THE STUDY OF WATERSHED RETENTION APPROACH TO IDENTIFY WATER RESOURCES PROBLEMS AT JOHOR WATERSHED

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Dedicated to my beloved Husband, Mother, Father, Mother in law and Father in law

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In the name of Allah, the Most Beneficent, the Most Merciful. All praise and thanks to Allah, lord of the universe and all that exists. Prayers and peace be upon His prophet Mohammad, the last messenger of all humankind.

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ABSTRACT

Rapid growth of urban area is threatening the watershed and reduces the sustainability. Since the principle of water quantity problem mitigation is to increase the capacity of available storage in the watershed, this study is done for the evaluation of watershed management using watershed retention capacity approach. The main approach of this study is the water balance. It use for use to check the reasonability data, to analyze watershed retention, and then to identify the solution for water problems. The result shows that 31% of the total becomes river discharge while 68% becomes evapotranspiration and only 1% becomes storage (groundwater). The Johor watershed retention capacity was calculated as 3885mm, and 14% of it comes from Linggui Dam, whose capacity is 760 MCM (553mm). The histogram of Johor river discharge shows that the droughts are more frequent as compared to floods. Considering the flood and drought volume it is found that the best option to mitigate such problems is by constructing a dam/reservoir. When install the reservoir with about 1462 MCM (with storage depth of 1064 mm), the river discharge become the moving average. This project can stop the floods, but only reduce the drought into 7% frequency. Different scenarios of water management were conducted to mitigate flood and drought completely. However no scenario has lower than 1064 mm of reservoir capacity. Therefore, a reservoir with capacity of 1796 mm (2468 MCM) is considered as better option since the capacity is minimum in order to fulfil the Johor watershed requirements as well as the water requirements of Singapore. The minimum discharge for this option is $21m^3/s$ while maximum discharge is $50m^3/s$.

ABSTRAK

Pertumbuhan pesat kawasan bandar mengancam kawasan tadahan dan mengurangkan kemampanan. Sejak prinsip mitigasi masalah kuantiti air adalah untuk meningkatkan kapasiti penyimpanan yang ada di kawasan tadahan, kajian ini dilakukan untuk penilaian pengurusan kawasan tadahan air menggunakan kapasiti pengekalan pendekatan tadahan. Pendekatan utama kajian ini adalah keseimbangan air. Ia gunakan untuk digunakan untuk memeriksa data reasonability, untuk menganalisis pengekalan kawasan tadahan air, dan kemudian untuk mengenal pasti penyelesaian untuk masalah air. Hasilnya menunjukkan bahawa 31% daripada jumlah keseluruhan menjadi pelepasan sungai manakala 68% menjadi evapotranspirasi dan hanya 1% menjadi penyimpanan (bawah tanah). Kawasan tadahan Johor pengekalan kapasiti dalam takungan telah dikira sebagai 3885mm, dan 14% daripada ia datang dari Linggui Empangan, yang kapasiti adalah 760 MCM (553mm). Histogram pelepasan Johor sungai menunjukkan bahawa kemarau adalah lebih kerap berbanding banjir. Memandangkan banjir dan jumlah kemarau ia mendapati bahawa pilihan terbaik untuk mengurangkan masalah tersebut adalah dengan membina sebuah empangan / takungan. Apabila memasang takungan dengan kira-kira 1462 MCM (dengan kedalaman penyimpanan 1064 mm, menunaikan sungai menjadi purata bergerak. Projek ini boleh menghentikan banjir, tetapi hanya mengurangkan kemarau ke frekuensi 7%. Senario berbeza pengurusan air telah dijalankan untuk mengurangkan banjir dan kemarau sepenuhnya. Walau bagaimanapun, senario tidak mempunyai lebih rendah daripada 1064 mm kapasiti takungan. Oleh itu, satu takungan dengan kapasiti 1796 mm (2468 MCM) dianggap sebagai pilihan yang lebih baik kerana ia boleh memenuhi keperluan kawasan tadahan Johor serta keperluan air Singapura. pembuangan minimum untuk pilihan ini adalah 21m^3 / s manakala pelepasan maksimum adalah 50m^3 / s.

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LIST OF SYMBOLS AND ABBREVIATIONS

Ac-ft	Acre feet
Bf	Base flow
Et	Evapotranspiration
FA	Frequency analysis
I	Infiltration
JB	Johor Bahru
O	Surface overflow
R	Runoff
WRC	Watershed retention capacity
Rso	Rainfall pattern
Rsc	River discharge
Mm	Mile meter
∑	Summation
%	Percentage
MCM	Million cubic meter
M^3	Meter cubic
s	Second
km	Kilo meter
M	Meter

CHAPTER 1

INTRODUCTION

Watershed is the basic unit that mostly used in the calculation of hydrological balance. It is defined as a contiguous area which all water drains down to the point of a common river, pond, stream, lake, or estuary. That borders can be drawn from topographic map that travel from top to low altitude in the direction perpendicular to the counter line.

Several watershed characteristics, such as size, shape, land slope, and soil type affect watershed response to rainfall that represented by hydrograph. Hydrograph is a plot of flow rate and time in given location within a stream. It has three parameters such as peak flow, time concentration, and recession time. For watershed with the length is bigger than the width, the hydrograph is sharp, while for watershed with the width is bigger than length, the hydrograph is wide and has lower peak flow. The similar hydrographs was produced also at watershed with high infiltration due to coarse soil type.

In term of water balance, a watershed can be represented by storage by all meaning. Therefore, the principle of watershed problem mitigation such as flood and drought is to increase the capacity of available storage in the watershed. It is divided into structural and non - structural methods. Structural methods reduce the peak rate of discharge by reservoirs or dam and increase the capacity by improving the channel stream; while non-structural methods deal with a kind of watershed characteristics improvement and management. Increase in storage will reduce the size of the runoff, then release it during the dry season for many purposes. In other words, storage and

its management control water release in each season to alleviate the flooding and drought.

In hydrologic water balance, Malaysia has received 990 km^3 annual rainfalls and lost 360 km^3 due to evaporation (36 percent), which has 540 km^3 (54percent) fresh water surpluses. The total surface runoff (the surface water generated by a combination of rainfall and watershed system) is 566 km^3 and about 64 km^3 contribute to groundwater recharge. Without considering water supply from groundwater system, it is clear that Malaysia has a surplus in fresh water supply.

Water is very important for people, food and rural development, economic development and environment. But unfortunately, many states in Malaysia still have a problem with water supply especially in water supply shortages, low water quality, flash flood in urban 2area and economy. So to prevent these problems, we need to manage our watershed from overall aspects. Management of watershed is suggested by using multi criteria decision making approaches.

1.1 Background of the study

Water problem and its occurrence are increasing, especially at tropical region. Many water supply reservoirs are empty during drought condition and in contrast reservoirs for flood protection are full or overflow during rainy season. The rapid growth of urban area inside the watershed, as well as the climate change, is the most acceptable reason for that situation. Since hydrological related processes are system dynamic, a kind of simple and applicable watershed monitoring program is required in order to determine what degraded or impaired areas may exist in the watershed. In this case, watershed retention capacity is expected to become effective and simple watershed monitoring program.

The monitoring of watershed can help to archive proper planning for the mitigation of floods and other natural hazards. Many studies have been carried out to plan properly, decrease the intensity, and prediction of floods. The study on floods

requires comprehensive hydrological and multidiscipline studies. Hydrological and topographical studies are interlinked with each other. Sometimes in flood season, water flows to different direction and then inundating the low lying areas, which may create life loss and property damage.

The Johor watershed is considered as a suitable study area since the Johor Watershed is located in the central region of Iskandar Malaysia. It is bound by Senai in the North, Nosajaya to the West, Singapore in the South and Pasir Gudang to the East. Johor watershed is the focus of industrial, tourist and commercial interest for South Peninsular Malaysia and Singapore Region. A series of floods that hit Malaysia during December 18, 2006 to January 13, 2007, resulted from above-average rainfall, which is attributed to the hurricane that hit Utor the Philippines and Vietnam a few days ago (Kusumastuti, DI., 2009). Although there are six dams in Johor, but it is required to build more dams/reservoir to prevent the disaster, such as flood and drought.

Malaysia has been supplying water to Singapore since 1961 were there was an agreement between the two countries to allow Singapore to draw (1.15 million m^3) per day, which is approximately about 13.15 m^3/s, from the Johor River, effective till 2061. In fact during 1983-2010, only about 70% of time that the river discharges was higher than13.15 m^3/s. However, for the past couple years Singapore has complain decreased in water flow rate. The rate of reduction might be due to changes in land use. As there has been push for economic development and urbanization in the state of Johor, which has led to excessive soil erosion, landslides, flash flooding and degradation of watershed and water pollution.

In his study I proposed an evaluation for watershed management using watershed retention capacity approach. It would access water management in terms of flood mitigation and drought at Johor watershed and provide a suitable reservoir characteristic

A watershed has a strong basis for management because all resources within it are interrelated with each others. All resources include water, soil, forest, minerals,

nutrient, habitats and clean air. So if we want all that resources preserve or sustainable for future generation, so we must identify, protect and improve the watershed first by using multi criteria decision making approaches. Problem statement

1.2 Study Objectives

The following are the objectives of study:

1. To access watershed retention at Johor watershed.
2. To access water management in terms of flood mitigation and drought.
3. To provide suitable reservoir characteristics

1.3 Scope of Study

The study is focused on the watershed management in terms of flood mitigation and drought control by applying watershed retention capacity approach. This study will provide suitable reservoir characteristics for the Johor River which can meet the requirements of water balance in the Johor watershed.

1.4 Importance of Study

Malaysia is gifted with an enormous source of good land and fresh water supply. It supported by more than 2500 mm annual rainfall and a dense network of rivers and streams which about 150 major river basins. So that’s mean, Malaysia supposedly must enjoy with these natural resources. No doubt Malaysia is called as a country of “water resource-rich” (Ayob Katimon and Supiah Shamsudin, 2005).

Johor River is the main river in the Malaysian state of Johor. The river is 122.7 km long and flows in a roughly north-south direction, originating from Mount Gemuruh and then empties into the Strait of Johor. Its major tributaries are Sayong, Linggui, Tiram and Lebam Rivers. Its banks are also known to be the location of past capitals of Johor.

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