ANALYSIS OF RELATIONSHIP BETWEEN THE INTENSITY OF THE RAINFALL AND FLOODS DURING THE DECEMBER 2014 IN SUNGAI PAHANG BASIN

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Thesis submitted in partial fulfilment of the requirements for award of the degree of
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources
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DEDICATION

It is with my deepest gratitude and warmest affection that I dedicate this to my family and lecturers who have been constant source of knowledge and inspiration.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful,

Alhamdulillah, all praises to Allah for the strengths and His blessing upon me. I would like to give credit to my Supervisor and Co-Supervisor, Pn. Hasmanie binti Abdul and Dr. Mohamad Idris bin Ali for their full support, expert guidance, understanding and encouragement throughout my study and research. Without their incredible patience and timely wisdom and counsel, my thesis work would have been a frustrating and overwhelming pursuit.

I express my appreciation to my parents, Mr. Amir Shariffudin bin Abd Majid and Mrs. Norzaihan binti Mohd Zainol Abidin for their unconditional love and support during the year.

Special thanks to my numerous friends and colleagues who helped me out throughout this research. Also because of their valuable opinions and sharing ideas during the progress of this project, finally i can complete the thesis successfully.

Last but not least, many thanks to Dr. Nurul Nadrah Aqilah binti Tukimat as the coordinator of final year project whose guidance of this project was deeply appreciated.

Thank you.

ABSTRACT

In December 2014, severe flooding had hit part of Peninsular Malaysia. As a result many casualty and damages, for Pahang state alone suffered losses of RM610 million. The main causes were the high intensity of rain and overflowing rivers to major settlements. The main objective of this study was to analyse the relationship between the intensity of the rain and floods during the December 2014 in Sungai Pahang basin. The specific objectives of the study are as follows; to validate satellite-based daily rainfall with rain-gauge rainfall and to analyse relationship between the intensity of the rainfall and floods. This study uses satellite-based daily rainfall, to map the spatial-temporal distribution of rainfall during flood events. The satellite-based daily rainfall over rain-gauge station retrieved and validated. Then, the analysis of intensity satellite-based daily rainfall data for each towns along the river Ulu Pahang and related areas was performed. The satellite-based and rain-gauge station daily rainfall data shows a good correlation *(r= 0.79 - 0.92; coefficient= 0.72-1.67).* From the analysis, the city experienced flooding even got a little rain intensity. This because the river overflowed due to the high intensity of rain in the upper reaches for example Merapoh, Kuala Tahan and Jerantut. In conclusion, the extreme rainfall event at the upstream area will cause the water level increase rapidly and unexpected flood will happen. The outcomes of this study shows satellite-based rainfall data could be used to help in prepare a flood incident report with more comprehensive.

ABSTRAK

Pada Disember 2014, banjir besar telah melanda sebahagian daripada Semenanjung Malaysia. Akibatnya, banyak mangsa dan kerugian dialami, bagi negeri Pahang sahaja mengalami kerugian sebanyak RM610 juta. Punca utama adalah kerana keamatan hujan yang tinggi dan sungai melimpah ke kawasan penempatan utama. Objektif utama kajian ini adalah untuk menganalisis hubungan antara keamatan hujan dan banjir semasa Disember 2014 di lembangan Sungai Pahang. Objektif khusus kajian ini adalah seperti berikut; untuk mengesahkan hujan harian berasaskan satelit dengan hujan di tapak dan untuk menganalisis hubungan antara keamatan hujan dan banjir. Kajian ini menggunakan hujan harian berasaskan satelit, untuk memetakan taburan spatial-temporal hujan sepanjang peristiwa banjir. Hujan harian berasaskan satelit dan hujan tapak stesen diambil dan disahkan. Kemudian, analisis intensiti data hujan harian berasaskan satelit untuk setiap bandar di sepanjang sungai Ulu Pahang dan kawasan yang berkaitan dilakukan. Hujan harian berasaskan satelit dan data hujan harian tapak stesen menunjukkan korelasi yang baik (r = *0,79-0,92*; m = *0,72-1,67*). Daripada analisis, bandar mengalami banjir walaupun mendapat keamatan hujan yang sedikit. Hal ini kerana sungai melimpah disebabkan keamatan hujan yang tinggi di hulu contohnya Merapoh, Kuala Tahan dan Jerantut. Kesimpulannya, hujan yang melampau di kawasan hulu akan menaikan paras air dengan cepat dan banjir yang tidak dijangka akan berlaku. Hasil kajian ini menunjukkan data hujan berasaskan satelit boleh digunakan untuk membantu dalam menyediakan laporan kejadian banjir dengan lebih menyeluruh.

.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

TRMM	Tropical Rainfall Measuring Mission
DID	Department of Irrigation and Drainage Malaysia
BH	Berita Harian
UM	Utusan Malaysia
Dec	December
Sg.	Sungai (River)
MRT	Mass Rapid Transit
GIS	Geographical Information System
IR	Infrared Radiation
PR	Precipitation Radar
NASA	National Aeronautics and Space Administration
TIFF	Tag Image File Format
SSM/I	Special Sensor Microwave Imager
IR4	Long Wave Infrared Imagery

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Natural disasters are happened every year and their impact and frequency seem to have greatly increased in recent decades, mostly because of environmental degradation, such deforestation, intensified land use, and the increasing population (Vincent, 1997). Floods are among the most frequent and costly natural disasters in terms of human and economic loss. As much as 90 percent of the damage related to natural disasters in Malaysia is caused by flood. Average annual flood damage is as high as US100 millions. These flooding have caused considerable damage to highways, settlement, agriculture and livelihood. In Malaysia, floods are caused by a combination of natural and human factors. Malaysians are historically river dwellers as early settlements grew on the banks of the major rivers in the peninsula.

Coupled with natural factors such heavy monsoon rainfall, intense convection rain storms, poor drainage and other local factors, floods have become a common feature in the lives of a significant number of Malaysians. Monsoon rains have profoundly influence on many aspects of the lives of the people in the east coast of Peninsular Malaysia (Chan, 1995).While the rains are needed for agriculture, particularly wet rice cultivation, they are also largely responsible for bringing seasonal floods. Recently, in 2006 and 2007, heavy monsoon rainfall has triggered floods along Malaysia's east coast as well as in southern state of Johor.

The hardest hit areas are along the east coast of peninsular Malaysia in the states of Kelantan, Terengganu and Pahang. The city of Johor was particularly hard hit in southernside. The flood cost nearly million dollars of property and many lives. The extent of damage could have been reduced or minimized if an early warning system would have been in place.

Major flood are shown in the Figure 1.1 below. It shows that severe flooding occurred nearby the sea and spreading to other places. Major flood prone areas are in Pahang, Johor and Terengganu.

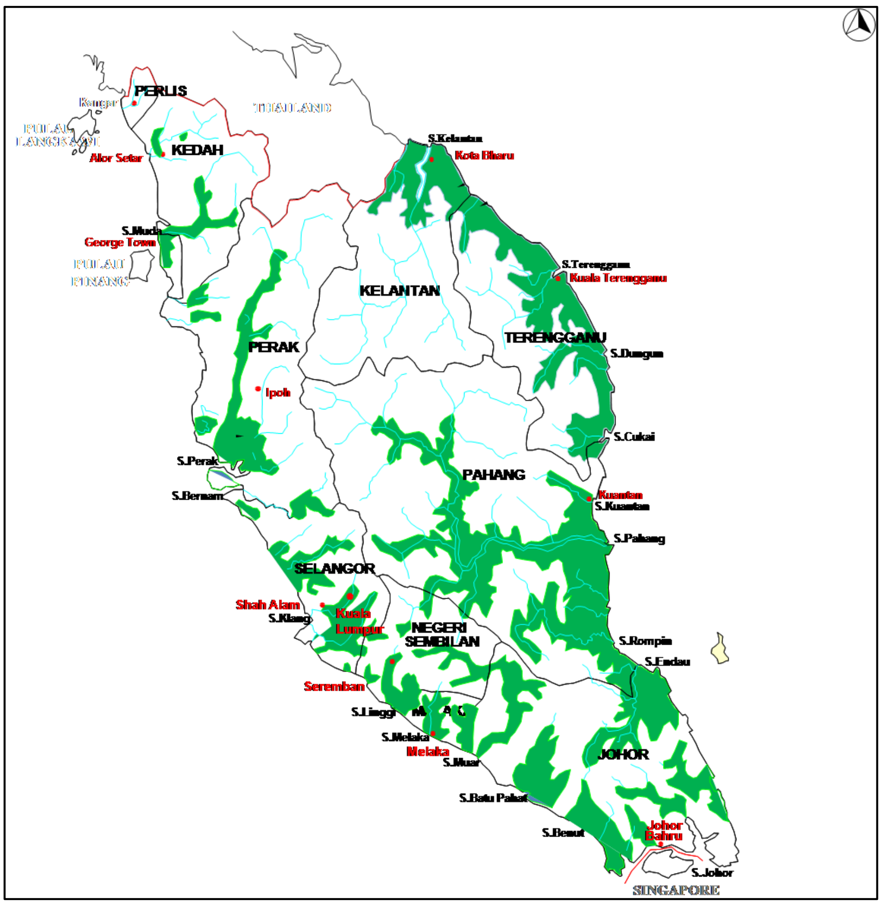

Figure 1.1 Flood Prone Peninsular Malaysia (DID Portal, water.gov.my)

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1.2 PROBLEM STATEMENT

At the end of year 2014, many states in Malaysia experienced severe floods. This was larger than in December two years ago. Regional and country involved are covering a wider area. The time is also longer. Consequently, the damage to property and infrastructure doubled. Depending on the place, a title is given to flood event this time. In Kelantan, 'Bah Merah', while in Pahang 'Bah 100 Tahun'. Title is based on the historical record and experience of local residents.

Various predictions were made pertaining to causes of this flood which are the cold weather in broad land in Asia, illegal logging and unplanned development. Based on records, the cause of frequent flooding associated with the three principles of high intensity rainfall, the rising water level of the river which eventually overflows the river to someplace, and the tide is higher than the norm. Malaysia is located near the equator, Malaysia's latitude and longitude is 2° 30' N and 112° 30' E.

Climate is influenced by the ocean and the changes of wind system that blowing from the Indian Ocean and South China Sea. Seasonal wind patterns with local topographic characteristics determine the rainfall pattern.

High-intensity rainfall patterns are changed. The period is between the two monsoon (October) to the early stages of the Northeast Monsoon (November). December and early January Northeast Monsoon winds bring high-intensity rainfall that caused flooding to the East Coast. From 2001 to 2013, the pattern position of the high intensity of rain in December is varying. This is shown by the big floods in the area. For example in 2001 and 2013, floods hit the district of Kuantan, Pahang and in 2006 and early 2007, heavy floods in Johor.

In December 2014, flooding occurred in Kelantan, Terengganu, Pahang and Perak. Before the incident, the satellite images show the cloud distribution that could potentially giving high-intensity rainfall covering most of the East Coast.

Records are also reported in the basin, the area experienced a high intensity of rain. This shows the high rainfall intensity of a few days of flooding was a major factor.

After the floods drained, severe damage to civilian property and infrastructure facilities can be seen. Pahang state alone suffered losses of RM610 million. This can be related to the movement of runoff in the basin (from higher to lower areas) and the water flow in the river (upstream and downstream). For example floods in Kelantan and Sungai Pahang River basin. River basin is a small unit of the hydrological cycle. In the hydrological cycle, rainfall that reaches the ground (including drainage, rivers, and lakes) will be surface runoff or infiltrated into the soil or become groundwater storage.

Overflowing water is the problem. It is then released into the atmosphere as evaporation (from the soil surface, lake, river, sea). How rainfall is distributed to the components of the hydrological (runoff, soil moisture, groundwater) is depend on the space and 'temporal' rainfall and its surface characteristics. Although the basin ecological system does not produce its own water, but it able to change the rate of water that went to the basin landscape. Since the 1960s, many forest areas explored to expand the trade area and placement to enhance the economic activities of the population. This causes in change of river basin landscape as coverage and land use diversity.

Before the floods event in December 2013 and December 2014, we are often told with news of high water rationing between February and March due to lack of water in the river. However, high-intensity rainfall limit the amount of water a lot, could cause flooding, when the river is full and overflowing into low-lying areas nearby. Sometimes it is not just high intensity rains that cause the overflow of rivers, change of streams and narrow waterway is also a factor. High tide also blocks the passage of river water into the sea, causing the water level of the river rising up and overflows into the lower area.

These disasters are unpredictable. We cannot cut down the intensity and amount of rainfall. We can only reduce the rainfall and delay the falling water coming to the earth's surface, with the help of tree canopy naturally. Tree canopy serves as the repository of some rain and then delaying the existence of the runoff. To avoid rapid river flow to full and overflows, the existence of natural storage areas (marshes and lakes) and artificial storage areas can slow the runoff into the river.

A flood in Maran (junction to Bandar Jengka) with a height of almost 3 meters on the last 1st January is an example of the effect of the overflow of Sungai Pahang. Though the town is 2.5 kilometers from the Sungai Pahang River, the routing pressure was pushing water into a small branch of the river, and then overflowed into low-lying areas.

Every year in December during the Northeast Monsoon winds, the authorities and the public had been expecting a flood will occur. Only the date and the scene at the right time cannot be ascertained.


Berita Harian :Kelemahan Jangka Banjir Besar Perlu Diatasi Segera

28 RENCANA

Kelemahan jangka banjir besar perlu diatasi segera

Rekod, pengalaman hadapi monsun patut mampu kurangkan risiko bencana

"Kita hanya boleh kurangkan curahan air dan melambatkan tempoh sampai air hujan ke permukaan bumi, dengan bantuan kanopi pokok. Secara semula jadi, kanopi pokok berfungsi sebagai tempat simpanan sebahagian curahan hujan dan seterusnya melewatkan kewujudan air larian"

RENCANA 29

Figure 1.2 Flood Article (Berita Harian, March.2015)

1.3 OBJECTIVES OF STUDY

The main objective of this study was to analyse the relationship between the intensity of the rain and floods during the December 2014 in Sungai Pahang basin. The specific objectives of the study are as follows:

1. To validate satellite-based daily rainfall with rainfall rain-gauge, and
2. To analyze the relationship between the intensity of the rainfall and floods.

1.4 SCOPE OF STUDY

This study was limit to the following:

a) The period of study was limited from 20 Dec to 31 Dec 2014.
b) Satellite based rainfall data downloaded from public domain (nasa earth observation) were used as daily- rainfall data.
c) The satellite-based daily rainfall over rain-gauge station retrieved and validated.

1.5 AREA OF STUDY

The Study area in this research is the flood affected areas in Pahang along Sg. Pahang Basin especially in Jerantut, Temerloh, Lipis and Pekan where the most severe and damaged flood affected are.

Pahang is the third largest state in Malaysia, after Sarawak and Sabah, and the largest in Peninsular Malaysia. The state occupies the huge Pahang River river basin. It is bordered to the north by Kelantan, to the west by Perak, Selangor, Negeri Sembilan, to the south by Johor and to the east by Terengganu and the South China Sea.

Its state capital is Kuantan, and the royal seat is at Pekan. Other important towns include Jerantut, Kuala Lipis, Temerloh and the hill resorts of Genting Highlands, Cameron Highlands, Bukit Tinggi and Fraser's Hill.

The ethnic composition is roughly 1,000,000 Malay and Bumiputra, 233,000 Chinese, 68,500 Indians, 13,700 others, and 68,000 non-citizens. The total population (2015) is 1,623,200 with the density of 45/km^2 (120/sq mi). The total area is 36,137 km^2 (13,953 sq mi).

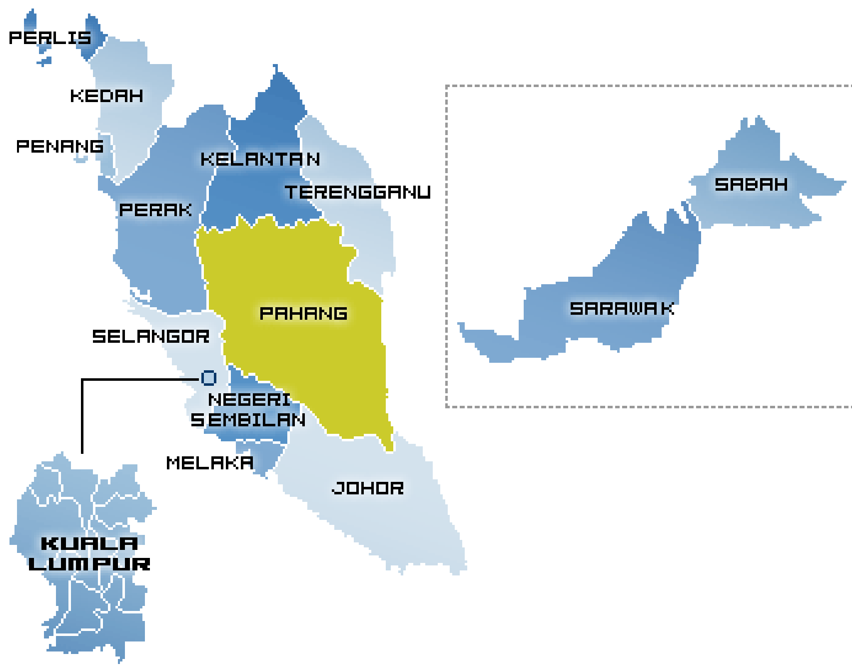

Figure 1.3 Pahang Maps location

1.6 SIGNIFICANCE OF STUDY

The rain-gauge rainfall data are limited; meanwhile with the use of satellite-based rainfall data, it can cover the entire areas. The utilization of satellite-based rainfall data will assist the information on rainfall distributions on the whole areas including the remote areas or the upper reach.

This study could be taken as a way to ease the existing and generated data to be stored and placed in an orderly arrangement. This study has a historical inundation in Pahang. Thus, to improve understanding; the study of flooding should be continued with a more focused. To increase human capacity to manage floods, the experience of flood events should be collected and used as a lesson. All measures are regulated to control the flooding will be effectively implemented.

1.7 THESIS STRUCTURE

This research consists of five chapters. Chapter one comprises the introduction section. It states the study background, problem statement, objectives of study, scope of study and lastly significant of study. For chapter two, describe the key term in-purpose of these study and comprises the literature reviews that related and suitable for these study. Chapter three explains the research methodology that used for planning research, type of data collected and the method of data analysis to be employed. For chapter four present the result that obtained from the study area and year of study and discussed the result from analysis. Finally, chapter five comprises the conclusion from the overall chapter and relates some recommendation for future work on research field.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A flood can be defined as any high water flow that dominates the natural or artificial banks in any part of the river system. Therefore, when a river bank is overtopped, the water extends over the flood plain and generally becomes hazard to the society (Ching et al., 2013).

When floods occurred, it has terrible impacts on people as it disrupts their day to day activities and the impacts can last for a week in the coming years, climate change is likely to make the situation even more challenging (NFRA, 2011).Flooding is a natural event, and no matter how hard a government or society tried to minimize or to stop it completely (FRMP 2012).

The most devastating natural disaster experienced in Malaysia is flood. Throughout Malaysia, including Sabah and Sarawak, there is total of 189 river basins with the main channels flowing directly to the south china sea and 85 of them are prone to recurrent flooding (89 of the river basins are in Peninsula Malaysia, 78 in Sabah and 22 in Sarawak). The estimated area vulnerable to flood disaster is approximately 29,800 km^2 or 9% of the total Malaysia area, and is affecting almost 4.82 million people which is around 22% of the total population of the country (DID, 2009).

2.2 TYPES OF FLOODS IN MALAYSIA

In Malaysia, flooding can be divided into three types. It is classified according to the duration and intensity of rainfall as well as the damage caused by the flooding. The followings are the common types of flood in Malaysia:

a) Flash Flood
b) Flood Area
c) Dams Flood

2.2.1 Flash Flood

The rain that fell with great intensity in a short period in an area particularly in urban areas is likely to cause flash floods. This occurs because the drainage system is no longer able to accommodate the runoff caused by the rain. Among the causes of flash floods is:

a) Load sewers and drains that are not large enough in size to accommodate the runoff.
b) Improper drainage due to a clogged drain by garbage or obstructions.
c) Most large spaces which water permeable surfaces have been replaced with asphalt and concrete construction.

Figure 2.1 Flash Flood in Raja Chulan (myMetro,2013)

2.2.2 Flood Area

Flood area is more serious than the flash floods because it covers a wider area and takes a longer time to recede. The flooding occurred as a result of the existing drainage that is unable to accommodate the excess flow that turns into runoff. This coupled with low infiltration rates due to factors that change due to land use development. Flood areas usually cause severe destruction, loss of property and sometimes can lead to loss of life.

Mangsa Banjir Meningkat Di Kelantan, Pahang Dan Perak

Diterbitkan: Khamis, 25 Disember 2014 7:30 PM

Antara kawasan yang dinaiki banjir di sekitar Manek Urai ketika tinjauan di sekitar Kelantan pada Khamis.
Foto: BERNAMA

Figure 2.2 Flood Affected Areas Manek Urai, Kelantan (Bernama, 25Dec14)

2.2.3 Dams Flood

Flood dam is rare in our country as all dams which have been designed taking into account the excess water. Failure and human error in the design of the dam is the root cause of this type of flooding. The destruction caused by the flood dams are the worst dam because the dam structure usually constructed upstream and when this structure fails, all the areas of the downstream will be affected.

2.3 FLOODS IN MALAYSIA ACCORDING TO DID

a) Flash Floods

b) Monsoon Floods

Floods in Malaysia have been classified in two categories by the Malaysian Drainage and Irrigation Department, i.e. flash flood and monsoon floods (DID, 2000a). Based on the hydrological perspectives, the clear difference between these two disasters is the period taken by the river flow to recede to the normal level. Flash floods take only some hours to return to the normal water level, while monsoon flood can last for a month (Noorazuan, 2006).

2.3.1 Flash Flood

Due to intense development, flash flood occurrence in the country has been on the increase and it can happen several times each year leading to massive disruption in business activities with immense socio-economic and financial impacts. Flash flood is normally caused by severe storms such as squall-lines or thunderstorms which are localized with rainfall of high intensity and short durations (2 to 5 hours).

Due to the high intensity rainfall, low lying and poorly drained areas may be subjected to heavy flooding as the squall-line passes. In late 1996 Penang and Prai was affected by flash flood caused by squall-line which developed in the northern Malacca Straits moving rapidly inland in the early morning. These floods resulted in considerable damage of property and public facilities.

Thunderstorms occur throughout the year but are most likely to happen in the inter-monsoon periods, namely April to May and October to November. Over land, thunderstorms frequently develop in the afternoon and evening hours while over the sea, thunderstorms are more frequent at night. Sometimes the thunderstorm cells are small and localized but can be severe with intense lightning activities, heavy rainfall and strong wind gust. It is difficult to forecast the precipitation intensity, direction and the speed of the thunderstorms. The severe thunderstorms with high intensity rainfall and short duration may cause flash flood in major cities and towns.

Flash floods

Even though water levels at dams were low, Klang Valley residents dread the sound of thunder.True to the Meteorological Department forecast of of heavy rain and thunderstorms in April, flash floods hit KL and Selangor. Traffic came to a standstill one rainy afternoon in May at the Jalan Duta-Jalan Semantan interchange.

The deluge of flood water, which came up to 30cm high, left motorists stranded as the exit heading towards Lebuhraya Mahameru was sealed off by muddy waters.

On Oct 1, following a 90-minutes' downpour, cars in a parking lot along Jalan Pinang in KL was submerged in flood waters. The lack of proper irrigation systems, rapid development including the ongoing MRT works and poor disposal habits continue to cause flood floods in the city.

Figure 2.3 Flood Article of Flash Flood (The Star,30Dec2014)

From the Figure 2.3 above it shows the flash flood that take place in Klang Valley. Even though water levels at dams were low, Klang Valley residents dread the sound of thunder. True to the Meteorological Department forecast of heavy rain and thunderstorms in April, flash flood hit KL and Selangor. Traffic came to a standstill one rainy afternoon in May at the Jalan Duta-Jalan Semantan interchange.

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2.3.2 Monsoon Flood

The Northeast monsoon is the major rainy season in the country. Occasionally, the Northeast monsoon brings heavy rains which may cause severe floods to the east coast states of Peninsular Malaysia during the months November till January and January till early March over the western part of Sarawak and Sabah. During the Northeast Monsoon, large-scale features such as the monsoon surges and the near-equatorial trough (and associated monsoon lows and cyclonic vortex) strongly influence the rainfall amounts and patterns. The cold surges or monsoon surges come in phase with the westward moving cyclonic vortex embedded in the near-equatorial trough will bring widespread torrential rain. The widespread heavy 2 monsoon rain normally lasts for 2 to 3 days. In severe cases, it can last for 3 to 8 days.

Figure 2.4 below shows the rainfall pattern in Malaysia and how is it influenced by the two monsoons: the South west and north east Monsoons. The location of Malaysia itself consists of West Malaysia (Peninsula Malaysia) and East Malaysia (Sabah and Sarawak) and they are divided by the South China Sea (Toriman et al., 2013).

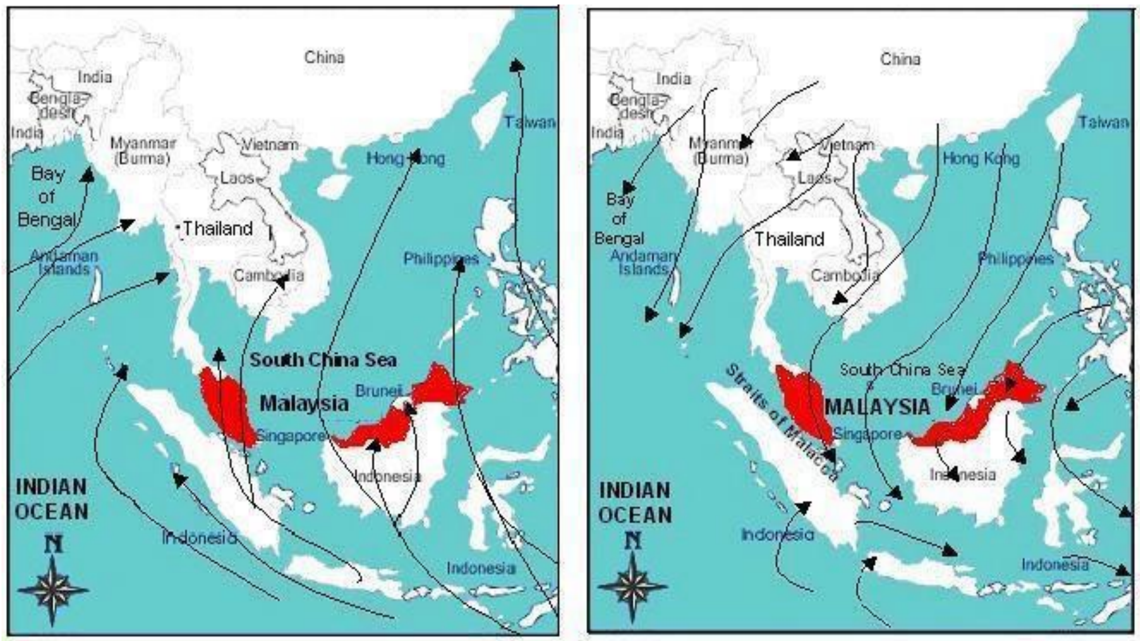

Figure 2.4 Southwest and Northeast Monsoons (Toriman et al., 2013)

Local weather changes are among the natural cause that triggered flash flood; while non-natural causes such as inefficient urban drainage system and increase of the number of building in the urban areas, and it is the causes of most of the flash floods event in the Klang Valley Peninsular (DID 2000a).

According to Chan, (1996), due to an increase in impervious surfaces such as roads, buildings and parking spaces, the risk and exposure of urban dwellers to floods has recently increased. It has been observed that, the economic repercussions of floods are more severely felt by the low-income dwellers especially in the flood-plain area (Chan, 2000).

With their minimal level of income, what they can do is only small effort to mitigate the impact of floods (Sulong et al., 2012). Malaysia has experienced series of floods since 1920s and one of the severest is the December 2006 and January 2007 floods, the rescue and recovery departments has learn a lot of experiences as a results of these floods (Barton, 1994, Drabek, 1995, Ewen et al., 2007 and Tompkins et al., 2008).

2.4 FLOOD HISTORY IN MALAYSIA

2.4.1 Review of Flood History in Some Areas in Malaysia

Terengganu receive heavy rainfall during the North east monsoon that occurs between October and March and leads to severe floods almost every year at all over the state. Terengganu is located at the east coast of Peninsular Malaysia that has never missed a flooding event especially during the months of November and December during the north east monsoon period. The floods that occur at Dungun area of Terengganu state was due to the combination of physical factors such as elevation and also its close proximity to the sea apart from heavy rainfall received during the monsoon period. Hence, a flood that affects the Terengganu area and other location along the eastern coast is termed as a coastal flooding (Muhd Barzani et al., 2007).

Historically, Muar River Basin has experienced frequent flooding over the years, there had been series of heavy rainfall events that had resulted in flooding within the Muar River Basin catchments. The recorded floods are shown from December 1926 to January 1927, February to April 1967, November 1967 to January 1968, December 1970 to January 1971 and November 1979 respectively. From 1980 to 2010, a total of 29 flood events have been recorded (Ching et al., 2013).

Another enormous flood in the Malaysian flood disaster history, striking in four states in the Peninsular Malaysia like: Melaka, Johor, Pahang and Negeri Sembilan. The flood incident started when the Northeast monsoon brought a heavy rain through series of continues storms, causing destructive flood in Kota Tinggi, Johor (MNRE 2007a). The flood strike as a result of two waves, the December 2006 which last for 13 days from 19 – 31 December, and January 2007 lasted for 7 days from 12 – 17 January. The series of floods were unusual as the 2006 average rainfall return period was 50 years while the 2007 had more than 100 years of return period (Shafie 2007, BadrulHisham et al., 2010).

The flood was destructive with the highest water level recorded reached 2.75m, is the highest level ever recorded since 1950 and it resulted in more than 100,000 people to be evacuated and the death of 18 people recorded (MNRE 2007a). Table 1, below shows the flood history in Malaysia, including the lost and the fatality rate.

Table 2.1 Floods History in Malaysia

Date/Year	Incidence	Property, Material, Crop or other losses USD	Number of Deaths	Source (Chan,2012)
1926	Flood Known as "The storm forest flood"	Thousands of hectares of forest destroyed	NA	
Dec 1996	Floods brought by Tropical Storm Greg in Keningau (Sabah State)	300 Million	241	
2000	Flood caused by heavy rains in Kelantan and Terengganu	Millions	15	
Dec 2004	Asian Tsunami	Millions	68	
Dec 2006 & 2007	Floods in Johor State	489 Million	18	
2008	Floods in Johor State	21.19 Million	28	
2010	Floods in Kedah and Perlis	8.48 Million (Aid Alone)	4	
2011& 2012	La Nina in 2011 and 2012 (which brought floods)	NA	NA	

2.5 HISTORY OF FLOODS IN PAHANG

2.5.1 Big Flood 1924

1923 a major flood occurred in Pahang. The floods destroyed large tracts of land in Lipis district, Temerloh, Kuantan and Pekan. Floods continue to occur until 1924 that suppress the system connection between Pekan with other district. Disasters occurring Pahang cause a shortage of rice. Thus, the British took the step of buying and sending rice to Mentakab then sent to Pekan by road. The floods that occurred in that year were the worst ever happened and claimed many lives, especially those who live along the Sungai Pahang in Pekan. At the end of 1926 another great flood, is noted.

Flash floods destroyed almost all regions except in Pahang Raub and Bentong. Most of the residents had to be relocated to higher areas. Road and rail system is disrupted. Telegraph and telephone services were also cut off and most of the stations are not fully functional and also the damage of public and private property. Many homes were destroyed by flooding when the flood receding, mud and sand left behind in certain areas and disrupting agricultural work. On the Ulu Tembeling, river sediment covers an area of nearly 20 feet thick. Despite the damage and destruction suffered by the local population is great but most of them still calm and try to help the British to restore normal condition that used to. Work began to repair the damage done in 1927 on concerns about flooding in the year. Therefore, the British government took initial steps to deal with the flooding. Food supplies are stored in large quantities. The floods in previous years also destroyed the coconut plantations covering an area of 500 acres (200 hectares) in Kuantan.

2.5.2 Big Flood 1972

History of the biggest floods ever to hit our country occurred in January 1971 until the government was forced to declare a state of emergency throughout the country after almost submerged by water due to heavy rains that fell continuously for nearly 1 week. The floods recede within a week after the killing of 24 people and property losses estimated at more than £ 84.7 million. The floods also left the worst effects of the damage, many lost their homes and possessions. Many are forced to live homeless, after all possessions washed away by floods.

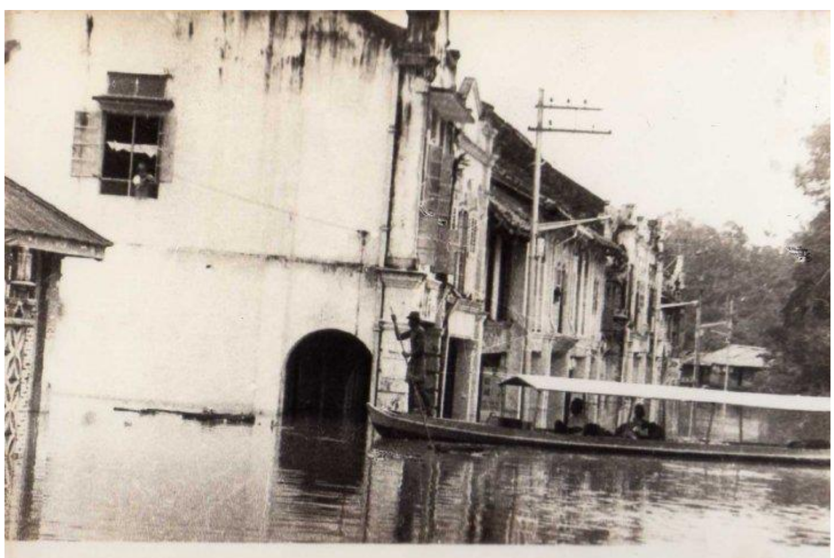

Figure 2.5 Flood in Kuala Lipis 1971 (courtesy: Nan Zul, Dec 2013)

Figure 2.6 Flood at Jalan Jelai year 1971 (courtesy: Nan Zul, Dec 2013)

2.5.3 Big Flood in Kuantan 2013

- **Before flood**

On 15 November, Pahang State Secretary Datuk Seri Muhammad Safian Ismail said the government was ready to face Pahang floods, which are expected to hit the country starting the end of November. Muhammad Safian said a total of 579 shelters are located which 60 percent of school buildings, while essential items like food will be placed at 73 bases starting 18November, involving an allocation of RM 1.2 million. "A total of 6,000 officials from 14 departments and agencies directly involved were getting ready to assist the flood victims," he said.

- **During flood**

On the first day of flooding in Kuantan, everything was chaos, including flood operations like security agencies shocked by the disaster. Sultan Ahmad Shah visited social site like Facebook and Twitter also abound with images and information which would worries all those who are not in Kuantan and Pahang to get actual information. Flood 2013 in Kuantan Pahang Chief Minister Datuk Seri Adnan Yaakob told reporters acknowledge many shortcomings and weaknesses on the first day floods hit three days ago. A problem when operating officer floods have found their homes was flooded. Kuantan city paralyzed, electricity and water cut off, and relief centers for flood victims also reported shortages of food and basic necessities.

- **Flood figure (victims)**

December 7, 2013 - Heavy rains hit once again this morning, the number of flood victims increased to 38,210 people, involved eight districts today. Flood Operations Room of Police Headquarters Pahang, Kuantan recorded the highest number of victims of 32.871, victims in Pekan(3,464), Temerloh(839), Jerantut(519), Maran (183) , Bera (117) and Lipis (53). He said all the victims are housed in 117 evacuation centers after their homes were flooded by the disaster.

Prime Minister Datuk Seri Najib Tun Razak today announced an assistance of RM500 for each family of victims who are being hit the East Coast and Johor. When delivering a speech holds on UMNO Assembly 2013 in Putra World Trade Centre (PWTC) here today, he also wants all banks allow victims to postponed repayment of their loans.

2.6 TOTAL FLOOD VICTIMS IN PAHANG DEC 2014

The date of flood report is on 27th December 2014 at 10pm. The report is from Ops Banjir Negeri Pahang, Sinar Harian. The affected flood area is in total of 9 districts in Pahang. The most severe areas in this flood event are Kuantan, Jerantut, Temerloh, Pekan and Maran.

Table 2.2: Total Flood Victims in Pahang Dec 2014

District	Total Village	Total Evacuation centre	Total Family	Total victims
KUANTAN	111	34	2,657	10,174
PEKAN	40	31	865	3,324
MARAN	42	28	827	3,455
TEMERLOH	69	67	1,330	5,700
JERANTUT	55	46	1,458	6,427
BERA	13	13	217	855
RAUB	7	7	81	262
ROMPIN	1	1	3	13
LIPIS	36	34	660	2,647
TOTAL SUM UP	**374**	**261**	**8,098**	**32,857**

2.7 GEOGRAPHICAL INFORMATION SYSTEM

GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations.

A GIS is an organized collection of computer hardware, software, geographic data, and personnel to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

The principle of Geographical Information System (GIS) is as follow:

a) Data Capture: Data sources are mainly obtained from manual digitization and scanning of aerial photographs, paper maps, and existing digital data sets.
b) Database Management and Update: Data security, data integrity, and data storage and retrieval, and data maintenance abilities.
c) Geographic Analysis: The collected information is analyzed and interpreted qualitatively and quantitatively.
d) Preparing Result: One of the most exciting aspects of GIS technology is the variety of different ways in which the information can be presented.

The Functions of Geographical Information System (GIS) is as follow:

a) Functions Data Capture: The input of data into a GIS can be achieved through many different methods of gathering. For example, aerial photography, scanning, digitizing, GPS or global positioning system is just a few of the ways a GIS user could obtain data.
b) Data Storage: Some data is stored such as a map in a drawer, while others, such as digital data, can be as a hardcopy, stored on CD or on your hard drive.
c) Data Manipulation: The digital geographical data can be edited, this allows for many attribute to be added, edited, or deleted to the specification of the project.
d) Query and Analysis: GIS was used widely in decision making process for the new commission districts. We use population data to help establish an equal representation of population to area for each district.
e) Visualization: This represents the ability to display your data, your maps, and information

2.8 ARCMAP APPLICATION

This section provides an introduction and overview to ArcMap, which is the central application used in ArcGIS. ArcMap is where user display and explore GIS datasets for the study area, where can assign symbols, and where can create map layouts for printing or publication. ArcMap is also the application where user use to create and edit datasets.

ArcMap represents geographic information as a collection of layers and other elements in a map. Common map elements include the data frame containing map layers for a given extent plus a scale bar, north arrow, title, descriptive text, a symbol legend, and so on.

2.8.1 Typical Tasks Performed in ArcMap

ArcMap is the primary application used in ArcGIS and is used to perform a wide range of common GIS tasks as well as specialized, user-specific tasks. The following is a list of some common workflows that can be performed:

a) Work with maps - open and use ArcMap documents to explore information, navigate around the map documents, turn layers on and off, query features to access the rich attribute data that is behind the map, and to visualize geographic information.
b) Print maps - User can print maps, from the simplest to very sophisticated cartography, using ArcMap.
c) Compile and edit GIS datasets - ArcMap provides one of the primary ways that users automate geodatabase datasets. ArcMap supports scalable full-function editing. User select layers in the map document to edit and the new and updated features are saved in the layer's dataset.
d) Use geoprocessing to automate work and perform analysis - GIS is both visual and analytical. ArcMap has the ability to execute any geoprocessing model or script as well as to view and work with the results through map visualization. Geoprocessing can be used for analysis as well as to automate many mundane tasks such as map book generation, repairing broken data links in a collection of map documents, and to perform GIS data processing.
e) Organize and manage the geodatabases and ArcGIS documents—ArcMap includes the Catalog window that enables user to organize all of GIS datasets and geodatabases, map documents and other ArcGIS files, you, geoprocessing tools, and many other GIS information sets. User can also set up and manage geodatabase schemas in the Catalog window.

f) Publish map documents as map services using ArcGIS for Server -ArcGIS content is brought to life on the web by publishing geographic information as a series of map services. ArcMap provides a simple user experience for publishing your map documents as map services.

g) Share maps, layers, geoprocessing models, and geodatabases with other users - ArcMap includes tools that make it easy to package and share GIS datasets with other users. This includes the ability to share your GIS maps and data using ArcGIS Online.

h) Document geographic information—A key goal in GIS communities is to describe geographic information sets to help user to document the projects and for more effective search and data sharing. Using the Catalog window, user can document all of GIS contents. For organizations who use standards-based metadata, user can also document datasets using the ArcGIS metadata editor.

2.9 SATELLITE-BASED RAINFALL DATA

Warming Measuring rainfall from space appears to be the only cost effective and viable means in estimating regional precipitation and the satellite rainfall products are essential to hydrological and agricultural modelling. Rainfall can be estimated remotely, either from ground-based weather radars or from satellite. Radars are active devices, emitting radiation at wavelengths ranging between 1 and 10 cm, and receiving the echo from targets such as raindrops.

The maximum range of radars is only about 300 km, so offshore coverage is limited. Also, radars are prohibitively expensive in the Third World. With the advent of geostationary weather satellites in the 1960s and 70's, positioned above the equator at 5-6 positions around the globe to provide complete coverage, various techniques have been developed to estimate rainfall from visible and infrared (IR) radiation upwelling from the Earth into space. The higher the cloud albedo, the more droplets and/or ice crystals it contains and the deeper it tends to be, so the more likely rainfall is on the ground. The lower the IR brightness temperature, the higher the cloud top and the more likely the rainfall on the ground.

Research by Prasetia (2012) to validate the satellite data by validate monthly and seasonal rain rates derived from the Tropical Rainfall Measuring Mission Precipitation Radar (PR) over Indonesian region using rain gauge data analysis from 2004 to 2008. The study area employed 20 gauges across Indonesia to monitor three Indonesian regional rainfall types. The validation analysis showed very good correlation with the gauge data of monsoonal type rainfall, high correlation for anti-monsoonal type rainfall.

2.10 SUMMARY

In this chapter, the reviews of floods history in Malaysia were already explained and also included their flood victims on certain date. The elaboration on software GIS, ArcMap and satellite-based rainfall have been discussed in this chapter.

CHAPTER 3

METHODOLOGY

3.1 PRIMARY UNDERSTANDING

The purpose of this study is to relate the intensity of the rain and floods during the December 2014 in Sungai Pahang basin. The purposes of this chapter are to:

1) Describe the research methodology of this study
2) Explain the selection of towns in Pahang
3) Describe the procedure used in collecting the data, and
4) Provide explanation of the maps created.

This chapter explains the methodology of research to accomplish the research objective. There are four (4) main phase for this research which is data collection, pre-processing, process and finally the output of the research (Figure 3.1).

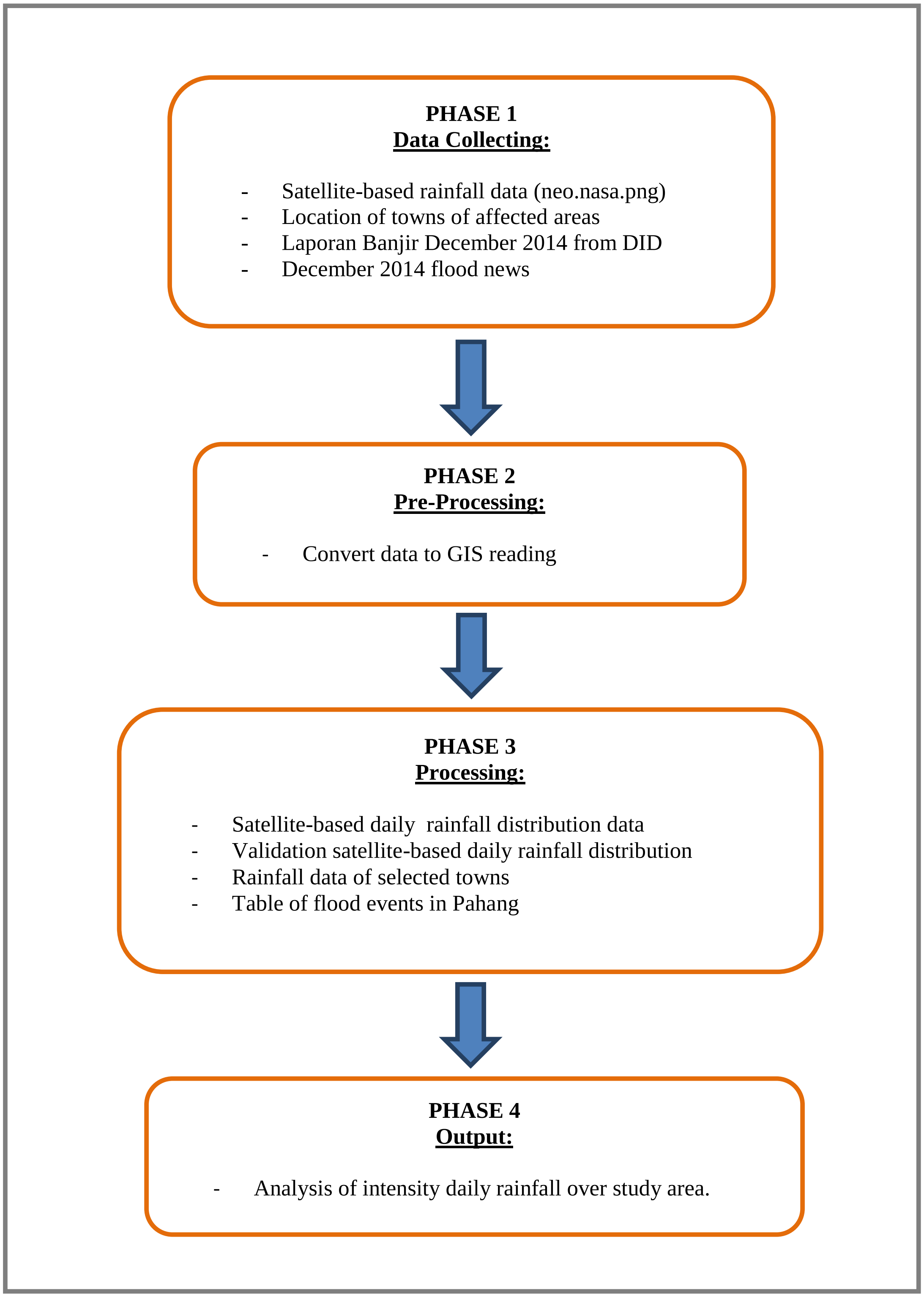

Figure 3.1 Methodology Flow Diagrams

3.2 AREA OF STUDY

Pahang has a tropical climate, with temperatures from 21 to 32 °C and intermittent rain throughout the year. The wet season is the east-coast monsoon season from November to January. Pahang situated in the eastern part of Peninsular Malaysia with the total area 36,107 km^2 (13,953 sq mi). The selected study area comprises of 11 administrative divisions: Bera, Bentong, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin and Temerloh. The next table shows the population, area and coordinates of districts in Pahang.

Table 3.1: Population, Area and Coordinates of Major Cities in Pahang

District	**Population (as of 2010)**	**Area (km^2)**	**Coordinates**
Bentong	119,817	1,831	3°31’19.80”N 101°54’37.27”E
Bera	97,882	2,228	3°16’13.89”N 102°27’13.91”E
Cameron Highlands	38,471	712	4°28’19.63”N 101°22’48.52”E
Jerantut	91,096	7,561	3°56’14.62”N 102°21’43.34”E
Kuantan	461,906	2,960	3°45’48.19”N 103°13’12.66”E
Lipis	89,730	5,198	4°11’03.59”N 102°03’15.24”E
Maran	115,424	1,996	3°35’00.17”N 102°46’44.63”E
Pekan	110,663	3,805	3°29’31.54”N 103°23’22.36”E
Raub	95,506	2,269	3°47’36.72”N 101°51’26.87”E
Rompin	114,901	5,296	2°48’02.12”N 103°29’09.98”E
Termerloh	165,451	2,251	3°26’55.14”N 102°24’58.85”E
Total	1,500,817	36,107	

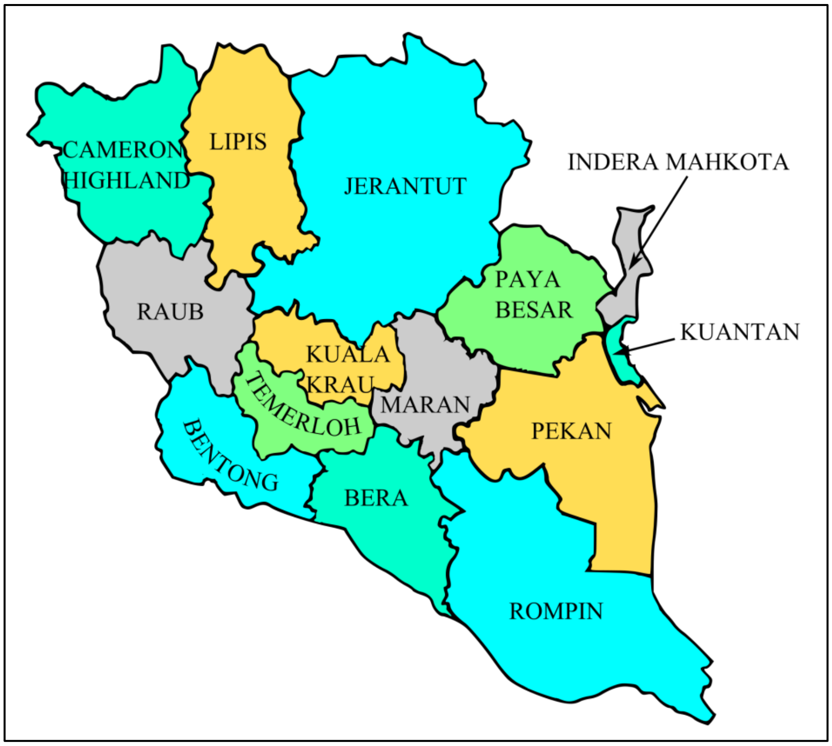

Figure 3.2 Sub divisions in Pahang

3.3 DATA COLLECTING

3.3.1 Data from Public Domain

The rainfall of intended period in Malaysia is obtained from Nasa Earth Observations website through their public domain. Nasa provides rainfall data by categories which is by Atmosphere category. Browse datasets by atmosphere and select rainfall to download the datasets needed.

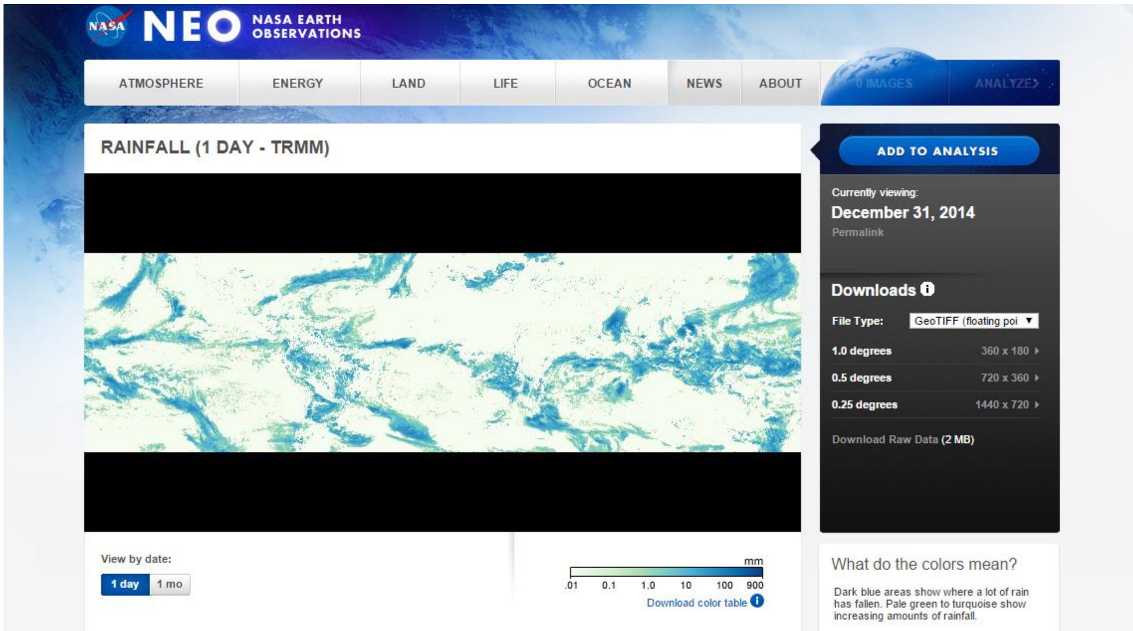

Figure 3.3 Portal Download of Daily Rainfall

(source: http://neo.sci.gsfc.nasa.gov/)

Rainfall is essential for life on Earth. Rain is a main source of fresh water for plants and animals. These maps show where and how much rain fell around the world on the dates shown. Notice that most rain falls near the equator. Notice also that more rain falls on the ocean than on land. The NASA instrument that made these rainfall measurements flies on a satellite orbiting our world near the equator, so it only measures rainfall near the equator and not at high latitudes, nor in Earth's Polar Regions.

3.3.2 Data from Newspapers Article and Online Portal

Flood article from numerous resources are the source for next analysis making. The sources are obtained from newspapers and online portal such as Berita Harian (BH), Utusan, Malaysia Kini, Says, BHOnline and Utusan Online.

The dates of flood events in some of affected areas were recorded. The period (daily) or duration of flood also recorded.

3.4 PRE-PROCESSING

The satellite-based rainfall datasets is obtained from Nasa Earth Observations (http://neo.sci.gsfc.nasa.gov/). It goes by the atmosphere category and followed by rainfall. The duration needed in this study is from 20th until 31st December 2014. The daily rainfall of selected date is obtained. Then, the files are downloaded in GeoTIFF (raster) type with 0.25 degree and 1440 x 720 resolutions. The format is in TIFF files of rainfall dataset satellite-based. If Render Data is being downloaded, then it cannot be used for the next processing data. The files must be in TIFF files only. The downloaded file is named starting with TRMM.

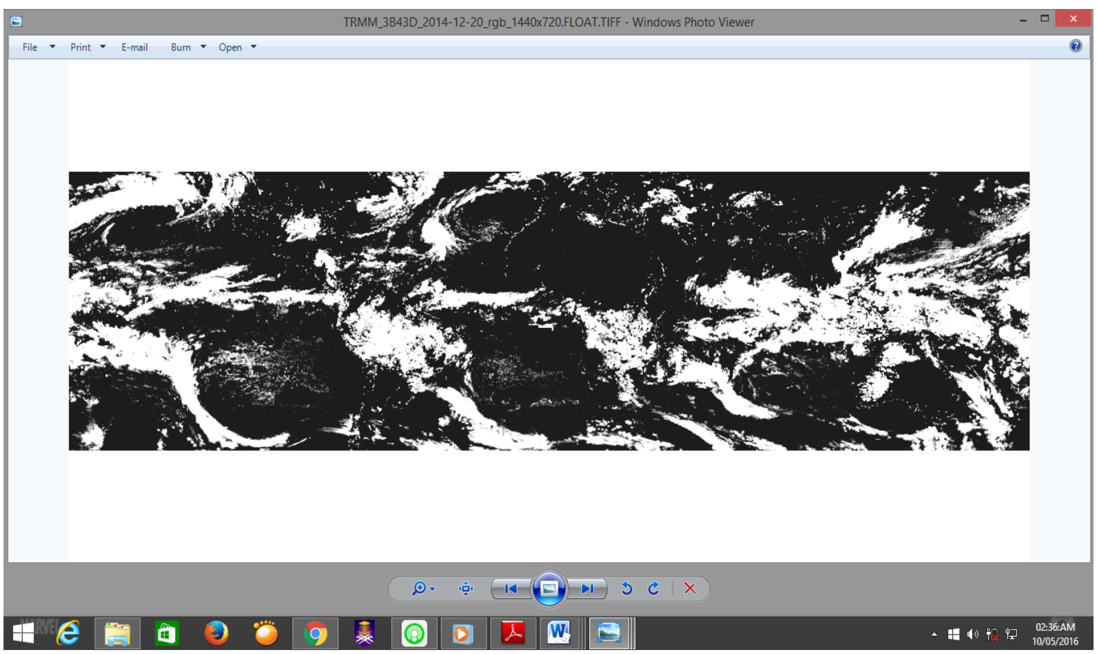

Figure 3.4 The Rainfall Data Downloaded in TIFF image

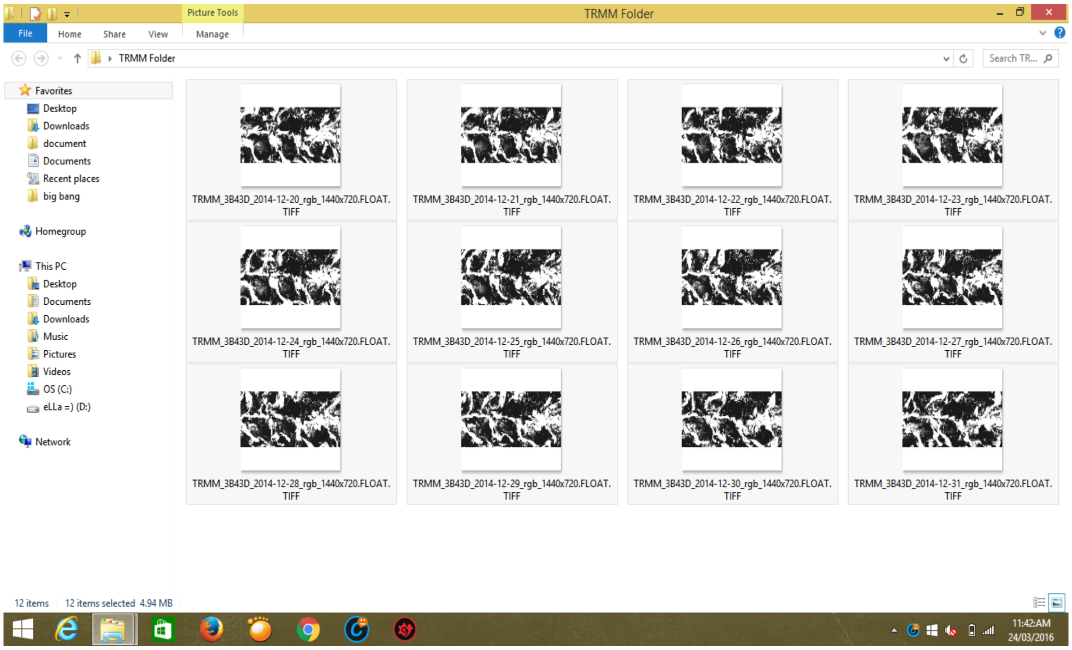

Figure 3.5 All Satellite-based Rainfall Datasets from 20th to 31st Dec 2014

3.5 PROCESSING

3.5.1 Satellite-based Rainfall Processing.

The process is started by using ArcGIS Software named ArcMap tool version 10.2.

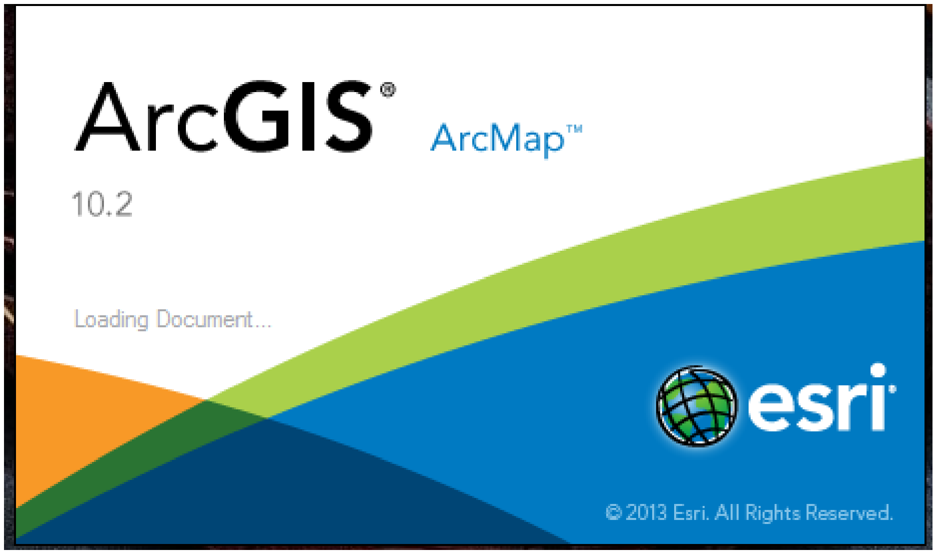

Figure 3.6 GIS Software Used

The satellite-based rainfall datasets that are obtained from the public domain will be entered in ArcMap which are originally in TIF image. Click Add Data from the icon in ArcMap to create one layer per day of the chosen image. Then, click icon Arc Toolbox and choose Data Management Tools. Continue click for Raster, then Raster Processing and finally chose Clip.

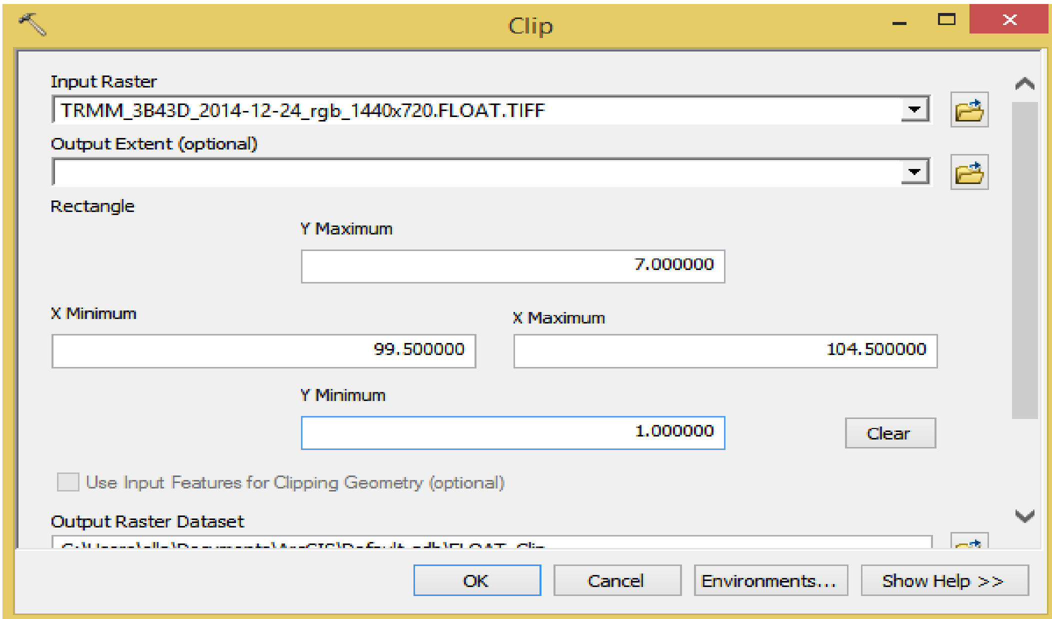

Figure 3.7 Clip Toolbox

Figure 3.7 shows the clip toolbox to input next data. Browse the first date of satellite-based data which is in TIFF format to be put at Input Raster. Y Maximum value is 7.000000, Y Minimum is 1.000000, X Maximum is 104.500000 and X Minimum is 99.500000. All the value entered just now is the coordinate of Peninsular Malaysia.

The first layer is done. Next step is to create second layer. In order to make it first is to create new file of the data ending with .TIF format only. Then, the second layer is created. Continue with next file renewal. Right click the .TIF layer at Table of Contents bar, chose Data then, Export Data.

Then one toolbox named Export Raster Data is appeared. Enter the value needed. Output raster value is 0.0083333338 of Cell Size (cx,xy) and enter 99999 at No Data as:

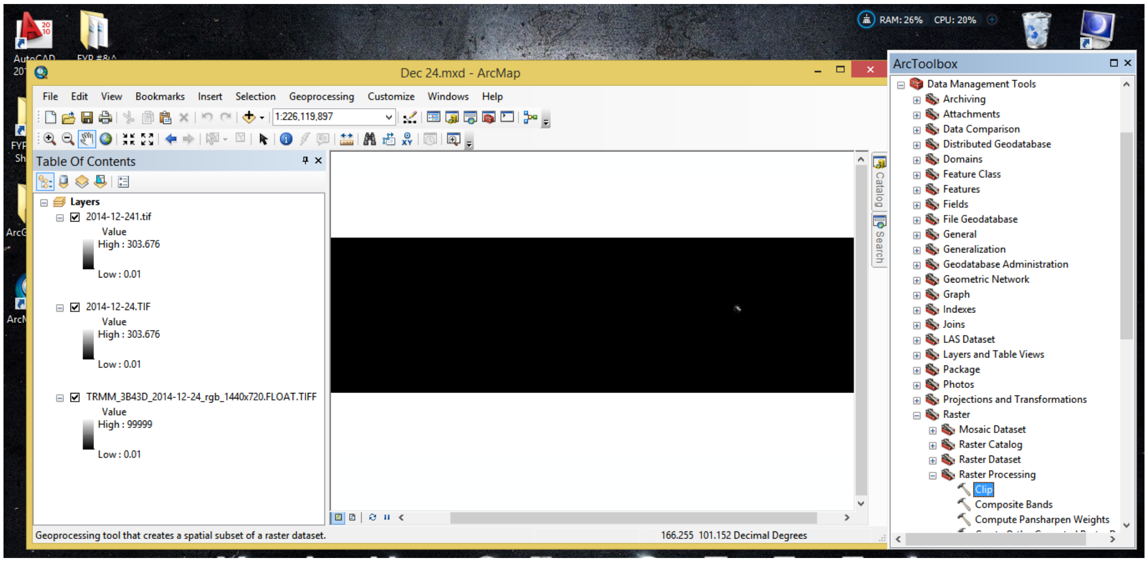

Figure 3.8 The Three (3) Layers Input

Figure 3.8 shows the three layers input of the process needed. The three layers are done to produce .mxd format of file. All steps above are done for each one satellite-based rainfall raw datasets obtained. The steps are repeated for daily rainfall from 20th December until 31st December of 2014.

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3.5.2 Mapping of Rainfall Point on Selected Places.

First, put one layer of Sg.Pahang watershed in the ArcMap tools. Figure 3.9 below shows the boundaries. It is highlighted with red colour.

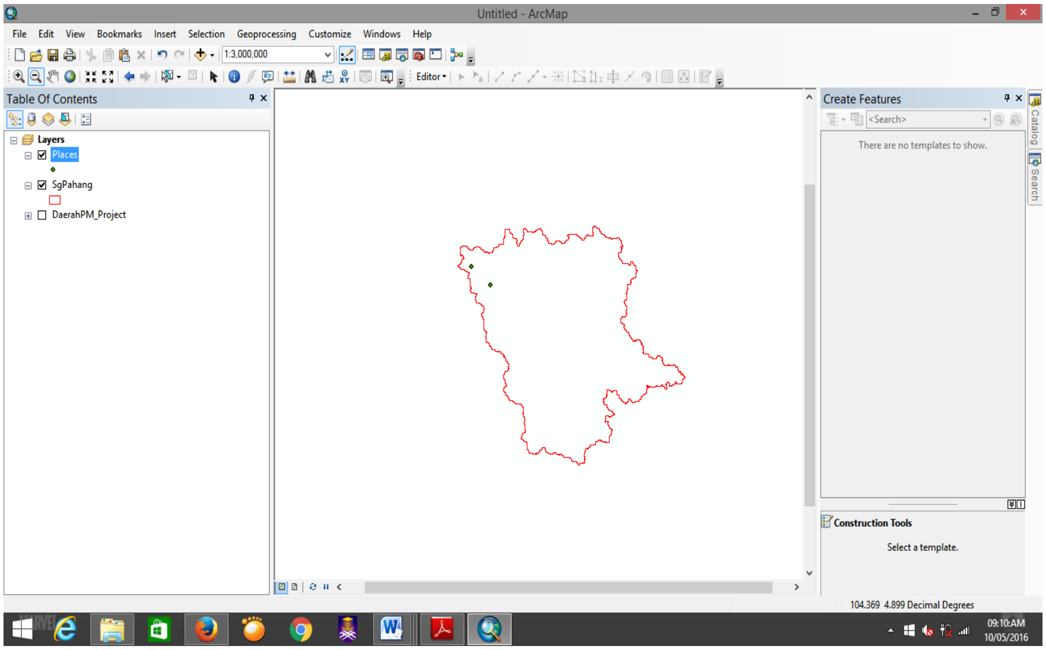

Figure 3.9 Sg.Pahang Watershed Layer

Next, put the second layer of district or divisions in Pahang. It will overlay with Sg Pahang watershed.

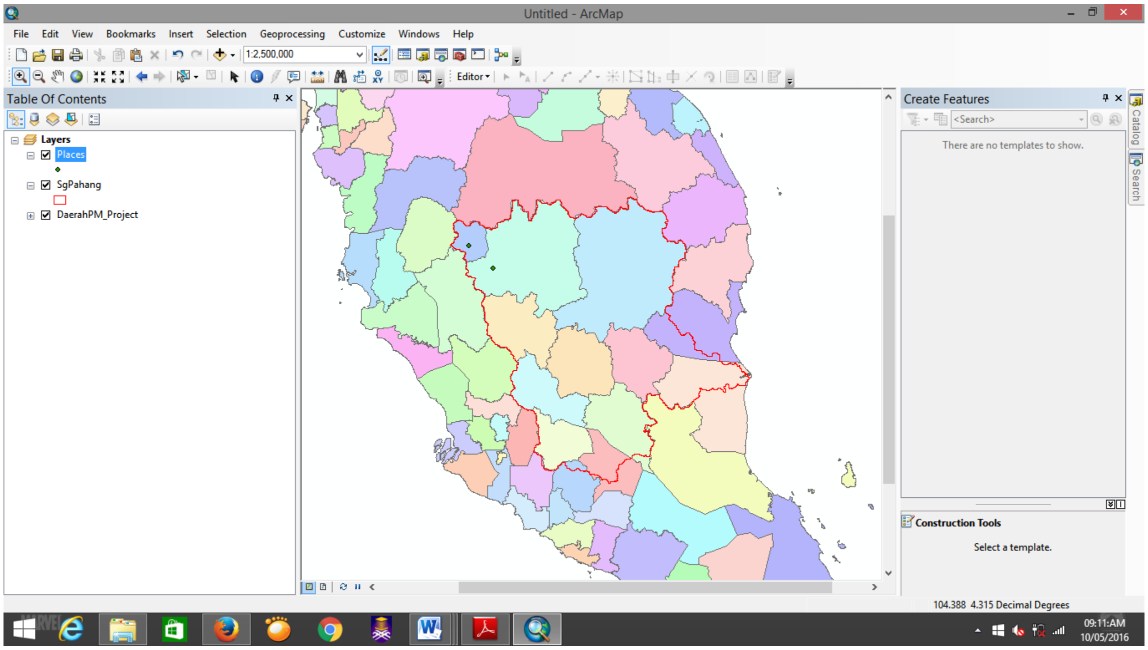

Figure 3.10 Districts Layer Overlayed with Sg Pahang Watershed

The process is continued with selection of main cities to be created in it. The places are chosen based on which places is near to Sg Pahang and the main cities in the district. The places chosen are to created and symbol in point only.

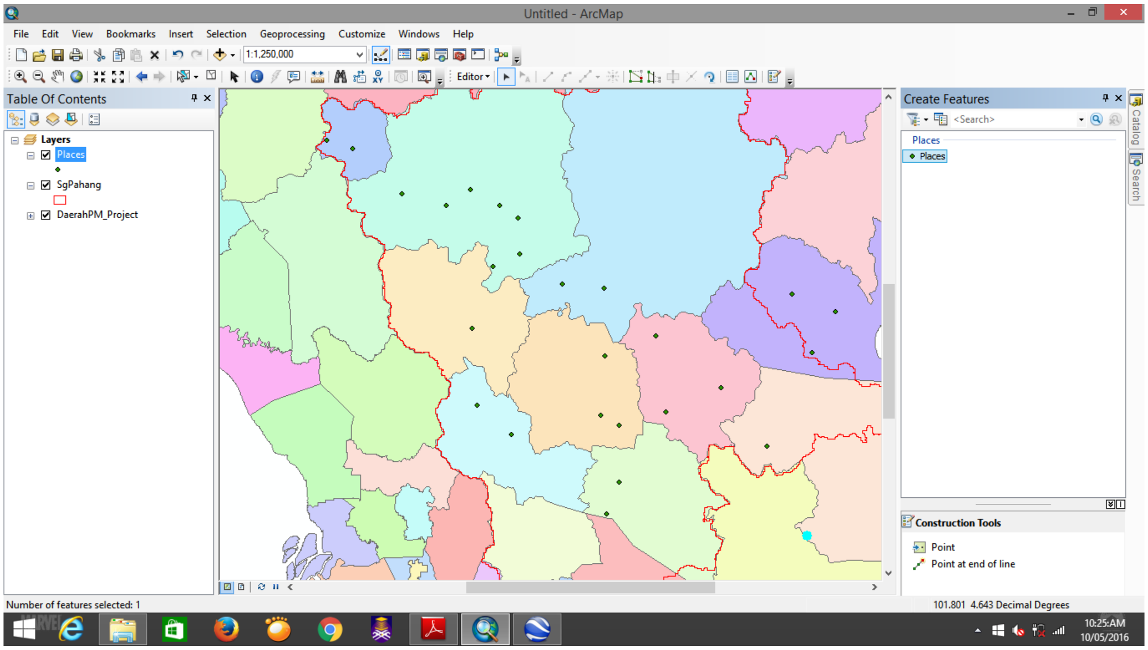

Figure 3.11 All Points within Sg Pahang Areas

Figure 3.8 shows the points selected for analysis. After the overlaying of district, Sg Pahang watershed and points layer, that is where the map is done. The map is already created, thus the rainfall distribution can be obtained according to places that are needed. The total places selected consist of 25 points.

Figure 3.9 below shows all the locations of points and their places' names. The places are put in as points where it is created according to theirs earth coordinates. All the coordinates are obtained and recorded from Google Earth.

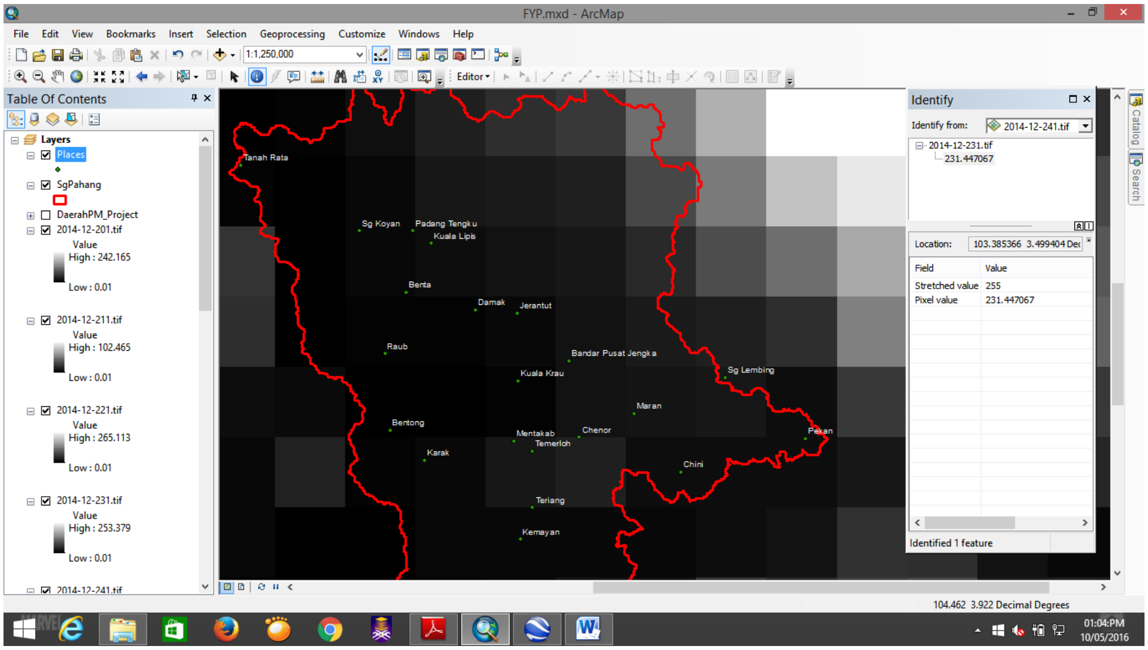

Figure 3.12 All Points (Towns) with Names

3.5.3 Coordinates of Places of Study Area

There are 25 points or coordinates of places put on the map to obtain the daily satellite-based distribution from 20th until 31st December 2014. All the places are within 9 Districts in Pahang which are Cameron Highland, Lipis, Jerantut, Raub, Bentong, Temerloh, Maran, Bera and Pekan. The latitude and longitude of each place were recorded.

Table 3.2 Coordinates of Places in Study Area

NO	Places	Latitude	Longitude
1	Tanah Rata	4°27’56.26”N	101°22’36.36”E
2	Sg Koyan	4°13’58.27”N	101°48’02.01”E
3	Kg.Kuala Lepar	4°38’01.68”N	101°51’00.16”E
4	Kg.Gua Lima	4°41’19.13”N	102°00’09.98”E
5	Padang Tengku	4°13’59.31”N	101°59’28.43”E
6	Kuala Lipis	4°11’18.17”N	102°03’19.81”E
7	Benta	4°00’53.17”N	101°58’01.52”E
8	Kg.Samas	4°30’12.77”N	102°00’09.98”E
9	Kuala Tahan	4°22’39.68”N	102°24’20.03”E
10	Damak	3°57’09.73”N	102°12’49.22”E
11	Jerantut	3°56’21.99”N	102°21’41.28”E
12	Raub	3°47’45.61”N	101°53’31.69”E
13	Bentong	3°31’23.20”N	101°54’35.50”E
14	Karak	3°24’59.58”N	102°01’55.58”E
15	Kuala Krau	3°41’56.55”N	102°21’53.74”E
16	Bandar Pusat Jengka	3°46’11.82”N	102°32’46.89”E
17	Mentakab	3°29’08.80”N	102°21’00.05”E
18	Temerloh	3°26’59.03”N	102°25’00.19”E
19	Chenor	3°29’53.32”N	102°35’00.49”E
20	Teriang	3°14’56.43”N	102°25’01.78”E
21	Kemayan	3°08’07.68”N	102°22’22.85”E
22	Maran	3°34’59.95”N	102°46’43.47”E
23	Chini	3°22’32.54”N	102°56’39.49”E
24	Sg Lembing	3°55’01.14”N	103°01’56.15”E
25	Pekan	3°29’39.24”N	103°23’22.64”E

3.5.4 Extraction of Rainfall Data

From the previous mapping and satellite-based rainfall, then the rainfall data is created or extracted manually from the software according to the places and duration needed from 20th December until 31st December 2014.

3.5.5 Correlation Graph

Correlation graph between satellite-based daily rainfall and rain-gauge daily rainfall is made for validation. There are five (5) towns selected which are Lipis, Pekan, Temerloh, Bera and Maran. The gradient and correlation values are identified to measure the strength between the two variables on a scatter plot.

3.6 OUTPUT

The final output obtained from the correlation graph and table of flood events are the analysis of intensity daily rainfall over the study area from upstream to downstream of Sungai Pahang basin during the December 2014 (Chapter 4).

3.7 SUMMARY

This chapter describes the methodology of this research, as such describe the satellite-based rainfall distribution data over the towns in Pahang, the correlation graph between the satellite-based daily rainfall and the rain-gauge daily rainfall data, provide explanation of sources used to obtain flood events information on certain duration. Thus, at the end of the research the objective is successfully achieved.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter, all the information from the previous chapter was analysed. This chapter shows the validation of satellite-based daily rainfall data with rain-gauge onsite daily rainfall data and the table of satellite-based daily rainfall distribution and flood events in Pahang.

The validation of satellite-based daily rainfall data were compared with onsite rainfall retrieved from DID at five (5) major towns in Pahang which are at Lipis, Pekan, Temerloh, Bera and Maran.

The result of the table of satellite-based daily rainfall distribution and flood events were analysed. There are 9 districts and 25 places of towns were selected. The period was from 20th until 31st December 2014. The satellite-based rainfall were taken as daily rainfall

4.2 VALIDATION ANALYSIS

The daily rainfall for the gauge observations and the satellite-based daily rainfall were computed for validation. The validation of satellite-based rainfall data with onsite rainfall data from DID was conducted for twelve (12) days starting from 20th December until 31st December 2014. The validation for 24, 25, 27 and 30 December 2014 not available for Triang station because there were no available onsite data from DID.

Linear graphs of single mass curves of rainfall displayed straight lines in all stations used in the study. Furthermore, the coefficient of determination (R^2) was above 0.5, an indication that more than 50% of gauge rainfall values fitted the linear regression line. Therefore, the data was considered valid and consistent over these stations and thus homogenous and good for further analysis.

Table 4.1 The Gradient and Correlation Values

Places	m,gradient value (y=mx)	Correlation value (R^2)	R value
Lipis	1.255	0.8244	0.91
Pekan	0.704	0.6283	0.79
Temerloh	0.943	0.7837	0.89
Bera	0.724	0.8441	0.92
Maran	1.665	0.7695	0.88

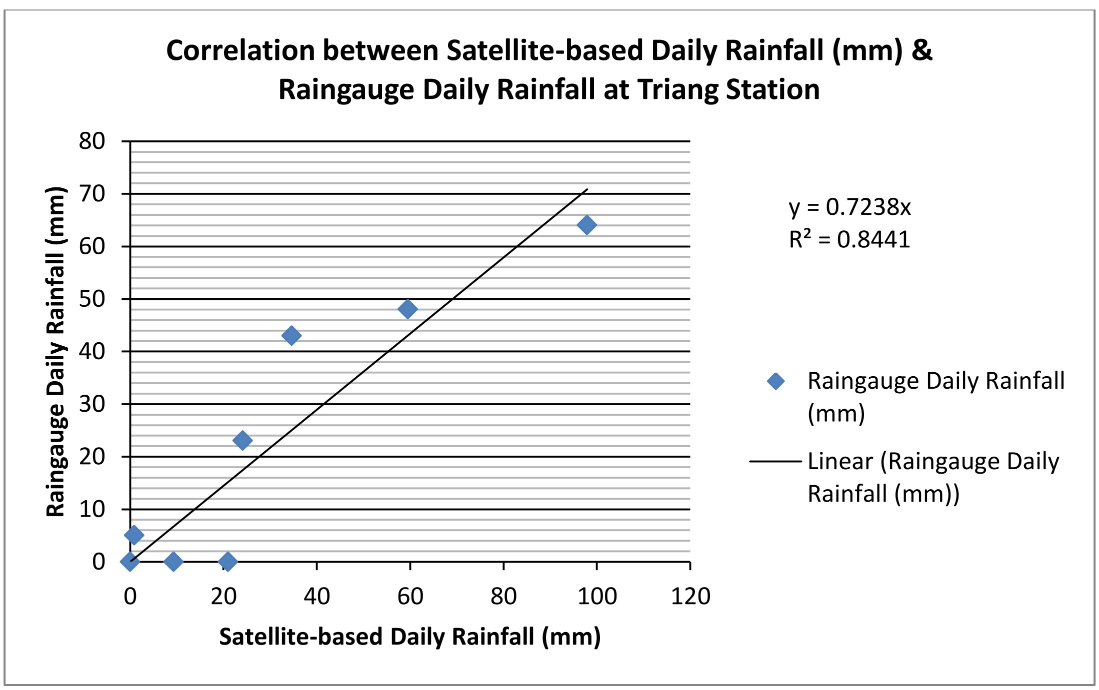

Figure 4.1: Correlation of Rainfall for Triang, Bera Station

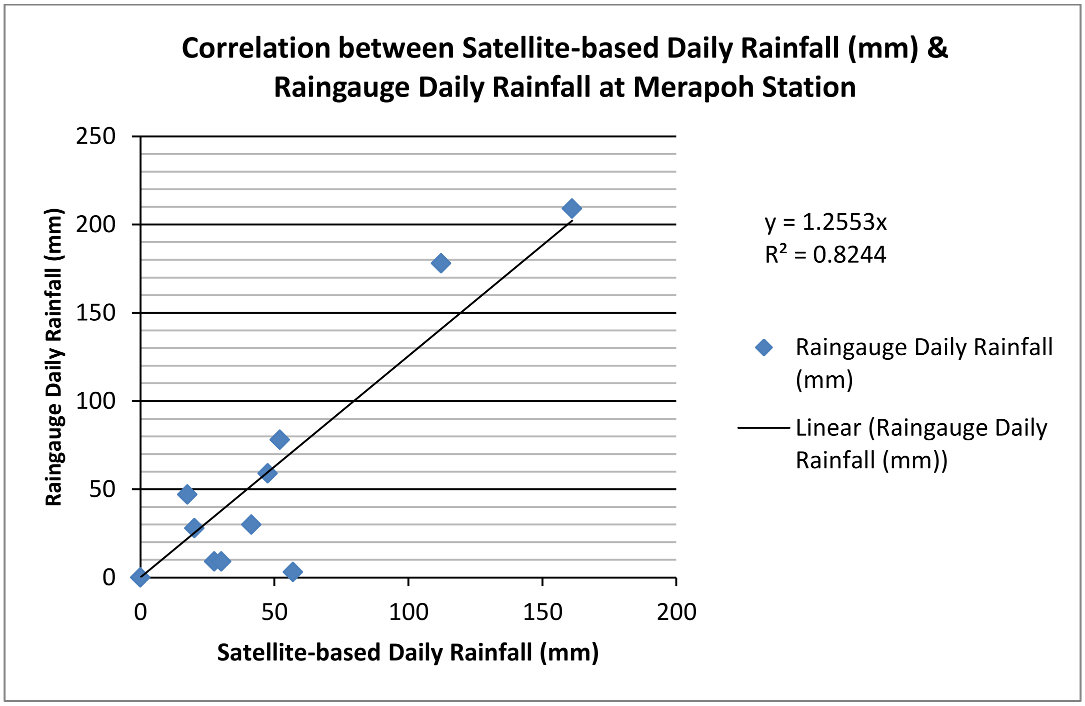

Figure 4.2: Correlation of Rainfall for Merapoh, Lipis Station

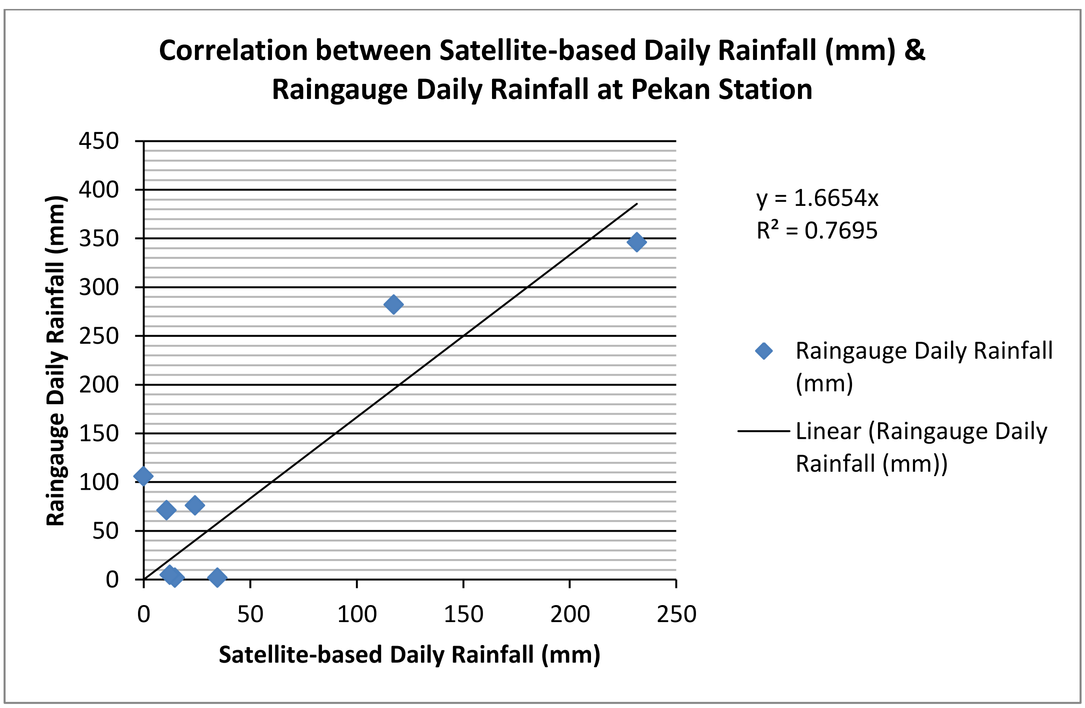

Figure 4.3: Correlation of Rainfall for Pekan Station

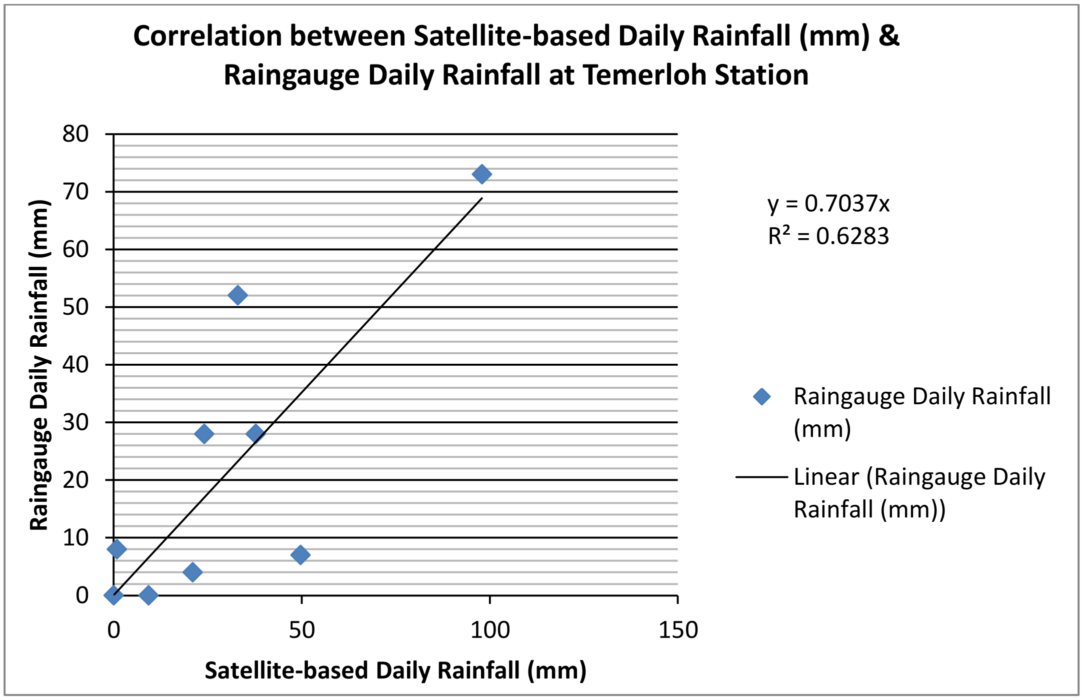

Figure 4.4: Correlation of Rainfall for Temerloh Station

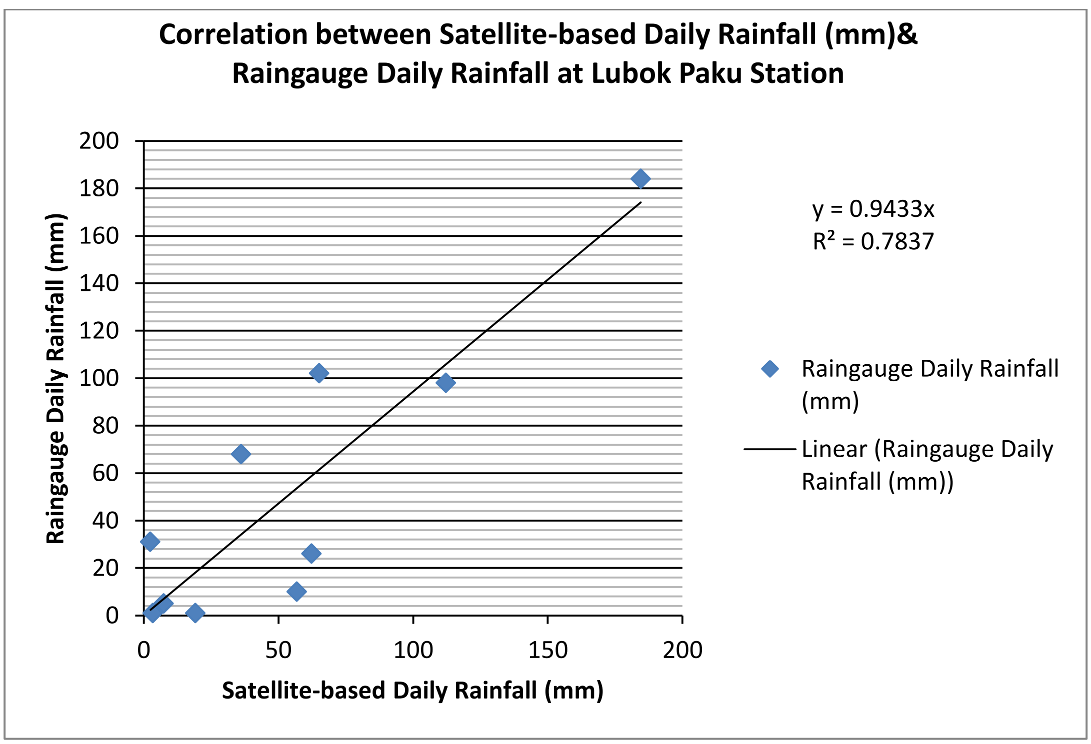

Figure 4.5: Correlation of Rainfall for Lubok Paku, Maran Station

4.3 SATELLITE-BASED DAILY RAINFALL AND FLOOD EVENTS ANALYSIS

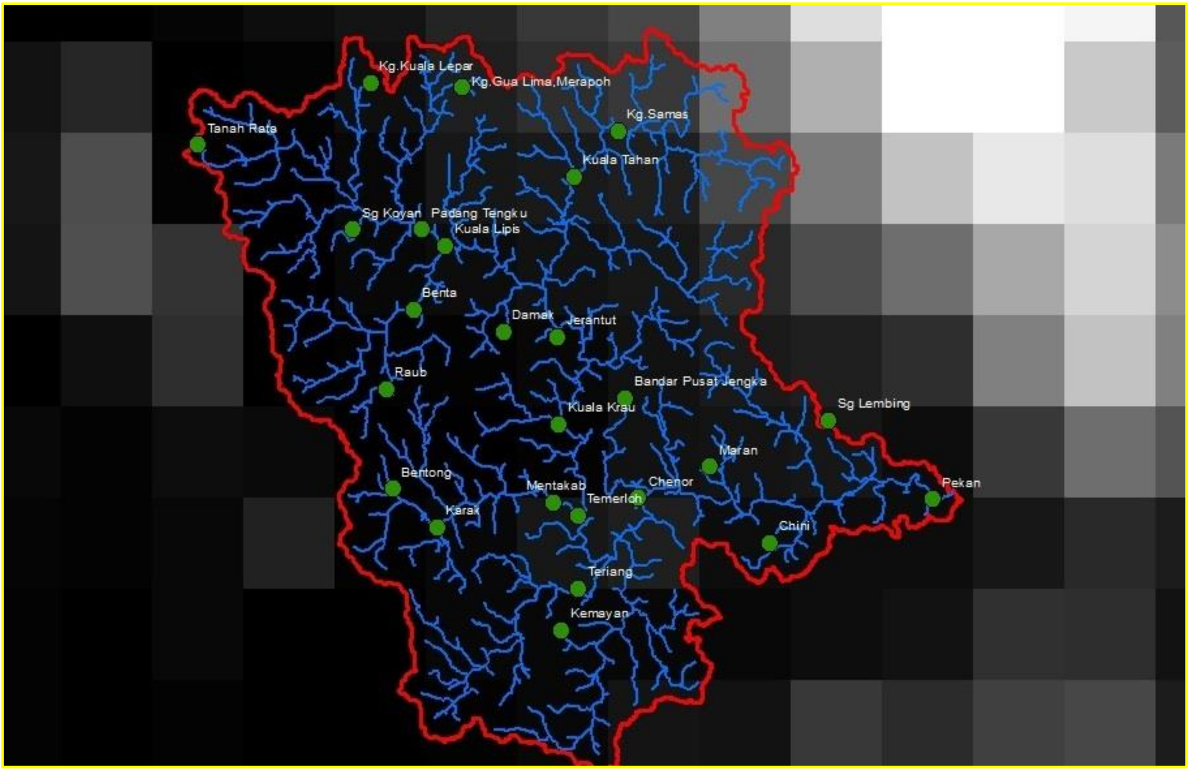

Figure 4.6 Maps of Pahang on Selected Areas within Sg Pahang

The analysis between the satellite-based daily rainfall distribution and the flood events in Pahang were made by referring the maps created (Figure 4.6). The flow of flood water were analysed from upstream to downstream of Sungai Pahang basin.

Table 4.2 Satellite-based Daily Rainfall Distribution and Flood Events (i)

	Cameron Highland				Lipis										Jerantut								Raub	
Date	Tanah Rata		Sg.Koyan		Kg.Kuala Lepar		Kg.Gua Lima,Merapoh		Pdg Tengku		Kuala Lipis		Benta		Kg.Samas		Kuala Tahan		Damak		Jerantut		Raub	
	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F
20th	5.2	X	10.7	X	16.0	X	27.6	X	10.7	X	14.6	X	10.7	X	46.7	X	24.1	X	6.5	X	9.3	X	6.8	X
21st	9.7	X	16.8	X	16.1	X	17.5	X	16.8	X	15.3	X	16.8	X	15.3	X	12.8	X	25.2	X	23.0	X	15.3	X
22nd	27.6	X	31.6	X	47.5	X	112.2	●	31.6	●	47.5	●	31.6	X	176.4	X	128.5	●	31.6	X	54.4	X	16.0	X
23rd	62.3	X	107.2	X	140.7	X	161.1	●	107.2	●	140.7	●	107.2	X	193.1	X	184.6	●	128.5	X	154.0	●	81.7	X
24th	54.4	X	81.7	X	168.6	X	184.6	●	81.7	●	117.4	●	81.7	X	202.1	X	168.6	●	74.6	X	128.8	●	45.4	X
25th	0.01	X	3.4	X	17.5	X	30.2	●	3.4	●	6.2	●	3.4	X	49.7	X	22.0	●	19.2	X	28.9	●	19.2	X
26th	30.2	X	45.4	X	31.6	X	41.4	●	45.4	●	52.0	●	45.4	X	37.8	X	37.8	●	71.3	X	78.1	●	65.2	●
27th	23.0	X	59.5	X	30.2	X	52.0	●	59.5	●	56.9	●	59.5	X	102.5	X	85.5	●	59.5	X	71.3	●	52.0	●
28th	2.7	X	1.5	X	10.2	X	20.1	●	1.5	●	9.7	●	1.5	X	25.2	X	16.8	●	4.5	X	1.6	●	1.5	●
29th	20.1	X	22.0	X	37.8	X	47.5	X	22.0	X	36.2	X	22.0	X	47.5	X	56.9	●	30.2	X	52.0	●	27.6	X
30th	31.6	X	52.0	X	45.4	X	56.9	X	52.0	X	78.1	X	52.0	X	52.0	X	62.3	●	85.5	X	85.5	●	62.3	X
31th	1.5	X	0.01	X	0.01	X	0.01	X	0.01	X	3.8	X	0.01	X	0.01	X	2.4	●	0.01	X	0.01	●	0.01	X

Table4.3 Satellite-based Daily Rainfall Distribution and Flood Events (ii)

	Bentong				Temerloh						Maran						Bera				Pekan			
Date	Bentong		Karak		Kuala Krau		Mentakab		Temerloh		Jengka		Chenor		Maran		Triang		Kemayan		Chini		Pekan	
	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F
20th	2.7	X	8.5	X	4.9	X	21.0	X	21.0	X	16.8	X	17.5	X	19.2	X	21.0	X	9.3	X	14.0	X	14.6	X
21st	13.4	X	24.1	X	7.4	X	9.3	X	9.3	X	12.2	X	3.1	X	7.4	X	9.3	X	0.9	X	6.8	X	24.1	X
22nd	4.5	X	12.8	X	47.5	X	24.1	X	24.1	X	93.6	X	65.2	X	112.2	●	24.1	X	9.7	X	71.3	X	117.4	X
23rd	62.3	X	74.6	X	117.4	X	97.9	X	97.9	X	184.6	X	147.2	X	184.6	●	97.9	X	71.3	X	176.4	X	231.5	X
24th	59.5	X	85.5	X	112.2	●	85.5	●	85.5	●	184.6	●	93.6	●	184.6	●	85.5	●	41.4	X	102.5	X	184.6	●
25th	8.9	X	24.1	X	37.8	●	49.7	●	49.7	●	45.4	●	45.4	●	56.9	●	49.7	●	552.0	X	107.2	X	122.8	●
26th	81.7	X	43.4	X	56.9	●	37.8	●	37.8	●	89.5	●	59.5	●	36.2	●	59.5	●	49.7	X	31.6	X	10.8	●
27th	31.6	X	39.6	X	59.5	●	56.9	●	56.9	●	93.6	●	52.0	●	62.3	●	56.9	●	65.2	X	74.6	X	34.6	●
28th	0.01	X	0.01	X	7.1	●	0.9	●	0.9	●	2.2	●	1.8	●	2.5	●	0.9	X	5.0	X	0.01	X	0.01	●
29th	27.6	X	30.2	X	45.4	●	33.0	●	33.0	●	68.2	X	65.2	X	65.2	X	34.6	X	34.6	X	71.3	X	112.2	●
30th	68.2	X	112.8	X	112.2	●	140.7	●	140.7	●	85.5	X	112.2	X	128.5	X	140.7	X	134.4	X	154.0	X	242.2	●
31th	0.01	X	0.01	X	0.01	X	0.01	X	0.01	X	0.01	X	0.01	X	3.4	X	0.01	X	0.01	X	0.01	X	12.2	●

The intensity of satellite-based daily rainfall data for each towns along the river Ulu Pahang and related areas was observed. Starting from the first day of flood event on 22^{nd} December 2014, five (5) towns were discovered to have flood on the same day. Kg,Gua Lima(Merapoh), Padang Tengku, Kuala Lipis, Kuala Tahan and Maran had flood event. Kg.Gua Lima (Merapoh) has very heavy rainfall intensity with 112.2 mm. The area was flooded due to continuous rainfall on catchment area and eventually the river overflowed to the other places nearby. For instance, Padang Tengku and Kuala Lipis were flooded because of high intensity of rain in the upper reach from Merapoh. As observed, Pdg Tengku and Kuala Lipis have medium average rainfall 31.6 and 47.5 mm respectively, thus not effects much on cause of flooding.

As for Kuala Tahan, the town has very heavy rainfall on site for three (3) consecutive days starting from 22^{nd} December 2014. The satellite-based rainfall captured 128.5, 184.6 and 168.6 mm respectively of daily reading in Kuala Tahan. The continuous great heavy rainfall gives devastating damages in Kuala Tahan. Kuala Tahan has the most severe flood event and victims start from 22^{nd} until 31^{st} which lasting for more than a week. Maran town also has very heavy rainfall for three (3) consecutive days starting from 22^{nd} December 2014. The satellite-based rainfall recorded 112.2, 184.6 and 184.6 mm respectively of daily reading in Maran. As reported from DID, flood event in Maran is due to the continuous non-stop heavy raining on catchment area. This flooding also because there were drainage problems that unable to accommodate the runoff on affected area and also many overflowed rivers nearby. Since, the water level increase rapidly coupled with heavy rain, flooding in Maran occurred early compared to other places even though it is located at downstream area.

While other towns mentioned above still experiencing flood, the next day on 23^{rd} December 2014, Jerantut also got flooded. On the day flood happened, the rainfall is very high with 154 mm recorded by satellite. The extreme rainfall event at the upstream area causes the water level increase rapidly and then affects the downstream area to be flooded.

In this case, Jerantut got flooded also because of the extreme flood water from Kuala Tahan that went to Jerantut along Sungai Pahang.

On 24th December 2014, most of the towns in Pahang approximately 80% of study area were already flooded. It includes Kuala Krau, Mentakab, Temerloh, Jengka, Chenor, Triang and Pekan. Kuala Krau for overall days of flood events has medium average rainfall intensity distribution. The maximum rainfall on flooded days is 112.2 mm. As observed, despite the medium rainfall on the area, flood water from Jerantut upper reach causes Kuala krau to be flooded. Mentakab and Temerloh have the same satellite-based daily rainfall from 20th until 31st December 2014 due to areas close to each other. Flood event also on the same date as Kuala Krau and continue to be flooded for a week from the day flood started. Triang experiencing flood for four (4) days only starts from date 24th until 28th December 2014. As reported from DID, Sg.Triang was at warning water level on 28th. Flooding was because there were some overflowed rivers from upper stream Sg. Maran, Sg. Pahang and other rivers.

Raub is the last town to be flooded. Raub experience flood only for three (3) days starts from 26th until 28th December 2014. The satellite-based rainfall reading on the three days of flood duration was not the reason of flood in Raub. The rainfall distribution is 65.2, 52.0 and 1.5 mm respectively. The rapid increase of water level at upper reach Sg.Lipis and other sub-rivers have caused the flood in Raub. The overflowed river from the upstream unexpectedly causes Raub to be flooded.

4.4 SUMMARY

In this chapter, the data from previous chapter was analysed in order to accomplish the objective that has been set. Based on analysed data and provided data from DID, the satellite-based daily rainfall with rain-gauge daily rainfall data were validated. From the maps and the table of satellite-based daily rainfall and flood event, the objective to analyse the relationship between the intensity of the rainfall and floods during the December 2014 in Sungai Pahang Basin was successfully achieved.

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research was carried out in order to analyse the relationship between the intensity of the rainfall and floods during the December 2014 in Sungai Pahang basin. This chapter will discuss on the conclusion and recommendation for the research. The conclusion of the research need to be evaluated based on the objective of the research. It is very essential in discover and evaluate back the methodology applied for the research could achieve the objective. The recommendation for future researcher in the related field is provided.

The study area was selected along Sungai Pahang basin which is the affected area during the flood incident in December 2014. The main objective of this research was to analyse the relationship between the intensity of the rain and floods during the December 2014 in Sungai Pahang basin. The specific objectives of the study were as follows; to validate satellite-based daily rainfall with the rain-gauge rainfall and to analyse the relationship between the intensity of the rainfall and floods.

The satellite-based and rain-gauge station daily rainfall data shows a good correlation (r = 0.79 - 0.92; coefficient= 0.72 – 1.67). From the analysis, the city experienced flooding even got a little rain intensity. This because the river overflowed due to the high intensity of rain in the upper reaches for example Merapoh, Kuala Tahan and Jerantut. In conclusion, the extreme rainfall event at the upstream area will cause the water level increase rapidly and unexpected flood will happen. The outcomes of this study shows satellite-based rainfall data could be used to help prepare a flood incident report with more comprehensive.

5.2 EVALUATION FOR OBJECTIVE

Two sub-objectives had been set-up to accomplish the main objective for this study, the objective have been verified and were discussed in previous chapter. Following shows how the objective are concluded

5.2.1 Sub-objective 1;

To validate satellite-based daily rainfall with rain-gauge daily rainfall data

Based on the result in chapter four (4), this objective was successfully achieved. From the result, there were good correlation of linear graphs of single mass curves of cumulated rainfall displayed straight lines in stations used in the study. The data was considered valid and consistent over these stations and thus homogeneous and good for further analysis.

5.2.2 Sub-objective 2;

To analyse the relationship between the intensity of the rainfall and floods

This objective was also successfully achieved. From the result, the relation was determined using the map and the intensity rainfall and floods based on the analysed data from chapter three (3).

5.3 RECOMMENDATIONS FOR FUTURE RESEARCH

To further this research, there are some action plans that can be taken in order to get better results. Some recommendations that can be implemented to further research are:

1. Data collected for this research was downloaded from nasa satellite. The results of data have been compared with rain-gauge station in order to get more precise result. Instead of using nasa of TRMM data, one can also use different type of satellite data like SSM/I or IR4 data to be compared with onsite-based data.

2. Instead of using only one method to get satellite-based rainfall data, one can also use different approach of method to get the rainfall rate like using Hydro-Estimator with Radar (HE-R), GOES Multi-Spectral Rainfall Algorithm (GMSRA), Self-Calibrating Multivariate Precipitation Retrieval (SCaMPR) or Hydro-Estimator (HE) to compare the results.

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APPENDIX A

Rain-gauge Daily Rainfall Data from DID

	Merapoh, Lipis	Pekan	Temerloh	Triang,Bera	Lubok Paku
Date	Rain-gauge Daily Rainfall (mm)				
20 Dec 2014	9	2	4	0	1
21 Dec 2014	47	76	0	0	5
22 Dec 2014	178	282	28	23	98
23 Dec 2014	209	346	73	64	184
24 Dec 2014					
25 Dec 2014	9		7		10
26 Dec 2014	30	71	28	48	68
27 Dec 2014	78	2			26
28 Dec 2014	28	106	8	5	31
29 Dec 2014	59		52	43	102
30 Dec 2014	3				
31 Dec 2014	0	5	0	0	1

APPENDIX B

Rain-gauge VS Satellite Daily Rainfall Data

District: LIPIS

	Place: Kg.Gua Lima	Station: Merapoh
Date	Satellite Daily Rainfall (mm)	Rain-gauge Daily Rainfall (mm)
20 Dec	27.6	9
21 Dec	17.5	47
22 Dec	112.2	178
23 Dec	161.1	209
25 Dec	30.2	9
26 Dec	41.4	30
27 Dec	52	78
28 Dec	20.1	28
29 Dec	47.5	59
30 Dec	56.9	3
31 Dec	0.01	0

District: PEKAN

	Place: Pekan	Station: Pekan
Date	Satellite Daily Rainfall (mm)	Rain-gauge Daily Rainfall (mm)
20 Dec	14.6	2
21 Dec	24.1	76
22 Dec	117.4	282
23 Dec	231.5	346
26 Dec	10.8	71
27 Dec	34.6	2
28 Dec	0.01	106
31 Dec	12.2	5

District: TEMERLOH

	Place: Temerloh	Station: Temerloh
Date	Satellite Daily Rainfall (mm)	Rain-gauge Daily Rainfall (mm)
20 Dec	21	4
21 Dec	9.3	0
22 Dec	24.1	28
23 Dec	97.9	73
25 Dec	49.7	7
26 Dec	37.8	28
28 Dec	0.9	8
29 Dec	33	52
31 Dec	0.01	0

District: BERA

	Place: Triang	Station: Triang
Date	Satellite Daily Rainfall (mm)	Rain-gauge Daily Rainfall (mm)
20 Dec	21	0
21 Dec	9.3	0
22 Dec	24.1	23
23 Dec	97.9	64
26 Dec	59.5	48
28 Dec	0.9	5
29 Dec	34.6	43
31 Dec	0.01	0

District: MARAN

	Place: Maran	Station: Lubok Paku
Date	Satellite Daily Rainfall (mm)	Rain-gauge Daily Rainfall (mm)
20 Dec	19.2	1
21 Dec	7.4	5
22 Dec	112.2	98
23 Dec	184.6	184
25 Dec	56.9	10
26 Dec	36.2	68
27 Dec	62.3	26
28 Dec	2.5	31
29 Dec	65.2	102
31 Dec	3.4	1