HYDRODYNAMIC MODELLING FOR FLOOD DAMAGE ASSESSMENT OF SUNGAI TUPAI, TAIPING, PERAK

by

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Thesis submitted in fulfillment of the requirements
for the degree of
Master of Science

Disember 2015

ACKNOWLEDGEMENTS

Alhamdulillah, in the name of Allah, Most Gracious and the Most Merciful for His guidance for me to complete this thesis.

I would like to take this opportunity to convey my deepest gratitude to my supervisor, Prof. Dr. Nor Azazi Zakaria, my former supervisor, En. Zorkeflee Abu Hassan, the staff of REDAC, IPS for their continuous guidance and support, The University (USM) for the Grant (University Postgraduate Research Grant Scheme) and Innovyze Sdn, Bhd. in providing the license for the modelling software.

I would like also to thank Department of Irrigation & Drainage Malaysia's top management, bosses and Human Capital Development Division for their trust and encouragement. The cooperation and support from Department of Irrigation & Drainage of Larut Matang and Selama District for is very much appreciated.

Last but not least, I would like to give my highest gratitude to my family especially my wife Saleha Binti Md Noor and my kids, for their kind understanding and motivation for me to finish and complete the study. This degree is dedicated to all of you.

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LIST OF ABBREVIATIONS

1D	1 Dimensional
2D	2 Dimensional
1D2D	1 Dimensional and 2 Dimensional
AEP	Annual Exceedence Probability
ARI	Average Recurrence Interval
FD	Finite Difference
FV	Finite Volume
GIS	Geographical Information System
ARI	Average Recurrence Interval
DOA	Department of Agriculture
DOE	Department of Environment
DID	Department of Irrigation and Drainage
DID LMS	Department of Irrigation and Drainage Larut Matang & Selama
IPET	Interagency Performance Evaluation Task
JUPEM	Department of Survey and Mapping, Malaysia
MACRES	Malaysian Center of Remote Sensing
MPT	Taiping Municipal Council
MSMA	Urban Stormwater Management Manual for Malaysia
NRCS	National Resource Conservation Services
PC	Personal Computer
RS	River System
SCS	Soil Conservation Service
Tideda	Time Dependent Data
UN	United Nation

USACE	United State Army Corps of Engineers
USSCS	United States Soil Conservation Service

LIST OF SYMBOLS

Q	Discharge
V	Velocity
A	Cross-sectional Area
C	Runoff coefficient
q	Flow rate per unit length
S_f	Friction Slope
x	Horizontal distance
K	Channel Conveyance
P	Wetted perimeter (Manning equation)
R	Hydraulic radius
n	Manning roughness coefficient
C	Discharge coefficient
T_p	Time to peak
t_c	Time of concentration
T_r	Effective rainfall duration
t_p	Catchment lag time
F	Detention depth (mm)
P	Precipitation (mm)
I_a	Initial abstraction depth (mm)
P_e	Effective rainfall depth (mm)
S	Maximum possible detention
CN	Curve Number

k_n	Unit conversion
S	Slope
WP	Wetted perimeter
N_p	Number of section point
rpl	Relative passage length
p	Number of vertical panel
C_d	Spillway coefficient
b	Width of the spillway
h	Depth of water
m	Modular point

PERMODELAN HIDRODINAMIK UNTUK PENILAIAN KEMUSNAHAN AKIBAT BANJIR DI SUNGAI TUPAI, TAIPING, PERAK

ABSTRAK

Pada masa dahulu, kerugian akibat banjir hanya dapat dinilai selepas kejadian tersebut. Namun begitu, dengan perkembangan teknologi maklumat terutama perkembangan teknologi komputer, kejadian banjir boleh di model dengan permodelan berkomputer dan anggaran kerosakan dan kerugian akibat banjir boleh dinilai dengan lebih cepat atau sebelum kejadian banjir tersebut berlaku. Gabungan teknik permodelan 1D di dalam saluran sungai dan 2D pula di dataran banjir dapat memberi keseimbangan dalam masa yang diperlukan untuk membina model dan ketepatan simulasi. Dengan bantuan teknologi sistem pengurusan geografi (GIS), hasil simulasi dapat dianalisis dan dipersembahkan dalam bentuk visual yang lebih menarik. Objektif kajian ini adalah untuk menghasilkan peta banjir melalui teknik permodelan komputer, menentukan kawasan yang terlibat dan seterusnya menaksir kerugian yang mungkin akan dihadapi. Kawasan yang dipilih untuk kajian ini ialah Sungai Tupai yang mempunyai kawasan tadahan seluas lebih kurang 950 hektar dan 7.5km panjang yang merangkumi kawasan perumahan dan perindustrian dan bertindak sebagai salah satu daripada sistem saliran Bandar Taiping. Hasil daripada kajian yang telah dijalankan, didapati pada kala ulangan 100 tahun, hanya 1.19 peratus daripada keseluruhan kawasan tadahan Sungai Tupai yang digenangi air banjir. Jumlah kerugian yang ditaksirkan menggunakan kaedah yang diperkenalkan oleh JICA (1995) adalah menghampiri RM700,000.00 dengan melibatkan lebih kurang 303 buah rumah dan 1333 penduduk.

HYDRODYNAMIC MODELLING FOR FLOOD DAMAGE ASSESSMENT OF SUNGAI TUPAI, TAIPING, PERAK

ABSTRACT

In the past, flood losses or damages can only be determined after the incident. However, with the development of information technology, especially computer technology, a flood can be modelled using desktop computer and estimation of damages and losses due to flooding can be assessed quicker or even before the flooding occurs. The combination of 1D modelling techniques in the river channels and 2D on floodplains balanced the time required to build the model and accuracy of the simulation. With the advancement of Geographical Information System (GIS) technology, simulation results can be analyzed and presented in a more visually appealing manner. The objective of this study is to produce flood maps through computer modeling technique, determine the area involved and further assess the losses that may be encountered. The area selected for this study is Tupai River with a catchment area of approximately 950 hectares and 7.5km in length of Tupai River that includes residential and industrial areas and served as one of the Taiping City drainage system. Finding from the study reveals that in 100 years Average Recurrence Interval of Rainfall, only 119 percent of the total catchment area of Tupai River inundated with flood waters. Total losses estimated using the method introduced by JICA (1995) is approximately RM700,000.00 that involved 303 houses and 1333 resident.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Flood is the most common natural disaster in Malaysia. Hiew (1996) indicates flood hazard is the only significant natural hazard that affects Peninsular Malaysia and Pin-Shuo (2003) stated that flooding is the most severe natural disaster in Malaysia due to heavy seasonal monsoon rains. There are two types of flood commonly occur in the country namely monsoon flood and flash flood. However, in this millennium flash flood is the most commonly occurring flood and causes the most damages especially in urban areas.

Heavy seasonal monsoon rains and the resultant of large run-off concentration which exceed river system were identified as the basic cause of flood incidence (Ho, 2002; Toriman, 2006). Rapid urbanization process in river catchments (especially in the upstream and middle stream region) contributed to the increase of run-off and resulted in increase of flood event frequency and magnitude.

As flood prone area provides very good locations for urban expansion and development, people lived in this area were the one identified as the most vulnerable to flood hazard (Al-Fugara et. al., 2008). Department of Irrigation and Drainage Malaysia reported that 22% (more than 4.8 million) of total population and 9% (29,000 km^2) of the total land area in Malaysia are affected by flooding annually causing about RM915 Millions of damages (Hassan A.J et al, 2002). However, significant urban expansion and escalation of land and property prices has increased the estimation of

current annual flood damage to be about RM2.7 billion a year (Al-Fugara et. al., 2008). Figure 1.1 shows the flood prone area in Peninsular Malaysia and Figure 1.2 covers flood prone area in Sabah and Sarawak.

In the latest 2014 flood disaster in three states (Kelantan, Terengganu and Pahang) in east coast of Peninsular Malaysia, it was estimated to cost 2.9 billion of damages. The estimate was made by estimating the cost needed to repair the public infrastructure, homes and other lost or damages in the flood, interviews and based on report made by the victim. This traditional method, even though the most accurate, is the most time taking way of estimating damages.

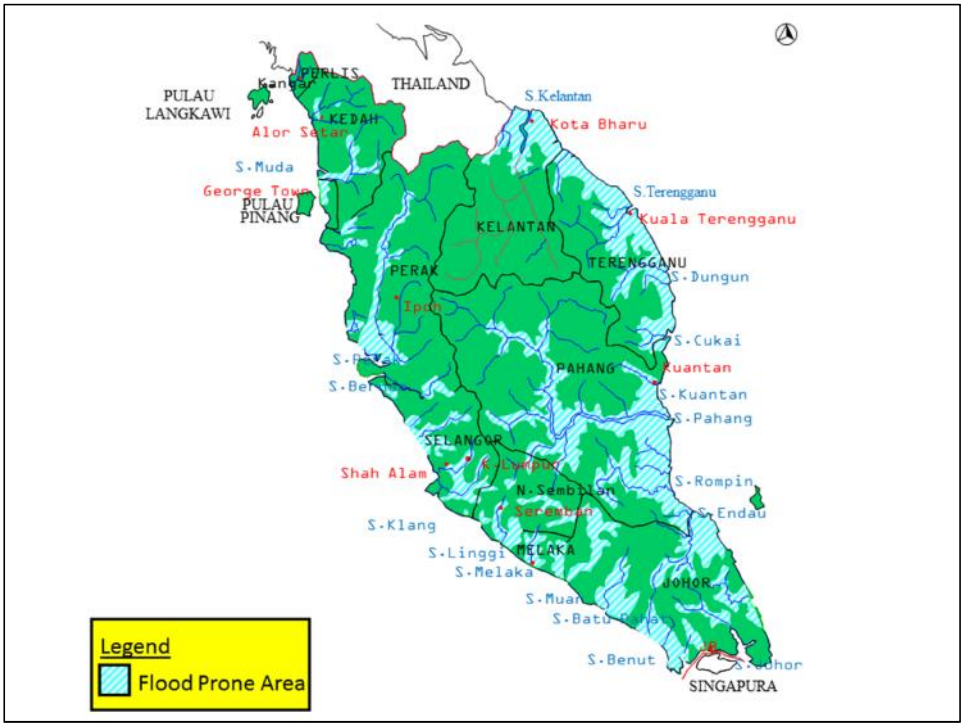

Figure 1.1 Flood Prone Area in Peninsular Malaysia (Source – DID Malaysia)

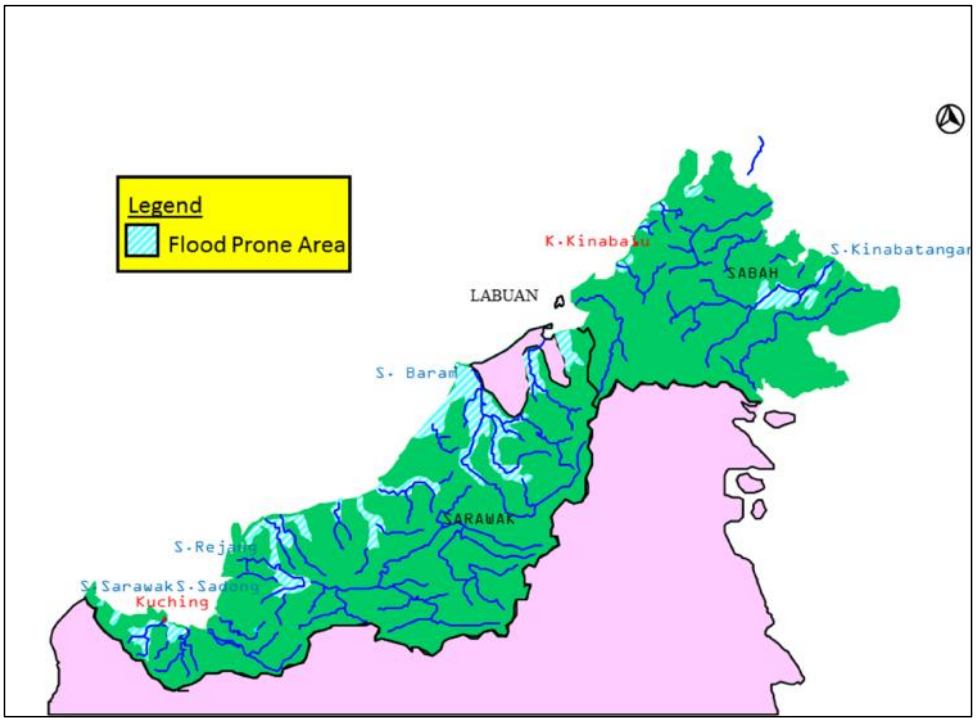

Figure 1.2 Flood Prone Area in Sabah and Sarawak (Source – DID Malaysia)

The advancement of technology especially in geospatial manipulation and remote sensing opens a possibility to understand or estimate the flood damage. However, despite years of research, flood damage estimation using combination of mathematical model for the flood replicating or predicting (even with the new technology available) is still a challenging task. A number of major problems in relation to the challenging task can be identified such as the question of what specific damages under what circumstances are seen as significant such as water depth, duration and velocity.

The study, therefore explore the possibility to assess flood damages using the current technology which are based on computer model (hydrodynamic model) and Geographical Information System (GIS).

1.2 Problem Statement

Sungai Tupai was flooded in 2008 without warning and is considered as the worst damaging flood event within the last 40 years. Based on normal practice of flood damage assessment, the assessment will be carried out by the flood victims or based on flood report from the respective government body such as Social and Welfare Department or National Security Council. This method, even though the most accurate method in assessing damages, it is also the most time consuming. With the information technology that has been around in recent years, there is a possibility that the assessment of damages, prediction of what kind of damages may occur when the flood happened and evaluation of flood mitigation project that has been deployed could be done quicker. This assessment will help to understand the flood characteristic as well as the damages impact in a certain area.

1.3 Research Objectives

The objectives of this research are: -

i. to build a hydrodynamic model of Sungai Tupai
ii. to determine the flood damages for selected design storm events
iii. to assess flood damage in Sungai Tupai using GIS

1.4 Research Scope of Works

The scope, limitation and consideration of the study are as follows: -

i. The study area is limited to Sungai Tupai catchment and it's sub-catchment
ii. All relevant data involved in the study is limited to 2009 – 2011 period.

iii. Additional ground survey was carried out to complement the existing survey data as most of the catchment lying in an almost flat area.

1.5 Structure of Thesis

Chapter 1 of this thesis introduces related issues on flooding and flood damages. The objectives and scope of works are also explained in this chapter.

Chapter 2 describes the studies from previous researchers which are related to this research topic and being presented in sub-chapters for better understanding.

All related theories are presented and the methodology of the research is explained thoroughly in Chapter 3. A flow charts being presented to summarize the research activities.

The results of the study are discussed in this Chapter 4.

Chapter 5 of the thesis highlights the findings of this research and outlines the recommendations for further studies on the related topic.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Flooding is the most natural disaster effecting Malaysia and other country in the world. Cook and Merwade (2009) stated that besides losing billions of dollar in infrastructure and property damages, hundreds (sometimes thousand) of human lives are lost each year due to flooding in the world.

Many regions of the world give their highest attention to flooding due to storm events (Townsend and Walsh, 1998). Wadsworth (1999) stated that flooding was the most (80%) declared federal disaster in the US. An average of four billion dollars was lost due property damage annually from flooding alone. These two statements are an indication that flooding is one of the most frequent natural disasters and has caused the most damage to the economy and social even to the world most developed country.

In August 2005, United States of America was hit by a massive flooding caused by Hurricane Katrina and lost 90 billion dollars in indirect damages associated with this catastrophe (USACE, 2006). IPET (2007) reported that flood damage to residential property in New Orleans was estimated at US$16 billion and damage to public structures, infrastructure and utilities (roads, electricity networks, drainage) at US$7 billion.

For the people living in the flood plain, a flood is always a painful experience. Some people get stuck in a traffic jam. Flood water can destroy furniture, carpet,

electrical appliances and important documents. It can be more serious as people can be trapped at home when the water rises too high. Left with no power or food and some are forced to climb up to the roof for safety. Otherwise people can be washed away by the speed of the in-flowing water.

The damage to property (houses, schools, factories, roads) is named as material damage. How much damage a flood can do to the property depends on the height, period and speed of the floor water, the type of material of the building and the susceptibility to water damage (Soetanto and Proverbs, 2004).

Dutta et al. (2003) conducted a research on flood loss estimation and concluded that a flood loss estimation model involves many issues due to the nature of the damage. The consequences for people depend on the amount of water; the speed of the water rises; access to evacuation centers; the strength and height of the houses and whether they are able to stay at home to wait out the flood in a good way.

After the flood, people can experience emotional problems. They may have lost their sense of security and have difficulty sleeping when it rains or storms, for instance. This is called immaterial damage. A company can be damaged not only directly by the water but also indirectly. It may have to close down and therefore will earn no money. If this situation lasting, the customer will go looking for another company to do a business with.

Also for nature a flood is often a disaster. Animals may have drowned. Salt water kills freshwater plants and fish. Flood water may be contaminated or polluted. For

example, if a chemical factory is flooded, toxic substances can be immersed and spreaded. Diseases also can spread through the water.

In Malaysia, every year there will be news in the newspaper about flood event. And the most frequent flood event is flash flood. The biggest flood ever recorded was in Malaysia was in 1926. Apart from that it was also recorded in 1931, 1947, 1957, 1967, 1971, 1988, 2005 and 2006 (Abdullah, 2006). According to Department of Irrigation and Drainage (DID), 9% or 29,720 km^2 of total area of Malaysia with 4.915 million people of the country are affected by flood (Hiew, 1996). DID's report also indicates that in average, damages due to flooding almost reaching RM915 million a year. The amount is not including economic drag effect that was estimated closely to RM1.83 billion a year (Abdullah, 2006).

DID (2005) report that Kuala Lumpur was seriously hit by flash flood in 2000, twice in 2001, 2002 and 2003. Those events were the cause leading to the construction of 'SMART TUNNEL" worth RM 1.9 billion. The loss of recent flood event in the east coast of Malaysia in the end of 2014 was estimated at 2.9 billion. It was estimated by the report from the government agency for the infrastructure loss and from the estimated budget needed to recover from the disaster.

At the same time, estimated damage will continue to increase as more activity cropping in the flood plain. For such areas, investigation or study on the possible damages is important as a support to decision-makers to make decision regarding flood management strategies and the determination of appropriate protection levels and type of protection (Jonkman et al, 2008).