ASSESSMENT OF CLIMATE CHANGE IMPACTS ON WATER YIELD IN PAHANG RIVER BASIN

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ABSTRAK

Perubahan iklim juga dikenali sebagai pemanasan global, merujuk kepada kenaikan purata suhu permukaan di Bumi. Objektif utama kajian ini ialah menilai kesan perubahan iklim ke atas hasilan air di Lembangan Sungai Pahang. Bagi mencapai objektif kajian yang utama, kajian spesifik telah dilakukan seperti berikut; menganalisis hasilan air, dan kesan perubahan iklim ke atas hasilan air di Lembangan Sungai Pahang. Hasilan air dianggarkan dengan analisis imbangan air yang mudah, iaitu curahan hujan sebagai input dan sejatpeluhan sebenar sebagai output. Dalam kajian ini, hujan bulanan yang diperolehi daripada Hujan Tropical Mengukur Misi Multi-satelit Analisis Pemendakan (TMPA) yang diperolehi daripada domain awam, sementara itu sejatpeluhan sebenar adalah anggaran menggunakan bio-fizikal indeks berasaskan (iaitu Perbezaan Ternormal Indeks Tumbuhan (NDVI)). Analisis bagi tahun 2015 dan 2016 terjejas oleh *El Nino*, menunjukkan curahan hujan semakin berkurangan berbanding dengan yang diterima kebiasaanya di rantau ini. Oleh itu ia menghasilkan kurang hasilan air. Sementara itu bagi tahun 2011 dipengaruhi oleh *La Nina*, menunjukkan curahan hujan semakin meningkat, oleh itu peningkatan dalam hasilan air. Keputusan kajian ini menunjukkan perubahan iklim memberi kesan ketara kepada lembangan hasilan air. Dengan itu untuk mengekalkan sumber air, pihak berkuasa perlu membina takungan yang sesuai di mana air boleh digunakan semasa musim kemarau.

ABSTRACT

Climate change also called global warming, refers to the rise in average surface temperatures on Earth. The study main objective were assessing the climate change impacts on water yield in Pahang River Basin. To achieve the study main objective, the specific study were performed as follows; analyse the water-yield, and the impacts of climate change on water yield in Pahang River Basin. The water-yield estimated with simple water-balance analysis, which is rainfall as input and actual evapotranspiration as output. In this study, monthly rainfall derived from the Tropical Rainfall Measuring Mission Multi-satellite Precipitation Analysis (TMPA) satellite image obtained from public domain, meanwhile the actual evapotranspiration estimated using satellite-based biophysical index (i.e. Normalized Difference Vegetation Indices (NDVI)). Analysis for year 2015 and 2016 affected by *El Nino*, shows rainfall is decreasing compare to typically receive by the region. Therefore produce less water-yield. Meanwhile for 2011 affected by *La Nina*, shows rainfall is increasing, hence water-yield increase. The results of this study shows climate change give significant impact to the basin water-yield. Thus to maintain water resources, the authorities need to build appropriate reservoirs which the water could be use during droughts.

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LIST OF SYMBOLS

c	Offset value
ET	Evapotranspiration
L	Depth
m	Coefficient value equal to 0.9
P	Precipitation
Q	Runoff
x	Bias coefficient
y	Calibrated TRMM data set
ΔG	Changes in groundwater storage
ΔWS	Changes in soil moisture storage

LIST OF ABBREVIATIONS

AET	Actual Evapotranspiration
ET	Evapotranspiration
GIS	Geoghrapical Information System
GOES	Geostationary Operational Environmental Satellite
GRACE	Gravity Recovery And Climate Experiment
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
MMD	Malaysia Meteorological Department
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NDVI	Normalized Differential Vegitation Index
NIR	Near Infrared
SEBS	Surface Energy Balance System
SHE	Systeme Hydrologique Europeen (European Hydrological System)
SWM	Stanford Watershed Model
TMPA	TRMM Multi-satellite Precipitation Analysis
TRMM	Tropical Rainfall Measuring Mission
UNFCCC	United Nation Framework Convention on Climate Change
WS	Water Surplus
WWF	World Wildlife Fund

CHAPTER 1

INTRODUCTION

1.1 Research Background

Water is one of the natural resources that are most important to all living things. Water also used for transportation, power sources, and many other useful purposes for domestic consumption, agriculture and industry. The main source of water for tropical country such as Malaysia is rainfall. There are three type of rainfall in Malaysia which are convectional, orographic, and monsoon. Excessive and prolonged absence of rainfall will cause droughts and floods, respectively. Malaysia yearly rainfall is 2500mm (Ranhill et al., 2012).

Recently, water tends to be limited and there are situations where water is always in short supply in some areas, especially due to the climate change. El Nino and La Nina are climate change phenomenon that often associated with water-yield. In 1997, Peninsular Malaysia experienced the El Nino phenomenon, and the occurrence of a long drought due to decrease of rainfall. The worst haze in the history of contamination that hit Southeast Asia in June until October 1997 (Penawaracun, 2002) is not just a coincidence but the impact of El Nino brought dry conditions in the region and combined with negligence management of human caused forest fires, including the use of machinery vehicles cause air pollution and at the same time, El Nino brought the worst water crisis in 1997 that has led to the Durian Tunggal Dam, Melaka dried up and lack of water supply.

1.2 Problem Statement

Climate change is not only about the temperature change. The overall water cycle is adversely affected. A warmer earth gives a meaning that the atmosphere has a capacity to hold moisture better. Thus there is a change in the amount of rainfall, water vapour, and water circulation in the atmosphere (Chahine, 1992). Rainfall is the water source of all basins.

El Nino with recorded temperatures up to over 36 degrees Celsius in Temerloh district have made Pahang River witnessed a remarkable low water level (Sinar Harian, 2016). A river water level able give a water-yield status of a water basin. However, in simple water balance relationship, water-yield for the entire basin could be estimated using rainfall data (input) and actual evapotranspiration (output). The information of water yield is very important for conservation planning and monitoring of the security of the water resource.

Since, climate change and land use are eco-hydrological responses that affect the space and temporal variability of information on the water yield (Brauman et al., 2007), a study should be conducted to assess the impacts of climate change on water yield.

1.3 Research Objective

The main objective in this study will be to assess the climate change impacts on water yield in Pahang River Basin. To achieve the main objective, the specific objectives will be as follows:

i. To analyse the water-yield in Pahang River Basin, and
ii. To analyse the impacts of climate change on water yield in Pahang River Basin.

1.4 Scope of Study

This research study considers the following conditions:-

i. Study area will be in Pahang River Basin
ii. Study conduct for period of 16 years (January 2000 until August 2016)
iii. This study uses rainfall data based on satellite based rainfall TRMM
iv. This study use Normalized Differential Vegetation Index (NDVI) satellite images obtained from the public domain to publish actual evapotranspiration (AET)

1.5 Research Significance

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. This research is aim to realize that both satellite based data is a simple technique to get the information and data faster. This research also to provide information to the water resource management about the water yield data.

1.6 Thesis Structure

The thesis is divided into five (5) chapters. Chapter One describes the background and objective of the study. While Chapter Two, looking back at the previous research studies related to the review of progress. In Chapter Three, the water yield study described the process of determination of the distribution of the monthly rainfall data and monthly AET based on satellite images, which will be a key component of the water balance analysis. Furthermore, the determination of the distribution of water yield and information accuracy analysis effected. The publication of a map of the distribution of rainfall, AET, water yield information and validation with previous reports are shown and explained in Chapter Four. Chapter Five is the conclusion of the study and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water yield is the amount of water resource availability or the difference between rainfall and loss of water (it is evapotranspiration) (Langbeindan Kathleen, 1995). Brauman et al. (2007) also defines that resource availability for runoff and soil water storage or groundwater after deducting for evapotranspiration. Based on HyperDictionary (2009), the water yield is known as water runs out the whole or part of the basin (or region) either by surface or sub-surface aquifer in a given time period (example one year). Meanwhile, the combined runoff is the river runoff discharges, runoff and groundwater runoff. For a small basin, the river runoff measurement give accuracy of the water yield, which is also the result of a combination of meteorological and hydrological processes in the basin.

Although the basin ecological systems does not produce its own water, it is able to change the amount of water through the landscape of the basin (Brauman et al., 2007). A quantitative assessment of the product information and water changes, the climate change affect and human activities, can be done using a basin of water balance analysis. Furthermore, the assessment of water resources to the provinces, regions and continents can be obtained (Sokolov and Chapman, 1974). Water balance analysis provides a good framework to study the hydrology of the area based on the studies by previous researchers. Imbalance that exists, leading to the identification and description of hydrological processes and better measurement techniques. Ideally, each component (example rainfall, AET, runoff and water storage changes) for the balance of the water should be measured. When each component is determined, the rest of the issue is the deviation of the water balance of zero. However, the measurement is limited to the main component (which are rainfall and AET), also can produce sufficient results for many purposes that violate the water yield, predicting the effects of changes in land use land cover on the water and climate change (Arnell, 1992; Gleick, 1987 a, b).

In addition, various hydrological models derived from the water balance equation. Hydrological model is a mathematical model to transform input elements such as rain water runoff or runoff river discharges. It can be a model concept which is simple to a complex physical. Rainfall-runoff model has been used for a variety of uses, to estimate the impact of the water basin of the characteristics as a result of changes in land use land cover and climate change (Singh and Frevert, 2002). The model is calibrated in the basin which has a record of river runoff discharge. Then, the model is used to estimate the changes in the basin of water and water that does not have a runoff rate of discharge. Two zoning procedures commonly used, first, to the nearest basin model, and second, the basin model that has the similar characteristics are used as reference for predicting the changing landscape of the basin system that does not have any information.

Furthermore, the use of satellite image data as a source of information on the two main components of the input (rainfall) and output (AET) will be considered for further details on the determination of water yield in this study. For the purposes of the study, literature review is divided into three main sections for the purposes of this study. There are, first, determination of water by water balance analysis and the effects of changes in climate change, second rainfall from satellite imagery data, and third determination evapotranspiration (AET) of satellite image data.

2.2 Determination of Water Yield With The Water Balance Analysis And The Impacts of Climate Change

Water balance analysis has been utilized for an assortment of uses, to evaluate from basins water yield and the effect on its characteristics as a result of changes in cover and land use and climate change.

2.2.1 Hydrological Cycle And Water Balance Analysis

Water balance is water represents a basin, locale or the entire world, considering the hydrological cycle quantitatively. In the hydrological cycle, rainfall that achieves the ground surface (example, irrigation, rivers, lake) will be the surface of water, or separated to invade into the soil moisture or groundwater storage. Next is discharged into the atmosphere through evaporation (from the soil surface, lake, river, sea) and transpiration (by plant). Precipitation is circulated to the hydrological segment (example, runoff, soil moisture, groundwater) relies on upon the space and temporal variability of precipitation and surface qualities (Figure 2.1).

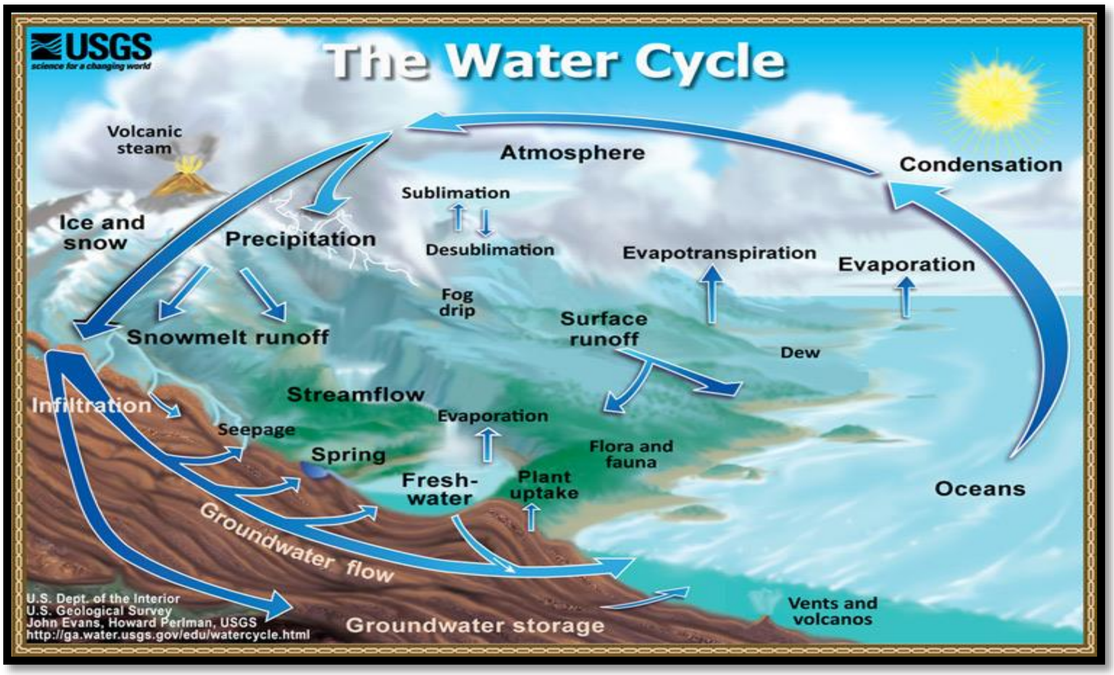

Figure 2.1: Hydrological Process
Source: Perlman (2016)

The general equation of hydrology is defined as the water balance, which is the lawful statement of hydrological time everlasting mass (law of conservation of mass) as utilized as a part of the hydrological cycle. The equation is (Sokolov and Chapman, 1974);

$$\text{Inflow} = \text{Outflow} + \text{Changes of storage} \qquad 2.1$$

In hydrology, water balance equation can be used to clarify water flow in or out of a system. There are four (4) characteristics as follows;

i. Water balance can assess the hydrological cycle in any sub-system, at any depth and any duration.
ii. Water balance can be either all components of the flow and savings involved were taken into account quantitatively.

iii. Water balance can compute the obscure segments of the water balance equation, when alternate parts are as of now known with great precision.

iv. Water balance can be utilized as a model for the complete process hydrology. This means it can be used to predict the effects of changes to the components on other components in a system or sub-system.

With the components delineated above, the water balance is an approach to address a vital issue in theoretical and practical hydrology. Empowering quantitative evaluation of water resources and changes in water resources because of human activities is in view of the water balance analysis approach. The most recent information on the water balance of the rivers and lakes for a short period (monthly, week of the season, and daily) is utilized for the operational management of water storage and hydrological estimates for water management (Sokolov and Chapman, 1974).

Water balance equation can be described as follows (Sokolov and Chapman, 1974; UKRAINE, 1989);

$$P= ET+ Q+ L+ \Delta WS+ \Delta G \qquad 2.2$$

Where: P is precipitation, ET is evapotranspiration, Q is runoff, L is depth or inactive groundwater, ΔWS is the changes in soil moisture storage and ΔG is changes in groundwater storage.

The segments that are included in water balance equation relies on upon two (2) of the following; 1) the duration and 2) flow domain. The water balance is constantly assessed in the yearly average, the calendar year or calendar year hydrology. Flow domain is partitioned into two (2), to be specific, a) that the domain comprises of physical elements, (for example, river basins), and b) the flow domain that has just a couple of physical element, (for example, irrigation schemes).

The basin boundary covers with underground water part which is in the river basin. Dividers considered impenetrable limits, no underground water crossing the divider. Water impermeable boundaries has forestalled practically land surface groundwater out, makes all the water from the river basin flows as the flow at the outpouring of the river basin. Taking the timetable year, water storage changes are immaterial. As per UKRAINE (1989), the value of L is irrelevant, while the ΔWS and ΔG not considered. Equation (2.2) is easy to;

$$P= ET+Q \qquad 2.3$$

If the basin has restricted water resources (water tight) and the division of topography (topography divide) overlap with the dispersion of underground water (groundwater partition), after a long stretch (5 to 10 years), it is sensible to consider the progressions of groundwater storage (ΔG) and changes in soil humidity stoarge (ΔWS) is there (Zhang et al. 2001). In this way, ET together with precipitation (P) and overflow (Q) control the accessibility of water in the Earth's surface (Wood and McCabe, 2006). Vulnerability in water balance for the following sub-basin and basin is a precise estimation of ET real impact (Cleugh et al., 2007). It likewise provides information relating with the management of water resources; i) the utilization of water resources, and ii) water efficiency of water use in the production of biomass per unit of water (Steduto et al., 2007).

2.2.2 Hydrological Model

The term hydrology can be dealt with as an imperative subject for the people and their environment. It treats water of the earth, their circulation and distribution, occurrence, their chemical and physical properties and their reaction with the environment including their relation to living things (Ray 1975). The relationship of water with the environment inside each period of hydrologic cycle likewise manages it. Different changes have been happened in hydrologic cycle because of quick urbanisation and industrialisation including land cover change, deforestation and irrigation. Alongside climate change, soil heterogeneity has additionally got an immediate effect on the releases of numerous rivers in and around the globe. With a specific end goal to discover these varieties, distinctive hydrologic phenomena and hydrologic cycle are to be completely considered. Presently days, to discover the effect of atmosphere and soil properties on hydrology and water resources, different hydrological models have been produced over the world. Each model has got its own particular remarkable qualities. The sources of info utilized by various models are air temperature, hydrogeology, precipitation, topography, soil characteristics, vegetation and other physical parameters. Every one of these models can be connected in extremely unpredictable and vast basins.

A model is a simplified portrayal of certifiable systems indicated by Sorooshian et al. (2008). The one which give comes about near reality with the utilization of minimum parameters and model many-sided quality is the best model. Models are fundamentally utilized for anticipating system behaviour and understanding different hydrological forms. A model comprises of different parameters that characterize the model. An arrangement of equations that aides in the estimation of runoff as an element of different parameters utilized for depicting watershed attributes is characterized as a runoff demonstrate. The rainfall data and drainage area are two vital sources of info required for all models. Alongside these, watershed characteristics like vegetation cover, soil moisture content, soil properties, watershed topography and qualities of ground water aquifer are likewise considered. Hydrological models are presently a day considered as a vital and fundamental apparatus for water and environment resource management.

Based on model input and parameters and the extent of physical principles applied in the model, rainfall-runoff models are classified. It can be named lumped and distributed model in view of the model parameters as an element of space and time and deterministic and stochastic models in light of the other criteria. Deterministic model will give same output for single set of input values of though in stochastic models, diverse estimations of output can be created for a single set of inputs. As indicated by Moradkhani and Sorooshian (2008) in lumped models, the whole river basin is taken as a single unit where spatial inconstancy is ignored and thus the output are produced without considering the spatial procedures where as an appropriated model can make forecasts that are circulated in space by isolating the whole catchment into little units, typically square cells or triangulated sporadic system, so that the parameters, inputs and outputs can vary spatially. Static and dynamic models in light of time component is another order. Static model reject time while dynamic model incorporate time. The models as occasion based and persistent models is classified by Sorooshian et al. (2008). The previous one create output just for particular eras while the last delivers a persistent output. A standout amongst the most imperative orders is observational model, theoretical models and physically based models.

Empirical model (metric model) is perception arranged models which take just the data from the current information without considering the elements and procedures of hydrological system and hence these models are additionally called data driven models. Mathematical equations got is included from simultaneous concurrent input and output time and not from the physical procedures of the catchment. These models are legitimate just inside the limits. An example of this method is unit hydrograph. Factually based strategies utilize regression and correlation models and are utilized to locate the utilitarian connection between inputs and outputs. Simulated neural system and fuzzy regression are a portion of the machine learning procedures utilized as a part of hydro informatics strategies.

All of the component hydrological processes is described in conceptual model (parametric model). It comprises of various interconnected reservoirs which represents to the physical components in a catchment in which they are revived by infiltration, rainfall and percolation and are purged by runoff, evaporation, drainage and so on. This technique is utilized semi empirical equations and the model parameters are surveyed from field data as well as through calibration. Huge number of meteorological and hydrological records is required for calibration.Curve fitting is included in the calibration which makes the interpretation difficult and hence the impact of land used change cannot be anticipated with much certainty. Fluctuating level of many-sided quality has created numerous calculated models. The first major theoretical model created by Crawford and Linsley in 1966 with 16 to 20 parameters is Stanford Watershed Model IV (SWM).

Physically based model is a mathematically idealized portrayal of the real phenomenon. These are likewise called robotic models that incorporate the standards of physical procedures. It utilizes state factors which are quantifiable and are elements of both time and space. Finite difference equations are respresented the hydrological processes of water movement. Extensive hydrological and meteorological data for their alignment is not required but rather the assessment of substantial number of parameters depicting the physical qualities of the catchment are required (Abbott et al. 1986 a). Huge amount of data in this method such as initial water depth topology, soil moisture content, topography, measurements of river network and so on are required. Physical model can conquer many imperfections of the other two models in light of the utilization of parameters having physical translation. It can give substantial measure of data even outside the limit and can connected for an extensive variety of circumstances. SHE/MIKE SHE model is an illustration. (Abbott et al. 1986 a, b).

2.2.2.1 Calibration Model

Rainfall-runoff model is spoken to in basic genuine, which implies that the parameters are the total of the hydrological basin utilizing the differing qualities procedure of observational relations (Beven et al., 1995). Thusly, all models (either basic or complex physical idea) which is generally with the information measured in the field to distinguish fitting model parameters with the given (Beven and Binley, 1992). This is on the grounds that there is no estimation strategy that permits coordinate estimations and assessments for parameter values on the scale required by the model (Kleme, 1983; Abbott et al., 1986). There are two orders of existing model parameters, i.e. parameters calibration emerging in the experimental relations and calibration from data climate and runoff data, measured, and physical parameters-based basically measured or evaluated specifically from the estimation in the basin. Limitations of utilizing physical-construct parameter is the reliance in light of the scale and nature of this parameter data acquired (Beven, 1989). The concentration of the talk in this area was at adjustment parameters. The fundamental explanations behind calibration model are three: to consider the effect of hydrological conditions in certain sub-basin, to alter the inclination in climate data for example, measurement error rain, variability space and temporal), and above all, to consider the physical qualities of the basin (land and plants) which is not exceptionally uniform and essentially not or if nothing else less known (Blöschl, 2006).

Have regularly proposed or inferred in the writing audit that the information utilized for the hydrological model ought to speak to calibration different wonders experienced by basin (Beven and Binley, 1992). In perspective of the restrictions of the data river runoff, and in addition the limitations of the structure of the model, it is regularly hard to accomplish one of a kind arrangements (Beven, 1993).practically speaking, atmosphere and river runoff important to discover appropriate parameters for existing conditions in basin, frequently not solid. River runoff data can have a record of lost and short, notwithstanding the impacts of advancement (for instance, dams or water system frameworks) to be considered before utilizing a model intended to reenacted characteristic state, while precipitation information might be uncommon, or entirely untrustworthy in light of the fact that mistake estimations.

According to M I Ali (2014), the equation for TRMM monthly rainfall have been calibrated using equation below:

$$y = mx + c \qquad 2.4$$

Where y is calibrated TRMM data set= 0.9, x is bias coefficient, and c is offset value=7.9094 0.9x + c, (R^2= 0.71, P<0.0001, n=1337).

2.2.2.2 Validation Model

The term validation is notable in hydrology and environmental modelling and is normally used to demonstrate a technique gone for breaking down execution of simulation and/or forecasting models. The term validation has a broader meaning including any process that has the goal of verifying the ability of a procedure to accomplish a given scope in the scientific context. For instance, it can demonstrate the verification of a preliminary hypothesis or the security appraisal of a computer network.

In hydrological modelling, the need for agreed and standardised validation protocols has become progressively more urgent. Indeed, over the most recent 30 years, hydrologic modelling has been enormously enhanced on account of the expanding accessibility of computational resources, the advancement in the process understanding and also the accessibility of spatially conveyed data, essentially given by remote sensors (Smith et al., 2004). The scientific literature persistently proposes new, refined sophisticated modelling gone for repeating the hydrological cycle at numerous scales (example, field, watershed and even global scale) and for a few goals, including research-situated targets, for example, propelling the information of physics of water movement, and more practical scopes, similar to water resources assessment, flood protection and design of civil infrastructures. These numerical models embrace approaches and computational plans that might be broadly unique. Therefore, validation conventions are required to (i)facilitate model inter-comparison, (ii) enhance improvement of superior models, and also their coupling and joining with data assimilation plans, and (iii) help forecast clients advance their decision making.

Another imperative explanation behind creating standard validation criteria is the progressive mismatch between the complexity of modelling tools and the limit of models and experts to thoroughly survey the unwavering quality of modelling application (Hug et al., 2009). This trouble is exacerbated by the absence of adequately instructive information. For instance, measured factors are regularly point values while simulated factors are often found the middle value of in time as well as in space. In addition, measured factors are influenced by instability because of the monitoring technology (e.g., Di Baldassarre and Montanari, 2009). The issue with information accessibility and instability has been highlighted since the main ways to deal with environmental modelling validation and has regularly constrained the likelihood to receive systems effectively utilized as a part of other logical orders (Santhi et al., 2001).

2.2.3 Determination of Water Yield of the Study Area

Water information items issued from P-AET relationship map in the study area. The water yield of a watershed may either be measured specifically on a single outlet on the standard or be computed through empirical equations in light of essential physical properties of a specific watershed. Utilizing the straightforwardly measured runoff values is, obviously, the most ideal path, however since it takes quite a while and speculations are deferred, the experimental technique is favoured in applications. Consequently, exact expectation of the water yield from a watershed is crucial for design capacity of water collecting structures and other hydraulic structures on the down streams.

2.2.4 Determination of Water Yield using Remote Sensing Technique

Remote sensing is the exploration of getting information about objects or areas from distance, typically from aircraft or satellites. Remote sensors gather information by recognizing the vitality that is reflected from Earth. These sensors can be on satellites or mounted on aircraft. Remote sensors can be either passive or active. Passive sensors react to outside stimuli. They record characteristic vitality that is reflected or discharged from the Earth's surface. The most widely recognized wellspring of radiation distinguished by inactive sensors is reflected sunlight. The output of a remote sensing system is typically an image speaking to the scene being observed. A further stride of image analysis and interpretation is required keeping in mind the end goal to extricate useful information from the image. The human visual system is a case of a remote sensing system in this general sense. Bastiaanssen and Chandrapala (2003) utilizes a mix of information distribution of rainfall and water flow rates rates from field estimations and satellite image data Moderate Resolution Imaging Spectroradiometer (MODIS) and the Surface

Energy Balance Algorithms for Land (resentful) to create data AET. Droogers et al. (2009), utilizing a water balance analysis of the segments of rainfall, groundwater AET and each of the TRMM satellite image data, MODIS and resentful algorithms and Gravity Recovery And Climate Experiment (GRACE).

2.2.5 Impacts of Climate Change on Water Yield

Global climate change is typically connected with an expansion in global temperature, also called a global warming. It is a sign or indication of rising temperatures well over the surface of the land, the sea, or a blend of both by and large. Climate change allutes to the variety of the Earth's global climate or in local atmospheres after some time. As indicated by United Nation Framework Convention on Climate Change (UNFCCC), climate change is brought about straightforwardly or in a roundabout way to human activities that adjusts the piece of the global atmosphere. The expansion in global temperature since the twentieth century is likely because of the increment in anthropogenic greenhouse gas emissions from fossil fuel combustion and conversion of forests, The Intergovernmental Panel on Climate Change (IPCC 2007). Climate change is genuine and happening now. The planet is now encountering its consequences for biodiversity, freshwater resources and local life (WWF, 2006).

Areas where the drought that has happened appear to be ready to be resolved for the most part by changes in temperature and sea level, particularly in the tropics, through a related changes in air circulation and precipitation. According to Adams (2008), the primary driver of drying pattern is a decrease in land precipitation over the most recent couple of decades, regardless of a gigantic surface warming amid the previous 2-3 decades may have added to the drying. Water is significant for domestic uses, as well as for its part in supporting aquatic ecosystems and environmental amenities, including recreational open doors, and as consider of production in irrigated agriculture, hydropower production, and other modern uses (Young, 2005).

According to MMD, the presence of El Niño moderate or strong, distribution rainfall in Sabah and Sarawak will be well below the average level during the southwest monsoon (June-August) and the northeast monsoon (November to February), but in Peninsular Malaysia, the distribution rainfall is below the average level during the southwest monsoon (June-August). Weak El Niño conditions are identified to have minimal impact on rainfall in Malaysia. Furthermore, rainfall below and above average can also occur in the years that El Niño / La Niña do not occur.

2.3 Determination of Distribution of Rainfall by Using Satellite Image Data

Rainfall is the most essential compelling data for hydrological models and prime need of life on Earth. To stimulate the water cycles over hilly locales with no or sparse rainfall gauge station systems, it is exceptionally difficult for hydrologists, particularly over complex hilly terrain or remote ranges. The utilization of satellite imagery is of awesome significance in meteorology and climatology applications. The present system for rainfall monitoring the world over by ordinary means is inadequate in numerous ranges, particularly if rainfall data are required in 'near real time', on the grounds that many rain gauges by and large give information on an everyday or month to month premise.

A few methods for rain estimation have been created over the most recent 30 year. Some of them are utilized for climatological purposes and rainfall gauges for a 12 or 24 hours time frame are made, weighting cloud type and area by local climatology coefficients (Barrett 1970, 1973, Follansbee 1973). Kilonsky and Ramage (1976) determined monthly evaluates over the Pacific Ocean by depending on the way that there was a high connection between's the quantity of days with very intelligent mists and monthly rainfall. Moreover, a few methods have been produced for evaluating ongoing precipitation. For instance, Scofield and Oliver (1977) and Scofield (1987) analyzed successions of half-hourly images from GOES and registered the precipitation in the convective framework. Tsonis and Isaac (1985) built up a strategy for quick rain-range depiction utilizing GOES data. Seze and Desbois (1987) discovered 9 cloud classes utilizing bunch investigation in a 4-dimensional space,obvious, infrared, fluctuation of noticeable and change of infrared and each group was related with one cloud class. The vast majority of the techniques depend on the utilization of noticeable and infrared channel.

Recently many satellite-based precipitation algorithms have been created (Ba and Gruber, 2001). These algorithms create precipitation items comprising of higher spatial and temporal resolution with potential to be utilized as a part of hydrologic research and water resources applications. Assessment of as of late created precipitation items over different areas is continuous (Ebert, 2004; Kidd, 2004; Janowiak, 2004).

2.4 Determination of Distribution of AET by using Satellite Image Data

Remote sensing can help with enhancing the estimation of the topographical distribution of evapotranspiration, and consequently water demand in huge developed regions for water system purposes and maintainable water resources management. The worldwide vitality adjust considers the energy flows inside the climate system and their trades with space. In numerous publications and textbooks, the worldwide mean vitality adjusts are noticeably highlighted through notable graphs. However, the real numbers speaking to the energy flow in the different pictures display extensive changes.

Evapotranspiration is one of the principle parts of the water cycle and the significance of its precise estimation is self-evident, be that as it may, this is hard to accomplish by and by in light of the fact that actual evapotranspiration cannot be measured straightforwardly and fluctuates impressively in time and space. For this reason, the estimation of actual evapotranspiration at provincial scale has been broadly considered as of late by consolidating traditional meteorological ground estimations with remotely-sensed data. A few strategies for evaluating evapotranspiration have been produced at different spatial and worldly scales. These strategies fluctuate in intricacy from statistical / semi-empirical direct ways to deal with more expository methodologies with a physical base, lastly to numerical models simulating the heat and water flux through the soil, the vegetation and the atmosphere (Kustas and Norman, 1996).

Remote sensing has various points of interest for estimation of hydro-meteorological factors including ET over vast ranges (Kite and Pietroniro, 1996), as remote sensing data give a superior portrayal of surface heterogeneity contrasted with point gauges gotten from local meteorological station information. Remote sensing data have preferred availability over the conventional meteorological data, and are accessible at no cost from information suppliers by means of web. With such focal points, Su (2002) recommended that surface vitality adjust formulae could be utilized to evaluate AET utilizing remote sensing data as sources of info, and created Surface Energy Balance System (SEBS) to gauge AET. In this strategy, leaf area index, surface temperature and surface albedo, which are altogether evaluated from remote sensing data were utilized as contributions to surface vitality adjust formulae with couple of meteorological factors, for example, air temperature, wind speed, every day normal ground radiation (daylight hours) and vapour pressure shortage acquired from ground estimations.

However, ground measured data on these meteorological factors, particularly wind speed, daily ground radiation and vapour pressure are not accessible for some zones on the planet. Therefore, it is important to get information for these factors through option sources, for example, the unreservedly accessible worldwide meteorological databases of IWMI climate and water map book and the University of East Anglia climate dataset, where these information are promptly accessible in different spatio-temporal scales over nation, area and worldwide levels (New et al., 2002). By and large these databases are top notch items with a higher spatial determination however regularly with a lower fleeting determination. The IWMI atmosphere and water map book was produced in light of the gathered meteorological information on a worldwide scale. It has been broadly utilized for local and worldwide scale applications, yet still cannot seem to investigate the appropriateness for water catchments. The review portrayed in this paper concentrates on assessing AET utilizing remote sensing data and other freely accessible information items, (for example, IWMI atmosphere and water atlas).The extreme point of this venture is to utilize these AET qualities to produce stream flow utilizing remote sensing data for catchments where meteorological information are not accessible. The surface vitality adjust framework (Su, 2002) was utilized as a part of this review to gauge day by day AET, as it has a self-alignment component which can be utilized to maintain a strategic distance from the dull manual adjustment.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Chapter three is starting with the focus of this research. In this part the research methodology utilized as a part of the review is portrayed. The geographical zone where the study was directed and the study outline. The instrument used to gather the information, including strategies executed to keep up legitimacy and dependability of the instrument, are portrayed. In light of Rajasekar et al. (2013), research is essential both logical and non-logical fields where researchers must do explore on issue happened with a specific end goal to discover their causes, arrangements and clarification.

3.2 Study Area

The Pahang River basin is located in the Malaysia Peninsula between latitude 2° 48'45" - 3° 40' 24"N and longitude 101° 16' 31"- 103° 29' 34"E. The basin has a total area of 27000km2. The length of the river is estimated to be 440 km and it is a confluence of the River Jelai and River Tembeling from the upstream which join together at Kuala Tembeling, about 304 km from the river mouth at the east coast of Pahang state (Muhammad, 2007).

River Jelai is one of the two main tributaries which drain from the eastern slope of Mountains Banjaran and Titiwangsa, the foot of Central mountain range. The Central Mountain ranges is the largest mountain in the Malaysia Peninsular and separates the Peninsular into an eastern and western. River Tembeling originates from the Besar Mountain Range in the Northeast of the basin. For the purpose of fixing its length, however, the Tembeling and Pahang are considered as one river (Takeuchi et al., 2007). Other main tributaries of the River Pahang are Semantan, Teriang, Bera, Lepar, Gelugor, and Chini. The two main natural reservoir sites in the basin are Lake Chini and Lake Bera. Lake Chini is surrounded by variously vegetated low hills and undulating lands which constitute the water-shed of the lake and drains north easterly into Pahang River via the Chini River (Muhammad et al.,1998). Lake Bera is located at the southwest in the basin and is the larger of the two lakes via area. It is shallow and seasonal flowing into the River Pahang via River Bera. This lake plays an important role in flood control, water flow regulation and also provides natural resources for local community. Hence, it is protected under the international Ramsar Convention, which was declared in November 1994 (Takeuchi,et al 2007). However the lake is under threat of drying up in the near future as the water source disappears due to in-creasing conversion of natural forests to palm oil plantations, excessive siltation, and soil erosion caused by uncontrolled logging activities in the area (Takeuchi et al., 2007).

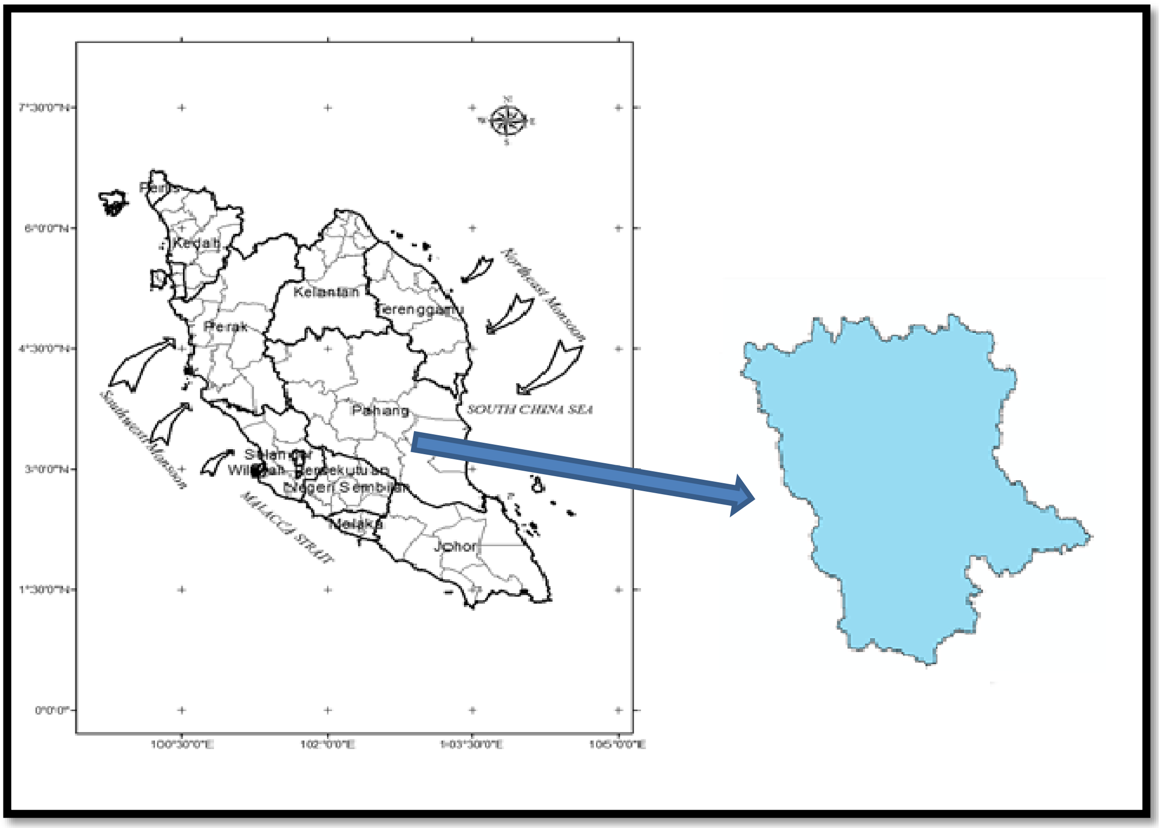

Figure 3.1: Pahang River Basin

3.3 Flowchart of Methodology

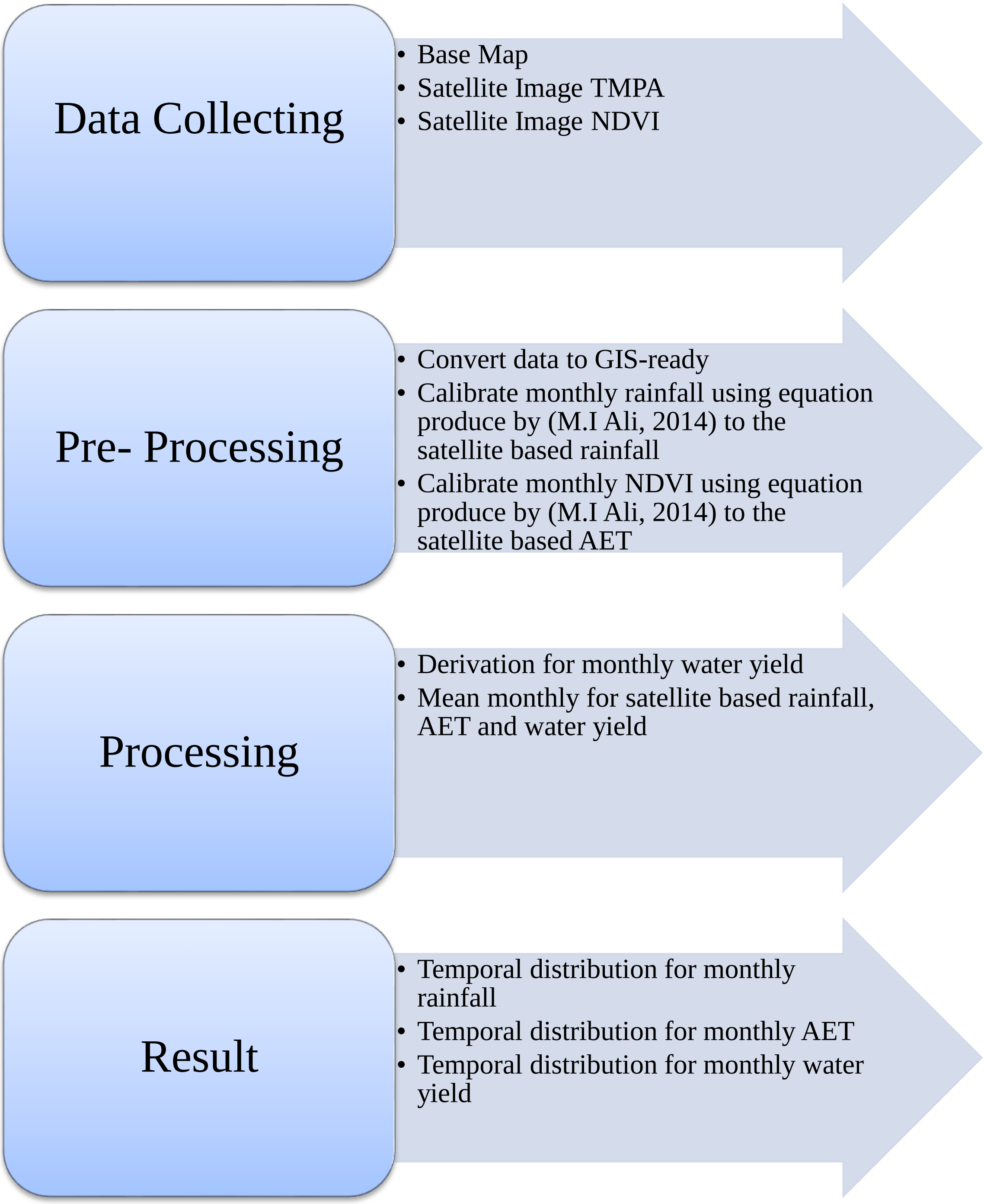

Figure 3.2: Flowchart of methodology

3.4 Data Collecting

Data for Pahang River Basin map, satellite-based rainfall and satellite-based biophysical index (i.e. Normalized Difference Vegetation Indices (NDVI) were collected by using public domain. There were two datasets used in this study, TRMM Multi-Satellite Precipitation Analysis (TMPA) satellite-based rainfall (Figure 3.2), and satellite-based biophysical index (i.e. Normalized Difference Vegetation Indices (NDVI).

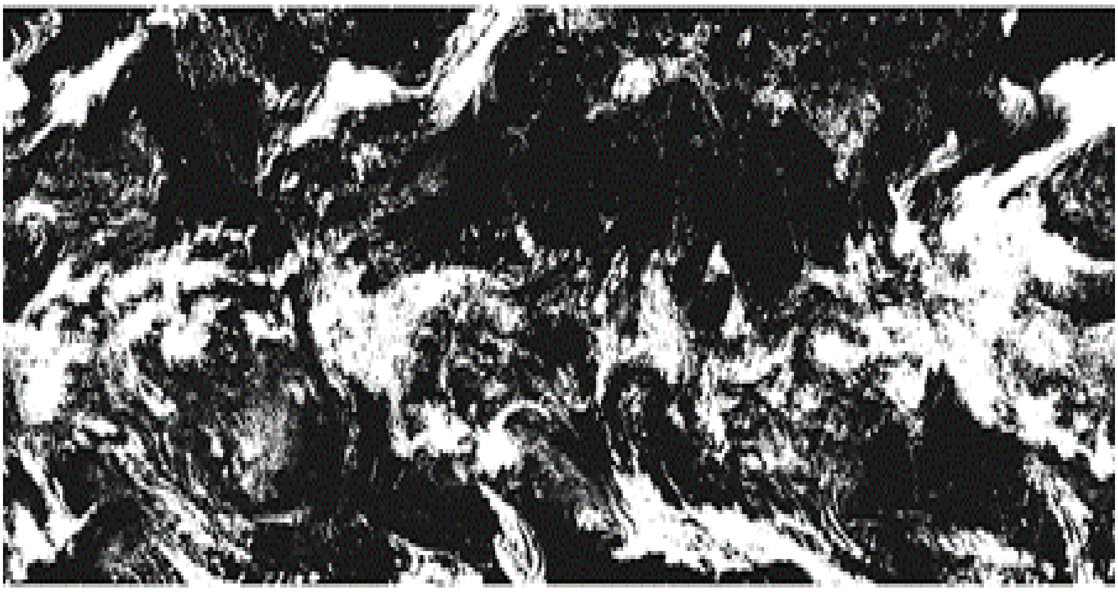

Figure 3.3: TMPA satellite-based rainfall

3.4.1 Satellite Image TMPA

Public domain archives (NASA) has provided satellite-based TRMM rainfall data. It has provided a wide range of rainfall data products processed with various types of algorithms in form of distribution of daily and monthly rainfall data. This study also used satellite image TMPA .Satellite image TMPA rainfall data is provided the archive database in the form of raster data model. The data series can be obtained by downloading cost for the user. The monthly rainfall distribution data and AET are used at an interval of period of (January 2000 until August 2016).

3.4.2 Satellite Image NDVI

Reto Stokli, NASA’s earth observatory team (NASA, 2010c) has provided the satellite image NDVI data. By using the data provided by Modis Land Science Team for the period 2000-2010 (NASA, 2010a), satellite image NDVI data is published. NDVI maps are being used in forestry, agriculture, ecology and more. Healthy vegetation (or chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths. It absorbs more red and blue light. NDVI uses the NIR and red channels to measure healthy vegetation. It generates a value between -1 and +1. If low reflectance (or low values) in the red channel and high reflectance in the NIR channel, this will yield a high NDVI value. And vice versa. It is really using the difference between these two bands to output a standardized way to measure healthy vegetation. When the NDVI values is high, the vegetation is healthier.

3.5 Pre- Processing

Data were converted to GIS-ready data to be used. Then, monthly TMPA satellite-based rainfall calibrated using equation produce by M.I. Ali (2014) to derived monthly satellite-based-calibrated rainfall and meanwhile, monthly NDVI images calibrated using equation (2.4) produce by M.I. Ali (2014) to derived monthly satellite-based actual-evapotranspiration.

3.6 Processing

This part clarify how the production local parameter, which is the commitment of this study performed; comprise of coefficient and consistent shortcut model relationship between rainfall estimation data in the field with rainfall data from satellite image data and model of the relationship between TMPA data estimation field with AET related data from satellite image NDVI. Publication information water yield is done through a water balance analysis with both significant segments of water balance in the field (i.e rainfall and AET) distributed data from satellite images.

3.6.1 Determination of Rainfall Data From Satellite Image TMPA

Below are the steps to determine the rainfall data from satellite image TMPA:

Step 1:

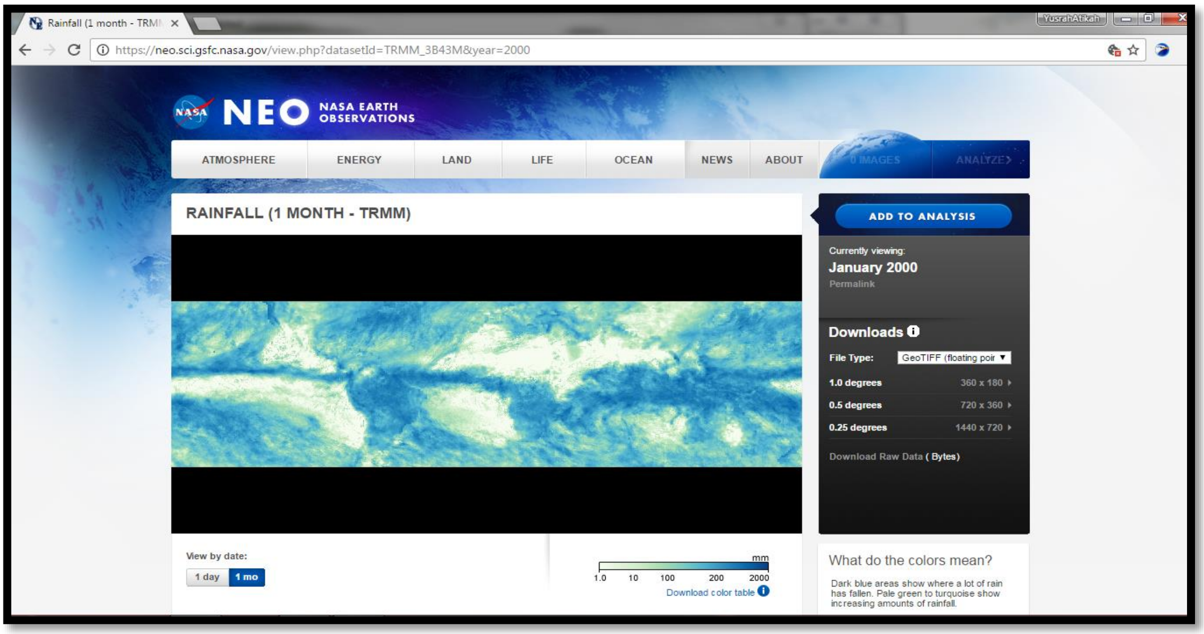

Figure 3.4: Show the rainfall (TRMM) that wants to get the data

Step 2:

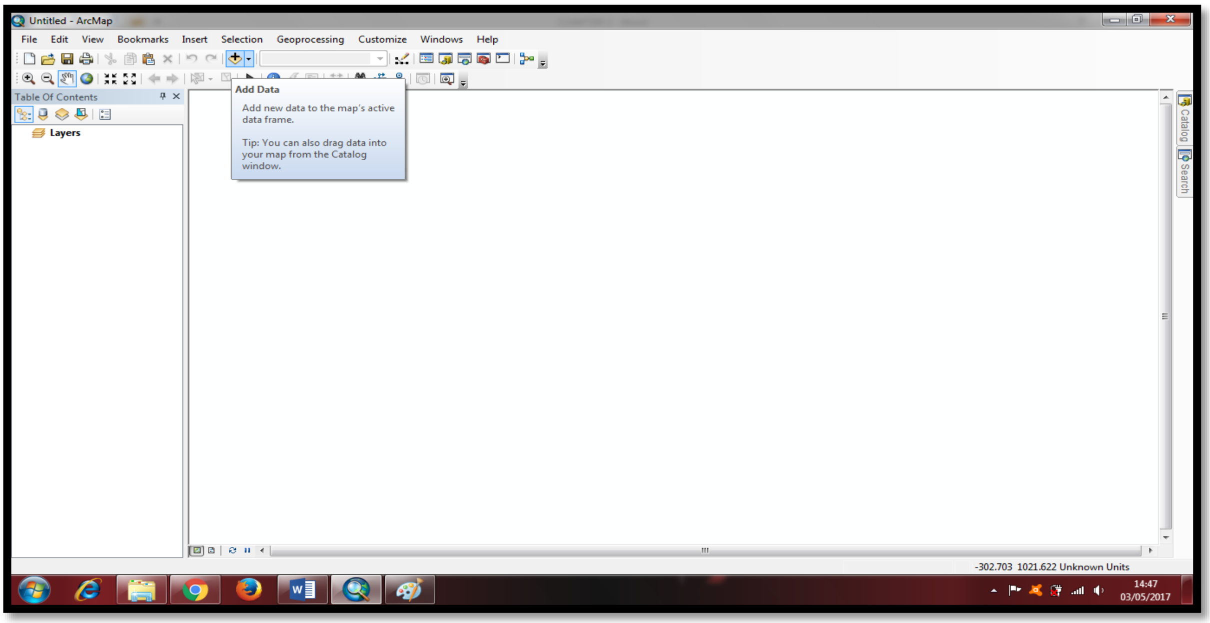

Figure 3.5: Add Data to GIS

Step 3:

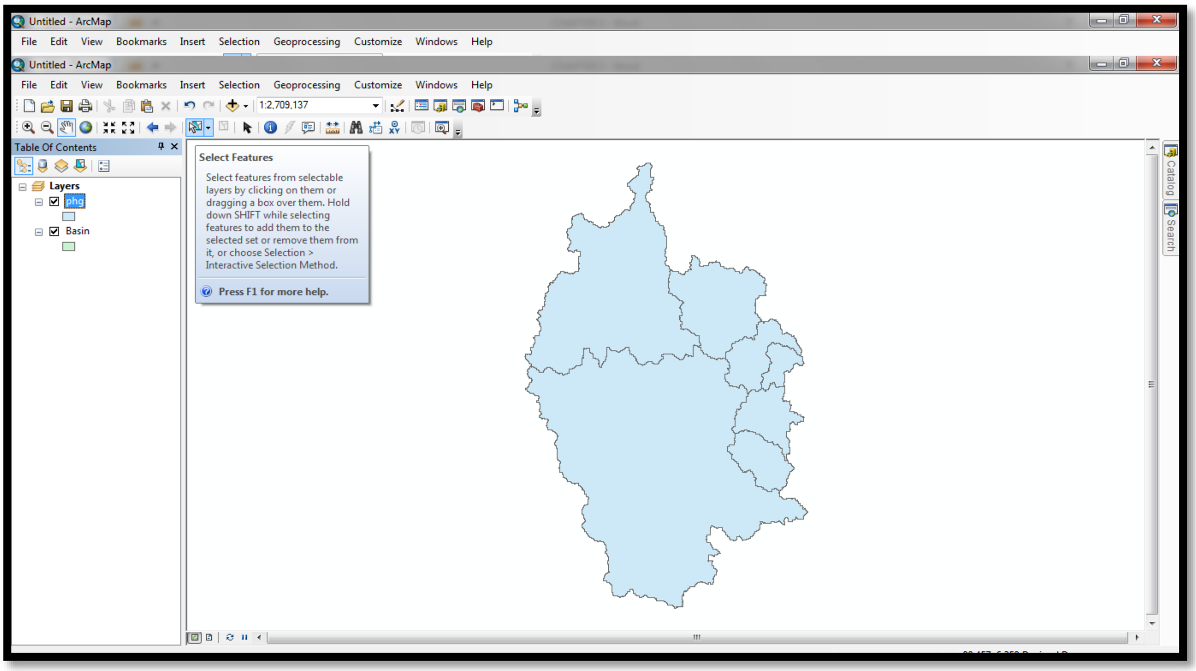

Figure 3.6: Select featured for Pahang River Basin

Step 4:

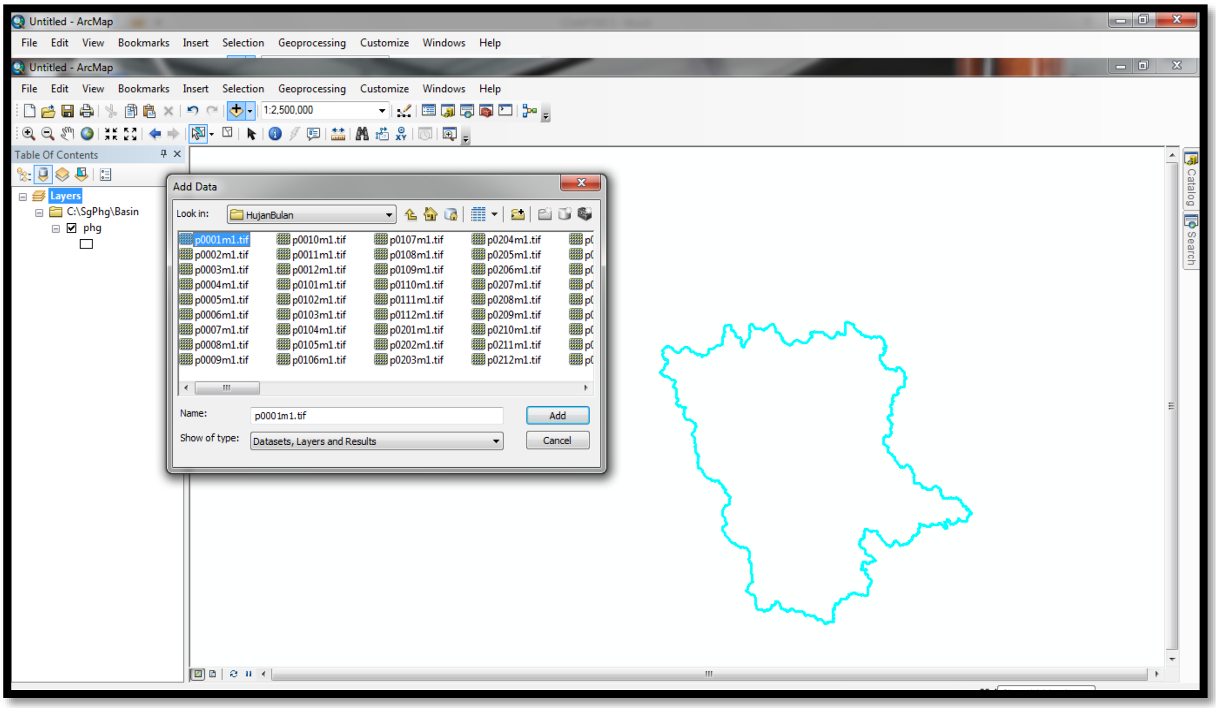

Figure 3.7: Features for Pahang River Basin and add data for monthly rainfall

Step 5:

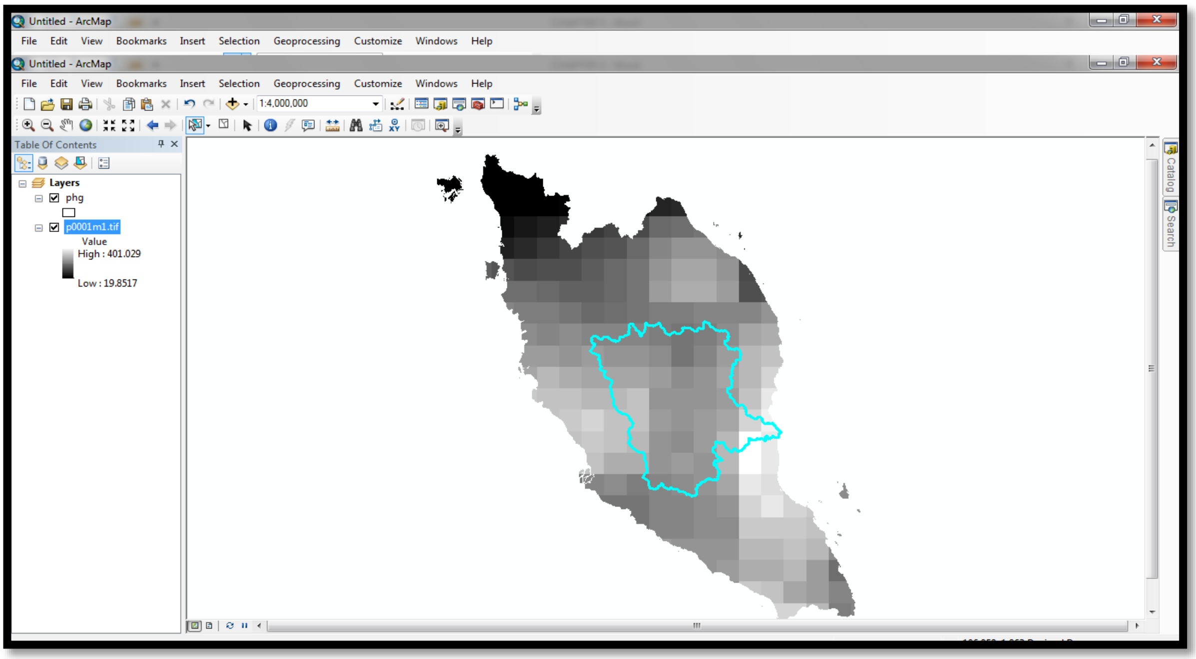

Figure 3.8: Show the monthly rainfall for Penisular Malaysia

Step 6:

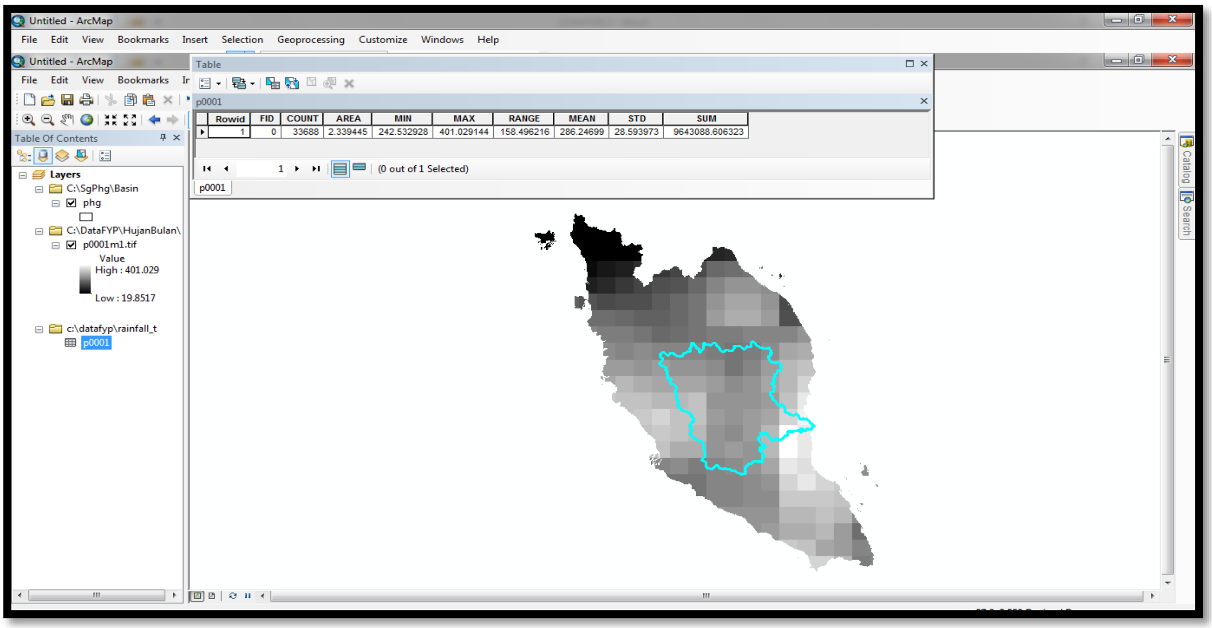

Figure 3.9: Zonal Statistics as Table

3.6.2 Determination of AET Using Satellite Image NDVI

The steps for determine AET data from satellite image NDVI are similar to the rainfall data except for the first step as shown below:

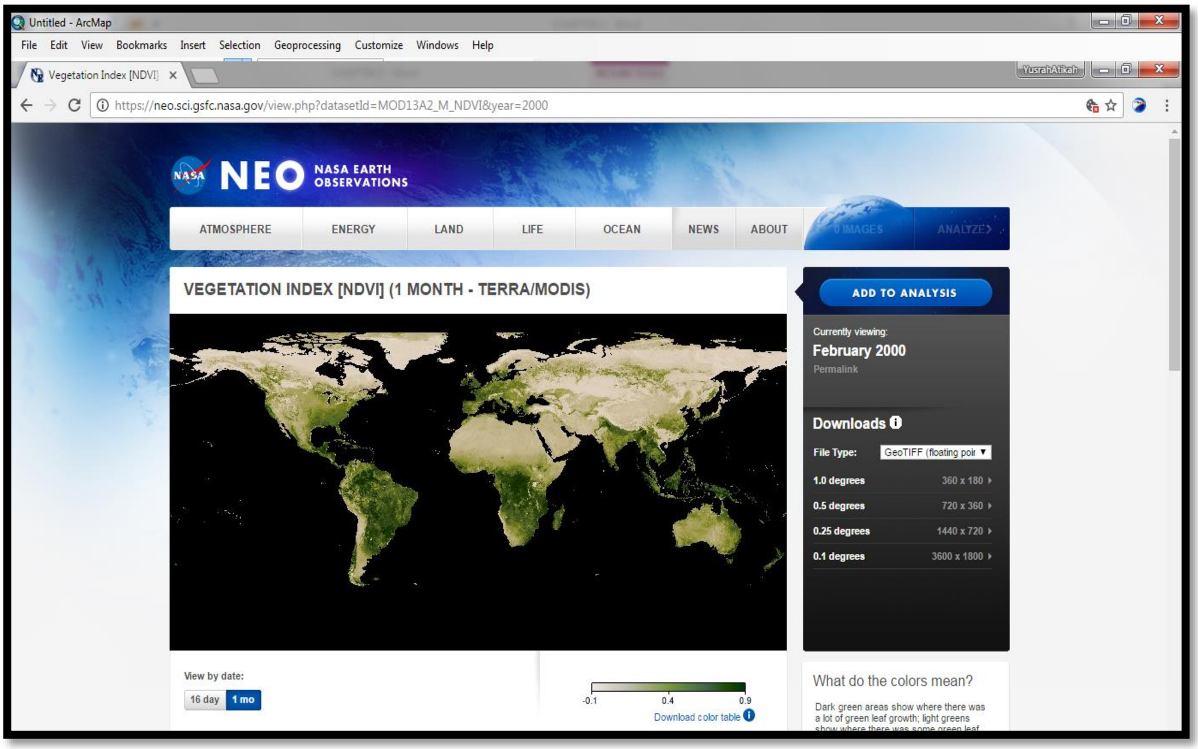

Figure 3.10: Show the web that the vegetation index data upload

3.6.3 Determination of Water Yield With Water Balance Analysis

The water yield is determine using equation (2.3). Determination of water production information monthly study area as well as validation, done using the data key is a series of monthly rainfall distribution maps, satellite image and maps TMPA-calibration and AET- calibration

3.7 Summary

By using remote sensing technology and data, with the water balance analysis, the study on determination of information of water yield is done. Determination of the main components of the water balance of the rainfall data (input components) and AET (component output). Monthly rainfall data from satellite images of the relationship has been calibrated TMPA issued and procedure of approval is performed against the data estimation in the field. Contact AET model field and the average monthly distributed satellite images an issue from AET monthly average NDVI data satellite image each month approved.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the findings obtained from Chapter 3, is shown in geographic information systems (GIS). Analysis of spatial and temporal variability of the study area implemented. An explanation of findings and analysis will be made in three (3) parts, there are; (i) temporal distribution of monthly rainfall, (ii) temporal distribution of monthly AET and (iii) temporal distribution of monthly water yield. In addition, the clarification is also made about the publishing application products distribution water in study area to see the impacts of climate changes on water yield.

4.2 Temporal Distribution of Monthly Rainfall, Temporal Distribution of AET And Temporal Distribution of Water Yield

According to Dale (1959), Peninsular Malaysia can be divided into five rainfall regions with distinctive patterns of rainfall. Based on the rainfall spatial and temporal variability characteristic, West Coast was divided into four region (North West Malaya, West Malaya, Port Dickson-Muar Coast and South West Malaya), whereas East Coast as East Malaya. Pahang River Basin located at East Malaya. East Malaya received heavy rainfall during the North East Monsoon and the rest received light rainfall. According to MMD, states in the east coast of Peninsular Malaysia, has a maximum rainfall during November, December and January, meanwhile the minimum rainfall are during June and July. Phenomenon El Nino and La Nina was divided into two phases for each year. The first phase is January to June, while the second phase is July until December. The results for the temporal distribution of monthly rainfall, AET and water yield for January until December for year 2000 – 2015 and January until December for year 2016 are shown in the 4.1 - 4.17 and Figure 4.1-4.17.

Table 4.1 and Figure 4.1 show the temporal distribution of monthly rainfall, AET and water yield in the year 2000. The monthly rainfall in 2000 shows that it is higher than typical receive by the region, meanwhile the AET has a consistent value throughout the year due to the transpiration process that using the groundwater storage. Thus, the water-yield increases due to the high input (rainfall) and consistent output (actual-evapotranspiration). Therefore, the river water level also increases. Apart from the excess of rainfall, groundwater storage also increases by the transpiration process. As stated by NOAA, the La Nina has occurred in year 2000.

Table 4.1: Distribution of monthly rainfall, AET and water yield, 2000

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	286.25	89.38	196.87
February	273.51	89.38	184.13
March	229.04	108.27	120.77
April	272.17	105.42	166.75
May	179.80	106.79	56.46
June	179.80	107.60	72.20
July	62.56	104.92	-42.36
August	147.69	104.03	43.66
September	177.43	97.84	79.58
October	240.19	103.76	136.42
November	223.34	103.14	119.20
December	333.01	102.81	230.20

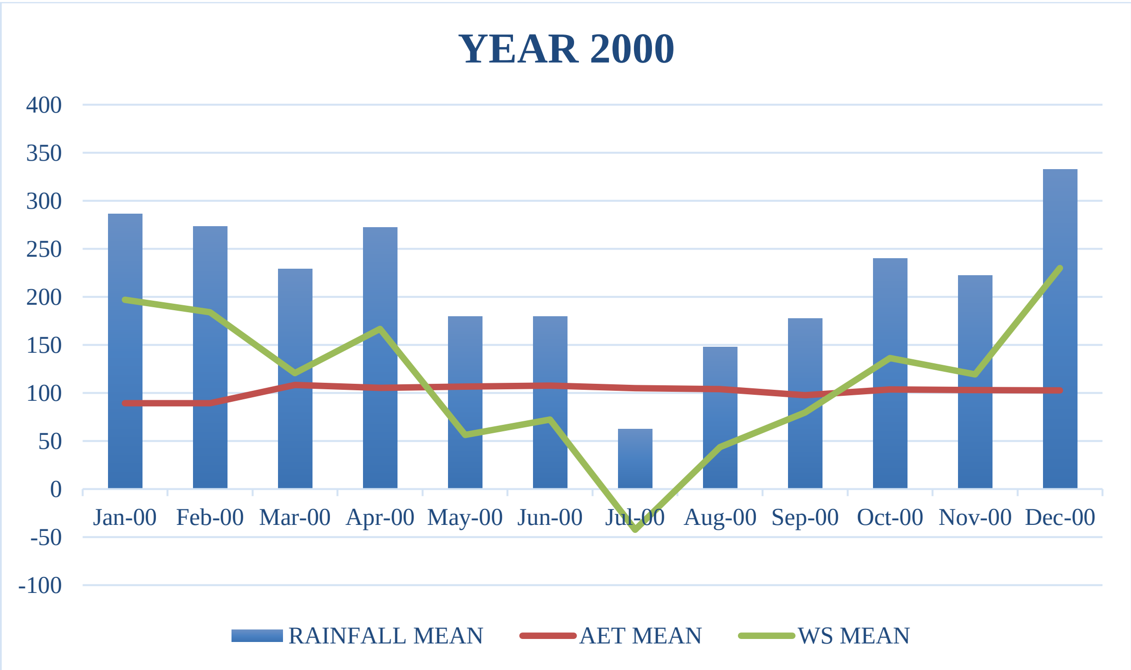

Figure 4.1: Temporal distribution of monthly rainfall, AET and water yield, 2000

Table 4.2 and Figure 4.2 show the temporal distribution of monthly rainfall, AET and water yield in the year 2001. The temporal distribution of monthly rainfall in 2001 shows that it is higher than typical receive by the region, meanwhile the AET has a consistent value throughout the year due to transpiration process. Apart from the excess rainfall, groundwater storage is also increased by the process of transpiration. As noted by NOAA, La Nina occurred in 2000. Thus, the distribution of water yield in 2001 has increased compared to the typical area.

Table 4.2: Distribution of monthly rainfall, AET and water yield, 2001

Month	**Rainfall (mm)**	**AET (mm)**	**Water Yield (mm)**
January	275.88	97.15	178.73
February	124.95	100.81	24.13
March	224.81	104.73	120.08
April	218.13	104.83	113.30
May	143.44	106.38	37.05
June	96.25	105.93	-9.68
July	104.73	107.81	-3.08
August	146.52	106.79	39.72
September	197.82	108.31	89.51
October	258.62	100.98	157.64
November	288.30	92.64	195.66
December	415.63	108.88	314.75

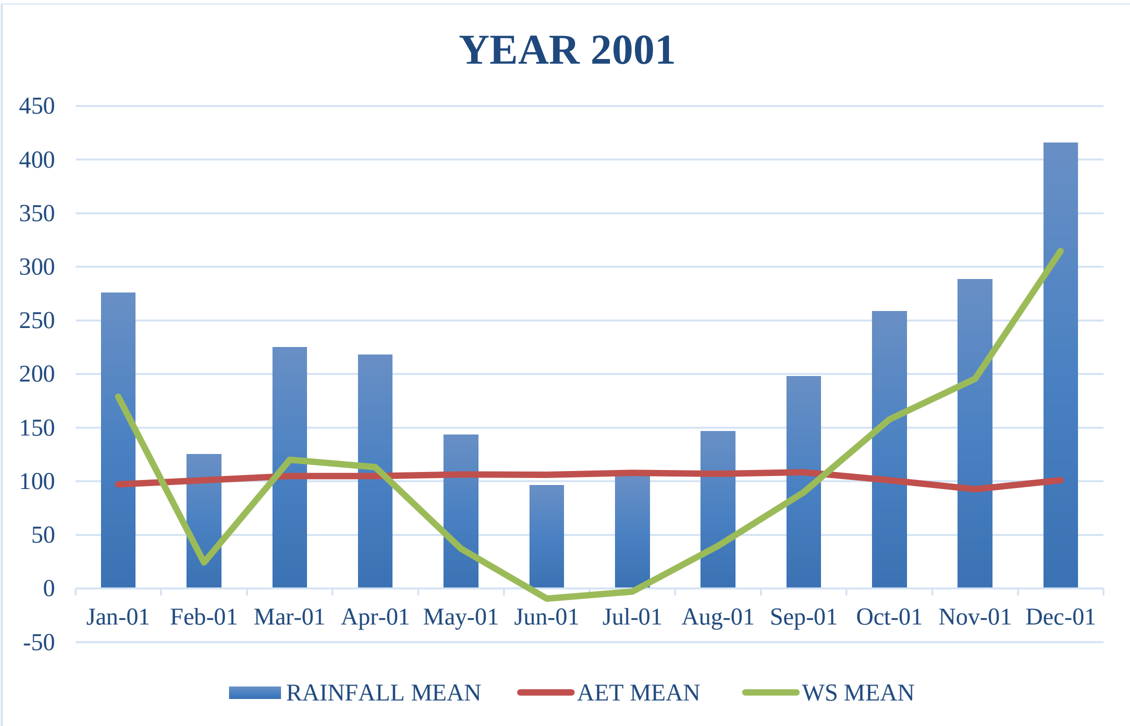

Figure 4.2: Temporal distribution of monthly rainfall, AET and water yield, 2001

Table 4.3 and Figure 4.3 show the temporal distribution of monthly rainfall, AET and water yield in the year 2002. The monthly rainfall in 2002 shows that it is lower than typical receive by the region, meanwhile the AET has a consistent value throughout the year due to the transpiration process. Thus, the water-yield decreases due to the low input (rainfall) and consistent output (actual-evapotranspiration). Therefore, the river water level also decreases. Apart from the lack of rainfall, groundwater also decreases due to the transpiration process. According to NOAA, El Nino has occurred in 2002.

Table 4.3: Distribution of monthly rainfall, AET and water yield, 2002

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	75.53	97.82	-22.29
February	6.82	107.58	-100.76
March	110.85	106.49	4.37
April	187.36	102.19	85.17
May	207.08	106.89	100.18
June	114.72	105.01	9.71
July	116.03	108.71	7.32
August	217.41	104.89	112.52
September	189.59	104.39	85.20
October	187.93	108.02	79.92
November	236.28	99.14	137.14
December	282.25	94.58	187.67

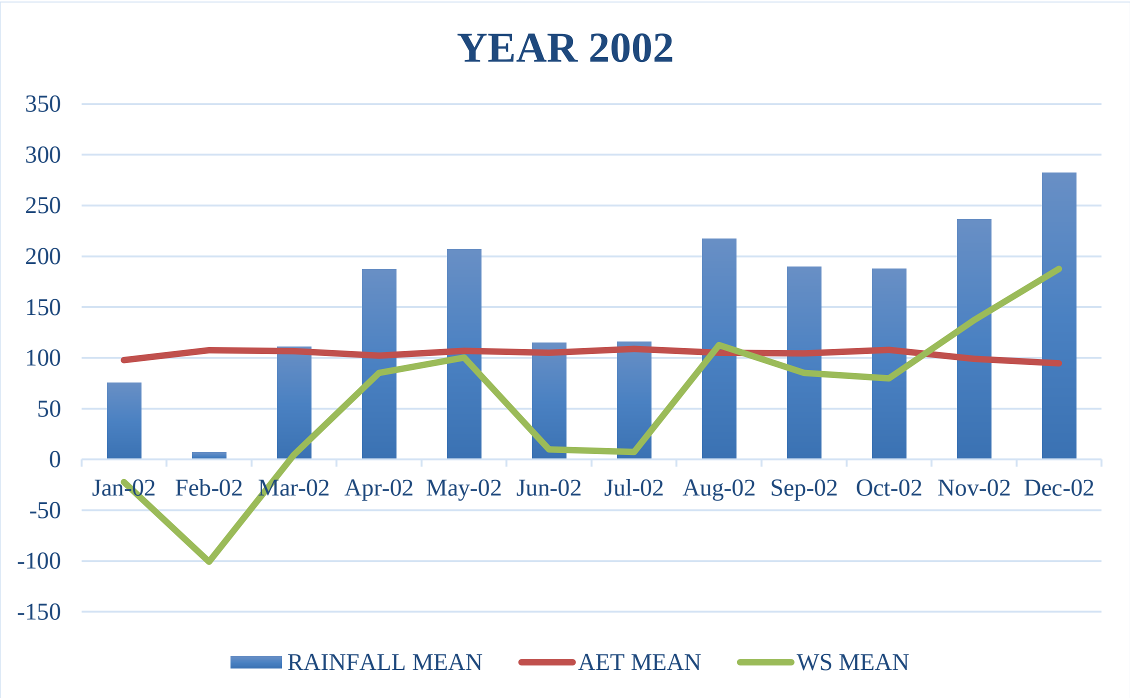

Figure 4.3: Temporal distribution of monthly rainfall, AET and water yield, 2002

Table 4.4 and Figure 4.4 show the temporal distribution of monthly rainfall, AET and water yield in the year 2003. The peak rainfall is December meanwhile, the minimum rainfall is in February. The minimum rainfall in the typical received by the region should be in June and July. The monthly AET throughout the year has a constant value. Therefore, the temporal distribution of water yield in year 2003 decreased This happened because according to NOAA, El Nino has occurred in 2003.

Table for 4.4: Distribution of monthly rainfall, AET and water yield, 2003

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	252.65	100.00	152.65
February	100.59	103.28	-2.70
March	164.62	104.27	60.35
April	172.93	100.91	72.02
May	130.12	109.66	20.46
June	201.78	106.65	95.12
July	179.30	101.32	77.98
August	203.30	105.92	97.37
September	137.03	104.01	33.02
October	266.61	101.87	164.74
November	324.88	98.95	225.93
December	369.08	89.21	279.87

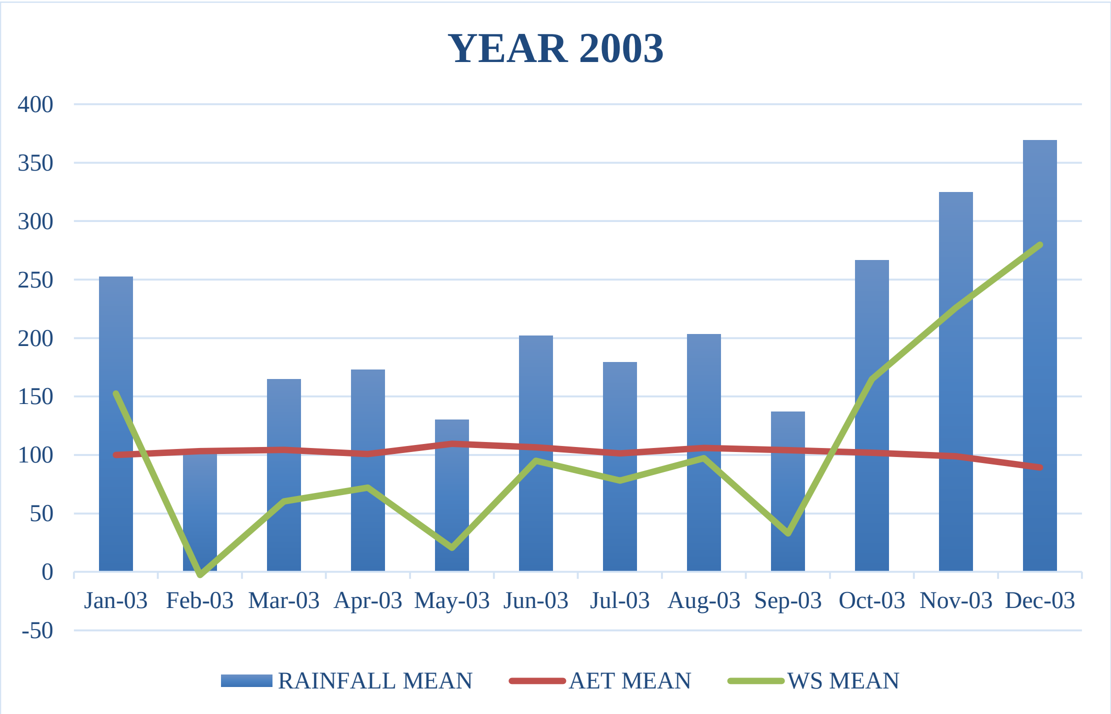

Figure 4.4: Temporal distribution of monthly rainfall, AET and water yield, 2003

Table 4.5 and Figure 4.5 show the temporal distribution of rainfall, AET and water yield, 2004. The peak rainfall is October and the minimum rainfall is February. The distribution of rainfall is less than typical received by the region. The water yield in the Pahang River Basin has decreased due to the low input and constant output. The output for the water yield is AET. Reported period in El Nino episode by the NOAA stated that El Nino has occurred in year 2004.

Table for 4.5: Distribution of monthly rainfall, AET and water yield, 2004

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	185.85	102.73	83.12
February	38.51	103.39	-64.88
March	174.15	97.42	76.73
April	135.49	101.99	33.50
May	181.14	109.66	71.48
June	89.98	107.09	-17.11
July	182.84	105.73	77.11
August	110.83	106.34	4.49
September	227.25	104.40	122.85
.October	359.86	98.16	261.69
November	227.23	103.10	124.14
December	258.71	95.02	163.69

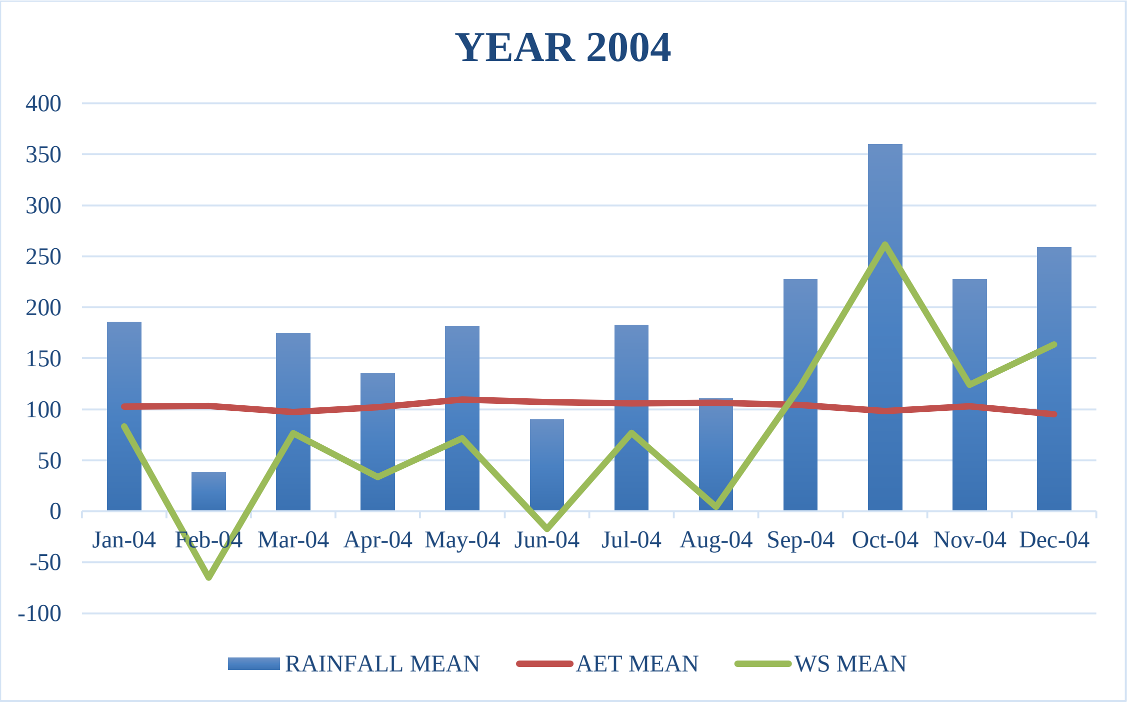

Figure 4.5: Temporal distribution of monthly rainfall, AET and water yield, 2004

As seen in the Table 4.6 and Figure 4.6 show the temporal distribution of rainfall, AET and water yield for January 2005 until December 2005 in Pahang River Basin. The peak rainfall is November, meanwhile the minimum rainfall is January. January should have high rainfall as it is the maximum rainfall with the November and December. In first phase of 2005, it shows that the water yield during that time is lower compared to second phase especially in January. This happened because of the output for the water yield which is AET is consistent throughout the year and the input is also low. According to NOAA, first phase is hit by El Nino meanwhile in second phase is La Nina.

Table for 4.6: Distribution of monthly rainfall, AET and water yield, 2005

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	44.93	101.55	-56.62
February	70.76	106.42	-35.65
March	89.29	102.78	-13.48
April	150.07	102.25	47.82
May	201.45	60.27	141.18
June	133.84	108.16	25.68
July	145.82	103.08	42.74
August	145.82	104.62	6.89
September	168.75	103.53	65.23
.October	247.22	97.33	149.88
November	463.51	99.88	363.64
December	382.74	98.22	284.52

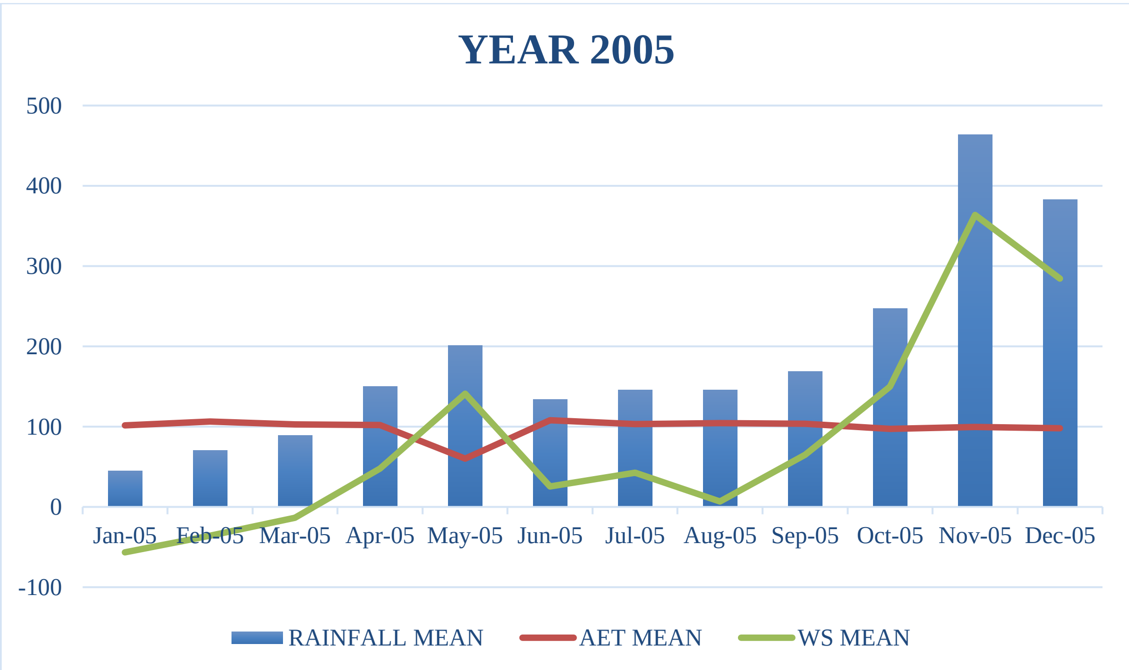

Figure 4.6: Temporal distribution of monthly rainfall, AET and water yield, 2005

Table 4.7 and Figure 4.7 show the temporal distribution of rainfall, AET and water yield for January 2006 until December 2006 in Pahang River Basin. The peak rainfall in second phase is December and the minimum rainfall is July. In first phase 2006 shows that the water yield is higher compared to second phase. In first phase it shows that majority have high rainfall especially in February even it supposed to have lowest rainfall. This happened because according to NOAA, at that time, a weak La Nina has occurred in first phase of 2001 while in second phase is by El Nino.

Table 4.7: Distribution of monthly rainfall, AET and water yield, 2006

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	162.67	98.25	64.42
February	297.39	100.43	196.96
March	110.19	104.04	6.15
April	238.64	104.63	134.01
May	257.14	105.30	151.85
June	179.32	104.54	74.77
July	101.80	106.55	-4.75
August	142.99	101.39	41.60
September	205.14	105.72	99.42
.October	184.50	97.07	87.42
November	269.48	99.82	169.66
December	305.65	97.08	208.57

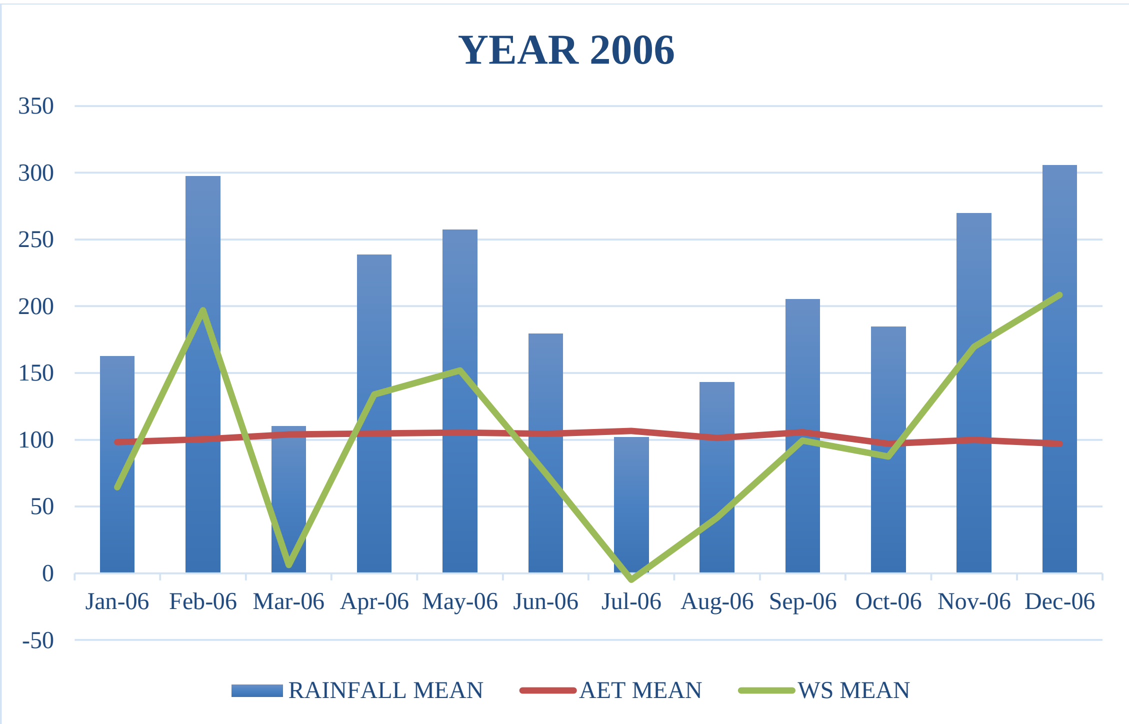

Figure 4.7: Temporal distribution of monthly rainfall, AET and water yield, 2006

As seen in the Table 4.8 and Figure 4.8 show the temporal distribution of rainfall, AET and water yield for January 2007 until December 2007 in Pahang river basin. The rainfall in first phase of year 2007 is lower than the typical rainfall meanwhile, the second phase is higher than that. However, the AET for both phases is actually consistent due to the transpiration process. In that case, the distribution of water yield in first phase is lower compared to the second. According to NOAA, the first phase of 2007 is hit by weak El Nino while in second phase is moderate La Nina.

Table 4.8: Distribution of monthly rainfall, AET and water yield, 2007

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	261.50	79.02	182.48
February	65.10	102.50	-37.39
March	161.66	103.23	58.43
April	178.13	105.89	72.24
May	242.91	108.68	134.23
June	186.59	102.97	83.62
July	167.88	101.84	66.03
August	154.51	109.03	45.49
September	206.78	123.53	83.25
.October	367.35	103.09	264.26
November	219.97	100.76	119.21
December	543.54	94.65	448.89

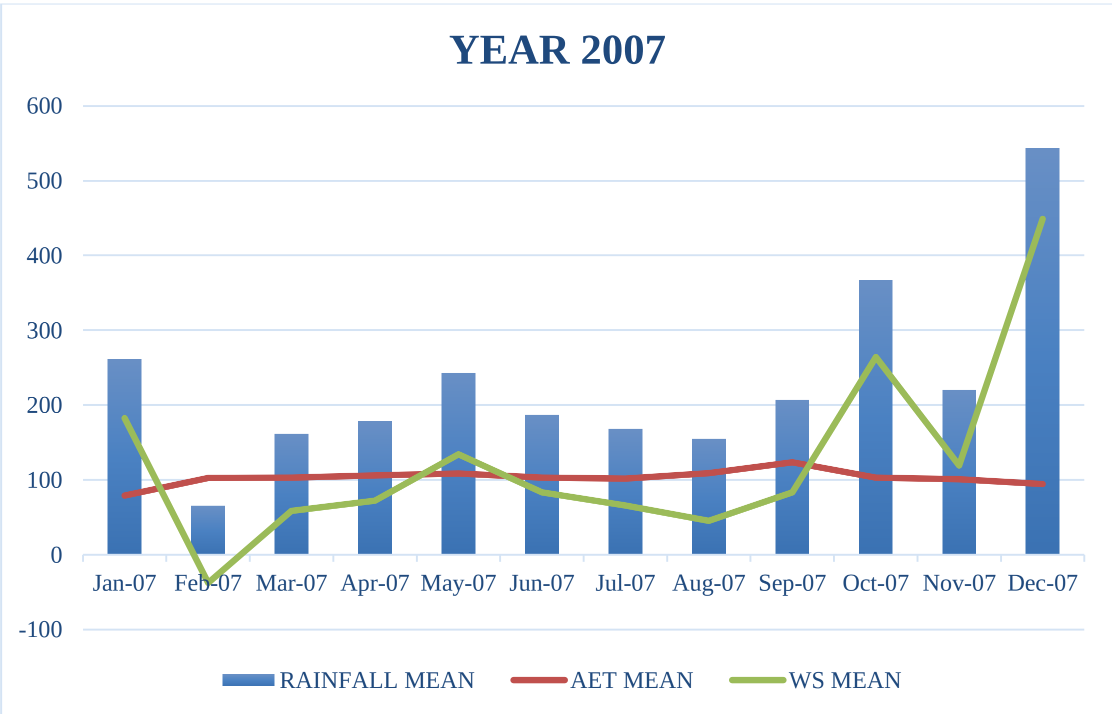

Figure 4.8: Temporal distribution of monthly rainfall, AET and water yield, 2007

According to NOAA, year 2008 has occurred phenomenon La Nina for both phases. As seen in the Table 4.9 and Figure 4.9 show the temporal distribution of rainfall, AET water yield in year 2008. The monthly rainfall in this year is higher compared to the normal distribution of rainfall. The temporal distribution of water yield in this year become increases due to the high input from rainfall and constant output from AET. Therefore, the river water level also increases. Apart from the excess of rainfall, the groundwater storage also increases due to the transpiration process.

Table 4.9: Distribution of monthly rainfall, AET and water yield, 2008

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	218.95	101.71	117.25
February	157.49	102.35	55.13
March	278.33	95.69	182.64
April	255.38	103.35	152.04
May	152.29	97.87	54.42
June	129.70	107.43	22.27
July	129.70	102.42	124.07
August	258.34	104.62	153.72
September	205.59	104.28	101.31
.October	303.35	101.66	201.69
November	300.35	96.26	268.52
December	300.93	97.37	203.56

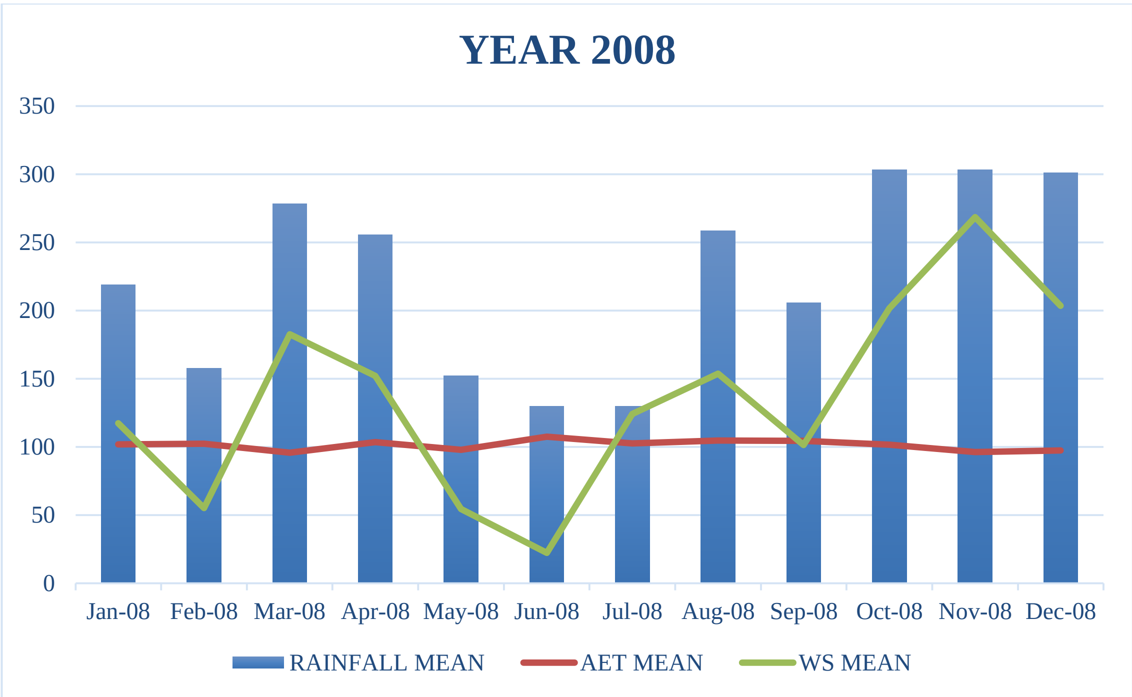

Figure 4.9:Temporal distribution of monthly rainfall, AET and water yield, 2008

Table 4.10 and Figure 4.10 show the temporal distribution of monthly rainfall, AET and water yield in the year 2009. The highest rainfall is December and the lowest rainfall in second phase is July. Meanwhile, in first phase of 2009 the highest rainfall is March and lowest rainfall is February. The second phase of year 2009 shows the water yield is higher compared to the first phase. However, as stated by NOAA that the second phase of year 2009 is hit by moderate El Nino meanwhile, the first phase is hit by weak La Nina. This is because the phenomenon is not necessarily happened all over the world.

Table 4.10: Distribution of monthly rainfall, AET and water yield, 2009

Month	**Rainfall (mm)**	**AET (mm)**	**Water Yield (mm)**
January	262.41	98.22	164.19
February	96.47	99.74	-3.27
March	350.12	123.58	226.54
April	171.24	109.55	61.69
May	267.06	108.00	159.06
June	122.25	107.21	15.04
July	103.18	103.54	-0.37
August	198.33	103.66	94.67
September	210.63	103.26	107.37
.October	305.26	107.49	197.77
November	329.13	100.04	229.09
December	403.80	98.35	305.46

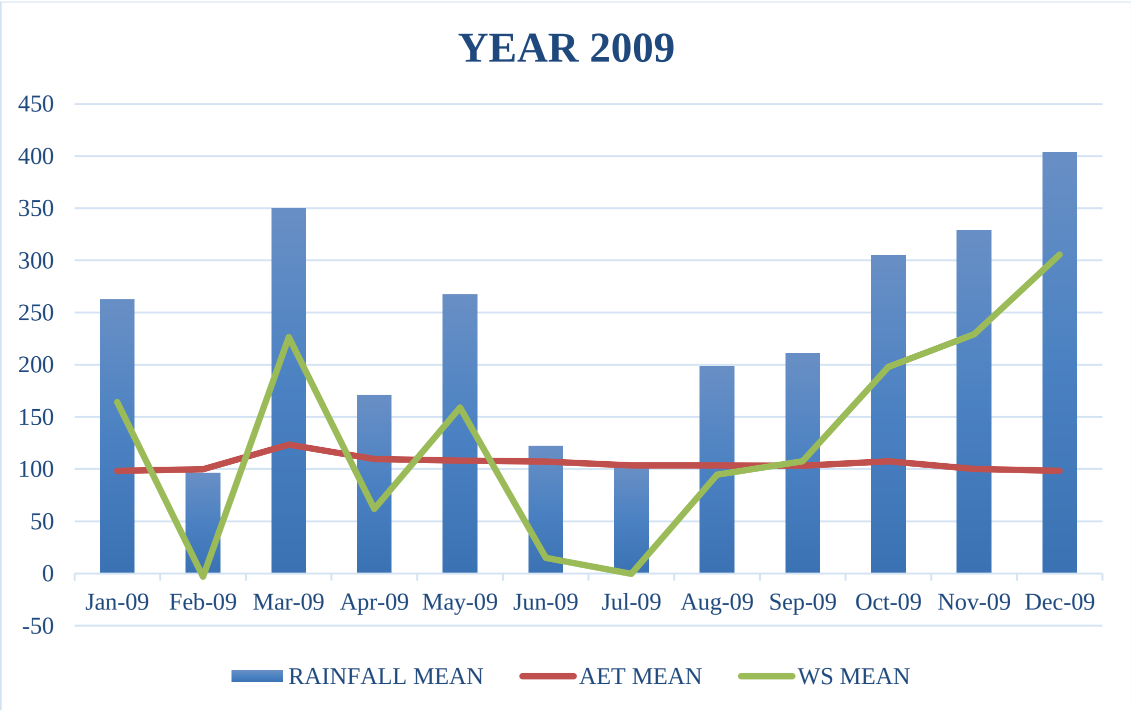

Figure 4.10: Temporal distribution of monthly rainfall, AET and water yield, 2009

Table 4.11 and Figure 4.11 show the temporal distribution of monthly rainfall, AET and water yield in the year 2010. The temporal distribution of monthly rainfall in 2010 shows that it is higher than typical receive by the region, meanwhile the AET has a consistent value throughout the year due to transpiration process. This is because apart from the excess rainfall, groundwater storage is also increased by the process of transpiration. However the monthly rainfall in first phase is lower than second phase. As noted by NOAA, weak La Nina has occurred in first phase and strong La Nina hit the second phase.

Table 4.11: Distribution of monthly rainfall, AET and water yield, 2010

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	117.33	105.78	11.55
February	54.88	103.96	-49.08
March	114.32	103.96	12.91
April	206.04	104.65	101.38
May	261.50	106.93	154.57
June	213.88	106.25	107.62
July	203.23	102.14	101.09
August	172.08	106.53	65.55
September	217.88	100.66	117.02
.October	159.67	101.06	58.61
November	302.72	96.85	205.87
December	326.16	92.15	234.01

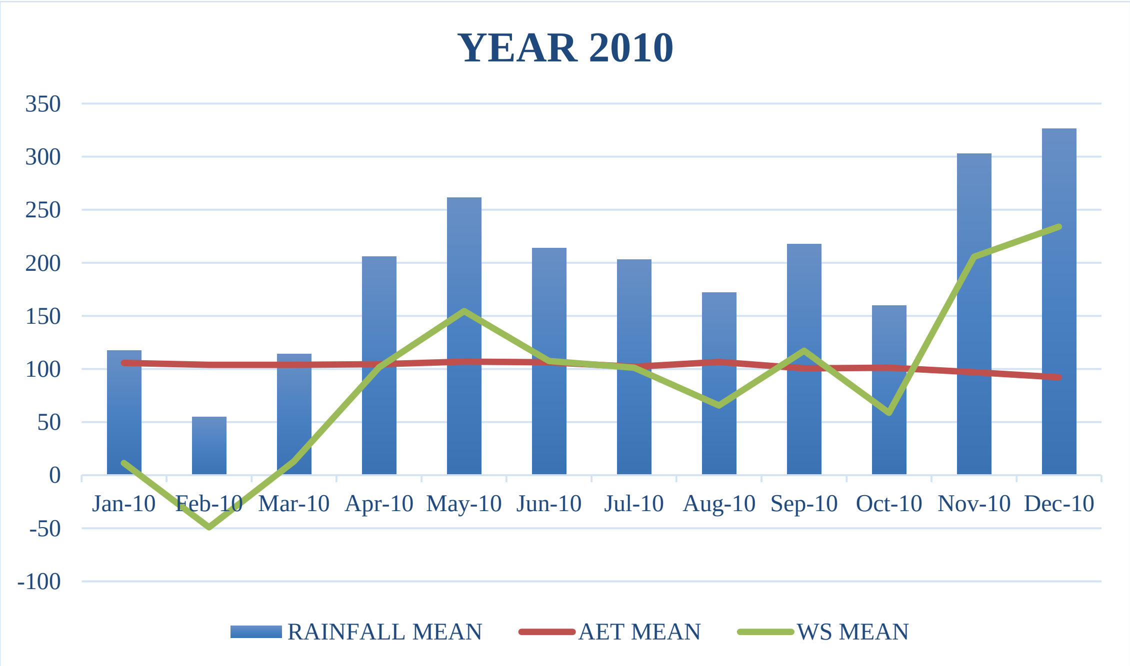

Figure 4.11: Temporal distribution of monthly rainfall, AET and water yield, 2010

According to NOAA, year 2011 has occur phenomenon La Nina for both phases. As seen in the Table 4.12 and Figure 4.12 show the temporal distribution of rainfall, AET water yield in year 2011. The monthly rainfall in this year is higher compared to the normal distribution of rainfall. The temporal distribution of water yield in this year become increases due to the high input from rainfall and constant output from AET. Therefore, the river water level also increases. Apart from the excess of rainfall, the groundwater storage also increases due to the transpiration process.

Table 4.12: Distribution of monthly rainfall, AET and water yield, 2011

Month	**Rainfall (mm)**	**AET (mm)**	**Water Yield (mm)**
January	298.61	99.57	199.04
February	25.27	102.59	-77.32
March	368.59	95.72	272.87
April	156.64	104.94	51.70
May	193.97	106.69	87.28
June	112.09	101.44	10.64
July	64.74	107.05	-42.31
August	163.89	105.59	58.30
September	198.39	104.54	93.84
.October	374.63	91.23	283.39
November	313.62	97.80	215.82
December	349.92	86.83	263.10

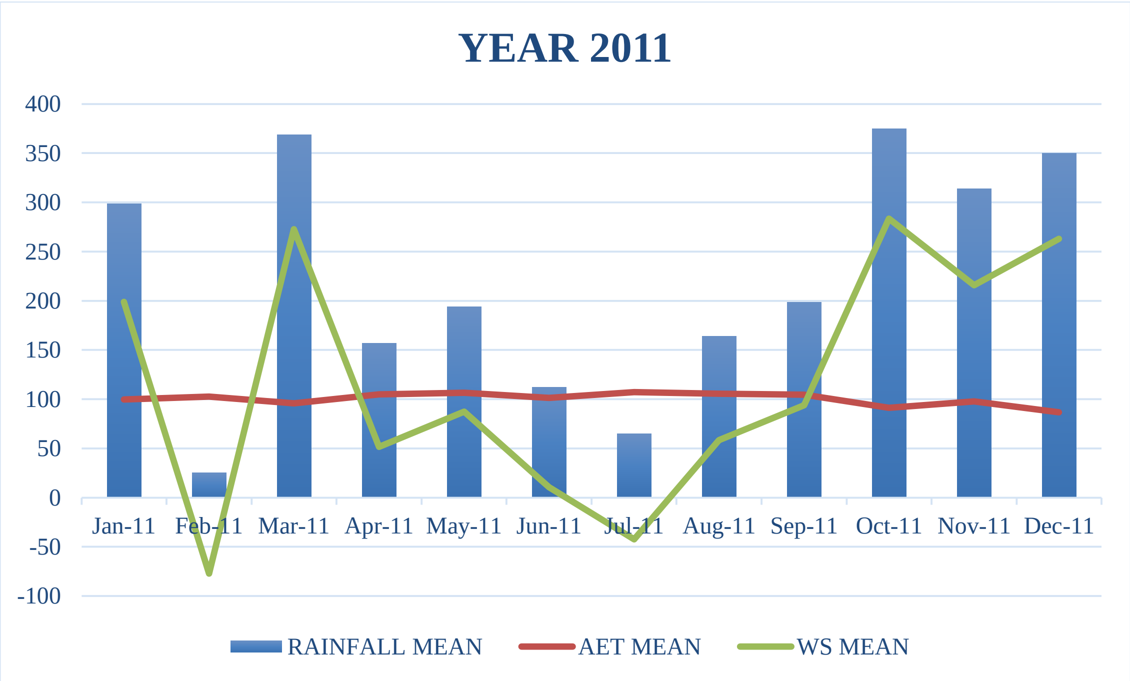

Figure 4.12: Temporal distribution of monthly rainfall, AET and water yield, 2011

Table 4.13 and Figure 4.13 show the temporal distribution of rainfall, AET and water yield for January 2012 until December 2012 in Pahang River Basin. The highest rainfall is December and the minimum rainfall is June. The distribution of rainfall is higher compared to the typical received by the region. However, the AET throughout the year is actually consistent due to the transpiration process. In that case, the distribution of water yield in year 2012 become higher. According to NOAA, phenomenon La Nina has occurred in year 2007

Table 4.13: Distribution of monthly rainfall, AET and water yield, 2012

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	230.50	99.01	131.49
February	138.30	99.37	38.93
March	241.76	99.44	142.32
April	268.03	104.03	164.00
May	257.82	105.54	152.28
June	81.30	107.28	-25.98
July	111.70	106.65	5.05
August	160.70	105.94	54.75
September	209.58	105.41	104.17
.October	238.20	103.46	143.75
November	274.71	97.78	176.93
December	415.71	91.43	324.28

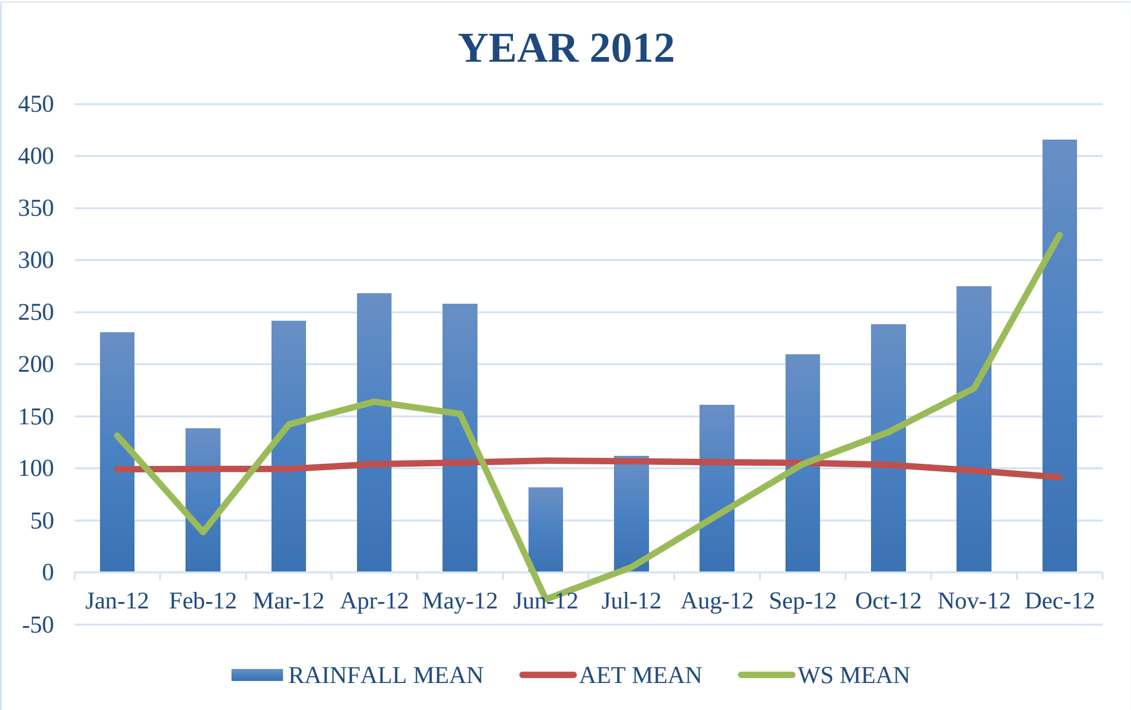

Figure 4.13: Temporal distribution of monthly rainfall, AET and water yield, 2012

Table 4.14 and Figure 4.14 show the temporal distribution of monthly rainfall, AET and water yield for January 2013 until December 2013 in Pahang River Basin. The highest rainfall is December and the minimum rainfall is March. The monthly rainfall is less than typical received by the region. The AET value throughout the year always remain constant. Therefore the water yield become decreases due to the low input of rainfall and constant output of AET. According to NOAA, the episodes for El Nino and La Nina only shows until 2012. Based on the trend in the graph below, it can be concluded that 2013 is hit by phenomenon El Nino.

Table 4.14: Distribution of monthly rainfall, AET and water yield, 2013

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	146.86	101.32	47.36
February	306.75	100.04	206.71
March	66.68	99.94	-33.26
April	176.99	105.73	71.26
May	237.00	107.81	129.20
June	109.73	106.24	3.49
July	178.13	105.22	72.91
August	128.66	102.39	26.27
September	237.26	105.46	131.80
.October	266.33	101.62	164.71
November	254.85	95.95	158.89
December	570.30	93.08	477.23

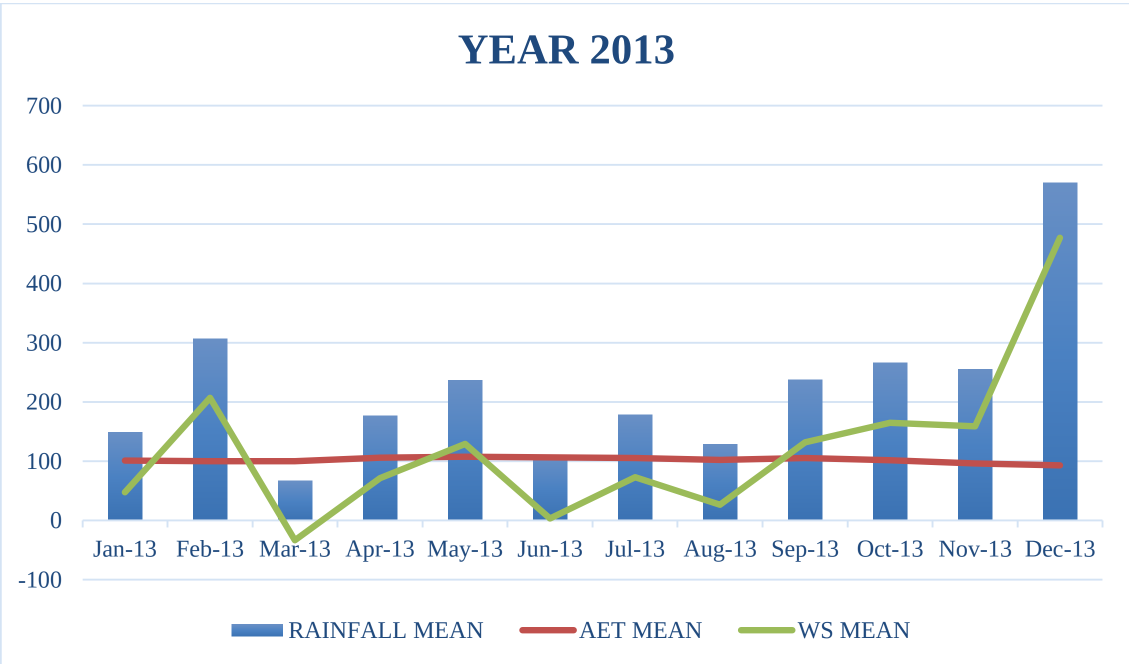

Figure 4.14: Temporal distribution of monthly rainfall, AET and water yield, 2013

According to Sinar Harian (2014), phenomenon El Nino has occurred in year 2014. Table 4.15 and Figure 4.15 show the temporal distribution of monthly rainfall, AET and water yield in year 2014. The monthly rainfall is less than typical received by the region, meanwhile AET value throughout the year always remain constant. Therefore the water yield become decreases due to the low input of rainfall and constant output of AET. Therefore, the river water level also decreases. This happens because of apart from the lack of rainfall, groundwater storage also decreases by the transpiration process

Table 4.15: Distribution of monthly rainfall, AET and water yield, 2014

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	208.15	100.52	107.63
February	-23.99	104.24	-128.23
March	62.24	103.65	-41.42
April	155.39	103.42	51.96
May	322.73	105.09	217.65
June	96.24	107.05	-10.81
July	122.66	105.38	17.28
August	169.57	103.38	66.19
September	134.97	101.35	33.62
.October	307.77	100.53	207.24
November	269.48	99.19	170.29
December	909.79	95.88	813.91

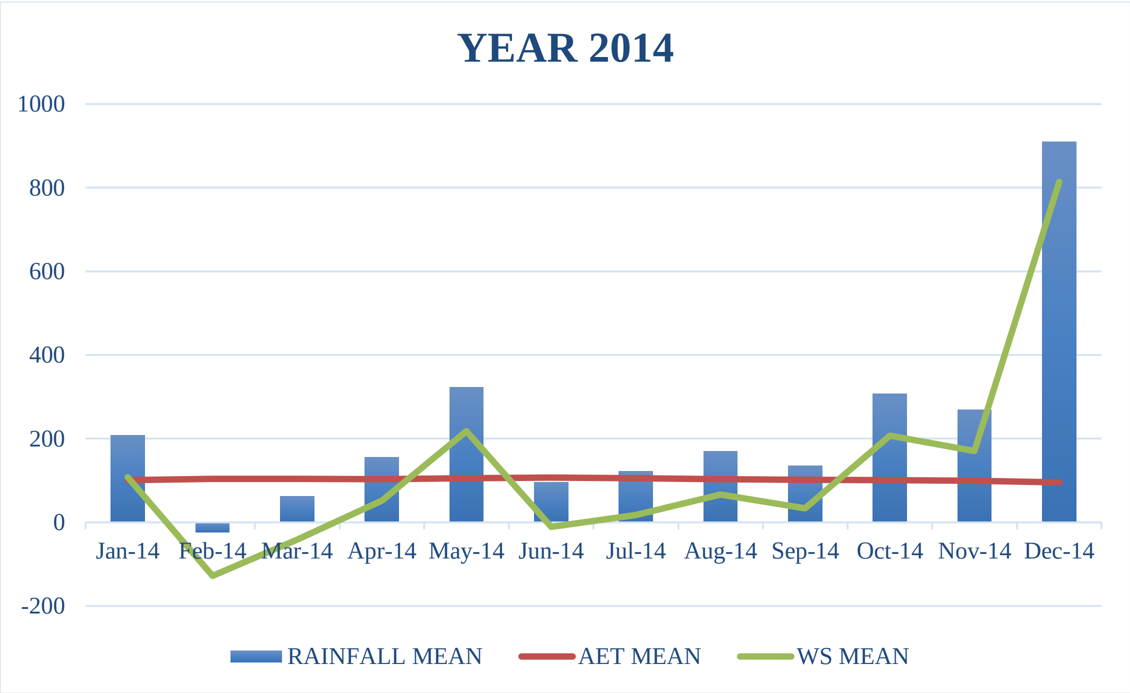

Figure 4.15: Temporal distribution of monthly rainfall, AET and water yield, 2014

According to Null (2017), the results from researcher showed the occurrence of El Nino which is the most powerful recorded in 1982-1983, 1997-1998 and 2015-2016. Table 4.16 and Figure 4.16 show the temporal distribution of monthly rainfall, AET and water yield in year 2015. The rainfall for the year 2015 shows that it is increases from the normal rainfall in the region, meanwhile the AET value remains consistent. In that case, the water yield in year 2015 becomes lower due to the lack of rainfall and consistent AET.

Table 4.16: Distribution of monthly rainfall, AET and water yield,2015

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	119.90	103.31	16.59
February	47.96	100.34	-52.38
March	78.43	101.77	-23.34
April	187.38	103.74	83.64
May	179.94	103.05	76.89
June	115.97	102.50	13.46
July	61.39	104.90	-43.51
August	248.51	105.48	143.04
September	173.77	100.50	73.27
.October	234.67	93.97	140.70
November	292.90	96.17	196.72
December	235.62	101.65	133.98

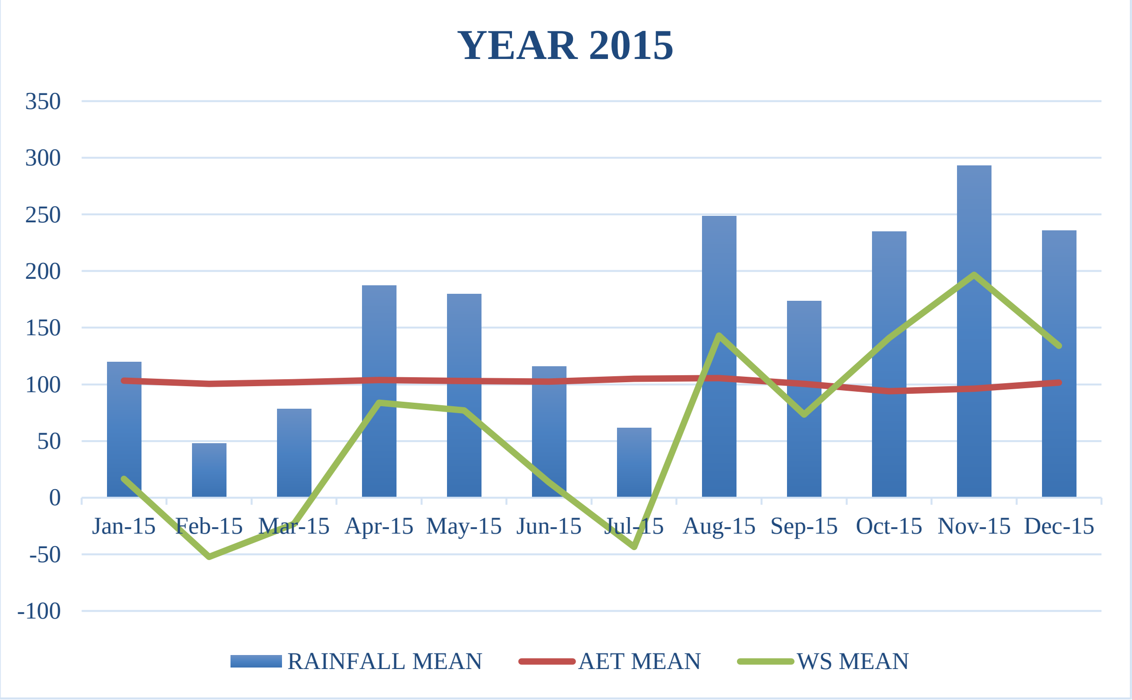

Figure 4.16: Temporal distribution of monthly rainfall, AET and water yield,2015

Table 4.17 and Figure 4.17 show the temporal distribution of monthly rainfall, AET and water yield for January 2016 until August 2016. The rainfall received by the region in year 2016 is lower than typical. The normal monthly rainfall is 200mm and all the monthly rainfall in year 2016 is lower than that. Therefore, the water yield decreases due to the lack of rainfall and consistent AET. As mentioned by Null (2017), year 2016 is hit by strong phenomenon El Nino.

Table 4.17: Distribution of monthly rainfall, AET and water yield,2016

Month	Rainfall (mm)	AET (mm)	Water Yield (mm)
January	31.65	106.03	-74.38
February	49.78	99.37	-49.59
March	-28.00	101.93	-129.94
April	60.72	99.91	-39.19
May	172.39	99.91	72.48
June	199.86	104.94	94.92
July	163.26	104.94	58.21
August	147.04	102.33	44.72

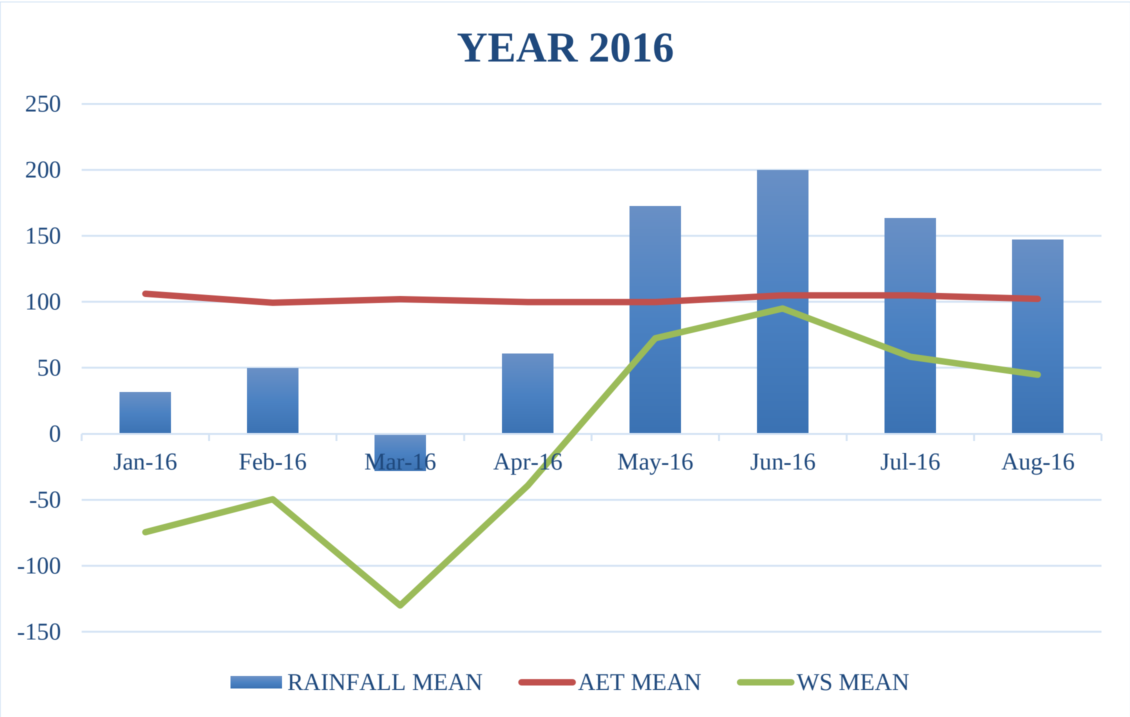

Figure 4.17: Temporal distribution of monthly rainfall, AET and water yield,2016

4.3 Discussion

From the results obtained, this analysis was carried out based on monthly rainfall data and Normalized Difference Vegitation Index (NDVI) data which is duration period about sixteen years (January 2000 until August 2016). From the results obtained, the climate change impacts on water yield can be analysis using the remote sensing satellite image.

4.4 Summary

Water information products for study area issued from satellite image data existing calibration accessed online and shows good accuracy with a report from the literature, to the entire area through different analysis period. It shows the approach and support of rainfall data and AET each from satellite image TMPA- calibration and NDVI-calibration can be used to estimate the water yield very well. The water yield- calibration can shows the evidence of calibration climate change occuring in the study area. With the findings obtained, this study has provided the starting point for the development of the techniques of water yield in areas by using satellite image data

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter focus to discuss about discoveries and results from the data analysis in Chapter 4 to accomplish the goal of this study. This chapter briefly discuss about the whole discoveries and result tending to the exploration objectives that clarify in Chapter 1.

Climate change and the hydrological variability of water's distribution and event are characteristic main thrusts that, when consolidated with the pressures from economic development and real populace change, make the sustainable development of our water resources a challenge. The mix of these components normally brings about expanded water utilize, competition and pollution notwithstanding profoundly wasteful water supply practices. These outcomes can be followed back to the way that most choices in water resources management, at all levels, remain chiefly determined by here and now economic and political considerations that do not have the long haul vision expected to execute sustainable development rehearses. Water management plans ought to consider the best existing practices and the most progressive logical achievements.

Remote sensing is a technique for acquiring data from far off articles without direct contact. This is conceivable because of the presence or the era of constrain fields between the detecting gadget and the detected object. Usable drive fields are mechanical waves in strong matter (seismology) or in fluids (sound waves). In any case, the primary constrain field utilized as a part of remote sensing is that of electromagnetic energy. In this review, assurance of water yield data distributed through the water balance analysis with data resources, the appropriation of precipitation and AET from satellite image.

5.2 Conclusion

The purpose of this study is to analyse the climate change impacts on water yield in Pahang River Basin. The climate change will affect water uses and water management in the basin. The occurrence of El Niño and La Niña event during the northeast and southwest monsoons has influenced the Malaysia's mean sea level

The impact from the phenomenon La Nina has increased the water yield in Pahang River Basin. Thus,it has made the Pahang River Basin witnesses the flood events, meanwhile, the water yield become decreases due to the phenomenon El Nino. The phenomenon El Nino has a negative impact on almost sectors in the state. The lack of rainfall has caused the reduction of water levels in dams. The effect of this phenomenon has led to the water shortages in Pahang River Basin. From this study, the lowest temporal distribution of water yield is in year 2016 compared to the years before.

From this review, the water management resources can control and plan water supply framework in Pahang. It is additionally can reduce the impacts of climate change amid the event of the phenomenon El Nino and La Nina.

5.3 Recommendation

The recommendations that can be made from this study are first, consider the complex interactions among climate change and other natural changes, for example, LULC and atmospheric changes in future reviews. It is to maintain the water resources in Pahang River Basin, clearly it is of basic significance of water yield informations. Next is anticipate AET with NDVI data from satellite images with better, future reviews. This is because it is important to distribute the contact model considering the wide open water areas.

On the other hand, the authorities need to build appropriate reservoirs which the water could be used during droughts events. In in order to store the water from the rainfall-runoff, the authorities also need to maintain the forest.

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