GEOLOGY IN KAMPUNG SUNGAI BATU, DABONG, KUALA KRAI AND A SPATIO-TEMPORAL ANALYSIS OF RAINFALL DATA IN KELANTAN.

by

QURRATUL AIN QISTINA BINTI IBRAHIM

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

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2021

DECLARATION

I declare that this thesis entitled "Geology in Kampung Sungai Batu, Dabong, Kuala Krai and a Spatio-Temporal Analysis of Rainfall Data in Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ____________________________

Student's Name : Qurratul Ain Qistina Binti Ibrahim

Date : 28 February 2021

APPROVAL

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

Verified by:

Signature : ______________________________

Supervisor's Name : Dr. Hjh. Marinah Binti Muhammad

Date : ______________________________

ACKNOWLEDGEMENT

It is a great pleasure to address people who helped me throughout this project to enhance my knowledge and practical skills especially in research area. This thesis becomes a reality with the kind support and help of many individual, I would like to extend my sincere thanks to all of them.

My gratitude also been extended to my final year project's supervisor, Dr Marinah Binti Muhammad for her guidance, and her advices in completing this report. Without her guidance and persistent help this report would not have been possible. Big thanks to all lecturers for their teaching during my years in university. All of their knowledge and teaching has equipped me with knowledge in the field of geosciences and encourages me to keep on learning.

Also, I would like to express my deep sense of thanks for helping me completing my specification study. My fellow undergraduate students should also be recognised for their support during this research such as accompany to the site for mapping process. Last but not least, I am nothing without their blessing, prayer and support. There are my lovely parents. All my hard work worthless without their support

GEOLOGY IN KAMPUNG SUNGAI BATU, DABONG, KUALA KRAI AND A SPATIO-TEMPORAL ANALYSIS OF RAINFALL DATA IN KELANTAN

ABSTRACT

This research is about ascertain the rainfall pattern that related to the occurrence of flooding and geological study on study area. The study area of Kampung Sungai Batu is located at Dabong in Kuala Krai district at the southern part of Kelantan which cover around 25 km^2 with the coordinates between longitude $102^0$57’49.19”E to $101^0$57’48.86”E and $5^0$20’23.63”N to $5^0$23’4.52”N for the latitude. The objective of this study is to update a geological map of the study area with scale 1:25000, to determine the most common geological structures at the study area and to analyze the pattern or direction of the present geological structures. Geological mapping is use as methodology and the Geographic Information System (GIS) tools used to generate geological maps. This research work on spatio-temporal analysis of rainfall data is aim to use appropriate spatial statistical methods on the time series rainfall data in Kelantan, to describe and determine the behaviour and pattern of the data. The data on the monthly amount of rainfall between (2009-2019), were collected from Department Irrigation and Drainage (DID). The main aim of this study is to statistically determine whether it is true the flooding in Kelantan throughout the year is because of heavy rainfall. The collected rainfall data has been spatially analysed using ArcGIS to compare the distribution of rainfall from year 2009 to 2019. Hence, the pattern of time series rainfall data has been analysed through Mann Kendall (MK) Test by using SPSS software. From those analysis this study can conclude that the huge amount of rainfall intensity is on year 2014 that contribute an extreme flood event on that particular year.

Keywords: Spatio-Temporal, Mann Kendall (MK), ArcGIS

GEOLOGI KAMPUNG SUNGAI BATU, DABONG, KUALA KRAI DAN ANALISIS SPATIO-TEMPORAL DATA HUJAN DI KELANTAN

ABSTRAK

Penyelidikan ini adalah untuk mengetahui corak hujan yang berkaitan dengan kejadian banjir dan kajian geologi di kawasan kajian. Kawasan kajian Kampung Sungai Batu terletak di Dabong di daerah Kuala Krai di bahagian selatan Kelantan yang meliputi sekitar 25 km^2 dengan koordinat antara garis bujur $102^0$57’49.19”E hingga $101^0$57’48.86”E dan $5^0$20’23.63”N hingga $5^0$23’4.52”N untuk garis lintang. Objektif kajian ini adalah untuk menghasilkan peta geologi kawasan kajian dengan skala 1: 25000, untuk menentukan struktur geologi yang paling biasa di kawasan kajian dan menganalisis corak atau arah struktur geologi yang terbentuk. Pemetaan geologi digunakan sebagai metodologi dan alat Sistem Maklumat Geografi (GIS) yang digunakan untuk menghasilkan peta geologi. Penyelidikan ini mengenai analisis spatio-temporal data hujan bertujuan untuk menggunakan kaedah statistik spasial yang sesuai pada data curah hujan siri waktu di Kelantan, untuk menerangkan dan menentukan tingkah laku dan corak data. Data mengenai jumlah curah hujan bulanan antara (2009-2019), dikumpulkan dari Jabatan Pengairan dan Saliran (JPS). Tujuan utama kajian ini adalah untuk menentukan secara statistik mengenai punca banjir di Kelantan sepanjang tahun adalah kerana hujan lebat. Data hujan yang dikumpulkan telah dianalisis secara spasial menggunakan ArGIS untuk membandingkan taburan hujan dari tahun 2009 hingga 2019. Oleh itu, corak data hujan siri masa telah dianalisis melalui Ujian Mann Kendall (MK) dengan menggunakan perisian SPSS. Dari analisis tersebut, kajian ini dapat menyimpulkan bahawa jumlah intensiti hujan yang besar adalah pada tahun 2014 yang menyumbang kepada kejadian banjir yang melampau pada tahun tersebut.

Kata kunci: Spatio-temporal, Mann Kendall (MK), ArcGIS

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DID	Department of Irrigation and Drainage
E	East
GIS	Geographic Information System
JMG	Mineral and Geosciences Department
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
N	North
MK	Mann Kendall
S	South
W	West

LIST OF SYMBOLS (optional)

km	Kilometre
m	Metre
mm	Millimetre
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 General Background

This research was carried out in order to satisfy the requirements of the University Bachelor's Degree in Applied Sciences (Geosciences) Kelantan Malaysia. This paper aims to identify the pattern or trend analysis of rainfall dataset in Kelantan state that influencing to flood event. Besides the statistical research on flooding in Kelantan, this study also aim to do some research in Kampung Sungai Batu, Dabong, Kuala Krai to fulfil the requirement of Geoscience students. Dabong has been chosen as research area as it was one of the most affected areas during the Kelantan floods event in year 2014. It consists of high hills and is situated west of Kelantan. Furthermore, the geological aspect of the research, such as the structural aspect, is geology, lithology, topography and geomorphology also being studied. Therefore this area might be relevant to the specific research of this study which is on statistical approach for spatial flooding analysis.

Water for its life is a primary requirement for humans and animals. The main source of water used by us for various activities is rainfall. Rainfall important as a central component of the hydrological cycle that returns the transported water to the Earth's surface from the atmosphere. Understanding the variability of rainfall in space and time is very important for a country whose economy depends largely on agriculture. Agricultural activities are mainly fed by rain, supplemented by artificial supplies through canals and groundwater extraction. However, due to the resulting simultaneous flood and drought situations in various parts of the world, the erratic and untimely distribution of rainfall in the country may have adverse effects on crop production. Many studies have been carried out to investigate the spatial and temporal variability and trends in rainfall (Nirdesh and others, 2016).

Floods are physical phenomena active in geological time and the result of excess runoff. When rivers overtop their banks, the excess water goes to the floodplain. The consequences of flood are not environmental, but social and economic as well, since it can cause damages to the surrounding area and agriculture lands and may even result in loss of lives. The actual losses are higher considering loss of economic productivity, compensation to victims, reconstruction, among others. Even though, flood us unpredictable event but it impact still can be minimize by some actions and precaution.

Spatial and temporal rainfall variability is a crucial factor in the preparation and management of water supply, irrigation planning, flood frequency analysis, and hydrological modelling proposed by Michaelides and others (2009). Trend analysis of rainfall has been of great concern in the recent past among the scientific community because of the recent evidences of global climate change. Trend analysis can help in better understanding of the changing pattern of the prominent climatic variables in a river basin or geographical region of interest. Precipitation is a key component of the hydrologic cycle and changes in its pattern would directly influence the water resources of a region, as it affects streamflow, soil moisture, and groundwater reserves(Mishra et al., 2013). Therefore, in this geographically diverse area, studying the rainfall pattern and its variability on spatial and temporal scales is of key importance in solving water scarcity issues. For the identification of the existence of patterns in the time series, the monthly rainfall data collection of 11 years (from 2009-2019) available for 53 stations was analysed. The existence of the annual time series of rainfall was checked by the application of non-parametric Mann-Kendall (MK).

1.2 Study Area

Figure 1.1 refers to map of Kelantan, the Kelantan River basin is located in the north eastern part of Peninsular Malaysia between latitudes 4° 40' and 6° 12' N, and longitudes 101° 20' and 102° 20' E. The International Hydrological Programme (IHP United Nations) stated that Kelantan River basin as a whole is about 11,900 km2 (Ibbitt et al., 2002). The central part of the river basin consist of two main tributaries of the Kelantan River are the Galas River (7,770 km2) and the Lebir River (2,430 km2). The length of the main river is 248 km. Its average annual rainfall is 2,505 mm (1970-1997) while average discharge is approximately 558 m3 /s (1950-1990). Galas and Lebir River meet at Kuala Krai. It has a broad upstream and a relatively small downstream (Sathiamurthy et al., 2019). Kelantan River basin is selected as a study area of which 53 rainfall station are chosen within this region for derivation of their characteristic.

However, to full fill as a geoscience student, one of area in Kampung Sungai Batu Dabong, Kuala Krai has been chosen and it is covered about 25km per square as study area. The coordinate for this study area is $5^0$23'4.52"N, $101^0$57'48.86"E, $5^0$20'23.63"N, $102^0$0'34.89"E, $5^0$23'23.33" N, $102^0$57'49.19"E and $5^0$23'4.52" N, $102^0$0'34.57"E. Dabong, also known as Kuala Krai Selatan is a small town in Kuala Krai District, Kelantan, Malaysia. Dabong is one out of four state seats in the Kuala Krai constituency. Dabong is a very strategic town and potentially be chosen as the new capital of Kelantan as its location in the middle of Kelantan state and accessible from all parts of Kelantan.

1.2.1 Location

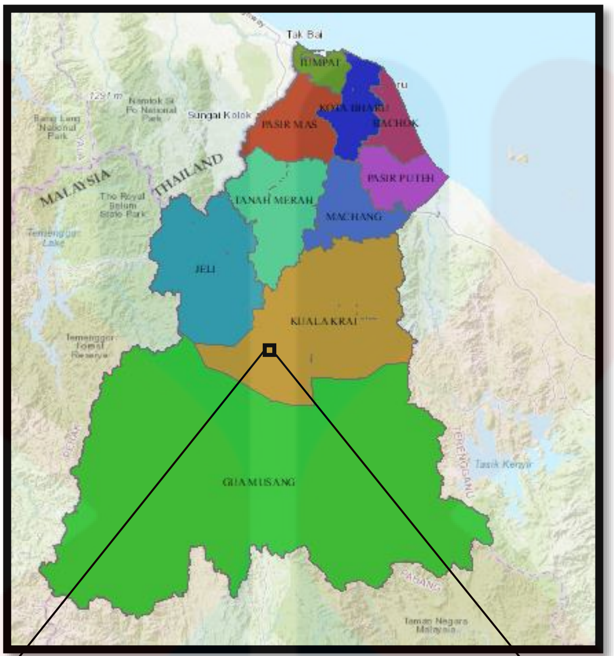


Figure 1.1: Map of Kelantan

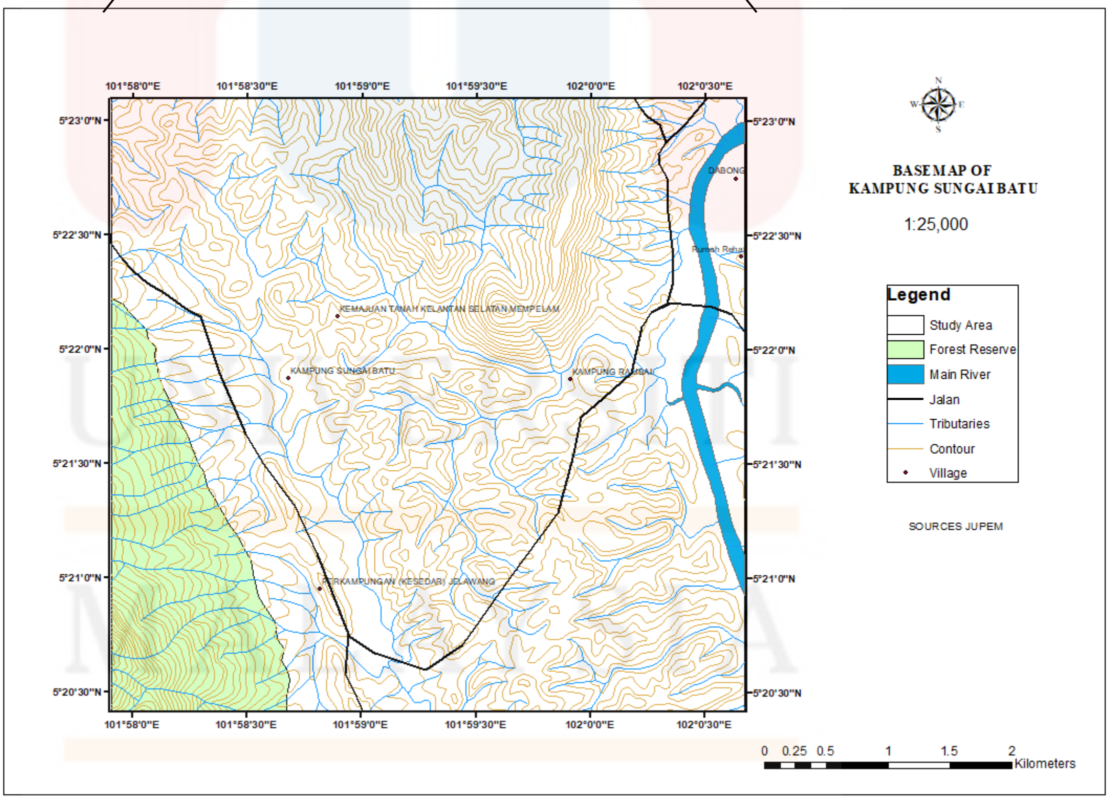


Figure 1.2:Basemap of Kampung Sungai Batu

1.2.2 Accessibility

Dabong is the second largest district in Kelantan state. The area can be accessible by transportation such as car, motorcycle, and train. The topography of the area which surrounded by top hill makes it the formation of the valley in the central. Dabong was connected from the north Kelantan to the other state such as Pahang, Perak, and Selangor. Based on the study area, the areas can be accessible by car and motorcycle but some area can’t be accessible by transportation.

1.2.3 Road connection

The length of road Kuala Krai is about 114 km to reach the destination. Moreover there is one attraction which mostly nearest located to study area which is Gunung Stong. The accessibility to connect the study area can through by any vehicle which road from the city of Kuala Krai to Dabong. Hence, it also can through by walking from Gunung Stong along 15 km. Furthermore, can reach the location of study area by using hilux. By car, Federal Route 66 is a federal road in Kelantan, Malaysia, linking the town of Jeli to Dabong town. The main road to reach study are connected to Dabong and either from Jeli and Gua Musang. Also can access by train and it station on the Jungle Railway line between Tumpat and Gua Musang.

Figure 1.3 : Road from Jeli to Dabong, Kuala Krai

1.2.4 Demography

In 2017, population for Kelantan was 1,829.7 thousands. Between 2008 and 2017, population of Kelantan grew substantially from 1,550.4 to 1,829.7 thousands rising at an increasing annual rate that reached a maximum of 2.54% in 2015 and then decreased to 1.84% in 2017. The population data of Kelantan is get it from website Department of Statistics Malaysia.

According to the Official portal of Dabong District Council, the total population of the area were 120,400 people which the highestamount of data recorded. Each of the population was divided by ethnic which are Malay, Chinese, India, Orang Asli and others. The percentages of Malay are 76%, Chinese 5%, 1% India, Orang Asli 13% and others 5%. Dabong area was dominated by Malay residential. Figure 1.7 the distribution of the residential.

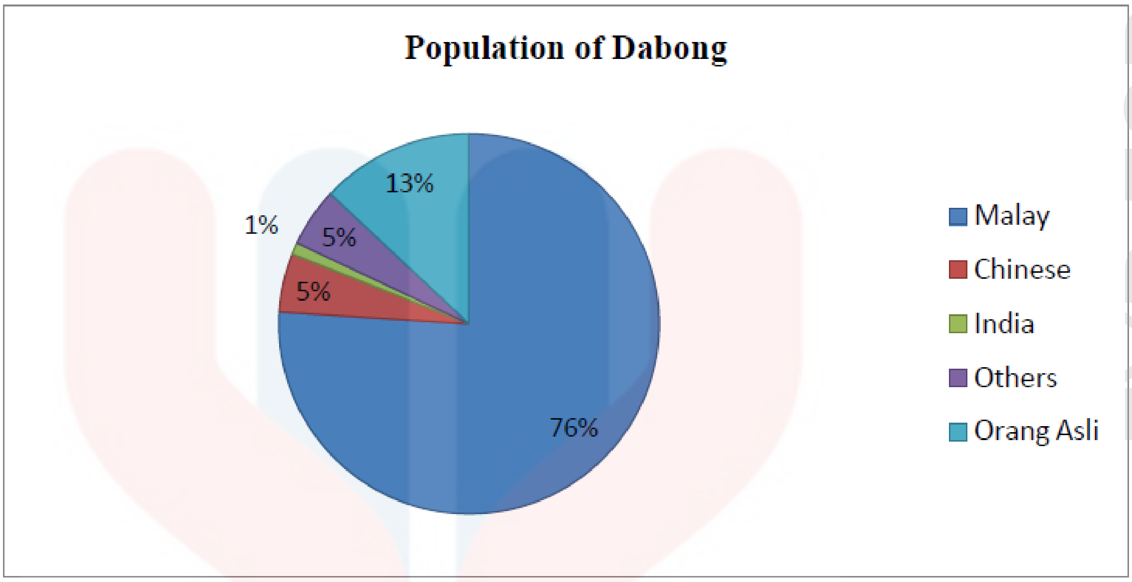


Figure 1.4: Population of Dabong

(Source: Official portal of Dabong District Council)

1.2.5 Land Use

Kelantan has established both its upstream and downstream regions in recent decades. Both for timber and vegetable cultivation, the upstream regions have been deforested. The hydrological regime has been compromised because of rapid land use changes, especially from deforestation to agriculture or urban land use, and this has been a factor that has intensified flooding (Chan et al., 2020).

Changes in land use and land cover represent changes in growth that occur in an area. Changes in land use from forest areas to various forms of land use, such as townships, cities, manufacturing, agriculture and tourism, can impact the environmental quality that can lead to natural disasters (Shaharudin Idrus et al., 2004, Tuan Pah Rokiah & Hamidi 2016).

The studies carried out by Tuan Pah Rokiah & Hamidi (2016) showed that the growth of land use in the Kelantan basin for 1984 is less diversified or, in other words, it is not complex where only few patterns of land use are classified as rubber, coconut, oil palm, vegetables, etc. The trend of land use development is moderate in order to demonstrate that the barrier to growth in the area of the Kelantan Basin was not as vibrant as in the 1980s. Agricultural activities, for example, were also moderate and exploited without the use of the latest technologies, which restricted forest discovery to agricultural activities. However, in 1997, in particular, the pattern of land use in Kelantan began to become complex compared to the year 1984. Due to the lifestyle pattern of the people in the Kelantan Basin in the face of the mainstream of national growth, vibrant land use development. Large-scale agricultural operations, including rubber, oil palm and agriculture, have resulted in technological advances. Several areas of forest reserve and rubber plantations were cut down and replanted, as well as existing palm oil.

1.2.6 Social Economic

The economic activities of Kelantan are mainly focused on agriculture, manufacturing and the agro-industrial sector, as well as tourism. Over the years, 43.2% of the economy decreased, as calculated by domestic product growth in 1980 and 19% in 1990, with a corresponding rise in manufacturing and industrial activities. The larger manufacturing industries are located in the agro-based and export-oriented sectors of wood processing. Wood-based industries include logs and sawn timber with secondary processing practices involved in the manufacture of plywood and veneer, furniture making, and match stick manufacturing. Annually, Kelantan produces 470,000 cu meters of sawn timber, while mainly processing rubber, rice and palm oil. An significant activity, too, is gold mining. Since the study area of Dabong, Kuala Krai is not well explored, there are several region which consists of unexplored forest especially on the upper side of the hill. As observed, the flora found are such as palm plantation which major activity of plantation site, rubber plantation and other forest.

The citizen mostly are involved in plantation which is in estate or rubber estate. The location of our study area at palm plantation area. The citizen mostly focused on the oil palm plantations which one of their source income. Next, as observed there are farmers who are involved in reaping the harvest in palm plantation and as well as the rubber plantation.

1.3 Problem Statement

Flooding is the main issues of hazard that caused a huge damage in Kelantan. The primary cause of the flooding taking place in the catchment is the monsoon flood due to the overflow of Sungai Kelantan. The entire town has a small and flat natural landscape that compounds the problem of flooding. Heavy rains brought by monsoon winds from the northeast that blew every year between November and March, resulting in floods in almost all provinces in Kelantan 4 state. Other factors, such as changes in topography and local drainage, are worse, aside from the heavy rain. The 2004 flood was the worst flood recorded since 1926 and was confirmed to have occurred from 8 to 12 December 2004 due to heavy rainfall. It caused a great deal of property damage and loss of life. To reduce the loss of life and damage caused by floods, an efficient flood forecasting system is required. Between January and mid-December 2011, 9 people were killed in the Kelantan flash floods. The flood issue is still unresolved, even with some steps and changes taken in some areas in Kelantan.

Rain is an agent which can lead to flood event. Descriptive analysis using hyetograph and hydrograph showed that there are two phase of extreme rainfall occurred in Kelantan river basin that influenced the approximately 1 in 1000 years flood event that known as Kelantan big Yellow Flood. On December 15 to 19, the first step had heavy rainfall coming down the stream of the Kelantan river basin on both the eastern and western side. This helps raise the water levels of the rivers Galas, Lebir and Kelantan. During this time, flooding occurred from 17 to 19 December 2014 in the Kota Bharu, Tualang, Kursial and Kuala Krai regions.

The second rainfall phase occurred from 20 to 24 December 2014. During this period, higher rainfall intensities were reported, especially in the upstream Gunung Gagau River Basin. Due to maximum soil, river and drainage power, the flood situation becomes more serious. Kuala Krai, Dabong and Manek Urai were the hardest affected in the region from 22 to 30 December 2014. During the flood period, several record breaking rainfall events occurred, particularly stations in the upstream of the river basin with the ARIs near and over 100 years and some of them more than 500 years with ARIs. This leads to the extreme amount of river discharge and damage to some of the river monitoring stations and, as seen in hydrographs, does not record the water level. The events of December 2014 are one confirmation of a rapidly occurring significant rainfall occurrence leading to record levels of breaking rainfall.

This enormous amount of rainfall thus leads to the intense flooding in Kelantan, where the relationship has been further examined statistically. From this further research we found that the flood depth that occurred in flood-prone areas is significantly correlated with the intensity of rainfall but not with the river distance of the region. This result leads us to believe without a doubt that the 2014 Kelantan major yellow flood is absolutely affected by heavy rainfall. It is therefore important to further examine the relationship between current flood events and historical rainfall records for future research to provide facts on the rarity and extreme level of rainfall causing the flood, so efficient flood prediction models can be suggested for practical use in mitigating the catastrophic impact of the flood (Marinah,2020).

There are some previous researcher have been conduct the research about rainfall analysis that influencing the flood event by using statistical analysis, but it still lack of studies to predict the flood event. Some of the statistical model still not accurate in prediction when the occurrence of flood and need further studies for forecasting the flood. In flooding modelling and forecasting, it is hypothesized that incorporating the catchment characteristic variables would improve prediction accuracy and model reliability (Badyalina & Shabri, 2013).

Dabong was undergoing development district, in terms of agriculture, industrial sector thus the rates of the flood event increased when high intensity of rainfall day by day due to uncontrolled development caused possibility of flood occur. So, it was important to find a new alternative or pattern in flooding analysis is needed.

Furthermore, the study does not have updated geological map. So, geological mapping required to updated lithology distribution on small scale 1: 25 000. The study area required mapping due might undergo changing of the topography or weathering process.

1.4 Objectives

The objective of this research is to update the geological map about the information of high-risk area of flood in Kampung Sungai Batu, Dabong, Kuala Krai by conduct interpretation analysis of this area using GIS application. In addition, to identify the pattern or time series analysis of rainfall that impact on flood event in Kelantan state. Furthermore, this research aim for development of spatial and temporal rainfall data analysis Lastly, provide more information about the current condition of this study area through rainfall pattern for forecasting flood event in the future.

- To update a geological map of the study area on a scale 1 : 25000
- To ascertain spatio-temporal analysis of rainfall in Kelantan
- To produce flood risk map of Kelantan

1.5 Scope of Study

The scope of the study was focused on the geological aspects such as stratigraphy, lithology, structural geology, drainage pattern and also the geomorphology of the study area. This research focussed within the 25 km2.

Dabong was known as an area which mostly surrounded by a mountainous area and wide main river of Kelantan. So, the area might have possibility to occur the huge flood event. And by analysis this area might know the potential of flood in this area.

Flood is the most natural disaster occur in Malaysia. The study about flood is important to account for the direct losses produced by floods and direct economic damage. Economic damage is the tangible economic loss associated with a floods impact as determined after the event. The losses occur after floods as a result of physical contact of the flood waters with damageable property. Indirect and intangible damages, as well as long terms macroeconomic effects are not considered. In addition, the study about flood can be upgrade by develop model of statistical analysis. It will use as the forecasting of flood by identify the best consistent variable. Moreover, this study is useful for people at prone area of flood to aware and get ready before evacuation occur. It is important as alarm system and may decrease the loss of death and their property. Other than that, more sector will be affect especially agriculture and infrastructure. Due to this condition, the study about rainfall pattern is the way to give prediction and find the way for forecasting flood event in the future.

This analysis included areas with extreme flooding and the site of the Kelantan rainfall station. Daily and monthly dataset of 53 rainfall station from 2009 until 2019 been collect. Moreover, this study area focused on to conduct a literature review and to discover the latest trends in this field of study. All data and information collect from Department of Irrigation and Drainage (DID). Lastly, this research is propose to develop the rainfall time series based on data collection.

1.6 Significances of Study

The significance of the research is to update the latest geological map of the Dabong in scale 1:25 000. The new geological map can be used as a reference to a different department. Other company also can refer to this geological map if they want to develop new activity in this area for urbanization.

This research is expected that the proposed research would mitigate the loss of property and existence. In addition, it is hoped that this study will come up with some values that can include ways and thoughts about how to mitigate the effects of flooding. Moreover, it is intended to protect life and property from the effects of destructive floods. This research is important for people at prone area of flood to get the updated information about this natural disaster from time to time. The present study of rainfall at Kelantan River basin will help to understand and evaluate the present rainfall trend analysis and possibly predicting the flood future event. Besides, it will be helpful for other researchers who will be interested in doing advance work on same topic.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the regional of geology and spatio-temporal analysis were discussed in detail based on the previous study and review article. The regional geology was summarizing about Peninsular Malaysia including geomorphology, structural geology, stratigraphy, lithology and topography and its history. The statistical analysis also discussed based on the past usage in the field. Trend analysis were discussed for choose the best method to perform this analysis.

2.2 Regional Geology and Tectonic

The world is formed by endogenous processes induced by forces from within the earth, resulting in harmful events such as earthquakes or volcanic eruptions, and exogenous processes caused by forces and their interactions with the atmosphere of the earth, hydrosphere, geosphere, biosphere and cryosphere. A number of these processes have been affected by anthropogenic activities, particularly in the last two hundred years, for example by increasing greenhouse gasses, leading to global warming, but also by drastic changes in land cover and land use and by the overexploitation of scarce resources. The endogenous, exogenous and anthropogenic processes listed above can lead to potentially catastrophic events, even in locations that may be far away.

Earthquakes, for example, may trigger landslides that can lead to landslides and dammed lakes that can break down and cause downstream flooding.Rainfall-runoffs parameters analysis found that continuous high rainfalls, geological setting and topography triggered the basin wide extreme event which only occurred twice in 88 years of flood records (1926-2014). It is concluded that physical factors, such as geological setting and topography are crucial in the analysis of the cause and effect of severe floods, and spatial distribution of flood depths when the terrain characteristics are considered (Sathiamurthy et al., 2019).

Floods in Peninsular Malaysia are also caused by surface factors such as low lying topography, poor drainage system and design, coastal areas located below high tide level and the loss of natural retention areas resulting from urbanization (Low & Leigh, 1973; Sooryanarayana, 1995; Chan, 1997; Sathiamurthy et al., 2007; Sathiamurthy, 2013).

Located in the east coast of Peninsular Malaysia, Kelantan State is historically a flood-prone state because of its seasonal exposure to Monsoon winds, as well as its low-lying topography on floodplains and the location of dense populations and settlements near rivers(Chan et al., 2020). The state is made up of low-lying topography with large tracts of flat floodplain sand drained by large rivers, resulting in more than a quarter of the state being flood prone. While it is generally accepted that exceptional heavy rainfalls was the main factor, the geological setting and topography of Kelantan Basin are key mechanisms (Sathiamurthy et al., 2019).

2.3 Stratigraphy

In general, Kelantan is categorized under Gua Musang group and it is relate with a few formation. The Gua Musang formation in South Kelantan – North Pahang was mapped by Yin (1965) to describe Middle Permian to Late Triassic argillite, carbonate, and pyroclastic/volcanic facies within Gua Musang area. Now, the term has been loosely used for nearly all Permo-Triassic carbonate-argillite-volcanic sequences in the northern part of Central Belt Peninsular Malaysia.Widespread distribution of argillite-carbonate-volcanic across northern Central Belt has triggered issue regarding current names assigned. For example, similar lithologies to the Gua Musang formation in Felda Aring is named as Aring Formation, while those in Sungai Telong is called Telong formation (Aw, 1990). Mohamed and Leman (1994) and later Mohamed (1995) explained that these lateral facies changes could be gathered within the same group as long as these sediments were deposited in shallow marine environment of the Gua Musang platform during the Permo-Triassic period.The relevance of grouping these formations lies behind the close associations observed among these formations in terms of sedimentological and paleontological aspects. The authors find the need to reasses the usage of the informal 'Gua Musang formation' for future rank elevation, formalization, and clearer understanding on the geology of the northern Central Belt, particularly with regards to deposition of various lithostratigraphic units within the Gua Musang platform.

The northern boundary of the Gua Musang platform is inferred to be bounded by low to medium grade metamorphic rocks of the Carbo-Permian Mangga formation (The Malaysian-Thai Working Group, 2006) and Taku schists (MacDonald, 1967) in the north. Just like the poorly delineated southern boundary, this northern boundary is subjected to future study for further refinement. In short, the proposed "Gua Musang Group" also functions to distinguish central-northern distribution of the Calcareous Series deposited in the Permo-Triassic shallow marine from adjacent dominantly deep marine "Raub Group". This is done by reviewing the sedimentological and paleontological aspects of the Permo-Triassic formations in Central Pahang to Central Kelantan.

2.4 Structural Geology

Kelantan is a northern state of Peninsular Malaysia. The boundary of this state to the north is Thailand, eastern part is Terengganu, and southern part is Pahang and western part with Perak and Kedah. This paper explains structural variation of all lithology of Gua Musang Formation in Kelantan. Geological of Kelantan are comprises of west Kelantan Olistostrom, Taku Schist and Gua Musang Formation. Igneous of Kelantan are granite, diorite porphyry, andesite, ignimbrite dan dolerite. Structural of Kelantan are boundary by olistostrom in the west and Lebir Fault Zone in the east. Gua Musang Formation is mainly separate in Kelantan. Main fold of Gua Musang Formation in the middle part towards north south up to north-northwest – south-southeast. In the northern part of this main fold turned by granite intrusion and diorite porphyry towards NE-SW. The main of fault in the Gua Musang Formation are dexstral fault with strike N30-45 ^{0} E and dipping 60-70 ^{0} to SE and of sinistral fault with strike N330-340 ^{0} E and dipping 60-80 ^{0} to ENE-WSW. In the area boundary by igneous granite intrusion and near than main fault, Gua Musang Formation formed the compact and strongly folding. Intrusion of diorite porphyry towards NE-SW have to turn the main fold of Gua Musang Formation to follow this intrusion. The main compression who formed the folding and faulting of the Gua Musang Formation towards between WNW-ESE up to ENE-WSW (*Structural Geology of Gua Musang Formation in Kelantan*, 2017).

2.5 Historical Geology

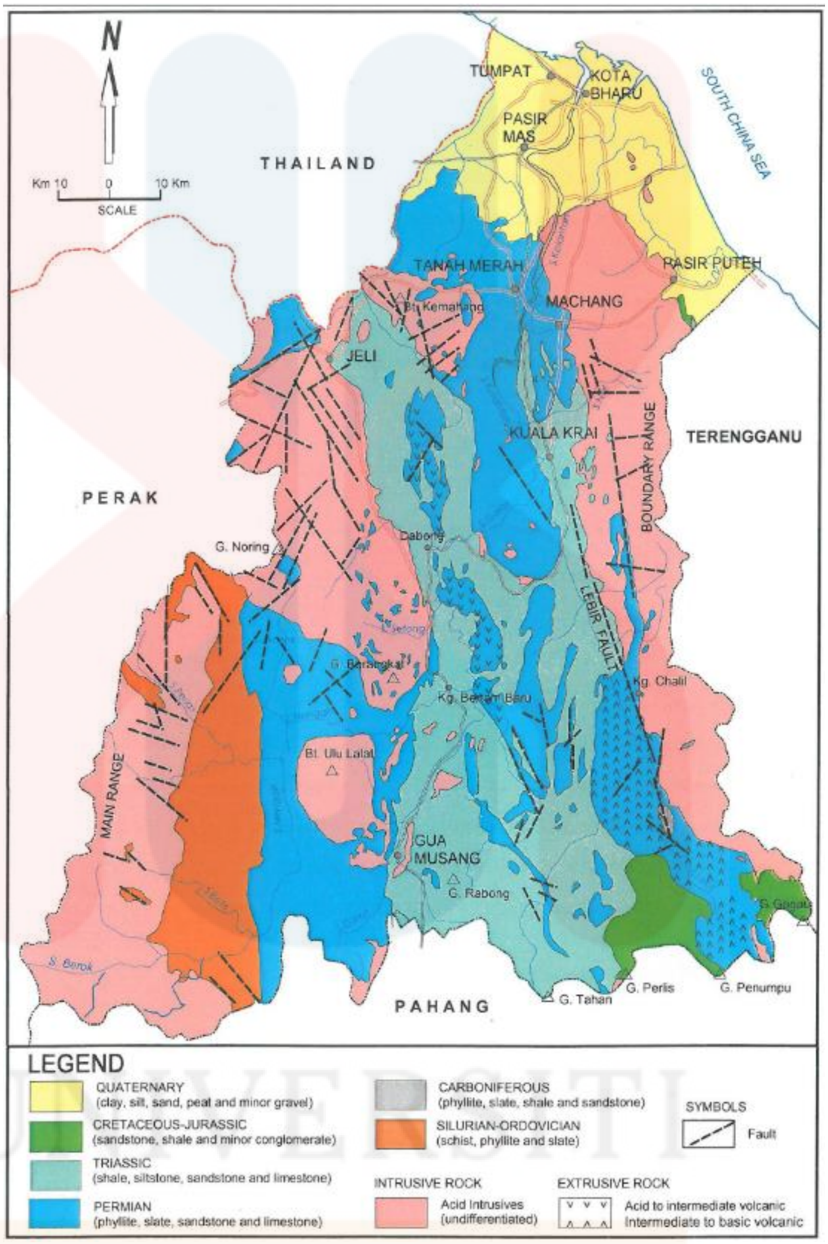


Figure 2.1 : Structural geology of Malaysia

The geology of Kelantan can be broadly classified into four rock types, they are unconsolidated sediments, volcanic rock, sedimentary, metasedimentary rocks and Granitic rocks. For granitic rocks in Kelantan, they can be divided into two main bodies: the granite bodies within the Main Range and the Boundary Range. The Main Range granite is generally of a Middle Triassic age, between 200 and 230 million years ago. The Main Range granite in Kelantan located roughly in the west of the state stretching along western Kelantan up to the state boundary of Perak and Pahang, and international boundary of Thailand. Moreover, the main rock type of the Main Range Granite Province is a coarse to very coarse grained megacrystic biotite granite. Large K-feldspar phenocrysts up to 7 cm long are common and often show a distinctly megacrystic appearance in hand specimen. The main force acting on the land mass of Peninsular Malaysia was compressional and its effects are principally faulting and folding in the scale of regional and local. Localised structures include folding, faulting, and jointing in the sedimentary rocks, and faulting and jointing in the granitic rocks. The dominant structural grain is along a N-S to NW-SE direction resulting from past orogenies (Nazaruddin et al., 2014).

2.6 Research specification

2.6.1 Spatio-temporal analysis of rainfall data

Water resource has the prime concern for any future planning and development including flood control, flood protection and sustainable watershed management. The rainfall available in the watershed is key factor for determining the availability of water to fulfil the different demand mainly for agriculture, hydropower water supply, industry, etc. The timely availability of water influences the agriculture sector, food security and energy sector. Global climate changes affect the long-term rainfall pattern causes availability of water and may danger of occurrence of serious drought and flood (Pal et al., 2017).

Any change in the behaviour of this crucial hydro-climatic variable is not uniformly spread throughout the region rather it has its own unique localized pattern. There is a need to take stock of nation's water resources by characterizing the changing rainfall patterns to better manage the water resources and preparedness against natural calamities like floods and droughts. Floods are caused by extreme rainfall events whereas droughts are caused by lack of rainfall thus leading to reduced crop yield. The increase in extreme events with the inter-annual variability of rainfall during Indian monsoon are widely attributed to increasing CO_2 concentration from various numerical modeling studies (Bhaskaran et al. 1995; May 2002). Historical trend analysis of rainfall pattern provides an insight to the local rainfall characteristics and aids policy makers to derive efficient hydrological plans to combat drought and mitigate flood risk by appropriate water resource management (Bisht et al., 2018).

Information on the temporal and spatial distribution of rainfall is important for a variety of applications in hydrology and water resources management (Campling et al. 2011). Associated with global warming, changing rainfall patterns and their impact on surface water resources are an important climatic problems facing society presently (Maragatham 2011).

Floods are known as one of the world's most frequent and devastating events including Malaysia (Osti et al., 2008). A substantial amount of the nation's annual expenditure has been allocated to the development of strategies to reduce the effects of flooding. In particular, the impact of flooding in terms of infrastructure damages, human causalities, and long-term economic downturn has been rapidly increasing. This scenario is brought about by the ballooning global population, unsystematic urbanization, and climate change in the form of higher sea levels and more intense cyclones weather systems and precipitation (Sanders, 2007).

Kelantan is situated at the east coast of Peninsular Malaysia. Due to its geographical location, it is exposed to the North-East Monsoon from November to March every year. The monsoon has invariably brought heavy rainfall over prolonged period, causing an almost annual recurrence of flood between the ends of November till early January (JPS, 2006). The “ Laporan Banjir 2005/2006” reported three deaths an estimated RM 12.1 million worth of JPS structures being damage during the past flood that occurred from 19 to 23 November 2005 and from 8 to 26 December 2005. Kelantan has a long history of flood disasters dating back to 1926 due to its exposure to heavy seasonal monsoon rains.

In Kelantan, the hydrological regime was dramatically altered by a combination of rapid urbanization, upstream deforestation and sedimentation, leading to more runoff entering the rivers in a short period. Significantly, due to higher volumes of runoff, flood peaks are often greater. Development of plantations, farms and logging is taking place on a large scale, especially in the hilly areas of Ulu Kelantan, often seen as a factor contributing to the recent floods in Kelantan. This condition was strengthened when the impact of the rains overflowed the Galas River with heavy currents that drowned the old town of Gua Musang and many nearby villages. According to Zulhazman, persistent heavy rain caused water flow from the highlands to flow faster, rushing to the rivers because trees are no natural barrier. It would cause landslides if there are no trees to keep the soil and it carried along the soil with the flow of the rivers and the mudslides occur. He also believes that the clearing of land for agriculture in some areas of Ulu Kelantan has caused many trees to be cut down, resulting in the loss of 'natural fortress' (Hamzah, 2015; Mohmadisa, 2016). Furthermore, in hydrological processes, the emphasis of opening a forest to the idea of one type of plant or 'monoculture' does not replace the functions of tropical forest plants (Mohmadisa et al., 2016). The amount of water that not intercepted by the plant will fall to the ground and so are the flow line of the trees. In contrast to the trees of tropical forests, the farms 'monoculture' such as rubber, palm oil and vegetables cannot provide coverage of natural forest canopy like a slow falling rain on the earth's surface thereby increasing the amount of runoff.

The floods are considered to be the worst flood disaster that continues to terrorize up to Kuala Krai, resulting from combined water from three rivers that meet in Kemubu, Kuala Krai, which forms Sungai Kelantan, Lebir, Nenggiri and Galas River. Strong and large currents such as 'Tsunami Land' rose as high as the third floor of Sekolah Kebangsaan Manek Urai Lama, which makes the affected areas' sea 'of water. Other districts of Tanah Merah, Pasir Mas, Machang, Tumpat, Kota Bharu and Jeli were significantly impacted by the floods during the same time.

The geographical position that is near to the South China Sea is the cause of a catastrophic flood due to the heavy rain that resulted from the northeast monsoon movement. Generally, monsoon flood is a natural occurrence as a result of the circulation of the earth in its axis which produces different wind movements, in which wind circulation (known as the northeast monsoon wind) which contains many steam vaporous moves from high pressure areas to low pressure area (Ooi et al., 2013; Braesicke et al., 2012)

Chang.R (2015), the weather in the South China Sea region is characterized by two monsoons: the Northeast and Southwest monsoons, so called because the predominant wind direction is from the northeast and the southwest respectively. The Northeast monsoon (Nov - Mar) occurs during the northern hemisphere winter, when the sun is nearer the Equator, while the Southwest monsoon (May - Sept) takes place during the northern hemisphere summer. Hua (2016) refers to physics theory, the monsoon floods that occur are from November to March or winter only because of the sun's rays falling on the Southern Hemisphere and forming a low pressure area in Australia, while in the Northern Hemisphere it forms a high area In Central Asia. Therefore, Kelantan's, should be given attention in terms of management of flood preparedness, whether physical or humanitarian, regarded as vulnerable to such natural disasters every year

Due to the geographical location adjacent to the coast of South China Sea and the expansion of settlements on plain topography, a majority of the population in Kelantan are highly exposed to floods, especially during the northeast monsoon seasons occurring from November to March. Floods have been recorded in the state every year over the past decade (Nurul Syazwani Yahaya, Choun-Sian Lim, 2015).

Based on a few articles, this area can be concluded as the major issue of floods that need all the concern to find solution. This issue need the other solution that will been conduct to investigate this issue.

2.6.2 Trend Analysis

Particularly, precipitation is the key climatic variable that affect both the spatial and temporal patterns of water resources. Analyzing the long-term trends and variability of rainfall is very important for sustainable water resources management. Studying the trends of precipitation and temperature have enormous use for researchers to describe the spatial and temporal variability and management of limited water resources for future development. Trend analysis of rainfall is also essential to study the impacts of climate change for water resources planning and management. Studies conducted so far suggested that the changes of precipitation shows a very diverse pattern in spatial-temporal trends at regional and national scales because of the natural resource disparity.

Additionally, these climatic variations will have unexpected consequences with respect to frequency and intensity of precipitation variability for many parts of the country(Gedefaw et al., 2018).

2.6.3 Mann Kendall

"There are various methods used to identify hydro-meteorological time series" (Duhan and Pandey, 2013). "Trend analysis of rainfall time series includes determination of increasing and decreasing trend and magnitude of trend and its statistical significance" (Jain and Kumar, 2012) by using parametric and non-parametric statistical methods. Trend analysis in various study shows that there are generally non-parametric methods were used, Mann-Kendall test (Mann, 1945 and Kendall, 1975) is one of the best methods amongst them, which is preferred by various researchers (D Khare, Douglas et al., 2000; Yue et al., 2003; Jain and Kumar, 2012). "Mann- Kendall test is used for analysis and ascertains statistical significance by hypothesis test of hydrological variables" (Yue et al, 2003). "Mann-Kendall test does not require that datasets to follow normal distribution and show homogeneity in variance; transformations are not basically required if data already follows normal distribution, in skewed distribution greater power is achieved" (Duhan and Pandey, 2013). "Mann Kendall test also discusses about function of slope in the trend, coefficient of variation, and type of probability distribution" (Yue et al, 2002a). "Mann-Kendall test is used for trend analysis as it eliminates the effect of serial dependence on auto-correlated data which modifies the variance in datasets" (Hamed and Rao, 1998).

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter described the materials and the procedure to conduct the research. This chapter also explained based on the preliminary studies in order to ensure the objective of this research achieves completely. There also included the flow chart of this research because it is important to conduct the research. Data used for this study were acquired from two main sources, official and primary. Data from official sources were obtained from published information such as rainfall within the study area. The data collected from the primary resources include different type of maps as geological maps, topographic maps, and satellite images. The methods used to collect other types of information include observation and interpretation satellite image and topographic map.

3.2 Material

Table 3.1: Data Preparation

Data	Description	Sources
Satellite Image	Landsat 8 OLI/TRS	https://earthexplorer.usgs.gov/U.S.
Topographic Map	Scale 1:25000	Geological Survey Department of Surveying and Mapping Malaysia
Digital Elevation Model (DEM)	Advance Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) with 30 meters pixel spacing	U.S. Geological Survey
Rainfall Intensity	Annual amount of rainfall	Department of Drainage & Irrigation

	(mm) in Kelantan (2009-2019 year)	Kelantan
Microsoft Excel (XLSTAT)	Extract the rainfall data and analysed the statistical test (Mann Kenndall)	Addinsoft, USA
Statistical Package for the Social Sciences (SPSS)	Software that used to perform statistical analysis (Mann Kendall)	
ArcGIS software	Processing, analysis and integration of spatial data.	ESRI, Redlands, USA

3.2.1 Data Sources

Rainfall is a principal element of the hydrological cycle and its variability is important from both the scientific as well as socio-economic point of view. This study presents an analysis based on the precipitation variation in Kelantan River Basin. Data of precipitation for the 53 rainfall stations were collected from the Water Resources Management and Hydrology Division, Department of Irrigation and Drainage (DID), Government of Malaysia and website of National Hydrological Network Management System (SPRHiN). The monthly rainfall data set of 11 years (from 2009-2019) available for 10 districts have been analyzed for detecting the presence of trends in the time series. This study uses the following data for rainfall time series analysis of flood forecasting. These data have been analyzed for annual variation. For trend analysis, Mann-Kendell test were used. Thus, study of rainfall pattern and its variability on spatial and temporal scales is of key importance in resolving water scarcity issues in this geographically diverse region.

Geological study of Kampung Sungai Batu, Dabong were conduct by using secondary data from previous research and from a few portal that related to geological mapping of Geographical Information System (GIS) such as United States Geological

Survey (USGS) for Digital Elevation Models (DEM) raster dataset and Google Earth for contour dataset. In order to produce the geological map of study area, ArcGIS, Google Earth and Google Map be used.

3.2.2 Trend Analysis

Trend analysis is used to investigate whether the trend is upward, downward, or no trend in data value points. The non-parametric Mann-Kendall (MK) test has been applied in most studies to detect the trends in hydro meteorological observations that does not need normal distribution of data points. In the present study, trend analysis has been done by using non-parametric Mann- Kendall test. This is a statistical method which is being used for studying the spatial variation and temporal trends of hydro-climatic series. A non-parametric test is taken into consideration over the parametric one since it can evade the problem roused by data skew (Smith, 2000). Man-Kendall test is preferred when various stations are tested in a single study (Hirsch et al., 1991). Mann-Kendall test had been formulated by Mann (1945) as non-parametric test for trend detection and the test statistic distribution had been given by Kendall (1975) for testing non-linear trend and turning point.

3.3 Methods

This part section was important to accomplish this research objective. With the help of method, this helps the research complete according to the duration given.

3.3.1 Preliminary research

This part focused on the desk study before doing the research regarding the chosen topic.

a. Trend analysis

Preliminary research is an initial exploration of rainfall and statistical method through review previous research and identify the high potential method that has been done by other researcher. All relevant experimental, descriptive, theoretical and analytical techniques used in other research will be outlined. From reviewing the research, the part of literature review can be done. Next, explore the important data that relate to trend analysis of rainfall. The data of rainfall can be extract from online website or related organisation.

b. Geology Kampung Sungai Batu

The geological mapping was one of the important tasks to achieve the objective of the research. This task was to identify all the geological aspects such as lithology, geomorphology and structural geology in the study area. This was to produce detailed and updated the geological map. Geological mapping of Kampung Sungai Batu, Dabong is done by review the previous journal and article from previous researcher that conduct mapping in the same study area. In addition, explore and extract the important and related data from the related organisation and website.

3.3.2 Desk Studies

a.Trend analysis

Trend analysis method in this research divide into two method which is the secondary data analysis and map interpretation. Secondary data analysis involves in three stage which is data exploration, model development and model evaluation. Distribution of rainfall map is produced by the yearly rainfall intensity map.

b.Geology Kampung Sungai Batu

Geological map of Kampung Sungai Batu is conduct by interpretation of geomorphology or land use in study area and based on the geological process occur and the geological structure form in this study area. Meanwhile, the type of rock and the variable from the data interpretation can be proposed to perform updated geological map. In addition, this part was performed by overlay other researcher map that do the same study area. Also, the observation by using satellite image from Google Earth.

3.3.3 Laboratory analysis

a. **Trend analysis**

The collection data from government open data and Department of Irrigation and Drainage (DID) will be extract and change the format of the data in to Microsoft Excel. Furthermore, all the data from rainfall station need to select, this is because not all the data from rainfall station could be uses, this way in which the data might be broken or can become outdated. The coordinate and location for 53 rainfall station will show in a map.

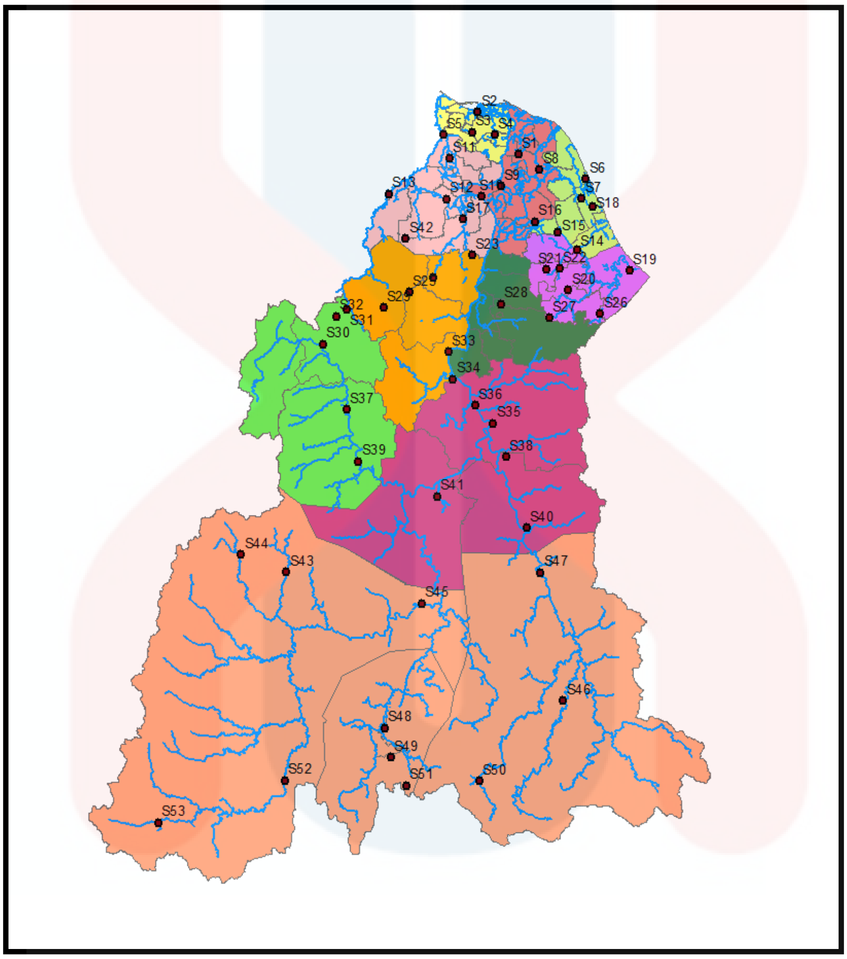


Figure 3.1 : Location of Rainfall Station Distribution in Kelantan State

Table 3.2: Rainfall station in Kelantan

Station	Station	ID	LOCATION	Latitude	Longitude
S1	Station 1	6122064	JPS Kota Bharu	6.1083	102.2569
S2	Station 2	6121067	Kereta api Tumpat	6.1986	102.1694
S3	Station 3	6121015	CHABANG AMPAT	6.1556	102.1569
S4	Station 4	6121001	Kg. Kebakat	6.1500	102.2056
S5	Station 5	6120014	KUALA JAMBU	6.1500	102.0958
S6	Station 6	6024074	JABATAN PERTANIAN BACHOK	6.0556	102.4014
S7	Station 7	6023072	TERATAK PULAI	6.0139	102.3917
S8	Station 8	6023001	KG. BINJAI	6.0750	102.3014
S9	Station 9	6022062	CHABANG TIGA PENDEK	6.0403	102.2194
S10	Station 10	6021060	RUMAH PAM SALOR	6.0181	102.1778
S11	Station 11	6021013	RUMAH KERAJAAN JPS. at MERANTI	6.1000	102.1083
S12	Station 12	6021010	RUMAH PAM REPEK	6.0125	102.1028
S13	Station 13	6019004	RUMAH KASTAM at RANTAU PANJANG	6.0236	101.9792

S14	Station 14	5923081	TOK AJAM	5.9042	102.3819
S15	Station 15	5923001	SERDANG at GUNONG BARAT BACHOK	5.9417	102.3417
S16	Station 16	5922001	STN. PERTANIAN MELOR	5.9639	102.2917
S17	Station 17	5921009	IBU BEKALAN TO' UBAN	5.9694	102.1375
S18	Station 18	5824081	SG. PETAI	5.9972	102.4153
S19	Station 19	5824080	KG. BERIS at CHERANG RUKU	5.8597	102.4944
S20	Station 20	5823077	LDG. CHERANG TULI	5.8181	102.3639
S21	Station 21	5823076	RUMAH PENGA. BKT. ABAL	5.8611	102.3167
S22	Station 22	5823001	IBU BKLN. TIGA DAERAH	5.8639	102.3444
S23	Station 23	5821007	STN. K'API BKT. PANAU	5.8917	102.1583
S24	Station 24	5820006	BENDANG NYIOR	5.8444	102.0736
S25	Station 25	5820005	PEJ.P'TANI BTG. MERBAU	5.8125	102.0236
S26	Station 26	5724002	KG. WAKAF RAJA	5.7667	102.4319
S27	Station 27	5723056	TELUSAN	5.7583	102.3222
S28	Station 28	5722057	JPS MACHANG	5.7875	102.2194
S29	Station 29	5719001	KG. DURIAN DAUN at (LAWANG)	5.7806	101.9681
S30	Station 30	5718033	KG. JELI	5.7014	101.8389
S31	Station 31	5718002	AIR LANAS	5.7750	101.8889
S32	Station 32	5718001	KG. GEMANG BAHRU	5.7611	101.8667
S33	Station 33	5621052	LDG. KERILLA	5.6847	102.1069
S34	Station 34	5621051	LDG. KENNETH	5.6264	102.1167
S35	Station 35	5522047	JPS KUALA KRAI	5.5319	102.2028
S36	Station 36	5521050	LDG. KUALA NAL	5.5708	102.1639
S37	Station 37	5518035	LUBOK BUNGOR	5.5611	101.8889
S38	Station 38	5422046	LDG. LAPAN KABU	5.4597	102.2306
S39	Station 39	5419036	LDG. KUALA BALAH	5.4500	101.9139
S40	Station 40	5322044	KG. LALOK	5.3083	102.2750
S41	Station 41	5320039	LDG. KUALA GRIS	5.3750	102.0819
S42	Station 42	5320038	DABONG	5.9278	102.0153
S43	Station 43	5217001	PASIK	5.2139	101.7597
S44	Station 44	5216001	GOB	5.2514	101.6625
S45	Station 45	5120025	BALAI POLIS BERTAM	5.1458	102.0486
S46	Station 46	4923001	KG. ARING	4.9375	102.3528
S47	Station 47	4922001	RKT LEBIR	5.2125	102.3042
S48	Station 48	4819027	GUA MUSANG	4.8792	101.9694
S49	Station 49	4816101	REDIP	4.8167	101.9833
S50	Station 50	4721001	UPPER CHIKU	4.7653	102.1736
S51	Station 51	4720026	LDG. MENTARA	4.7556	102.0167
S52	Station 52	4717001	BLAU	4.7667	101.7569
S53	Station 53	4614001	BROOK	4.6764	101.4847

3.3.3.2 Geology Kampung Sungai Batu

Laboratory work conduct by the interpretation of base map, topographic map, and DEM data. The purpose of maps interpretation are to identify the types of rock that dominate in study area based on different contour pattern, lineament as indicator for structure geology, and correlate and compare the study area with nearest study area from other researcher. Moreover, catchment topography and shape can be determined by the interpretation of map. Catchment topography which is size, shape, soil type and elevation of study area.

3.3.4 Data processing

a.Trend analysis

For further understanding for time series of rainfall analysis, Mann-Kendall Test was performed. Statistical non-parametric tests, viz., Mann-Kendall (MK) test were applied to the rainfall series. The Mann Kendall (MK) test method is a ranked non-parametric test used to analyze trends of hydrometeorological series. The Mann–Kendall (MK) test method also shows upward and downward trends with statistical significance. The strength of the trend depends on the magnitude, sample size and variations of data series. The trends in MK test is not significantly affected by the outliers occurred in the data series since the MK test statistic depends on positive or negative signs.

Individual time series data of rainfall is compared with all corresponding time series data of the year. When the data point of later year is larger than the data point of previous year, the MK statistics is increased by one otherwise the MK statistics decreased by one. Thus, the MK statistics is the cumulative result of all the data values. The Mann-Kendall test statistics “S” is then equated as:

$$S = \sum_{i=1}^{n-1} \cdot \sum_{j=i+1}^{n} sgn(\, X_j - X_i) \quad (1)$$

The trend test is applied to X_i data values (i = 1, 2,..n − 1) and Xj (j = i + 1, 2,…n). The data values of each X_i is used as a reference point to compare with the data values of X_j which is given as:

$$sgn(X_j - X_i) = \begin{cases} +1 \text{ if } (X_j - X_i) > 0 \\ 0 \text{ if } (X_j - X_i) = 0 \\ -1 \text{ if } (X_j - X_i) < 0 \end{cases} \quad (2)$$

where X_i and X_j are the values in period i and j. When the number of data series greater than or equal to ten (n ≥ 10), MK test is then characterized by normal distribution with the mean E(S) = 0 and variance Var(S) is equated as:

$$E(S) = 0 \quad (3)$$

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{k=1}^{m} t_k(t_k - 1)\,(2t_k + 5)}{18} \quad (4)$$

Where m is the number of the tied groups in the time series, and t_k is the number of ties in the kth tied group. The test statistics Z is as follows:

$$Z = \begin{cases} \frac{S-1}{\delta} \text{ if } S > 0 \\ 0 \text{ if } S = 0 \\ \frac{S+1}{\delta} \text{ if } S < 0 \end{cases} \quad (5)$$

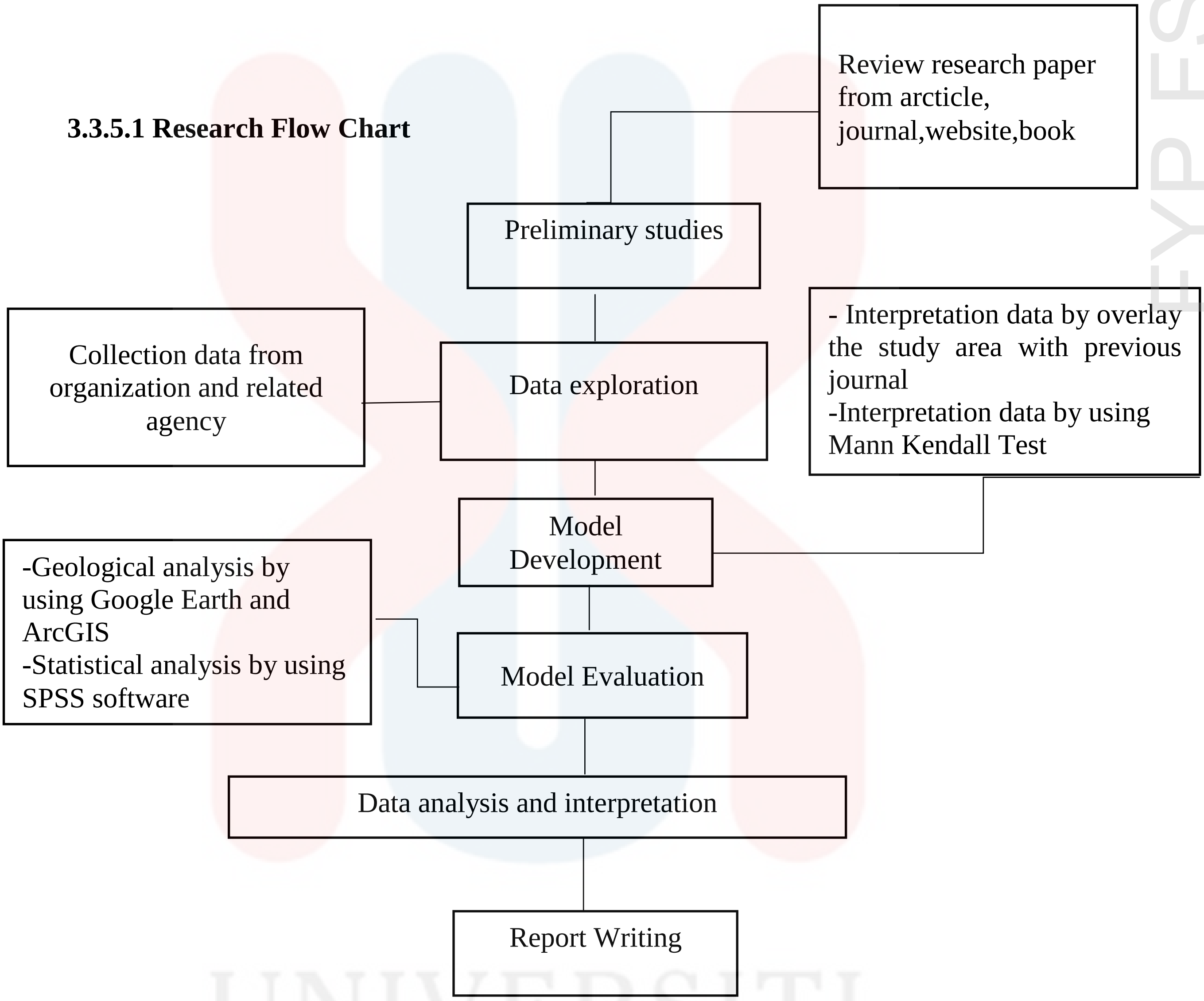
When Z is greater than zero, it indicates an increasing trend and when Z is less than zero, it is a decreasing trend.

b.Geology Kampung Sungai Batu

A topographical map is a map that shows the physical features of the land. Besides just showing landforms such as mountains and rivers, the map also shows the elevation changes of the land. Elevation is shown using contour lines. When a contour line is drawn on a map it represents a given elevation. Every point on the map touching the line should be the same elevation. Topography determines the speed which the runoff will reach a river clearly, clearly rain that falls in the steep mountainous area will reach the river faster than flat or gently sloping areas .Shape will contribute to the speed with the runoff reaches a river. A long thin catchment will take longer to drain than a circular catchment. Size will help determine the amount of water reaching the river, as the larger the catchment the greater the potential for flooding. Soil type will help to determine how much water reaches the river. Certain soil types such as sandy soils are very free draining and rainfall on sandy soil is likely to be absorbed by the ground. However, soils containing clay can be almost impermeable and therefore rainfall on clay soils will run off and contribute to flood volumes. Land use will contribute to the volume of water reaching the river, in a similar way to clay soils. Rainfall on roofs, pavement and roads will be collected by rivers with no absorption into groundwater (Vishwas et. al, 2002).

3.3.5 Data analysis and interpretation

3.3.5.1 Research Flow Chart



3.3.5.2 Data analysis

Firstly, the availability of the lost data was checked in the research through frequency analysis. All the collection data from DID was analysed for each quantitative. In order to do this, the data need to convert in Microsoft Excel format is examine and correlate with others station. Through the data which will analyse so as to see whether the data is complete or not, the analysis will perform.

The GIS analysis was an interpretation of the geological map by using ArcGIS 10.3 software. By using this software, the topographic of the selected area was analyzed and determined. Moreover, this software also was used to updated new geological features.

3.3.6 Data evaluation

Trend Analysis: The secondary data from Department of Irrigation and Drainage (DID) will be analysed using the daily, monthly, yearly data has been aggregated to prepare annual rainfall series for different station. The statistical parameters like standard deviation, and maximum were computed for these series. Further, the rainfall series were checked for presence of serial correlation, and if the series were found to be correlated. The nature of trend in time series were determined by time series analysis.

The data analysis was carried out to find the statistical parameters (mean, standard deviation, maximum of annual precipitation series for the period 2009-2019). The Mann-Kendall trend test are used to perceive statistically significant decreasing or increasing trend in long term temporal data. The Mann-Kendall trend test based on two hypothesis: one is null (H_0) and the other is the alternative (H_1). The H_0 express the existence of no trend while H_1 elucidate significant rising or declining trend in precipitation data.

3.4 Report writing

This was the final step for final year project research. The final year project included six chapters which consist of introduction, literature review, materials and methodologies, general geology, specification, and conclusion. The specification referred to a selected topic of the research which spatio-temporal data of rainfall data analysis by using Mann-Kendall Test. All data collected and the findings were written in the report. The format of the report followed by the guidelines given by Faculty of Earth Science, University Malaysia Kelantan.

CHAPTER 4

GENERAL GEOLOGY OF KAMPUNG SUNGAI BATU, DABONG

4.1 Introduction

This chapter is important because it more focus to complete the report. General geology is related to the part of geomorphology, stratigraphy, historical geology and structural geology of study area will described in detailed. This chapter is done by geological mapping and also literature review.

4.1.1 Accessibility

Accessibility is defined as the connection road in study area which connected from one area to another area. Accessibility usually exists because related with the socioeconomic activities in an area. In the study are, Kampung Sungai Batu is classify as an accessible area in certain area due to the villagers main activities is plantation. There are two types of road, paved and unpaved road. Normally, paved road can be access by big automobile such as lorry and car, but unpaved road that only can found in the forest mainly can be access by small vehicle, motorcycle. Based on figure 4.1, can be seen clearly there only main road to access mapping area. The main road connects Jeli to Dabong. Also, there is railway station at Dabong to access the study area and a huge river nearby, called Sungai Galas which provided accessibility to this mapping area.

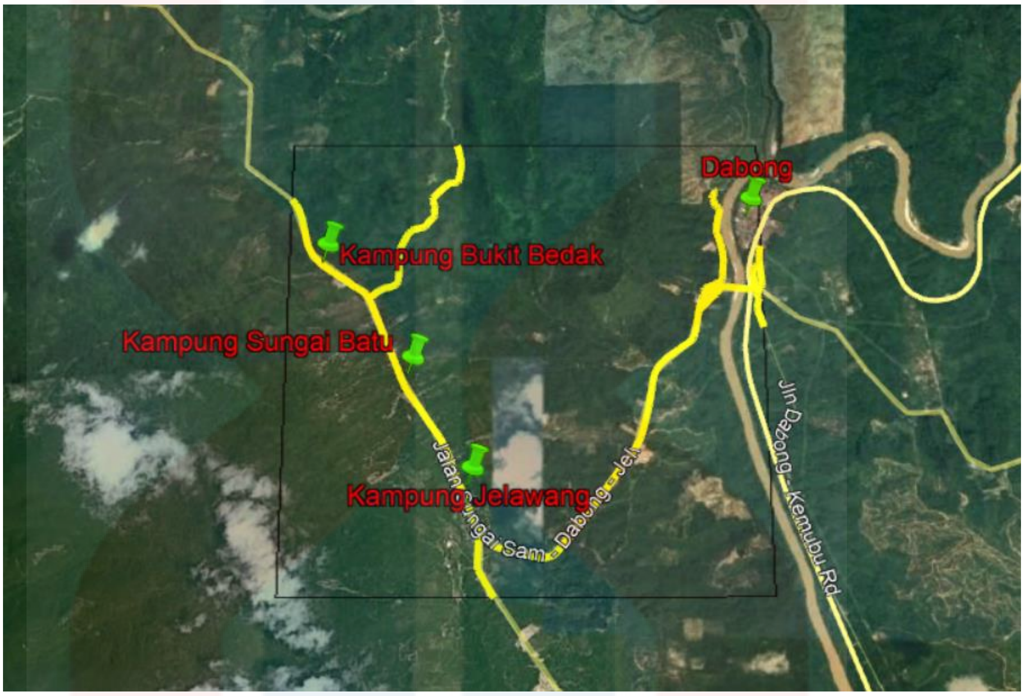


Figure 4.1 : Show the road system in the study area in yellow line

4.1.2 Settlement

Settlement is related to the activities that are settled by human. Gunung Stong is considering as Recreation Park due to the climbing activities. In the study area, there are several name of village area. The village are Kg Sg. Batu, Kg Bukit Bedak and Kg Jelawang. In each of the village, there are different population that settled in there and Kg Sg.Batu is covered the high population among others village. Kg Sg. Batu is located at the northern part while Kg Jelawang located at western part in the study area. Also, Dabong town were located in this mapping area at North to East mapping area.

4.1.3 Land use

Figure 4.2 refers to land use map of research area that has been dominated by rubber plantation and forest reserves. The main activities among the villagers in the study area are the vegetation which is also their main source income. Forestry is natural phenomena because in the study area because the area mostly still covered by forest because the small population. The villagers mostly work as a rubber tapper because the rubber plantation area can be found in the study area. The rubber plantation is mainly being planted in the flat area. The vegetation in the study area related to the landscape itself. The villagers planted the rubber tree at slope area and plain area. They utilize the landform and natural resources in their daily main socioeconomic.

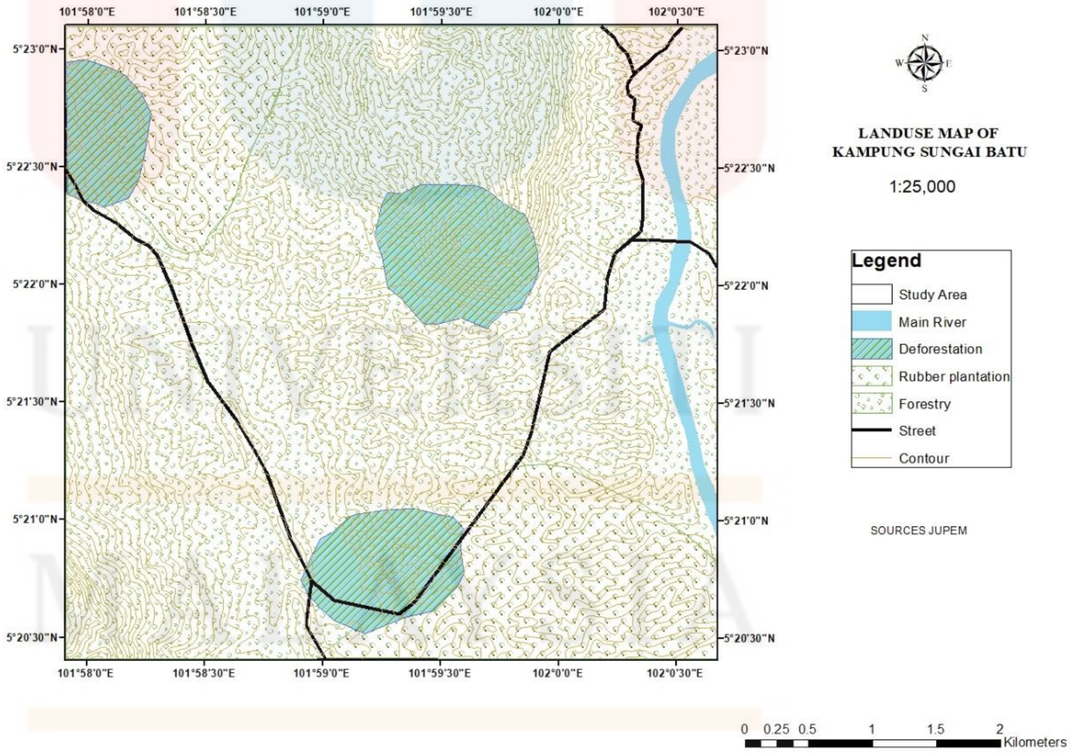


Figure.4.2 : Landuse Map of study area

4.2 Geomorphology

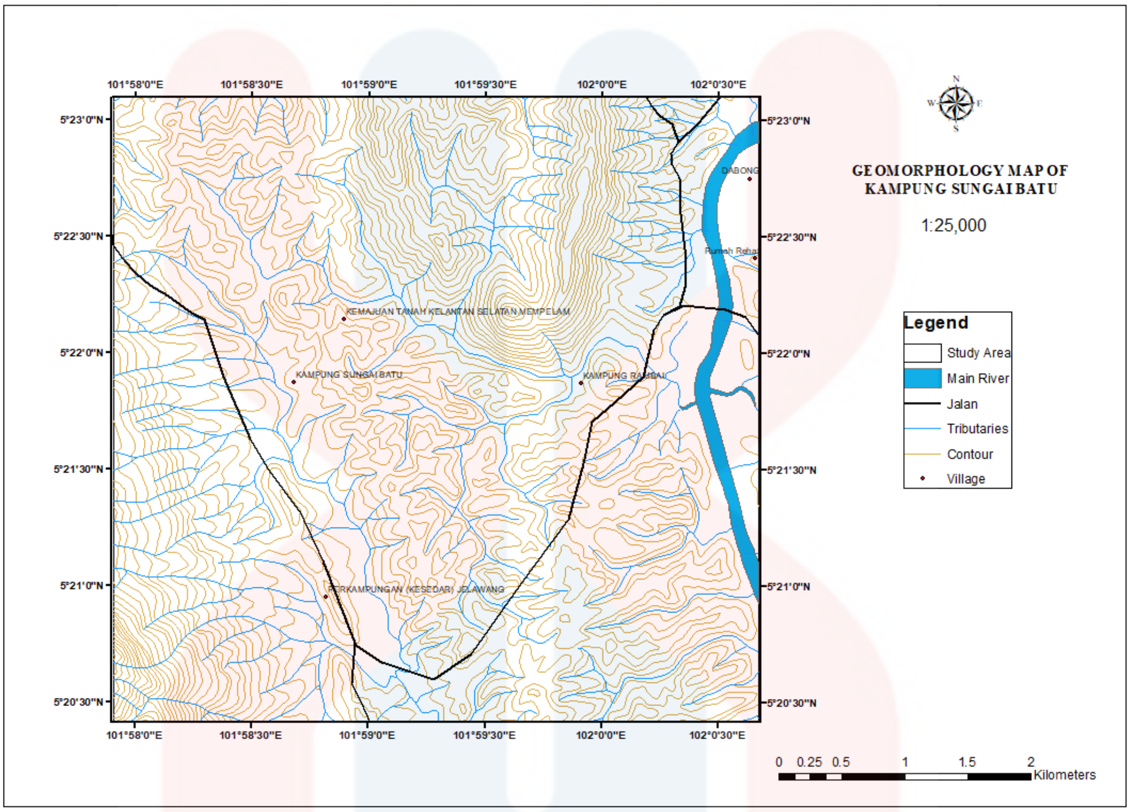


Figure 4.3: Geomorphology Map of study area

Geomorphology focused on geomorphologic classification, topography, type and process of weathering and drainage pattern of study area. The geomorphology is differentiating based on the elevation and important to be indicator movement of water. Various planning can be done to manage the natural resources based on it is categorized of landform. Generally, geomorphology is defined as study of the characteristics, origin and development of the landforms. The geomorphology part included the study of the topography, weathering and drainage pattern of the study area in the study area.

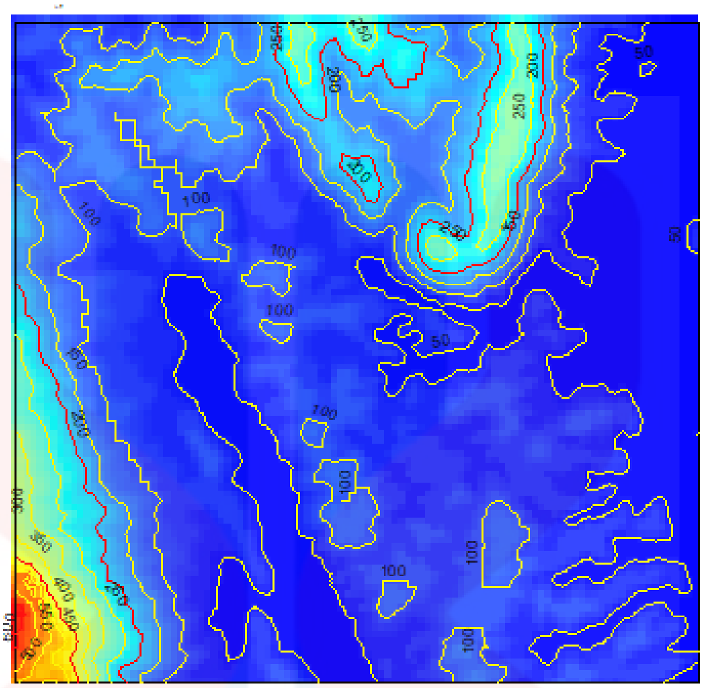


Figure 4.4: Geomorphology map

	< 250 Meter	Inland Low Land
	250 Meter – 500 Meter	Hill
	500 Meter – 1500 Meter	High Hill

4.2.1 Geomorphologic classification

Geomorphology is referred to the landform and landscape of Earth. Landform such as mountain, valley and slope are those are characterizing as an individual features. Landscape is defined as combination of numerous landforms such as mountainous and terrain. The processes that shape the landforms are because of two broad categories either endogenic and exogenic process which the processes take a long period of time to form. Endogenic is described as process that driven by internal convection that operate beneath the surface of Earth such as tectonic process, volcanism and isostacy animation. Endogenic is a process that operates on the Earth surface such as weathering, erosion and aeolian activity. Based on the study area, geomorphology can be divided into three major parts which are mounts, plains and hills. Mostly the study area covered by mountain and the highest mountain located at the eastern part of study area known as Stong Mount. Mountain usually recognizes in form of peak, is a large landform that rise above the surrounding land.

Valley is identifying drained by rivers and occur in flat plain or between hills while flat area landform that commonly occurs in low land known as plain area. Fluvial process is a morphology formed by the process deposition that associated by rivers and stream.

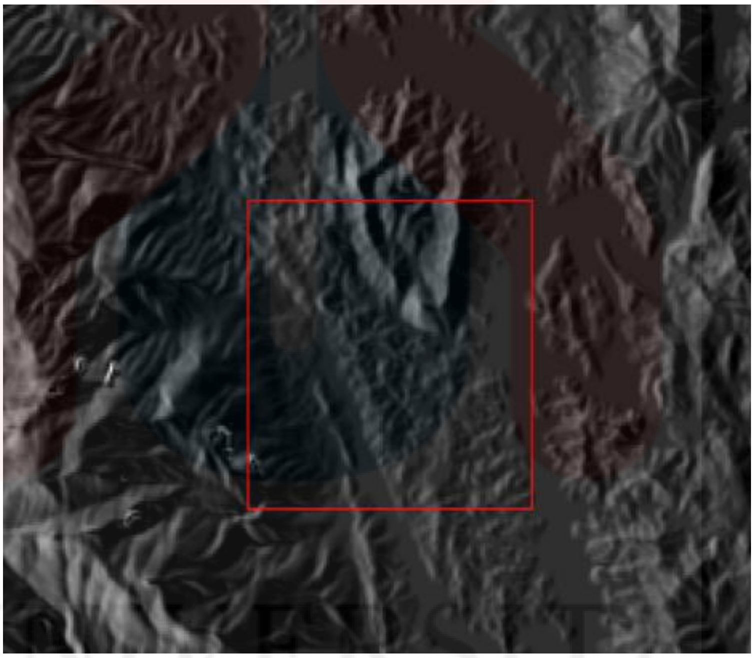


Figure 4.5: The image of terrain map for study area

4.2.2 Drainage Pattern

Drainage pattern in other word also called as river system is classifying as one of the types of geomorphology. The formation of river system is created by the streams, lakes and river in a particular drainage basin. The pattern is control by topography and gradient of land either the presence of bedrock and structures. Stream also classifying as a drainage basin where is topographic region from which receives groundwater flow, runoff and through flow. There are some types of drainage pattern such as dendrite, parallel, trellis, rectangular and radial.

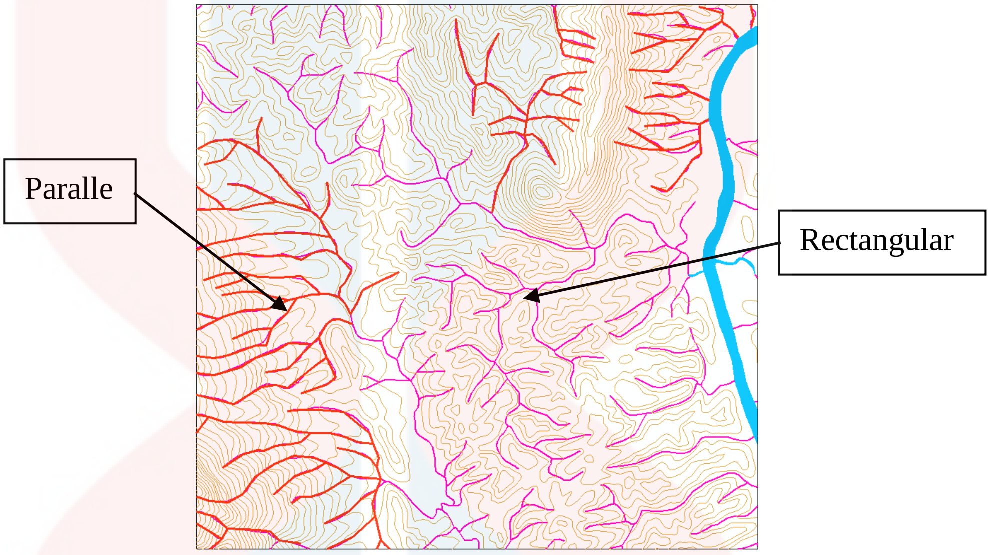


Figure 4.6 : Drainage Pattern

Drainage pattern found in the study area mostly found rectangular and parallel pattern and drainage basin which all the small river are being accumulated and then separated to other adjacent basin. Figure 4.6 shows the overall types of drainage pattern. New updated drainage pattern is produce after being observed. The rectangular pattern is identified at the low hill in the study area. Rectangular drainage pattern commonly form in the area that faulting occurs. This pattern develops when stream flow to the rock which is uniform resistance to erosion. The faulting that happens to the surface produces the off sets to the stream. Finally, straight line of stream produced with small tributaries join into the main stream. The parallel pattern is observed at the western side of study area. Parallel is one type of drainage pattern that can be found in the study area. The formation is caused by the steep slopes with some terrain. The steep slopes make the stream to flow straight in same direction with a very few tributaries. The pattern also develops in a region of parallel, elongate landform like outcropping resistant rock bands. Tributaries system encourages stretching out in a form of parallel following the surrounding of slopes. Parallel pattern usually act as an indicator existence of the structure such as faulting that across the steeply bedrock area.

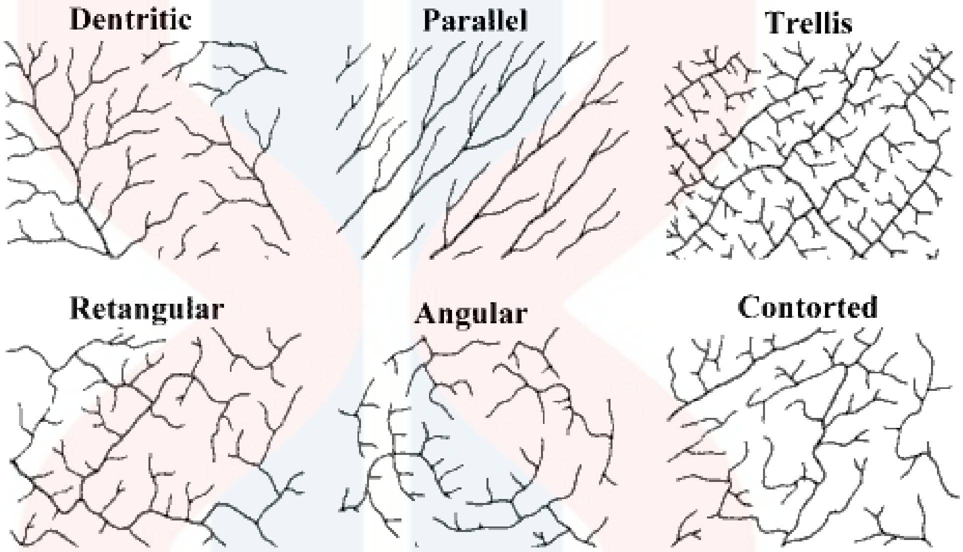


Figure 4.7 : Type of drainage pattern

4.2.3 Topography

Topography is a study of shape, features of surface and also description of the formation. The features that related to the study area are included hilly, mountainous, plain, rolling and undulating. Based on (Raj,2009) and (Van Zuidam, 1985), the topographic unit can be divided into differences elevation:

Table 4.1: Topography unit from Van Zuidam

< 50 METER	LOW LAND
50 METER – 100 METER	INLAND LOW LAND
100 METER - 200 METER	LOW HILL
200 METER – 500 METER	HILL
500 METER – 1500 METER	HIGH HILL
1500 METER – 3000 METER	MOUNTAIN
> 3000 METER	HIGH MOUNTAIN

Source: Van zuidam (1985)

Table 4.2: Topography unit form Raj (2009)

Description	Low lying	Rolling	Undulating	Hilly	Mountainous
Mean elevation(m)	<15 meters above sea level	16-30 meters	31-75 meters	76-300 meters	>301 meters

Source : Raj (2009)

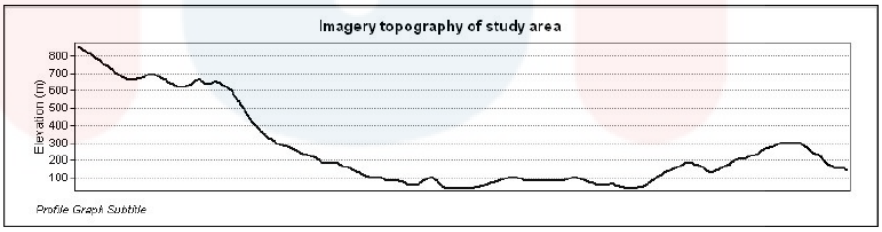


Figure 4.8: Topography profile of study area

The hill area have characteristic of igneous rock. Meanwhile, the undulating area is consisting of sedimentary rock, metasediment and metamorphic rock. From geomorphology analysis carried out in this area, the types of rocks that presences in the area are identified based on topography pattern. Metamorphic rock is classified as the major rock constituent in the research area. There is also sedimentary rock that undergoes metamorphism process and metamorphed into metasediment rocks.

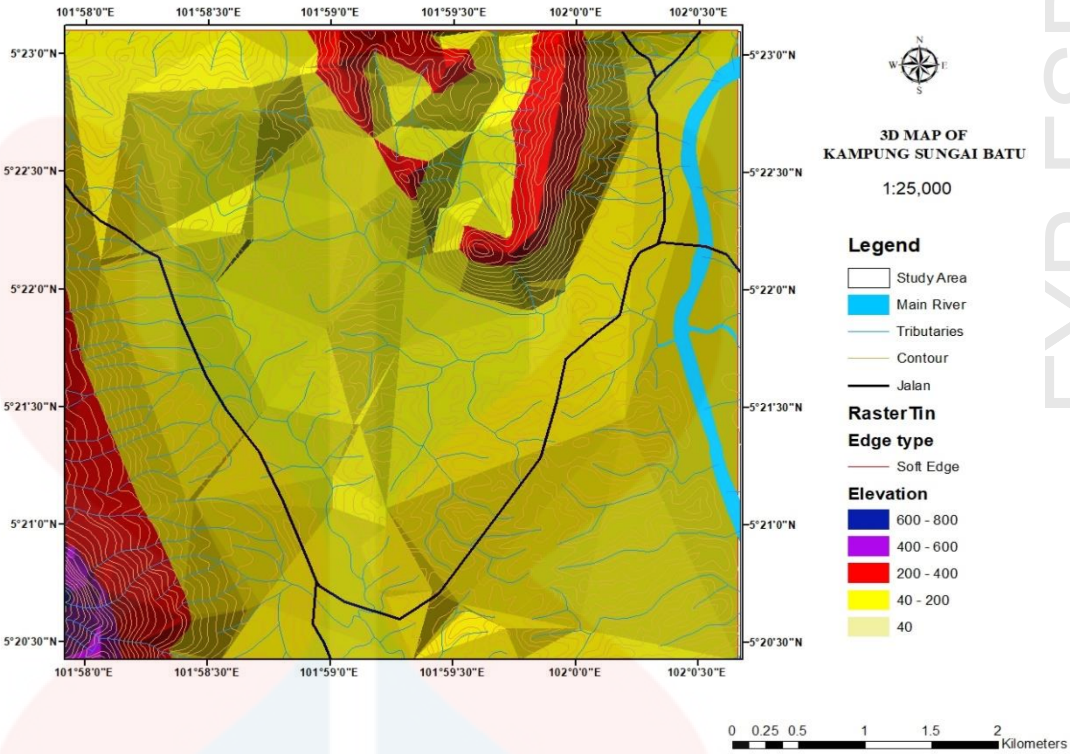


Figure 4.9: 3D map of study area

4.3 Lithostratigraphy

Table 4.3: Lithology unit of study area

ERA	PERIOD	UNIT	LITHOLOGY	DESCRIPTION
CENOZOIC	QUATERNARY	ALLUVIAL		Alluvial consists mainly of sand, silt and clay. Widespread in the flat valley
UNCONFORMITY				
MESOZOIC	TRAISSIC	STONG MIGMATIC COMPLEX		Granite : acid intrusive rock
				Metasandstone
				Marblelized limestone
				Phyllite

This part focused on rock description in detail which is started from the youngest to the oldest based on their ages. The units were named based on the dominant lithology.

Stratigraphy is involved studying about the strata and layering (stratification) of rock layer. This part divided to the several subfields such as lithostratigraphy, biostratigraphy, sequence of rock, and chronostratigraphy. The most concerned will focused about the lithostratigraphy. This also involved studies about sequence of lithology of the study area and deformation formed due the formation occurs. Research area consists of rocks from Permian until Triassic. This Permo-Trias formation composed of main several rock which extended to North Kelantan and North Pahang (Shafeea,2004). Lithology on this area is mainly covered by the oldest rock from Phyllite during Mesozoic era. And continue with overlay rock from marbleized limestone, metasandstone and igneous rock as the younger rock. There are hiatus after the formation of igneous rock and deposited by alluvium as the recent.

4.4 Structural geology

Structural geology explained all the structure that found during geological mapping. The structure geology found is lineament mechanism of structures. This part is important to investigate the information about the strain and stress in the rocks to seek and explored about the past history of the Earth.

Structural geology is the processes or product of rock deformation. This part is carried out to identify the structure that occurs in mapping area by lineament analysis. The structural analysis is done by plotting all the data into the software which are Rose diagram for joint analysis. ArcGIS also being used for analyse the topography and lineament as indicator of structure to mapping.

4.4.1 Geology structures

Joint is defined as break, brittle-fractured and natural process occurs on rock which exposed to the surface. Commonly, joint can be identifying nearly to the surface of rock and form in various directions either vertical or horizontal. Joint can be form in singly, but mostly in a joint set. Joint has been carried out by using terrain map from google map.

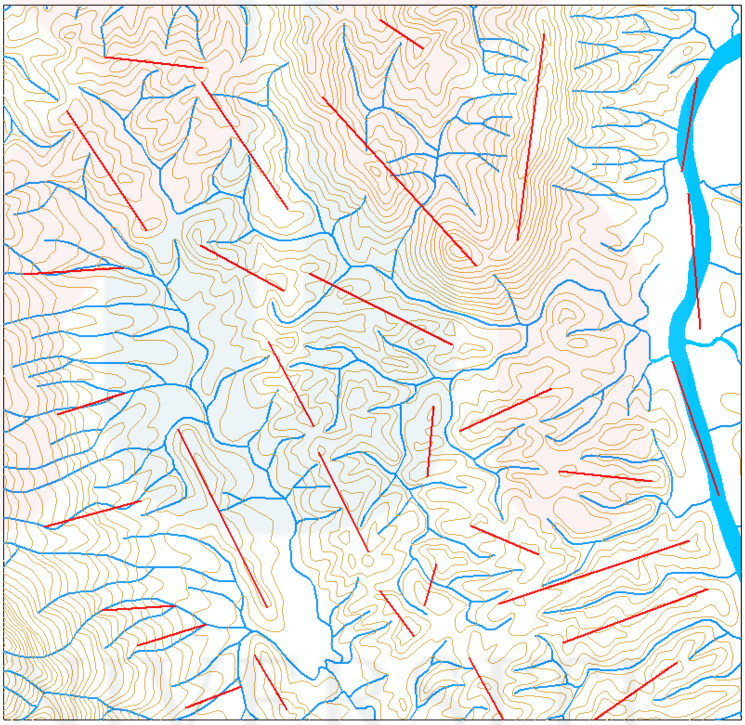


Figure 4.10: Lineament analysis

There are two main types of lineament which is positive and negative, referring to ridge trends and river valleys respectively. Whilst the topographically negative straight lineaments may represent joints, faults and shear zones, the topographically positive straight lineaments may be interpreted as dykes and dyke swarms. The slightly curved and sub-parallel lineaments indicate foliation or bedding trends, depending on rock type (crystalline or limestone) while circular features may delineate ring dykes (Koch and Mather 1997).

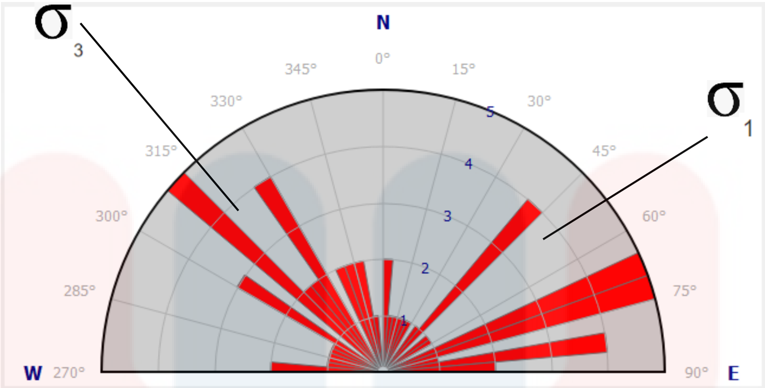


Figure 4.11 : Rose diagram

Based on figure 4.11, from the rose diagram result shows that force comes from two direction which in from North to East and North to West. North to East is classified as sigma 1 and North to west refer as sigma 3. In order to completely understand and resolve the state of stress at some point in the earth's crust, there are nine components to consider. Three of these are normal stresses, and six are shear stresses. The concept of principal stress helps simplify this understanding. By definition, all states of stress include three mutually perpendicular normal stresses, which are referred to as sigma 1, sigma 2, and sigma 3. Principal stresses are perpendicular to principal plains, where are defined as a plane where no shear stress exists. The Earth's surface is a principal plane because it is a free surface, and thus can't support a shear stress. This means that one principal stress is always vertical, and the other two are perpendicular to it and in the plane of the Earth's crust. Sigma 1 is defined as the greatest compressive stress, sigma 2 is the intermediate stress, and sigma 3 is the least principal stress. In normal fault systems, sigma 1 tends to be vertical, or cleavage tends to form in the plane of flattening, which is perpendicular to sigma 1.

4.5 History of geology

For historical geology, this was focused on chronology of the events that changes of Earth including geologic process is similar to the past and its life form. History geology in structture studied the rock changes due to the tectonic setting occur. An example that occurs because of the tectonic setting was Peninsula Malaysia. Due to the collision between western Gondwana which integral part of Peninsula Malaysia (Sibumasu) and Indochina continental block (East Malaya), a major normal fault form known as Bentung-Raub Line. The fault extends from Thailand and Peninsular Malaysia (Mustaffa, 2009). The northern part of Peninsula was consists of complex high-grade metamorphic which the process of uplifting occurs and deeply eroded while tilted down occurs to the south. Stong Migmatite Complex formed a mountainous country which lying 8km west of railway town of Kemubu and Dabong and Gunung Stong is including to the formation (Hutchison, 2009). Migmatite Stong Complex is located in northern part of Peninsular consist three plutonic components which are Berangkat Tonalite, Kenerong Leucogranite and Noring Granite. Berangkat Tonalite and Kenerong Leucogranite categorized as the oldest are deformed while the youngest, pink Noring Granite is undeformed. Kenerong Leucogranite consists of three dominant lithology, biotite granite, schist and metasedimentary rock. According to (Hutchison, 2009), the Kenerong Leucogranite is interpreted as Cretaceous ages. The geologic processes that occur are Berangkat Tonalite is cut by Kenerong Leucogranite and being intruded by Noring Granite. Based on (Ghani, 2009), the characteristic of Kenerong Leucogranite known as a complex network of small intrusive which is emplaced in magmatic metasedimentary, pelitic. Pelitic is a sedimentary rock that undergoes metamorphosed (Kurt, 2002). The changes of Kenerong Leucogranite involving three generation from unfoliated to intensely foliate.

As a conclusion for this chapter, Geology of Kampung Sungai Batu can be classified as flood prone area due to the location of Main River which is Sungai Galas include in this study area. Moreover, the geomorphology of Kampung Sungai Batu is mostly covered by inland low land with elevation below than 250 meters. Area of North to East is high tendency prone area to overflow by water which covered the residential area. This study area is mostly covered by forestry and deforestation. During rainfall, the soil moisture content present within the soil is increase. This is because after a rainfall, the surface soil will absorb high amount of water which then increases the soil moisture content present within the soil. If there is a heavy rainfall, it will have the possibility of overflow to be occurred. All of these factor will be proven to discussion on the next chapter.

CHAPTER 5

RESULT AND DISCUSSION

5.1 Flood prone area

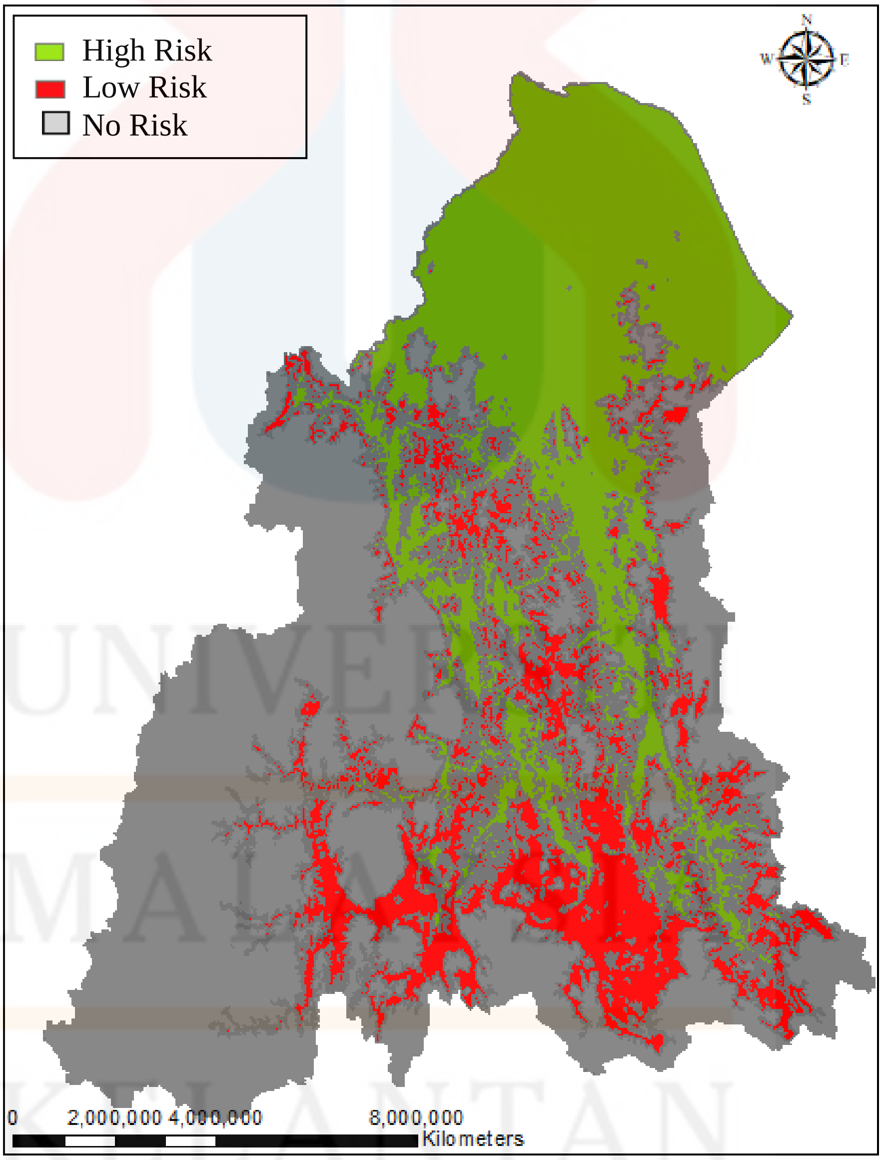


Figure 5.1:**Flood prone area map in Kelantan**

Based on Figure 5.1, the high risk of flood prone area show covered on north to central area of Kelantan and the low risk of flood prone area occur at south of Kelantan. The central part of Kelantan which covered from North Jeli, Tanah Merah and Kuala Krai and then go to North of Kelantan which is covered by Kota Bharu, Tumpat, Machang, Bachok, Pasir Mas and Pasir Puteh are part of Kelantan that having a low and high probability on flood events. For area which covered by the green colour less probability on flood events. The area of low flood probability which is a few area on central and south part which covered by Gua Musang area .For grey area, there is no potential for flood to be occur . The flood risk map produce based on the reclassify of elevation.

5.2 Spatial Analysis of Rainfall Data

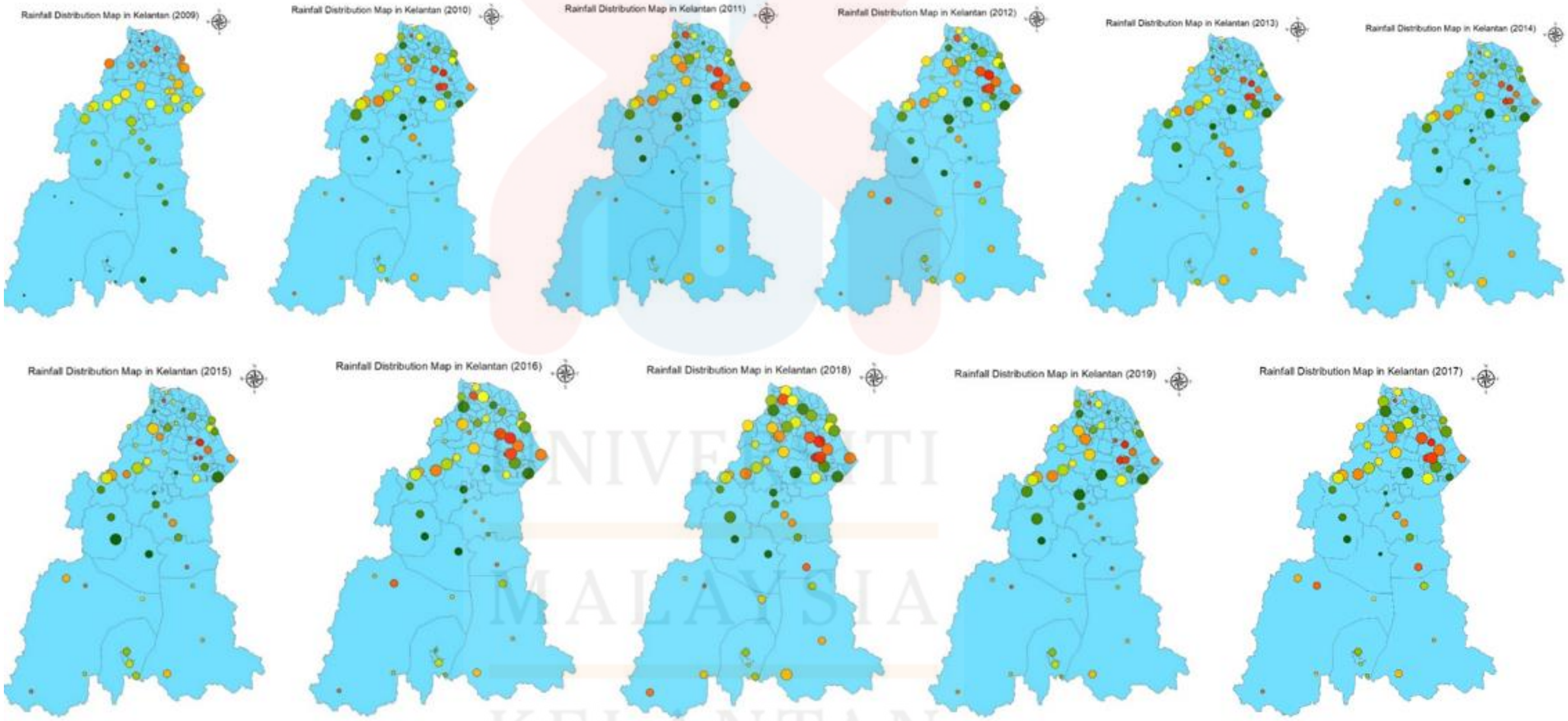


Figure 5.2: Distribution of rainfall by year

The spatial analysis is conduct by produce 11 rainfall distribution map. The average rainfall data be used and classified by year. Based on 11 rainfall distribution map in Kelantan from 2009 to 2019, the change of size is perpendicular with the average rainfall in year. Based on figure 5.2, most of the rainfall station that received heavy rainfall is on year 2018 which has the bigger size of rainfall distribution than other years. During year 2009, the areas which received highly precipitation are Tanah Merah, Machang and Pasir Puteh. On year 2010, North of Jeli and Tanah Merah have received the most precipitation of rainfall. From map rainfall distribution on year 2011 and 2012, it shows that the same area has received most precipitation of rainfall which is Jeli, Tanah Merah, Machang, Pasir Puteh and Pasir Mas. During 2013, Jeli, Tanah Merah, Pasir Mas, Kuala Krai and Machang have received the highest annual rainfall. Based on map of year 2014, Tanah Merah and Machang rainfall station have recorded the highest annual total rainfall for year 2014. Compare to 2009 until 2019 map, year 2015 has experienced the lowest total precipitation at all station in Kelantan and the highest rainfall station occurred at Jeli. Most of the rainfall station located at North Kelantan have experienced highly precipitation along the year 2016. During year 2017, Tanah Merah, Pasir Puteh, Pasir Mas and Machang experienced the highest precipitation of rainfall. All of the rainfall station received the increasing recorded of precipitation during year 2018. The total rainfall for 2019, the area that have experienced heavy rainfall are Jeli, Pasir Putih and Machang. As a conclusion based on all of map distribution of rainfall station, it shows that certain area experienced the heavy rainfall for every year and a few area experienced the uneven pattern of annual total rainfall.

5.3 Trend Analysis of Rainfall Data

5.3.1 Descriptive statistic of rainfall station and dataset from 2009 to 2019

Table 5.1: Descriptive analysis

Station	Latitude(N)	Longitude(E)	Average	Maximum	Total	Standard Deviation
Station 1	6.108	102.257	14.65	269	16426.5	2.3736
Station 2	6.199	102.169	14.53	244	16244.5	2.3121
Station 3	6.156	102.157	13.99	339.5	15360	2.2792
Station 4	6.150	102.206	15.77	305	17929.5	2.8817
Station 5	6.150	102.096	16.07	470.5	16893	3.9606
Station 6	6.056	102.401	16.36	281	18662	2.1678
Station 7	6.014	102.392	14.99	253.5	17972	3.1086
Station 8	6.075	102.301	15.14	329.5	17830	2.0934
Station 9	6.040	102.219	15.85	515.5	18736.5	2.9560
Station 10	6.018	102.178	17.14	528	20723.5	2.9454
Station 11	6.100	102.108	16.79	451.5	19210	3.9879
Station 12	6.013	102.103	19.18	435	21155	2.8892
Station 13	6.024	101.979	18.08	368.5	19548	3.3786
Station 14	5.904	102.382	17.72	455.5	22044	3.8548
Station 15	5.942	102.342	16.37	494.5	20199	3.6437
Station 16	5.964	102.292	15.99	313	18216.7	6.2193
Station 17	5.969	102.138	19.11	401.5	20655	4.0978
Station 18	5.997	102.415	17.72	455.5	22044	4.3384
Station 19	5.860	102.494	17.07	495.5	20199	3.4673
Station 20	5.818	102.364	18.31	465.5	22922.5	3.2589
Station 21	5.861	102.317	15.42	319.5	17746	3.5386
Station 22	5.864	102.344	18.24	537	21467.5	4.2804
Station 23	5.892	102.158	18.00	382	21883.5	3.5769
Station 24	5.844	102.074	16.56	399	18977	2.4119
Station 25	5.813	102.024	19.12	306.5	24741.5	2.2257
Station 26	5.767	102.432	18.96	434.5	24402.5	2.7510
Station 27	5.758	102.322	17.45	387	22322	2.7491
Station 28	5.788	102.219	18.70	482.5	22406	3.8217

Station 29	5.781	101.968	18.27	239	24702	1.9242
Station 30	5.701	101.839	16.72	309	22132.4	2.9627
Station 31	5.775	101.889	18.17	333	24655.5	2.4607
Station 32	5.761	101.867	17.21	345	23090.5	2.4787
Station 33	5.685	102.107	14.86	223.5	16966.4	2.6415
Station 34	5.626	102.117	15.08	169	17562.4	2.3468
Station 35	5.532	102.203	13.71	229	15990	2.4895
Station 36	5.571	102.164	14.04	193	16601	2.7153
Station 37	5.561	101.889	14.88	194.5	21614.5	1.9960
Station 38	5.460	102.231	13.74	214	16766.5	2.9330
Station 39	5.450	101.914	14.37	258	18764	2.5298
Station 40	5.308	102.275	12.90	222	16462	2.4805
Station 41	5.375	102.082	13.27	199.5	17203.5	1.5591
Station 42	5.928	102.015	13.56	190	17182	1.6300
Station 43	5.214	101.760	12.53	178.5	15229.5	1.5505
Station 44	5.251	101.663	11.72	276.5	16227.5	2.0406
Station 45	5.146	102.049	11.43	190.1	15254	2.0028
Station 46	4.938	102.353	13.78	295.5	15955	3.1964
Station 47	5.213	102.304	13.07	143.5	17022.5	2.6455
Station 48	4.879	101.969	13.27	218.5	16490.5	1.7878
Station 49	4.817	101.983	13.20	174.5	15595	1.6180
Station 50	4.765	102.174	16.32	370.5	21621.5	2.6713
Station 51	4.756	102.017	12.15	237.5	15003.5	1.2868
Station 52	4.767	101.757	11.23	163	14839	2.9351
Station 53	4.676	101.485	10.44	145.8	13736.5	2.0740

Descriptive statistic refer to average, maximum, total and standard deviation for annual total rainfall during 2009 to 2019. For maximum is 24655.5 mm and highest standard deviation is 6.2193 mm. The maximum total rainfall is 23090.5 mm.

5.3.2 Analysis of average rainfall for 2009 to 2019

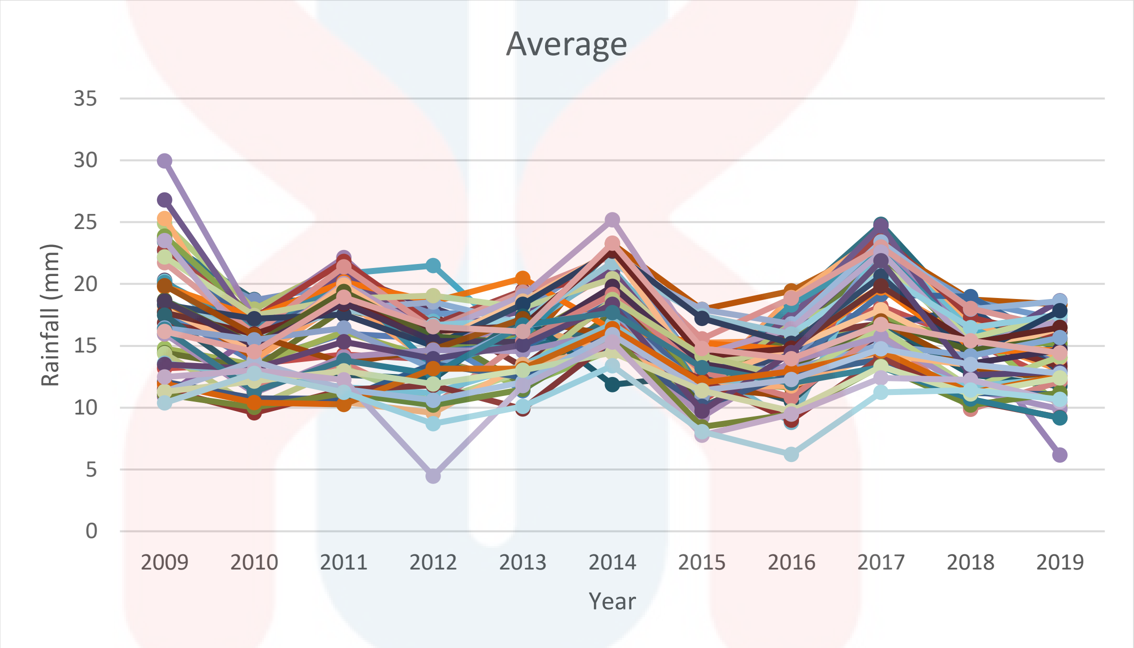


Figure 5.3: Graph of average annual rainfall (2009-2019)

Average rainfall for each station from 2009 to 2019 were produced in graph. Range for average of rainfall of this graph from 0 to 35 mm. The maximum of rainfall occur during year 2009, 2014 and 2017. It is based on comparison the movement of graph between each year. During year 2009, 2014, and 2017, most of the station are experience increasing of the precipitation when compared to the other year.

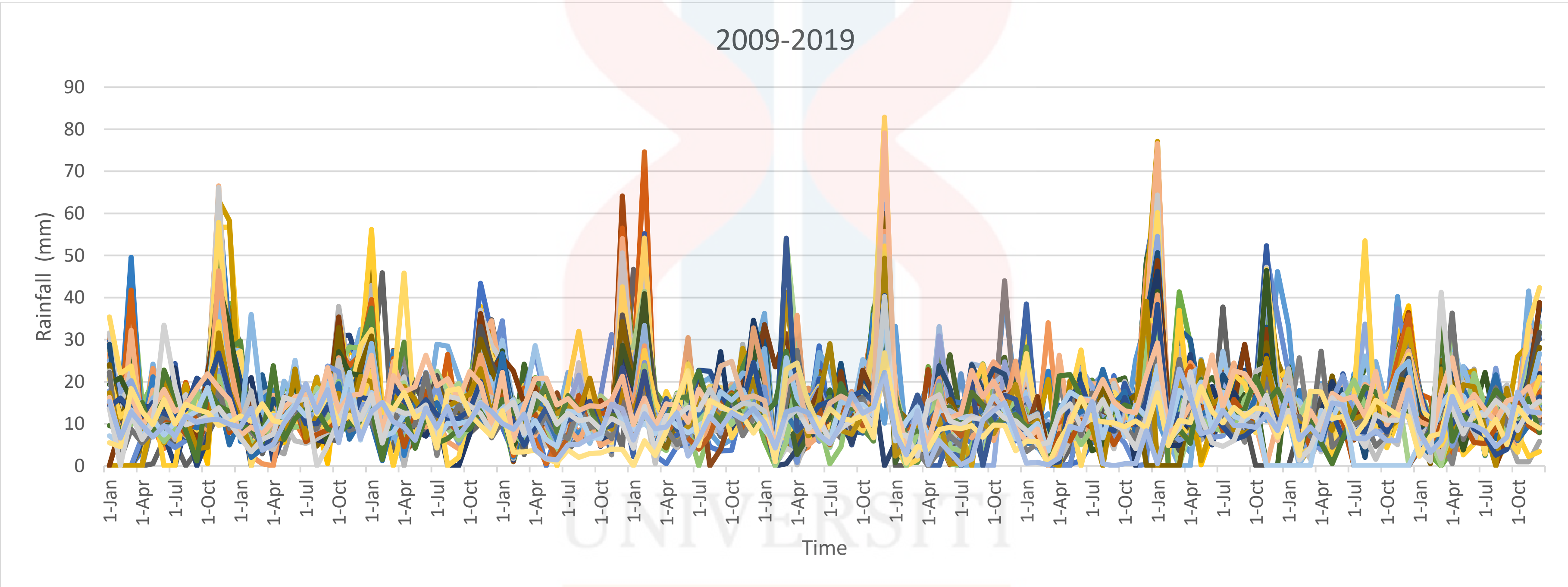


Figure 5.4 : Graph of average rainfall in month

Based on the Figure 5.4, pattern for monthly rainfall shows that the increasing precipitation of rainfall occur during end and early of the year from October until April. The highest of precipitation of rainfall can be observed during October 2014 until January 2015 with value more than 80mm.

5.3.3 Analysis of average rainfall in each year for each station

Table 5.2: Statistical rainfall analysis by year

Station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Station 1	30.92	24.34	30.41	46.63	24.80	19.18	40.24	34.82	46.15	40.24	29.55
Station 2	28.28	27.28	26.41	41.29	22.61	33.48	25.83	40.88	40.30	37.40	22.46
Station 3	32.00	24.92	31.26	41.65	21.80	30.06	17.90	42.72	50.93	36.23	23.03
Station 4	43.59	27.50	37.88	53.13	28.92	39.52	19.74	45.15	50.13	38.05	27.50
Station 5	45.75	28.52	47.21	42.65	31.85	31.33	17.12	48.89	63.98	34.17	26.71
Station 6	38.78	25.98	31.58	53.55	25.86	37.52	24.27	36.43	41.33	32.17	27.12
Station 7	47.93	27.42	34.81	48.98	26.71	29.24	19.50	37.21	36.89	35.63	24.82
Station 8	38.48	27.46	31.34	64.14	23.82	33.63	22.88	45.45	40.69	36.48	25.83
Station 9	35.87	28.91	45.91	21.18	46.74	40.39	17.74	45.19	62.10	30.80	27.36
Station 10	46.44	23.71	46.45	52.23	38.39	47.02	20.54	37.61	66.40	24.83	32.43
Station 11	43.30	31.06	30.93	52.05	24.41	34.81	20.68	48.66	55.79	34.95	26.70
Station 12	40.24	22.91	31.60	43.30	33.38	54.34	26.40	49.00	59.20	27.68	33.88
Station 13	49.42	32.46	32.03	42.04	31.78	48.19	22.21	28.41	42.68	25.67	41.55
Station 14	64.86	27.97	38.32	47.84	31.08	44.75	18.46	45.77	65.18	30.04	28.10
Station 15	56.15	37.90	42.89	41.12	33.94	33.89	15.44	38.61	51.85	35.28	32.88
Station 16	56.80	35.03	56.20	47.29	28.00	37.78	20.00	37.77	60.21	32.61	18.00
Station 17	49.41	27.17	34.45	34.45	42.80	53.61	20.50	26.94	50.00	37.33	28.44
Station 18	60.77	28.25	31.71	40.83	39.34	40.40	22.04	32.19	61.12	29.00	30.96
Station 19	62.29	27.36	34.24	46.69	30.13	38.48	17.78	32.28	41.96	34.85	25.48
Station 20	58.02	27.59	39.53	56.50	74.63	52.34	21.84	39.52	67.17	35.85	31.77
Station 21	55.54	27.50	33.97	49.58	38.83	49.52	44.00	22.61	46.64	30.38	27.62
Station 22	63.15	26.72	36.55	51.22	39.76	47.81	18.10	41.02	77.14	32.52	30.12
Station 23	46.37	27.12	37.06	20.73	55.18	63.16	14.85	38.50	53.52	27.52	32.77
Station 24	51.59	29.69	37.50	48.52	45.14	55.08	28.81	28.27	48.50	20.86	28.20
Station 25	39.98	27.25	31.87	31.77	40.16	55.06	33.12	31.83	53.03	25.28	34.14
Station 26	66.55	28.11	34.46	54.02	41.45	64.70	24.73	35.06	76.62	27.31	33.70
Station 27	66.15	29.13	36.88	50.59	48.97	63.59	19.73	24.33	64.40	25.78	31.07
Station 28	57.79	30.18	45.80	42.52	54.17	82.88	20.88	29.04	60.19	26.43	42.33
Station 29	35.70	29.00	29.36	30.86	37.97	62.15	30.86	32.31	54.55	33.67	31.10

Station 30	36.88	26.50	29.98	27.42	41.50	58.07	20.11	26.87	46.05	19.69	33.24
Station 31	37.88	33.44	31.86	26.93	36.50	57.00	24.05	35.25	50.66	23.52	37.55
Station 32	38.30	35.41	36.19	25.74	35.06	53.98	17.46	26.21	48.79	19.33	38.83
Station 33	44.26	23.41	33.18	35.88	37.61	59.91	17.56	22.69	43.50	25.56	31.74
Station 34	43.65	32.82	30.87	34.26	36.08	58.70	18.15	19.50	29.20	21.38	28.17
Station 35	43.35	24.54	20.03	27.85	40.18	23.10	23.26	33.75	46.28	20.08	21.88
Station 36	42.77	27.14	22.21	28.66	40.91	48.19	19.88	19.48	46.44	20.67	23.50
Station 37	39.59	36.00	29.13	24.55	33.39	50.73	18.92	28.15	35.77	26.08	26.74
Station 38	46.32	25.68	26.33	23.06	32.75	55.75	24.93	23.79	40.61	13.98	20.34
Station 39	27.29	25.17	18.76	14.54	17.58	54.50	20.04	30.93	32.10	23.09	19.88
Station 40	34.24	17.66	22.56	31.96	27.45	52.27	24.06	34.22	34.89	53.50	22.25
Station 41	22.75	23.72	19.18	17.54	24.56	43.59	20.04	30.30	28.64	21.34	23.19
Station 42	21.23	20.13	15.59	14.56	23.88	45.04	19.19	29.79	31.60	20.41	34.88
Station 43	16.24	19.54	15.00	26.66	15.70	41.30	13.81	22.92	23.79	14.75	21.63
Station 44	18.80	14.80	17.68	16.69	17.34	46.79	18.76	11.85	25.50	14.37	14.94
Station 45	22.23	15.92	22.11	16.50	19.71	42.28	14.22	17.77	26.79	27.25	36.30
Station 46	31.59	23.00	23.07	21.47	20.60	49.36	19.35	39.17	25.58	18.10	23.00
Station 47	26.81	16.24	20.10	23.30	24.55	54.13	19.85	19.74	38.37	20.02	17.40
Station 48	22.77	23.78	14.97	19.44	22.54	34.52	17.47	21.67	21.21	18.80	33.00
Station 49	18.58	22.19	17.46	15.68	18.05	35.64	16.55	17.57	23.79	16.89	18.13
Station 50	21.88	23.34	26.31	22.19	24.82	79.13	22.64	21.57	29.20	22.48	25.72
Station 51	33.40	16.30	16.90	17.23	18.20	40.26	16.88	15.73	22.32	16.21	41.25
Station 52	18.33	19.53	18.38	13.13	22.63	26.86	12.21	16.21	18.83	17.79	18.75
Station 53	15.36	19.53	15.10	14.65	13.66	22.20	15.03	15.27	23.00	18.04	17.56

The maximum precipitation of rainfall occur during 2014 for 79.13 mm and followed by 2017 with 77.14 mm. During 2009, the precipitation also higher than other with 64.86 mm.

5.3.4 Trend Analysis using Mann-Kendall (MK)

Table 5.3: Mann Kendall Analysis

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
S1	132	0	132	1.167	46.630	13.339	9.142
S2	132	0	132	0.000	41.292	12.044	8.851
S3	132	0	132	0.000	50.925	11.788	8.779
S4	132	0	132	0.000	53.125	13.623	10.472
S5	132	0	132	0.000	63.975	13.355	11.207
S6	132	0	132	0.000	53.545	14.587	9.706
S7	132	0	132	0.000	48.981	13.851	9.429
S8	132	0	132	0.000	64.143	13.392	9.880
S9	132	0	132	0.000	62.100	13.199	10.720
S10	132	0	132	0.000	66.400	15.129	10.944
S11	132	0	132	0.000	55.786	13.904	10.504
S12	132	0	132	0.000	59.200	16.355	10.019
S13	132	0	132	0.000	49.417	16.038	9.894
S14	132	0	132	0.000	65.175	15.722	11.130
S15	132	0	132	0.000	56.152	14.866	10.164
S16	132	0	132	0.000	60.214	14.743	12.194
S17	132	0	132	0.000	53.614	15.592	10.618
S18	132	0	132	0.000	61.119	14.657	10.827
S19	132	0	132	0.000	62.286	15.577	10.110
S20	132	0	132	0.500	74.625	16.832	12.274
S21	132	0	132	0.000	55.540	14.251	10.183
S22	132	0	132	0.000	77.139	15.842	12.350
S23	132	0	132	0.000	63.158	15.583	11.138
S24	132	0	132	0.000	55.083	15.834	10.326
S25	132	0	132	0.000	55.060	17.218	9.258
S26	132	0	132	0.000	76.619	16.775	11.427
S27	132	0	132	0.500	66.146	15.914	11.431
S28	132	0	132	0.000	82.881	16.635	12.504
S29	132	0	132	0.000	62.152	16.631	9.304

S30	132	0	132	0.000	58.068	15.512	9.163
S31	132	0	132	0.000	57.000	16.231	8.993
S32	132	0	132	0.000	53.981	15.571	8.782
S33	132	0	132	0.000	59.906	13.926	9.067
S34	132	0	132	0.000	58.705	14.102	8.457
S35	132	0	132	0.000	46.278	12.349	8.116
S36	132	0	132	0.500	48.188	13.828	8.550
S37	132	0	132	0.000	50.729	14.271	7.694
S38	132	0	132	0.000	55.750	12.402	8.317
S39	132	0	132	0.000	54.500	12.197	6.984
S40	132	0	132	0.000	53.500	13.097	8.305
S41	132	0	132	1.000	43.593	12.053	6.177
S42	132	0	132	0.000	45.038	11.674	6.386
S43	132	0	132	0.000	41.295	10.977	5.785
S44	132	0	132	0.000	46.792	10.363	5.565
S45	132	0	132	0.000	42.277	10.885	6.280
S46	132	0	132	0.000	49.357	13.034	7.614
S47	132	0	132	0.000	54.125	12.865	7.036
S48	132	0	132	0.500	34.519	12.354	5.500
S49	132	0	132	0.000	35.636	11.119	5.603
S50	132	0	132	0.500	79.125	15.348	7.862
S51	132	0	132	0.000	41.250	11.416	5.974
S52	132	0	132	0.000	26.858	10.422	5.239
S53	132	0	132	0.000	23.000	9.363	4.930

Mean precipitation of the study region from 2009–2019 was found to be 17.218 mm. The minimum and maximum recorded rainfall was 0.00 and 82.881 mm per year. The maximum standard deviation show 12.54 mm. The value of a variable may increase or decrease with respect to time. Trend analysis can judge whether the variable value may increase or decrease in a particular time or period.

Table 5.4: Mann Kendall Analysis

Series\Test	Kendall's tau	p-value	S	Var(S)	p-value (Two-tailed)	alpha
S1	-0.005	0.936	-41	258404.33	0.936	0.05
S2	0.061	0.301	526	258414.67	0.301	0.05
S3	0.017	0.768	150	258400.67	0.768	0.05
S4	0.016	0.789	136	258408.00	0.789	0.05
S5	0.072	0.219	625	258387.00	0.219	0.05
S6	-0.033	0.571	-288	258415.33	0.571	0.05
S7	0.005	0.931	44	258406.67	0.931	0.05
S8	0.042	0.474	364	258408.67	0.474	0.05
S9	0.182	0.002	1574	258388.00	0.002	0.05
S10	0.040	0.496	346	258398.67	0.496	0.05
S11	0.112	0.056	970	258365.33	0.056	0.05
S12	0.059	0.314	512	258415.33	0.314	0.05
S13	-0.048	0.410	-419	258401.67	0.410	0.05
S14	0.016	0.780	142	258415.33	0.780	0.05
S15	0.037	0.525	323	258399.67	0.525	0.05
S16	-0.019	0.751	-161	258373.00	0.751	0.05
S17	0.061	0.304	523	258397.67	0.304	0.05
S18	-0.031	0.599	-267	258416.33	0.599	0.05
S19	0.006	0.915	54	258408.67	0.915	0.05
S20	-0.014	0.810	-122	258412.67	0.810	0.05
S21	-0.025	0.671	-216	258398.67	0.671	0.05
S22	0.048	0.411	418	258398.67	0.411	0.05
S23	-0.048	0.415	-414	258408.67	0.415	0.05
S24	-0.101	0.086	-873	258413.67	0.086	0.05

S25	0.070	0.235	604	258415.33	0.235	0.05
S26	0.001	0.991	6	258417.33	0.991	0.05
S27	-0.043	0.460	-376	258415.33	0.460	0.05
S28	-0.083	0.158	-717	258415.67	0.158	0.05
S29	0.017	0.778	143	258415.67	0.778	0.05
S30	-0.104	0.076	-901	258414.33	0.076	0.05
S31	-0.040	0.501	-342	258417.33	0.501	0.05
S32	-0.043	0.468	-369	258413.67	0.468	0.05
S33	-0.088	0.134	-762	258386.00	0.134	0.05
S34	-0.032	0.584	-278	258402.67	0.584	0.05
S35	-0.015	0.804	-126	258400.67	0.804	0.05
S36	-0.065	0.271	-559	258414.33	0.271	0.05
S37	-0.053	0.368	-458	258417.33	0.368	0.05
S38	0.002	0.978	14	258411.33	0.978	0.05
S39	0.042	0.474	364	258419.33	0.474	0.05
S40	-0.067	0.255	-579	258418.33	0.255	0.05
S41	-0.033	0.575	-285	258416.33	0.575	0.05
S42	0.097	0.100	836	258415.33	0.100	0.05
S43	-0.040	0.499	-344	258390.00	0.499	0.05
S44	-0.084	0.156	-722	258388.00	0.156	0.05
S45	0.033	0.571	288	258417.33	0.571	0.05
S46	-0.061	0.303	-524	258406.67	0.303	0.05
S47	-0.173	0.003	-1494	258413.33	0.003	0.05
S48	0.062	0.289	539	258414.33	0.289	0.05
S49	-0.017	0.778	-143	258252.33	0.778	0.05
S50	-0.054	0.361	-464	258419.33	0.361	0.05

S51	-0.037	0.529	-320	258413.33	0.529	0.05
S52	-0.007	0.904	-61	258414.33	0.904	0.05
S53	-0.084	0.154	-724	258406.67	0.154	0.05

Based on the result from Mann-Kendall Test, most of the p-value is higher than alpha. When p-value is higher than 0.05, it show that this analysis is has trend and if less than 0.05 it refer to no trend in this analysis. Table 5.4 shows only five stations in Kelantan which are stations 9,11, 24, 30 and 47 that located in Chabang Tiga Pendek (Kota Bharu), Rumah Kerajaan JPS. At Meranti (Pasir Mas), Bendang Nyior (Tanah merah), Kampung Jeli (Jeli) and Rakit Lebir (Gua Musang) respectively has significant rainfall intensity trend at 0.05 and 0.1 significance level.

5.3.5 Discussion

Time series analysis seeks to understand patterns in changes over time. The study region characterized with maximum rainfall during 2014. There is inter-annual variability of rainfall over the stations. The result of this study is generally consistent with other research results which reported increased rainfall.

The Mann-Kendall Test analysis showed that decreasing and increasing trend of rainfall was observed across the station. However, there is no statistically significant trend at 95% level in all stations.

It was clear that increasing of rainfall in 2014 during the study of period was probably caused the major flooding in certain station and area affected. Some of other station also showed slightly increasing trend during 2014.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

This chapter will summarize all the objectives stated early in this research from the general geological mapping and trend analysis of rainfall. Both are described detail in Chapter 4 and 5. The objective of this research is to update the geological map and to study trend and time series analysis of rainfall. The previous geological map was obtained by overlay and compared with other researcher and peninsular geological map from JMG. In chapter 4, geological map was being updated with new finding during mapping and being described detail. The morphology and landform of study area are being explained by the help of contour map, drainage pattern and 3D topography map. The stratigraphy column of the study area was being classified. Phyllite is determining as the oldest rock, followed by marbleized limestone, metasandstone and the youngest, granite. The rock age arrangement is according to relative and several researches.

The second objectives are to study trend and time series analysis of rainfall in Kelantan. Based on the result obtained from Department of Irrigation and Drainage (DID), it indicates that the study rainfall trend analysis has the highest rainfall occur during October to January (2014). As can be seen it prove that the factor of major flood event on 2014 occur due to the highly intensity of rainfall. This study assessed the presence of trends in the annual of Kelantan River Basin. The findings of this study provide an insight into future development projects; for instance, it can present valuable information and a priori view to support the engineers and practitioners to implement the structures to be constructed to cope with the floods and droughts when looking at prevailing climatic events. The finding of the study can be beneficial in planning and management of water resources at Kelantan River Basin. The present analysis would be useful for implementing water conservation measures in the region to avoid water overflowing problems in near future given the increase in amount of total rainfall over the century.

6.2 Suggestion

Based on the result, there are some recommendations and suggestion can be done to improve the result of trend analysis of rainfall. Increasing the number of sample stations improves the precision and accuracy of the result for partical implementation. In addition, improve the quality of data from station need to be focus when has error and it will affect the final result. For further research, another test method need to be used in order to determine the accurate and consistence parameter of flooding. Rainfall data required to give more variable result and less error.

REFERENCES

Alias, N., Mohamad, H., Chin, W., & Yusop, Z. (2016). RAINFALL ANALYSIS OF THE KELANTAN BIG YELLOW FLOOD 2014. *Jurnal Teknologi*, *78*(9-4). doi: 10.11113/jt.v78.9701

Abdulkareem, J., & Sulaiman, W. (2016). TREND ANALYSIS OF PRECIPITATION DATA IN FLOOD SOURCE AREAS OF KELANTAN RIVER BASIN. *Jurnal Teknologi*, *78*(9-4). doi: 10.11113/jt.v78.9705

Badyalina, B., & Shabri, A. (2013). Streamflow Forecasting at Ungauged Sites using Multiple Linear Regression. *Matematika*, *29*(1), 67–75.

Bisht, D. S., Chatterjee, C., Raghuwanshi, N. S., & Sridhar, V. (2018). Spatio-temporal trends of rainfall across Indian river basins. *Theoretical and Applied Climatology*, *132*(1–2), 419–436. https://doi.org/10.1007/s00704-017-2095-8

Chan, N. W., Ghani, A. A., Samat, N., Hasan, N. N. N., & Tan, M. L. (2020). Integrating Structural and Non-structural Flood Management Measures for Greater Effectiveness in Flood Loss Reduction in the Kelantan River Basin, Malaysia. *Lecture Notes in Civil Engineering*, *53*(January), 1151–1162. https://doi.org/10.1007/978-3-030-32816-0_87

Gedefaw, M., Yan, D., Wang, H., Qin, T., Girma, A., Abiyu, A., & Batsuren, D. (2018). Innovative trend analysis of annual and seasonal rainfall variability in Amhara Regional State, Ethiopia. *Atmosphere*, *9*(9). https://doi.org/10.3390/atmos9090326

(Marinah Muhammad, 2020) *Kelantan Big yellow Flood 2014: Statistical Analysis on Relationship between Rainfall Intensity and water level*

Mishra, N., Khare, D., & Shukla, R. (2013). *TREND ANALYSIS OF ANNUAL*

RAINFALL IN UPPER GANGA CANAL COMMAND. *October*.

Nazaruddin, D. A., Fadilah, N. S., & Zulkarnain, Z. (2014). *Geological Studies to Support the Tourism Site : A Case Study in the Rafflesia Trail , Near Kampung Jedip , Lojing Highlands , Kelantan ,*. *2014*(July), 835–851.

Nashwan, M., Ismail, T., & Ahmed, K. (2018). Flood susceptibility assessment in Kelantan river basin using copula. *International Journal Of Engineering & Technology*, *7*(2), 584. doi: 10.14419/ijet.v7i2.10447

Nurashikin Sungip, F., Khairul Amri Kamarudin, M., Hafiz Md Saad, M., Abd Wahab, N., Puad Mat Som, A., & Umar, R. et al. (2018). The Impact of Monsoon Flood Phenomenon on Tourism Sector in Kelantan, Malaysia: A Review. *International Journal Of Engineering & Technology*, *7*(4.34), 37. doi: 10.14419/ijet.v7i4.34.23577

Nurul Syazwani Yahaya, Choun-Sian Lim, U. A. J. & J. J. P. (2015). The December 2014 flood in Kelantan : A post-event perspective. *Warta Geologi*, *41*(3), 54–57.

Pal, A. B., Khare, D., Mishra, P. K., & Singh, L. (2017). Trend Analysis of Rainfall, Temperature and Runoff Data: a Case Study of Rangoon Watershed in Nepal. *International Journal of Students' Research in Technology & Management*, *5*(3), 21–38. https://doi.org/10.18510/ijsrtm.2017.535

Salleh, A., & S Ahamad, M. (2019). Flood risk map (case study in Kelantan). *IOP Conference Series: Earth And Environmental Science*, *244*, 012019. doi: 10.1088/1755-1315/244/1/012019

Sathiamurthy, E., Halim, S. A., Supar, L., Atika, A., Abd, A., Hui, K. Y., & Pauzi, N. S. (2019). *Kelantan central basin flood , December 2014 : Causes and extend*. *68*(December), 57–67.

Structural geology of Gua Musang Formation in Kelantan. (2017). *36*(2), 2017.

Wan Jaafar, W., Liu, J., & Han, D. (2011). Input variable selection for median flood regionalization. *Water Resources Research*, *47*(7). doi: 10.1029/2011wr010436