ASSESSING \ ... ')TE SENSING AT SUNGAI KUANTAN, PAHANG

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ABSTRACT

This study investigates the potential of the satellite based rainfall estimates data product from Tropical Rainfall Measuring Mission (TRMM) satellites, known as TRMM 3B43 Version 6. The satellite-based rainfall is used as the main input in the water balance equation to estimate the water-yield at monthly basis from Jul 2005 to Jun 2010. Sungai Kuantan, Pahang which located in east coast region in the Peninsular Malaysia is used as a study area to evaluate the model performance. The rainfall patterns for both data TRMM and JPS during period Jul 2005-Jun 2010 is almost similar. Pattern of water yield at east coast region based on seasonal rainfall be investigated. The results are presented in attribute table and graphical forms. The highest monthly water-yield is 721.7 mm during Dec 2005-2006 periods. And the lowest water-yield monthly during Feb 2009-2010 periods is -96.81 mm. Assessment of the relationship between flow rata data get from JPS, Malaysia and water-yield product at the study area watershed indicates good accurate assessment of coefficient is R= 0.65. Public domain data should be practiced in a broader horizon in hydrologic studies in Malaysia to achieve the development of more accurate assessment.

ABSTRAK

Kajian tentang Potensi hujan data produk berasaskan satelit anggaran dari Hujan Tropika Mengukur Misi (TRMM) satelit, yang dikenali sebagai Versi TRMM 3B43 6 telah dijalankan. Hujan yang berasaskan satelit digunakan sebagai input utama dalam persamaan imbangan air untuk menganggarkan air hasil pada asas bulanan dari Jul 2005 hingga Jun 2010. Sungai Kuantan, Pahang yang terletak di wilayah pantai timur di Semenanjung Malaysia digunakan sebagai kawasan kajian untuk menilai prestasi model. Corak hujan untuk kedua-dua data TRMM dan JPS dalam tempoh Jul 2005-Jun 2010 adalah hampir sama. Corak hasil air di kawasan pantai timur berdasarkan hujan bermusim disiasat. Keputusan dibentangkan dalam jadual atribut dan bentuk grafik. Bulanan tertinggi hasil air adalah 721,7 mm semasa tempoh Disember 2005-2006. Dan hasil air terendah bulanan sepanjang tempoh Februari 2009-2010 adalah -96,81 mm. Penilaian hubungan antara aliran data rata dapat daripada JPS, Malaysia dan produk hasil air di kawasan tadahan air di kawasan kajian menunjukkan penilaian yang baik dengan pekali bersamaan R = 0.65. Jesteru, data domain awam perlu diperluaskan dalam kajian hidrologi di Malaysia untuk mencapai pembangunan penilaian yang lebih tepat.

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LIST OF SYMBOLS / SHORT FORMS

GIS	=	Geographical Information System
TRMM	=	Tropical Rainfall Measuring Mission
JUPEM	=	Jabatan Ukur dan Pemetaan Malaysia
DID	=	Department of Irrigation and Drainage, Malaysia
PET	=	Potential Evapotranspiration
(ΔS)	=	Change in watershed storage
P	=	Precipitation
Q	=	Flow Rate / Water-yield
NEM	=	Northeast monsoon
SWM	=	Southwest monsoon
WRP	=	Water Resourcers Publication
tiff	=	Satellite Image Format
MMD	=	Malaysian Meteorological Department
R	=	Accurate Assessment

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CHAPTER 1

INTRODUCTION

1.1 Background

Water will be vital, precious and scarce resources. In hydrologic service, quantity is the first attribute of a water service that many people consider. Users may be concerned with the volume of water stored in or discharged from watershed, either above or below ground. Estimation of catchments water balance (water balance equation) is needed to give an overview of periodic water availability for the purpose of water resources planning and management. Therefore, there are need to develop tool (remote sensing data and GIS technique) that can used to make rapid assessment for hydrological components quantitatively.

The water-yield of a watershed is a measurement of the amount of input precipitation that eventually exits the watershed. Typically, most of this water moves as surface runoff. It can be expressed as an equivalent depth or in a volume. It also represents the amount of precipitation not lost to ET or retained as watershed moisture storage. Changes in watershed storage over a long-term period greater than 5 years can generally be assumed negligible. So that, annual water yield is equal to the gross precipitation input less potential evapotranspiration (PET) output plus change in watershed storage (ΔS). (WRP, 1989).

In hydrology, water balance equation can be applied to describe water flow enter or out a system. Water balance can be used to manage water supply and expect where supply shortage occurred. It also was used in irrigation system, flood control and pollution control. Water balance could be described by use of water balance graph where rainfall level mapping and monthly potential evapotranspiration (PET) be done. Model water balance for a period of a few months developed for various purposes. Water-yield will be calculated based on Water Balance Equation.

It is identified that the watersheds are the main water resources with rainfalls as their main water inputs. Therefore, accurate rainfall measurement is crucial for run-off estimations from watershed. However, water-yield assessment from rainfall runoff based models is commonly insufficient to the existing weakness of conventional rainfall measurements. Even that the ground rain gauged provides high accuracy measurements, but it is only reliable for the surrounding areas. In developing region, where the rain gauge is seldom, especially in remote areas, the indeterminacy of rainfall measurements are increased. High cost maintenance and settlement are the main constraints of establishing the effective rain gauge distributions, especially for large areas.

Public domain data are serious issues and it is strongly desired to overcome the lack of data using satellite derived datasets. Therefore, by using of satellite-based technology as an alternative data source is considered to be a practical solution which enables us to estimate the rainfall before it reaches the ground surface, through radar reflectivity. Those data were providing as public domain that give an advantage. The aim of this study is to use of public domain data for assess water-yield.

1.2 Problems Statement

Determining the spatial and temporal depth of rainfall input to a catchment's is necessary for everyday planning and management of the water resources. Conventionally the estimation of rainfall has been accomplished by using rain gauges that sample the rain by capturing a volume over a continuous or fixed time interval. Rain gauges provide a fairly accurate measure of point rates and depths of rainfall.

In developing region, where the rain gauge is sparse, especially in remote areas, the uncertainties of rainfall measurements are increased. Even though that the ground rain gauged provides high accuracy measurements, it is only reliable for the surrounding areas. In this study, it was conducted at Sungai kuantan, Pahang which found none rain gauge due to forested watershed is difficulty in accessing and collecting due to forested watershed can be solved.

1.3 Objectives of Study

The objectives of this study are:

a) To estimate rainfall and water-yield over Sungai Kuantan, Pahang watershed.
b) To assess relationship between water-yield derived and measured flow-rate.

1.4 Scope of Study

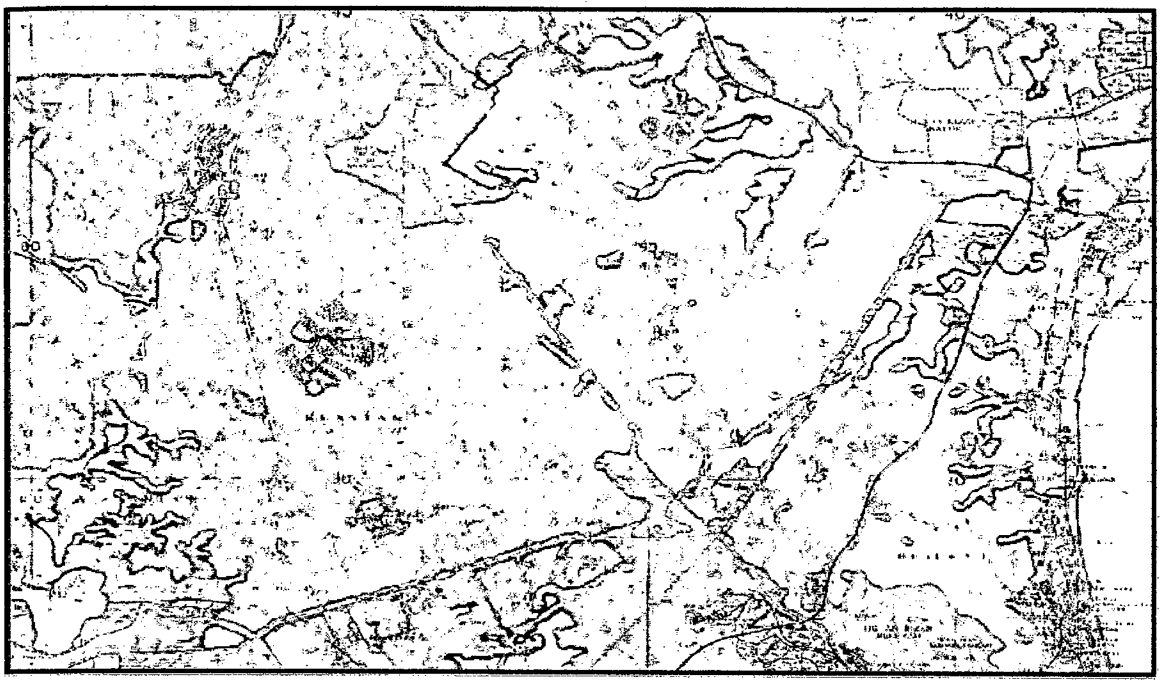
Satellite-based rainfall data collected from Tropical Rainfall Measurement Mission (Jul 2005-Jun 2010) were used as rainfall data (http:// mirador.gsfc.nasa.gov). Meanwhile, Potential evapotranspiration (PET) data collected from public domain provider (www.cgiar-csi.org/data). And addition, flow rate data collected from Department of Irrigation and Drainage for verification purposed. Water-yield was derived based on Water Balance Equation. Geographical Information System technique was used to performed water-yield analysis.

1.5 Study Area

The study area is located in selected forested watershed at Sungai Kuantan, Pahang. The flow is from Gunung Tapis (1502m above sea level) through Bandaraya Kuantan (5m above sea level) before discharge to South China Sea.

Table 1.1: Information of Sungai Kuantan, Pahang

Forested Watershed ID	Region	River basin (km^2)	Catchment Area (m^2)	Latitude	Longitude
Sungai Kuantan	East Coast Peninsular Malaysia	< 80 km^2	89365579 3.73	3.8°	103.35°



Source : Jabatan Ukur dan Pemetaan Malaysia (JUPEM)

Figure 1.1: Catchment area of Sungai Kuantan, Pahang

1.6 Significance of Study

The importance of this study is to define the capabilities of GIS technique in order to perform Satellite-based rainfall data could be used as input in water-yield calculation. Therefore, an accurate rainfall measurement for water-yield can be estimate. In developing region, where the rain gauge is sparse, especially in remote areas, the uncertainties of rainfall measurements are increased. So that, high cost maintenance and deployment are the main constraints of establishing the effective rain gauge distributions, especially for large areas. Therefore, remote sensing technology is cheapest to use as a research of project.

1.7 Thesis Structure

This thesis is divided into five chapters. First chapter presents an introduction and an overview of the problem statement objectives scope of studies and study area. Chapter two describes the literature related to the research objectives. Chapter three details the methodology used in the research. Chapter four discusses the results obtained from the case study. Finally, chapter five presents the conclusions discusses drawn from the works and provides the direction for the future work.

CHAPTER 2

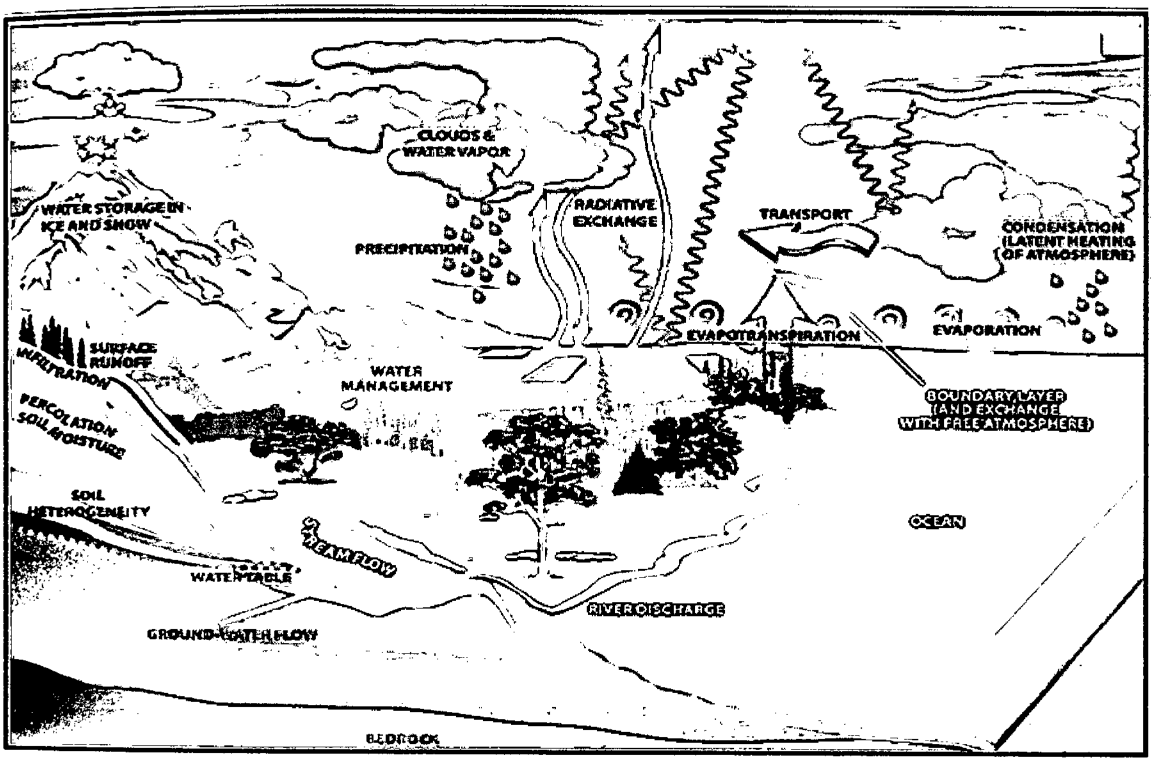
LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature on Hydrological Cycle, water balance model and the previous research studies in water yield and Remote Sensing technologies.

2.2 Hydrological Cycle

Hydrology is a study about movement and occurrence of water on or above of earth surface. It is related to a various condition of water either in gas, solid or liquid in earth atmosphere or inside the earth surface. It is also related to oceans, sources and reservoirs that turn human being, flora and fauna into development in this planet. (Wilson E.M, 1990). The hydrologic cycle occur by continuous when unsteady circulation of water from the atmosphere to and under the land surface and then back to the atmosphere by various processes. Processes in hydrology would include precipitation, infiltration, surface runoff, percolation, ground water flow, evaporation, transpiration. Water on earth occurs in many forms such as water vapour, rainfall, surface water storage and ground water storage. The occurrence of water in its various forms and the processes water undergoes as it moves from on form to another is best illustrated by the hydrological cycle in **figure 2.1.**



Source: (http://www.civilcraftstructures.com)

Figure 2.1: Process of hydrology life cycle

Temporal variations may occur in the atmosphere, in surface waters, in the groundwater of an area and also on land surface. There are some important processes which on factors that influence each process and its significance in the planning, design, and operation of stormwater management systems (Walesh, 1989).

Water precipitated over land passes through a number of storage media which can be regarded as subsystems of the hydrological cycle. The hydrodynamics is the flow of water between and through the different storage media. Surface detention and interception storage are considered as separate system. Interception storage refers to the precipitation by vegetation before it evaporates. Detention storage is water temporarily stored in pools or depressions. This water may evaporate or infiltrate into the soil to replenish the soil moisture reservoir or to percolate to the groundwater. Percolation occur when the flow of soil moisture in downward direction and in upward direction capillary rise. The annual amount of percolation is usually larger than capillary rise, resulting in a recharge of the groundwater reservoir. Groundwater flow ultimately discharges from the groundwater storage into the channel system.

Evaporation can be described as a process which water is transformed from the liquid or solid state into the gaseous state. While transpiration is the mechanism which water moves up through vegetation and is subsequently evaporated. While evapotranspiration rates are affected by factors such as plant characteristics, vapour pressure, wind, temperature and availability of soil moisture. Evapotranspiration is determining of factor in the water balance. The model calculates the total actual evapotranspiration as a sum of the evaporation of water intercepted by vegetation, the transpiration of the vegetative cover and the evaporation from the bare soil between the vegetation.

Groundwater recharge is recharge is the entry of water into the saturated zone of water made available at the water table surface; together with the associated flow away from the water table within the saturated zone (Freeze, 1969). Recharge is an important factor in evaluating groundwater resources but is difficult to quantify (Alley et al., 2002).

2.3 Rainfall Characteristics

Rainfall in Malaysia is strongly dependent on the monsoons and their associated meteorological phenomena such as monsoon trough and tropical storm track. Generally, Peninsular Malaysia receives the highest precipitation during the transition period between the northeast which December to March and southeast monsoons which June to September. The annual average rainfall in Malaysia is 2,400 mm for Peninsular Malaysia, 2,360 mm for Sabah and 3,830 mm for Sarawak.

Rainfall event is measure if precipitation in a particular area that drops to the ground is at least in the range of 0.5 mm to 3 mm (Chin, 2000). In Malaysia, in areas where thunderstorm is often, large variation of rainfall depth will occur even in a short distance (Dale, 1959). Therefore, the sufficiency of rain gauge is need if the rainfall depth over a particular catchment is to being investigated in detail. Further, the intensity of frequent rainfall in Malaysia is known to be very higher than that of the temperate country (DID, 2000).

Rainfall characteristics affect the amount of runoff which occurs, the severity of erosion possible in various parts of the country, and our dependency on irrigation for crop growth. Specific important characteristics of rainfall are:

a) Size and shape

Rainfall occurs when moisture in the atmosphere condenses into drops. Raindrops occur about in any shape up to approximately 9 mm mean diameter after which they tend to break up. However, they do tend, if turbulence does not interfere, toward an aerodynamically stable shape (tear-drop) because this affords the least surface resistance to movement.

b) Intensity and Duration

These are usually inversely related like high intensity storms are likely to be of short duration and low intensity storms can have a long duration.

c) Intensity and Area

We can expect a less intense rainfall over a large area than we can over a small area.

d) Intensity and Drop Size

High intensity storms have a larger drop size than low intensity storms.

e) Drop size and Terminal Velocity

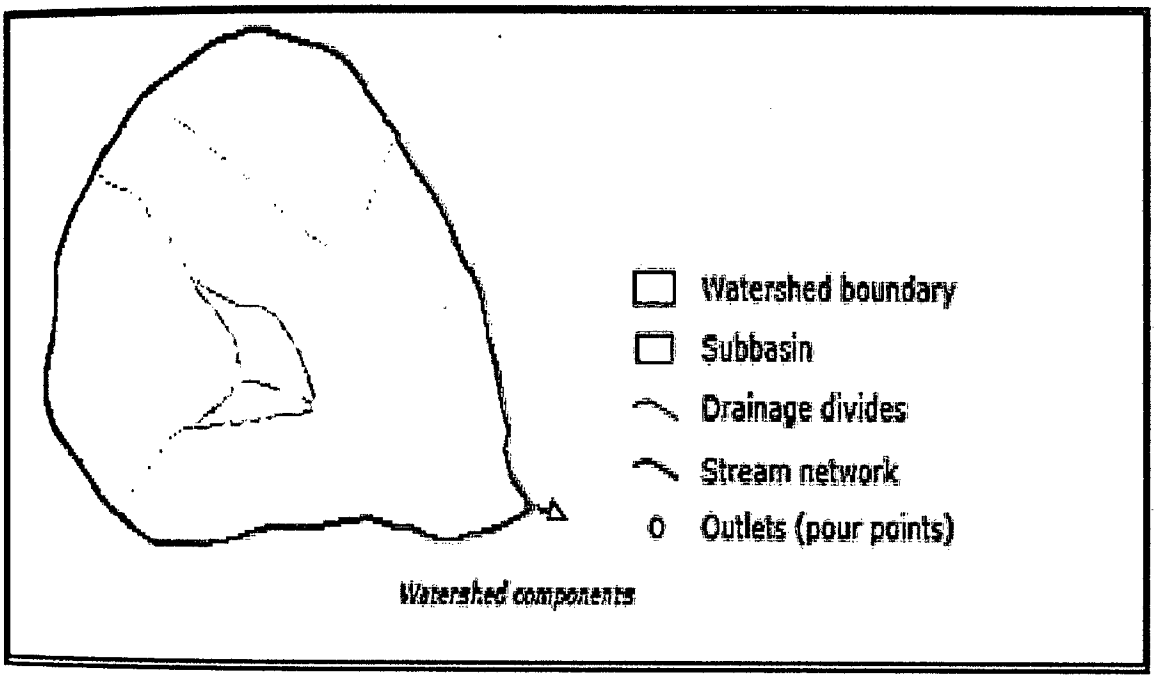
The terminal velocity of raindrops increases as the drop size increases up to about 35 feet per second. Storms with large drop sizes have a high erosion potential.

f) Rainfall Distribution and Supply

These are difficult to predict for a given season, but averages based on long-term records tells us much about the kind of water management necessary for an area.

2.4 Watershed

A watershed is the upslope area that contributes flow generally water to a common outlet as concentrated drainage. It can be part of a larger watershed and can also contain smaller watersheds, called sub basins. The boundaries between watersheds are termed drainage divides. The outlet, or pour point, is the point on the surface at which water flows out of an area. It is the lowest point along the boundary of a watershed.



Source: ArcGIS Resource Center

Figure 2.2: Watershed component

2.5 Water Balance

Accurate assessment of water balance at the watershed scale is a major importance in a context of a global dramatic increase of human demand for water, either for urban or agricultural requirements. This balance results from the interaction of climate, geology, morphology, soil and vegetation (De Vries and Simmers, 2002).

In the natural environment, water is almost constantly in motion and is able to change state from liquid to a solid or a vapour under appropriate conditions. Conservation of mass requires that, within a specific area over a specific period of time, water inflows are equal to water outflows, plus or minus any change of storage within the area of interest. The water entering an area has to leave the area or be stored within the area.

Water balance techniques, one of the main subjects in hydrology, are a means of solution of important theoretical and practical hydrological problems. On the basis of the water balance approach, it is possible to make a quantitative evaluation of water resources and their change under the influence of people's activities. The study of the water balance structure of lakes, river basins, and ground-water basins forms a basis for the hydrological substantiation of projects for the rational use, control and redistribution of water resources in time and space (sokolov & chapman, 1974).
Water balance equation could be described as follows (WRP, 1989);

$$P = ET + Q + L + \Delta WS + \Delta G \qquad (2.4.1)$$

Where:

P is amount of rainfall a basins

PET is potential evapotranspiration estimate

Q is runoff

L is diffusion depth (seepage)

ΔWS is soil humidity reserve change

G is underground water reserve change

In this report of Sungai Tekam Experimental basin, L is value deserted, while ΔWS is value and ΔG is unconsidered. Equation (2.4.1) simplifies to (WRP, 1989);

$$P = PET + Q \quad (2.4.2)$$

Refer to study of Zhang, et al.(2001) that also found, if basin area have limited sources of water (Water tight) and topography division (topographic divide) overlap with underground water division (groundwater divide), after a timeframes that long (5 to 10 years), it is no reasonable to presume underground water reserve change (G) and soil humidity reserve change (WS). As such, together ET with rain (P) and runoff (Q) control water readiness in earth surface (McCabe and Wood, 2006).

For the study equation above changed by regard various factors at basin of water loss:

$$P - PET = Q \quad (2.4.3)$$

In Peninsular Malaysia, Goh (1974) have used equation (2.4.3) to produce a map rain-potential evapotranspiration (P-ETO) and compare it to the specific outflow (specific charge it) annual average flow stations (flow station) available. The data used are for the period July 1950-June 1965 (annual average P), July 1950-June 1965 (average annual outflow specific) and 1928-1958 (annual average ETO). It was found that the method of estimating P-ETO less (under-estimate) of water resources in some basins. Meanwhile, Teh et al., (1976), a study to improve the study Goh (1974) by using the water balance for the period 1959/1960 to 1969/1970. The results indicate, the estimated average annual runoff obtained from the map of water resources there is a similarity with the observed values of the average of the record water level and outflow