ANALYSIS OF LAG TIME BETWEEN THE RAINFALL AND FLOODING DURING DECEMBER 2014 FLOOD INCCIDENT IN PAHANG RIVER BASIN, MALAYSIA

‘ALYAA’ ‘IZZATI BINTI IBRAHIM

BACHELOR OF ENGINEERING (HONS.) IN
CIVIL ENGINEERING
UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's full name : 'ALYAA' IZZATI BINTI IBRAHIM

Date of birth : 26th OCTOBER 1993

Title : ANALYSIS OF LAG TIME FOR DECEMBER 2014 FLOOD INCCIDENT IN PAHANG RIVER BASIN, MALAYSIA

Academic Session : 2015/2016

I declare that this thesis is classified as:

[ ]	**CONFIDENTIAL**	(Contain confidential information under the Official Secret Act 1972)*
[ ]	**RESTRICTED**	(Contains restricted information as specified by the Organization where research was done)*
[/]	**OPEN ACCESS**	I agree that my thesis to be published as online open access(Full text)

I acknowledge that University Malaysia Pahang reserve the right as follows:

1. The thesis is the property of University Malaysia Pahang
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified By:

____________________	____________________
(Student's Signature)	(Signature of Supervisor)
931026 – 14 - 5706	Dr. Mohamad Idris bin Ali
Date: 28 June 2016	Date: 28 June 2016

NOTES:* If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

ANALYSIS OF LAG TIME BETWEEN THE RAINFALL AND FLOODING DURING DECEMBER 2014 FLOOD INCCIDENT IN PAHANG RIVER BASIN, MALAYSIA

‘ALYAA’ ‘IZZATI BINTI IBRAHIM

Thesis submitted in partial fulfilment of the requirements for award of the degree of
B. ENG (HONS.) CIVIL ENGINEERING

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

SUPERVISOR'S DECLARATION

"I hereby declare that I have checked this project report and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering (Hons.) in Civil Engineering."

Signature	:	
Name of Supervisor	:	DR. MOHAMAD IDRIS BIN ALI
Position	:	LECTURER
Date	:	28 JUNE 2016

STUDENT'S DECLARATION

"I hereby declare that the work on this thesis is my own except for quotation and summaries which have been duly acknowledge in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

Signature :

Name : 'ALYAA' 'IZZATI BINTI IBRAHIM

ID Number : AA12096

Date : 28 JUNE 2016

DEDICATION

Families, friends and teachers are the compass that guides us.
My humble efforts are dedicated to them.

ACKNOWLEDGEMENT

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

Alhamdulillah, all praises to Allah for the strengths and His blessing for the good health and wellbeing that I was necessary to complete this thesis.

I wish to express my sincere thanks to my supervisor,Dr. Mohamad Idris bin Ali, for providing me with all the necessary facilities for the research. His continuous guidance and constant support has made this research possible. I am extremely thankful and indebted to him for sharing expertise, and sincere and valuable guidance and encouragement extended to me.

I place on record, my sincere thank you to my parents, Mr. Ibrahim bin Kamal and Mrs. Sharifah ‘Azwan binti Syed Yusoh, for their unceasing encouragement, support and attention for me to complete this thesis.

I take this opportunity to express gratitude to all of my friends and colleagues for their help and support. I thank my friends and course whose are also helping me out by giving the moral support, valuable opinions and sharing ideas during the progress of this project. . I am also grateful to my partner who supported me through this venture.

I dedicated my thanks to Dr. Nadrah as the coordinator of final year project whose guidance of this project was deeply appreciated

I also place on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand in this venture.

Thank you.

ABSTRACT

Pahang River Basin is highly vulnerable to the risk of flood. Frequent flooding can cause a lot of cost property damages and losses of lives. December 2014 flood event was on an unprecedented scale. The water level increase rapidly and the local people do not expected the situation become worst. The main objective of this study was to analysing lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin occurred during the end of December 2014 (from 20th until 31st). The specific objectives of the study are as follows; to validate satellite-based data and to analyse lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin. The study area covered the area that effected during the flood event; Jeram Bugor, Bukit Betong, Sungai Yap, Temerloh, Lubuk Paku and Paloh Hinai. In this study, Auto-estimator method was used to derive satellite-based hourly rainfall rate data from satellite image of top of cloud temperature data taken from the public domain meanwhile the water level and rain gauge rainfall data obtained from Department of Irrigation & Drainage (DID). The satellite-based hourly rainfall rate over rain-gauge station retrieved and validated. The estimated value and measured value shows a very good agreement (r = 0.89 to 0.97). The regression line fitted through origin has a slope of 0.58 to 1.06 the dataset. Flood lag analyses were conducted by referring to the satellite-based hourly rainfall rate data and the water level data obtained from DID based on four water level station situated along Pahang river which is Sungai Yap, Temerloh, Lubuk Paku and Paloh Hinai. The time series graphs were produced to derive the lag time, (Δt) for the flood event. From the result, the satellite-based rainfall rate data from public domain able to be used for the flood forecasting. In future, it will give benefit to relevant parties for systematic planning in flood management system.

ABSTRAK

Lembangan Sungai Pahang adalah sangat terdedah kepada risiko banjir. Banjir yang kerap boleh menyebabkan banyak kerosakan harta, kos dan kerugian nyawa. Banjir pada Disember 2014 berada di dalam skala yang tidak disangka. Paras air meningkat dengan cepat dan rakyat tempatan tidak menjangkakan keadaan menjadi teruk. Objektif utama kajian ini adalah untuk menganalisis masa lag, (Δt) antara hujan dan banjir semasa kejadian banjir di Lembangan Sungai Pahang yang berlaku semasa akhir Disember 2014 (dari 20 hingga 31). Objektif khusus kajian ini adalah seperti berikut; untuk mengesahkan data berasaskan satelit dan untuk menganalisis masa lag, (Δt) antara hujan dan banjir semasa kejadian banjir di Lembangan Sungai Pahang. Kawasan kajian meliputi kawasan yang dilaksanakan semasa acara banjir; Jeram Bugor,Bukit Betong, Sungai Tembeling, Sungai Yap, Temerloh, Lubuk Paku dan Paloh Hinai. Dalam kajian ini, kaedah Auto-penganggar telah digunakan untuk mendapatkan data kadar hujan setiap jam berasaskan satelit daripada imej satelit atas data suhu awan yang telah diambil dari domain awam manakala data paras air hujan dan tolok hujan diperolehi daripada Jabatan Pengairan dan Saliran (JPS). Kadar hujan setiap jam berasaskan satelit alih stesen hujan tolok diambil dan disahkan. Anggaran nilai dan nilai diukur menunjukkan perkaitan yang sangat baik (r = 0.89-0.97). Garisan regrasi selaras melalui titik asal mempunyai kecerunan 0.58-1.06 set data. Analisi lag banjir telah dijalankan dengan merujuk kepada data kadar hujan setiap jam berasaskan satelit dan data paras air yang diambil dari JPS berdasarkan empat stesen paras air yang terletak di sepanjang sungai Pahang iaitu Sungai Yap, Temerloh, Lubuk Paku dan Paloh Hinai. Graf siri masa telah dihasilkan untuk memperolehi masa lag, (Δt) untuk kejadian banjir. Dari keputusan, data kadar hujan yang berasaskan satelit dari domain awam dapat digunakan untuk ramalan banjir. Pada masa akan datang, ia akan memberi manfaat kepada pihak yang berkenaan untuk perancangan sistematik dalam sistem pengurusan banjir.

.

TABLE OF CONTENTS

CHAPTER 4 RESULT AND DISCUSSIONS

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Δt	Lag Time

LIST OF ABBREVIATIONS

TRMM	Tropical Rainfall Measuring Mission
DID	Department of Irrigation and Drainage Malaysia
BH	Berita Harian
UM	Utusan Malaysia
SH	Sinar Harian
PR	Precipitation Radar

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Flood defined as a situation where water flows exceed the carrying capacity of a river resulting in overflows over the river banks (Goh, 1981). Another definition of a flood is considered to be unusually high stage of the river. It is often described as that stage at which the stream channel becomes filled and above which it overflows its banks (Saul, 1992). Normally, this overflow happens when heavy rain takes place nonstop for a long period time at certain location. It will cause place that usually dries be overflow with water. It situation may also bring death and properties damage. 90% of population who affected by natural hazards are subjected to flood (Haider, 2006).

The most devastating natural disaster experienced in Malaysia is flood. The flooding of Malaysian rivers is mainly due to the high amount of rainfall in river basins. Malaysia is a tropical country, receiving more than 2 500mm of rain annually. There are total of 189 river basins with the main channels flowing directly to the South China Sea throughout Malaysia, including Sabah and Sarawak (89 of the river basins are in Peninsula Malaysia, 78 in Sabah and 22 in Sarawak), and 85 of them are prone to recurrent flooding. The estimated area vulnerable to flood disaster is approximately 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).

In Malaysia history, the massive flood occurred in 1886, 1967, 1971, 2007, and 2008 and lately this situation has continuously worsened. One of the severest are 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).

In Malaysia history, the massive flood occurred in 1886, 1967, 1971, 2007, and 2008 and lately this situation has continuously worsened. One of the severest are 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).

Figure 1.1: December 2014 Flood in Pahang

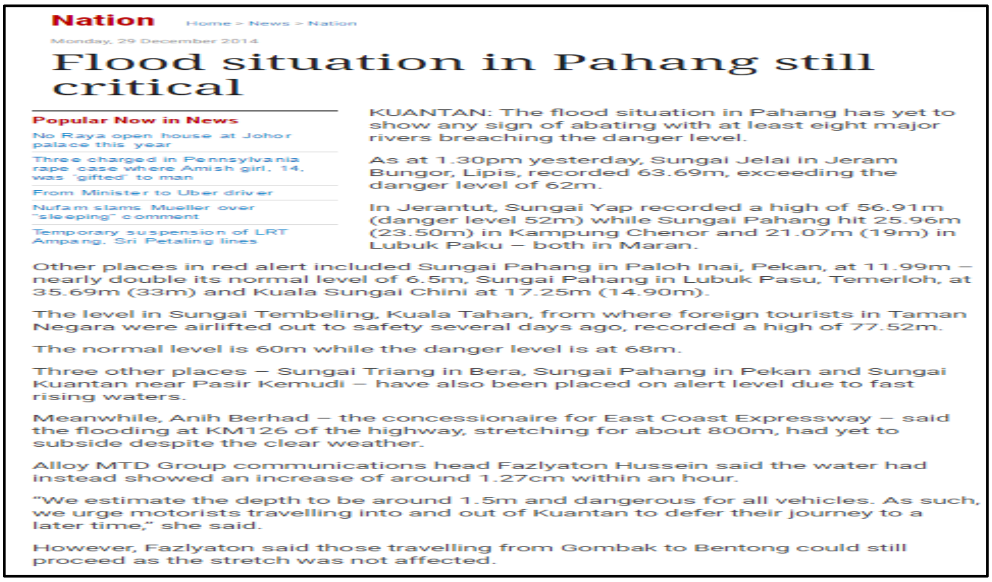
Source: www.nst.com.my/ (2014)

Pahang on the other hand has faced a number of severe floods over several past years and its vulnerability to these resulted from the rapid urban development of the Pahang. The impacts of river flooding are even more damaging and interrupt economic activities and the livelihoods of people in the area.

1.2 PROBLEM STATEMENT

Flooding is a natural event, and no matter how hard a government or society tried to minimize or to stop it completely (FRMP 2012). Due to unexpected flood in December 2014, the villagers that lived in effected area do not have enough time to move to the higher place since the transportation cannot be used and the main roads also inundation. The situations become worst during 25 December 2014 when water level increase rapidly at the downstream area such as Temerloh and Kuantan town. During that period most of the locals at the downstream area did not expected the increasing of water level will cause flood at their area.

The flood event during December 2014 almost hit 90 percent of Pahang state; only a few district in Pahang did not affected with the flood. Figures 1.2 to 1.6 are some of the articles from the local newspaper about flood in Pahang. The articles show the difficulty faces by the villagers during the flood occur. The daily activities cannot be doing and it causes a huge amount of losses. Due to the high water level and strong current flow, some of the affected area cannot be connected and the aid cannot be extended to the victim. It is necessity for flood forecasting in a practical way to save lives and property. The possibility of satellite-based rainfall data from public domain to be use together with water level data from DID to determine the lag time of the event.


Nation Home > News > Nation

Monday, 29 December 2014

Flood situation in Pahang still critical

Popular Now in News
No Raya open house at Johor palace this year
Three charged in Pennsylvania rape case where Amish girl, 14, was "gifted" to man
From Minister to Uber driver
Nufam slams Mueller over "sleeping" comment
Temporary suspension of LRT Ampang, Sri Petaling lines

KUANTAN: The flood situation in Pahang has yet to show any sign of abating with at least eight major rivers breaching the danger level.

As at 1.30pm yesterday, Sungai Jelai in Jeram Bungor, Lipis, recorded 63.69m, exceeding the danger level of 62m.

In Jerantut, Sungai Yap recorded a high of 56.91m (danger level 52m) while Sungai Pahang hit 25.96m (23.50m) in Kampung Chenor and 21.07m (19m) in Lubuk Paku — both in Maran.

Other places in red alert included Sungai Pahang in Paloh Inai, Pekan, at 11.99m — nearly double its normal level of 6.5m, Sungai Pahang in Lubuk Pasu, Temerloh, at 35.69m (33m) and Kuala Sungai Chini at 17.25m (14.90m).

The level in Sungai Tembeling, Kuala Tahan, from where foreign tourists in Taman Negara were airlifted out to safety several days ago, recorded a high of 77.52m.

The normal level is 60m while the danger level is at 68m.

Three other places — Sungai Triang in Bera, Sungai Pahang in Pekan and Sungai Kuantan near Pasir Kemudi — have also been placed on alert level due to fast rising waters.

Meanwhile, Anih Berhad — the concessionaire for East Coast Expressway — said the flooding at KM126 of the highway, stretching for about 800m, had yet to subside despite the clear weather.

Alloy MTD Group communications head Fazlyaton Hussein said the water had instead showed an increase of around 1.27cm within an hour.

"We estimate the depth to be around 1.5m and dangerous for all vehicles. As such, we urge motorists travelling into and out of Kuantan to defer their journey to a later time," she said.

However, Fazlyaton said those travelling from Gombak to Bentong could still proceed as the stretch was not affected.

Figure 1.2 Flood Article (The Star Online, Dec. 2014)

BANJIR GELOMBANG KEDUA

Enam daerah dinaiki air

Oleh Syah Rul Aswari Abdullah
am@hmetro.com.my
Kuantan

Keadaan banjir di negeri ini semakin buruk apabila enam daerah dinaiki air susulan hujan berterusan sejak Ahad lalu dan keadaan air pasang besar malam kelmarin.

Mengikut jurucakap Bilik Gerakan Banjir Ibu Pejabat Polis Kontinjen Pahang, sehingga jam 8 malam tadi, seramai 8,193 mangsa banjir daripada 2,089 keluarga dipindahkan ke 80 pusat pemindahan sementara (PPS), meningkat hampir 10 kali ganda berbanding 821 orang daripada 226 keluarga di 13 PPS, kelmarin.

FAKTA
8,193 mangsa banjir daripada 2,089 keluarga dipindahkan ke 80 pusat pemindahan sementara

Menurutnya, Kuantan mencatatkan mangsa banjir paling ramai dengan 3,809 orang daripada 1,055 keluarga ditempatkan di 22 PPS, diikuti Maran (2,218 orang, 536 keluarga, 15 PPS) dan Lipis (1,104 orang, 277 keluarga, 18 PPS), Jerantut (621 orang, 124 keluarga, 17 PPS), Rompin (258 orang, 59 keluarga, tiga PPS) dan Pekan (183 orang, 38 keluarga, lima PPS).

Timbalan Pengawal Pusat Kawalan Operasi Banjir Ibu Pejabat Polis Daerah Maran Asisten Superintendan Mazlan Mat Daud berkata, mangsa banjir di Maran dipindahkan secara berperingkat-peringkat sejak malam kelmarin.

Menurutnya, pihaknya menjangka bilangan mangsa bertambah berikutan hujan lebat masih melanda daerah itu.

"Berdasarkan laporan Jabatan Pengaliran dan Saliran Daerah Maran berlaku trend peningkatan paras air di beberapa sungai utama di daerah ini.

"Bagaimanapun pusat kawalan operasi banjir daerah sentiasa bersiap siaga bersama jabatan lain, tentera, pertubuhan bukan kerajaan (NGO) bagi membantu mangsa banjir," katanya.

Katanya, antara pusat pemindahan banjir ialah Masjid Kampung Luit, Kampung Bak Bak, Kampung Kuala Sentol, Taman Sri Chedung, Taman Maran Jaya, Kampung Bukit Kuin, Felda Jengka 14 dan Kampung Ulu Luit.

Beliau berkata, jalan lama Kuantan-Maran di kawasan Jambatan Belimbing hanya boleh dilalui kenderaan berat, jalan lama Maran-Jerantut ditutup kepada semua kenderaan manakala Lebuh Raya Pantai Timur (LPT) boleh dilalui seperti biasa.

"Kami sentiasa mengawasi paras air Sungai Maran, Sungai Chedung dan Sungai Sri Jaya berikutan hujan lebat masih lagi berterusan petang ini (semalam)," katanya.

Bandar Maran turut dinaiki banjir air pagi semalam tetapi pulih dalam jangka masa singkat.

Dalam pada itu, Jabatan Meteorologi Malaysia mengeluarkan amaran hujan lebat peringkat merah bagi daerah Kuantan, Jerantut, Maran, Pekan dan Rompin yang berterusan hingga hari ini.

Keadaan angin diramalkan berkelajuan antara 60 sehingga 70 kilometer sejam selain keadaan laut bergelora yang mencapai ketinggian ombak setinggi 5.5 meter.

Figure 1.3 Flood Article (Harian Metro (Setempat), 24 Dec. 2014)

Banjir di Petronas kuala lipis pahang semakin buruk

KUALA LIPIS - Keadaan banjir di Lipis semakin buruk dengan 1,916, orang membabitkan 412 keluarga dipindahkan ke 25 buah pusat pemindahan di tiga Dewan Undangan Negeri (Dun) yang terjejas banjir.

Peniaga di sekitar Jalan Jelai juga telah bertindak segera memindah keluar barang dari premis perniagaan mereka kerana dibimbangi air bah masuk ke dalam kedai sekaligus merosakan barangan.

Selain itu, beberapa batang jalan di sekitar bandar Lipis termasuk jalan berhadapan Dataran Lipis, Institut Pertanian dan Pejabat Pertanian telah digenangi air dan ditutup kepada semua kenderaan.

Pengerusi Jawatankuasa Bencana, Datuk Ahmad Daud berkata, bekalan makanan dan peralatan untuk mangsa banjir yang kian bertambah di pusat penempatan juga telah diedar dan dijamin mencukupi.

"Buat masa sekarang kita menghantar bantuan kepada mangsa banjir melalui bot di kawasan yang terputus hubungan.

"Sekiranya keadaan semakin meruncing kita tidak menolak kemungkinan untuk meminta khidmat helikopter bagi menghantar bantuan makanan terutama di kawasan pedalaman seperti Kampung Chegar Perah,"katanya.

Figure 1.4 Flood Article (Utusan Online, Dec. 2014)

KUALA LUMPUR, Dec 27 — The number of flood victims in Pahang and Perak has increased as at 9 pm, with 33,324 flood evacuees were recorded in Pahang and 6,335 in Perak.

In **PAHANG**, 8,477 families from eight flood-hit districts were recorded to have taken shelter at relief centres tonight from 8,280 families recorded this afternoon.

Spokesman at Pahang police contingent flood operations room said Kuantan still had the most number of flood evacuees with 16,266 people from 4,416 families at 43 relief centres.

"Seven other flood-hit districts are Jerantut with 5,403 victims at 51 relief centres, Temerloh (3,200 victims/41 centres), Maran (3,035 victims/24 centres), Pekan (2,573 victims/28 centres), Lipis (2,425 victims/34 centers), Bera (384 victims/eight centres) and Rompin (38 victims/two centres), he said.

He said only Raub, Bentong and Cameron Highlands had not recorded any flood evacuees.

Figure 1.5 Flood Article (Malay Mail Online, Dec. 2014)

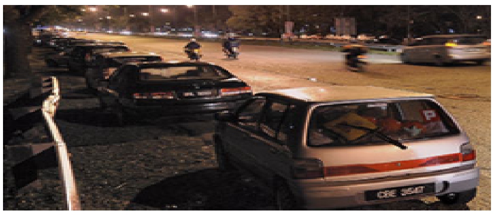
astro AWANI NEWS PHOTOS VIDEOS LIVE TV SHOWS KINI TRENDING APPS MORE...

MALAYSIA WORLD BUSINESS SPORTS ENTERTAINMENT TECHNOLOGY LIFESTYLE POLITICS OPINION

NEWS | MALAYSIA

Pahang record increase in flood victims as 6,286 people evacuated

Bernama | December 23, 2014 22:13 MYT



Car parked beside the road as flood waters spill over on to the road in Kuantan. - BERNAMA Photo

KUANTAN: The number of flood victims evacuated to relief centres in Kuantan increased to 6,286 from 1,614 families tonight compared with 4,729 people from 1,163 families this afternoon.

A spokesman from the Kuantan district police headquarters' flood operations room said Kuantan had the most number of victims evacuated with 3,525 from 986 families, housed at 22 relief centres.

"In Maran there are 1,373 victims from 337 families who are placed at 12 relief centres, Lipis (659 from 158 families at 12 centres), Jerantut (384 from 57 families at 14 centres), Rompin (246 from 55 families at 2 centres) and Pekan (99 from 21 families at one centre)," he told Bernama.

The spokesman said traffic was closed to all vehicles along Jalan Kuantan-Sungai Lembing (near Sungai Riau bridge), Jalan Kuantan-Sungai Lembing (Simpang Tiga Panching), Jalan Jerantut-Lipis and Jerantut-Kuala Tahan.

Meanwhile, the Drainage and Irrigation Department in its Facebook page stated that the water level at four main rivers remained at the danger level, namely Sungai Tembeling in Kuala Tahan at 76.56m (danger level 68.00m), Sungai Pahang in Sungai Yap at 56.21m (danger level 52.00m), Sungai Kuantan in Pasir Kemudi at 9.02m (danger level 8.20m) and Sungai Kuantan Bypass at 55.5m (danger level 52.00m).

Figure 1.6 Flood Article (Awani Online, Dec. 2014)

1.3 OBJECTIVES OF STUDY

The main objective of this study was to analysing lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin occurred during the end of December 2014 (from 20th until 31st). The specific objectives of the study are as follows;

1. to validate satellite-based rainfall data, and

2. to analyse lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin.

1.4 SCOPE OF STUDY

This study was limited to the following:

a. The study area was limited to affected areas along Pahang River Basin during flood in December 2014 which is Jeram Bugor, Bukit Betong, Sungai Yap, Temerloh, Lubuk Paku and Paloh Hinai (Fig 1.7 and Fig 1.8).
b. The period of study was limited from 20 December until 31 December 2014.
c. Satellite based rainfall data downloaded from public domain were used as hour-rainfall data
d. The onsite rainfall data obtained from Department of Irrigation & Drainage Malaysia were used to validate the satellite-based rainfall data.
e. The water level data obtained from Department of Irrigation & Drainage Malaysia (DID) were used to measure the flood level.

1.5 STUDY AREA

The Sungai Pahang basin (Figure 1.7) is located in the eastern part of Peninsular Malaysia and drains an area of 29,300 km2, of which 27,000 km2 lies within Pahang (about 75% of the State) and 2300 km2 is located in Negeri Sembilan. Sungai Pahang is the longest river in Peninsular Malaysia of about 435 km. Sungai Pahang originates at Kuala Tembeling as a result of the confluence of two equally large and long rivers: Sungai Jelai and Sungai Tembeling. Other main tributaries of Sungai Pahang are Sungai Semantan, Sungai Teriang, Sungai Bera and Sungai Lepar. Sungai Pahang begins to flow in a south east and south direction, passing along several major towns such as Kuala Lipis, at the mouth of the river bearing the same name on Sungai Jelai; Jerantut, the gateway to Taman Negara Sungai Tembeling; Temerloh, midway on the river at its confluence with Sungai Semantan; and finally turning eastward at Mengkarak in the central south of the catchment and flowing through the royal town of Bandar Diraja Pekan near the coast before discharging into the South China Sea. (JRBM, 2007)

The Sungai Pahang basin has an annual rainfall of about 2136 mm, a large proportion of which is brought by the North-East Monsoon between mid-October and mid-January. Due to the gentle terrain, the flow velocity drops and the river channel of the Sungai Pahang proper is wider and shallower than that of Sungai Jelai and Sungai Tembeling. The mean flow of Sungai Pahang measured at Station 3527410 (Lubok Paku), which is the most downstream stage station in the Sungai Pahang basin, is 689 m3/s based on the latest 10-year (1999–2008) data (Japan International Cooperation Agency (JICA) 2011).

Figure 1.7 The map of Pahang

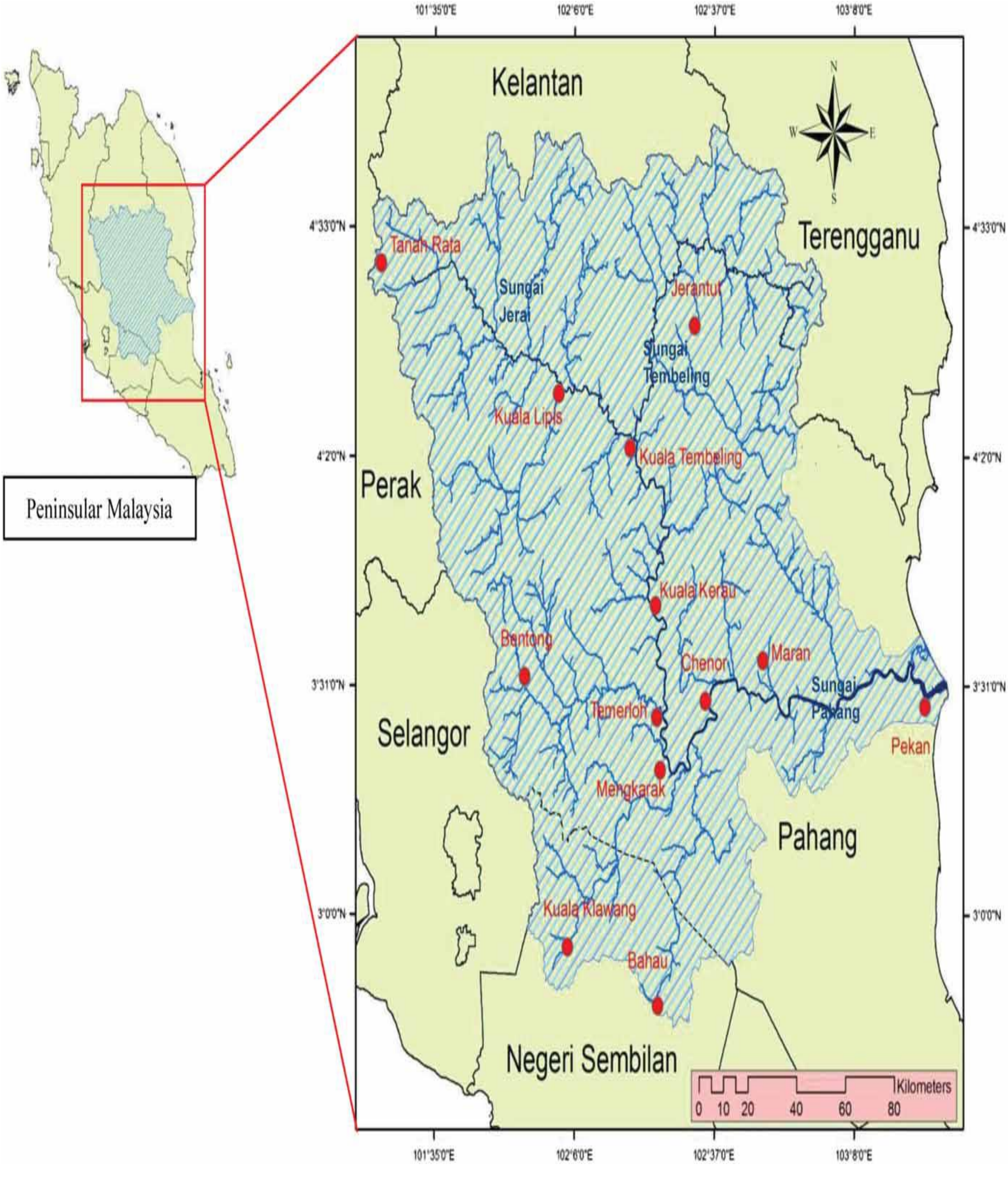


Figure 1.8 The Pahang River Basin Boundary

1.6 SIGNIFICANCE OF STUDY

Pahang River is the longest river in Peninsular Malaysia with the length of 435km and its upstream is located at the Main Range of Titiwangsa. Pahang River which is located at Pahang River Basin is the main channel responsible to drain the water from this basin to South China Sea. Pahang River is divided into the Tembeling and Jeram Bugors and both rivers meet at a confluence at Kuala Tembeling which is located 300km away from the estuary of Pahang River (Kuala Pahang). The river meanders through townships such as Jerantut, Temerloh, Maran, Bera, Pekan and lastly flows into the South China Sea which was located at the East Coastal of Peninsular Malaysia. Annual rainfall of the Pahang River Basin is ranged from 1609 mm (Temerloh) to 2132.36 mm (Lubuk Paku). Mostly, the high rainfall in this area was occurred at the end of the year (November to March every year) and it influenced by the northeast monsoon season.(Pa Ia Lun.2011)

From this study, the pattern of the rainfall and the water level at Pahang River Basin during the flood 2014 incident can be determined. Besides the pattern of time travelling of the flood flow also can be determine. Therefore, the comprehensive planning can be made to ensure all the villagers can be alert to make preparation and planning with any possible of flood incident in future. The data is importance and can be used for the authorized party such as Department of Drainage and Irrigation (DID) or Pahang State Government for future development.

1.7 THESIS STRUCTURE

This thesis comprises of five chapters. The first chapter consists of introduction section. It states the background, problem statement, objectives of study, scope of study and lastly the significant of study. For chapter two, the key terms in purpose for this study are described and also the literature review that related and suitable for this study. Chapter three explains the methodology of study, data collected and the method of data analysis to be employed. For chapter four, the results obtained from study area and year of study were presented and the analysis from the result was discussed. Finally, chapter five comprises the conclusion from the overall chapter and relates some recommendations for future work on research field.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A flood issue is synonym with the community especially for those who live in East Coast area of Peninsular Malaysia which is Kelantan, Terengganu and Pahang state. In Pahang, flooding is the most devastating natural hazard that usually occurs during end of the year. Flood takes hours or even days to develop, the resident have time to prepare for moving to the higher place. There are many factor causes the flood. The high rainfall intensity, the design of drainage that not enough to support the demand and also the water discharge system that has been disturbed by human activity such as human development and deforestation are several factor that cause the flood.

Over the year, flood leaves a very huge impact and causes suffering to human life and loss of materials and properties. Floods are the most common occurring natural disaster that affects human and its surrounding environment (Gebeyehu, 1989). The flood hazard comprises many aspects including structural and tensional damage, loss of life and property, contamination of food, water and other material, disruption of socioeconomic activity including transport and communication, and in some cases the spoiling of agricultural land (Jamaluddin, 1985).

2.2 FLOODS IN PAHANG

Several major floods have occurred in the last few decades in the Sungai Pahang basin, causing extensive damage and inconvenience to the local community. In January 1971, a catastrophic flood swept across many parts of the country and it is considered as the second largest flood on record. Pahang was severely affected, suffering great economic losses to properties and crops, with the inundated area of about 3000 km2, 150,000 evacuees and loss of 24 lives. This led experts to conclude that the estimated flood damage was around US$38 million including the intangible damages.

The water level exceeded the danger level at the Lubok Paku, Temerloh and Pekan stations. According to field survey, the inundation depth ranged from 1.0 to 2.0 m in Pekan Town Center and from 0.5 to 2.0 in the major towns in Temerloh and Maran districts. The long-duration flood forced people to stay at designated evacuation centres in Rompin, Maran, Kuantan, Pekan, Raub, Bera, Jerantut, Bentong, Temerloh and Kuala Lipis districts for as long as 22 days. A total of eight casualties were als recorded in the state of Pahang, with one casualty at Rompin, two at Pekan, three at Temerloh and two in Maran district,respectively. The flood damage was estimated at US$ 86 million by DID (JICA 2011).

2.3 CHRONOLOGY OF THE FLOOD IN PAHANG IN DECEMBER 2014

Awani Astro online article on 15 January 2015 Bentong-Raub route was still closed to traffic after a bridge at Kampung Baru Bentong was damaged by floods and it was being repaired.(Figure 2.1). Motorists were advised to use the alternative routes at Bentong-Karak Highway-Cinta Manis-Sertik-Mempaga or Lebu-Raub or Sertik-Kuala Krau.

Figure 2.1 Damaged Kampung Baru Bentong bridge

(Source: The Star Online, Jan 2015)

The online article, Awani Astro (23 December 2014) has reported that number of flood victims evacuated to relief centres in Kuantan increased to 6,286 from 1,614 families on 23 December compared with 4,729 people from 1,163 families that afternoon. Kuantan had the most number of victims evacuated with 3,525 from 986 families, housed at 22 relief centres. In Maran there are 1,373 victims from 337 families who are placed at 12 relief centres, Lipis (659 from 158 families at 12 centres), Jerantut (384 from 57 families at 14 centres), Rompin (246 from 55 families at 2 centres) and Pekan (99 from 21 families at one centre. Traffic was closed to all vehicles along Jalan Kuantan-Sungai Lembing (near Sungai Riau bridge), Jalan Kuantan-Sungai Lembing (Simpang Tiga Panching), Jalan Jerantut-Lipis and Jerantut-Kuala Tahan.

The local newspaper, The Star Online (TSO, 23 December 2014) reported that The water level of Sungai Tembeling in Kuala Tahan rose to 75.35 metres (danger level: 68 metres) and Sungai Pahang at Sungai Yap to 54.93 metres (danger level: 52 metres).Two rivers in Kuantan, namely, Sungai Kuantan at Pasir Kemudi rose to 8.79 metres (danger level: 8.2 metres) and Sungai Kuantan Bypass (5.27 metres) (danger level:3.50 metres).

Figure 2.2 An aerial view of the flood situation in Temerloh.

(Source: The Star, Dec. 2014)

Rough seas with winds of 60 kilometers per hour and waves reaching 5.5 meters are dangerous to all coastal and shipping activities including workers on oil platform. Meanwhile, until 6pm, several locations in Sungai Lembing and Lipis level readings recorded heavy rain exceeded 100 millimeters (mm) including upstream Sungai Kuantan.This caused the water level in major rivers including Sungai Kuantan and Sungai Belat rose above the danger level. The upstream water moved down to the estuary and added tide scheduled to peak at 3.6 meters at about 11.30 tonight cause water levels continue to rise.

Some centers cannot be used when the place was flooded and caused the evacuees there had to be moved elsewhere. Evacuees at the relief centers in Cegar Perah, Merapoh, Lipis, had to be evacuated when the place was flooded.However, their efforts to move the difficulties posed by the helicopter could not land due to no landing area and the lack of appropriate lifeboat.Another problem that arises during the flood this time is the disruption of water supply in some areas in the affected area when the plant was closed because there was no electricity and the plant flooded.

Figure 2.3 Session saving flood victims

(Source: Utusan Online, Dec. 2014)

Astro Awani on 3 January reported that the flood waters start to recede and flood situation improved drastically in Pahang sending back more evacuees to their homes. Number of evacuees in the state dropped slightly to 42,703 people compared to 42,938 that housed in 183 evacuation centers in seven affected districts. Although the flood situation continued to improve, there were still many evacuees at the relief centres as they had lost their homes, or their houses were badly damaged or covered with mud.

Figure 2.4 An aerial view of the flood situation in Kuala Tahan,Jerantut,Pahang.

(Source: Utusan Online, Dec. 2014)

Figure 2.5 Condition Sungai Tanum bridge , Kuala Lipis , which was badly damaged by floods

(Source: Sinar Harian, Dec. 2014)

Figure 2.6 Condition at Kuala Tahan

(Source: Online Article, Dec. 2014)

2.4 FLOOD LAG

According to Chow, Maidment and Mays (1988), the term flood lag refers to procedures to determine the outflow hydrograph at a point downstream in a river as a function of the inflow hydrograph at a point upstream. As flood waves travel downstream they are attenuated and delayed. That is, the peak flow of the hydrograph decreases and the time base of the hydrograph increases. The shape of the outflow hydrograph depends upon the channel geometry and roughness, bed slope, length of channel reach, and initial and boundary flow conditions. The propagation of flood waves in a channel is a gradually varied unsteady flow process, which is governed by conservation of mass and momentum equations. Brass (1990) agree with the solution of these equations in a distributed manner is referred to as distributed lag of flood waves. When no spatial variability is taken into account and when the channel reach or reservoir is considered as a black box, the corresponding lag procedure is referred to as lumped lag.

Two categories of lag can be recognised which is reservoir lag and channel lag. Reservoir lag is used to determine the peak-flow attenuation that a hydrograph undergoes as it enters a reservoir or other type of storage pool. Input data needed for storage lag include the inflow hydrograph and reservoir characteristics which is storage and outlet facilities. In channel lag, the change in the shape of a hydrograph as it travels down a channel is studied. By considering a channel reach at an input hydrograph at the upstream end, this form of lag aims to predict the flood hydrograph at various sections of the reach. Information on the flood-peak attenuation and the duration of levels obtained by channel lag is of utmost importance in operations and flood protection works.

2.5 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 56 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.

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.

2.6 AUTO ESTIMATOR METHOD

The Hydro-Estimator (H-E) is a single-channel (11-µm) rain rate algorithm whose origins go all the way back to the semi-automated Interactive Flash Flood Analyzer (IFFA; Scofield 1987) which was originally developed in the late 1970's.
According to Vicente et al (1998), many of the IFFA's features were automated into the Auto-Estimator (AET) in the late 1990's, including rainfall rate as a function of IR window brightness temperature which is calibrated against radar and corrections for atmospheric moisture. However, the A-E frequently assigned high rain rates to cold (non-raining) cirrus clouds, leading to the H-E which replaced the A-E in 2002. The HE assigns rainfall only to pixels that are colder than the average of the surrounding cloudy pixels in order to eliminate cirrus clouds.

2.6.1 Precipitation Rate Equations

The primary feature of the A-E is a fixed relationship between rainfall rate and temperature that was derived from 6800 pairs of collocated IR brightness temperatures and radar rainfall rates from convective cores of mesoscale convective systems (MCS's) for 16 events from March-June 1995 (Vicente et al. 1998). Regression was used to derive the following relationship:

$$R = 1.1183(10^{11}).\exp[-3.6382(10^{-2}).T^{1.2}] \quad \text{(Eq.1)}$$

$$T(K) = T(°C) + 273.15 \quad \text{(Eq.2)}$$

Where:

R = rainfall rate $(mm.h^{-1})$

T = temperature (K)

2.8 SUMMARY

In this chapter, the review of chronology of flood incident during December 20114 already explained. The elaboration of satellite-based rainfall data used and the significant of data validation have been discussed in this chapter.

CHAPTER 3

METHODOLOGY

3.0 METHODOLOGY

The purpose of this study is to analyse lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin. The purposes of this chapter are to;

(1) Describe the research methodology of this study,

(2) Explain the sample selection,

(3) Describe the procedure used in collecting the data, and

(4) Provide an explanation of the statistical procedures used to analyse the data.

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

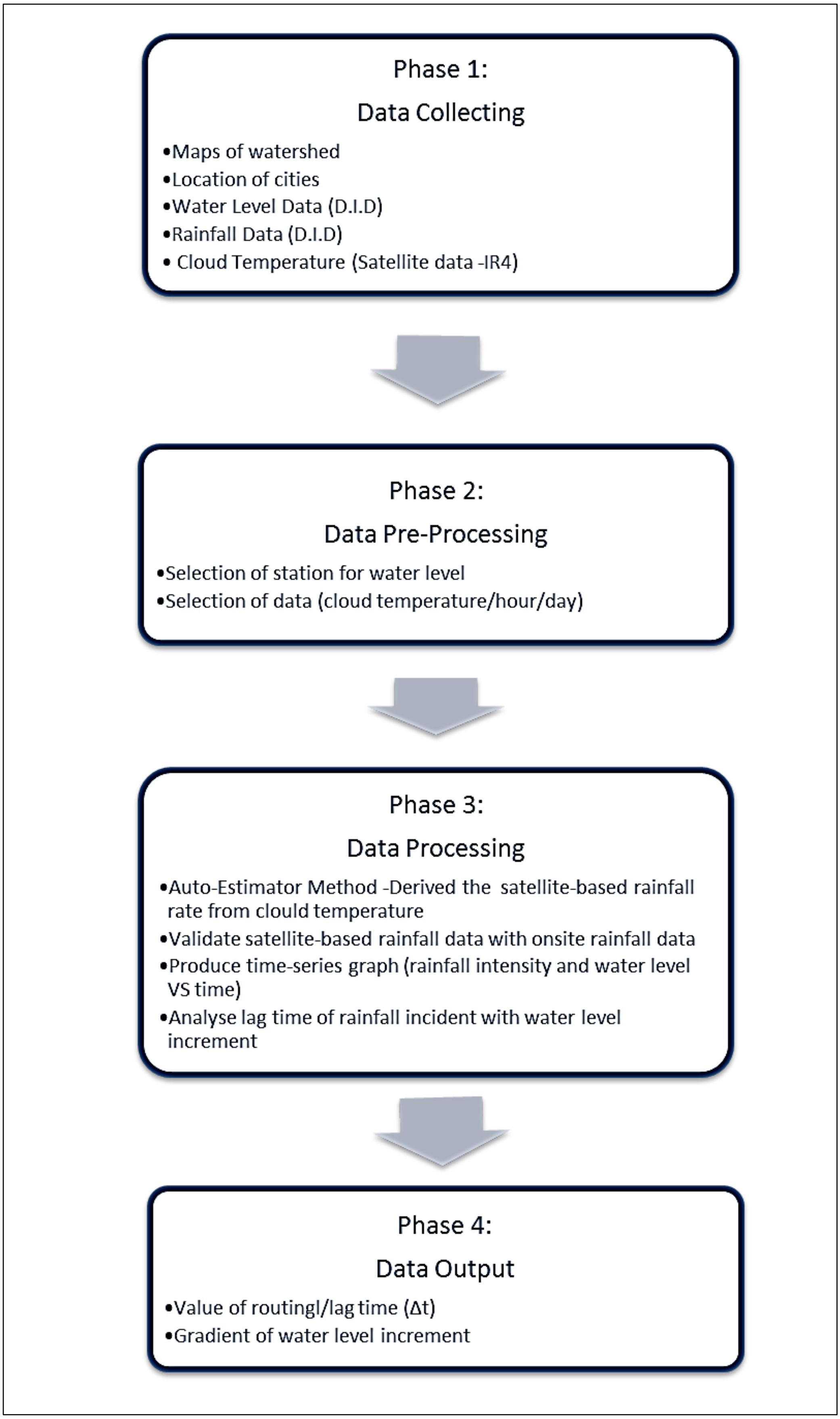


Figure 3.1 Flow diagram of Research Methodology

3.1 Study Area

Pahang has a tropical climate, with temperatures from 23 to 33 °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, 137 km^2. The selected study area comprises of five major cities in Pahang which are Jeram Bugor, Bukit Betong, Sungai Yap, Temerloh, Lubuk Paku and Paloh Hinai.

3.2 DATA COLLECTING

The water level and on site rainfall data for this study obtained from the Department of Irrigation & Drainage Malaysia (DID). The DID provide dataset of water level and rainfall rate for entire Pahang state through their online inventory (Figure 3.2 & 3.3).

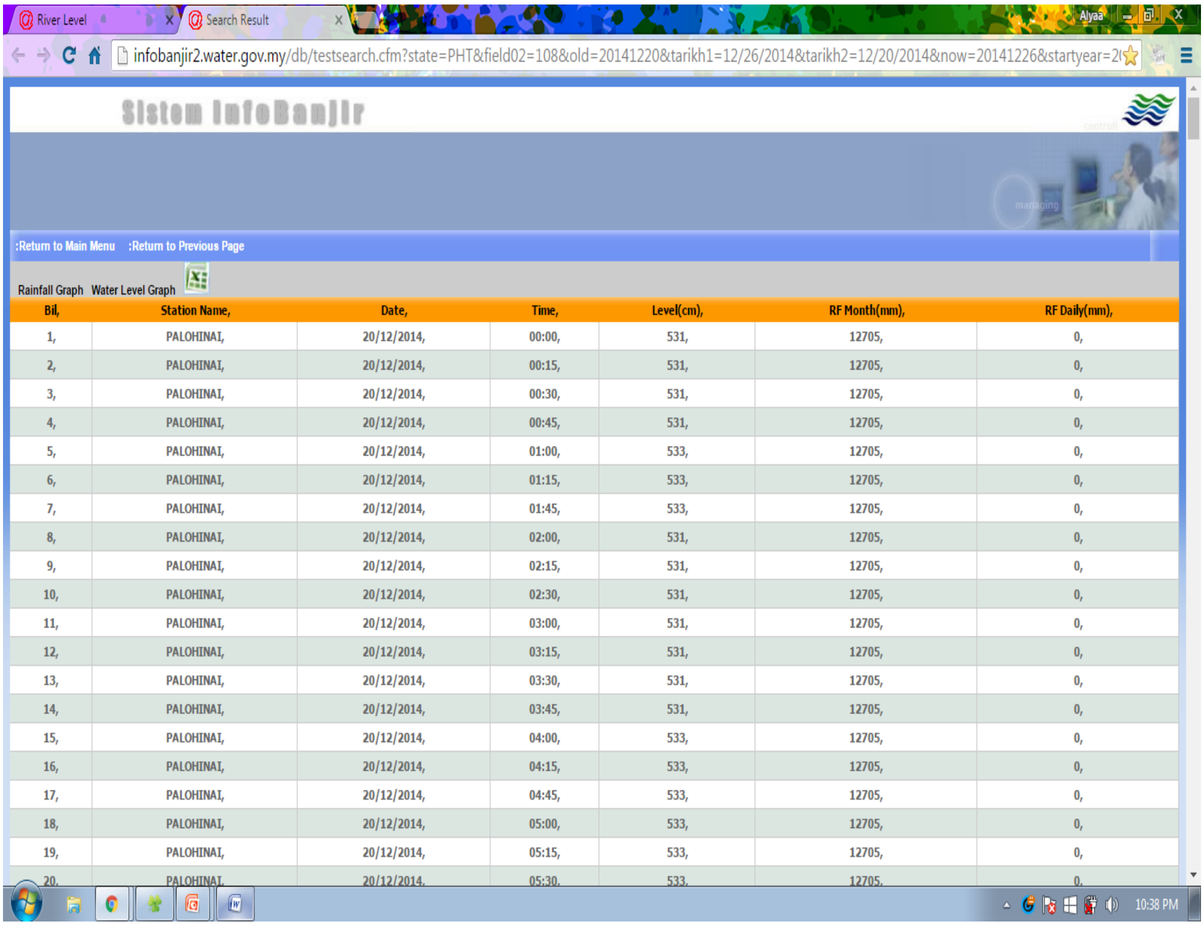
PAHANG
On-Line River Level Data (m) - above Mean Sea Level
Date:25/05/2016 Time:22:33
Home Main Page Explaination
Water Level Data

StationID (Photo)	Station Name (Cross-section)	District	River Basin (Trend)	Last Update Time	River Level (Graph)	Normal level	Alert Level	Warning Level	Danger Level
4514401	Sg.Ikan	Cameron Highland	Sg.Pahang	25/05/2016 - 15:00	1,277.00	1,277.34	1,277.90	1,278.08	1,278.50
4219415	Sg.Jelai di Bukit Betong	Lipis	Sg.Jelai	25/05/2016 - 17:00	65.81	67.00	71.00	72.00	73.00
4121413	Sg.Jelai di Jeram Bungor	Lipis	Sg.Pahang	25/05/2016 - 16:00	53.52	55.00	58.00	60.00	62.00
4324454	Sg.Tembeling di Kuala Tahan	Jerantut	Sg.Pahang	25/05/2016 - 15:00	59.38	60.00	64.00	66.00	68.00
3220401	Sg.Perdak di Telemong	Bentong	Sg.Perdak	25/05/2016 - 17:00	91.50	92.00	95.00	95.30	96.00
3519426	Sg.Bentong di Kuala Marong	Bentong	Sg.Pahang	25/05/2016 - 16:00	-99.99	86.00	88.00	88.30	89.00
3518401	Emp. Repas	Bentong	Sg.Repas	Rainfall Only	17.26	99.00	111.10	112.70	114.30
3420432	Sg.Semantan di Kg. Lengkong	Temerloh	Sg.Pahang	25/05/2016 - 17:00	48.87	49.00	51.00	52.00	53.00
3424411	Sg.Pahang di Temerloh (Lubuk Pasu)	Temerloh	Sg.Pahang	25/05/2016 - 15:00	26.16	26.00	29.00	31.00	33.00
3224433	Sg.Triang di Triang	Bera	Sg.Pahang	25/05/2016 - 17:00	30.44	31.00	33.50	33.80	34.50
3527410	Sg.Pahang di Lubuk Paku	Maran	Sg.Pahang	25/05/2016 - 16:00	12.27	14.00	17.00	18.00	19.00
3434401	Sg.Pahang di Pekan	Pekan	Sg. Pahang	25/05/2016 - 15:00	1.61	1.00	2.44	3.05	3.66
3930401	Sg.Kuantan di Bukit Kenau	Kuantan	Sg.Kuantan	25/05/2016 - 16:00	16.25	17.00	20.00	20.75	21.50
3832420	Kuantan Bypass	Kuantan	Sg.Kuantan	25/05/2016 - 17:00	-0.59	0.60	3.00	3.15	3.50
3629403	Jambatan Gelugor	Kuantan	Sg.Lepar	25/05/2016 - 16:00	26.11	27.00	29.50	29.65	30.00

Page 1 of 2 Next

Figure 3.2 Water Level Dataset Retrieved from DID website.

(Source: http://infobanjir.water.gov.my/waterlevel_page.cfm?state=PHG)



Sistem InfoBanjir

:Return to Main Menu :Return to Previous Page

Rainfall Graph Water Level Graph

Bil,	Station Name,	Date,	Time,	Level(cm),	RF Month(mm),	RF Daily(mm),
1,	PALOHINAI,	20/12/2014,	00:00,	531,	12705,	0,
2,	PALOHINAI,	20/12/2014,	00:15,	531,	12705,	0,
3,	PALOHINAI,	20/12/2014,	00:30,	531,	12705,	0,
4,	PALOHINAI,	20/12/2014,	00:45,	531,	12705,	0,
5,	PALOHINAI,	20/12/2014,	01:00,	533,	12705,	0,
6,	PALOHINAI,	20/12/2014,	01:15,	533,	12705,	0,
7,	PALOHINAI,	20/12/2014,	01:45,	533,	12705,	0,
8,	PALOHINAI,	20/12/2014,	02:00,	531,	12705,	0,
9,	PALOHINAI,	20/12/2014,	02:15,	531,	12705,	0,
10,	PALOHINAI,	20/12/2014,	02:30,	531,	12705,	0,
11,	PALOHINAI,	20/12/2014,	03:00,	531,	12705,	0,
12,	PALOHINAI,	20/12/2014,	03:15,	531,	12705,	0,
13,	PALOHINAI,	20/12/2014,	03:30,	531,	12705,	0,
14,	PALOHINAI,	20/12/2014,	03:45,	531,	12705,	0,
15,	PALOHINAI,	20/12/2014,	04:00,	533,	12705,	0,
16,	PALOHINAI,	20/12/2014,	04:15,	533,	12705,	0,
17,	PALOHINAI,	20/12/2014,	04:45,	533,	12705,	0,
18,	PALOHINAI,	20/12/2014,	05:00,	533,	12705,	0,
19,	PALOHINAI,	20/12/2014,	05:15,	533,	12705,	0,
20,	PALOHINAI,	20/12/2014,	05:30,	533,	12705,	0,

Figure 3.3 Onsite Rainfall Dataset Retrieved from D.I.D website

(Source:http://infobanjir2.water.gov.my/db/testsearch.cfm?state=PHT&field02=108&old=20141220&tarikh1=12/26/2014&tarikh2=12/20/2014&now=20141226&startyear=2014&endyear=2014&CFID=28681677&CFTOKEN=12610930)

The temperatures of cloud for every hour starting from December 20 (00:00) until December 31(23:00) were collected from satellite based data (IR4), (Figure 3.4).

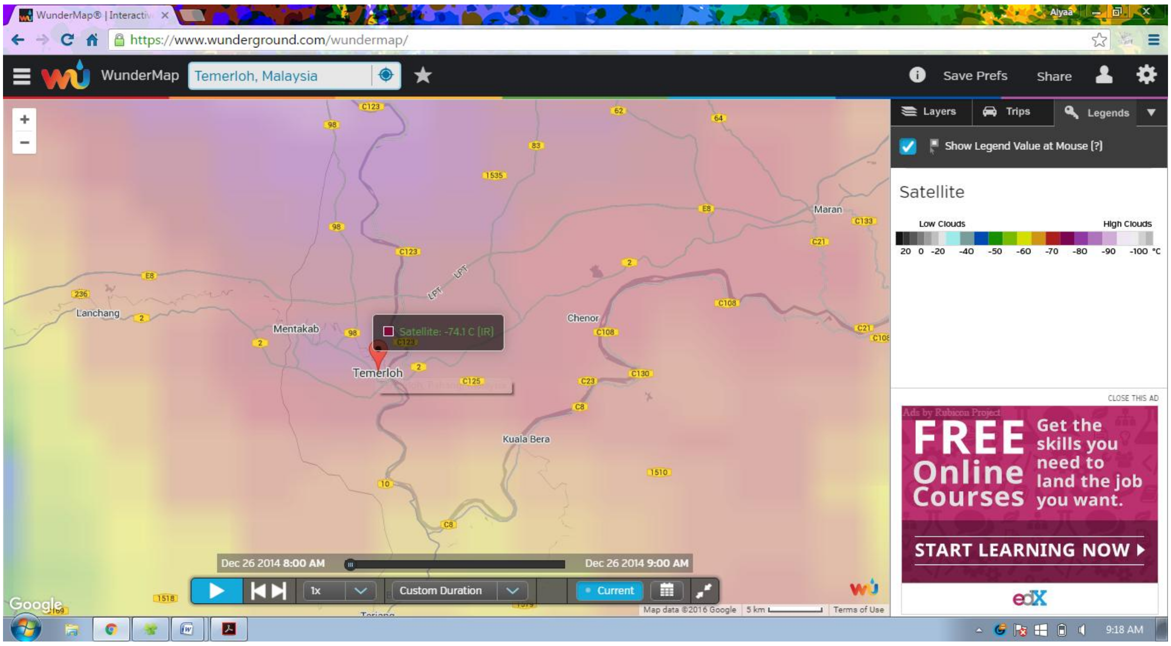


Figure 3.4 The interface of Satellite base Dataset (IR4)

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. A combination of both channels works best (Arkin, P.A. and P.E. Ardanuy, 1989).

The visible/IR rain retrieval algorithms work best at low latitudes, because at higher latitudes the view is more slanted, confusion arises with high-albedo surfaces of snow or ice, and deep-convective precipitation is less common. Another problem is incomplete pixel filling for small cumulonimbus clouds (Vicente, G.A., R.A. Scofield & W.P. Menzel 1998)

.

3.3 PRE - PROCESSING

The dataset of water level and rainfall rate provide by DID were selected. Only the data from Pahang River Basin were selected from the dataset. Table 3.1 were the example of selected data retrieve from DID.

\

Table 3.1 Selected water level dataset by DID (20 December 2014)

SUNGAI PAHANG FLOOD LEVEL STATION [20/12/14]						
TIME	BUKIT BETONG	JERAM BUGOR	SUNGAI YAP	TEMERLOH	LUBOK PAKU	PALOH HINAI
00:00	66.76	55.63	47.45	27.74	16.99	5.31
01:00	66.76	55.63	47.40	27.65	16.99	5.33
02:00	66.74	55.61	47.36	27.56	16.99	5.31
03:00	66.73	55.61	47.33	27.49	16.99	5.31
04:00	66.72	55.59	47.27	27.41	16.99	5.33
05:00	66.71	55.59	47.22	27.35	16.99	5.33
06:00	66.69	55.58	47.15	27.28	16.99	5.33
07:00	66.69	55.56	47.10	27.20	16.91	5.33
08:00	66.68	55.56	47.03	27.16	16.91	5.33
09:00	66.67	55.56	46.97	27.11	16.81	5.33
10:00	66.66	55.53	46.90	27.05	16.77	5.31
11:00	66.65	55.53	46.85	27.00	16.75	5.33
12:00	66.64	55.51	46.80	26.97	16.71	5.34
13:00	66.63	55.51	46.73	26.93	16.69	5.41
14:00	66.63	55.49	46.69	26.90	16.67	5.46
15:00	66.62	55.48	46.63	26.86	16.63	5.54
16:00	66.62	55.48	46.59	26.81	16.59	5.54
17:00	66.61	55.46	46.55	26.79	16.57	5.54
18:00	66.60	55.46	46.50	26.74	16.55	5.59
19:00	66.60	55.46	46.47	26.69	16.49	5.59
20:00	66.59	55.46	46.45	26.66	16.47	5.54
21:00	66.59	55.46	46.43	26.62	16.43	5.51
22:00	66.59	55.45	46.41	26.60	16.39	5.48
23:00	66.59	55.43	46.40	26.57	16.37	5.46
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

3.4 PROCESSING

3.4.1 Auto-Estimator Method

The Auto-Estimator methods as state in previous chapter 2 were used to derive the rainfall rate for satellite database (IR4). The temperatures of the cloud in Celsius were converted to Kelvin using Eqn 2 as stated in Chapter 2. Then the Eqn 3 will be used to generate the rainfall rate, Table 3.2 show the example of complete processing data. From the complete satellite based rainfall rate data, the time series graph of rainfall versus time was produce and combine together with the time series graph of water level versus time (Chapter 4).

Table 3.2 Rainfall rate using Auto-Estimator method at Bukit Betong (20 December 2014)

DATE	TIME	TEMPERATURE (°C)	TEMPERATURE (K)	RAINRATE (mm/hr)
	00:00	-15	258.15	0.05
	01:00	-10	263.15	0.02
	02:00	-11	262.15	0.03
	03:00	-22	251.15	0.12
	04:00	-55	218.15	8.48
	05:00	-45	228.15	2.34
	06:00	-55	218.15	8.48
	07:00	-	-	-
	08:00	-	-	-
	09:00	-45	228.15	2.34
	10:00	-60	213.15	16.08
20/12/2014	**11:00**	-58	215.15	12.46
	12:00	-	-	-
	13:00	-45	228.15	2.34
	14:00	-48	225.15	3.45
	15:00	-25	248.15	0.17
	16:00	-22	251.15	0.12
	17:00	-15	258.15	0.05
	18:00	-14	259.15	0.04
	19:00	-16	257.15	0.05
	20:00	-14	259.15	0.04
	21:00	-15	258.15	0.05
	22:00	-10	263.15	0.02
	23:00	-9	264.15	0.02

3.4.2 Descriptive Statistics

After all the data have been opened in excel to be organized in the form of tables and graphs. Graphical analysis of time series graph was used to compare water level and rainfall from satellite based rainfall estimates over selected stations in Pahang River Basin. This method involved plotting water level and satellite based measurements against time. This method is simple and provides quick visual observation at a given time.

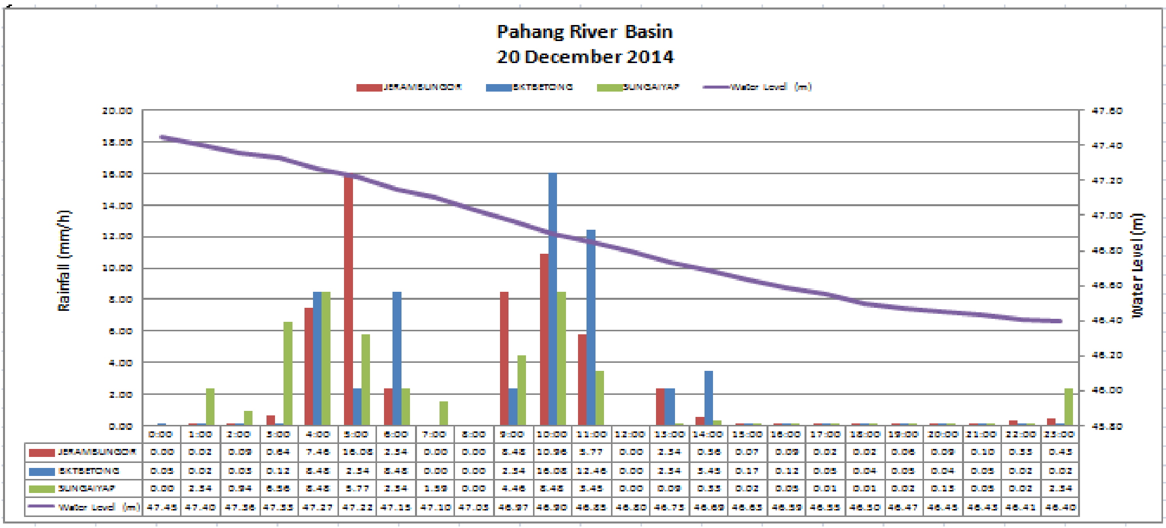


Figure 3.5 Time-series graph for 20 December 2014

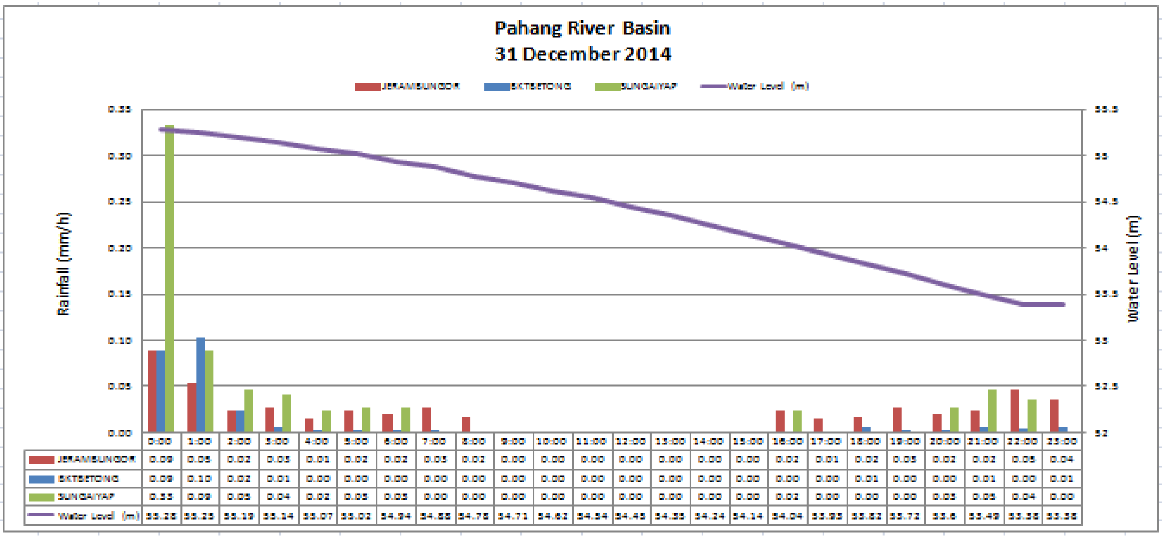


Figure 3.6 Time-series graph for 31 December 2014

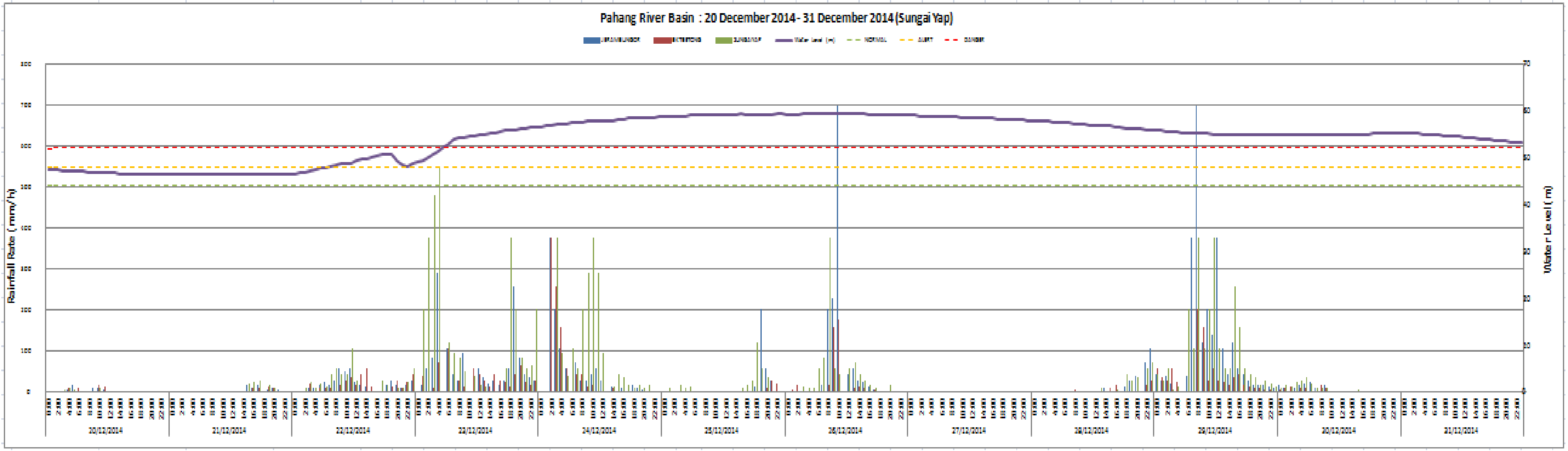


Figure 3.7 Time-series graph for Sungai Yap Flow

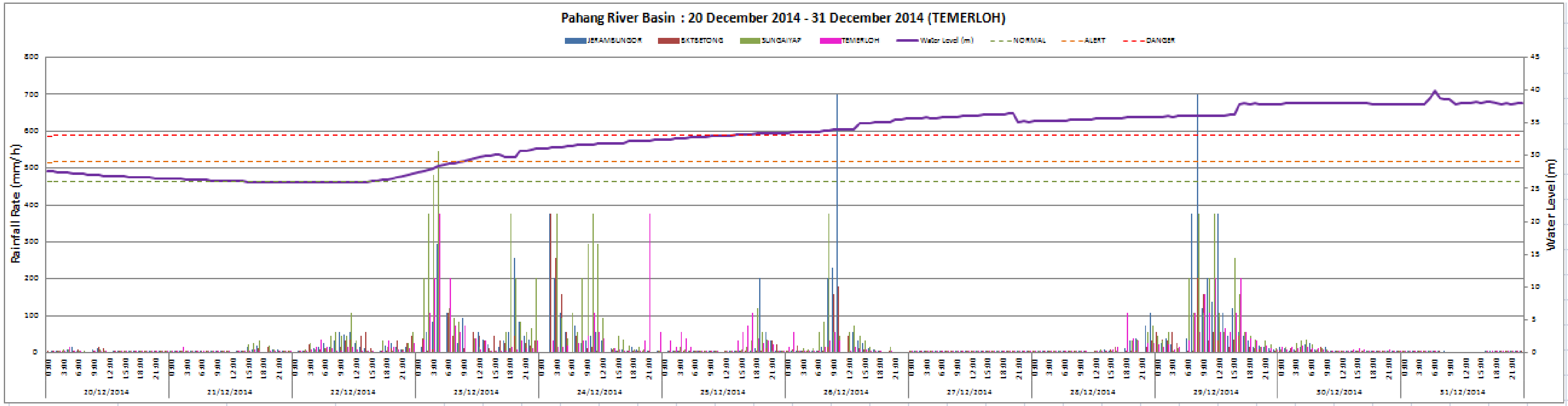


Figure 3.8 Time-series graph for Temerloh Flow

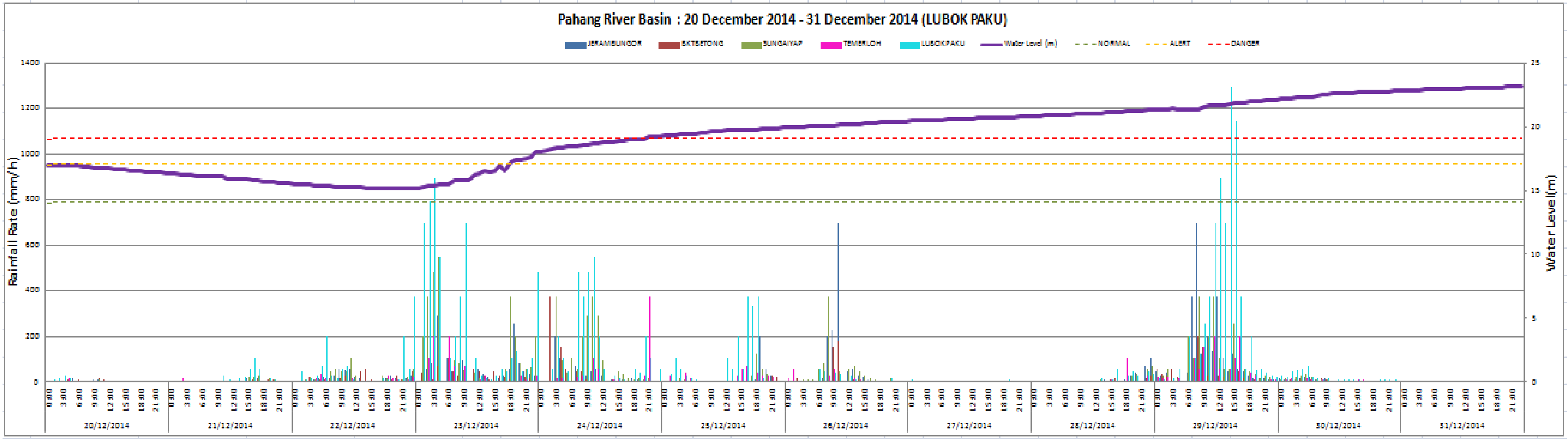


Figure 3.9 Time-series graph for Lubok Paku Flow

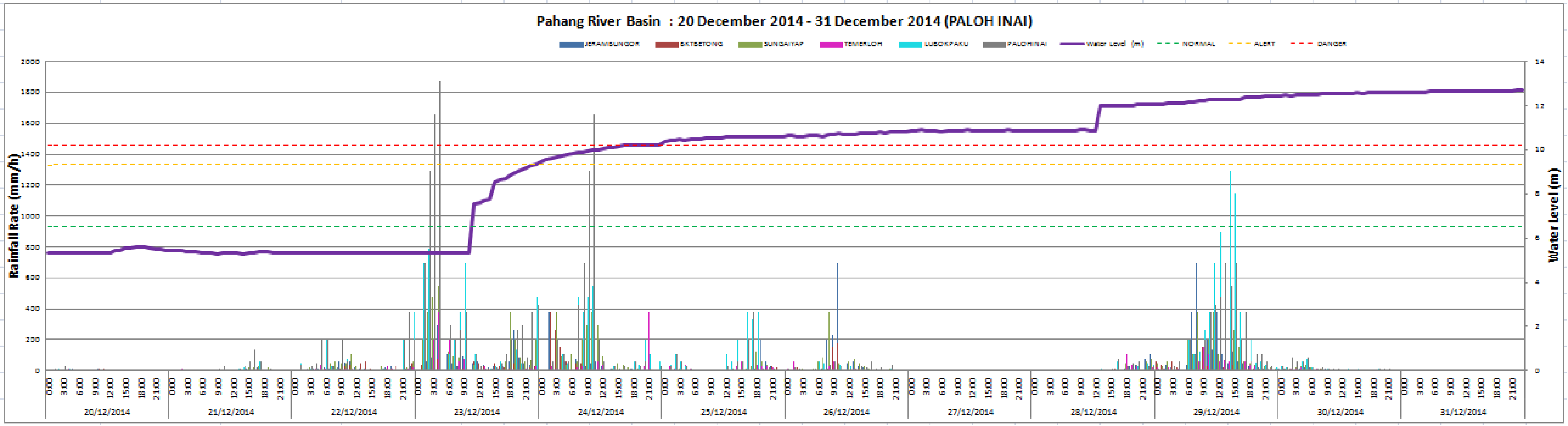


Figure 3.10 Time-series graph for Paloh Inai Flow

3.5 OUTPUT

The final output obtain from the graph was the lag time (Δt) of the flood incident from upstream to downstream of Pahang River Basin during December 2014 (Chapter 4).

3.6 SUMMARY

This chapter was describe the methodology of this research, as such describe the procedure used in collecting the data, derived satellite-based rainfall data from temperature of top cloud data from public domain, provide an explanation of the procedures used to analyse the data and produce time series graph of satellite based rainfall data and water level versus time.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter, all the information from the previous chapter was analysed. This chapter shows validation of satellite-based rainfall data with onsite rainfall data and also all the result that involves to determine the lag time (Δt) of the flood event at Pahang River Basin. The validation of satellite-based rainfall data were compared with onsite rainfall retrieve from DID. The lag time (Δt) of the flood event were based on two difference analysis which is satellite-based rainfall rate analysis and also water level analysis from DID. In this study, time series graph were produce; (graph of rainfall versus time) and (graph of water level versus time). From the graph the lag time (Δt) were determined. The lag time (Δt) for this study is based on:

i. Lag time (Δt) influence of water level; when water level exceed danger level for each flow (upstream to downstream)
ii. Lag time (Δt) influence of rainfall rate; from heavy rainfall rate to water level exceed danger level for each flow

The data from DID onsite for Jeram Bungor at 26 until 30 December 2014 are not available.

4.2 VALIDATION ANALYSIS

The daily rainfall accumulations for the gauge observations and the satellite estimates were computed by aggregating hourly values. The validation of satellite-based rainfall data with onsite rainfall data was also conducted separately for the six days (6) starting from 20 December until 25 December 2014. The validation from 26 until 30 December 2014 for Jeram Bungor not available because there were no available onsite data from DID. Correlation of Bukit Betong, Sungai Yap, Lubok Paku and Paloh Inai on December 31 and Temerloh on December 27 and December 31 are not applicable because there was no rainfall during that day.

The quantity R, called the linear correlation coefficient, measures the strength and the direction of a linear relationship between two variables. The value of R is such that $-1 \leq R \leq +1$. If x and y have a strong positive linear correlation, R is close to +1. An R value of exactly +1 indicates a perfect positive fit. Positive values indicate a relationship between x and y variables such that as values for x increase, values for y also increase. If x and y have a strong negative linear correlation, R is close to -1. An R value of exactly -1 indicates a perfect negative fit. Negative values indicate a Relationship between x and y such that as values for x increase, values for y decrease. If the R is no linear correlation or a weak linear correlation, R is close to 0. A value near zero means that there is a random, nonlinear relationship. Between the two variables a perfect correlation of ± 1 occurs only when the data points all lie exactly on a straight line. If R = +1, the slope of this line is positive. A correlation greater than 0.8 is generally described as strong, whereas a correlation less than 0.5 is generally described as weak.

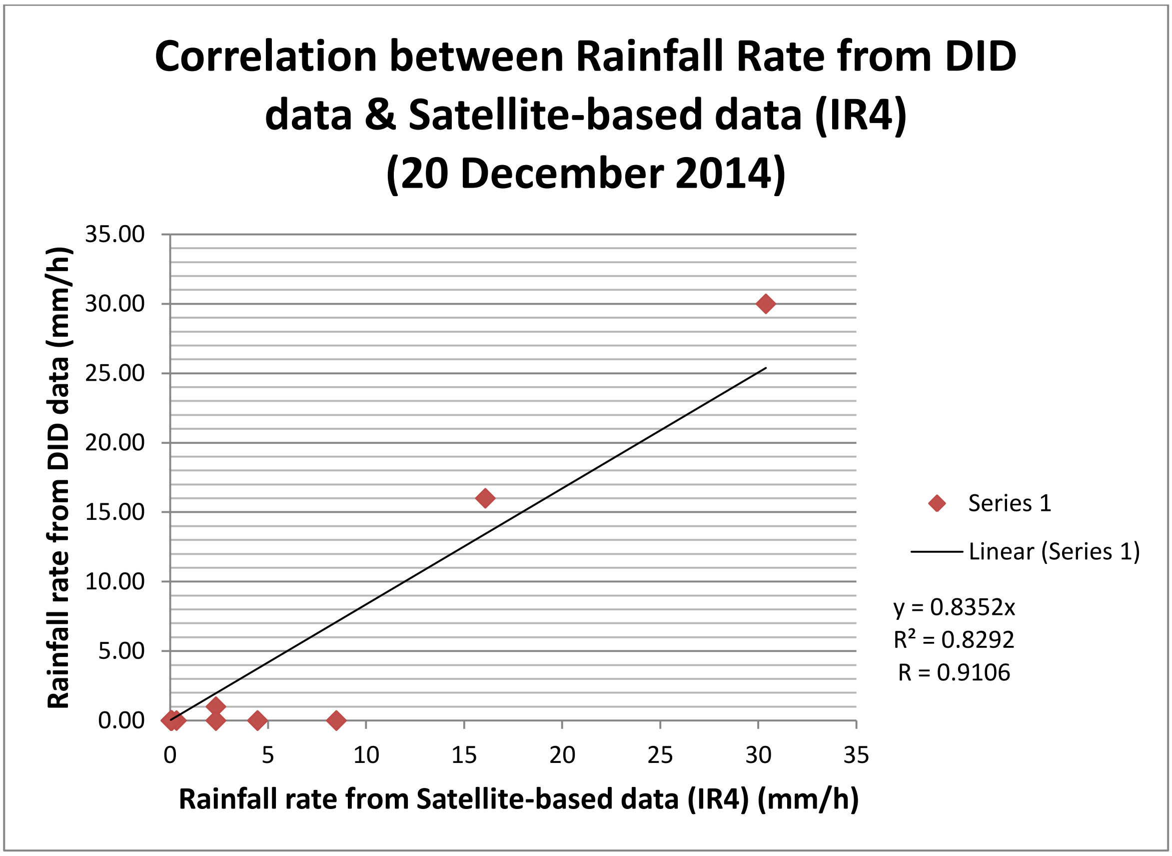


Figure 4.1: Correlation of rainfall rate for 20 December 2014

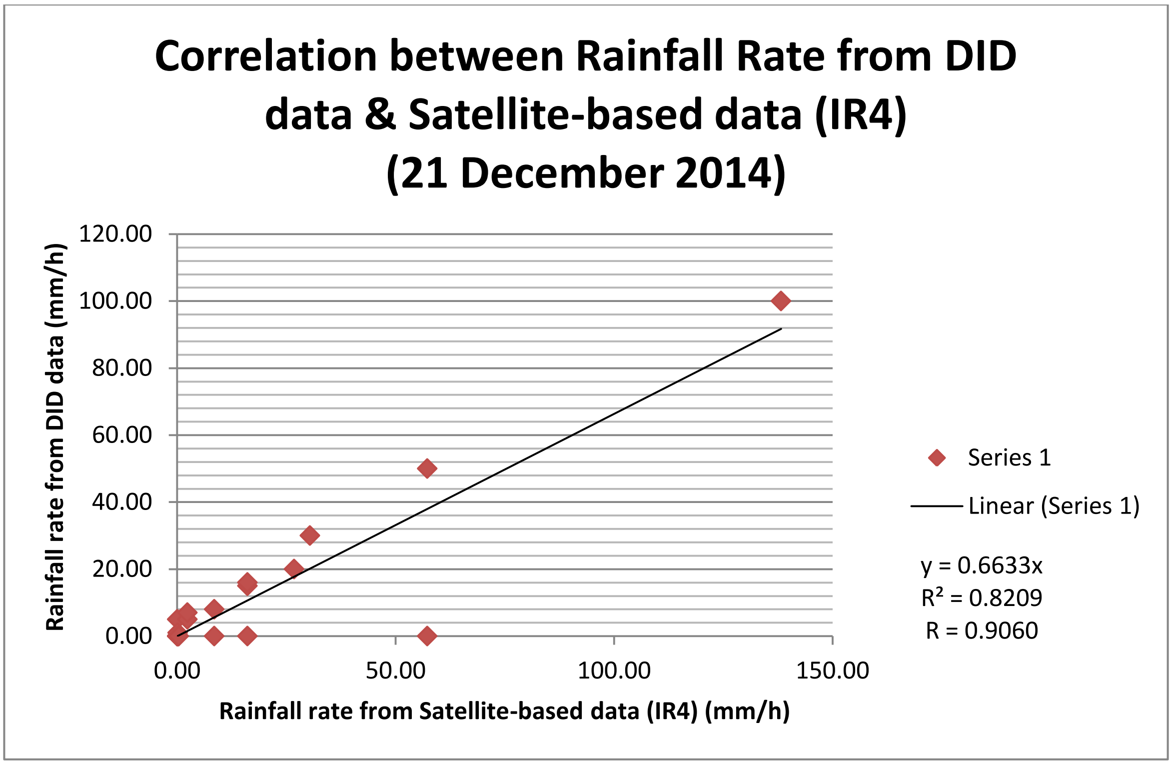


Figure 4.2: Correlation of rainfall rate for 21 December 2014

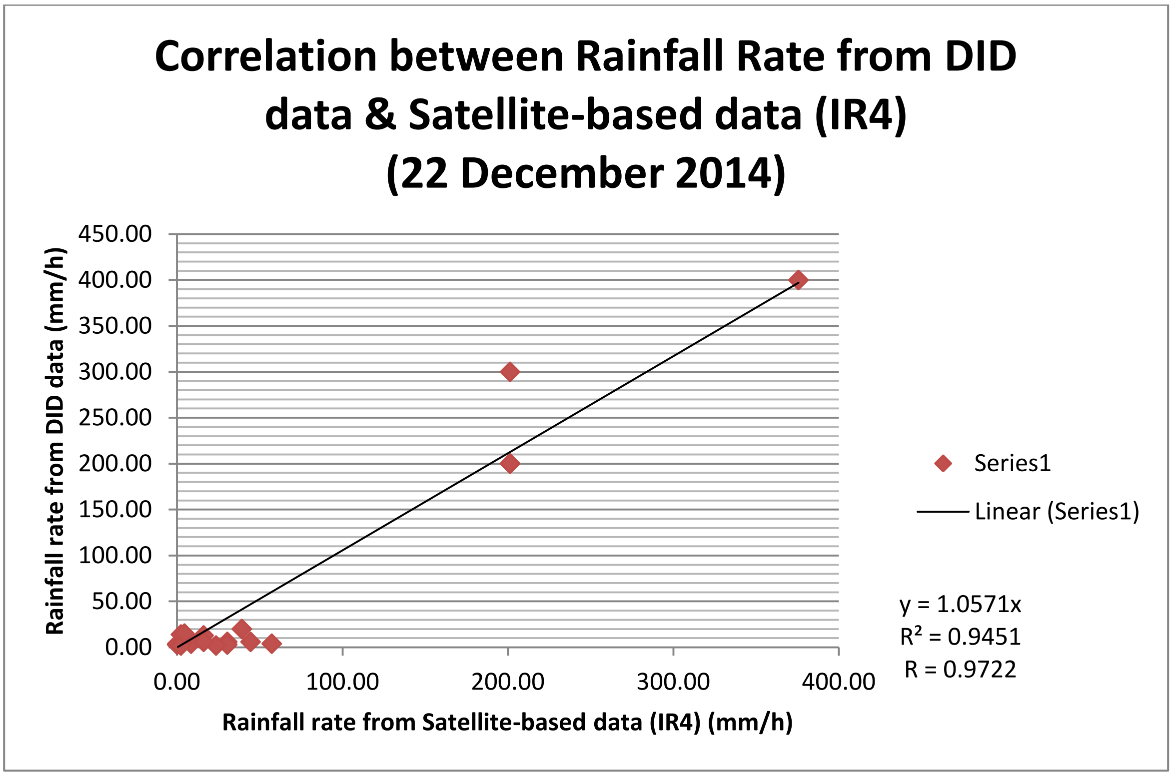


Figure 4.3: Correlation of rainfall rate for 22 December 2014

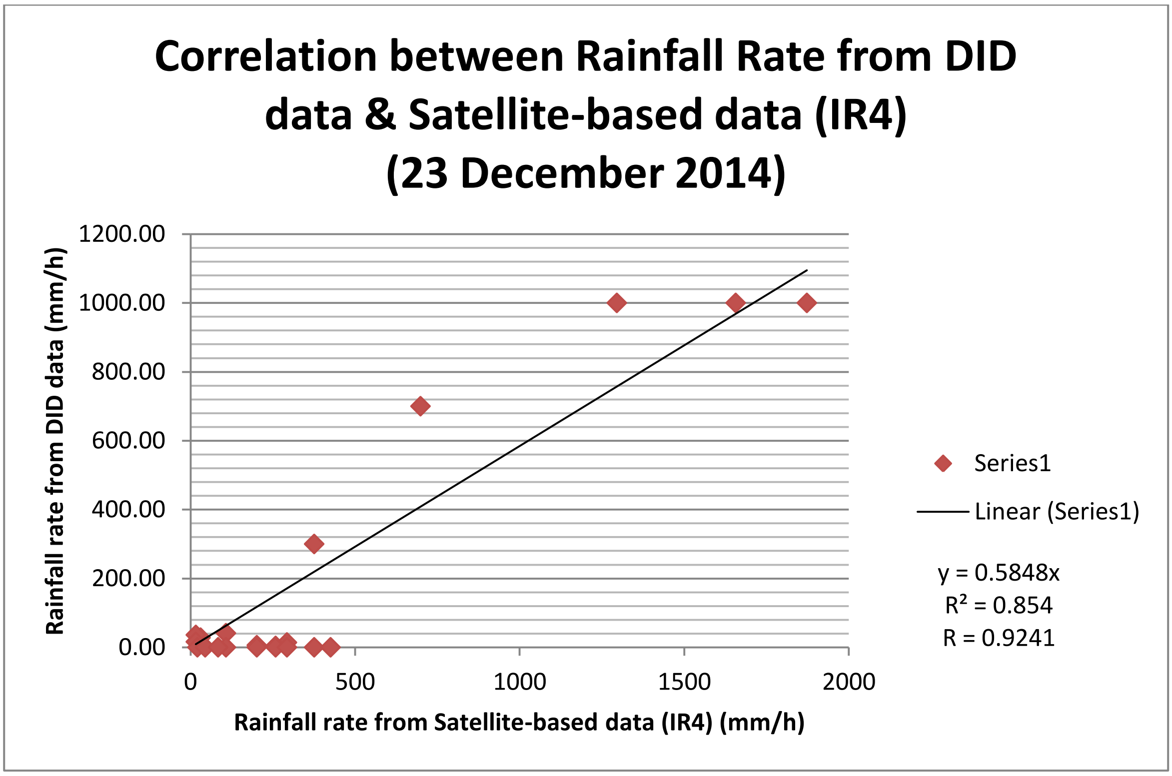


Figure 4.4: Correlation of rainfall rate for 23 December 2014

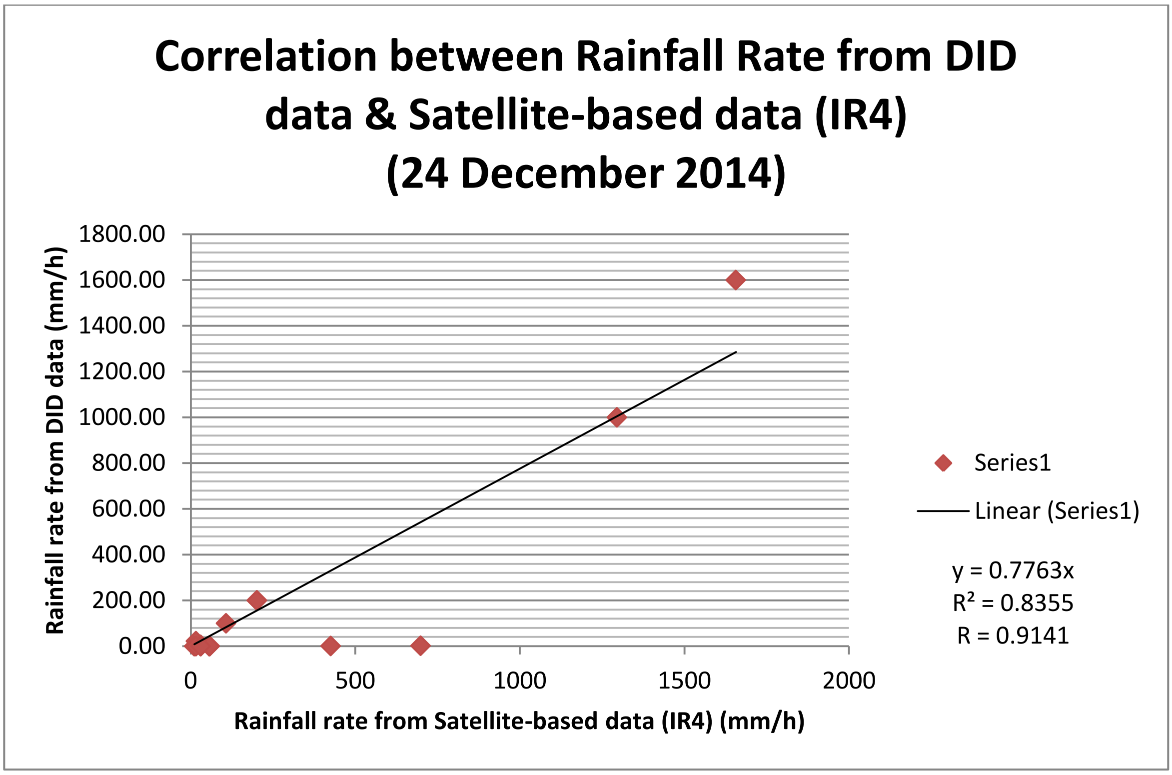


Figure 4.5: Correlation of rainfall rate for 24 December 2014

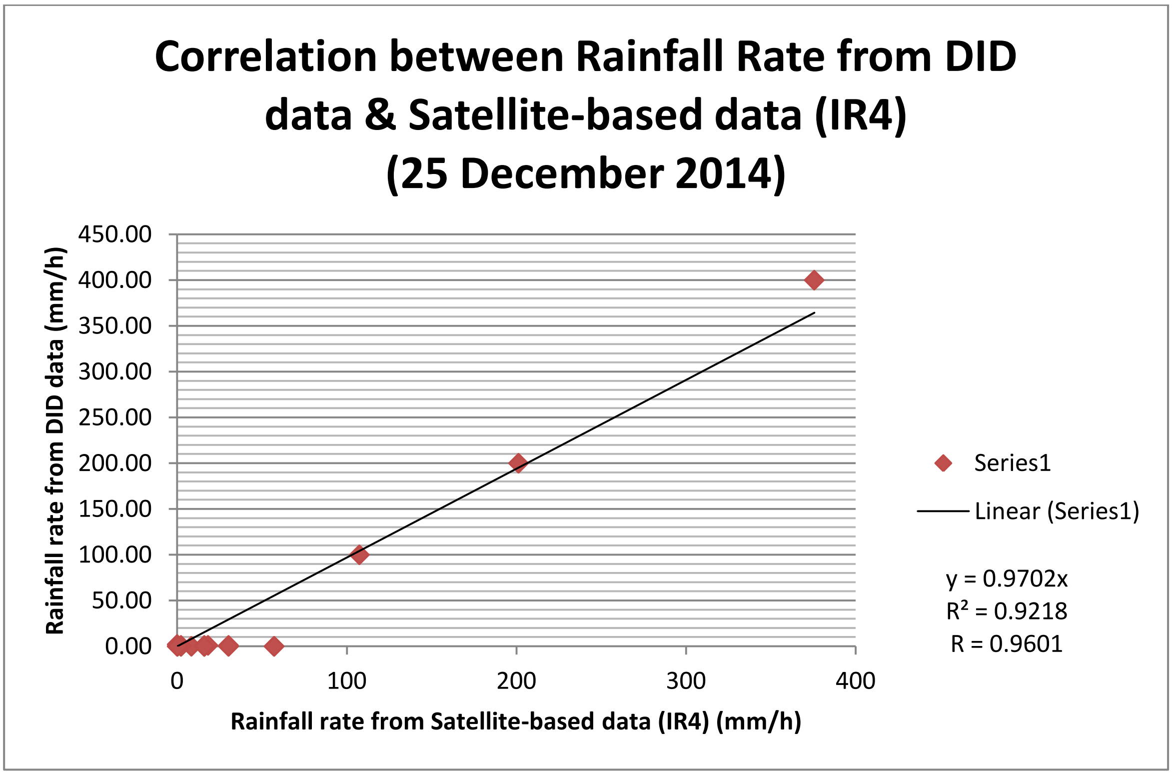


Figure 4.6: Correlation of rainfall rate for 25 December 2014

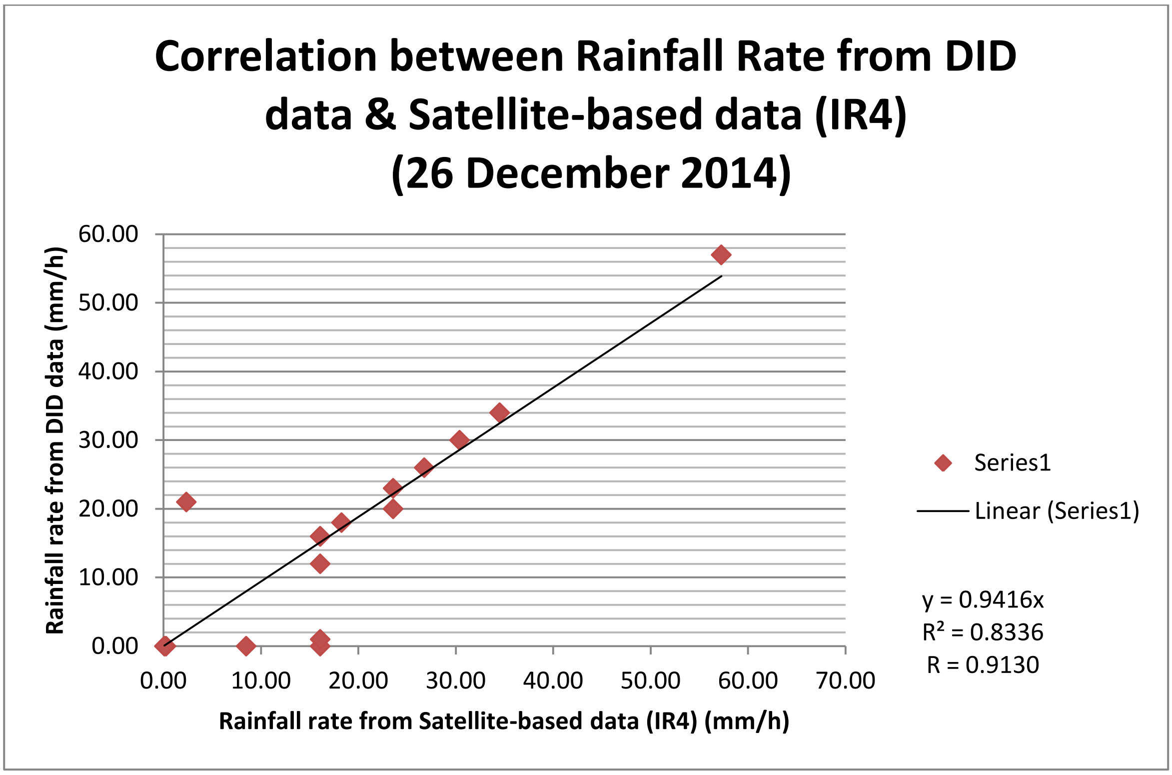


Figure 4.7: Correlation of rainfall rate for 26 December 2014

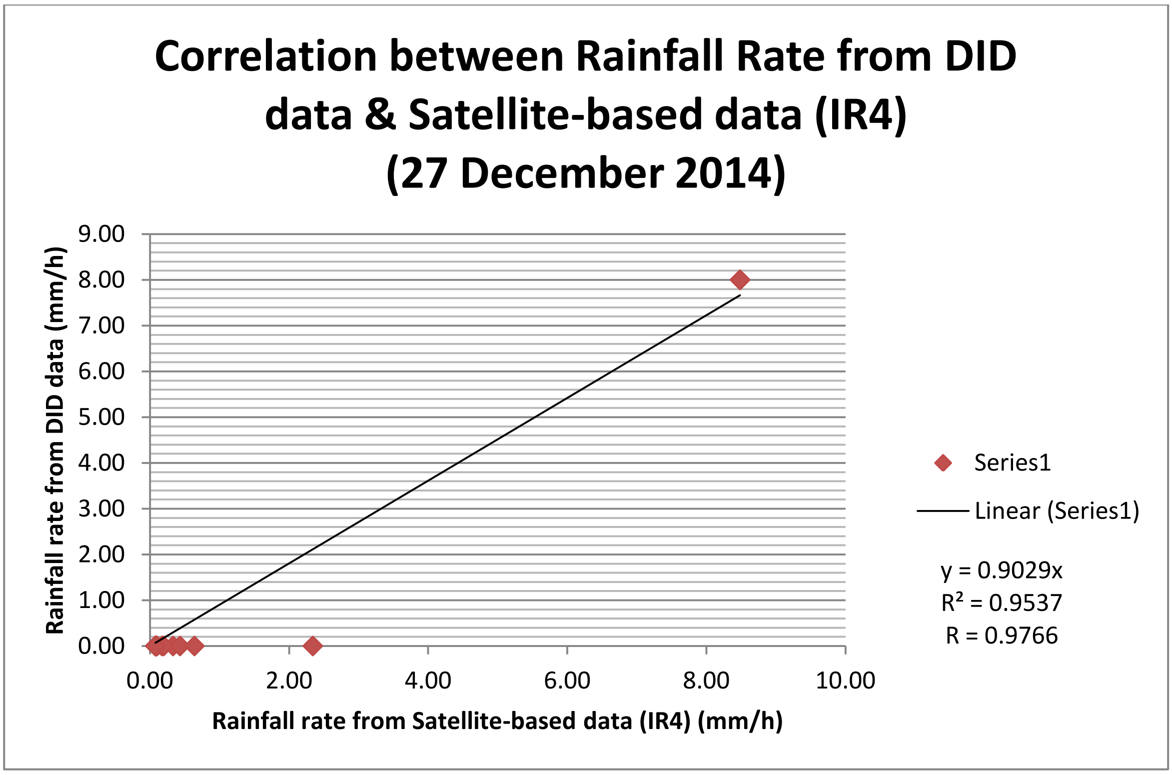


Figure 4.8: Correlation of rainfall rate for 27 December 2014

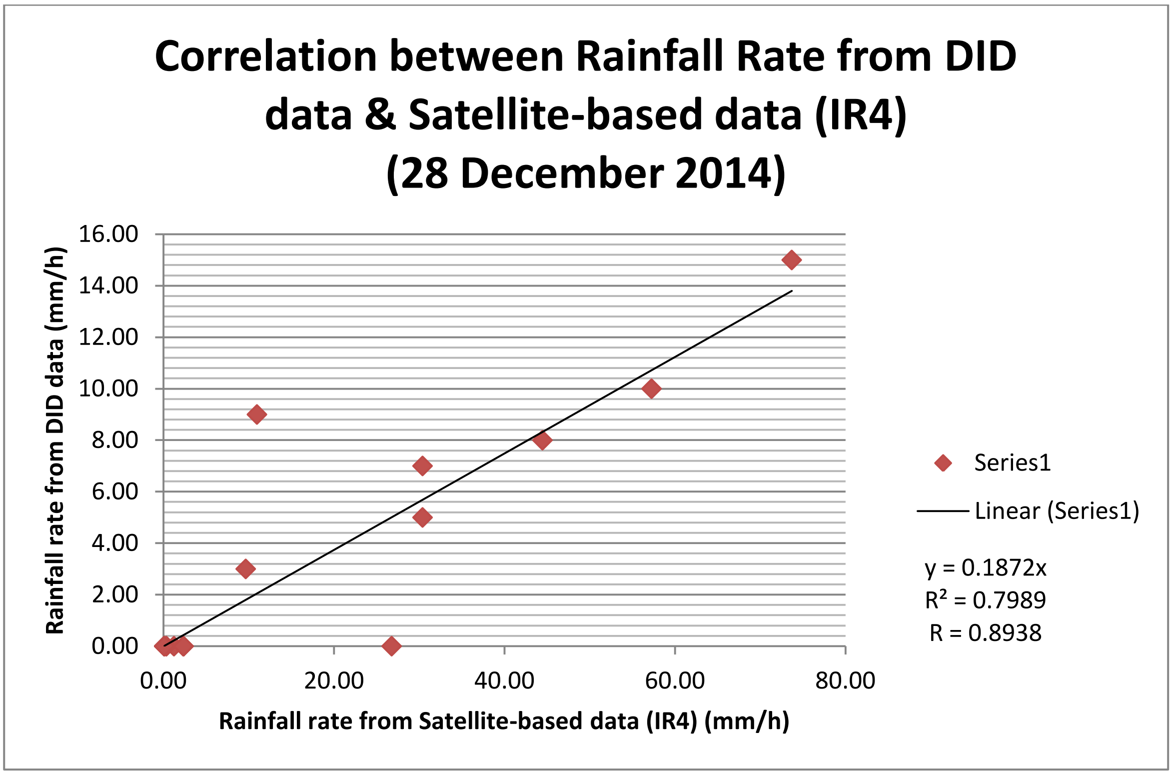


Figure 4.9: Correlation of rainfall rate for 28 December 2014

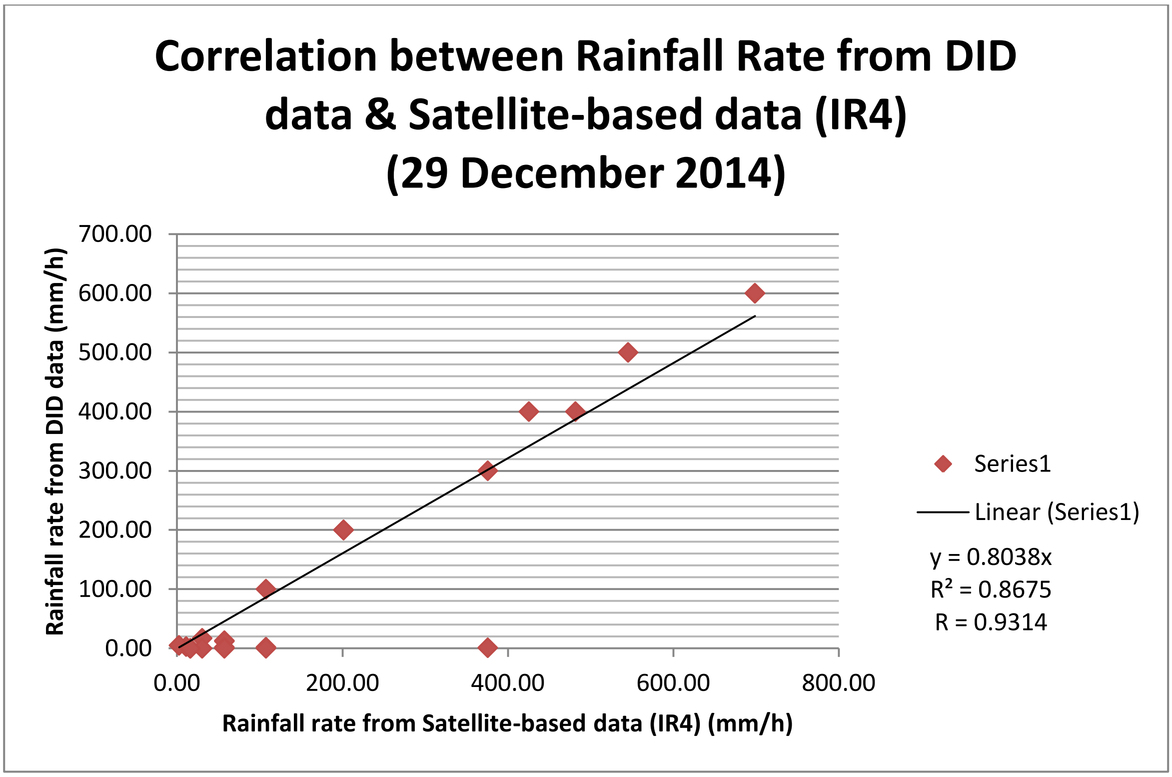


Figure 4.10: Correlation of rainfall rate for 29 December 2014

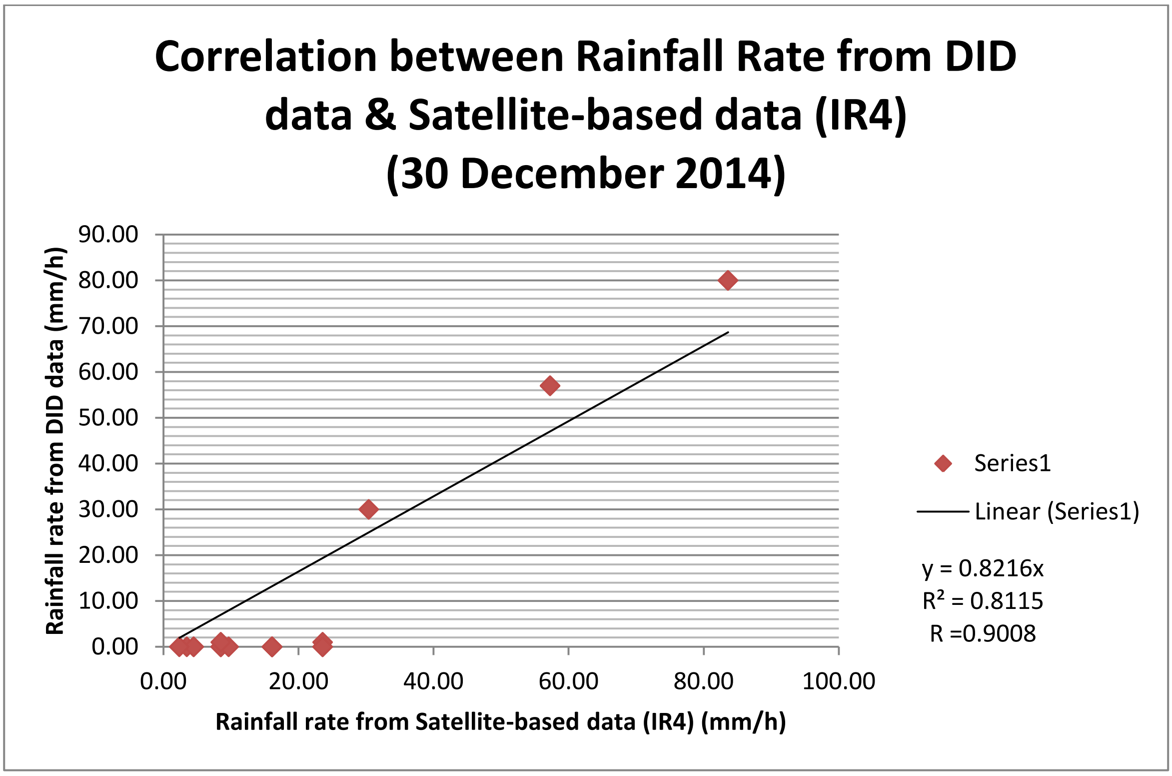


Figure 4.11: Correlation of rainfall rate for 30 December 2014

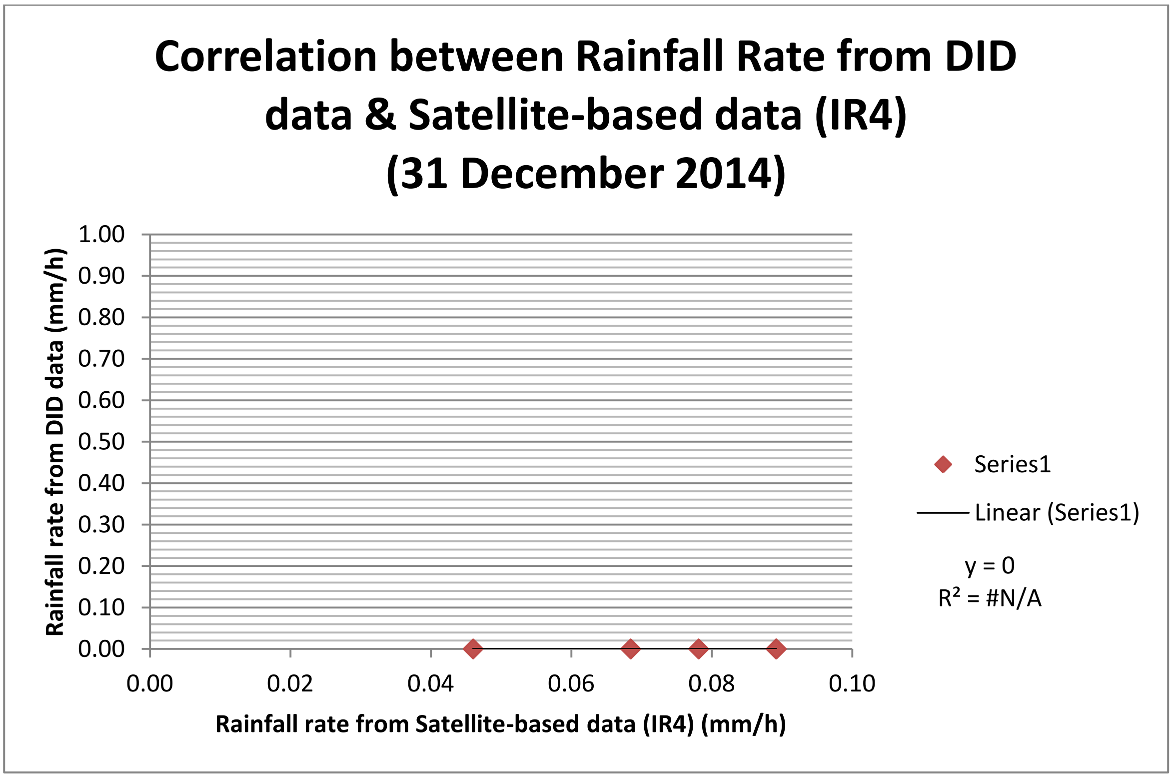


Figure 4.12: Correlation of rainfall rate for 31 December 2014

4.3 LAG TIME (Δt) ANALYSIS

4.3.1 Lag time (Δt) of water level in Sungai Yap Flow with the influence of rainfall rate at Jeram Bungor and Bukit Betong.

The study area for this analysis focuses at Jeram Bungor and Bukit Betong flow which is the upstream flow of Pahang River basin. The lag time (Δt) from three type of flow; i) Heavy rainfall to the water level exceed danger level, ii) water level exceed danger level to next heavy rainfall rate and iii) Heavy rainfall to the water level exceed maximum water level is analysed with the time series graph (Figure 4.13). Based on the graph gradient of the flow rate based on the rainfall rate and water level were computed (Table 4.1).

From the graph, the danger level of Sungai Yap is 52.0 meter. On December 23 (04:00), the upstream areas, Jeram Bungor and Bukit Betong receive a very heavy rainfall and it continues for a few hours. The heavy rain effect the water level rise until it exceeds the danger level at December 23 (05:00) which after the first hour of heavy rain start. The increment of water level for this period is 0.79 m/hour.

Even this upstream area did not receive lot of heavy rain during December 23 (09:00) until December 23 (16:00) the water level keep rise up to 59.44 meter which is more 7 meter from the danger level. It took almost 13 hours from the time of water exceed danger level until the next heavy rainfall. The increment of water level for this period is 0.28 m/hour.

The heavy rainfalls continue starting from December 23 (18:00) for more than 19 hours. The lag time from the heavy rainfall until the maximum water level is about 61 hours. The increment of water level for this period is 0.06 m/hour. The water level start to decreases after reach the highest water level at 59.44 meter during December 26 (06:00).

Table 4.1 Lag Time of Sungai Yap influence by Jeram Bungor And Bukit Betong Rainfall Rates

TYPE OF FLOW	PERIOD	LAG TIME (Δt)	GRADIENT (m/hr)
Heavy rainfall	23/12 (04 : 00)		
to	to	1 hour	0.79
Exceed danger level	23/12 (05 : 00)		
Exceed danger level	23/12 (05 : 00)		
to	to	13 hours	0.28
Heavy rainfall	23/12 (18: 00)		
Heavy rainfall	23/12 (18: 00)		
to	to	61 hours	0.06
Exceed Max. level	26/12 (06 : 00)		

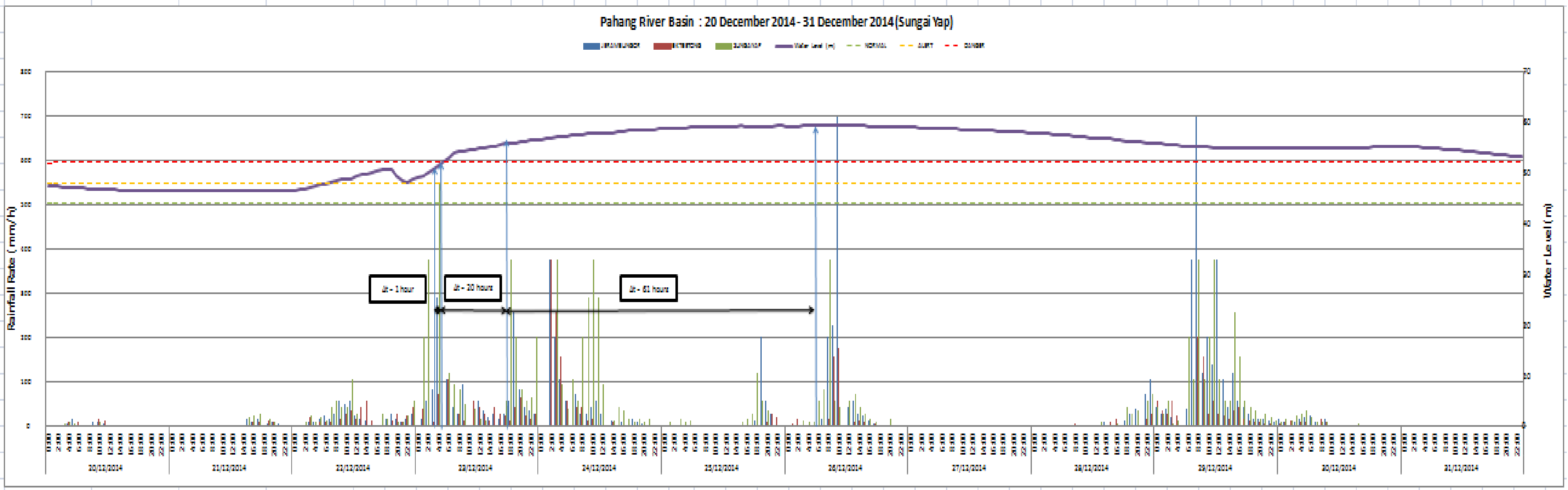


Figure 4.13 Lag Time for Sungai Yap

4.3.2 Lag time (Δt) of water level in Temerloh Flow with the influence of rainfall rate at Jeram Bungor, Bukit Betong and Sungai Yap.

The study area for this analysis focuses at Jeram Bungor, Bukit Betong and Sungai Yap flow which is the upstream flow of Pahang River basin. The lag time (Δt) from three type of flow; i) Heavy rainfall to the water level exceed danger level, ii) water level exceed danger level to next heavy rainfall rate and iii) Heavy rainfall to the water level exceed maximum water level is analysed with the time series graph (Figure 4.14). Based on the graph gradient of the flow rate based on the rainfall rate and water level were computed (Table 4.2).

From the table 4.2 and figure 4.14, the danger level of Temerloh is 33.0 meter. On December 23 (04:00), these areas which are Jeram Bungor, Bukit Betong and Sungai Yap receive a very heavy rainfall and it continues for a few hours. The heavy rain effect the water level rise until it exceeds the danger level at December 25 (12:00) which is 57 hours after the first hour of heavy rain start. The increment of water level for this period is 0.08 m/hour.

Even the upstream area did not receive lot of heavy rain during December 24 (16:00) until December 26 (05:00) the water level keep rise up to 35.28 meter which is more 2 meter from the danger level. It took almost 23 hour from the time of water exceed danger level until the next heavy rainfall. The increment of water level for this period is 0.04 m/hour.

The heavy rainfalls continue starting from December 26 (10:00). The heavy rain effect the water level rise until it reach water level 35.28 meter at December 27 (22:00) until before it start to decreases before the next heavy rainfall. The lag time from the heavy rainfall until the maximum water level is about 37 hours. The increment of water level for this period is 0.03 m/hour.

Table 4.2 Lag Time of Temerloh influence by Jeram Bungor, Bukit Betong and Sungai Yap Rainfall Rates

TYPE OF FLOW	PERIOD	LAG TIME (Δt)	GRADIENT (m/hr)
Heavy rainfall	23/12 (04 : 00)		
to	to	57 hours	0.08
Exceed danger level	25/12 (12 : 00)		
Exceed danger level	25/12 (12 : 00)		
to	to	23 hours	0.04
Heavy rainfall	26/12 (10: 00)		
Heavy rainfall	26/12 (10: 00)		
to	to	37 hours	0.03
Exceed Max. level	27/12 (22 : 00)		

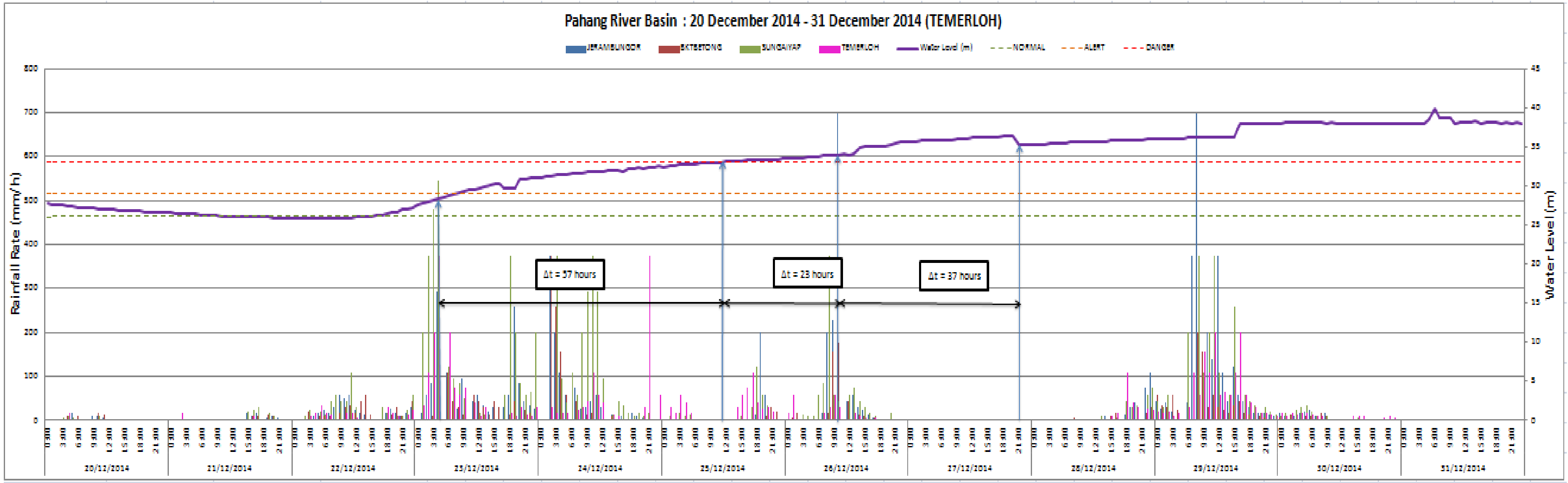


Figure 4.14 Lag Time for Temerloh

4.3.3 Lag time (Δt) of water level in Lubok Paku Flow with the influence of rainfall rate at Jeram Bungor ,Bukit Betong, Sungai Yap and Temerloh

The study area for this analysis focuses at Jeram Bungor, Bukit Betong, Sungai Yap and Temerloh flow of Pahang River basin. The lag time (Δt) from three type of flow; i) Heavy rainfall to the water level exceed danger level, ii) water level exceed danger level to next heavy rainfall rate and iii) Heavy rainfall to the water level exceed maximum water level is analysed with the time series graph (Figure 4.15). Based on the graph gradient of the flow rate based on the rainfall rate and water level were computed (Table 4.3).

From the table 4.3 and figure 4.15, the danger level of Lubok Paku is 19.0 meter. On December 23 (03:00), Jeram Bungor, Bukit Betong, Sungai Yap and Temerloh receive a very heavy rainfall and it continues for a few hours. The heavy rain effect the water level at downstream area increases until it exceeds the danger level at December 24 (18:00). The increment of water level for this period is 0.09 m/hour.

Even the downstream area did not receive lot of heavy rain during December 24 (18:00) until December 29 (6:00) the water level keep rise up 21.39 meter which is 2 meter more from the danger water level.. It took almost 109 hour from the time of water exceed danger level until the next heavy rainfall. The increment of water level for this period is 0.02 m/hour.

The heavy rainfalls continue starting from December 29 (06:00) for more than 17 hours. The heavy rainfall effect the water levels until it reach the maximum reading for the water level at Lubok Paku. The lag time from the heavy rainfall until the maximum water level is about 66 hours. The water level increases rapidly during this period. The increment of water level for this period is 0.02 m/hour.

Table 4.3 Lag Time of Lubok Paku influence by Jeram Bungor, Bukit Betong, Sungai Yap and Temerloh Rainfall Rates

TYPE OF FLOW	PERIOD	LAG TIME (Δt)	GRADIENT (m/hr)
Heavy rainfall	23/12 (03: 00)		
to	to	40 hours	0.09
Exceed danger level	24/12 (18 : 00)		
Exceed danger level	24/12 (18 : 00)		
to	to	109 hours	0.02
Heavy rainfall	29/12 (06: 00)		
Heavy rainfall	29/12 (06: 00)		
to	to	66 hours	0.03
Exceed Max. level	31/12 (23 : 00)		

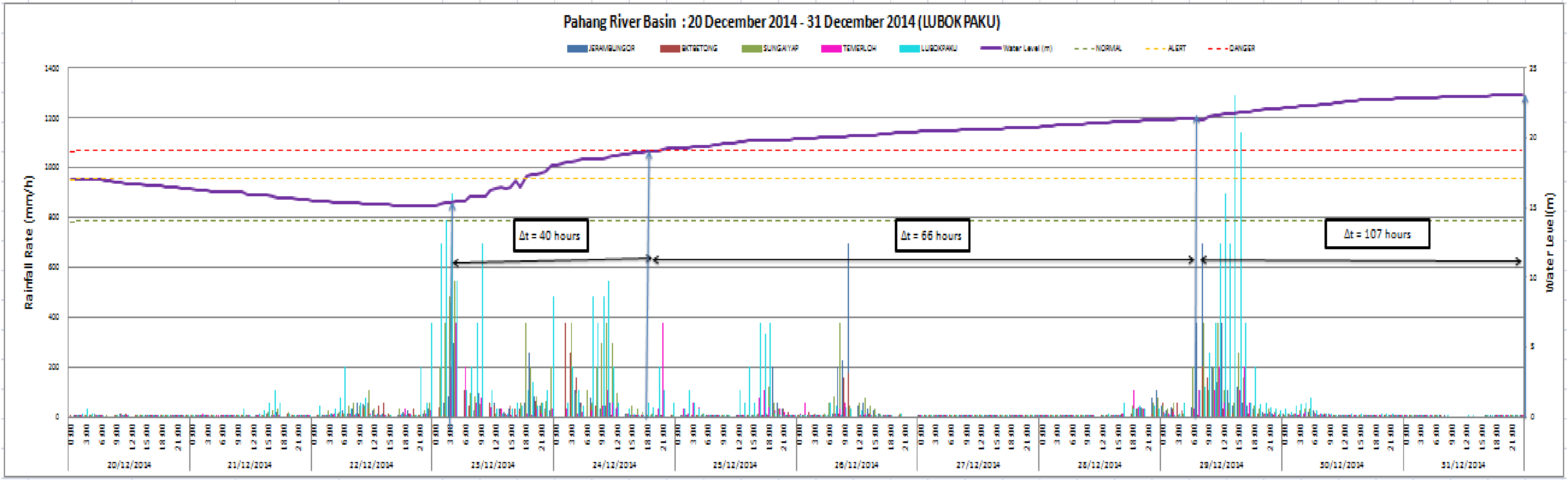


Figure 4.15 Lag Time for Lubok Paku

4.3.4 Lag time (Δt) of water level in Paloh Inai Flow with the influence of rainfall rate at Jeram Bungor, Bukit Betong, Sungai Yap, Temerloh and Lubok Paku.

The study area for this analysis focuses at Jeram Bungor, Bukit Betong, Sungai Yap,Temerloh and Lubok Paku flow which is the downstream flow of Pahang River basin. The lag time (Δt) from three type of flow; i) Heavy rainfall to the water level exceed danger level, ii) water level exceed danger level to next heavy rainfall rate and iii) Heavy rainfall to the water level exceed maximum water level is analysed with the time series graph (Figure 4.16). Based on the graph gradient of the flow rate based on the rainfall rate and water level were computed (Table 4.4).

From the table 4.4 and figure 4.16, the danger level of Paloh Inai is 10.20 meter. On December 23 (04:00), the upstream and downstream areas receive a very heavy rainfall and it continues for a few hours. The heavy rain at upstream and downstream effect the water level at downstream area increases rapidly until it exceeds the danger level at December 24 (17:00) which is 38 hours after receive very high rainfall. The increment of water level for this period is 0.12 m/hour.

Even the downstream area did not receive lot of heavy rain during December 24 (17:00) until December 29 (06:00) the water level keep rise up to 12.15 meter. It took almost 110 hour from the time of water exceed danger level until the next heavy rainfall. The increment of water level for this period is 0.02 m/hour.

The heavy rainfalls continue starting from December 29 (06:00) for more than 11 hours. The heavy rainfall effect the water levels until it reach the maximum reading for the water level at Paloh Inai. The lag time from the heavy rainfall until the maximum water level is about 66 hours. The increment of water level for this period is 0.01 m/hour.

Table 4.4 Lag Time of Paloh Inai influence by Jeram Bungor, Bukit Betong, Sungai Yap, Temerloh and Lubok Paku Rainfall Rates

TYPE OF FLOW	PERIOD	LAG TIME (Δt)	GRADIENT (m/hr)
Heavy rainfall	23/12 (04 : 00)		
to	to	38 hours	0.13
Exceed danger level	24/12 (17 : 00)		
Exceed danger level	24/12 (17 : 00)		
to	to	110 hours	0.02
Heavy rainfall	29/12 (06 : 00)		
Heavy rainfall	29/12 (06 : 00)		
to	to	66 hours	0.01
Exceed Max. level	31/12 (23 : 00)		

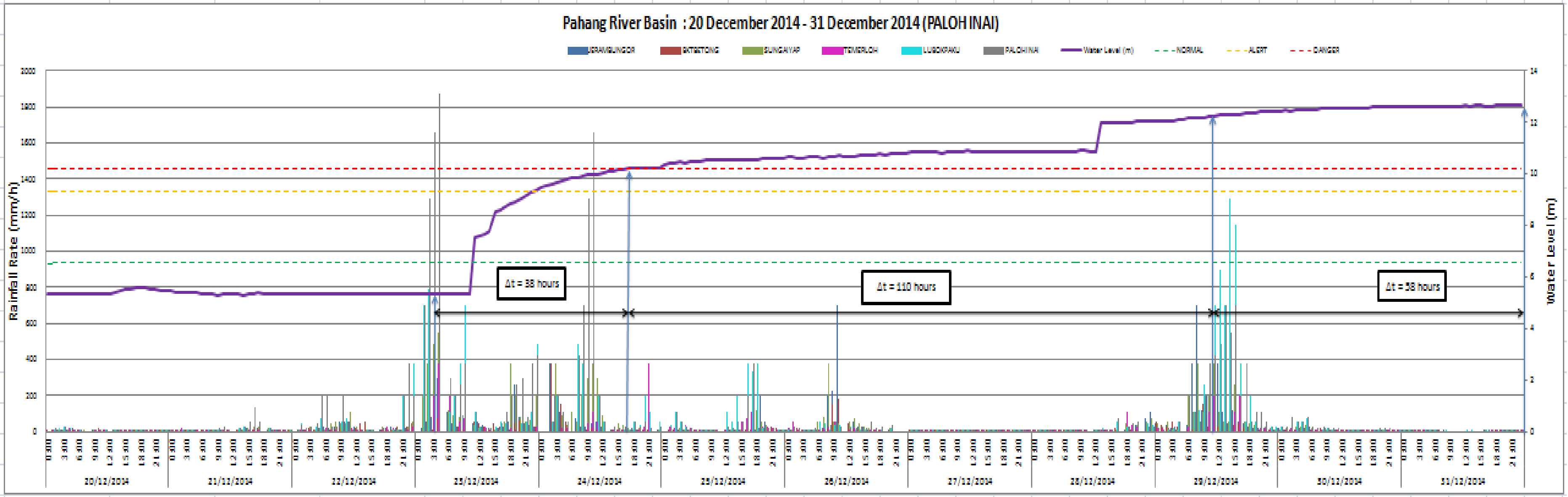


Figure 4.16 Lag Time for Paloh Inai

4.4 LAG TIME (∆t) OF WATER LEVEL INCREMENT

The lag time (∆t) of water level at Pahang River basin is analyse with the illustration of time series graph based on data provided by DID. From the graph (Figure 4.17), after upstream flows (Sungai Yap) exceed danger level it take about 54 hours for mid-stream area (Temerloh) to exceed danger level.

The downstream area (Lubok Paku) exceed danger level faster due to high intensity of rainfall rates at Lubok Paku compare to Temerloh.It takes 17 hours after Lubok Paku exceed danger level, the mid- stream (Temerloh) also exceed danger level.

The downstream area (Paloh Inai) exceeds danger level faster due to high intensity of rainfall rates at Paloh Inai compare to Lubok Paku and Temerloh. It takes 2 hours for downstream (Lubok Paku) exceed danger level after downsteam flows (Paloh Inai) exceed danger level.

The predictions of lag time for the flood happen were very crucial for executed plan or early warning. A disaster usually occurs when people are not prepared for a flood due to the lack of warning system, preparedness and mitigation measure.

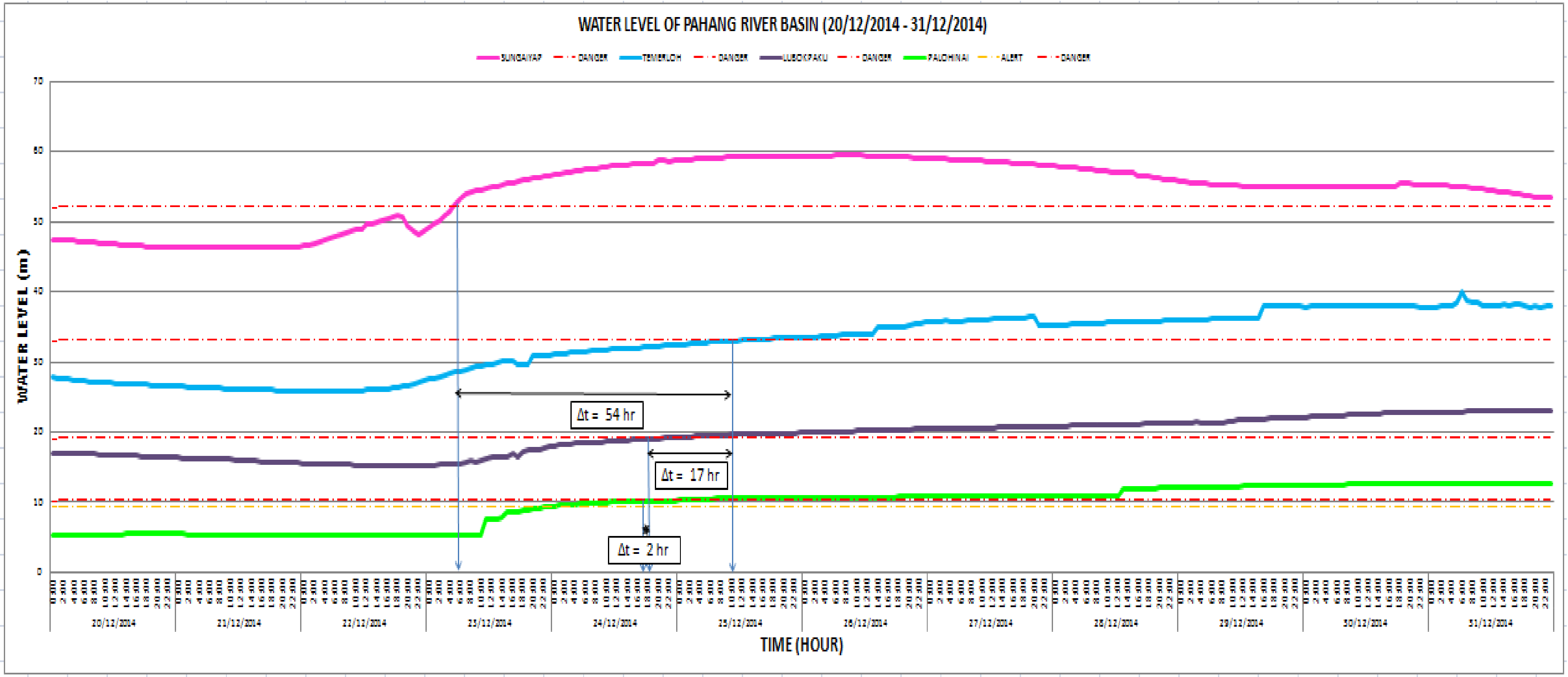


Figure 4.17 Lag time for water level of Pahang River Basin based on DID dataset

4.5 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 rainfall rate with onsite-based rainfall rate were validate. From the graphically illustration of time series graph (satellite-based rainfall data and water level versus time), the objective to determine the lag time of flood incident at Pahang River Basin in December 2014 was successfully achieved.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study was carried out in order to determine the la time of flood incident in Pahang River Basin during December 2014. This chapter will discuss on the conclusion and recommendation from the study. The conclusion of the study 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 Pahang River Basin which is the affected area during the flood incident in December 2014.The main objective of this research were to determine the lag time (Δt) of the flood incident from upstream to downstream area of Pahang River Basin. To achieve the main objective, there were two sub objective which is i) to validate satellite-based rainfall data and ii) to analyse lag time (Δ t), of rainfall incident with the water level at Pahang River Basin. Auto-estimator method was the method used to determine the satellite-based rainfall rate for this research.

Literature was carried out from various sources. There were several method used by previous researcher to determine the satellite-based rainfall rate. In this study, the simple Auto-Estimator method was selected where the method used the temperature of top cloud from satellite data (IR4). Necessary data which is the onsite-based rainfall data and water level data was obtained from Department of Irrigation and Drainage Malaysia (DID) (Appendix A).

The analysis in this study was carried out using Microsoft Excel. Starting with the converting temperature from Celsius to Kelvin and determining the satellite-based rainfall rate.

In this study, time-series graph of satellite-based rainfall intensity and water level versus time was used to determine the lag time. The satellite-based data and onsite-based data also being validate.

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 conclude

5.2.1 Sub-objective 1: To validate satellite-based 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 lag time, (Δt) between the rainfall and flooding during flood event in Pahang River Basin

This objective was also successfully achieved. From the result, the lag time (Δ t), of the flood incident were determined using the time-series graph produced 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 IR4 satellite. The results of data have been compared with rain-gauge station in order to get more precise result and compare both data to calibrate the data. Instead of using IR4 data, one can also use different type of satellite data like SSM/I or TRMM data to be compared with onsite-based data.

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

REFERENCES

Bedient & Huber. Hydrology and Flooding Analysis. Addison Wesley Publishing Co (1948).

Brunetti, M., Colacino, M., Maugeri, M. & Nanni, T. (2001). Trends in the daily intensity of precipitation in Italy from 1951 to 1996. *International Journal of Climatology* 21: 299-316.

Carvalho, J.R.P., Assad, E.D., Evangelista, S.R.M., Pinto, H.D.S., 2013. Estimations of dry spells in three Brazilian regions — Analysis of extremes. *Atmos. Res*. 132–133, 12–21.

Dale, W.L.,(1959). Rainfall of Malaysia, Part I. Journal of Tropical Geography, Vol. 13, D.I.D. Malaysia, 1970. Rainfall Records, 1959-1965.

Faisal Ahammed, Guna Alankarage Hewa, John R. Argue. (2014). Variability of annual daily maximum rainfall of Dhaka, Bangladesh. *Atmospheric Research* 137. (178)(1)(6).

Gallant, A.J.E., Hennessy, K.J. & Risbey, J. 2007. Trends in rainfall indices for six Australian regions: 1910-2005. *Australian Meteorological Magazine* 56: 223-239

Hector Quevedo Urias , Humberto Garcia , Jorge Salas Plata Mendoza (2007). Determination of the Relationship Between Precipitation and Return Periods to Assess Flood Risks in the City of Juarez, Mexico. (1-9)

Hobye, J.H. (2009) . Pekan Coastal Flooding assessement impact, page 2.

Jabatan Kerja Raya (JKR) Daerah Temerloh, (2015). http://www.jkrtemerloh.net/v2/index.php?option=com_content&view=article&id=540:keadaan-banjir-di-temerloh-membimbangkan&catid=41:tajuk-utama

Jabatan Kerja Raya (JKR) Negeri Pahang. (2015). http://jkr.pahang.gov.my/index.php/arkib/arkibberitaaktiviti/itemlist/category/217-

Jabatan Meteorologi Malaysia (JMM). (2010). Monsun. Portal Rasmi Jabatan Meteorologi Malaysia. http://www.met.gov.my/index.php?option=%20com_content&task=view&id=69&Itemid=160&limit=1&limitstart=0.Jabatan%20Meteorologi%20Malaysia.

Karl, T.R. & Knight, R.W. (1998). Secular trends of precipitation amount, frequency and intensity of the United States. *Bulletin of American Meteorological Society* 79(2): 223-241.

Lucero, O.A. & Rozas, D. (2002). Characteristics of aggregation of daily rainfall in a middle-latitudes region during a climate variability in annual rainfall amount. *Atmospheric Research* 61: 35-48

Malaysian Meteorological Department (MetMalaysia). (2015). Monsun. Portal Rasmi Jabatan Meteorologi Malaysia. http://www.met.gov.my/index.php?option=com_content&task=view&id=75

Mediaharia.blogspot.com, (2015). http://mediaharia.blogspot.com/2013/12/sekitar-keadaan-banjir-dikuantan.html

Nadarajah, S., Choi, D., (2007). Maximum daily rainfall in South Korea. *J. Earth Syst. Sci*. 11 (4), 311–320.

National aeronautics and space administration, (2015). http://pmm.nasa.gov/trmm

Ni Lar Win, Khin Maung Win, (2014).The Probability of Daily Rainfall for Kuantan River Basin in Malaysia. International Journal of Science and Research (IJSR). 3(8):977-983

Ott, R.L., Longnecker, M., (2010). An introduction to statistical methods and data analysis. Mcmillan Publishing Solutions, New York.

Sangati, M., Borga, M., (2009). Influence of rainfall spatial resolution on flash flood modelling. *Nat. Hazards Earth Syst. Sci.* 9 (2), 575-574.

Suhaila. J., Deni. S.M. & Jemain. A.A., (2010). Trend in Peninsular Malaysia Rainfall Data During the Southwest Monsoon and Northeast Monsoon Season: 1957-2004. *Sains Malaysiana* 39(4): 533-542

The Encyclopedia of Earth (2015) http://www.eoearth.org/view/article/153627

Ven Te Chow, D . R. (1988). Applied Hydrology (McGraw-Hill Series in Water Resources and Environmental Engineering). United States of America: McGraw-Hill.

Warren Viessman, J. (2003). Introduction to Hydrology Fifth Edition. United States of America: Pearson Education.

SUNGAI PAHANG FLOOD LEVEL STATION [20/12/14]						
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	66.76	55.63	47.45	27.74	16.99	5.31
01:00	66.76	55.63	47.40	27.65	16.99	5.33
02:00	66.74	55.61	47.36	27.56	16.99	5.31
03:00	66.73	55.61	47.33	27.49	16.99	5.31
04:00	66.72	55.59	47.27	27.41	16.99	5.33
05:00	66.71	55.59	47.22	27.35	16.99	5.33
06:00	66.69	55.58	47.15	27.28	16.99	5.33
07:00	66.69	55.56	47.10	27.20	16.91	5.33
08:00	66.68	55.56	47.03	27.16	16.91	5.33
09:00	66.67	55.56	46.97	27.11	16.81	5.33
10:00	66.66	55.53	46.90	27.05	16.77	5.31
11:00	66.65	55.53	46.85	27.00	16.75	5.33
12:00	66.64	55.51	46.80	26.97	16.71	5.34
13:00	66.63	55.51	46.73	26.93	16.69	5.41
14:00	66.63	55.49	46.69	26.90	16.67	5.46
15:00	66.62	55.48	46.63	26.86	16.63	5.54
16:00	66.62	55.48	46.59	26.81	16.59	5.54
17:00	66.61	55.46	46.55	26.79	16.57	5.54
18:00	66.60	55.46	46.50	26.74	16.55	5.59
19:00	66.60	55.46	46.47	26.69	16.49	5.59
20:00	66.59	55.46	46.45	26.66	16.47	5.54
21:00	66.59	55.46	46.43	26.62	16.43	5.51
22:00	66.59	55.45	46.41	26.60	16.39	5.48
23:00	66.59	55.43	46.40	26.57	16.37	5.46
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [21/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	66.59	55.43	46.39	26.53	16.33	5.44
01:00	66.59	55.43	46.39	26.50	16.29	5.43
02:00	66.59	55.43	46.39	26.46	16.27	5.41
03:00	66.59	55.43	46.41	26.41	16.23	5.40
04:00	66.59	55.43	46.42	26.38	16.19	5.40
05:00	66.58	55.43	46.42	26.34	16.15	5.39
06:00	66.58	55.43	46.42	26.30	16.13	5.35
07:00	66.58	55.43	46.42	26.25	16.11	5.35
08:00	66.58	55.43	46.43	26.22	15.95	5.33
09:00	66.58	55.43	46.43	26.18	15.95	5.30
10:00	66.58	55.43	46.43	26.14	15.93	5.33
11:00	66.58	55.43	46.43	26.13	15.93	5.31
12:00	66.58	55.43	46.43	26.10	15.89	5.33
13:00	66.60	55.43	46.43	26.07	15.79	5.31
14:00	66.61	55.43	46.43	26.05	15.77	5.30
15:00	66.63	55.43	46.43	26.02	15.77	5.34
16:00	66.64	55.43	46.43	25.98	15.75	5.35
17:00	66.64	55.43	46.45	25.98	15.71	5.38
18:00	66.64	55.43	46.44	25.97	15.69	5.36
19:00	66.64	55.43	46.43	25.96	15.65	5.36
20:00	66.74	55.43	46.41	25.93	15.63	5.34
21:00	66.64	55.43	46.41	25.94	15.63	5.33
22:00	66.64	55.43	46.43	25.93	15.57	5.33
23:00	66.64	55.43	46.48	25.92	15.57	5.33
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [22/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	66.67	55.44	46.59	25.92	15.51	5.33
01:00	66.69	55.44	46.75	25.92	15.49	5.31
02:00	66.72	55.45	46.96	25.92	15.47	5.33
03:00	66.77	55.47	47.21	25.92	15.43	5.31
04:00	66.82	55.50	47.47	25.94	15.41	5.33
05:00	66.88	55.52	47.70	25.92	15.39	5.33
06:00	66.95	55.54	47.96	25.93	15.35	5.33
07:00	67.03	55.58	48.21	25.93	15.35	5.33
08:00	67.11	55.64	48.46	25.94	15.31	5.33
09:00	67.22	55.75	48.71	25.95	15.31	5.33
10:00	67.35	55.88	48.96	25.94	15.27	5.31
11:00	67.63	56.15	49.50	25.99	15.23	5.33
12:00	67.66	56.18	49.58	25.98	15.23	5.33
13:00	67.73	56.25	49.71	26.01	15.23	5.34
14:00	67.85	56.38	49.94	26.04	15.21	5.31
15:00	67.97	56.57	50.17	26.09	15.17	5.33
16:00	68.12	56.84	50.43	26.21	15.17	5.31
17:00	68.21	56.99	50.73	26.28	15.17	5.33
18:00	68.34	57.19	50.90	26.40	15.15	5.33
19:00	68.49	57.42	50.69	26.55	15.15	5.33
20:00	68.65	57.58	49.49	26.70	15.15	5.33
21:00	68.86	57.81	48.65	26.91	15.15	5.33
22:00	69.10	58.06	48.27	27.08	15.15	5.33
23:00	69.37	58.29	48.70	27.29	15.15	5.33
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [23/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	69.63	58.53	49.17	27.51	15.19	5.33
01:00	69.86	58.76	49.60	27.70	15.25	5.33
02:00	70.07	59.01	50.15	27.92	15.35	5.33
03:00	70.28	59.24	50.82	28.10	15.41	5.31
04:00	70.49	59.48	51.55	28.35	15.47	5.33
05:00	70.70	59.71	52.34	28.55	15.77	5.31
06:00	70.89	59.93	53.15	28.75	15.79	5.33
07:00	71.08	60.14	54.01	28.90	15.81	5.33
08:00	71.26	60.36	54.22	29.11	15.83	5.33
09:00	71.46	60.57	54.37	29.28	15.77	5.33
10:00	71.31	60.80	54.55	29.45	15.83	5.31
11:00	71.46	61.00	54.71	29.59	16.23	7.54
12:00	72.03	61.21	54.95	29.74	16.37	7.60
13:00	72.26	61.40	55.12	29.89	16.51	7.69
14:00	72.38	61.60	55.25	30.05	16.41	7.76
15:00	72.53	61.77	55.43	30.19	16.51	8.51
16:00	72.42	61.94	55.56	29.63	16.41	8.63
17:00	72.53	61.94	55.78	29.66	16.51	8.71
18:00	72.97	61.94	55.93	29.74	17.23	8.84
19:00	73.12	61.94	56.04	30.79	17.37	8.94
20:00	73.25	61.94	56.21	30.80	17.41	9.06
21:00	73.37	61.94	56.30	30.83	17.51	9.18
22:00	73.51	61.94	56.49	30.94	17.63	9.28
23:00	73.60	61.94	56.60	31.03	18.01	9.36
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [24/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	73.71	64.84	58.26	31.07	18.09	9.45
01:00	73.84	64.84	58.26	31.19	18.17	9.56
02:00	73.94	64.84	58.26	31.28	18.23	9.60
03:00	74.05	64.84	58.26	31.35	18.31	9.65
04:00	74.16	64.84	58.26	31.41	18.39	9.71
05:00	74.25	64.84	58.26	31.48	18.45	9.78
06:00	74.36	64.84	58.26	31.53	18.45	9.83
07:00	74.46	64.84	58.26	31.61	18.45	9.86
08:00	74.54	64.84	58.26	31.64	18.53	9.90
09:00	74.62	64.84	58.26	31.74	18.55	9.96
10:00	74.70	64.84	58.26	31.77	18.65	9.98
11:00	74.78	64.84	58.26	31.81	18.69	10.01
12:00	74.82	64.84	58.26	31.86	18.73	10.05
13:00	74.86	64.84	58.26	31.92	18.79	10.08
14:00	74.86	64.84	58.26	31.97	18.83	10.10
15:00	74.86	64.84	58.26	31.96	18.89	10.14
16:00	74.86	64.88	58.34	31.89	18.93	10.18
17:00	74.86	64.98	58.39	32.23	18.99	10.21
18:00	74.86	65.11	58.68	32.28	19.19	10.21
19:00	74.86	65.18	58.62	32.28	19.19	10.21
20:00	74.86	65.20	58.67	32.25	19.19	10.21
21:00	74.86	65.30	58.65	32.37	19.23	10.21
22:00	74.86	65.35	58.67	32.40	19.23	10.21
23:00	74.86	65.43	58.71	32.48	19.25	10.21
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [25/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	-	65.45	58.76	32.45	19.27	10.36
01:00	-	65.55	58.84	32.54	19.29	10.40
02:00	-	65.58	58.85	32.62	19.33	10.40
03:00	-	65.66	58.98	32.68	19.39	10.46
04:00	-	65.69	58.95	32.74	19.41	10.44
05:00	-	65.75	59.04	32.78	19.43	10.48
06:00	-	65.81	59.03	32.82	19.43	10.49
07:00	-	65.85	59.12	32.90	19.49	10.50
08:00	-	65.85	59.17	32.91	19.49	10.53
09:00	-	65.85	59.19	32.97	19.59	10.53
10:00	-	65.97	59.19	33.01	19.65	10.53
11:00	-	65.97	59.22	33.04	19.67	10.55
12:00	-	65.98	59.19	33.10	19.69	10.56
13:00	-	66.00	59.25	33.09	19.73	10.56
14:00	-	66.03	59.32	33.18	19.79	10.56
15:00	-	66.00	59.40	33.24	19.79	10.56
16:00	-	65.99	59.34	33.27	19.79	10.56
17:00	-	65.98	59.32	33.27	19.79	10.56
18:00	-	65.97	59.34	33.34	19.79	10.56
19:00	-	65.97	59.34	33.34	19.81	10.60
20:00	-	65.96	59.34	33.38	19.85	10.60
21:00	-	65.93	59.34	33.40	19.87	10.60
22:00	-	65.94	59.43	33.40	19.87	10.60
23:00	-	65.94	59.39	33.48	19.91	10.61
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [26/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	-	65.91	59.33	33.50	19.93	10.65
01:00	-	65.89	59.33	33.54	19.97	10.64
02:00	-	65.88	59.31	33.56	19.99	10.60
03:00	-	65.85	59.39	33.61	19.99	10.61
04:00	-	65.86	59.38	33.63	20.01	10.66
05:00	-	65.86	59.43	33.67	20.03	10.65
06:00	-	65.88	59.44	33.70	20.03	10.65
07:00	-	65.88	59.44	33.84	20.03	10.61
08:00	-	65.91	59.44	33.90	20.07	10.68
09:00	-	65.92	59.44	33.92	20.11	10.69
10:00	-	65.91	59.44	33.99	20.13	10.73
11:00	-	65.88	59.44	34.05	20.19	10.69
12:00	-	65.92	59.43	33.98	20.19	10.68
13:00	-	65.92	59.42	34.07	20.19	10.70
14:00	-	65.96	59.39	34.93	20.21	10.73
15:00	-	65.96	59.35	34.97	20.23	10.73
16:00	-	65.92	59.32	35.05	20.27	10.73
17:00	-	65.96	59.30	35.08	20.29	10.74
18:00	-	65.90	59.26	35.09	20.33	10.78
19:00	-	65.89	59.21	35.08	20.35	10.75
20:00	-	65.91	59.20	35.17	20.37	10.78
21:00	-	65.89	59.18	35.49	20.39	10.80
22:00	-	65.88	59.10	35.57	20.41	10.79
23:00	-	65.87	59.09	35.65	20.43	10.78
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [27/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	-	65.84	59.07	35.67	20.47	10.86
01:00	-	65.81	59.03	35.72	20.47	10.85
02:00	-	65.81	58.99	35.75	20.49	10.89
03:00	-	65.77	58.95	35.88	20.51	10.84
04:00	-	65.74	58.92	35.75	20.51	10.83
05:00	71.99	65.67	58.88	35.85	20.53	10.83
06:00	71.94	65.65	58.85	35.90	20.53	10.81
07:00	71.86	65.60	58.82	35.90	20.55	10.85
08:00	71.80	65.56	58.82	35.89	20.57	10.86
09:00	-	65.51	58.82	36.01	20.57	10.86
10:00	-	65.45	58.69	36.06	20.57	10.84
11:00	-	65.40	58.64	36.06	20.59	10.90
12:00	-	65.35	58.60	36.14	20.61	10.86
13:00	-	65.29	58.60	36.17	20.65	10.86
14:00	-	65.23	58.60	36.22	20.65	10.83
15:00	71.48	65.15	58.60	36.29	20.67	10.86
16:00	71.46	65.13	58.40	36.28	20.67	10.83
17:00	71.40	65.06	58.36	36.29	20.69	10.85
18:00	71.37	64.99	58.29	36.34	20.69	10.85
19:00	71.31	64.93	58.23	36.41	20.75	10.85
20:00	71.25	64.89	58.19	36.42	20.75	10.85
21:00	71.17	64.82	58.13	35.17	20.77	10.85
22:00	71.09	64.74	57.99	35.28	20.77	10.85
23:00	71.71	64.70	57.97	35.25	20.79	10.85
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [28/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	70.91	64.65	57.95	35.29	20.81	10.85
01:00	70.81	64.57	57.86	35.29	20.85	10.85
02:00	70.70	64.51	57.82	35.29	20.87	10.85
03:00	70.60	64.43	57.74	35.41	20.91	10.85
04:00	70.48	64.27	57.67	35.43	20.93	10.85
05:00	70.37	64.27	57.58	35.43	20.93	10.85
06:00	70.27	64.22	57.51	35.43	20.93	10.85
07:00	70.13	64.14	57.43	35.57	20.95	10.85
08:00	70.07	64.01	57.32	35.57	21.01	10.85
09:00	69.99	63.96	57.27	35.59	21.01	10.90
10:00	69.92	63.88	57.18	35.62	21.03	10.90
11:00	69.84	63.80	57.06	35.65	21.05	10.86
12:00	69.81	63.69	56.98	35.69	21.07	10.88
13:00	-	63.44	56.91	35.72	12.00	11.99
14:00	-	63.41	56.91	35.70	21.17	11.99
15:00	69.58	63.35	56.91	35.76	21.13	11.99
16:00	69.54	63.23	56.60	35.76	21.13	11.99
17:00	69.47	63.08	56.51	35.80	21.17	12.00
18:00	69.41	62.97	56.41	35.83	21.23	12.01
19:00	69.36	62.84	56.31	35.83	21.23	12.01
20:00	69.31	62.70	56.21	35.83	21.25	12.03
21:00	69.26	62.56	56.12	35.90	21.27	12.04
22:00	69.22	62.43	56.02	35.93	21.33	12.05
23:00	69.18	62.28	55.93	35.95	21.31	12.06
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [29/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	69.16	62.14	55.83	36.01	21.33	12.06
01:00	69.14	62.00	55.71	36.01	21.35	12.06
02:00	69.13	61.86	55.63	36.03	21.33	12.08
03:00	69.13	61.71	55.55	36.00	21.41	12.08
04:00	69.13	61.56	55.47	36.02	21.39	12.10
05:00	69.14	61.43	55.39	36.10	21.39	12.13
06:00	69.17	61.28	55.31	36.13	21.39	12.15
07:00	-99.99	61.15	55.20	36.11	21.35	12.16
08:00	69.25	61.05	55.19	36.14	21.35	12.19
09:00	69.31	60.96	55.18	36.17	21.51	12.19
10:00	69.38	60.89	55.13	36.16	21.61	12.24
11:00	69.46	60.85	55.13	36.17	21.67	12.26
12:00	69.56	60.81	55.12	36.17	21.71	12.29
13:00	69.56	60.79	55.12	36.17	21.71	12.28
14:00	69.78	60.79	55.09	36.21	21.79	12.28
15:00	69.90	60.83	55.09	36.23	21.83	12.30
16:00	70.06	60.88	55.09	37.91	21.87	12.30
17:00	70.14	60.92	55.09	37.97	21.91	12.36
18:00	70.26	60.98	55.09	37.91	21.95	12.36
19:00	70.36	61.04	55.09	37.94	21.99	12.39
20:00	70.46	61.19	55.09	37.89	22.03	12.40
21:00	70.56	61.21	55.09	37.92	22.07	12.41
22:00	70.65	61.25	55.09	37.91	22.11	12.43
23:00	70.75	61.32	55.09	37.91	22.13	12.43
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [30/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	-	61.40	55.09	37.88	22.15	12.45
01:00	-	61.46	55.09	38.07	22.19	12.46
02:00	71.05	61.55	55.09	38.09	22.23	12.45
03:00	71.11	61.60	55.09	38.06	22.25	12.49
04:00	71.18	61.73	55.09	38.05	22.27	12.49
05:00	71.27	61.74	55.09	38.06	22.27	12.50
06:00	71.32	61.78	55.09	38.06	22.31	12.51
07:00	71.37	61.83	55.09	38.06	22.37	12.51
08:00	71.41	61.89	55.09	38.04	22.47	12.53
09:00	71.45	61.92	55.09	38.02	22.47	12.54
10:00	71.48	61.97	55.09	38.05	22.57	12.54
11:00	71.49	62.02	55.09	38.00	22.57	12.55
12:00	71.49	62.05	55.09	38.02	22.61	12.56
13:00	71.50	62.07	55.09	38.02	22.63	12.55
14:00	71.48	62.10	55.09	38.00	22.65	12.56
15:00	71.46	62.11	55.09	37.98	22.71	12.58
16:00	71.43	62.14	55.09	38.02	22.73	12.56
17:00	71.37	62.15	55.09	37.96	22.75	12.58
18:00	71.33	62.15	55.40	37.92	22.75	12.59
19:00	71.26	62.15	55.42	37.91	22.75	12.59
20:00	71.20	62.14	55.41	37.91	22.77	12.59
21:00	71.10	62.14	55.35	37.90	22.77	12.60
22:00	71.05	62.12	55.34	37.88	22.81	12.60
23:00	70.96	62.10	55.31	37.87	22.83	12.61
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20

	SUNGAI PAHANG FLOOD LEVEL STATION [31/12/14]					
TIME	**BUKIT BETONG**	**JERAM BUGOR**	**SUNGAI YAP**	**TEMERLOH**	**LUBOK PAKU**	**PALOH HINAI**
00:00	70.87	62.11	55.28	37.86	22.83	12.61
01:00	70.76	-	55.25	37.91	22.85	12.61
02:00	70.50	-	55.19	37.90	22.87	12.61
03:00	70.47	-	55.14	37.90	22.87	12.61
04:00	70.42	61.97	55.07	37.90	22.87	12.61
05:00	70.30	61.93	55.02	38.58	22.89	12.63
06:00	70.16	61.91	54.94	39.93	22.91	12.63
07:00	70.03	61.84	54.88	38.73	22.91	12.64
08:00	69.90	61.80	54.78	38.61	22.93	12.64
09:00	69.78	61.73	54.71	38.61	22.93	12.64
10:00	69.53	61.67	54.62	37.92	22.95	12.64
11:00	69.50	61.59	54.54	38.03	22.95	12.64
12:00	69.46	61.51	54.45	38.08	22.95	12.65
13:00	69.36	61.42	54.35	38.09	22.99	12.64
14:00	69.27	61.31	54.24	38.22	22.99	12.65
15:00	69.22	61.21	54.14	37.99	23.01	12.65
16:00	69.15	61.09	54.04	38.14	23.01	12.64
17:00	69.10	60.97	53.93	38.20	23.03	12.64
18:00	69.05	60.84	53.82	38.06	23.05	12.65
19:00	69.00	60.71	53.72	37.85	23.05	12.66
20:00	68.96	60.56	53.60	38.09	23.09	12.66
21:00	68.91	60.42	53.49	37.86	23.11	12.66
22:00	68.89	60.26	53.38	38.11	23.11	12.68
23:00	68.86	60.11	-	38.02	23.13	12.68
NORMAL	67.00	67.00	44.00	26.00	14.00	6.50
ALERT	71.00	71.00	48.00	29.00	17.00	9.30
DANGER	73.00	73.00	52.00	33.00	19.00	10.20