INVESTIGATION ON THE RAINFALL-RUNOFF RELATIONSHIP FOR THE ROMPIN RIVER BASIN

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B. ENG (HONS.) CIVIL ENGINEERING

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Maklumat hidrologi yang diperoleh daripada hubungan hujan-larian adalah penting untuk perancangan dan pengurusan lembangan sungai yang cekap. Masalah banjir dan kemarau di kawasan tadahan sangat bergantung kepada output analisis hidrologi untuk tujuan reka bentuk mitigasi. hubungan hujan-larian adalah unik untuk setiap lembangan dan oleh itu perlu dimodelkan secara individu.. Di samping itu, data hidrologi mentah juga penting dan oleh itu mesti boleh dipercayai untuk digunakan dalam pemodelan. Kajian ini bertujuan untuk: 1) menghasilkan skim hubungan hujan-larian untuk Sungai Rompin; 2) menentukib dan mengesahkan hasil simulasi dengan perbandingan dengan data yang diperhatikan. Pemodelan hubungan hujan-larian secara berterusan telah dijalankan menggunakan HEC-HMS untuk musim hujan dan kering dengan menggunakan data hujan dari 6 stesen pengukur dan data aliran sungai dari 2 stesen pengukur di dalam lembangan Sungai Rompin. Hidrograf Unit Clark dipilih sebagai kaedah transformasi untuk kajian ini dengan parameter Tc dan R yang dianggarkan menggunakan Prosedur Hidrologi 27 yang dibangunkan oleh Jabatan Pengairan dan Saliran (JPS) Malaysia. Nombor Kurungan SCS digunakan sebagai kaedah kehilangan untuk meramal larian langsung daripada hujan. Untuk laluan aliran dan lag, peralihan bulanan digunakan. Dari hasil yang diperoleh, Hidrograf Unit Clark menunjukkan prestasi yang lebih baik dalam memodelkan tempoh basah berbanding dengan kering. Untuk tempoh basah, nilai RMSE dan NSE untuk model terbaik adalah 59.83 dan -0.64. Bagi tempoh kering, nilai RMSE dan NSE bagi model terbaik adalah 6.22 dan -1.84. Model untuk tempoh basah menghasilkan corak aliran yang sama dengan anggaran aliran berlebihan, tetapi ia boleh diaplikasikan jika dilengkapkan dengan data peta tanah.

ABSTRACT

Hydrological information derived from rainfall-runoff relationship are essential for efficient planning and management of watersheds. Flood and drought issues in a watershed are highly dependent on the hydrological analysis output for mitigation design purpose. Rainfall-runoff processes are unique for each basin and therefore needed to be modelled individually. Additionally, the raw hydrological data is also crucial and thus must be reliable to be applied in the modelling. This study aims to: 1) generate a rainfall-runoff relationship scheme for the Rompin River; 2) calibrate and validate the simulated rainfall-runoff streamflow by comparison with the observed data. The continuous rainfall-runoff modelling was carried out using HEC-HMS for both wet and dry period utilizing rainfall data from 6 gauging stations and streamflow data from 2 gauging stations within the Rompin River Basin. Clark Unit Hydrograph was selected as the transform method for this study with the Tc and R parameters estimated using Hydrological Procedure 27 which was developed by the Department of Irrigation and Drainage (DID) Malaysia. SCS Curve Number was used as the loss method to predict the direct runoff from precipitation. For the baseflow and lag routing, constant monthly was used. From the results obtained, Clark Unit Hydrograph showed better performances in modelling the wet period compared to the dry. For wet period, the RMSE and NSE value for the best model are 59.83 and -0.64. As for dry period, the RMSE and NSE value for the best model are 6.22 and -1.84. The model for wet period is producing similar flow pattern with overestimation of flow, however it is applicable if provided with soil map data.

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LIST OF SYMBOLS

A	Catchment Area (kilometre square)
L	Main Stream Length (kilometre)
L	Lag (hour)
Q_B	Base flow (m^3/s)
R	Storage Coefficient (hour)
S	Weighted Slope of the Main Stream (kilometre)
SCS CN	Soil Conservation Service Curve Number
T_c	Time of Concentration (hour)

LIST OF ABBREVIATIONS

CPA'	Coefficient of Performance
DID	Department of Irrigation and Drainage
EF	Modelling Efficiency
EI	Efficiency Index
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Centre- Hydrologic Modelling System
USDA	United Stated Department of Agriculture
HP-1	Hydrological Procedure 1
HP-26	Hydrological Procedure 26
HP-27	Hydrological Procedure 27
JUPEM	The Department of Survey and Mapping Malaysia
NOF	Normalized Objective Function
RE	Relative Error
RRB	Rompin River Basin
SRTM	Shuttle Radar Topography Mission
TR-55	Technical Release 55
UH	Unit Hydrograph
USACE	United States Army Corps of Engineers

CHAPTER 1

INTRODUCTION

1.1 Background

With the increasing trend of human population, the demand on water resources is getting higher. According to the World Population Prospects (2015) by the Department of Economic and Social Affairs of the United Nations, the growth in world population have the possibility to reach 9.7 billion by year 2050. This calls for a better management of the current water resources to sustain the needs for the human consumption either in term of domestic supply or agricultural irrigation. Although water is renewable, this is only true if it is well managed.

In tropical countries that experience tropical monsoon, generally have higher annual rainfall compared to countries from other regions. Reasonably, these countries receive abundant of water and should not have water resources issue. Unfortunately, poor water resources management has led to floods occurrence during the wet period, and water scarcities during the dry period. Malaysia, which lies near to the equator has two climatic periods every year, wet and dry period. At the Peninsular Malaysia, the average rainfall is about 2400mm which indicates abundant of water resources to sustain the water demand in the country (Lee, Mokhtar, Mohd Hanafiah, Abdul Halim, & Badusah, 2016). However, there are still water shortages during the dry period and excess of water during the wet period, causing droughts and flooding issues (Zin, Jemain, & Ibrahim, 2013). Drought often cause the reservoir's water storage level to decrease, affecting the water supply for agriculture, industrial and domestic usage. Flood on the other hand brings damage to the properties, causing economic loss and sometimes human lives (Merz, Kreibich, Schwarze, & Thieken, 2010).

The Rompin River Basin (RRB) is situated at the south of the Pahang State in Malaysia. Since RRB is located at the East Coast of the Peninsular Malaysia, it is subjected to the Northeast Monsoon every year starting from November to February, which brings a huge amount of rainfall to the east coast (Yendra, 2017). This high precipitation has caused a huge amount of runoff into the river, until the stage that it overflows and induced floods at the river banks and lowland areas. There are two types of floods occurred in the RRB which are the monsoon and flash flood (M et al., 2014). Flash flood is more localize and have shorter period, while monsoon flood is more widespread and have longer period. On the other hand, RRB also experiences drought during dry period, whereby the rainfall is below average and resulted in shortages in water supply and agriculture needs (Rahim, Noor, & Usli, 2017).

Considering the unpredictable rainfall pattern in the Rompin River Basin, there is a need to develop a rainfall-runoff scheme for this area to simulate the discharge for the Rompin River. By utilising the precipitation data together with streamflow data available from the Department of Irrigation and Drainage (DID), a hydrological model was setup to represents the basin's hydrological response to the rainfall events. This hydrological model is important to assist the water manager to predict the streamflow pattern in the Rompin River based on rainfall data, which subsequently providing water volume information when dealing with potential drought or flood.

1.2 Problem Statement

Located at the East Coast of Peninsular Malaysia, RRB is subjected to the North East monsoon period and also the dry period. High rainfall from the monsoon period often lead to overflow of the Rompin River, causing flood at the Rompin District. During dry period, the areas faced a risk of drought due to low flow. This phenomenon has affected the water supply for domestic and agriculture usage. Similar to other regions in Malaysia, there are still insufficient hydrological gauging stations available in the RRB. Precipitation data is only available from 6 rainfall stations and streamflow data is available from only 2 streamflow station. Moreover, there were many missing values for both rainfall and streamflow data recorded. Rainfall-runoff study for RRB is also still lacking, indicating little knowledge about the basin characteristics and water management system.

1.3 Objectives of Study

The objectives of this study are:

1. Generate a rainfall-runoff relationship scheme for Rompin River Basin by using HEC-HMS hydrological model adopting Clark Unit Hydrograph transform method.

2. Calibrate and validate the rainfall-runoff streamflow by comparing the simulated results with the observed data.

1.4 Scope of Study

The hydrological area selected in this study is the Rompin River Basin. Hydrological data including water level, rainfall, and flow discharge were collected from the existing 6 rainfall stations and 2 streamflow station situated in the Rompin River Basin for the year 2000 to 2017. The hydrological stations available are managed by the DID. Since this study focused on the water resources management, the data for both wet and dry period were collected for analysis. The sub-basins were extracted based on the data from the digital elevation model. For the rainfall at the sub-basins, the distributions were compiled by using Thiessen-Polygon according to the location of rainfall stations. The hydrological analyses were conducted via the HEC-HMS hydrological modelling in which the calibration and validation processes were done by comparing simulated streamflow result from the model with the observed data.

1.5 Significance of Study

There is little study being done on the water resources management for the RRB. The surge of rainfall volume during the monsoon has caused a higher than normal discharge at the downstream of RRB leading to flood problems, while during the dry

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