GEOLOGY AND A SPATIO-TEMPORAL ANALYSIS OF RAINFALL DATA IN JELI, KELANTAN

by

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A proposal submitted in fulfillment in the requirements for the degree of Bachelor of Applied Science (Geosciences) with Honors.

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2023

DECLARATION

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

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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".

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Date :

ACKNOWLEDGEMENT

This is a great honour for me to address the individuals that assisted me during the entirety of this project to improve both my theoretical and practical abilities, particularly in the research domain. Because of the generous assistance and support of a large number of people, my thesis was able to become a reality; thus, I would like to offer my most deepest gratitude to each one of them.

My compliments also express my gratitude to Dr. Marinah Binti Muhammad, who oversaw the completion of my final year project and provided invaluable direction and feedback during the process of writing this report. This report would not have been attainable without her direction and the steadfast assistance she provided throughout the process. Many thanks to each and every professor who helped me learn during my time spent at the institution. The entirety of their expertise and instruction has not only provided me with knowledge in the field of geosciences but also inspired me to continue acquiring new information.

Also, I would like to use this opportunity to convey how grateful I am to you for assisting me in finishing the specification research. My fellow friends, likes Nik Amri, Muhammad Ibrahim and other classmates who are deserve recognition as well for the support they provided during this research project, such as accompanying me to the location for the mapping procedure. Not quite the least of which is the fact that I would be nothing without their blessing, prayer, and support. My wonderful parents are represented here. Without their backing, all of my hard work would be for nothing.

GEOLOGY AND SPATIO TEMPORAL ANALYSIS

IN JELI KELANTAN

ABSTRACT

This research is based on the selected flood-prone locality in the chosen region. Jeli is one of the districts in Kelantan which located in East Coast of Peninsular Malaysia, at the foot of the Main Range. The range is mostly made up of granitic rocks, with a few enclaves of sedimentary and meta sedimentary rocks thrown in for good measure. The objectives of the research are to update a 1:25,000-scale geological map of the area , to identify the spatio temporal pattern of rainfall data in Jeli area and last but not least to develop flood prone area map. To create geological maps, geographers employ a specific methodology, and GIS tools are used. The purpose of this study is to use suitable spatial statistical methods to time series rainfall data in Kelantan, with the intention of characterizing and determining the pattern of this data. Rainfall totals for each month from 2009 to 2019 were culled from records kept by the Department of Irrigation and Drainage (DID). The primary goal of this research is to use statistical methods to verify or disprove the hypothesis that excessive rainfall is the primary cause of perennial floods in the Jeli district of Kelantan. ArcGIS has been used to do a geographical analysis on the obtained rainfall data, allowing for a comparison of the rainfall distribution between 2009 and 2019. As a result, the Mann-Kendall (MK) Test implemented in SPSS has been used to examine the structure of the time series rainfall data. This study concludes from its analyses that the extreme flood event of 2014 was caused by the year's exceptionally high rainfall intensity.

Keywords : Peninsular Malaysia, Main range, Rainfall, Man Kendall, GIS

GEOLOGI DAN ANALISIS SPATIO TEMPORAL DATA HUJAN DI JELI, KELANTAN

ABSTRAK

Penyelidikan ini adalah berdasarkan lokaliti rawan banjir yang terpilih di kawasan yang dipilih. Jeli merupakan salah satu daerah di Kelantan yang terletak di Pantai Timur Semenanjung Malaysia, di kaki Banjaran Utama. Julat ini kebanyakannya terdiri daripada batuan granit, dengan beberapa enklaf batuan enapan dan meta dibuang ke dalam untuk ukuran yang baik. Objektif penyelidikan adalah untuk mengkaji corak atau arah struktur geologi semasa, mengenal pasti struktur geologi yang paling lazim di wilayah kajian dan mengemas kini peta geologi berskala 1:25,000 bagi kawasan yang dikaji. Untuk mencipta peta geologi, ahli geografi menggunakan metodologi tertentu, dan alat GIS digunakan. Tujuan kajian ini adalah untuk menggunakan kaedah statistik spatial yang sesuai untuk data siri masa hujan di Kelantan, dengan tujuan untuk mencirikan dan menentukan corak data ini. Jumlah hujan bagi setiap bulan dari 2009 hingga 2019 telah diambil daripada rekod yang disimpan oleh Jabatan Pengairan dan Saliran (JPS). Matlamat utama penyelidikan ini adalah untuk menggunakan kaedah statistik untuk mengesahkan atau menyangkal hipotesis bahawa hujan yang berlebihan adalah punca utama banjir saka di daerah Jeli Kelantan. ArcGIS telah digunakan untuk melakukan analisis geografi terhadap data hujan yang diperolehi, membolehkan perbandingan taburan hujan antara tahun 2009 dan 2019. Hasilnya, Ujian Mann-Kendall (MK) yang dilaksanakan dalam SPSS telah digunakan untuk meneliti struktur daripada data hujan siri masa. Kajian ini menyimpulkan daripada analisisnya bahawa kejadian banjir melampau pada tahun 2014 adalah disebabkan oleh intensiti hujan yang sangat tinggi pada tahun itu.

Kata kunci : Semenanjung Malaysia, Julat utama, Hujan, Man Kendall, GIS

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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

The study of geology, which includes lithology, topography, and geomorphology, this study's key objective in order to determined which areas of any site are most likely to be impacted by flooding. This research, which tries to identified any locations in a specific site that are more likely to be flooded than others, focuses a significant emphasis on the study of geology as its primary focus area which is the region of Jeli. This is as a consequence of the fact that, for instance, in this study region, which may be important to the particular research that is presently being carried out on statistical methodologies for spatial flooding analysis.

During this time, it is possible to connect that the geological feature of any region may have contributed to the flooding that has been occurring in Malaysia, specifically in the state of Kelantan for this current year. Particularly, it is feasible to link the flooding in Malaysia to the geological characteristics of each place. Recent years have been particularly catastrophic for the state of Kelantan due to floods. When doing this research study from a geological perspective, there are a number of considerations that need to be prioritized in the order that they are considered. These considerations take into account all of the information that is required and provide a contribution to the spatial temporal analysis.

Monitoring land use/cover for the development of site selection and survey data for urban planning, agriculture, and industry layout has been given increasing attention due to the evident emergence of Geographic Information Systems (GIS). More consideration and useful detail has been devoted to the mapping of land use/cover for the improvement of site selection and survey data provided for the improvement of urban planning, agricultural and industrial layouts. In many cases, the tool helps to accurately and precisely estimate the projected changes in land use/coverdata.

In the eyes of the United Nations, tropical cyclones and floods are the most devastating natural disasters that can occur. If satellite photos are processed, such as through the production of a digital elevation model (DEM) or the use of light detection and ranging (LiDAR), an early visual record of the situation can be obtained. In addition, a number of statistical analyses conducted in previous studies have demonstrated and assisted to discover patterns of rainfall and floods in a particular location and will support this study using spatial and temporal data.

During the monsoon rainy season in Malaysia, severe rainfall prompted flooding along many other parts of the country. Kelantan was one of the most struck places along Peninsular Malaysia east coast, and the state was one of the worst affected. For example, Kelantan experienced floods of variable severity every year. Terengganu and Pahang, two of the state's bordering states, are particularly hard hit. Kelantan's previous floods, such as those in 1927 and 1967, were historic disasters. Nearly a half of the state's residents were displaced as a result of the 1967 floods, which damaged 70 percent of Kelantan's communities. The 2014 Kelantan flood was the greatest and most devastating in the area's history.

At the end of December 2014, an extreme flooding event that had disastrous impacts occurred in the state of Kelantan, particularly in Jeli, one of the region that has been identify as flood prone area. Unfortunately, the effects of this floods were so severe that it rendered all facets of existence impossible. These natural disasters have a direct impact on the majority of the population, wreaking havoc on houses, infrastructure, and public utility networks (such as supply, water, power, and telephone) and interfering with business operations and other essential services. The economic damage caused by the flooding that occurred in December 2014 was expected to amount to two hundred million dollars.

1.1.2 Background of Study

One of the most common types of natural disasters that can cause widespread destruction to both lives and property is a flood. It is estimated that floods are responsible for as much as 90 percent of the damage caused by natural catastrophes in Malaysia. The typical amount of damage caused by floods each year can reach up to one hundred million dollars. The floods has caused significant damage to the roadways, the settlements, the agricultural, and the livelihoods of those affected. The occurrence of floods in Malaysia can be attributed to both natural and man-made reasons. Early communities in Malaysia built up along the banks of the peninsula's major rivers, therefore river life has always been ingrained in the culture of the Malaysian people. Flooding has become a regular occurrence in the life of a sizeable portion of Malaysians as a result of the interaction of natural elements, such as excessive monsoon rainfall and severe convective rainstorms, with other local variables, such as inadequate drainage.

Flooding caused by excessive rains not just to damages property, but also results in fatalities and severe suffering for the victims. In many places of the globe, including Malaysia, heavy rainfall was lead to cause of floods. Flood were a frequent occurrence in Malaysia, since the country's geographical position near the equator and surrounded by oceans exposes it to a climate with consistent temperatures and high humidity. As a result, the monsoon seasons have an effected on the rainfall distribution in Malaysia. Peninsular Malaysia, in particular, receives the greatest amount of precipitation during the transition period of the monsoon season. The months of December through March make up the northeast monsoon season, whereas the months of June through September make up the southeast monsoon season.

The topography of the land and the weather conditions during the monsoon season in the region are the two primary natural factors that contributed to the devastating flood. In order to identify flood-prone locations and the behaviours associated with flooding, the purpose of this study was to employ geographical and temporal rainfall data. The Department of Irrigation and Drainage (DID) of the Ministry of Natural Resources and Environment is in charge of managing flood control operations (NRE). Each year, flooding threatens to cover over 29,800 square kilometres of land that is located in Malaysia.

In the month of December 2014 in the state of Kelantan, there were a number of significant rivers that flowed from the higher elevations in the southern and southwestern parts of the state. When it reaches the lower heights of northern Kelantan, the amount of water in the river increases because it meets up with other, smaller rivers. This occurs as the river lowers in height. The region known as Jeli contains the highest concentration of river crossings of any other region in the country. As a direct consequence of this, even more attention has been focused on this region since the disaster.

1.2 Study Area

This study was conducted in the state of Kelantan, with the specific location of Jeli serving as the focal point of the investigation. Kelantan is a state in Malaysia that has a total land area of 15,099 square kilometres and is subdivided into a total of fourteen districts. The climate is generally warm and humid throughout the entire year, with low temperatures averaging between 21 and 32 degrees Celsius on a daily basis. According to the findings of the government in recent years, the district of Jeli in Kelantan has been identified as being particularly vulnerable to flooding, which is why it was chosen.

1.2.2 Location

This figures show the base map of the study area which is include Kampung Berdang and Bandar Jeli area in Jeli, Kelantan. As shows in the figure, some of the study was covered by high vegetation area and has different types of contour and elevation.

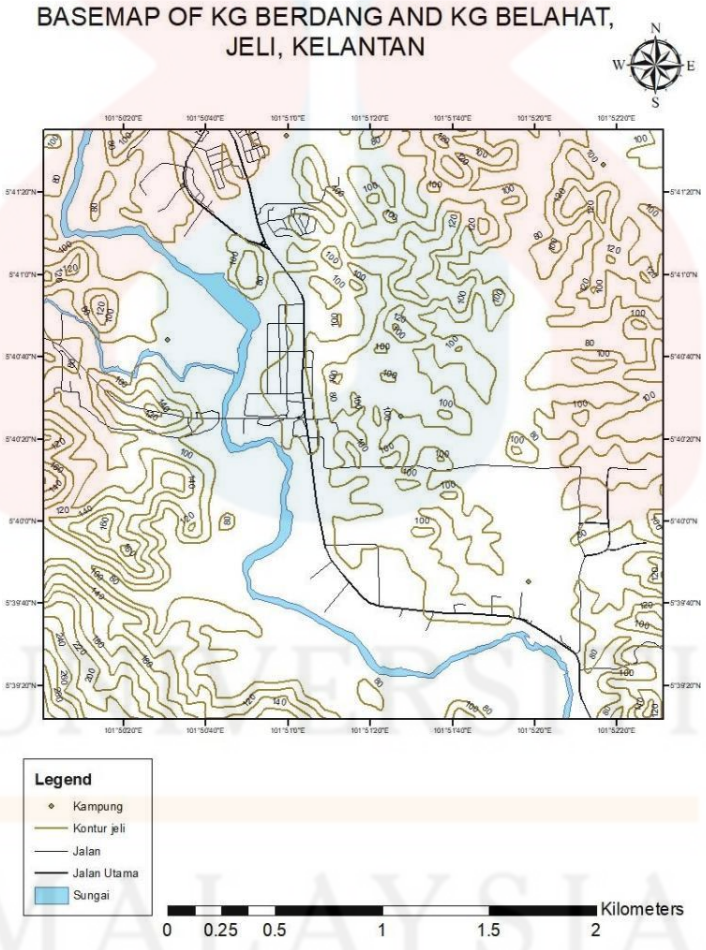


Figure 1.2 show base map of study area

1.2.1 Accessibility

Jeli District is a Malaysian district and parliamentary district located in western Kelantan. The district's population is predicted to be 42,150 as of 2010. The Jeli District Council is in charge of governing Jeli. Because of the area's hilly terrain, a valley was created in the middle of the land. According to the research area, some sites are accessible by automobile or motorcycle, while others are not.

1.2.2 Demography

There were 1,829.7 thousand people living in Kelantan in the year 2017. The population of Kelantan increased from 1,550.4 thousand in 2008 to 1,829.7 thousand in 2017 at an increasing annual rate that reached a maximum of 2.54 percent in 2015 and then decreased to 1.84 percent in 2017. This growth occurred between the years 2008 and 2017. You can obtain information regarding Kelantan's population at the website of the Malaysian Department of Statistics.

According to the Official portal of Jeli District Council, the total population of the area were 39 170 people in 2010 from some of data that has been recorded. Each of the population was divided by ethnic which are Malay, Chinese, India, Orang Asli and others. The percentages of Malay are 97%, Chinese 1%, 1% India, and others 1%. Jeli area was dominated by Malay residential.

1.2.3 Land Use

In recent decades, Kelantan has made significant strides in developing both its upstream and downstream districts. Upstream areas have been cleared of their forests in order to make room for cropland, particularly vegetable agriculture. Due to rapid changes in land use, notably the conversion of forested land to agricultural or urban use, the hydrological regime has been disrupted, which is one of the factors that has contributed to the increase in the intensity of flooding. . Differences in land use and land cover reflect changes in a region's rate of growth. Changes in land use from forest regions to other land uses, such as townships, cities, manufacturing, agriculture, and tourism, can have an effect on environmental quality, which can result in natural disasters (Shaharudin Idrus et al., 2004, Tuan Pah Rokiah & Hamidi 2016).

The research conducted by Tuan Pah Rokiah and Hamidi (2016) revealed that the expansion of land use in the Kelantan basin for 1984 is less diverse or, in other words, it is not complicated, as only a few land use patterns are classed as rubber, coconut, oil palm, vegetables, etc. To indicate that the barrier to expansion in the Kelantan Basin region was not as robust as it was in the 1980s, the trend of land use development is moderate. Agricultural activities, for instance, were moderate and exploited without the use of the most advanced technologies, limiting forest exploration to agricultural activities. In comparison to 1984, Kelantan's land use pattern became increasingly complex in 1997. Due to the lifestyle pattern of the inhabitants of the Kelantan Basin in contrast to the national growth trend, robust land use development. Agricultural operations on a large scale, including rubber, oil palm, and agriculture, have led to technological advancements. Several sections of forest reserve and rubber plantations were felled and replanted, in addition to palm oil.

1.2.4 Social Economic

Kelantan's economic activities centre mostly on agriculture, manufacturing, the agro-industrial sector, and tourism. As determined by domestic product growth between 1980 and 1990, 43,2 percent of the economy shrunk through time, accompanied by an increase in manufacturing and industrial activities. The largest manufacturing industries are found in the agricultural and export-oriented wood processing sectors. Logs and sawn timber, as well as the secondary processing methods involved in the creation of plywood and veneer, furniture, and matchsticks, constitute wood-based enterprises. Rubber, rice, and palm oil are the main exports of Kelantan, which generates 470,000 cubic metres of sawn timber each year. The mining of gold is likewise a major undertaking. Since the Jeli research area has not been well studied, there are numerous undiscovered forest regions, particularly on the top slope. As noticed, the flora present includes palm plantations, which are the primary activity of plantation sites, rubber plantations, and various types of forest.

The vast majority of the population is engaged in agricultural labour on plantations, the vast majority of which are rubber estates or estates inside estates. The oil palm plantations, which were one of the locals' key sources of revenue, were the focus of the bulk of the inhabitants' attention. The next thing that has been seen is that there are farmers working in both the palm plantation and the rubber plantation. These farmers are the ones who are in charge of gathering the produce from the palm and rubber plants.

1.3 Problem Statement

It was tough to argue that flooding was the primary problem that caused enormous damage in Kelantan. The flooding is produced by a number of factors, the most important of which are the geological structure itself and the rainfall pattern. Proceed to the geology aspect, which will include the structure of the area under investigation as well as the lithology, which will contain all of the different kinds of rock that may have an effect on the area that is prone to flooding. In Jeli, other than the overflow of Sungai Kelantan, which is possibly the primary cause of flooding in this area, that may be the primary cause of flooding in this area. Other than that, the changes in terrain and local drainage are more problematic than the heavy rain that occurs in Jeli, Kelantan, which is the primary focus of this research study. Other than that, the phrase "major point" refers to the fact that this research study was conducted.

Floods have recurred in several parts of the nation, particularly in Kelantan, where a large flood hit the state near the end of the year in 2014, during the monsoon season, which brings the maximum amount of rainfall during that period. Flooding has been particularly severe in Jeli recently, despite the fact that the region as a whole does not generally suffer flooding. This is because, like example the flood in Jeli occur after get a highest rate of rainfall compared to other places. As a result, a large number of homes have been damaged, and the surrounding population has been forced to live in discomfort. Flooding is caused by a variety of sources. It is not possible to ascribe the occurrence of these floods solely to natural factors. Furthermore, if a major flood happens, it is possible that lives will be lost. As a result, a research is required in order to discover the true causes of flooding and, as a result, to lessen the effect of floods in the studied regions.

1.4 Objectives

The purpose of this study was to update the geological map of flood-prone areas in Jeli by conduct an interpretative analysis of this region using a GIS programme. In addition, determine the pattern or time series analysis of precipitation that influenced flood events in the state of Kelantan. Moreover, the objective of this study was the creation of spatial and temporal rainfall data analysis Finally, offer further information about the existing status of this research region via rainfall pattern in order to predict future flood events.

1. To update the geological map in Jeli area
2. To identify the spatial-temporal pattern of rainfall intensity in Jeli
3. To develop flood prone area map of Jeli

1.5 Scope of Study

The purpose of this project was to create and update geological mapping, with an emphasis on any flood-prone areas that contribute to floods in the Jeli region. In addition, this study explores the spatial-temporal pattern of rainfall in the Kelantan area, specifically in terms of detecting rainfall data and water levels utilising information collected from the Malaysian Department of Irrigation and Drainage (DID).

1.6 Significance of Study

This concept that research updated the most current geological map of the Jeli area, which be constructed at a scale of 1:25 000, is the primary reason why the study is relevant. In the event that it is required, the geological map that was just recently prepared may act as a reference for another department. If another company is interested in establishing new operations in this area for urbanization, they are welcome to consult the geological map that has been supplied here for their purposed.

The relevance of this work was to use spatial-temporal analyzed to comprehend rainfall data and water levels that may have impacted the flood-prone region. As a result, the results may give critical information to both populations. Additionally, the research revealed the sort of rainfall that typically occurs in the study sites. It also reflected the degree of satisfaction with flood warnings, a critical component of flood management, and serves as a reminder to local governments to improve the efficacy of flood preventive and preparation countermeasures. Additionally, this survey reflect the community's degree of knowledge about flood problems.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

At the base of Peninsular Malaysia's Main Range focused on in the Jeli district was very known for flood prone area after faced some heavy flood in the past years as mentioned by Arham Muchtar Achmad Bahar et al 2020. Granitic rocks make up the majority of the range, however there were pockets of sedimentary and meta sedimentary rocks scattered throughout. Granite from the Main Range may be founded approximately in the western section of Kelantan and continue along the western side of the state line between Perak and Pahang. According to Nursufiah Sulaiman et al 2020, Jeli area was generally made up of 3 rock types, which are Triassic sedimentary rocks (Gunong Rabong Formation), which consists of shale, siltstone, sandstone, and limestone; Permian sedimentary rocks (Gua Musang Formation), which contains of phyllite, slate, sandstone, and limestone; and Granitic rocks. This composition is based on the basic geology of Kelantan (acid intrusive).

Water availability, floods, and droughts are all affected by precipitation, which is an essential climatic variable whose fluctuation has an influence on them. This was particularly critical in arid and semi-arid locations such as Iran, where water supply is restricted and there are frequent natural catastrophes such as floods and droughts to contend with. Precipitation information that is trustworthy, long-term, and with high spatial temporal resolution is required for investigating precipitation variability. There have been a number of studies undertaken to explore global precipitation fluctuations at both the global and local scales, utilizing a variety of precipitation estimate datasets.

2.2 Regional Geology and Tectonic Setting

Endogenous processes produced by forces from within the earth, resulting in destructive events such as earthquakes and volcanic eruptions, and exogenous processes induced by forces and their interactions with the planet's atmosphere, hydrosphere, geosphere, biosphere, and cryosphere build the world. A lot of these processes have been influenced by human activity, especially in the last two centuries, such as the increase in greenhouse gases, which has led to global warming, as well as the severe changes in land cover and land use and the overexploitation of scarce resources. Even in distant locales, the endogenous, exogenous, and anthropogenic processes outlined above might lead to potentially catastrophic occurrences.

For instance, earthquakes can generate landslides that can lead to landslides and dammed lakes that can fail and cause downstream flooding. Analysis of rainfall-runoff characteristics revealed that sustained high rainfall, geological context, and topography generated the basin-wide exceptional event that has occurred just twice in the past 88 years of flood records (1926-2014). It is stated that physical elements, such as geological setting and topography, are significant in analysing the origin and effect of severe floods and the geographical distribution of flood levels when terrain characteristics are taken into account (Sathiamurthy et al., 2019).

State of Kelantan is historically prone to flooding due to its east coast location on Peninsular Malaysia's coast and its proximity to rivers, as well as its low-lying topography on floodplains (Chan et al., 2020). The Kelantan Basin's geology and topography have a significant role, too, even if unusually heavy rains were the primary cause (Sathiamurthy et al., 2019).

2.3 Stratigraphy

Kelantan is part of the Gua Musang group and has different shapes. In the Gua Musang area, Yin (1965) made a map of argillite, carbonate, and pyroclastic/volcanic facies from the Middle Permian to the Late Triassic. Now, the name is used informally for Permo-Triassic carbonate-argillite-volcanic formations in the northern part of Peninsular Malaysia. Widespread argillite-carbonate-volcanic in the northern Central Belt raises questions about how to name it. The Gua Musang formation is similar to the Aring formation in Felda Aring, and the Telong formation is similar to the Gua Musang formation in Sungai Telong (Aw, 1990). Mohamed and Leman (1994) and Mohamed (1995) said that lateral facies changes might be grouped together if the sediments were laid down in shallow marine environments of the Gua Musang platform during the Permo-Triassic period. Putting these formations together is important because of how closely they are related in terms of sediments and fossils.

2.4 Structural Geology

Kelantan is a state located in the northern section of the Peninsular Malaysia. This state shares its borders with Thailand to the north, Pahang to the south, Kedah and Perak to the west, and Terengganu and Kedah to the east. This paper details the structural differences that can be seen in each lithology of the Gua Musang Formation that can be found in Kelantan. The west Kelantan Olistostrom, the Taku Schist, and the Gua Musang Formation are the three main components that make up Kelantan's geology. Igneous rocks that can be found in Kelantan include granite, diorite, porphyry, andesite, and dolerite, among others. The olistostrom in the west and the Lebir Fault Zone in the east serve as the structural limits of the Kelantanese province. Gua Musang Formation is largely isolated in Kelantan.

2.5 Historical Geology

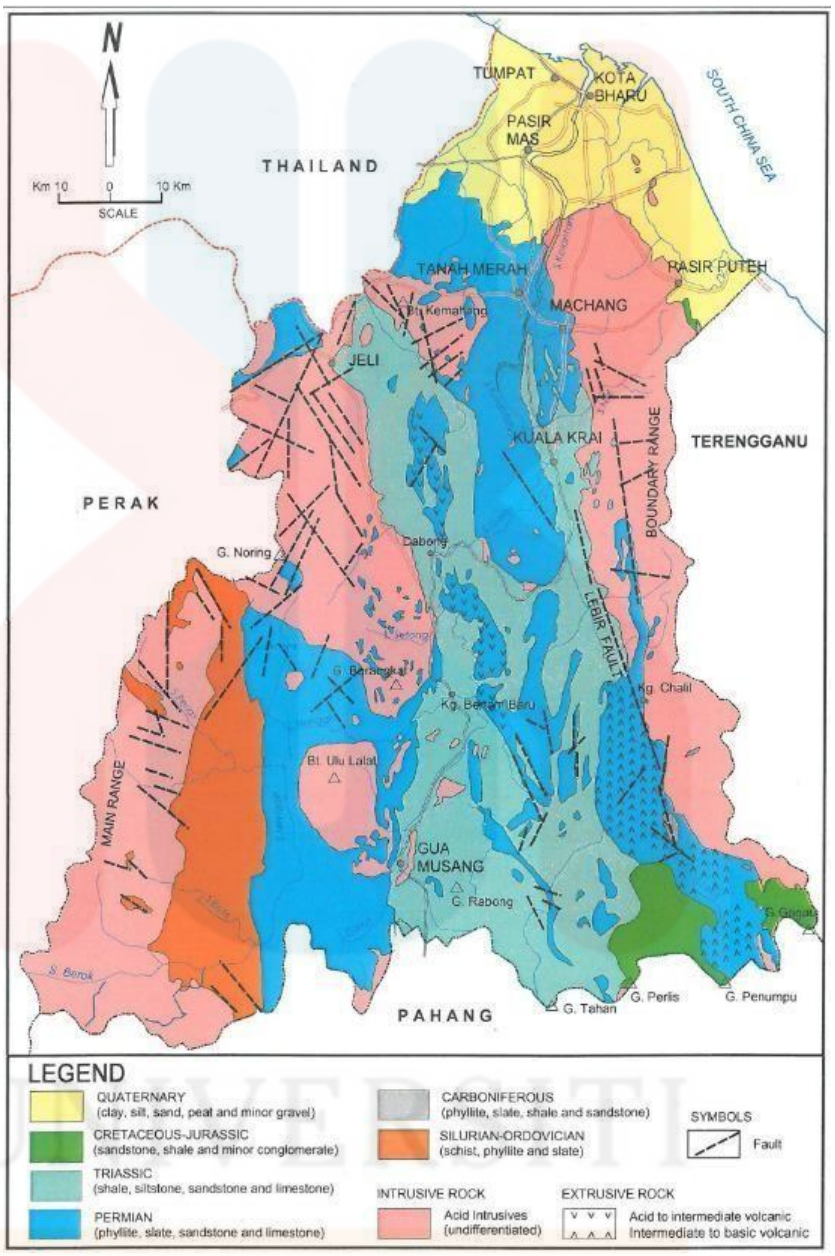


Figure 2.1 *: Structural geology of Malaysia*

The geology of Kelantan is best characterized by four types of rock: unconsolidated sediments, volcanic rock, sedimentary and meta sedimentary rocks, and granitic rocks. In Kelantan, granitic rocks are the most abundant form of rock. Granitic rocks in Kelantan can be divided into two basic bodies, the Main Range granite bodies and the Boundary Range granite bodies. Granite from the Main Range was created between 200 and 230 million years ago, during the Middle Triassic period. The Main Range granite in Kelantan is located roughly in the western portion of the state and extends along the western side of the state up to the state boundaries of Perak and Pahang as well as the international boundary of Thailand.

In addition to this, the primary rock type found in the Main Range Granite Province is a megacrystic biotite granite with very coarse to extremely coarse grains. In hand specimens, large K-feldspar phenocrysts of up to 7 centimetres in length are not uncommon and frequently exhibit a markedly megacrystic look. The predominant compressive force that acted upon the landmass of Peninsular Malaysia was compressional, and the impacts of this force are mostly faulting and folding at the regional and local scales. In the sedimentary rocks, localised structures can be found in the form of folding, faulting, and jointing. In the granitic rocks, localised structures can be found in the form of faulting and jointing. Because of previous orogenies, the predominant structural grain runs in a north-south to northwest-southeast orientation (Nazaruddin et al., 2014).

2.6 Research specification

2.6.1 Spatio-temporal analysis of rainfall data

Spatio-temporal analysis of rainfall data is the process of examining and making sense of patterns in the spatial and temporal distribution of precipitation. This study investigates the spatial and temporal variability of precipitation and how it affects fields including agriculture, hydrology, and weather forecasting. Spatial and temporal correlations, trends, and outliers in the data can be uncovered by the analysis, which can be carried out using statistical methods, geospatial techniques, and time series analysis. Water management and resource allocation are two areas where the outcomes of the spatio-temporal analysis can help guide decision-making. Changes in the global climate have an effect on the long-term rainfall pattern, which in turn affects the amount of water that is available and may increase the risk of major drought and flood (Pal et al., 2017).

Typically, geospatial approaches, statistical methods, and time series analysis are used in the spatio-temporal study of precipitation data. Rainfall may be seen in terms of its spatial distribution, areas of high and low rainfall can be identified, and rainfall trends over time can be evaluated, all with the use of geospatial tools. Regression analysis and other statistical methods can be used to determine if and how temperature, soil type, and land use are related to rainfall patterns. Rainfall can be analysed using time series analysis to reveal changes in pattern as well as recurring trends over time. Policymakers may develop more effective hydrological strategies to battle drought and reduce flood risk by managing water resources according to historical trends, which can be gleaned via historical rainfall trend research (Bisht et al., 2018).

2.6.2 Trend analysis and men-kendal Test

"Meteorological time series may be identified using a variety of ways" (Duhan and Pandey, 2013). According to Jain and Kumar (2012), "Trend analysis for rainfall time series comprises the identification of a growing and decreasing trend, as well as the amplitude of the trend, as well as its statistical significance." The Mann-Kendall test (Mann, 1945 and Kendall, 1975), one of the finest techniques among them, is favoured by many researchers, as shown by trend analysis in numerous studies (D Khare, Douglas et al., 2000; Yue et al., 2003; Jain and Kumar, 2012).

"Mann-Kendall test analyses hydrological variables and determines statistical significance" (Yue et al, 2003). "Mann-Kendall test does not need datasets to follow normal distribution and have homogeneous variance; modifications are not necessary if data already follows normal distribution; skewed distribution has better power" (Duhan and Pandey, 2013). "Mann Kendall test addresses slope function, covariance, and probability distribution" (Yue et al, 2002a). "Mann-Kendall test reduces serial dependency on auto-correlated data, which modifies dataset variance" (Hamed and Rao, 1998).

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This section covers the study materials and procedures. Preliminary studies were also referred to in order to guarantee that this research's goal was met to the letter. This research's flow chart was also provided since it's critical to do so. This research relied on official and unofficial sources for its data. Data from officialsources, such as rainfall in the research region, was acquired from public information. There are a variety of maps that may be found in the main resources that include geological maps, topographic maps, and satellite imagery. Observation and analysis of satellite images and topographic maps are some of the techniques used to gather additional sorts of data.

3.2 Materials and Data Source

Materials

In this research project, several materials has been used in order to complete the objective and get a better result. All the materials has different types and each one has their specialization.

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 (mm) in Kelantan (2009-2019 year)	Department of Drainage & Irrigation 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

Table 3.2.1: Data Preparation

3.2.1 Data Source

Whenever it comes to the hydrological cycle, rainfall is a key component and its unpredictability is important to both the scientific and socioeconomic aspects. Precipitation patterns in the Kelantan River Basin are examined in this research. 53 rainfall stations were obtained from the Department of Irrigation and Drainage (DID), Malaysia's government, as well as from the National Hydrological Network Management System (NHNMS) (SPRHiN). Monthly rainfall data for 10 districts have been examined to see whether there are any patterns over the last 11 years (from 2009-2019). For the purpose of flood forecasting, the following rainfall time series data were analysed. The yearly fluctuation of these statistics has been examined. The Mann-Kendall test was employed for trend analysis. To address water shortage challenges in this physically varied area, researchers must analyse rainfall patterns and their variations on spatial and temporal scales.

3.3 Methodology

To accomplish the goal of this piece of research, it was important to finish this particular chapter. Because of this, it is now possible to complete the research within the allotted amount of time thanks to the aid provided by the approach.

3.3.1 Preliminary Study

The first part in doing proper research was conduct the preliminary research, which is conducting an early study of rainfall and statistical approach. This was done by review all the prior research in order to locate high potential methods that have been completed by other researchers. In this section, an overview of all pertinent experimental, descriptive, theoretical, and analytical methods that have been employed in previous research will be provided. The component of the literature review that involves reviewing the research may be finished. The next step is to investigate the significant data that are connected to the trend analysis of rainfall. The information about rainfall may be received from an internet domain or an organization that is associated to it.

3.3.2 Field Study

One of the essential activities that needed to be completed for the research to be successful was the creation of a geological map. In order to complete this job, you needed to determine all of the geological aspects that are present in the research region, such as the lithology, geomorphology, and structural geology. This was done in order to develop a geological map that was detailed and up to date. Reviewing older journals and articles written by researchers who have already carried out geological mapping in the same study region is an integral part of the mapping process for Jeli. In addition, investigate the relevant organization and website and extract the data that is both important and relevant to the investigation.

3.3.3 Laboratory Work

The data will be extracted from governmental open data and the Department of Irrigation and Drainage (DID), and the format of the data will be converted into Microsoft Excel. In addition, all of the data from the rainfall station need to be selected. This is due to the fact that not all of the data as from rainfall station might be used, which means that the data could've been corrupted or could seem to be out of date.

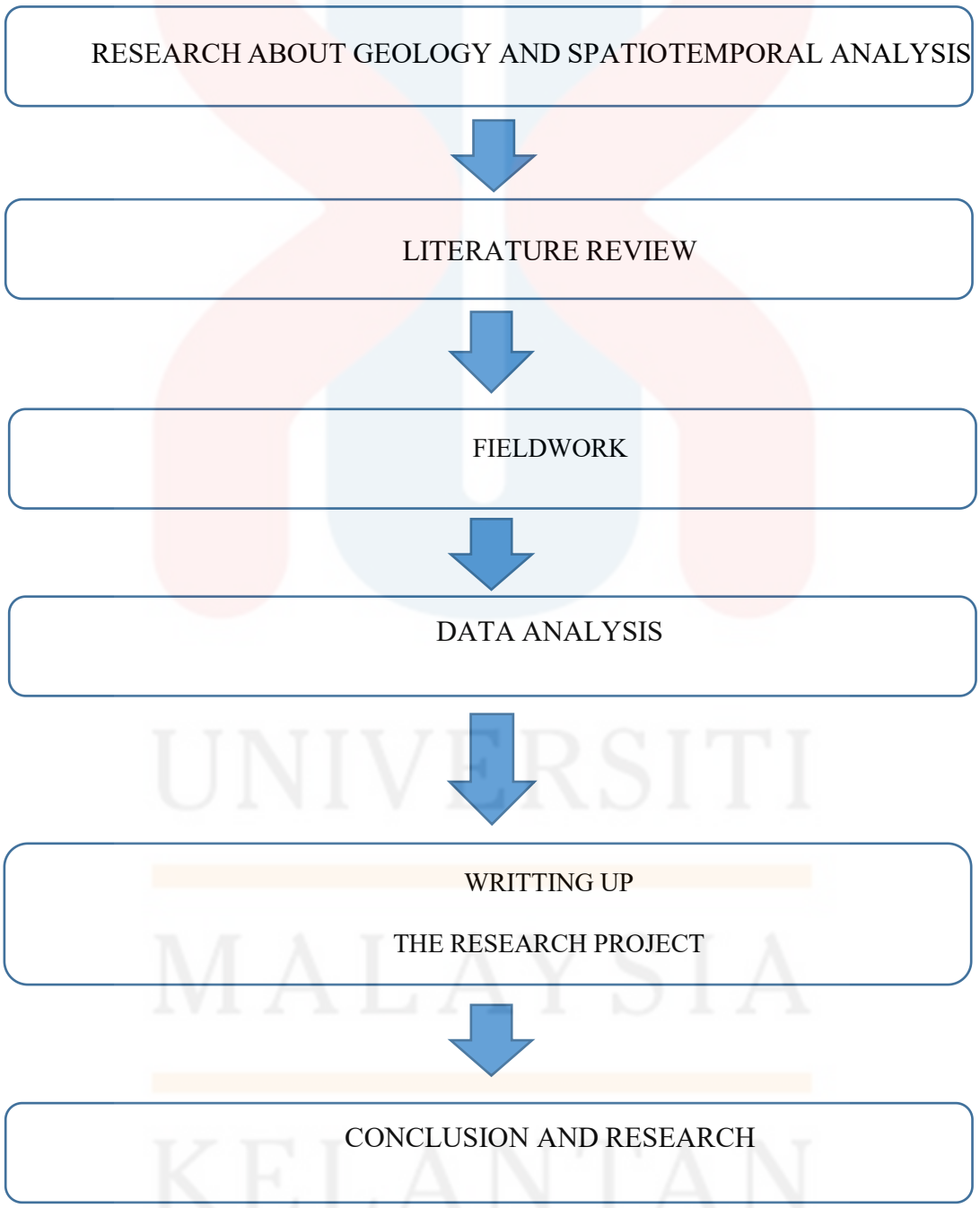
3.3.4 Data Processing

The Mann-Kendall test was used to get a better understanding of the rainfall time series. The Mann-Kendall (MK) statistical non-parametric test was used to examine the rainfall data. Hydrometeorological trends may be studied using the Mann Kendall (MK) non-parametric test. In addition, the statistically significant Mann–Kendall (MK) test reveals upward and downward trending patterns. The strength of a trend is determined by the magnitude, sample size, and volatility in data series. Since the MK test statistic relies on positive or negative signs, outliers in the data series have little effect on the trends in the MK test.

There is a comparison made between a specific rainfall time series and the annual rainfall data. If the data point of the following year is larger than the data point of the year before, the MK statistics will be increased by one. If this does not occur, the MK statistics will be reduced by one. As a direct result of this, the value that is represented by MK statistics is the aggregate total of all data values.

3.3.5 Data Analysis and Interpretation

Data analysis involves studying and evaluating data to conclude. This can include early research on the specification issue, literature review, data analysis, and more. Data analysis transforms raw data into decision-making information. Data interpretation involves clearly presenting data analysis findings.



Figures 3.3 *show the flow chart in this research project*

CHAPTER 4

GENERAL GEOLOGY OF KAMPUNG BERDANG AND BANDAR JELI, JELI

4.1 Introduction

This chapter is essential in order to complete the report because it provides additional focus. The study area's geomorphology, stratigraphy, historical geology, and structural geology, in addition to general geology, will each be described in greater detail. General geology is relevant to all of these sub fields. Geological mapping and a review of the relevant literature were both used to complete this chapter.

The study of general geology is a specialty that entails the compilation and analysis of data gleaned from prior studies and from various government bodies. Its goal is to gain an understanding of the processes and mechanisms that are responsible for giving the earth its many distinctive characteristics. Geomorphology, or the study of land forms and the processes that shape them, is an essential part of general geology. Geomorphology is the study of land forms and the processes that shape them. This encompasses the birth and development of the planet, as well as its history and the ways in which it has developed over time. Learning about the processes that are responsible for these shifts can help one gain significant insights into the history of the earth and gain a better understanding of the situation in which it currently finds itself.

The study of rock layers and layering is referred to as stratigraphy (strata). The term is most commonly utilized in the field of earth sciences to refer to the stratification of rocks and sediments that constitute the crust of the earth. Both the rock's age and its lithology, which refers to the rock's physical features, are used to describe the stratigraphic units that make up the rock. Understanding the history of the Earth, including the development of life and the climates that existed in the past, is essential for stratigraphy, as is the process of identifying and extracting beneficial resources such as oil and gas. The study of human and dinosaur remains, which fall under the purview of archaeology and palaeontology, respectively, makes use of stratigraphic principles.

The exploration of the three-dimensional distribution of rock units in relation to their respective deformation histories is what structural geology is all about. Understanding how the crust of the Earth deforms, how stresses are transported across the crust, and how rocks behave to these pressures is the primary emphasis of this research. It involves the study of rock outcrops, maps, and boreholes, as well as the application of field, laboratory, and numerical techniques, with the goal of comprehending the physicochemical and mechanical characteristics of rocks as well as the processes that shape the outermost layer of the Earth's crust. It is a multidisciplinary area of study that draws upon concepts from the fields of geology, physics, mathematics, and engineering.

4.1.1 Accessibility

One definition of accessibility is the presence of roads connecting different parts of the study region. Connected to the economic and social activities of a region, accessibility is typically present. Because farming is the main source of income for the residents of Kampung Berdang, the town has been designated as an easily accessible region within the study area. Two distinct varieties of roadway exist: those with pavement and those without. Large vehicles like trucks and cars can usually use paved roads, while the narrow, dirt roads located in the woods can typically only be accessed by motorcycles. Figure 4.1 shows the one major route into the area we're mapping. Jeli city and Kampung Berdang can be reached via the main road. Every day, a great deal of traffic passed along this major thoroughfare.

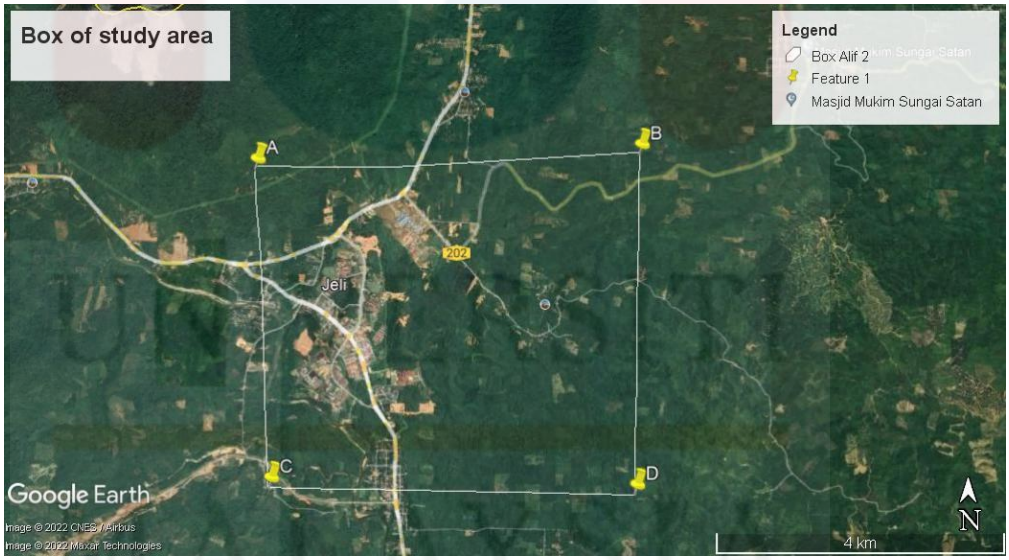


Figure 4.1 *: Show the road system in the study are*

4.1.2 Settlement

The activities that are settled by humans are related to the concept of settlement. Bandar Jeli and Kampung Berdang are known to be two of the busiest places in the research region in terms of human activity. Both of these locations are included. Bandar Jeli is where the majority of the day-to-day activities and a lot of other things, such as banking or government business, can be completed, whereas Kampung Berdang places a greater emphasis on the plantation area, and its population is significantly higher than that of Bandar Jeli. In each of these cases, the population of Kampung Berdang is also higher than that of Bandar Jeli. In most cases, residents of the village will sell their entire plantation to the market located in the city.

4.1.3 Land use

The majority of the study area has been converted into rubber plantations and protected forests, as shown in Figure 4.2. People in the study area rely heavily on their vegetation-based economies. Because of the low human density in the study area, forestry has been allowed to flourish naturally. Because of the proximity of the rubber plantations to the population centre, most of the villagers in the region of study are engaged in the rubber tapping industry. The flat area is where the majority of the rubber plantation is being established. Vegetation in the study area was reflective of the underlying topography. The locals spread rubber trees throughout both hilly and flat terrain. They base the majority of their economy on exploiting the landform and natural resources.

4.2 Geomorphology

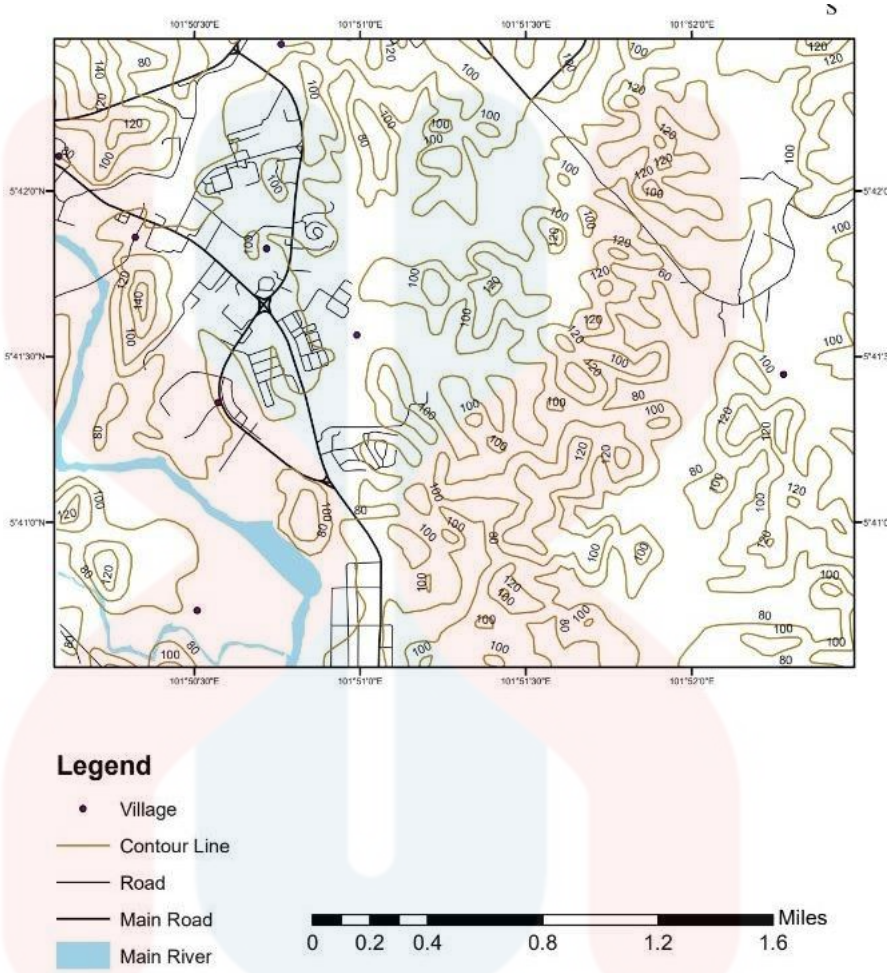


Figure 4.3: Geomorphology Map of study area

The study of geomorphology focuses on geomorphologic classification, topography, the type and process of weathering, as well as the drainage pattern of the subject area. The geomorphology differs according to the elevation, which is a crucial factor in determining the flow of water and plays a role in the differentiation. When it comes to the management of natural resources, various types of planning are possible depending on the landform in question. The study of the properties, origin, and development of land forms is referred to as geomorphology. This is the general definition of the term. The investigation of the topography, weathering, and drainage pattern of the research area were all included in the geomorphology section of the investigation.

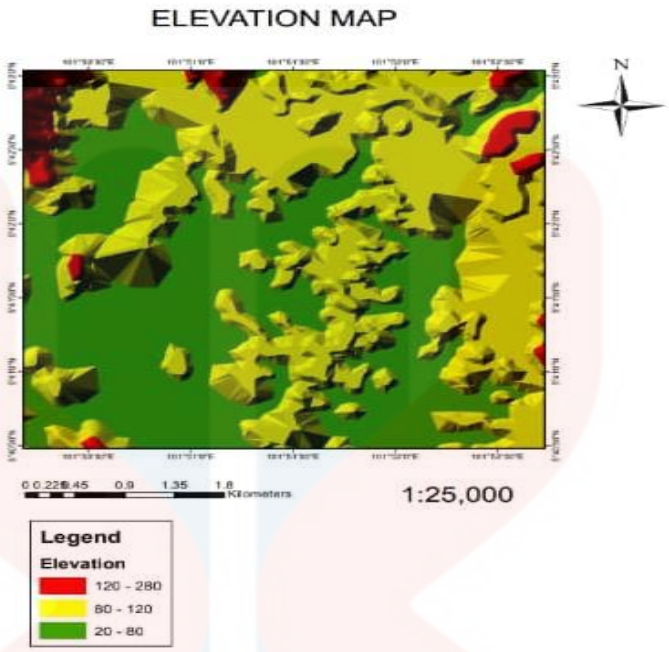


Figure 4.4: *Elavation map*

NO.	GEOMORPHOLOGICAL UNIT	SYMBOL
1	Slightly slooping plain	
2	Slooping hills	
3	Steep hills	

4.2.1 Geomorphologic classification

Earth's land forms and topography are collectively known as geomorphology. Mountains, valleys, and slopes are all examples of distinct types of land forms. As a term, "landscape" refers to a broad category that includes a variety of landf orms, such as mountains and valleys. It takes a long time for land forms to form, and they are shaped by processes that fall into two major categories: endogenic and exogenic processes.

Endogenic processes are those that operate deep within the Earth but are driven by the Earth's internal convection. Some examples of endogenic processes are volcanism, isostacy animation, and tectonic movements. Endogenic processes are those that take place on the surface of the Earth and include phenomena like weathering, erosion, and eolian activity, among other things.

In geomorphology, the three primary categories that can be broken down are mountains, plains, and hills. These categories are broken down based on the region that is being examined. A plain is a sort of landform that is flat and typically occurs on low land, whereas a valley is a distinctive landform that is drained by rivers and can exist either in between hills or on a flat plain. Plains and valleys both tend to be found on low terrain. The process of deposition that occurs in conjunction with rivers and streams is referred to as the "fluvial process," and the phrase "fluvial process" refers to a certain form of morphology that is produced as a result of this process.

4.2.2 Drainage Pattern

Another of the sub fields of geomorphology that can be classified under this heading is drainage pattern, which is sometimes referred to as river system. The rivers, streams, and lakes that are located within a certain drainage basin are what give rise to the formation of a river system. The topography and gradient of the land, as well as the existence of bedrock and structures, are the factors that govern the pattern.

A stream is also considered to be a drainage basin because it is a topographic region that is the source of groundwater flow, runoff, and through flow. There are numerous distinct patterns of drainage, including dendritic, parallel, trellis, rectangular, and radial, among others.

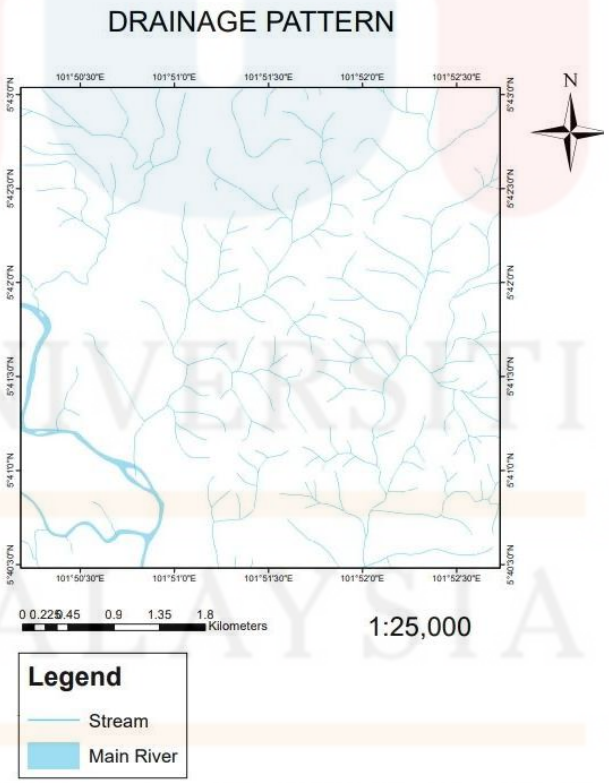


Figure 4.6 : Drainage Pattern

The drainage pattern that was discovered in the study area was predominantly found to be rectangular and parallel, as well as drainage basins in which all of the tiny rivers were found to be accumulating before being divided to other nearby basins. The many forms of drainage patterns are illustrated in figure 4.6. Following the observations, a newly updated drainage pattern will be produced. In the study region, the rectangular pattern can be seen at the top of the relatively low hill. It is usual for a rectangular drainage pattern to form in the region where faulting takes place.

When water flows over rock with a consistent resistance to erosion, a pattern like this can be seen. Stream deviations result from surface faulting. A straight line of stream is formed when a series of smaller streams converge. In the western part of the research region, the same pattern can be seen. The research area features a variety of drainage patterns, including parallel. Some of the land has very steep slopes, and this has led to the creation. The steep terrain ensures that the stream always flows in the same direction, with only a few of side channels. Parallel, elongated landforms, such as outcropping resistant rock bands, are also fertile ground for the growth of this pattern. The tributary system encourages a parallel expansion over the landform's surface, which is in harmony with the land's natural inclinations. Structures like faulting across steeply dipping bedrock are often indicated by patterns of parallelism.

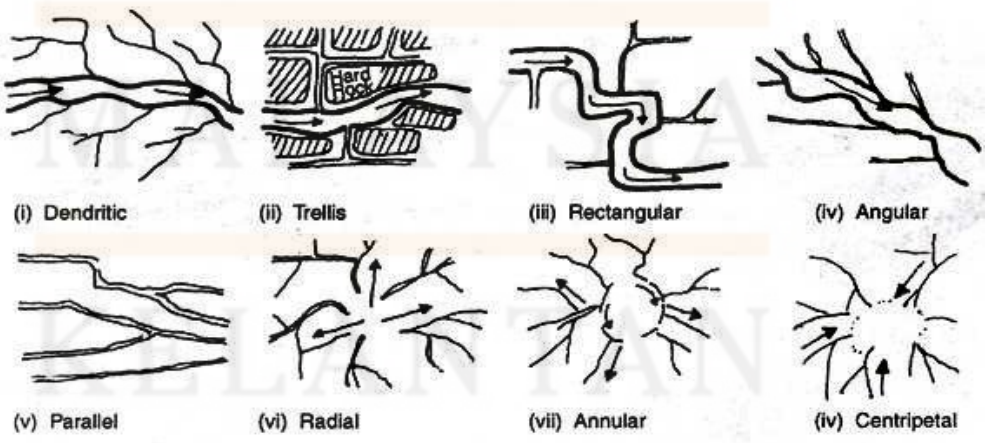


Figure 4.7 : *Type of drainage pattern*

4.2.3 Topography

The study of form, characteristics of the surface, and a description of the formation are all aspects of topography. The characteristics of the area under study include being hilly or mountainous, plain, rolling or undulating, or any combination of these. According to Raj (2009) and Van Zuidam (1985), the topographic unit can be divided into different elevations according to the following criteria:

The hilly region exhibits characteristics typical of igneous rock. In the meantime, the undulating region is composed of meta sedimentary rock, sedimentary rock, and metamorphic rock. The types of rocks that are present in this region have been identified based on the topography pattern as a result of geomorphology research that was conducted in this area. The majority of the rocks that make up the research area are classified as being metamorphic in nature. There is also a type of sedimentary rock known as meta-sediment rock, which is formed when sedimentary rocks go through the metamorphism process.

4.3 Lithostratigraphy

Lithology	Describtion	Unit	Period	Era
	The main feature of this unit is alkaline feldspar microcline phenocrysts.	Granite	Tertiary	Cinozoic
	Schist is a medium-grade metamorphic rock formed from mudstone or shale.	Schist	Permian	Mesozoic

***Table 4.3**: Lithology unit of study area*

In this section, the focus was on providing a detailed description of rocks, with the younger rocks being discussed first and the older rocks being discussed last. The prevailing lithology was used to generate the names for each unit.

Stratigraphy is the science of examining the layers and strata (stratification) of rocks. This section is subdivided into several different subfields, including lithostratigraphy, biostratigraphy, rock sequence, and chronostratigraphy. The lithostratigraphy is where the majority of the attention will be directed. The sequence of the lithology in the area under study, as well as the deformation that occurred as a result of the formation, were also studied as part of this project. The study area includes Permian to Triassic era rocks. The Permo-Trias formation included several main rock types and reached as far north as Kelantan and Pahang (Shafeea,2004). The oldest rock in the area is Mesozoic Phyllite, which has been studied extensively for its implications for local lithology. Later, younger rocks like metasandstone, igneous rock, and marbleized limestone were laid on top of the older ones. Igneous rock formation is followed by a pause followed by alluvial deposition representing recent geologic time.

4.3.1 Unit explanation

a) Granite

In the geological sense, granite is an igneous rock that solidifies over time from molten magma or lava. Quartz, feldspar, and mica are the primary minerals that make up this rock. This is what gives granite its distinctive salt-and-pepper appearance, which is caused by the presence of certain minerals. Due to its high strength and durability, granite may be used for many different purposes. It's tough, won't chip or scrape, and can take a pounding. Granite's signature salt-and-pepper look comes from the minerals quartz, feldspar, and mica that make up the stone. White, black, grey, and even pink varieties of granite exist. Granite's hue is based on its mineral make-up and the geographic origin from whence it was extracted.

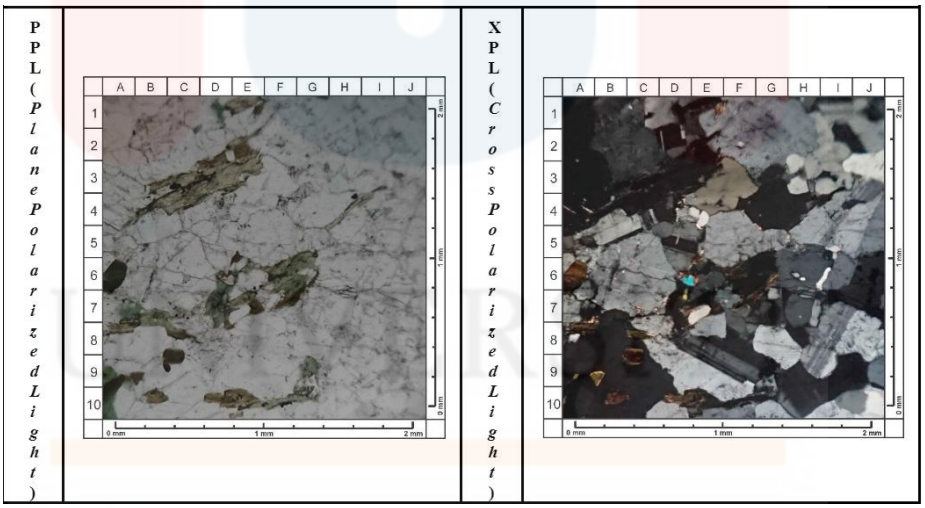


Figure 4.3.1 *show the thin section of granite from the study area*

The observations were made at 10x ocular magnification and 5x objective magnification and at observation of massive structure, phaneric texture - weak foliation, coarse mineral size - medium. It is a meta-igneous rock, characterized by apparently interlocking mineral arrangements and parallel mineral direction arrangements that have not yet formed a foliation structure but have not yet appeared to be mineralized.

Mineral Composition :

Feldspar (I8) – 30%

In PPL, the absorption color is colorless, low relief, The feldspars in granite are typically plagioclase feldspar, which is a combination of albite and anorthite, euhedral - anhedral crystal form, 1-way cleavage. At XPL, the interference color is gray - white, order 1, parallel darkening angle, albite - kalsbad-albite twins, An value 20 (oligoclase).

Mica – 15%

A group of minerals that have a layered structure and are typically black or silvery in color. Mica minerals in granite include biotite and muscovite.

Quartz (J10) – 46%

In PPL, absorption color is colorless, low relief, pleochroism is absent, anhedral crystal form, cleavage is absent. On XPL, the color of gray-white interference is order 1, the angle of darkness is wavy, there is no twin.

Chlorite (F6) – 8%

On PPL, the absorption color is green, low relief - medium, weak - medium pleochroism, anhedral - subhedral crystal form, 1-way cleavage - none. On XPL, the interference color is gray - dark green order 1 - order 2, the darkening angle is oblique, there is no twin.

b) Schist

Schist is a metamorphic rock that was formed when older rocks were subjected to intense heat and pressure. It is often made up of minerals like mica, chlorite, and feldspar, and has a layered or foliated structure. Mica, chlorite, and feldspar are the main minerals found in schist. Other minerals, such quartz and garnet, may be present in schist depending on its precise mineral composition and the conditions under which it developed. Schist is a tough rock, yet it can't compare to the likes of granite. Some common schist colours include grey, green, red, and even black. When compared to granite, schist's resistance to weathering and erosion is about average.

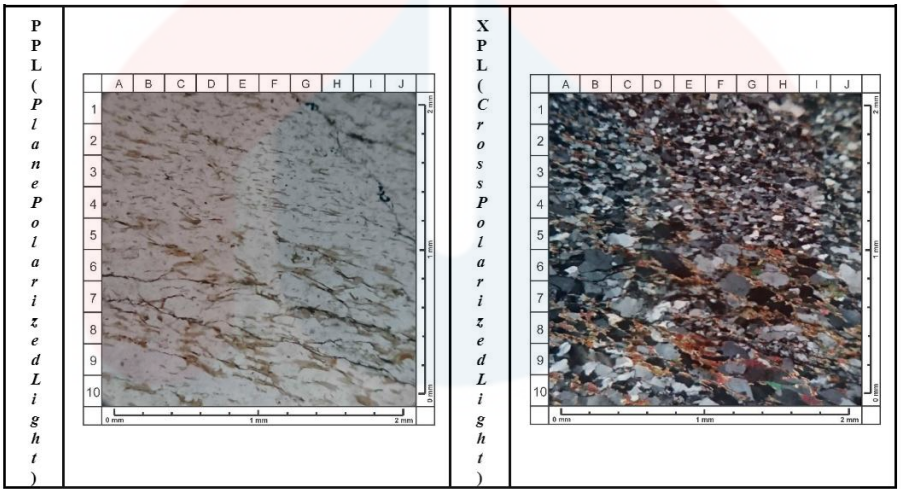


Figure show the thin section of schist from the study area

The observations were carried out with an ocular magnification of 10x and an objective magnification of 5x. Additionally, an observation of foliation structure (schistose), crystalloblastic (nematoblastic) texture covering grain size of 1/128 – 1/5 mm, and good sorting were carried out.

Mineral Composition :

Quartz (H1) – 89%

In PPL, absorption color is colorless, low relief, pleochroism is absent, anhedral crystal form, cleavage is absent. On XPL interference color gray - white order 1,

Biotite (E8) - 10%

On PPL absorption color is brown - greenish, medium relief, strong pleochroism, subhedral - euhedral crystal form, 1-way cleavage. In XPL color interference green - orange order 3, there is no twin parallel darkening angle.

Opaque Minerals (G1) – 1%

In PPL, black absorption color, low relief, no pleochroism, euhedral - anhedral crystal form. At XPL, the black interference color of the 1st order, twins do not exist.

4.4 Structural geology

All of the structure that was discovered during geological mapping may be explained by structural geology. The lineament mechanism of structures was discovered inside the structure geology. It is essential to research the information about the strain and stress in the rocks in order to seek and explore the history of the Earth in the past, which is why this portion is so significant.

Rocks are deformed by a series of processes that are referred to as structural geology. The purpose of this step is to determine, by lineament analysis, the type of structure that can be found in the mapping area. To carry out the structural analysis, all of the data are first plotted into the appropriate software, which is a Rose diagram for the joint analysis. ArcGIS is also used for researching the topography and lineament as an indicator of structure to mapping. This is done using mapping.

4.4.1 Geology structures

The term "joint" refers to a break, brittle-fractured, or naturally occurring process that takes place on rock that is exposed to the surface. In most cases, joints are identifiable almost up to the surface of the rock and can occur in a variety of directions, including vertical and horizontal planes. Joints can be formed alone, but most commonly they are made as part of a joint set. The joint was carried out with the assistance of the terrain map from google map.

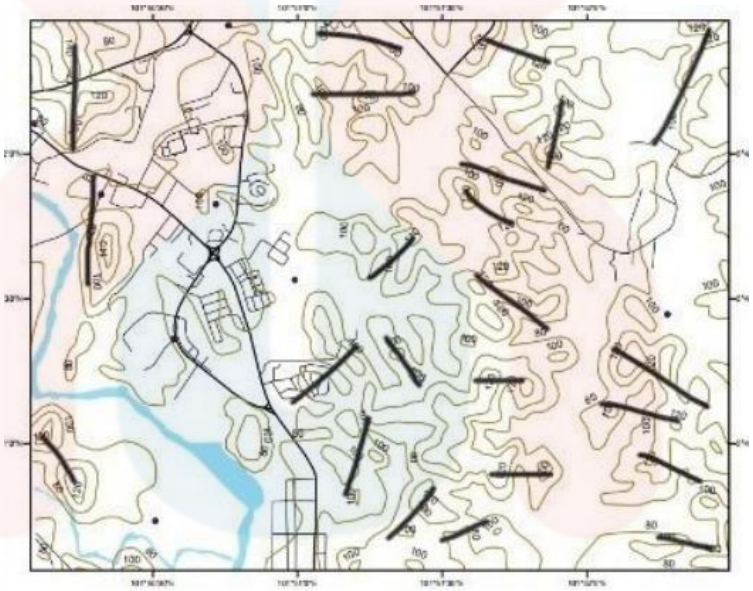


Figure 4.10: Lineament analysis

Positive and negative lineament, respectively referring to ridge trends and river valleys, are the two most common types of lineament. Topographically positive straight lineaments may be read as dykes and dyke swarms, while topographically negative straight lineaments may be understood as joints, faults, and shear zones. Depending on the kind of rock (crystalline or limestone), the slightly curved and sub-parallel lineaments represent foliation or bedding trends and the circular features may define ring dykes (Koch and Mather 1997)

4.5 History of geology

In the Malaysian country of Malaysia, the state of Kelantan is home to a number of extremely noteworthy natural and geological features. This research was carried out in the Jeli district of the state, which is one of the state's ten districts. The Jeli district is particularly rich in precious earth materials, such as hills, caves, rivers, waterfalls, cascades, the hot spring, and gold deposits. In addition, the Jeli district is home to some of the state's most breathtaking geological landforms and landscapes.

Jeli is located in the western portion of Kelantan and is advantageously situated close to the state border between Kelantan and Perak as well as the international border between Malaysia and Thailand. The Jeli district may be found at the base of the Main Range, which serves as Peninsular Malaysia's geographic spine. Granitic rocks make up the majority of the range, although there are pockets of sedimentary and metasedimentary rocks scattered throughout. The Main Range granite may be found about to the west of Kelantan and continues all the way down the western side of the state all the way up to the state line between Perak and Pahang. According to an overview of Kelantan's geology that was published in 2003 by the Malaysian Department of Minerals and Geo-science.

The Jeli district is generally made up of three different types of rocks: Triassic sedimentary rocks (Gunong Rabong Formation), which are made up of shale, silstone, sandstone, and limestone; Permian sedimentary rocks (Gua Musang Formation), which are made up of phyllite, slate, sandstone, and limestone; and granitic rocks, which are acid intrusives.

According to their topography, the state of Kelantan can be broken down into four distinct regions: the mountains, the hills, the plains, and the coast (Tanot et al., 2001). Except for the coastal areas, which only occur in the northern section of Kelantan, all of these types of terrain may be found in the Jeli district. The western and northern parts of the area include a mountainous scenery. The Main Range granite and schist, as well as the Stong Migmatite Complex, make up this terrain. Some of the topographical features of this area include ridges and valleys typical of mountainous terrain. Jeli's hilly terrain is typically found at the base of nearby mountains. There are two distinct sorts of hills that form in this landscape: singular hills and string hills. Gunung Reng is one of many low-lying places where the lonely hills of limestone are exposed. Ridges are longer than hills, but not as high as mountain ridges. Central and eastern parts of the area have a flat environment.

As nothing more than a summary for this chapter, the Geology of the Kampung Berdang and Jeli area can be characterised as a flood-prone area due to the placement of the Main River, which is Sungai Pergau. Moreover, Kampung Berdang's geomorphology is dominated by inland lowlands with an elevation lower than 250 metres. The land from the north to the east is highly prone to flooding, which has engulfed the residential area. This study region is predominantly forested and deforested. The soil's moisture content increases as a result of precipitation. This is because, following a downpour, the surface soil will absorb a large amount of water, hence increasing the soil's moisture content. If there is a strong downpour, there is a chance that the river will overflow.

CHAPTER 5

RESULT AND DISCUSSION

5.1 Base Map of Rainfall and Water Level Station

The base map as shown in the figure are focus on the rainfall and water level station in the Jeli region because it has all the data needed to identify the rainfall pattern in the study area.

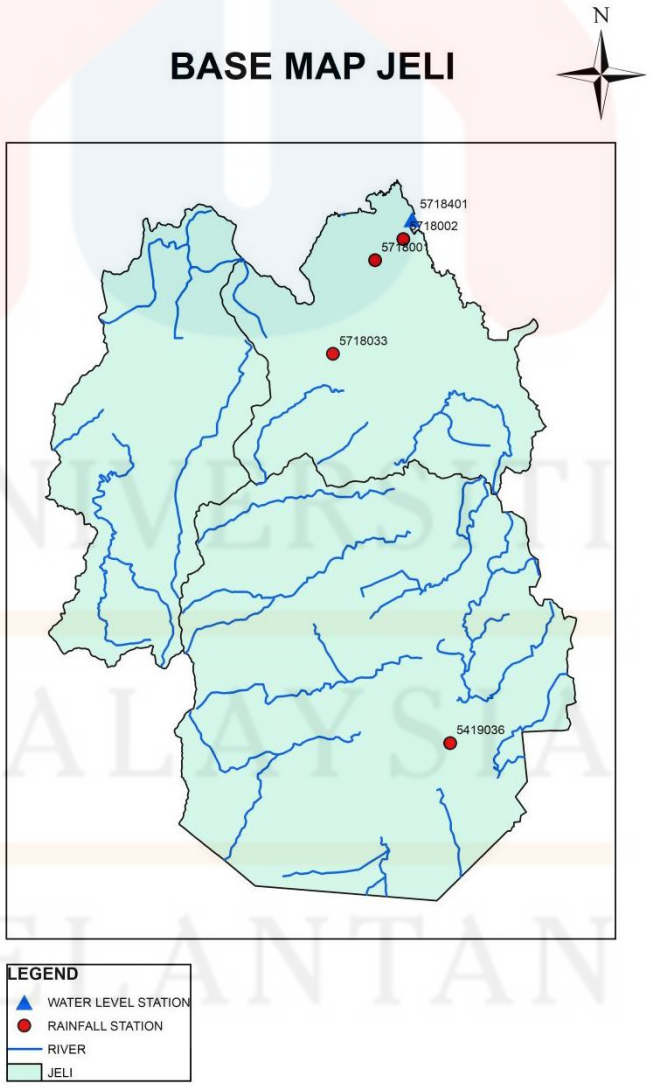


Figure 5.1:Rainfall and Water Level Station in Jeli

5.2 Trend Analysis of Rainfall Data

In this trend analysis for the rainfall data, the descriptive statistic table has been completed in order to get all the information needed. From that, some of the value likes average and the maximum can be analyzed. Descriptive statistic refer to average, maximum, total and standard deviation for annual total rainfall during 2009 to 2019 and 2020. For maximum is 14280.80 mm and highest standard deviation is 201.10 mm. The maximum total rainfall is 17229.40 mm.

- **Descriptive statistic of rainfall station and data set from 2009 to 2019**

Station	Latitude(N)	Longitude(E)	Average	Maximum	Total	Standard Deviation
Station 1	05 27 00	101 54 50	321.10	929.30	15412.10	190.76
Station 2	05 45 50	101 52 00	223.36	700.40	10721.30	131.38
Station 3	05 42 05	101 50 20	301.48	901.80	14471.10	185.93
Station 4	05 46 30	101 53 30	307.62	930.70	14765.70	201.10

- **Descriptive statistic of rainfall station and data set from 2020**

Station	Latitude(N)	Longitude(E)	Average	Maximum	Total	Standard Deviation
Station 1	05 27 00	101 54 50	267.65	520.60	3211.80	135.93
Station 2	05 45 50	101 52 00	289.17	520.50	3470.00	144.13
Station 3	05 42 05	101 50 20	282.97	688.50	3395.60	187.08
Station 4	05 46 30	101 53 30	287.53	520.50	3470.00	144.3

5.3.2 Analysis of average rainfall for 2009 to 2019

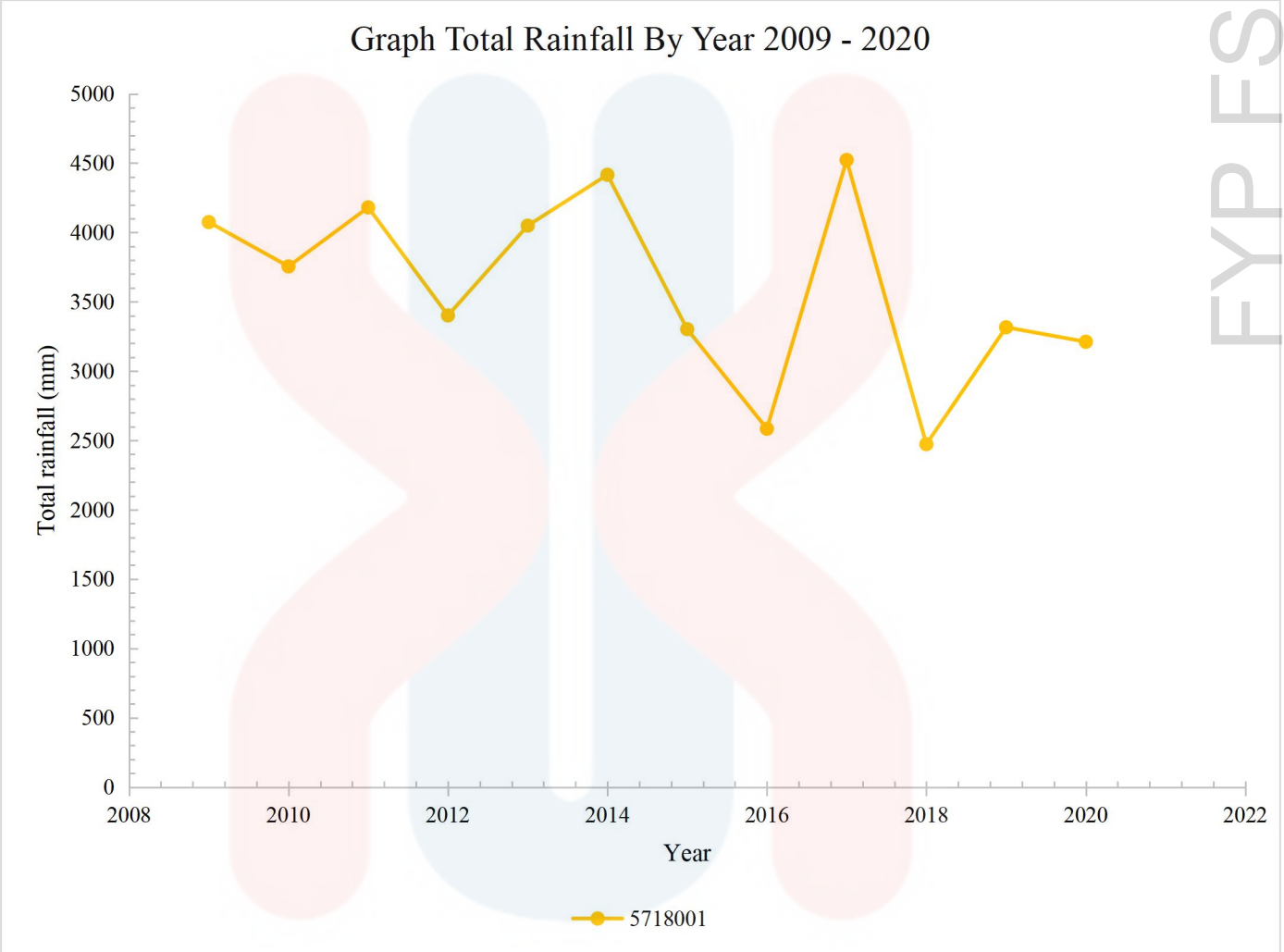


Figure 5.3: Graph of total annual rainfall (2009-2019)

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 2011, 2014 and 2017. It is based on comparison themovement of graph between each year. During year 2011, 2014, and 2017, most of the station are experience increasing of the precipitation when compared to the other year.

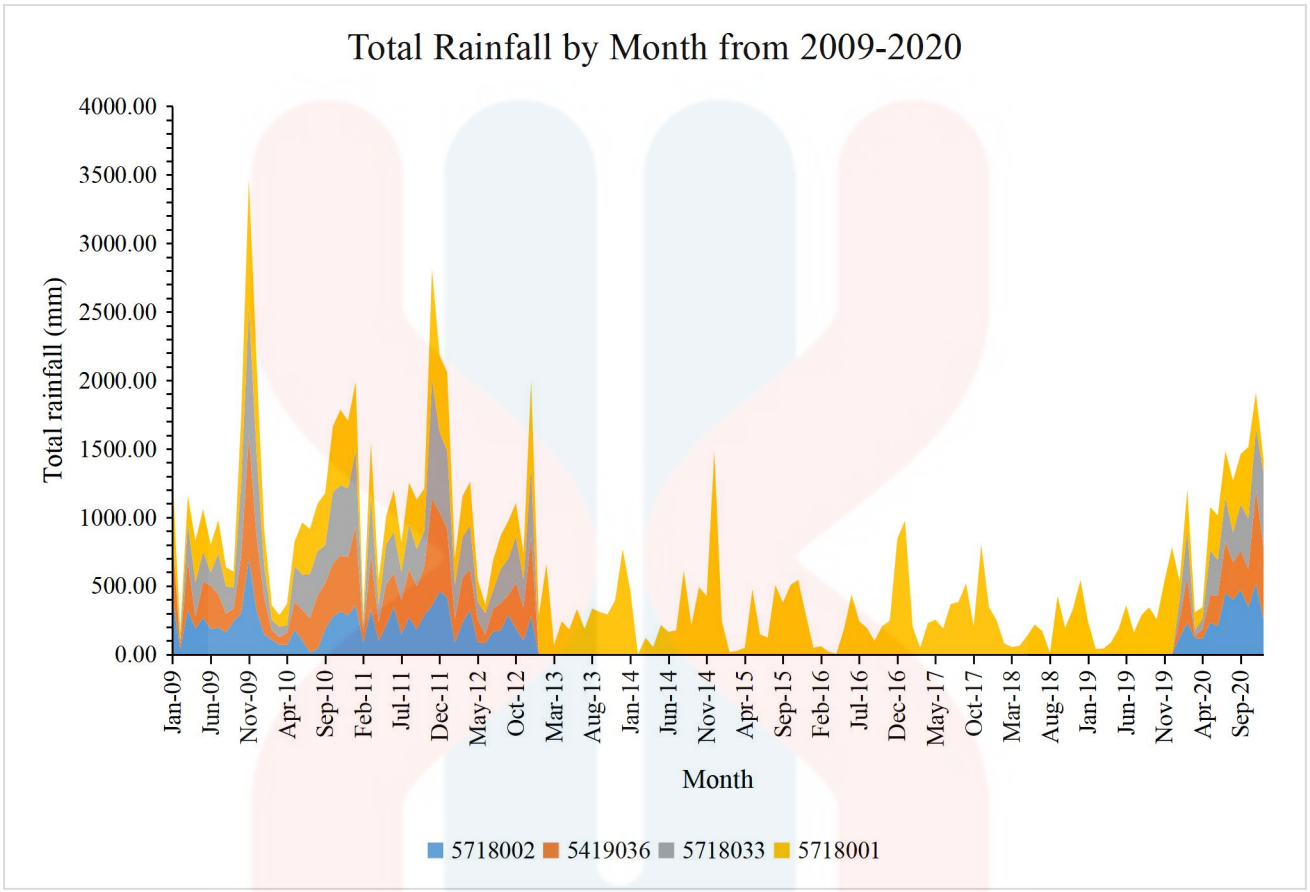


Figure 5.4: Graph of total rainfall in month

5.3.3 Trend Analysis using Mann-Kendall (MK)

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
438.2	47	0	47	59.500	929.300	318.604	192.306
408.3	47	0	47	16.000	700.400	219.426	129.911
445.6	47	0	47	36.100	901.800	298.415	186.711
7	47	0	47	32.100	930.700	314.015	198.280

Figure of Man Kendall Analysis

Mean precipitation of the study region from 2009–2019 was found to be 219.426 mm. The minimum and maximum recorded rainfall was 16.000 and 930.700 mm per year. The maximum standard deviation show 129.911 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.

Series\Test	Kendall's tau	p-value	S	Var(S)	p-value (Two-tailed)	alpha
S1	0.077	0.452	83	11889.000	0.452	0.05
S2	0.051	0.620	55	11889.000	0.620	0.05
S3	0.082	0.420	89	11891.000	0.420	0.05
S4	0.106	0.296	115	11891.000	0.296	0.05

Table 5.4 for Man Kendall Analysis

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. Most of the rainfall stations respectively has significant rainfall intensity trend at 0.05 and 0.1 significance level.

5.3.4 Discussion

The fundamental purpose of conducting an analysis of time series is to gain an understanding of recurrent patterns in the shifts that take place over a period of time. The research area had the greatest quantity of rainfall in 2014, which was one of the defining characteristics of the region. The amount of precipitation that falls on the stations during a given year can vary from one to the next depending on the year. This study's findings, which found an increase in rainfall, are generally in agreement with the findings of previous studies, which also reported an increase in rainfall.

According to the results of the Mann-Kendall Test, there was both a decreasing and an increasing trend of rainfall observed across all of the stations. However, at the 95% confidence level, there is not a statistically significant trend in any of the stations.It was obvious that the major flooding that occurred in certain stations and areas affected in 2014 was probably caused by the increasing rainfall that occurred in 2014 during the study period. A few of the other stations also demonstrated a slight upward trend throughout the year 2014.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The purposes of this study, which include broad geological mapping and trend analysis of rainfall, will be summed up in this chapter. You may read a detailed account of both in Chapters 4 and 5. The study's goals are to analyse rainfall trends and patterns throughout time and to update the geological map.

Overlaying and comparing the previous geological map with other researcher and JMG's geological map of the peninsula allowed for its creation. In this chapter, we see an updated geological map and a thorough description of the mapping process and its results. Also with assistance of a contour map, a drainage pattern map, and a 3D topography map, the morphology and landform of the research region are being explained. It had been decided how to categorize the stratigraphic column of the study region. The rock that is determined to be the oldest is schist and granite, which is the most recent rock. The arrangement of the rock ages was determined using relative dating and various other study methods.

The second set of goals involves doing research on rainfall trends and performing time series analyses in Kelantan. According to the findings that were provided by the Department of Irrigation and Drainage (DID), the months of October through January are the ones that see the most amount of rain, as determined by the study's rainfall trend analysis (2014). As can be observed, this proves that the factor of significant flood event that occurred in 2014 was due to the highly intense rainfall. The existence of trends in the annual data for the Kelantan River Basin was investigated in this study.

Future development projects can benefit from this study's findings in several ways. For instance, the study's findings can provide valuable information and an a priori view to help engineers and practitioners implement the structures to be built to cope with floods and droughts in light of the study's examination of the most common climatic events. The research's findings could help with water resource management and planning in the Kelantan River Basin. Considering the century-long rise in total rainfall, the current analysis could help in the implementation of water conservation measures in the region to prevent water overflowing problems in the near future.

6.2 Suggestion

Based on the findings, several suggestions and recommendations can be made to enhance the outcome of the trend analysis of rainfall. The precision and accuracy of the result for partical implementation is improved by increasing the number of sample stations. Additionally, when a station's data quality needs improvement and errors are present, this must be a top priority. To get the precise and reliable flooding parameter, additional research will need to employ a different test method. Data on rainfall is needed to get results that are more accurate and variable.

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