model without having caused much labor to others and would allow easier parameter or layer differences with reliability. Each ModelBuilder unit allowed menu-driven operations by identifying input or output parameters, input data and output storage places. The result was graduated colour raster showing areas low, moderate and high.

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

In this method, it is essential to study some materials and methods to complete this study. To produce geological mapping of study area and flood hazard assessment mapping, several approaches and techniques were proposed. This section provides a detailed description of the study methods and techniques. Geographic Information System (GIS) platform for flood assessment includes several elements data types of methods of collection and interface for flood hazard assessment.

3.2 Material

3.2.1 Geological mapping

Table 3.1: Material for geological mapping

NO	Material	Function
1.	Geological hammer	Geological hammer is used to crush/break the rock outcrop to take rock sample. Also, geological hammer used as a scale in a photograph. The common type of hammer used is one square faced end and one chisel end.
2.	Global Positioning System (GPS)	It was employed to find station points in geologically complicated locations, where accurate plotting was essential for constraining the geologic interpretation.

3.	Brunton Compass	Compass were used to measure the orientation of geological planes and lineation. Also, the compass was used as a protractor in the field.
4.	Field Notebook and Stationeries	Field data was collected and write in the field notebook. Besides, the stationeries also were used as a scale in photograph.
5.	Geographic Information System (GIS)	A computer-based tool useful for mapping and to determine the geological events of the selected area. ArcGIS is used analysis, interpretation, overlay and represent the factor maps preparation.
6	Google Earth	Known as computer program which represent 3D effect of Earth based on satellite imagery. In addition to Google Earth Pro, we utilized a different programmer to plan a route and then get the area's coordinates and elevation.
7.	Base map	The base map is utilized to obtain the geological information of Dabong.
8.	Camera	It is important to capture and stores the pictures of rock outcrops and other.

3.2.2 Flood Hazard Mapping

Table 3.2: Material for Flood Hazard Mapping.

No	Material	Function
1.	Contour map	Contour lines on a topographic map depict the land's form and slope.
2.	ArcGIS Software	All secondary data will transfer to the ArcGIS software to produce flood hazard map of the study area. Flood hazard map are producing by using Weighted Overlay Method (WOM) tool in ArcGIS software.
3.	Drainage Pattern map	The drainage pattern of a certain drainage basin is the pattern that is created by the streams, rivers, and lakes in that drainage basin. The pattern that is left behind after years of erosion by streams provides clues about the types of rocks and geologic formations that are present in an area of the terrain that is drained by streams. Drainage density map describe the fundamental watershed property which designed by United States Geological Survey (USGS).

3.3 Methodology

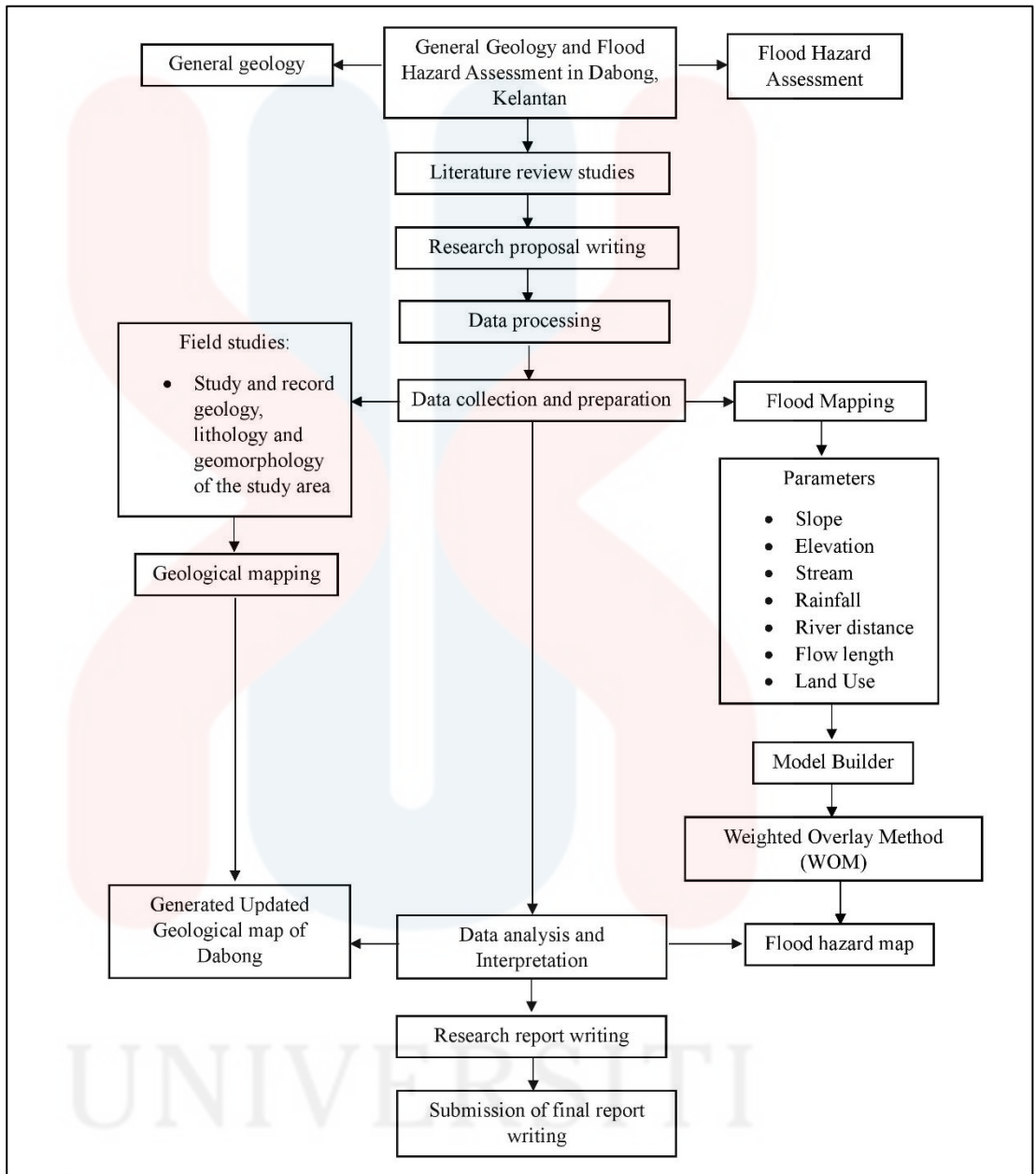


Figure 3.1: Research flow chart of study area

3.3.1 Preliminary studies

In this preliminary studies also involve in understanding the selected techniques and approaches that was used. Especially the triggering factors or parameters of the study area is important to acknowledge to updated geological map and for the specification which is to produce flood hazard mapping of the study area. Furthermore, the data achieved is important to measure the geology which are the

rock types, lithology, geomorphology, structural geology, mineralogy, and petrology in the study area. An appropriate research and preparation are crucial to accomplish this study within the duration given.

3.3.2 Field Studies

a) Geological Mapping

One of the important steps in completing this study were obtaining and collecting field data of the study area to produce updated geological mapping. GPS instrument was used for tracking and traverse activities in the study area. Geological mapping was carried out by reading the structural analysis such as strike and dip and geological structures such as fault and dyke. The reading was carried out using Brunton compass. The information was described in the field notebook. Rock samples was taken into sample bags for further investigation.

Another observation made by observe the geomorphology of the study area. Also, observation on the weathering classes at some of the outcrops in the field have been made. The data we obtained are through visual recognition of degree of discoloration, the ratios of rock and soil, the presence of original texture and structure and by assessed the rock's strength by breaking the rock fragment and investigated sound emitted when the rock is struck with the geological hammer.

b) Flood Hazard Mapping

During field survey, before doing a hazard assessment, it is important to find out what kinds of floods happen most often or cause the most damage in the area. This is because, in most cases, the choice of hazard methods will depend on the type of flood. Specific rules for assessing the risk of flooding can be found (Federal Emergency Management Agency, 2019).

3.2.3 Laboratory work

To classify rocks taken at area was determines the origin and mineral composition of a rock. Microscopical characteristics such as mineral content, texture, grain size and evidence of modification or deformation were observed in thin sections of the tested sample and described in conjunction with the macroscopic facets of the rock such as its fabric, colour, grain size and other relevant properties that were observed visually in hand specimens or outcrops.

3.3.4 Data collection

For this study, primary and secondary data were obtained to achieve the objectives. Data collection is really needed to do the study in the study area and specification. The methods and approaches are the main procedures to measure and generate the final output for this study. The elements of the methodologies for this study are comprises of the preliminary studies, materials, data collection, field studies, data preparation and processing and data analysis and interpretation. Secondary data can be obtained from previous research such as articles, journal, book and internet.

Observation is also part of data collection steps. Field observation data is crucial to makes the geological mapping of the study area. The secondary data of Dabong collected by various sources were used which are comprises of land use, vegetation, geomorphology, lithology, structural geology, mineralogy, petrology and data collection of flood hazard.

a) Rainfall

The rainfall was record for monthly data through a chosen year to create the average annual data by using ArcGIS tool. Rainfall data can get from agencies such

as Jabatan Pengaliran dan Saliran (JPS). The rainfall distribution data at 10 station which is Dabong, Kuala Geris, Kuala Nal, Lapan Kabu, Laloh, Aring, Gua Musang, Jeli, Ladang Pergau and Kampung Sungai Batu in 2017 to 2020 because these 10 rain stations surrounded the dabong area.

3.3.5 Data Preparation & Processing

All secondary data either in geological data or flood data that have been collect are process by using specific software such as ArcGIS. These data needed to update and produce the new geological map of the study area.

This present study purpose is to generate a flood hazard map of the study area and prepare seven parameters which triggering the flood. To produce flood hazard map, ArcGIS software was used to determine the flood hazard map by using the Weighted Overlay Method (WOM) by giving weighting and scoring for each parameter.

The modelbuilder was employed in the study, and it was also used to do GIS-based spatial analysis with the help of the ArcGIS software (Elangovan, 2006). Reclassification and Weighted Overly Method (WOM) tools were utilized in the model builder to create the final risk zoning maps for sub and main criteria (Schumann, 2018). This method was overlay all the parameters which influence the flooding based on the consideration of the effect of each parameter on flooding. Then, the result was generated to flood hazard map of the study area.

3.3.6 Data Analysis and Interpretation

The analysis and interpretation were accomplished after the data needed were obtained to proceed in this study. Result from the analysis was obtained to for further interpretation. Secondary data collected was analyzed by using ArcGIS software to generate geological map and flood hazard assessment map of the study area. The interpretation of data such as lithology, elevation, drainage system and accessibility and structural geology was used to generate updated geological map.

Flood hazard was analyzed based on the triggered factors based on some slope, elevation, drainage density, land use, rainfall, river distance and flow length. **Figure 3.2** shows the main criteria of flood hazard determination of an area. There are three (3) main criteria that involves such as physical environment, socioeconomic environment and rainfall. Each of these criteria has its own sub criteria such as slope, elevation, drainage density, land use, rainfall, river distance and flow length. All these sub criteria were the proposed parameters to determine a flood hazard phenomenon.

Petrography analysis was carried out on a wide range of sample types and quality depending on the kind and location of the sample collection because petrographic data was readily compared to porosity and permeability measurements, thin sections are routinely generated from porosity-permeability plugs taken from standard cores. The procedure of preparing a thin segment is one that must be done with great care and precision.

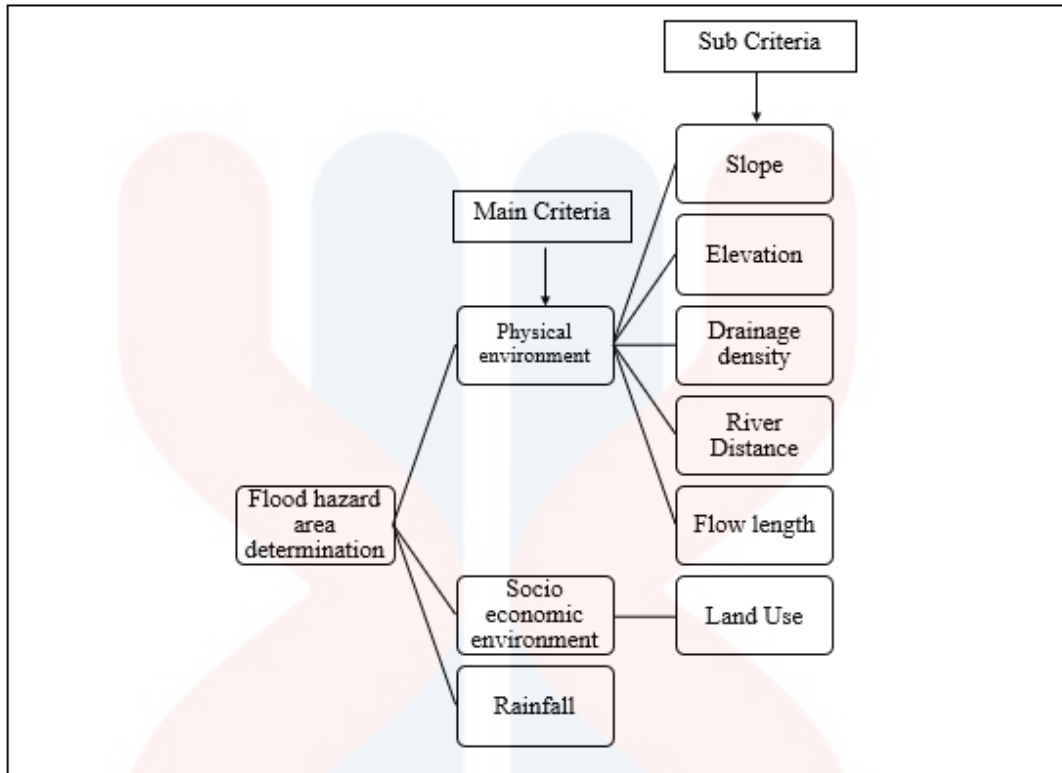


Figure 3.2: Flood hazard area determination.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this section, will talk about the geology of the region. The geological maps and literature reviews in this chapter provide the information and data shown here. Geomorphology, stratigraphy, structural geology, historical geology, lithology, mineralogy, and petrology are the main subfields of the field of general geology that make up the studied area because the research area must in 25 km², traversing is required. Based on the findings of the preliminary investigations conducted before the mapping process began, the journey was continued on foot through areas that were inaccessible by automobile due to plantation areas and steep hills, except for residential areas.

4.1.1 Accessibility

Accessibility is measured by the number of roads that connect one area to another in the study area. Based on **Figure 4.1**, the map shows that the study area is easy to access. There are two kinds of roads: paved and unpaved roads. Most of the time, big cars and trucks can drive on paved roads, but small cars and motorcycles can drive on unpaved roads that are only found in the forest and plantation. Since the study area is close to the city of Dabong, it is easy to get to because there are many ways to get there, such as by car, bus or train.

In addition, from **Figure 4.1**, there is also a train track on the right side of the study area and **Figure 4.2** show railway road in the study area. This track goes from the Tumpat station to the Gemas station. This building will make it easier for people to move from one place to another. **Figure 4.1** Shows the Galas and Pergau rivers.

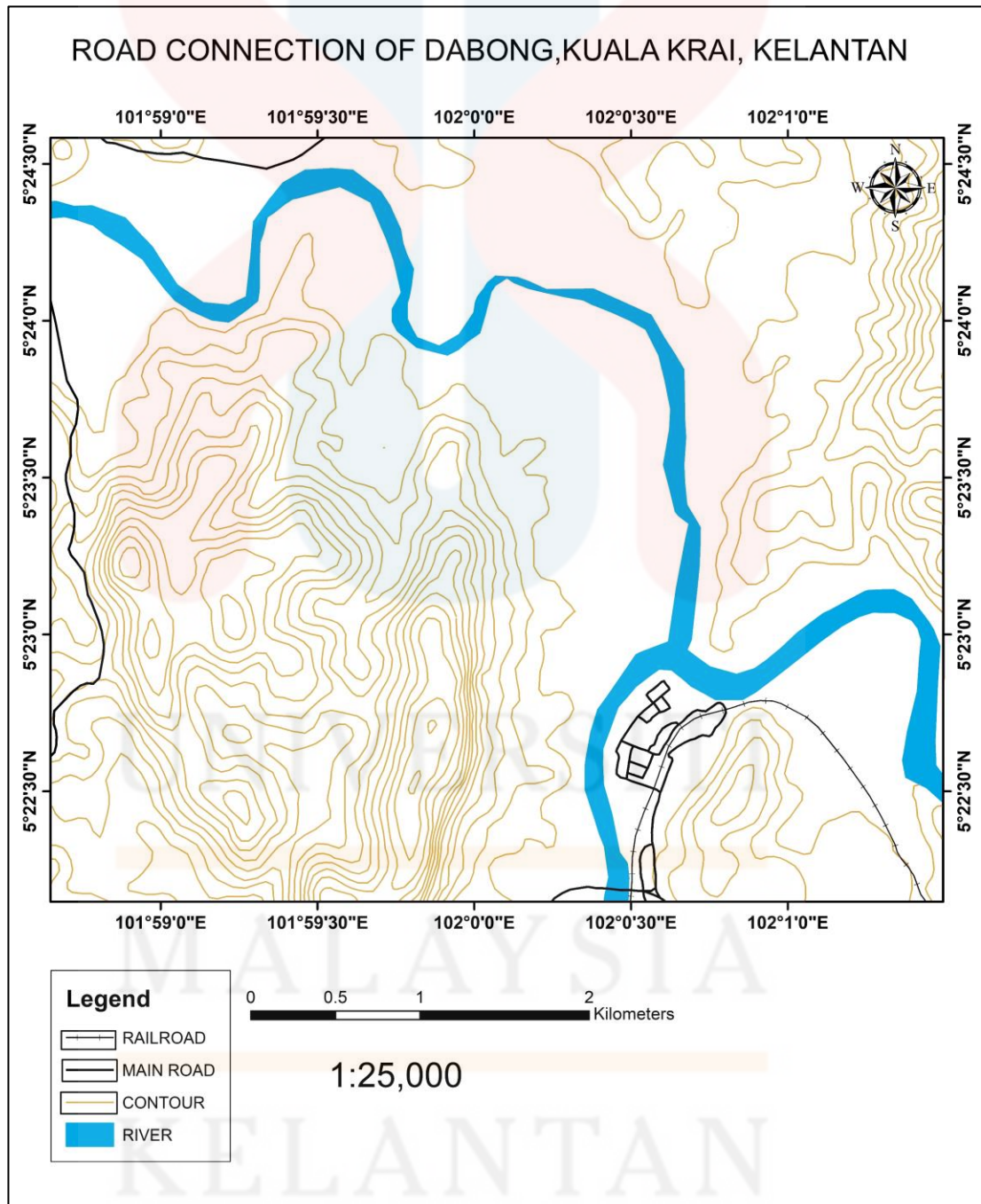


Figure 4.1: Road connection of study area



Figure 4.2: Railway track of Dabong

4.1.2 Settlement

According to Department of Statistics Malaysia (2020), Dabong has a total population of 17,411 people. There are 3 routes to Dabong town, namely Jalan Dabong - Jeli, Jalan Dabong - Kemubu and Federal route 66. Federal Route 66 connects Jeli, to Kampung Bukit Tebok and Manek Urai. **Figure 4.4** shows traverse map of Dabong travel route while doing field mapping.

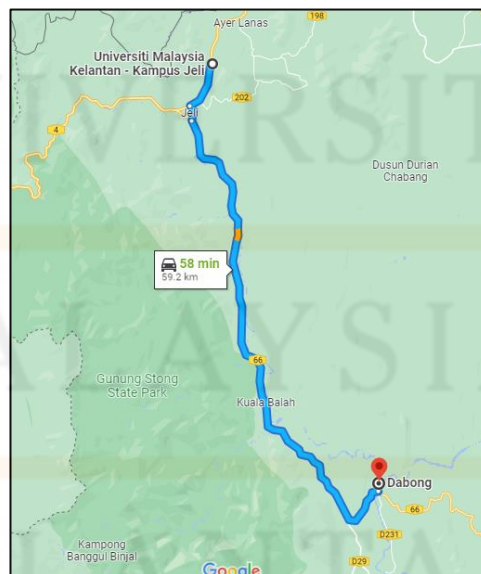


Figure 4.3: Path Road of the study area.

4.1.3 Traverse and observation

Figure 4.4 show traverse map of the study area. The traverse map shows the road track and location of rock. When important outcrops and geological structures are found in a research area, an outcrop station is set up there. At different stations with different rock types, samples are taken. Through petrography analysis, this sample is used to figure out what kind of rock it is. **Table 4.1** Shows the location of station, sample and observation.

Table 4.1: The location of observation

Station	Coordinates	Observation
S1	N 05° 40' 02.88" E 101° 98' 54.33"	Weathering outcrop
S2	N 05° 40' 60.55" E 101° 98' 54.33"	Fresh outcrop (Schist)
S3	N 05° 37' 40.20" E 102° 00' 44.28"	Weathering outcrop
S4	N 05° 38' 21.63" E 102° 00' 59.13"	Weathering outcrop
S5	N 05° 38' 23.22" E 102° 00' 50.56"	Weathering outcrop
S6	N 05° 38' 47.71" E 102° 00' 32.34"	Weathering outcrop and slope
S7	N 05° 38' 66.37" E 102° 00' 41.74"	Weathering outcrop
S8	N 05° 38' 70.45" E 102° 00' 42.53"	Weathering outcrop
S9	N 05° 38' 92.17" E 102° 00' 42.53"	Fresh outcrop (phyllite)
S10	N 05° 38' 27.75" E 102° 01' 76.38"	Weathering outcrop

S11	N 05° 38' 25.3" E 102° 01' 45.61"	Fresh outcrop (schist)
S12	N 05° 39' 47.39" E 102° 01' 12.56"	Weathering outcrop
S13	N 05° 37' 98.68" E 102° 02' 45.31"	Weathering outcrop
S14	N 05° 40' 83.9" E 101° 98' 81.06"	Weathering outcrop and slope

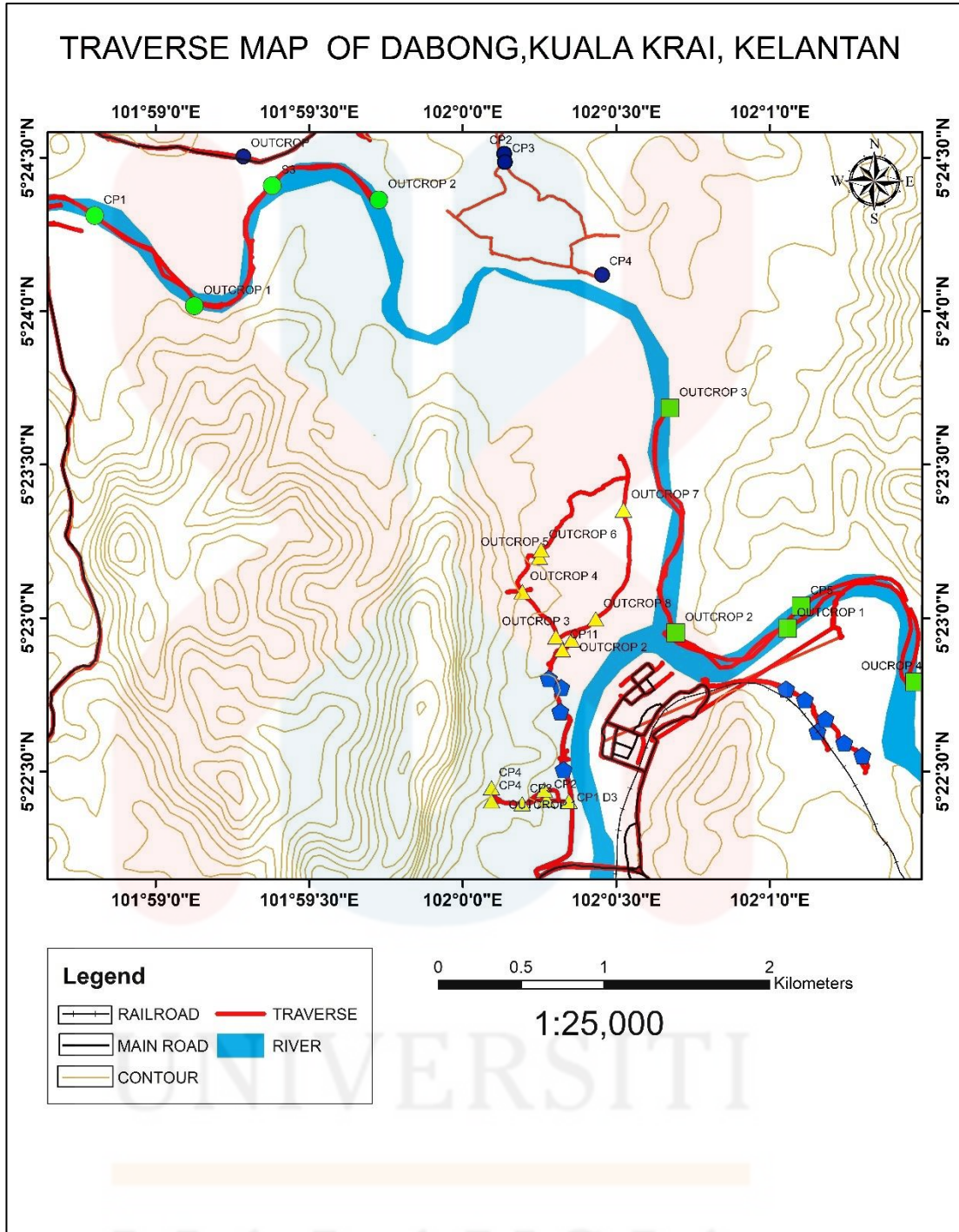


Figure 4.4: Traverse map of Dabong.

MALAYSIA
KELANTAN

4.1.4 Forestry (or vegetation)

People in the village in the study region make most of their money and do most of their own work with plants. Since most of the study area is composed of forests, plantation is a natural occurrence. The villagers also work as rubber tappers and palm oil farmers because rubber and palm plantations are in the study area (Figure 4.5). Figure 4.6 shows land use map of the study area.



Figure 4.5: (a) Palm oil plantation and (b) rubber plantation of study area.

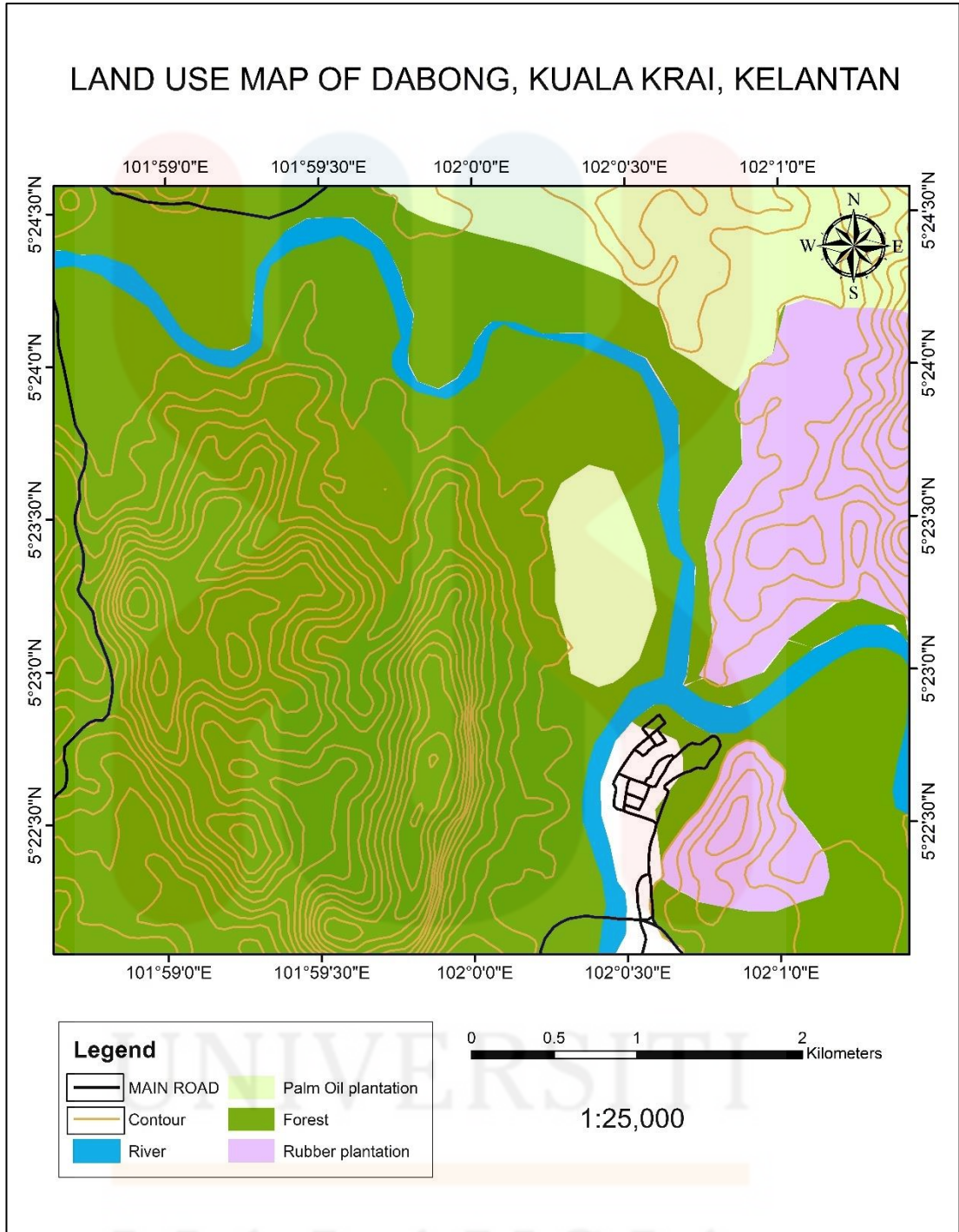


Figure 4.6: Land use map of Dabong

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4.2 Geomorphology

Geomorphology is the study of landforms, including how they form, how they change, and what makes them up. It has both flat and hilly parts in Dabong and the nearby area. Forest still grows all around it because some places turn into industrial areas.

4.2.1 Geomorphology classification

Topography is the study of how the land is shaped and what it looks like, with elevation data in digital elevation model (DEM). Depending on the area being studied, geomorphology can be split into two parts which is plains and hills. A valley is a type of landform that is drained by rivers and can be found on flat plains or between hills. A plain area is a type of flat land that is usually found in lowlands.



Figure 4.7: Hilly landscapes in the study area.

Based on the elevation map in **Figure 4.8**, it shows geomorphology at the study area. A hilly landform can be thought of as an area with a high contour. In the area under study, the hills were used as forest. The area's highest point be found out to the southwest. It stated around 200m to 500m from sea level and shown as red

colour. The lowest elevation is located along the main river about 0 m to 50 m shown as dark green colour.

Table 4.2: Geomorphological unit of study area

GEOMORPHOLOGICAL UNIT	LANDFORM	ELEVATION (m)
Sloping plain	Low land	50 – 100
Sloping hill	Low hill	100 – 200
Steep hill	Hill	200 – 500

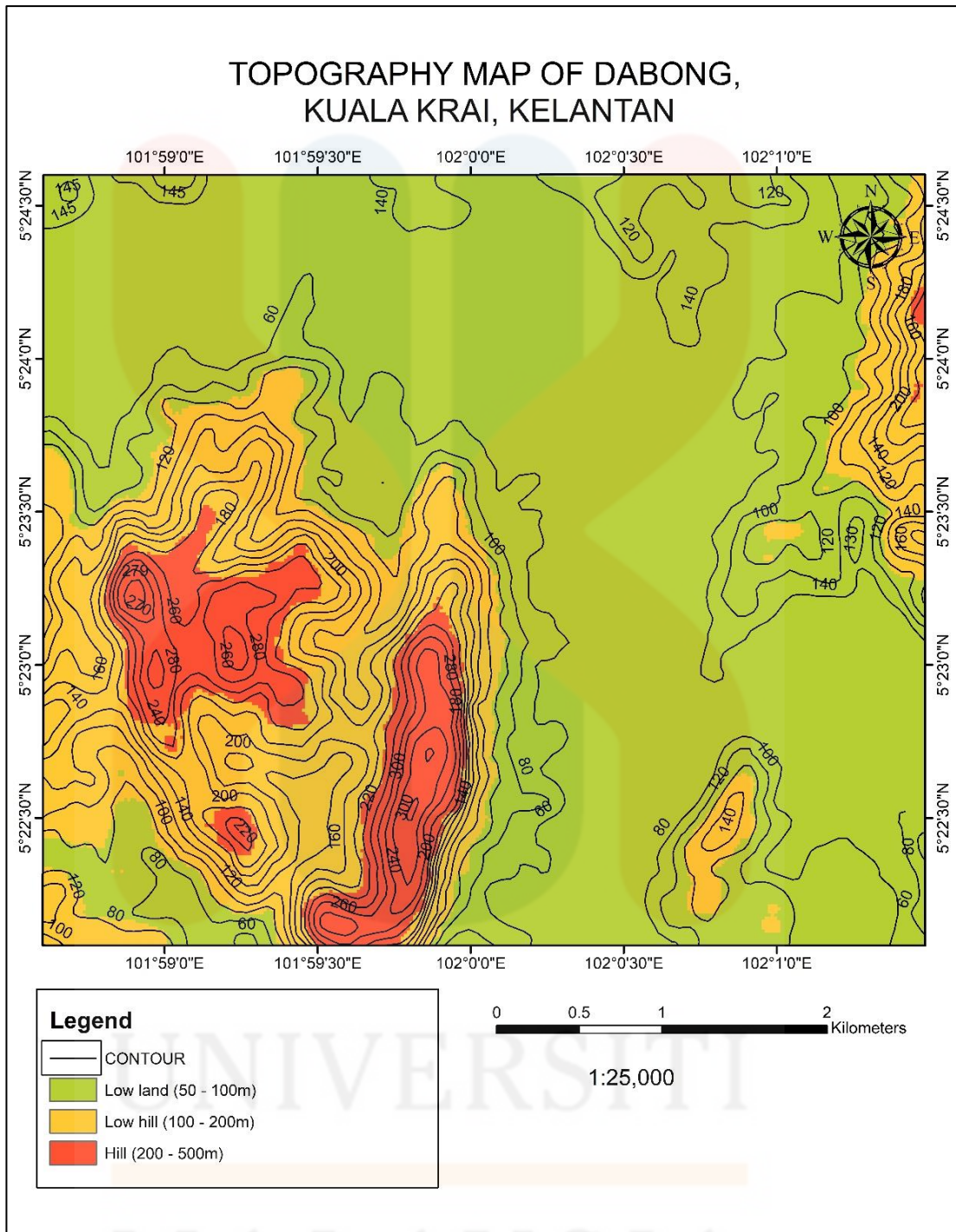


Figure 4.8: Topography map of study area.

4.2.2 Weathering

Weathering is the process by which rocks and minerals on the surface of the Earth break down or dissolve. After a rock has been broken up, the pieces of rock and minerals are carried away by a process called erosion.

Based on **Figure 4.9**, there are two type of weathering is physical and biological weathering. For Physical weathering, can be seen on the rock especially near the river. The process by which rocks are broken down into smaller bits by organisms such as plants, animals, and microorganisms are known as biological weathering. Erosion occurs during floods because the force of the moving water is usually enough to rip away the topsoil layers. Since the water may either pound on the earth or draw it away, riverbanks and cliffs can be washed away during a flood.



Figure 4.9: Physical and biological weathering of study area.

4.2.3 Drainage

The drainage pattern of a region is the pattern formed by its waterways (streams, rivers, and lakes). Streams may be conceptualized as drainage basins, which are regions of land that provide water to other regions through groundwater flow, runoff, as well as through flow. Based on **Figure 4.10** shows three distinct drainage patterns: dendritic, parallel and subparallel. To put it simply, a dendritic pattern is a randomly generated tree-like structure with branching streams and a mainstream.

A parallel drainage pattern is defined by the general directionality of the principal streams within the pattern. The Pergau and Galas River is the primary river in the study region, and it eventually meets up with the Kelantan River.

In a GIS system, river networks are stored as lines with geographical coordinates and information about how they fit into the landscape. The network makes it easier to notice different patterns and see how they relate to other geographical factors. Drainage systems can be manually digitized or taken from a Digital Elevation Model (DEM) by figuring out how water flows and builds up on the terrain. Drainage pattern is important because it provides a basic way to divide a river basin into areas with rivers and areas with hills.

Based on map in **Figure 4.10**, the most common drainage pattern found in the study area is dendritic, parallel and sub parallel. The study region has a mostly dendritic drainage pattern. For parallel drainage patterns are found in the northeast and south. Sub-parallel drainage patterns are mostly found in the east.

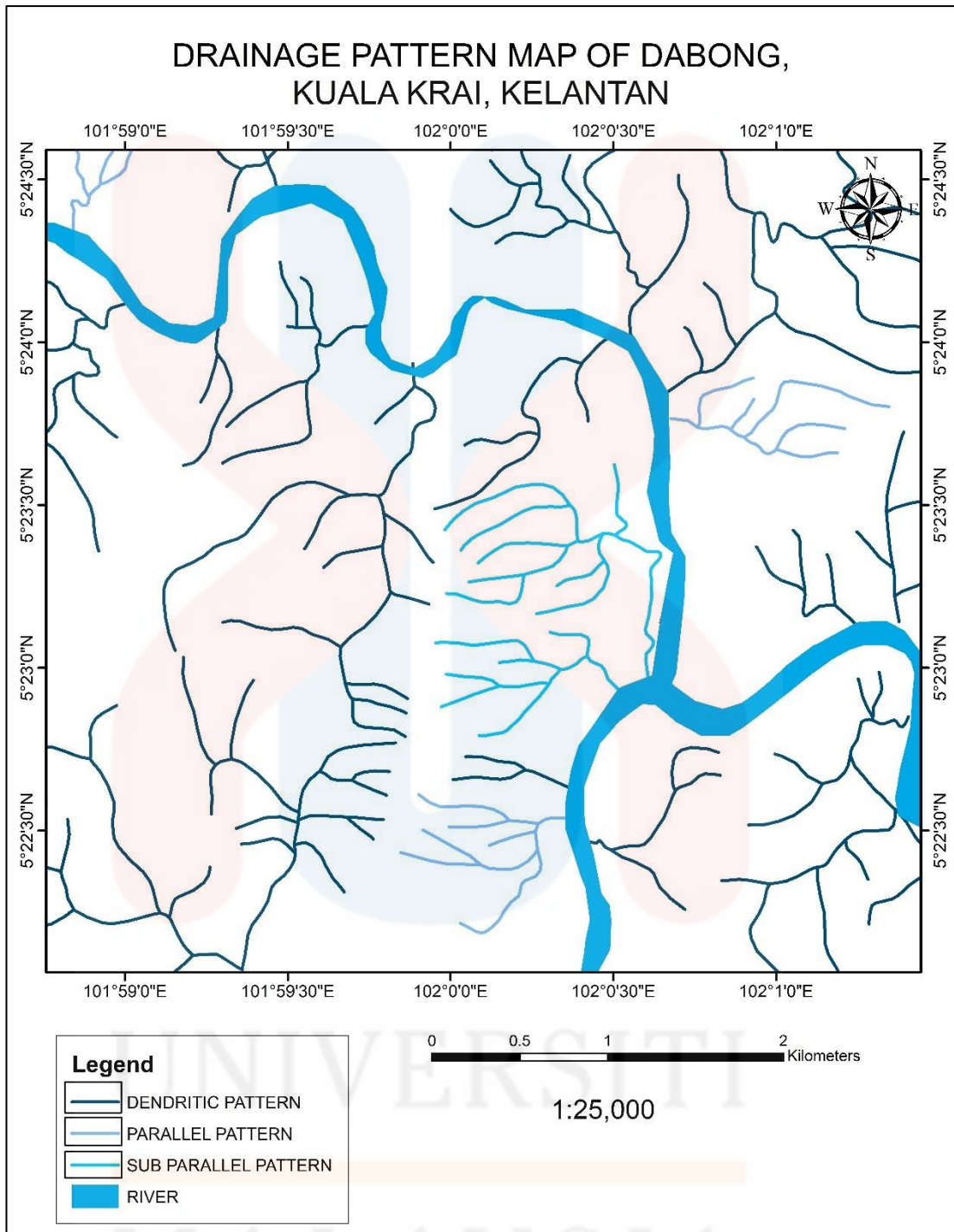


Figure 4.10: Drainage pattern of study area.

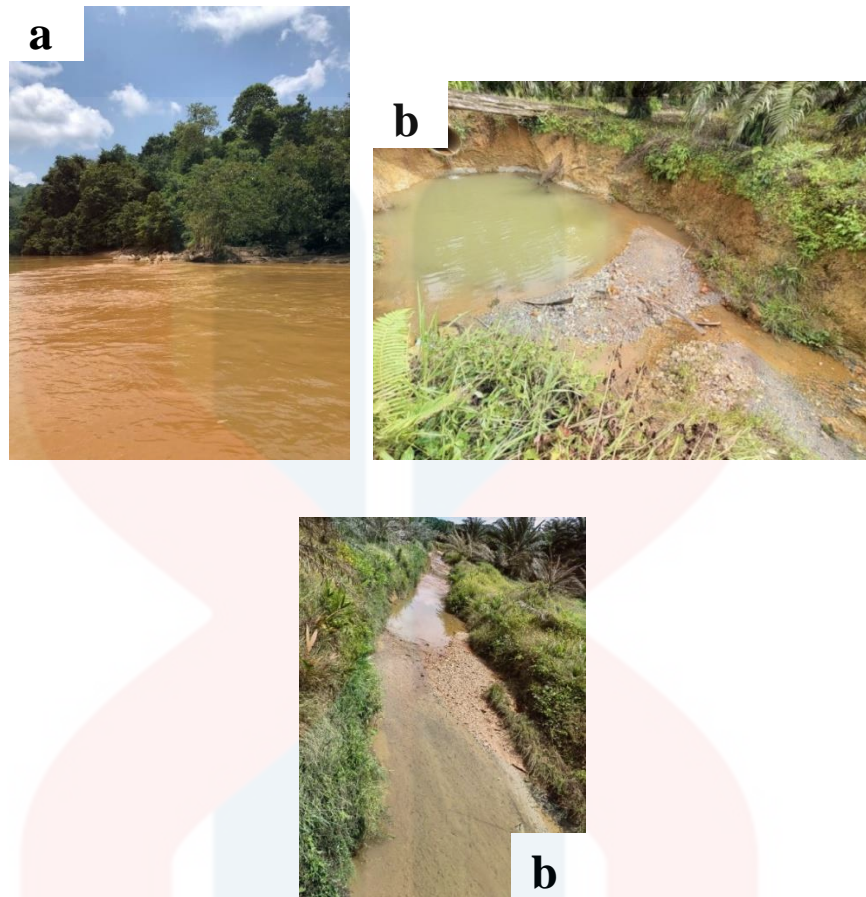


Figure 4.11: (a) Main River and (b) stream of study area.




4.3 Lithostratigraphy

Lithostratigraphy aims to figure out how the layers fit together, while petrography analysis uses thin sections to figure out what rocks. Descriptive information on rocks is included in this chapter as well, beginning with the newest and working its way to the oldest.

4.3.1 Stratigraphy

Stratigraphy is a subdiscipline of geology and earth sciences that studies the formation, content, and distribution of geological layers, and their order and succession across time. **Table 4.3** shows the stratigraphy column based on study area.

Table 4.3: Stratigraphic column

LITHOLOGY	DESCRIPTION	PERIOD	ERA
Schist 	The Permian Taku Schist had been metamorphosed to medium grade metamorphic rocks.	Permian	Paleozoic
Phyllite 	Phyllite is between slate and schist in the spectrum of metamorphic rocks.	Permian	Paleozoic
Alluvium 	Comprises of sand, silt, mud, and gravel. Alluvium deposited along the riverbanks.	Quaternary	Cenozoic

From **Table 4.3**, the stratigraphic column of the study area is important in determined the age of rock unit and to describe the relationship between strata and stratigraphic column in the location. The rock layers have been determined from younger to oldest which is schist and phyllite.

Figure 4.12 shows the elevation, cross section, and lithology rocks in the study area. Based on the **Figure 4.12**, the north and south parts of the study area are made up of schist and phyllite. A geological map was made by comparing a paper map from the Geological Society of Malaysia with a spatial data set like a terrain map. The geological map was the same colour as the colour of lithology on the website of the United States Geological Survey (USGS).

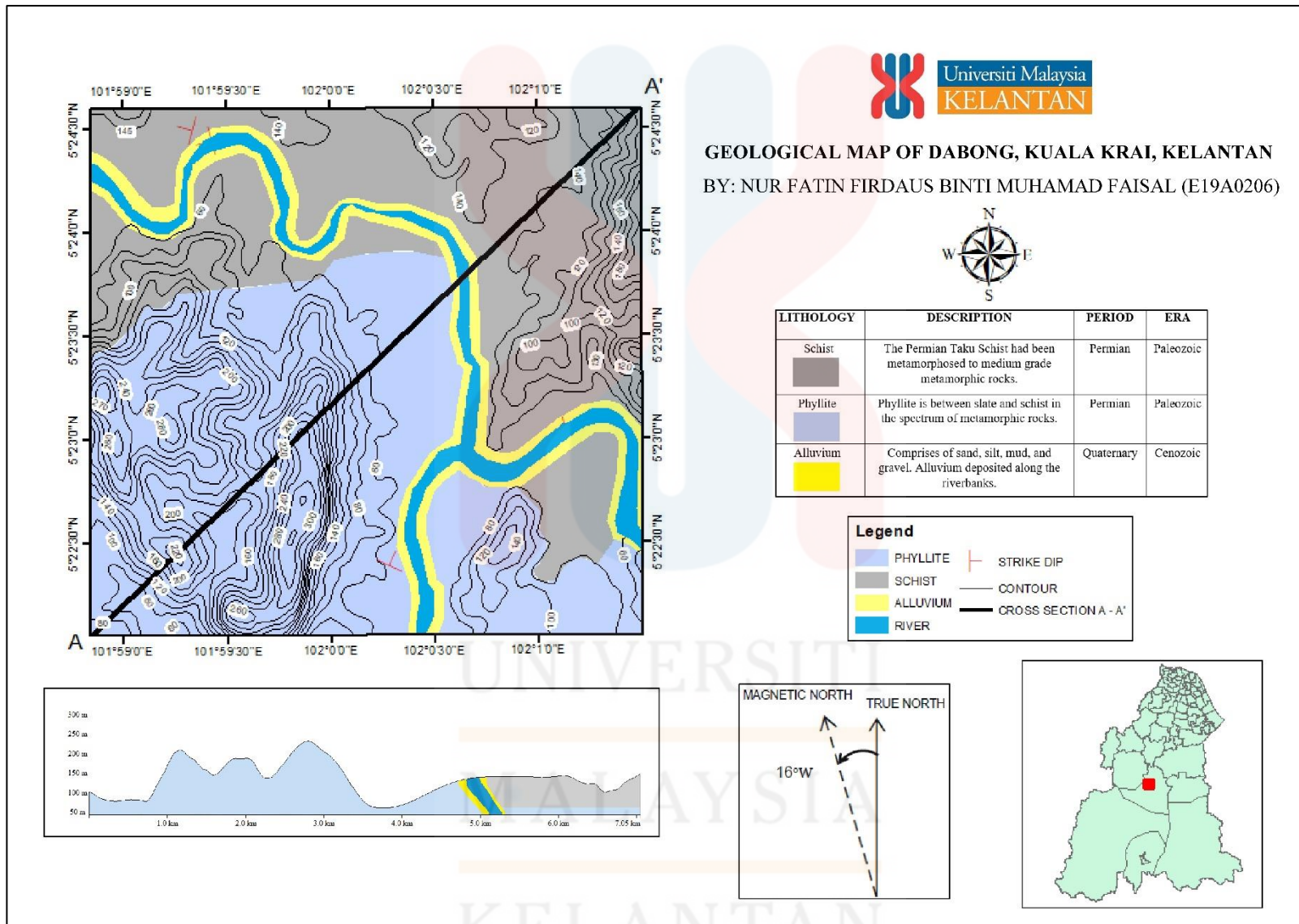


Figure 4.12: Geological map of Dabong.

4.3.2 Unit explanation

In these parts, information about the rock units, from the oldest to the newest, was given. Based on petrography analysis, the exact compositions of each unit rock, such as how many minerals it has, were described. Several places in the study area were used to get rock samples, which were then cut into thin sections for further study.

a) Phyllite

Phyllite is a kind of metamorphic rock that has fine-grained crystals and a well-developed laminar structure and classify as the oldest rock. It is classified as an intermediate rock between slate and schist. The colour of phyllite range from black to grey and light greenish grey tone. Its foliation may be described as having a crinkled or wavelike look. The rock known as phyllite is both hard and pliable. This rock was found near the main river. **Figure 4.13** shows the outcrop of phyllite, and **Figure 4.14** shows hand specimen of the rock.



Figure 4.13: Outcrop phyllite in the study area



Figure 4.14: Hand specimen of Phyllite

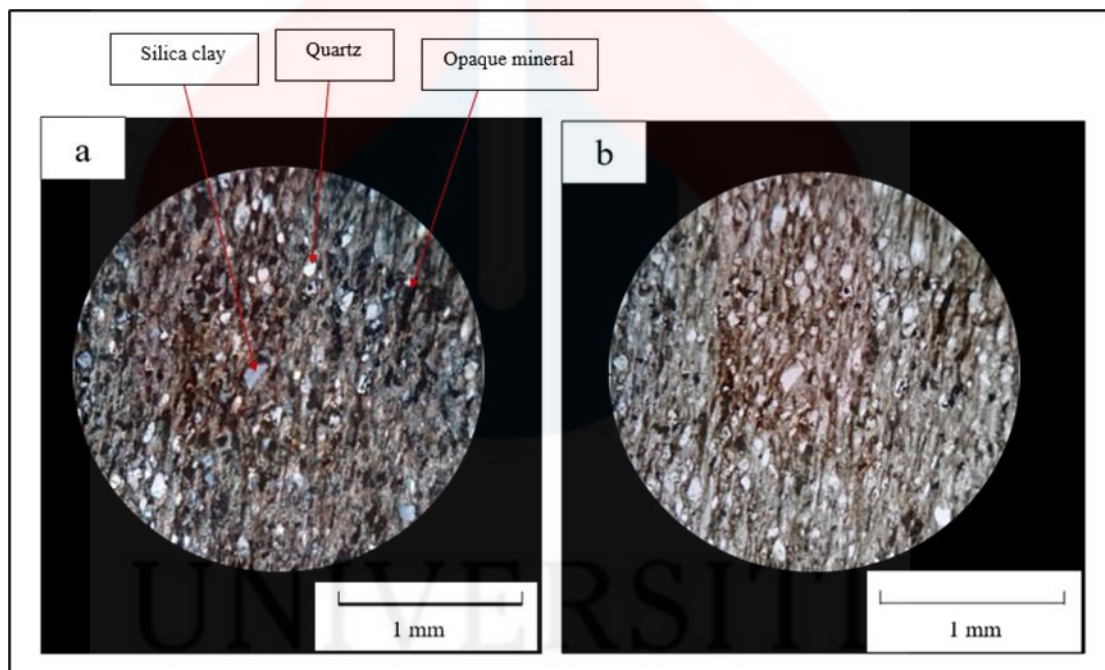


Figure 4.15: The photomicrograph of phyllite under (a) cross polarized light (XPL) and (b) plain polarized light (PPL)

Based on observations through hand specimens, these rocks feel dusty when held. The colour are grey, black and brownish. Under the microscope in **Figure 4.15**, this sample mostly formed by quartz, silica clay and opaque mineral. For quartz, the plane polarized light (PPL) shows the quartz color is colorless, low relief, no pleochroism, no cleavage and anhedral crystal form while in cross polarized light

(XPL) the interference color is gray – white and there is no twinning. For silica clay in PPL shows the absorption color is colorless – brown while in XPL the interference color is dark gray – black. For opaque mineral, in PPL shows the absorption color is black, low relief, no pleochroism and euhedral – anhedral crystal form while in XPL color interference black and there is no twinning.

b) Schist

Schist is a metamorphic rock that underwent medium-grade transformation. The rock unit was dispersed somewhat evenly over the north-eastern portion of the research region. Quartz and feldspar make up the bulk of the rock unit's make-up as its constituent minerals. The outcrop had a colour that was between brownish and black in appearance. During field research have been found two schists but in different places at Galas and Pergau River.



Figure 4.16: Outcrop of schist in the study area



Figure 4.17: Hand specimen of schist.

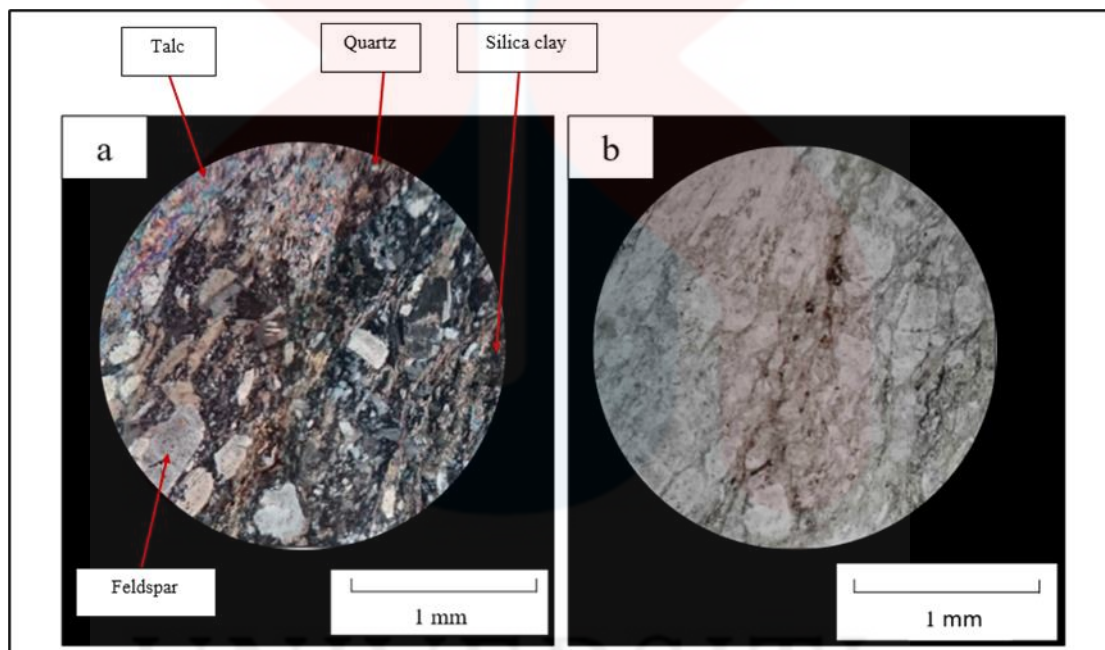


Figure 4.18: The photomicrograph of schist under (a) cross polarized light (XPL) and (b) plain polarized light (PPL).

Based on observations through hand specimens has been found at Pergau river, these rocks feel dusty when held. The colour are blackish and grey. Under the microscope in **Figure 4.18**, this sample mostly formed by feldspar, quartz and opaque mineral. For feldspar, the plane polarized light (PPL) shows the absorption color is colorless, way cleavage, low relief and no pleochroism while in cross polarized light (XPL) the interference color is gray – white. For quartz, in PPL the

absorption color is colorless, low relief, no pleochroism and no cleavage while in XPL the interference color is gray – white, the dark corners are wavy and there is no twinning. For silica clay, in PPL the absorption color is colorless – brown while in XPL the interference color is dark gray – black. For talc, in PPL the color of the absorption is colorless, low relief, weak pleochroism and no cleavage while in XPL the interference color is blue – yellow and there is no twinning.

C) Alluvium

Alluvium is loose clay, silt, sand, or gravel deposited by moving water in a stream bed, floodplain, alluvial fan, or beach, among other places. Alluvium is also known as alluvial deposit. Alluvium deposited along Galas River and Pergau River.

4.4 Structural Geology

Structural geology is the study of how rocks form and how their shapes change over time. All the data from geomorphology, stratigraphy, and structural geology are put together to figure out what happened in geology in the past. Structures like lineament, joint, fold, fault, and fracture are the result of geological events that happened in the past, like earthquake or plate tectonics. Under this subtopic, it will talk about the joint, lineament analysis and bedding.

4.4.1 Lineament Analysis

Lineament can be divided into two, namely positive and negative. For positive lineaments can be found on the ridge while negative lineaments can be found in streams and valleys. Each lineament has been calculated and plotted on a rose diagram to determine direction, force, structure of joint and fault.

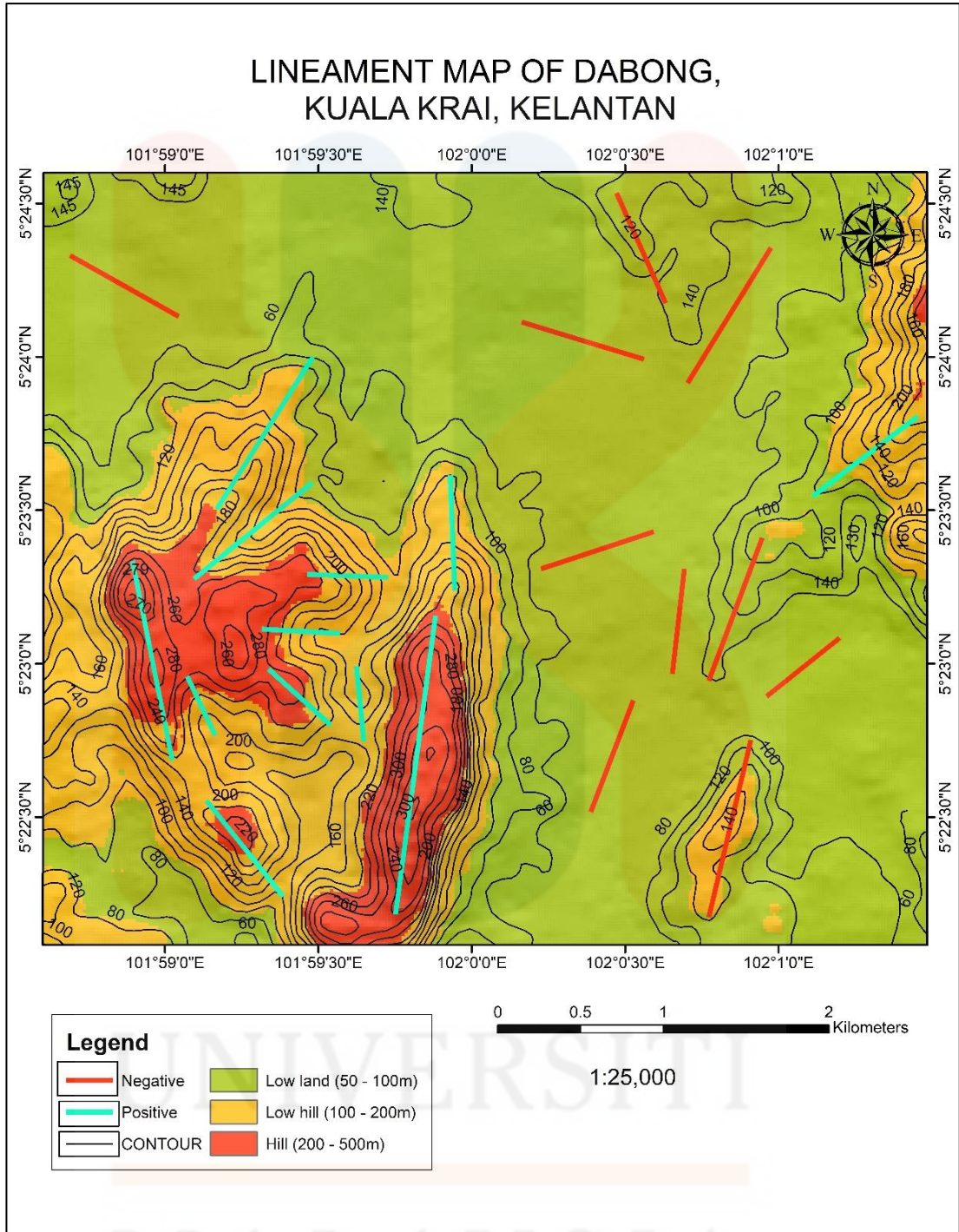


Figure 4.19: Lineament map of Dabong.

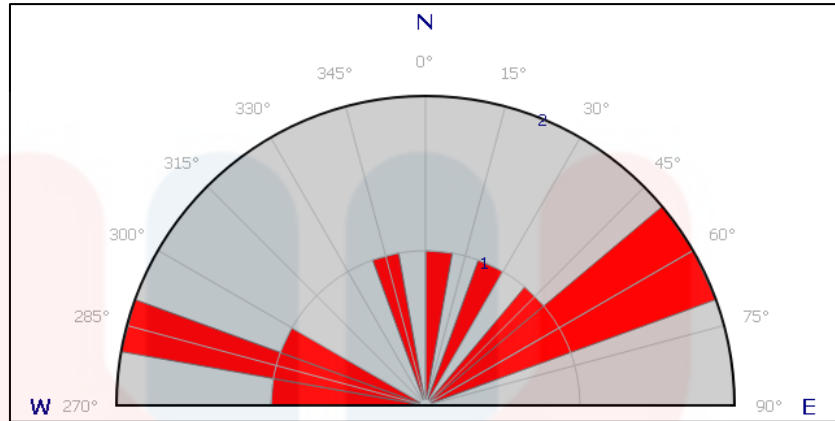


Figure 4.20: Positive lineament of study area.

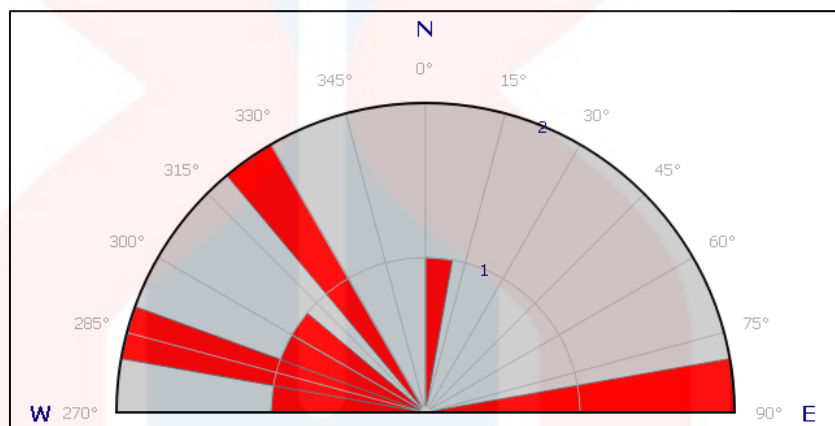


Figure 4.21: Negative lineament of study area.

Based on the **Figure 4.20 and 4.21**, trend lineament in the study area. The linear trend contributes to the Western part of the study area. The lineament analysis for positive lineament at NE area and negative lineament at NW area part of study area.

4.4.2 Joint

After identifying the type of structure in the area, 60 readings for the joint were taken at the outcrop. Then, the Georose software was used to look at the data and make a rose diagram. When rocks are stretched until they break, cracks appear. This pattern made it easier to figure out where the forces were going. At certain times, the joint can be seen close to the rock surface, and it can be vertical or

horizontal. Based on **Figure 4.23**, the result of rose diagram joint data shows the trending at NW direction.



Figure 4.22: The joint.

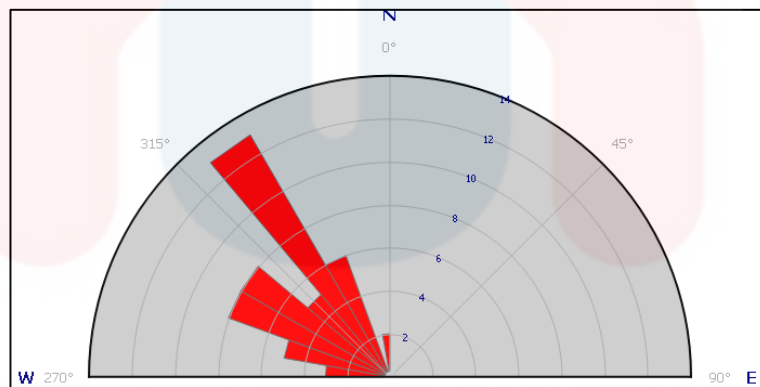


Figure 4.23: Rose diagram of the region area.

4.4.3 Bedding

Bedding is distinguished not only by variances in colour and texture, but also by partings (gaps) among beds that, at first glance, may seem to be very identical to one another. Cross - bedding is a kind of bedding that is characterized by the presence of angled strata that develops because of the deposition of sediments by moving water or wind. Based on **Figure 4.25**, the trending of bedding is NE direction.



Figure 4.24: Bedding outcrop in the study area.

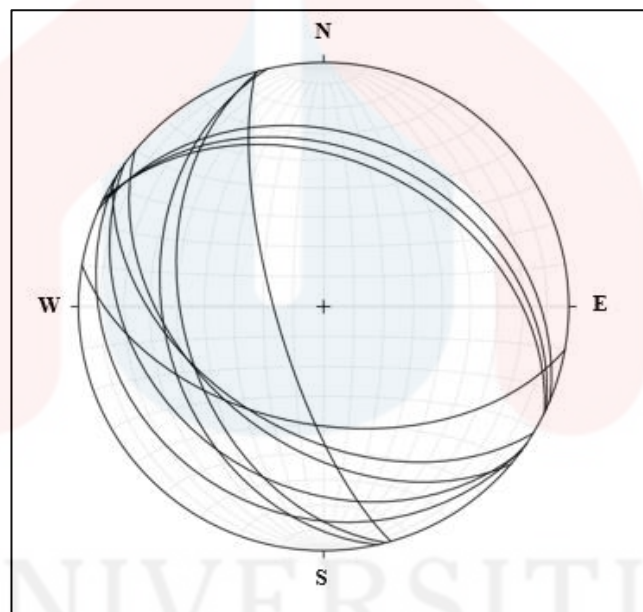


Figure 4.25: Stereonet of bedding

4.5 Historical geology

In the middle of Peninsular Malaysia, a new stratigraphic unit called the Gua Musang Group has been suggested. Calcareous and argillaceous rocks were reported to make up the bulk of the formation, with arenite, pyroclastic, and lava flow serving as subordinates. Both the Gua Musang Formation and the Gunung Rabong Formation belong to the larger Gua Musang Group. Dabong is a settlement in the southeast corner of Kelantan.

According to Muhammad Afiq (2018), the rocks along the Jeli-Gua Musang motorway are made of mudstone, sandstone, marble, and tuffs that are carbonaceous or calcareous. As it moves toward the strong complex, the rock changes from slate to fine phyllite. It causes the penetrative cleavage to get bigger, and the phyllitic rocks along the Kuala Balah - Dabong Road change into quartz mica schist.



CHAPTER 5

FLOOD HAZARD ASSESSMENT USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

5.1 Introduction

This section provided background on the study's focus area hazard mapping for floods. ArcGIS was used to create and compile flood danger maps. Using the Weighted Overlay Method (WOM) in GIS, this map will display the areas classified as low, medium, and high flood risk.

Globally, GIS has found a home in the fields of risk assessment and management of natural disasters. Simple GIS applications allow for the creation of flood hazard mapping, which describes the research area's most at-risk regions for flooding. Geological data is saved in a database and then analyzed visually by use of GIS software.

5.2 Parameter of Flood Hazard Assessment

Flood hazard assessment requires a few characteristics, including slope, elevation, drainage density, land use, river distance, flow length and rainfall. When employing the Weighted Overlay Method (WOM) are required in each parameter which determines flooding. Each parameter is given a weightage based on the Analytic Hierarchy Process (AHP) fundamental scale. (Saaty, T.L, 1980)

Table 5.1: Weightage for each parameter

No	Parameter	Weightage
1	Slope	8
2	Elevation	7
3	Drainage Density	9
4	Land use	3
5	Rainfall	9
6	River Distance	7
7	Flow length	7

(Source: Saaty, T.L, 1980)

5.2.1 Slope

One of the primary factors that determines flood danger is the length of the slope. The length of a slope is measured from the point where overland flow first starts until the slope flattens enough for deposition to begin or runoff enters a channel (Zhang et al. 2017). The significance of slope length on erosion is a topic that has received a lot of attention in recent years. Slope length has an impact on erosion because it raises the frequency and intensity of runoff, which in turn increases the runoff's ability to disaggregate and carry sediments.

Slope map is one of the important parameters in flood hazard assessment studies. The parameter for this slope is generated from DEM data and it uses units of degrees. Based on the study area, the slope parameter consists of range values from 0° to 140°. Majority of Dabong has slope range 0° to 35° it has a significant risk of flooding due to its flat terrain and relatively low height compared to more mountainous regions.

Table 5.2: Weightage for slope parameter

No	Slope	Weightage (Wi)
1	0° - 35°	8
2	36° - 70°	
3	71° - 105°	
4	106° - 140°	

(Source: Saaty, T.L., 1980)

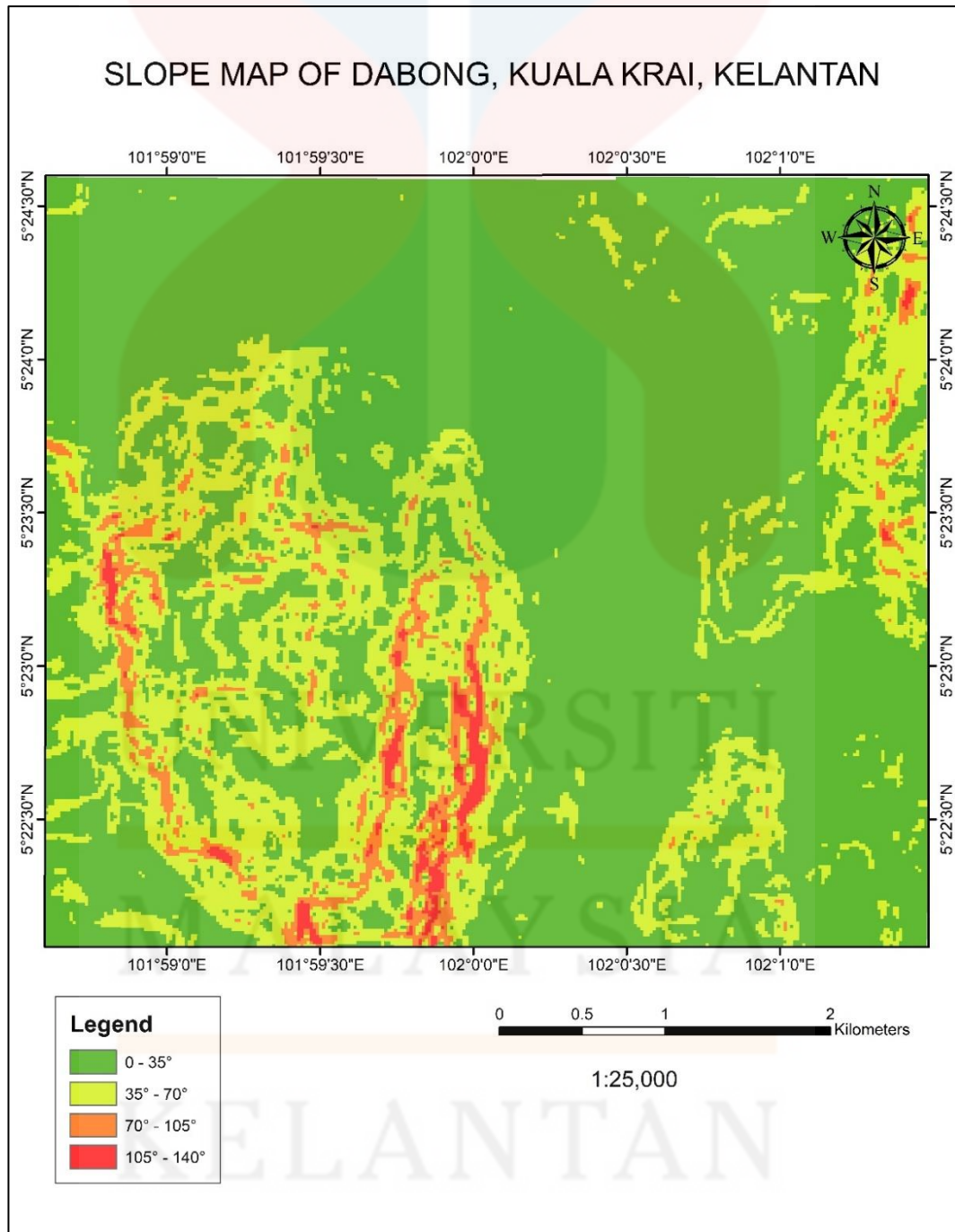


Figure 5.1: Slope Map of Dabong.

5.2.2 Elevation

The DEM data was used to analyze the elevation data until an elevation map with a range of values from 0 to 500m was generated. Water moving from higher to lower elevation increases the likelihood of flooding in low-elevation areas. However, the impact of elevation on flood is considered in the score analysis for elevation reclassification. According to the analysis's scoring methodology, flood occurrences decrease with increasing altitude.

Table 5.3: Weightage for elevation parameter.

No	Elevation	Weightage (Wi)
1	0 – 50m	7
2	50 – 100m	
3	100 – 200m	
4	200 – 500m	

(Source: Saaty, T.L., 1980)

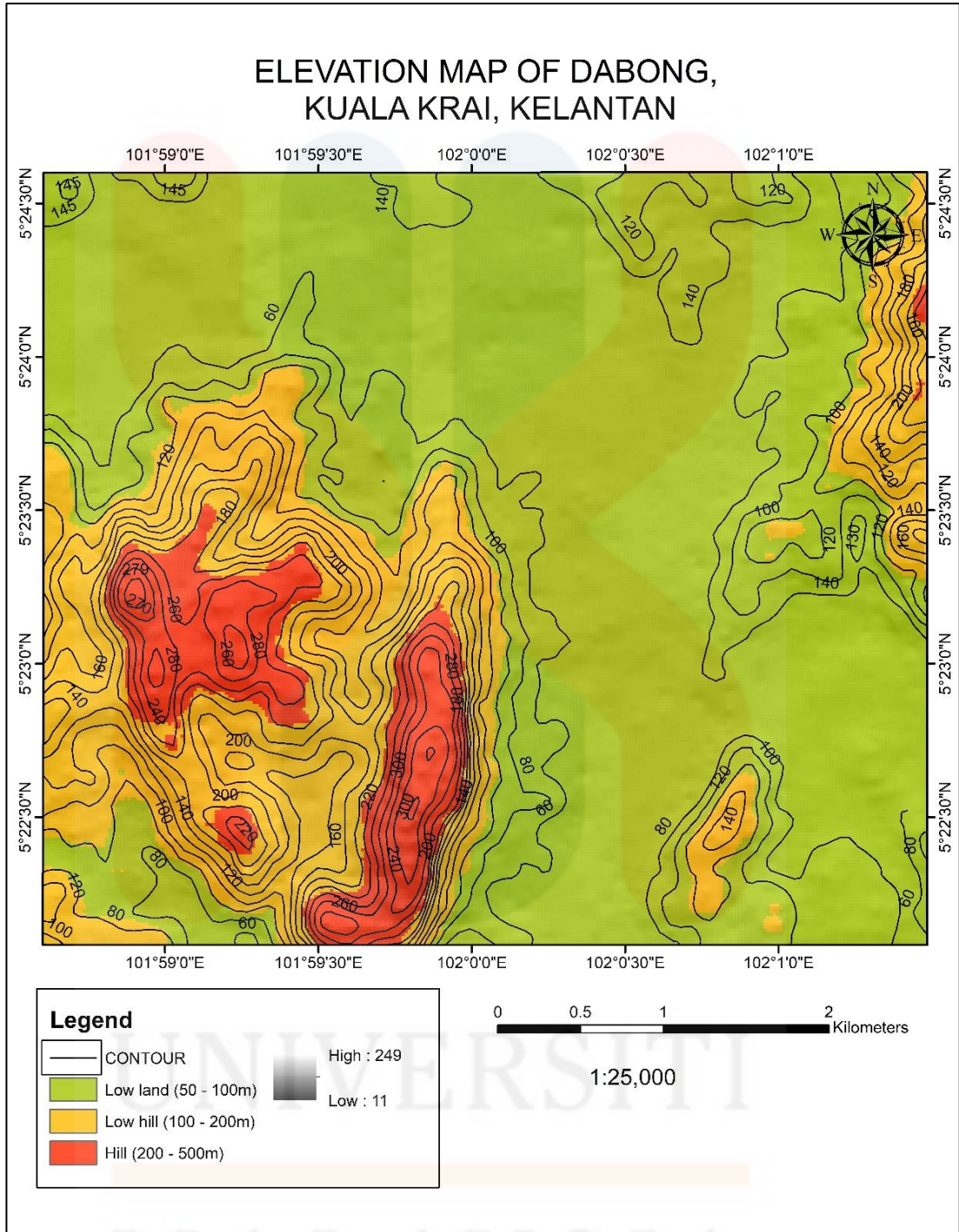


Figure 5.2: Elevation Map of Dabong

5.2.3 Drainage density

The drainage density of an area is one of the major factors that go into determining the flood risk. The morphometric study of drainage networks may benefit from include this value as a valuable variable. The drainage density map is shown in **Figure 5.3**, and it reveals that most of the research region is covered with a high drainage density. There are sporadic areas of medium drainage density, and some of these areas relate to areas of lower drainage density.

Table 5.4: Weightage for drainage density parameter

No	Drainage Class (m)	Weightage (Wi)
1	0 – 90	9
2	91 – 180	
3	181 -260	

(Source: Saaty, T.L., 1980)

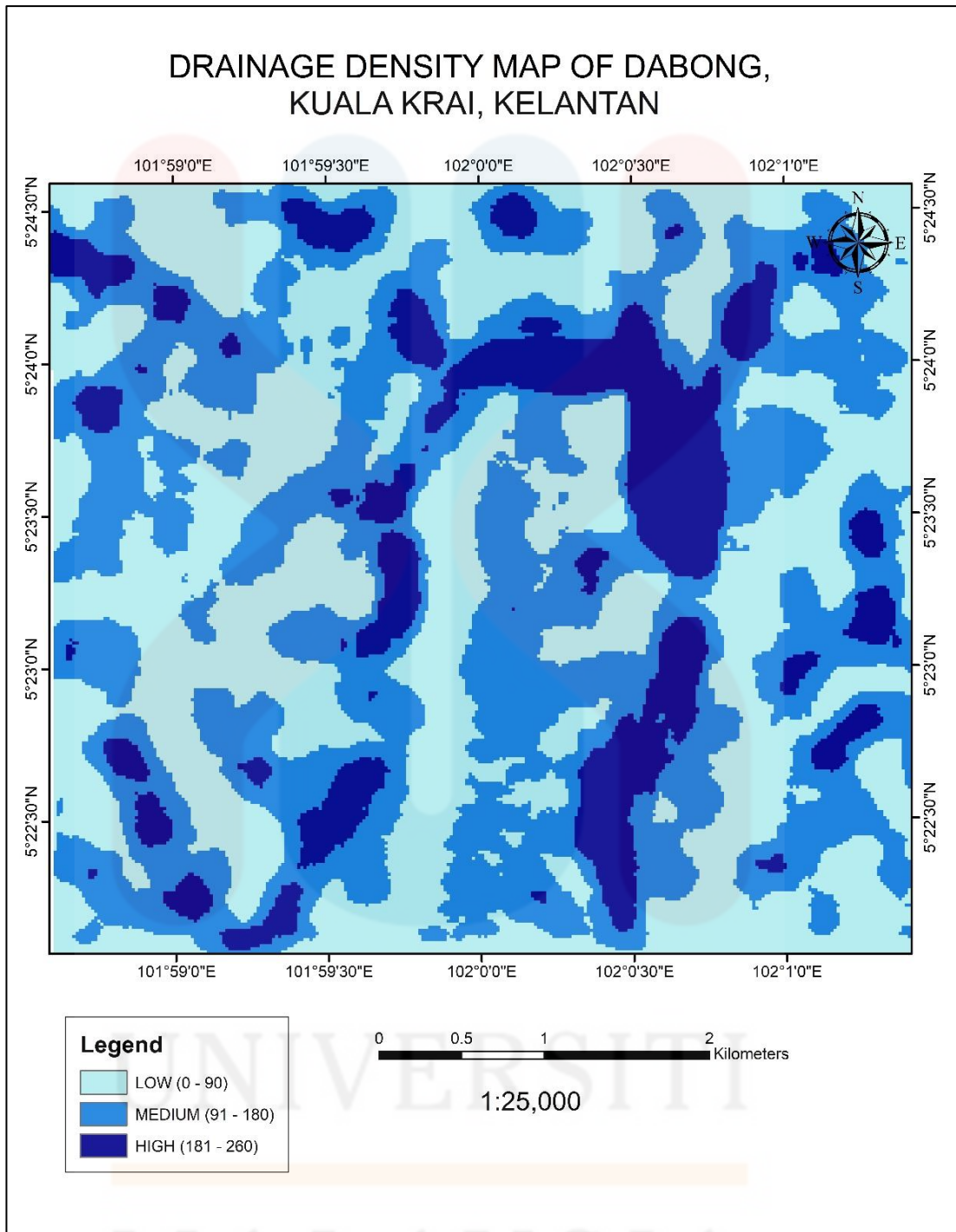


Figure 5.3: Drainage Density Map of Dabong.

5.2.4 Land use

Land use is a way to describe what the land is used for. It's about taking care of the physical and socioeconomic environment because of how water can get into the ground, how the land is used can affect whether the study area floods. When there was dense vegetation on the land, like a forest, surface water could soak in. This made it less likely that flooding would happen.

Table 5.5: Weightage for land use

No	Land Use	Weightage (Wi)
1	Forest	3
2	Palm Oil Plantation	
3	Rubber plantation	

(Source: Saaty, T.L, 1980)

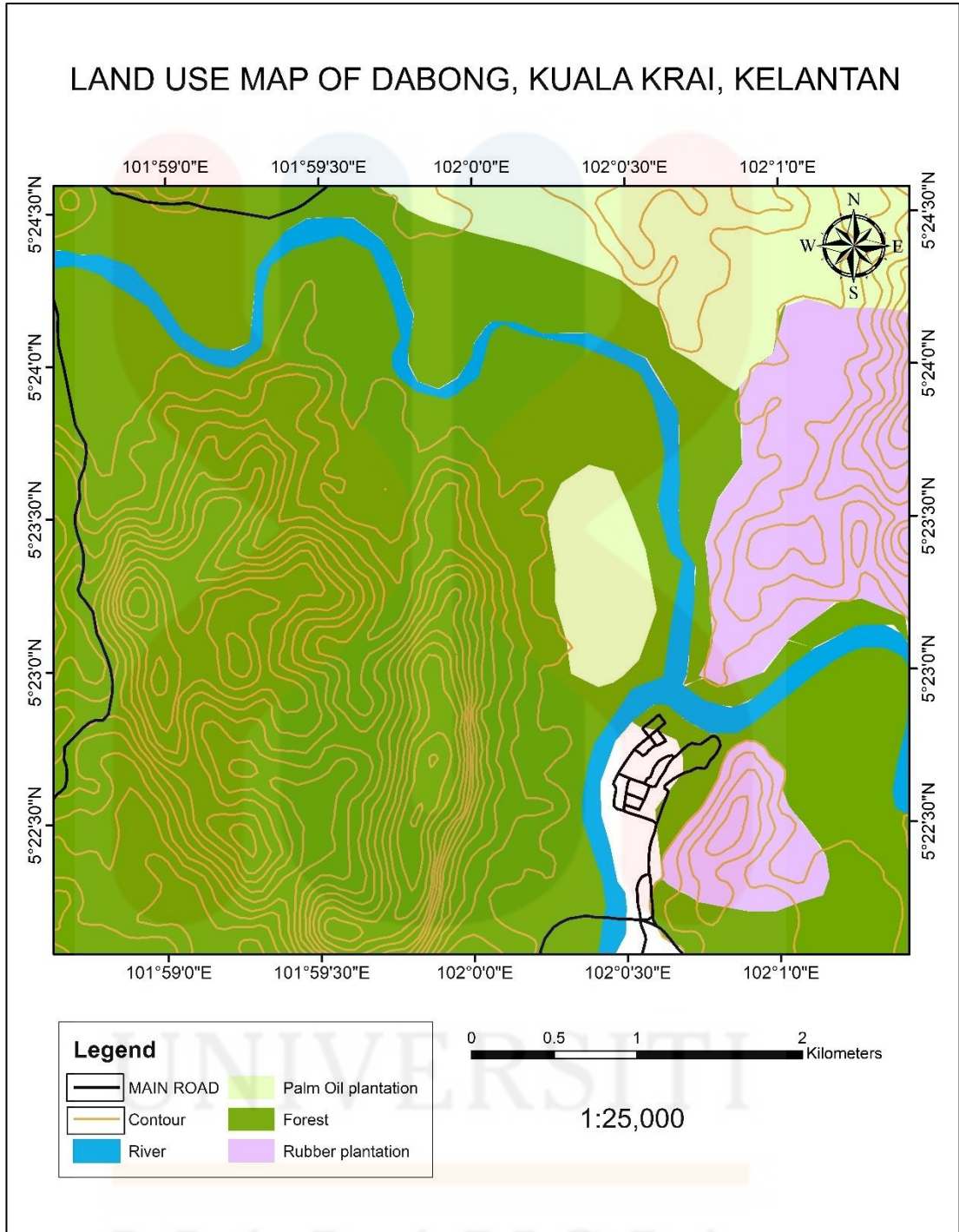


Figure 5.4: Land Use Map in Dabong

MALAYSIA
 KELANTAN

5.2.5 Rainfall

Rainfall distribution is important as evidence to show the occurrence of flood occurring in the Dabong. Kelantan occurring flooding annually especially November to March.

The rainfall data from 2017 to 2020 was gathered from Jabatan pengairan dan Saliran (JPS) at 10 station which is Dabong, Kuala Geris, Kuala Nal, Lapan Kabu, Laloh, Aring, Gua Musang, Jeli, Ladang Pergau and Kampung Sungai Batu. The study area is also in a settlement and town area which is a fast-growing area with no control over its growth. Even if the land clearing was done to grow oil palm or other crops, the effects of this, especially in high areas will cause the soil to wash away when it rains.

Based on **Table 5.7, 5.8, 5.9** and **5.10** shows the rainfall distribution data at 10 station which is Dabong, Kuala Geris, Kuala Nal, Lapan Kabu, Laloh, Aring, Gua Musang, Jeli, Ladang Pergau and Kampung Sungai Batu in 2017 to 2020 because these 10 rain stations surrounded the dabong area which the average heavily raining in this area. This is the occurrence of flooding in the area and reach the most dangerous level.

Table 5.6: Weightage for rainfall parameter.

No	Year/Rainfall	Weightage (Wi)
1	2017	9
2	2018	
3	2019	
4	2020	

(Source: Saaty, T.L, 1980)

Based on the **Table 5.7, 5.8, 5.9** and **5.10**, the highest rainfall is at the Kuala Nal station which is 255mm while the lowest is the Gua Musang station which is 98mm in 2017. In 2018, the highest rainfall is the Dabong station which is 211mm and the lowest is Kampung Sungai Batu station which is 67mm. In 2019, the highest rainfall was Jeli station which was 259mm while the lowest was Laloh station which was 150mm. Lastly in 2020, the highest rainfall is Dabong station recording a record of 325mm while the lowest is Kuala Nal station which is 124mm. The highest total rainfall was 2208 mm in 2020 while the lowest was 1173 mm in 2018 because in 2020 the rain that fell with a very large quantity caused the area to flood. In other years it also rains heavily but it can still be controlled except in places with slopes that are at risk of flooding.

Table 5.7: Rainfall distribution in 2017.

Station	Average (mm)
Dabong	171
Kuala Geris	242
Kuala Nal	255
Lapan Kabu	253
Laloh	103
Aring	104
Gua Musang	98
Jeli	135
Ladang Pergau	114
Kampung Sungai Batu	109
Total	1584

(Source: Department of Irrigation and Drainage, 2020)

Table 5.8: Rainfall distribution in 2018.

Station	Average (mm)
Dabong	211
Kuala Geris	184
Kuala Nal	190
Lapan Kabu	155
Laloh	68
Aring	82
Gua Musang	69
Jeli	77
Ladang Pergau	70
Kampung Sungai Batu	67
Total	1173

(Source: Department of Irrigation and Drainage, 2020)

Table 5.9: Rainfall distribution in 2019.

Station	Average (mm)
Dabong	197
Kuala Geris	180
Kuala Nal	176
Lapan Kabu	169
Laloh	150
Aring	158
Gua Musang	185
Jeli	259
Ladang Pergau	169

Kampung Sungai Batu	191
Total	1834

(Source: Department of Irrigation and Drainage, 2020)

Table 5.10: Rainfall distribution in 2020.

Station	Average (mm)
Dabong	325
Kuala Geris	219
Kuala Nal	124
Lapan Kabu	196
Laloh	143
Aring	270
Gua Musang	217
Jeli	280
Ladang Pergau	175
Kampung Sungai Batu	259
Total	2208

(Source: Department of Irrigation and Drainage, 2020)

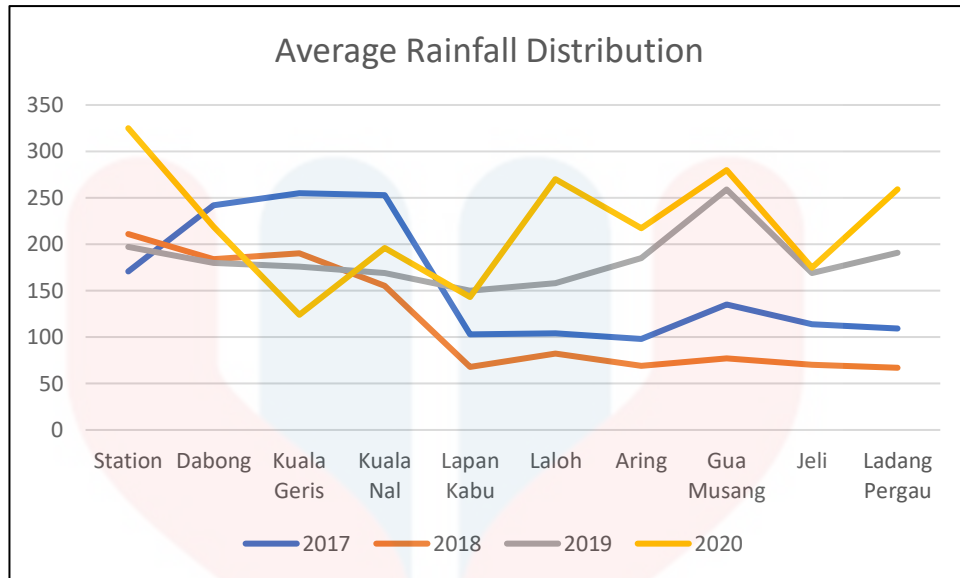


Figure 5.5: Graph of rainfall distribution from 2017 to 2020.

(Source: Department of Irrigation and Drainage, 2020)

Based on the map **Figure 5.6, 5.7, 5.8** and **5.9**, it can see the change in rainfall from 2017 to 2020. Each map is averaged for each area. After the data is entered, just select the study area to see the occurrence of rainfall along with the value. **Figure 5.5** show the trend of the average rainfall increase or decrease from 2017 to 2020.

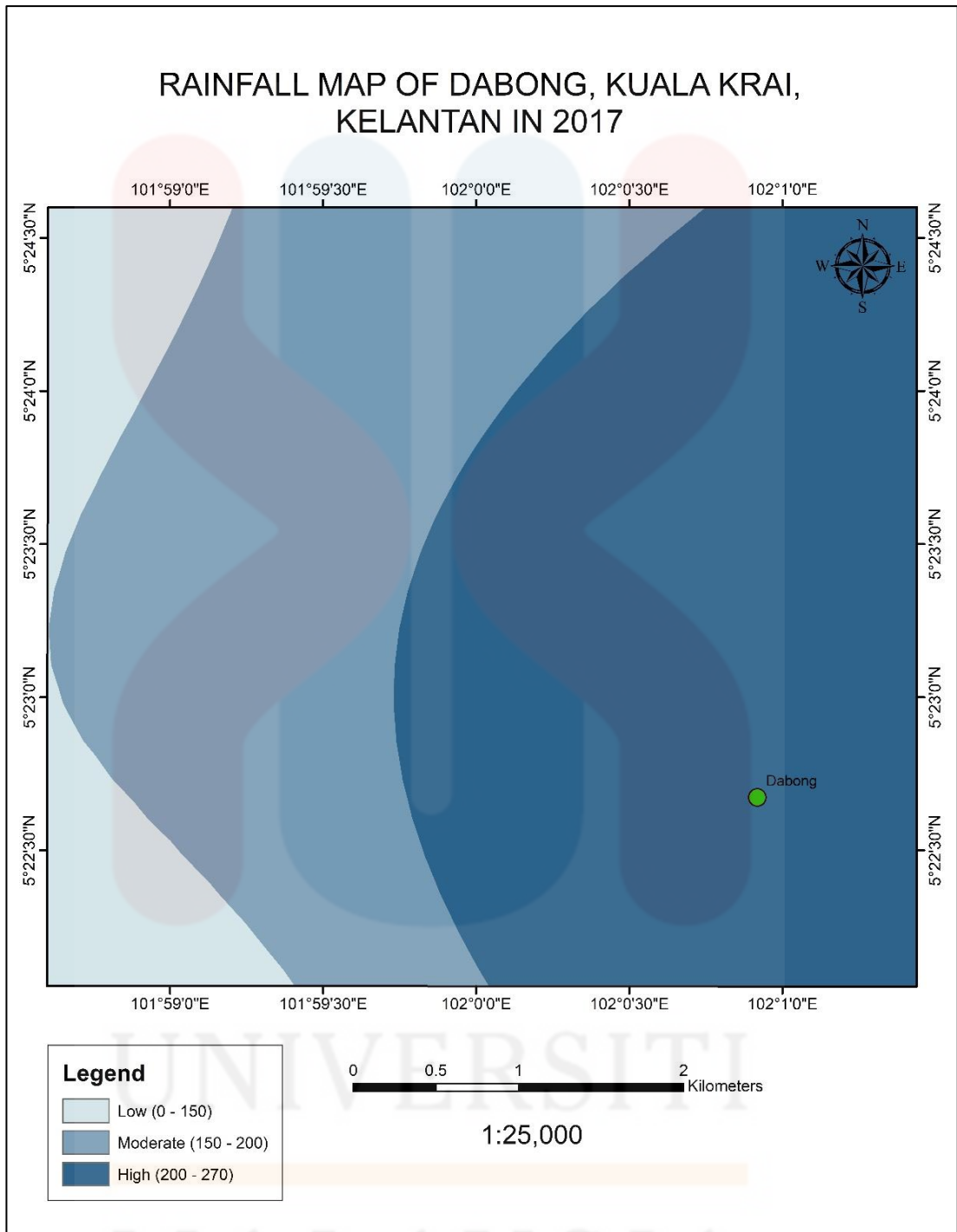


Figure 5.6: Rainfall Map of Dabong in 2017.

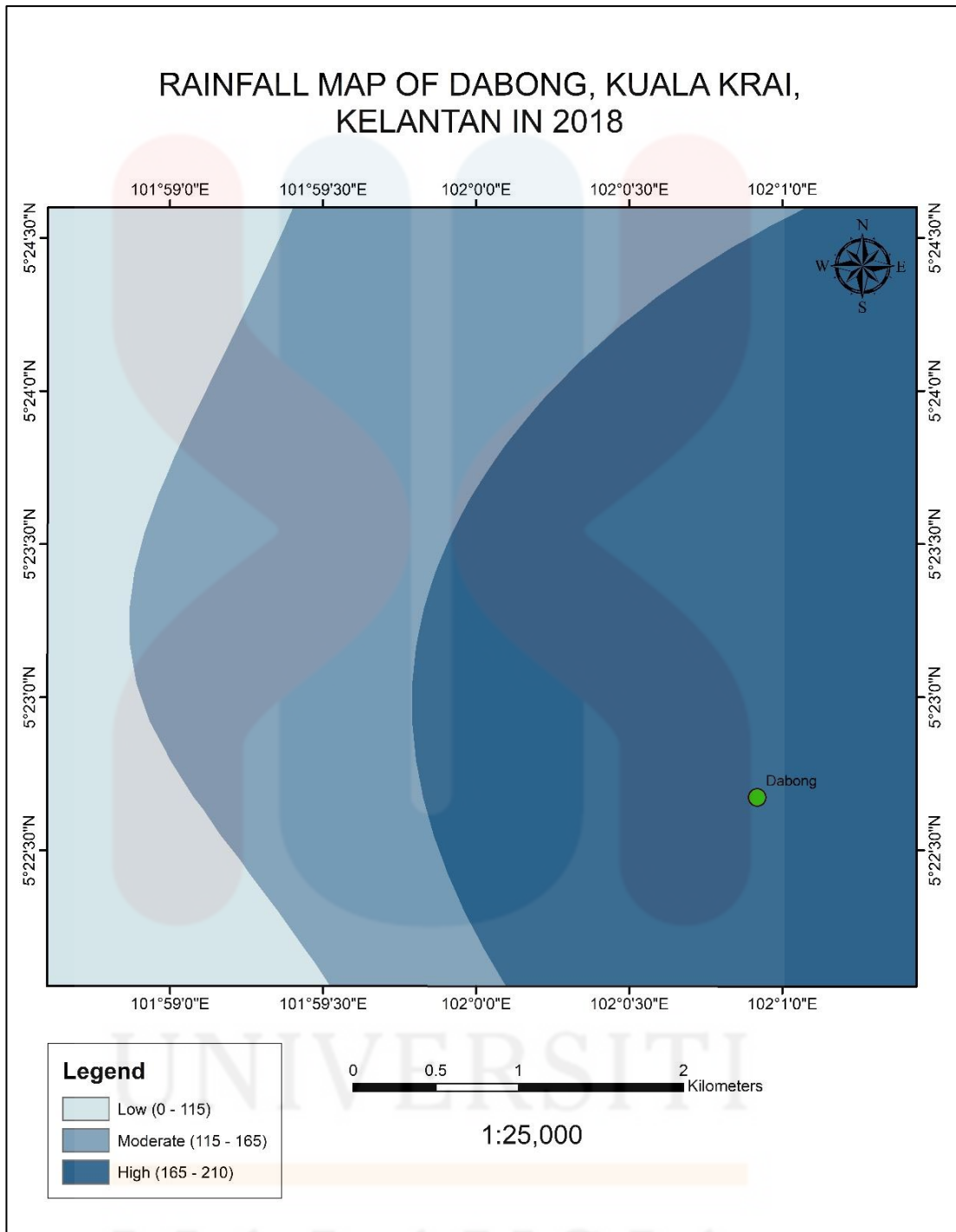


Figure 5.7: Rainfall Map of Dabong in 2018.

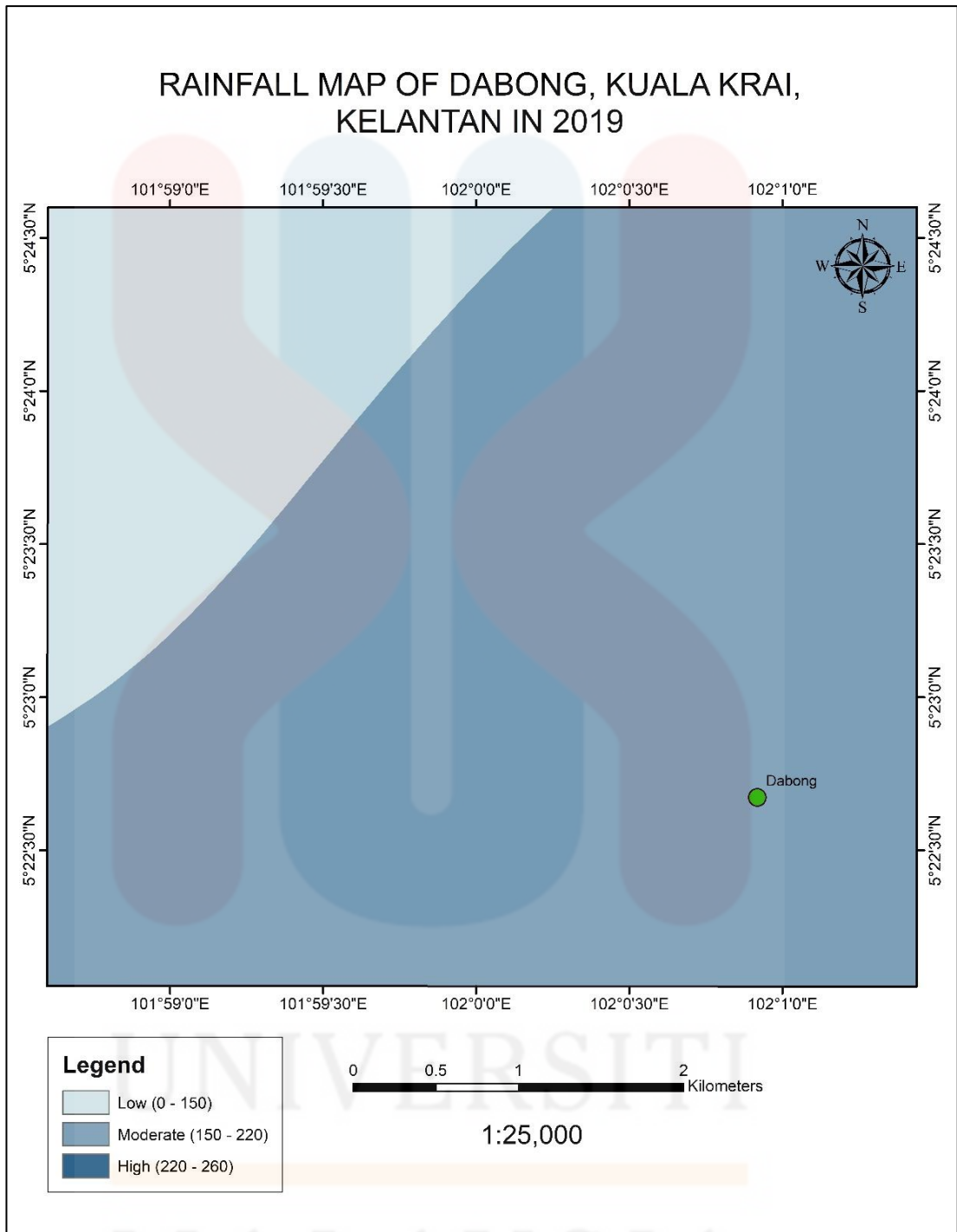


Figure 5.8: Rainfall Map of Dabong in 2019.

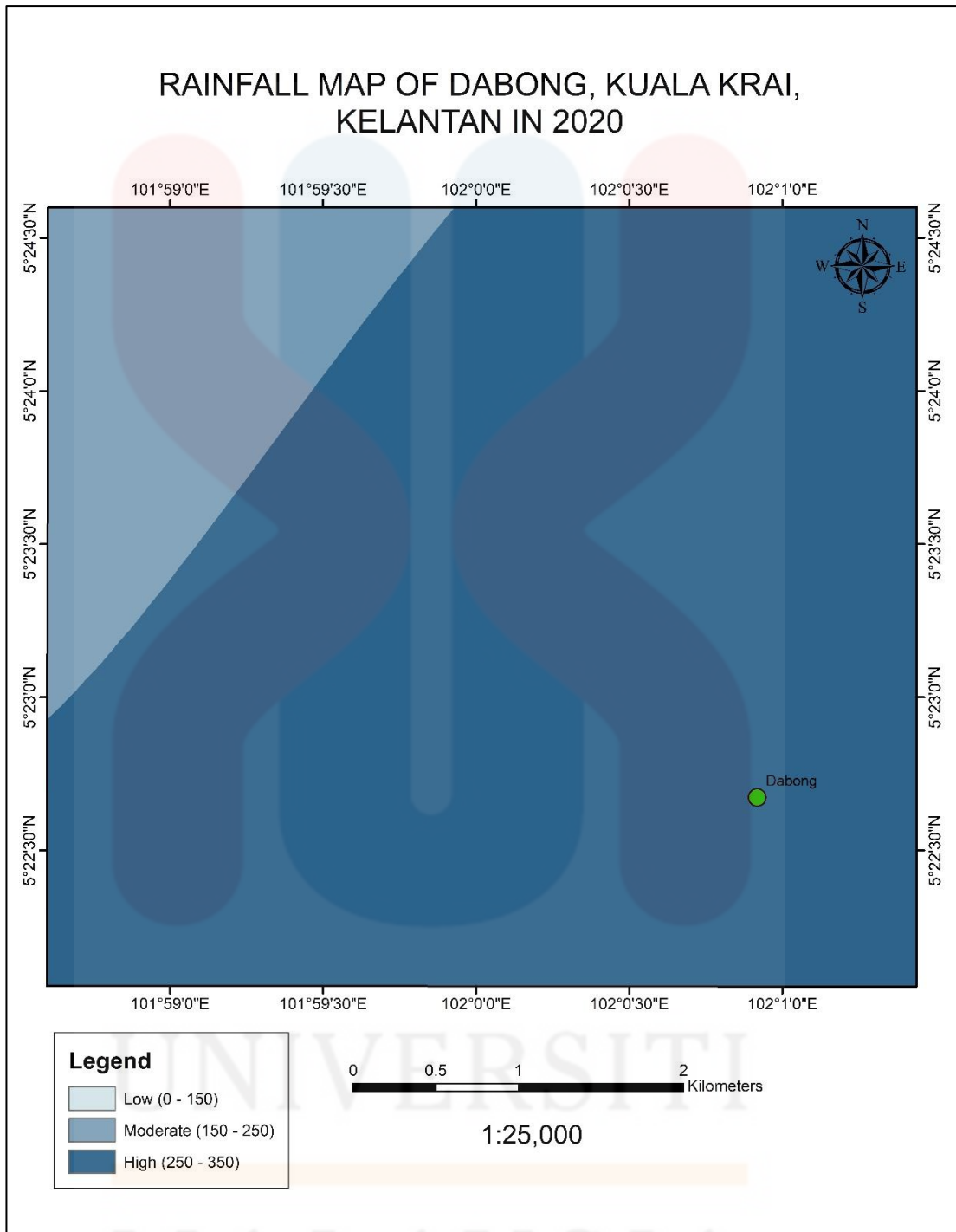


Figure 5.9: Rainfall Map of Dabong in 2020.

5.2.6 River Distance

Dabong is an area close to the main river, so it is prone to normal floods and flash floods caused by water flowing from high elevation to low elevation. Based on the map **Figure 5.10**, most of the lows are in this forest area because the big river is close to the river that is in the low area. In the study area, there are many small rivers that connect with the main river, when there is a flood, the water level of the main river will rise causing the water level of the small river to also rise.

Table 5.11: Weightage for river distance parameter

No	River Distance	Weightage (Wi)
1	Low (0 – 300)	7
2	Moderate (300 - 600)	
3	High (600 - 900)	

(Source: Saaty, T.L, 1980)

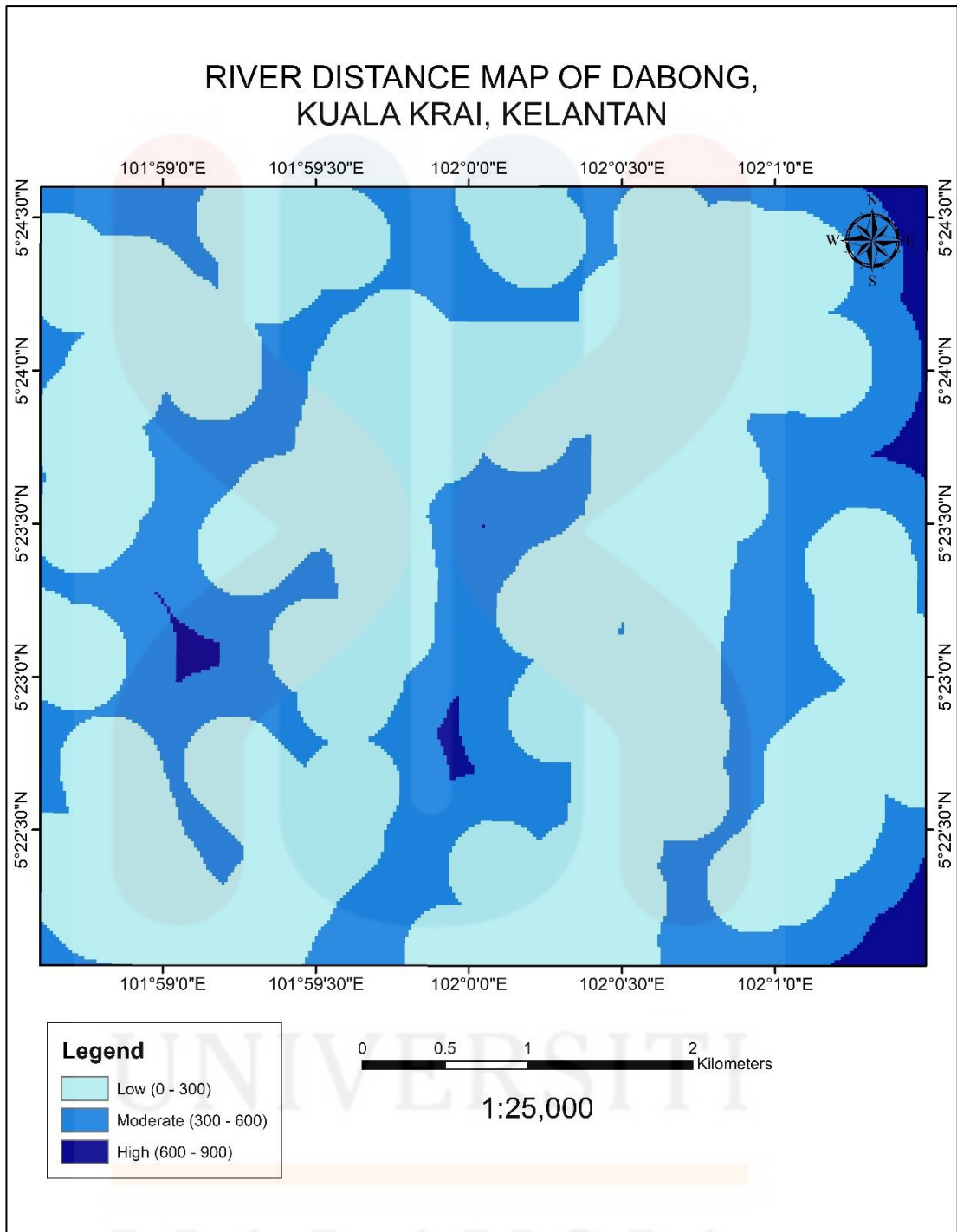


Figure 5.10: River Distance Map of Dabong.

5.2.7 Flow Length

Flow length is the horizontal projections of the largest surface range from a point on the ground to the beginning or end of the stream. Flow length is important for soil preservation; if it's lengthy, the measured and expressed was large and erosion would be worse. Based on the map **Figure 5.11**, the high flow length area is in the forest area.

Table 5.12: Weightage for flow length parameter

No	Flow Length (m)	Weightage (Wi)
1	Low (0 – 4000)	7
2	Moderate (4000 - 6000)	
3	High (6000 - 8000)	

(Source: Saaty, T.L, 1980)

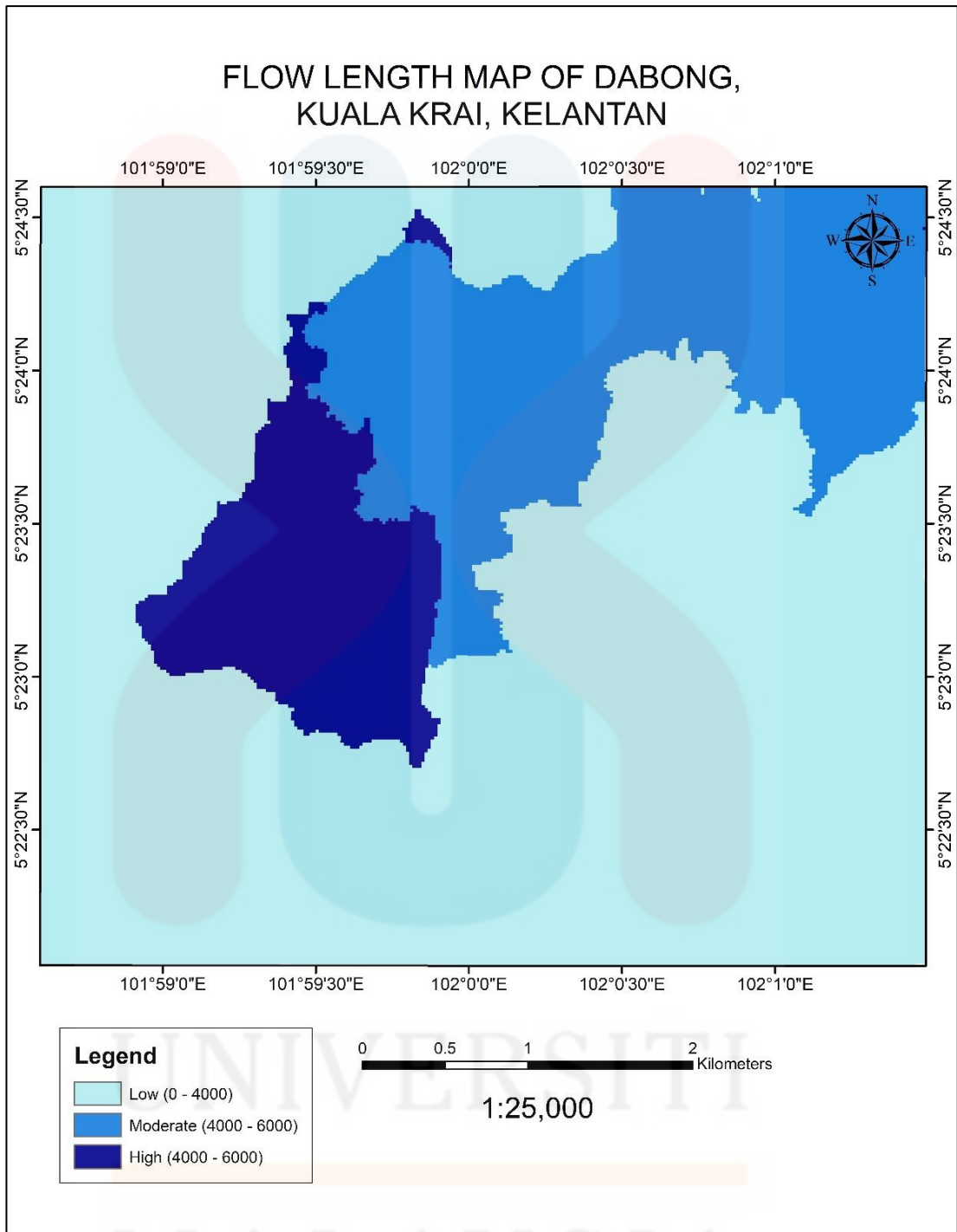


Figure 5.11: Flow Length Map of Dabong.

5.3 Flood Hazard Map

To produce and generate a flood hazard map of Dabong, Kelantan, each parameter needs to be in the form of raster data before reclassification. With a scale from 1 to 5, new categories were assigned to the raster data sets. Among the parameters that have been selected are slope, elevation, drainage density, land use, rainfall, river distance and flow length. According to the **Table 5.12**, the total effect of all the factors was 100%.

Before obtaining the flood hazard map, modelbuilder was used and it used to perform GIS-based spatial analysis with the Arc GIS 10.8 software. Each shapefile was converted into raster format and then reclassify. After that raster reclassification and weighted overlay tools used in modelbuilder to get final flood hazard map. From the weighted overlay, it can get a flood hazard map and Analytic Hierarchy Process (AHP) to score each parameter. Based on **Figure 5.13, 5.15, 5.17** and **5.19**, the levels for the classes of the factors also were examined through flood hazard mapping in the GIS tool with three levels of relative hazard classes which are low, moderate and high.

Table 5.13: Weightage overlay and influence for each parameter.

Raster Datasets	Weightage Overlay	Influence (%)
Slope	8	16%
Elevation	7	14%
Drainage Density	9	18%
Land use	3	6%
Rainfall	9	18%
River Distance	7	14%
Flow length	7	14%
Total		100

(Source: Saaty, T.L, 1980)

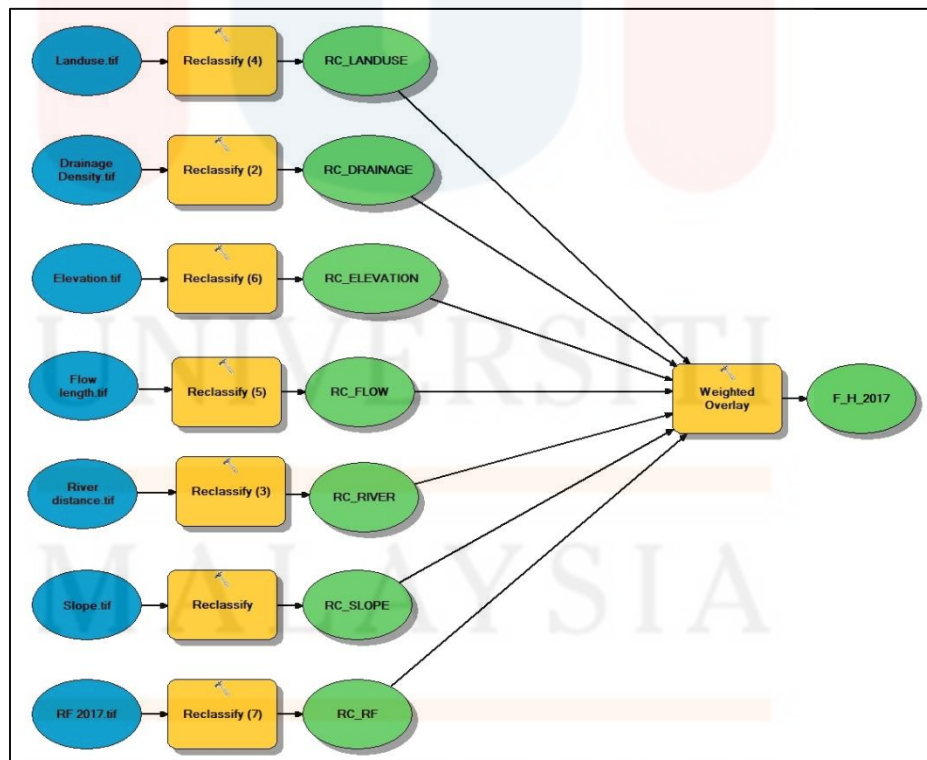


Figure 5.12: ModelBuilder representing of flood hazard parameters in 2017.

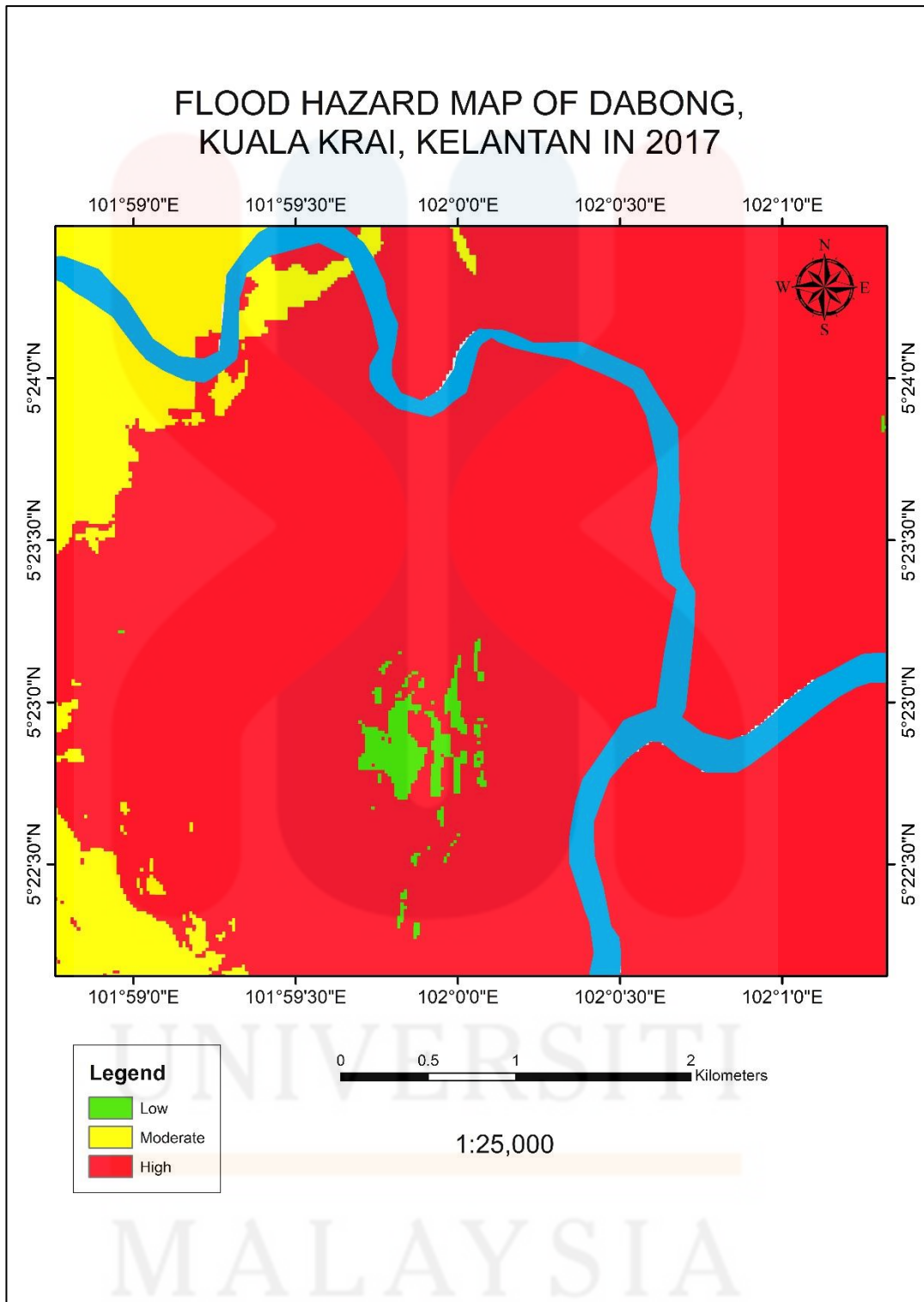


Figure 5.13: Flood Hazard Map in 2017.

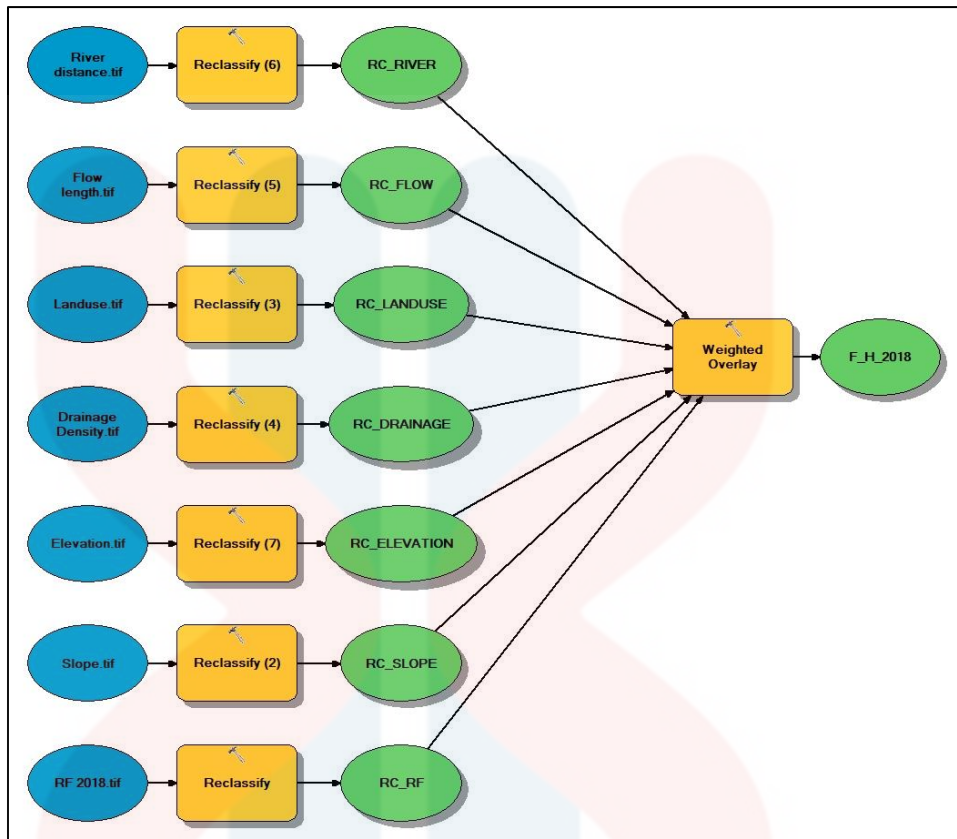


Figure 5.14: ModelBuilder representing of flood hazard parameters in 2018.

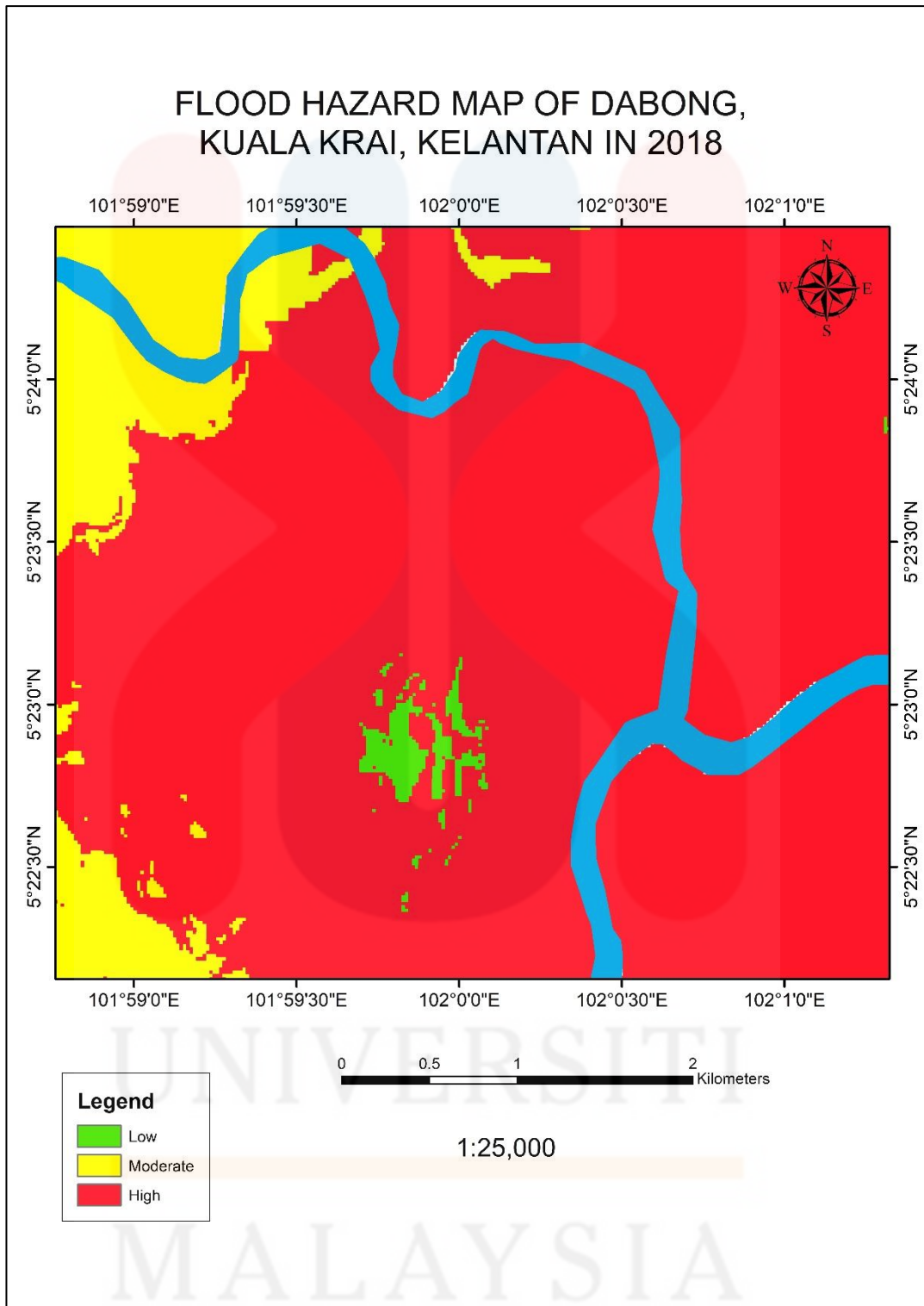


Figure 5.15: Flood Hazard Map in 2018.

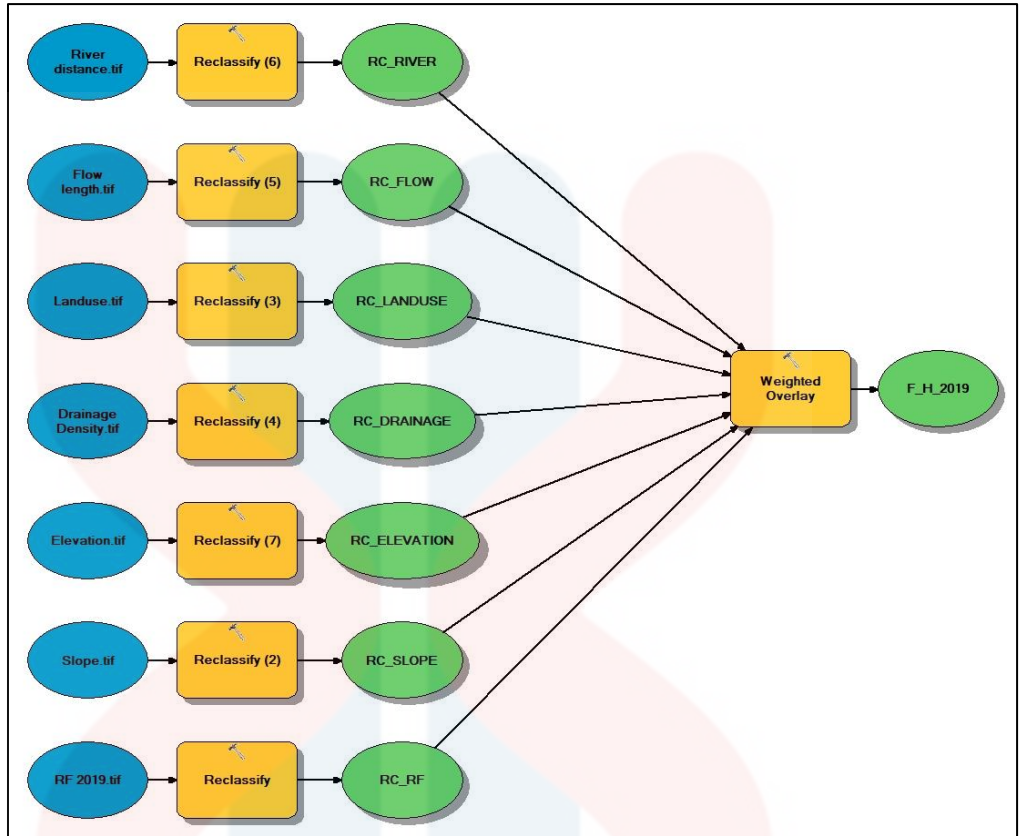


Figure 5.16: ModelBuilder representing of flood hazard parameters in 2019

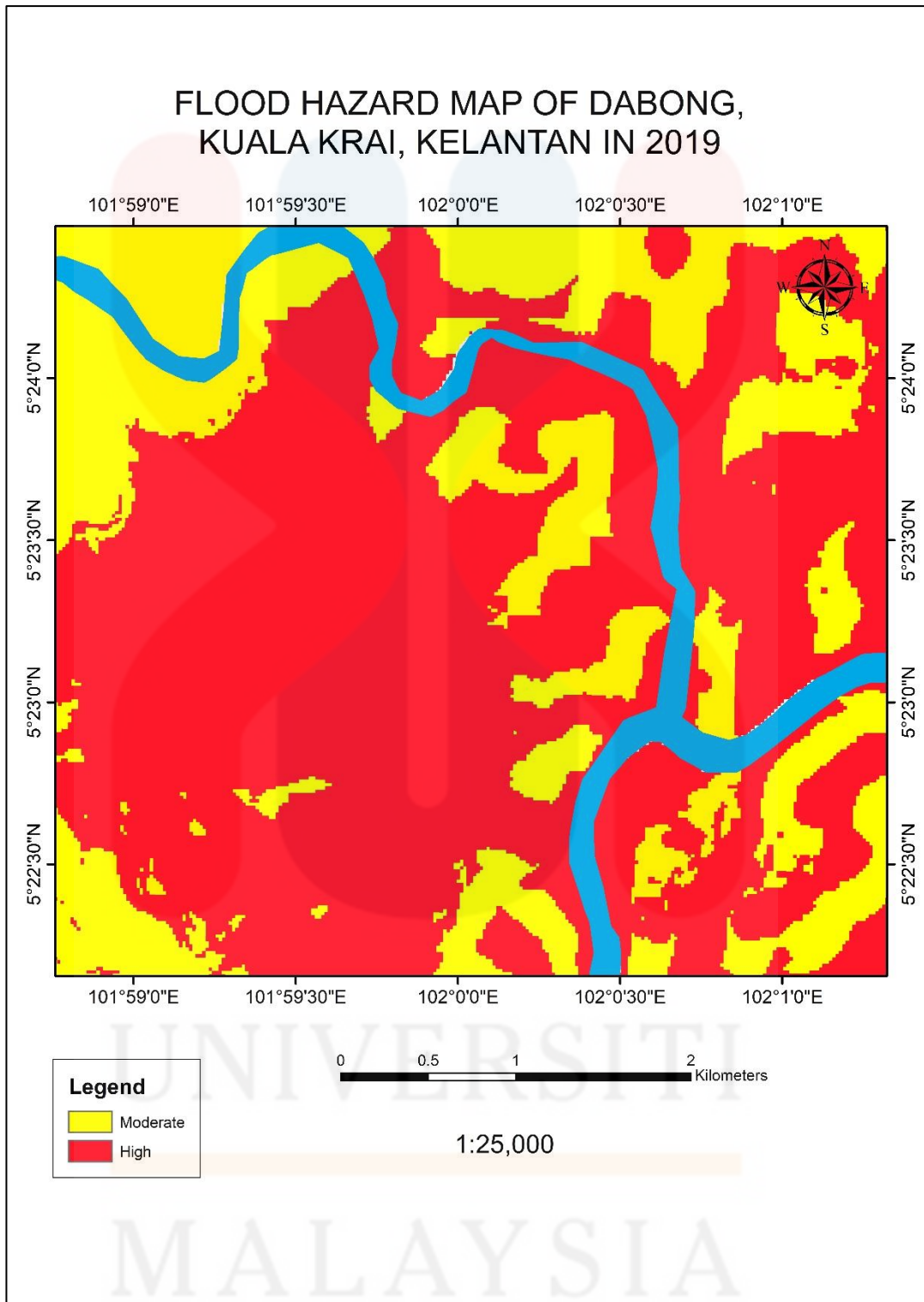


Figure 5.17: Flood hazard Map in 2019.

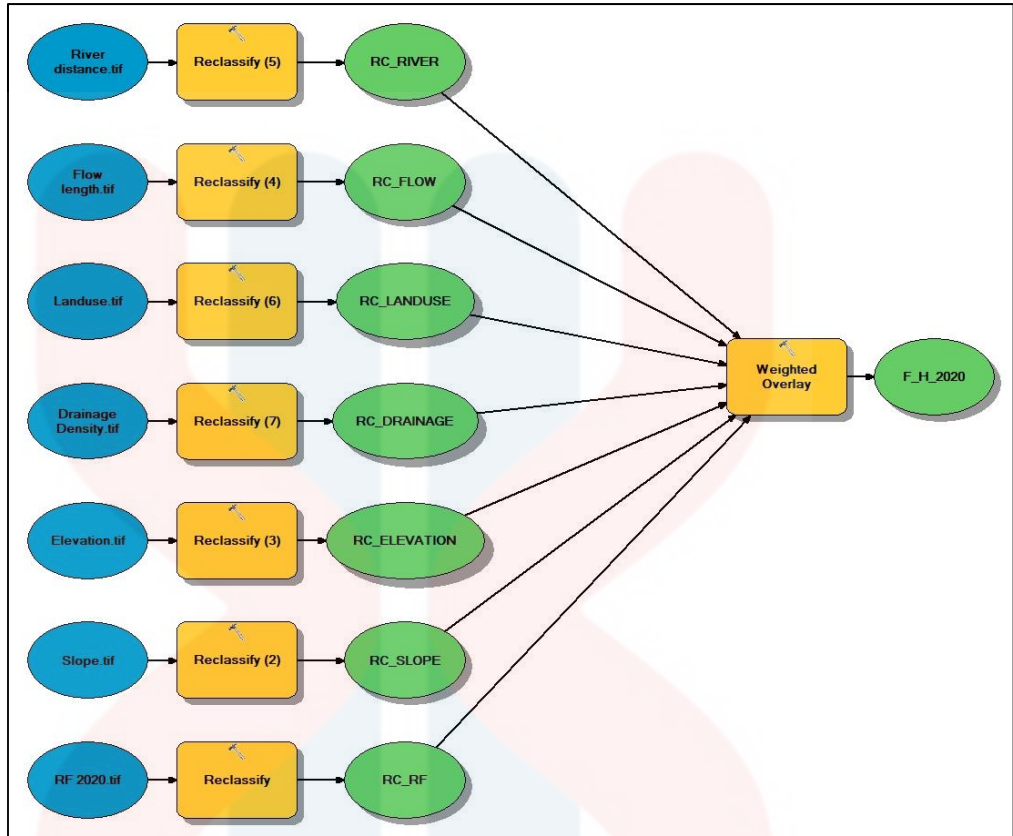


Figure 5.18: ModelBuilder representing of flood hazard parameters in 2020.

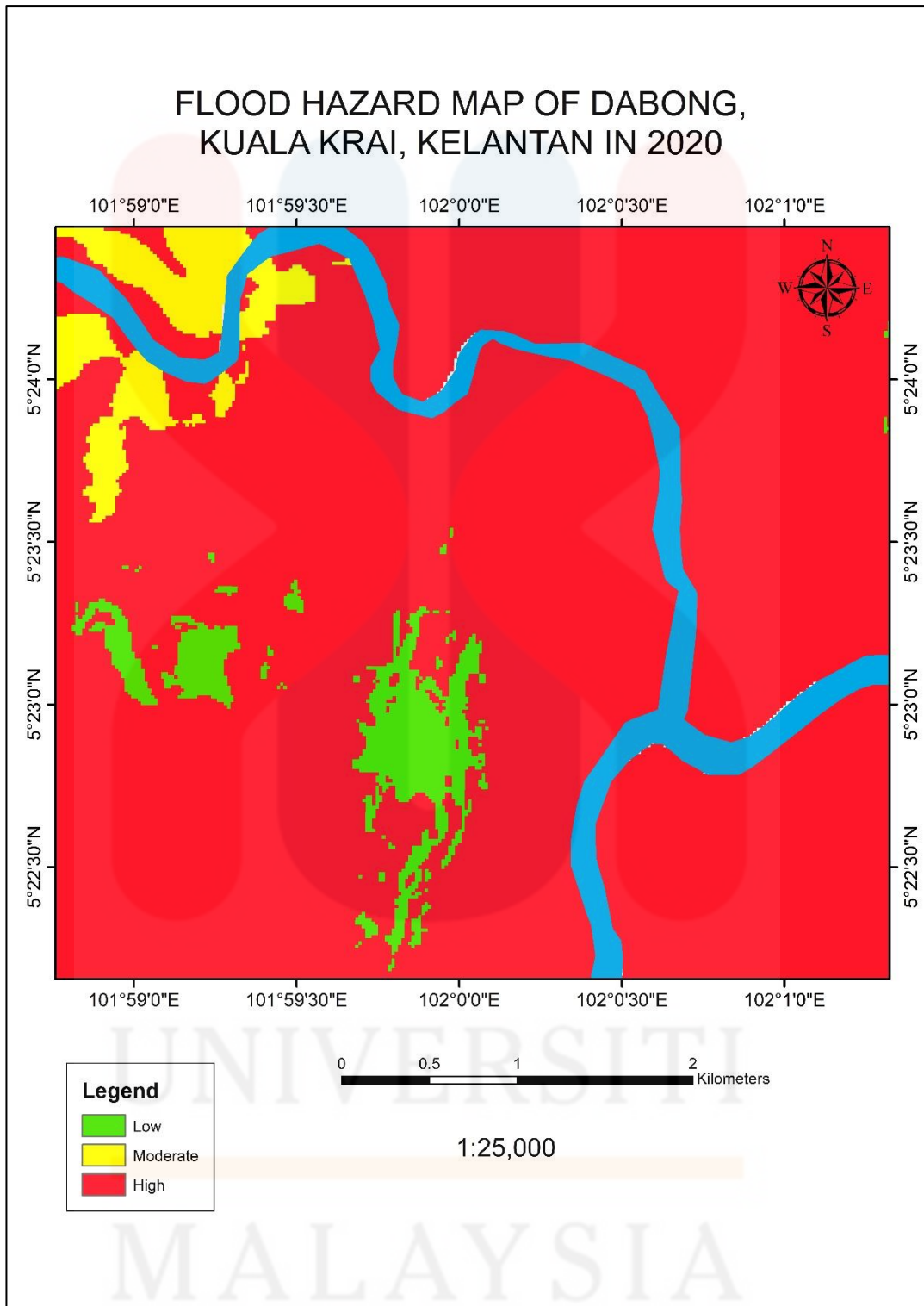


Figure 5.19: Flood Hazard Map in 2020.

5.4 Flood Hazard Assessment

Flood hazard map was produced by weighted overlay method for each parameter is slope, elevation, drainage density, land use, rainfall, river density and flow length. The selected seven parameters have been given weights so that they can be used in the modelbuilder. The spatial pattern of the flood hazard map that was made has been put into three risk classes: low, moderate, and high.

Based on analysis and flood hazard map, can be seen the zone change for each year because it is affected by the rainfall from year 2017 to 2020. The red color indicates the area with the highest potential for flooding, while the yellow color has a moderate potential and green has the least potential.

Table 5.14: Classify zone in percentage (%) from 2017 to 2020.

Zone Year	Low (%)	Moderate (%)	High (%)	Total
2017	1	15	84	100%
2018	1	16	83	
2019	0	35	65	
2020	4	5	91	

In 2017, the low flood zone occurred at an elevation 160m above because this area is a forest. In the moderate low flood zone, it occurs at an elevation of 100m and above while in the high flood zone, it occurs at an elevation below 100m. Based on the **Figure 5.13** and **Table 5.14**, the ranges of classification in 2017, the hazard of flooded area was classified into a high hazard area cover 84% of the study area, a

moderate hazard area cover 15% and low hazard area cover 1%. This is also due to the amount of rainfall which is 1584 mm causing a high flood potential that year.

Based on the **Figure 5.15** and **Table 5.14**, in 2018 the flood zone for the high flood zone was slightly increase compared to 2017. The ranges of classification in 2018, the hazard of flooded area was classified into a high hazard area cover 83% of the study area, a moderate hazard area cover 16% and low hazard area cover 1%. The amount of rainfall in 2018 also decreased which was 1173mm causing less flooding that year.

Based on the **Figure 5.17** and **Table 5.14**, the ranges of classification in 2019, the hazard of flooded area was classified into a high hazard area cover 65% of the study area, a moderate hazard area cover 35% and low hazard area cover 0%. The flood zone for the high flood zone increases and the amount of rainfall in 2019 also increased back to 1834mm, this may be due to the increase in the river water level which is close to the study area.

Based on the **Figure 5.19** and **Table 5.14**, the ranges of classification in 2020, the hazard of flooded area was classified into a high hazard area cover 91% of the study area, a moderate hazard area cover 5% and low hazard area cover 4%. In this 4-year period, in 2020 has the highest rainfall compared to other years. This is because of the experienced this flood due to the construction of infrastructure and others. The amount of rainfall also increased sharply which is 2208 mm compared to the previous year.

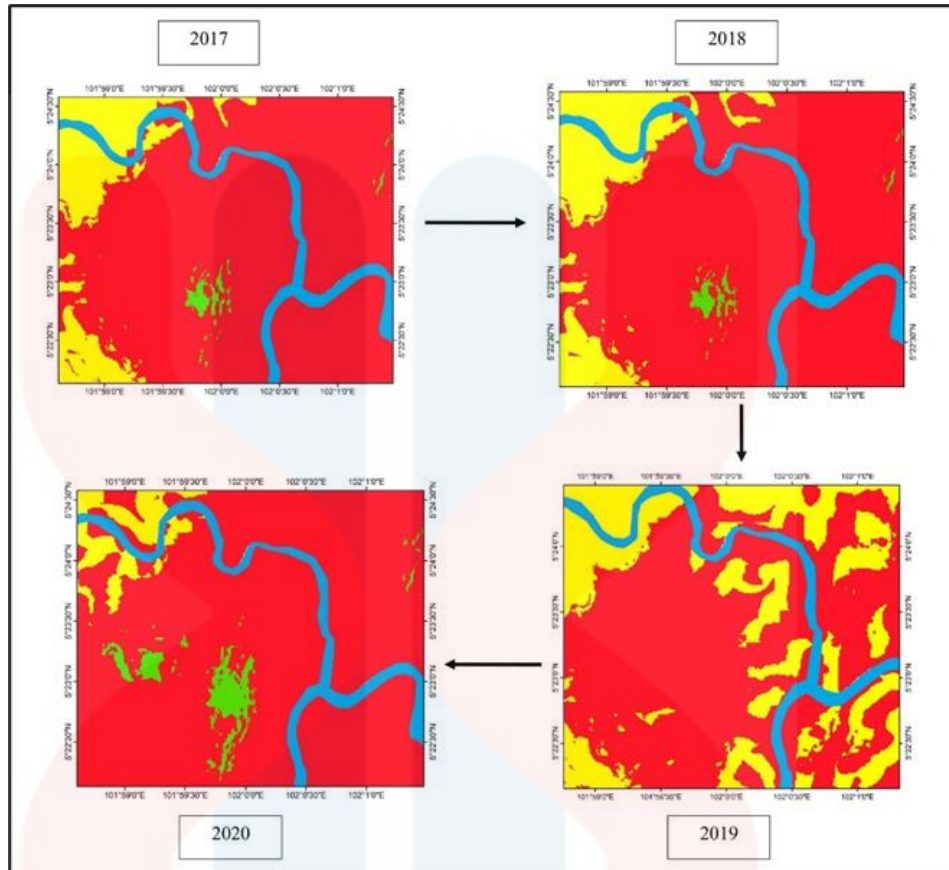


Figure 5.20: Trend changes of flood in Dabong from 2017 to 2020.

Based on **Figure 5.20**, the trend direction for 2017 and 2018 of highest floods cover north, east, and south area while moderate floods cover northwest, and southwest area and low floods occur in the south- southwest area. The trend direction for 2019, the highest flood cover south, little east area and moderate cover north area. The trend direction for 2020, highest flood cover north, east, south area, moderate flood covers northwest area and low flood cover southwest area.

As a result of flood hazard, trend climate change has become one of factor flood. The factor flood should an increase in the frequency and severity of severe rainfall events and more days with heavy precipitation. When the atmosphere retains more water, the rain that eventually falls is more powerful and causes floods. Climate change also affects monsoon weather systems, which determines where precipitation

falls. It also implies that rain is more likely to occur in intense bursts, leading to floods in some areas and drought in others, rather than gradually decreasing over time.

In this scenario, people will face a greater risk of flooding because of climate change. Due to its low height and proximity to the Kelantan River is particularly vulnerable to monsoons and frequent flooding. Since more rain is projected due to climate change, the overlapping of weighted overlay method (WOM) using Model Builder were generated to see how this affects flood hazard maps.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, the geological map of Dabong, Kuala Krai, Kelantan has been updated with findings that were discovered while it was being mapped, and those findings were being explained in depth. The stratigraphic column of the region under investigation was being category at the time Phyllite is determining as the oldest rock, following by schist. Most of the region under investigation is comprised of weathered rocks as a direct result of the persistently high temperatures and heavy rains. This research region was formed during the Permian period of geologic time. The geological mapping of this study area has been updated.

In this study, flood hazard map for Dabong was created withing Geographic Information System (GIS) environment. The flood hazard map was utilized by overlaying seven parameter which is slope, elevation, drainage density, land use, rainfall, river distance and flow length. These parameters were reclassified and weighted overlay method (WOM) in model builder.

The rainfall data has been conducted in ArcGIS during a period of from 2017 to 2020. The result shows that northern to west parts of study area are susceptible for flood that mainly caused by rainfall as the heightened score from Analytic Hierarchy Process (AHP). Based on the results, the pattern of flood hazard for each year from 2017 to 2020 can be seen to change according to rainfall data and changes in morphology. Due to infrastructure and daily rainfall, Dabong has

experienced flooding since the observation. Additionally, this is due to the residential proximity to the primary river.

6.2 Recommendation

For recommendation, the next researcher who will conduct additional geological mapping should focus on the structure geology of Dabong. In addition, fieldwork and laboratory studies must be conducted to obtain geological information about flood in the study area. In future work, will investigate how to include other physical factors. Also, the weighting of how important different factors are must be changed if important factors change.

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MALAYSIA

KELANTAN

APPENDIX

STATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUN	JULAI	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Dabong	632	106	127	136.5	192.5	181	150	204.5	301.5	398	491.5	228.5
Kuala Geris	601.5	107.5	48.5	110.5	243	74.5	128.5	227.5	298	277	551	232.5
Kuala Nal	788.5	94	82	184.5	193.5	211	303	257	238	115	371.5	222.5
Lapan Kabu	731	124.5	85.5	108.5	177.5	178	180	265	166.5	174.5	567	282
Laloh	21.4	3.7	3.8	2.2	7.1	4.2	6.9	10.5	14.3	7.2	15.8	6.1
Aring	23.1	6	1.8	2.6	14.5	8.8	5.8	6.6	7.2	6.9	13.3	7.3
Gua Musang	12.1	2.9	2.5	2.2	13.9	7.2	4.9	11	7.6	13	11.47	9.5
Jeli	32.7	7.5	6.8	7.2	6.3	6.6	6.6	8.1	12.8	5.7	25.5	9.2
Ladang pergau	26.9	3.1	1.4	6	7.5	8.2	7.1	10.2	6.7	6.1	21.1	9.3
Kampung Sungai Batu	17	11.4	9.1	7.6	11.9	3.9	1.9	7.3	10.5	7.2	10.3	11.2

Rainfall data in 2017

STATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUN	JULAI	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Dabong	309.5	37.5	59.5	107.5	213	232	224.5	114.5	426	244.5	252	316.5
Kuala Geris	337	24	28.5	31	248	342	177	71.5	186	213.5	279	264.5
Kuala Nal	224	35.5	43.5	103	207.5	226	290	119.5	206	121	264	434
Lapan Kabu	227	41	38.5	65	181	116	163.5	119	141.5	144.5	297	321.5
Laloh	11.75	1.29	1.34	7.47	3.75	7.38	1.61	1.73	5	4.29	10.63	11.73
Aring	9.65	2.89	2.06	3.43	4.08	6.57	3.12	9.42	11.42	4.52	9.23	15.16
Gua Musang	9.02	1.05	4.35	2.2	0.23	2.63	4.84	3.03	13.42	9.52	9.13	9.84
Jeli	11.89	3.43	3.8	3.48	11.43	7.8	4.73	3.45	12.73	7.44	6.65	0
Ladang pergau	7.42	1.32	2.06	4.27	8.41	6.11	3.53	2.58	6.3	7.06	8.85	12.27
Kampung Sungai Batu	0	0	0	3.67	8.82	6.57	4.38	1.53	6.82	14.97	6.73	13.44

Rainfall data in 2018

STATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUN	JULAI	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Dabong	108.5	30.5	30	139.5	160.5	352	160	250.5	167.5	222.5	430	312.5
Kuala Geris	40.5	80.5	91.5	33	132	366	106.5	301.5	164.5	174	465.5	200.5
Kuala Nal	168.5	47.5	70.5	119	38	231	177.5	138	158.5	115.5	453	395.5
Lapan Kabu	180	75.5	26	122	63.5	208	94.5	204.5	110.5	96	457	386.5
Laloh	77	39	24.5	100.5	121.5	203	67	222.5	106.5	78	390	369
Aring	69	39.5	69	57	231	263	96	0	239	135	425	276
Gua Musang	71	39.5	231	53	217.5	159	172.5	216	272	285	383	131
Jeli	4.5	37	0.5	88	274	244	208	311	231	246	700	764
Ladang pergau	157	42.5	52.5	107.5	85	303	94	173.5	108	157	406	345
Kampung Sungai Batu	179	73.5	43	156.5	205.5	107	195.5	69.5	143.5	460	311.5	349

Rainfall data in 2019

STATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUN	JULAI	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Dabong	13.5	195.2	94	74.5	292.9	231	159.9	1340.9	288.1	381.5	500.9	333.5
Kuala Geris	47.5	125.5	96.5	99.5	237	199	280	171	175	302.5	506.5	0
Kuala Nal	68	182	15.5	70.5	118.5	253	261	154.5	127.5	240	0	0
Lapan Kabu	38.5	146.5	18	93	163.5	272	135	86	202	232.5	491	479
Laloh	71	97	34	75	137.5	91.5	230.5	14	20.5	284.5	308	348.5
Aring	116	156.5	72.5	116	275	63.5	307.5	217	125.5	191	638.5	955.5
Gua Musang	116.5	93.5	53	84.5	445	229	262	144	262	317	349	246
Jeli	143	330	12	68	205	216	330	273	241	275	688	530
Ladang pergau	36.5	200.5	27.5	106	195.5	154	310	155.5	123.5	205	491	90.5
Kampung Sungai Batu	217	229	46.5	310	252.5	229	432	281.5	457	135	0	0

Rainfall data in 2020