UNIVERSITI PUTRA MALAYSIA

EVALUATION OF RAINFALL EFFECT ON GROUNDWATER RECHARGE USING SWAT JENDERAM HILIR.

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EVALUATION OF RAINFALL EFFECT ON GROUNDWATER RECHARGE

USING SWAT

JENDERAM HILIR.

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APPROVAL SHEET

This project report entitled "Determination of Rainfall Effect on Groundwater Recharge Using SWAT at Jenderam Hilir, Selangor" is prepared and submitted by Nurfateha Binti Mohd Pilus in partial fulfillment of the requirement for the Degree of Bachelor of Agricultural and Biosystem Engineering with honors is hereby accepted.

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ABSTRACT

This study was evaluating the effect of rainfall on the groundwater recharge using SWAT at the Jenderam Hilir, Selangor. Therefore, some of the data on-site were collected to be characterizing the study area and develop a surface water model of the study area to determining the recharge rate by using SWAT. The recharge had been analyzing the capacity based on changing the environment In Malaysia, climate change increases the temperature which leads to rapid change in rainfall intensity Change in rainfall intensity will affect the groundwater recharge which will contribute to a major problem if the discharge of groundwater was higher than recharge. These problems need to be overcome because the impact that happens to the groundwater cannot be seen on the surface and it will impact the sustainability and storage of groundwater if there are extreme changes recharge occurs. So, Soil Water Assessment Tools (SWAT) is a computer model that had been developing to access the recharge and using the rainfall as the parameter. From the result, it shows that the groundwater recharge had been determined by changing the amount of rainfall and the recharge was evaluated.

Keywords: Soil Water Assessment Tools (SWAT) model, Rainfall, Recharges, Changing Environment.

Abstrak

Kajian ini menilai kesan hujan di dalam aliran semula air bawah tanah menggunakan SWAT di Jenderam Hilir,Selangor. Oleh itu, sesetengah data di tapak telah dikumpulkan untuk mencirikan kawasan kajian dan membangunkan model air permukaan kawasan kajian untuk menentukan kadar cas semula dengan menggunakan SWAT. Pengisian semula telah menganalisa keupayaan berdasarkan perubahan persekitaran Di Malaysia, perubahan iklim meningkatkan suhu yang membawa kepada perubahan intensiti hujan yang ketara Perubahan intensiti hujan akan memberi kesan kepada pengisian air bawah tanah yang akan menyumbang kepada masalah utama jika pembuangan air bawah tanah adalah lebih tinggi daripada cas semula. Masalah-masalah ini perlu diatasi kerana kesan yang berlaku kepada air bawah tanah tidak dapat dilihat di permukaan dan ia akan memberi kesan kepada kemampanan dan penyimpanan air bawah tanah jika terdapat perubahan semula ekstrem berlaku. Jadi, Alat Penilaian Air Tanah (SWAT) adalah model komputer yang telah dibangunkan untuk mengakses cas semula dan menggunakan hujan sebagai parameter. Dari hasilnya, ia menunjukkan bahawa aliran air bawah tanah telah ditentukan dengan mengubah jumlah hujan dan reaksi dinilai.

Kata kunci: Model Alat Kawalan Air Tanah (SWAT), Recharges, Perubahan Alam Sekitar.

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CHAPTER 1

INTRODUCTION

1.1 Background

Recharge is the primary method in which water enters an aquifer which these processes usually occur below plant roots and often called a flux to the water table surface. The interaction between groundwater recharge and rainfall related to each other because it involves in hydrological circle process.

A watershed is a catchment basin that is bound with topographic features. The total amount of water that falls from rains within the catchment area will either flow as surface runoff in the river which drains the basin or sinks into the ground or becomes groundwater. From a watershed hydrologic unit or area of land from water drains, running downhill, to a shared destination or which produce water as the end product by the interaction of precipitation and the land used surface (Jain, SK et.,2010).

Interactively, groundwater recharge dependent on a few factors such as infiltration capacity, features of rainfall, and climate factors. The spatial and temporal distribution of the rainfall mainly controls the natural groundwater recharge. These are the main reasons why we need to observe the interaction of rainfall and groundwater recharge to avoid the imbalance process that can occur and impact the groundwater storage.

Therefore, many researchers had a searching method to establish computer modelling for the future effect on groundwater. SWAT (Soil and Water Assessment Tools) is a conceptual, continuous-time model that was develop in the early 1990s to assist manage in assessing the impact of management and climate on water supplies and continuous of over 30 years of model development within the US Department of Agriculture's Research Service in a watershed and large river basin. By using the SWAT model which allows studying the impact of predicted weather and future land use on watershed hydrology. For that reason, SWAT was selected for allows simulating and forecasting stream flow and assess the impact of land use effect on the watershed (Santhi et al., 2006). Surface water model can be used to assess changes of the groundwater recharge rate towards rainfall intensity during normal and extreme condition.

1.2 Problem statement

In Malaysia, climate change increases the temperature which leads to rapid change in rainfall intensity. Change in rainfall intensity will affect the groundwater recharge which will contribute to a major problem if the discharge of groundwater higher than recharge. The amount and the times for extreme event to happen are increased in future (Sunyer et al, 2012).

During long term El-Niño, drought will occur and the rate of groundwater recharge will decrease. For global climate change increases, water resource stress in locations where runoff and groundwater resources decrease, and droughts will become substantially more frequent (Arnell, 2004). So, proactive management of groundwater was had strongly related to rainfall intensity.

These problems need to be overcome because the impact that happens to the groundwater cannot be seen on the surface and it will impact the sustainability and storage of groundwater if there are extreme changes recharge occurs. So, we need the indicator to observe the rainfall and predict for the future impact of our changing to our groundwater recharge.

1.3 Research objective

The aim of this study is to evaluate the effect of changes in rainfall during the extreme season impact on groundwater.

The specific objectives are:

1. To develop a surface water model of the study area to determining groundwater recharge rate by using SWAT.
2. To analyze the recharge capacity based on changing the environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Rainfall intensity

Evaluation in groundwater resources requires several factors, one of which is the rainfall factor (Zhang and Liu, 1993). The International Climate Change Governmental Panel (IPCC) states that climate change is causing in changes in precipitation and extreme weather events. Heavy and extreme precipitation will increase as the mean of total precipitation rises, as said by Dore (2005). Many researchers use a statistical approach in their study that related to investigate changes in intensity and frequency of extreme rainfall events.

Malaysia falls within the humid tropics and has a climate which is equatorial and greatly influenced by both North East (NE) and South West (SW) monsoons. The monsoons typically bring heavy rainfall while convectional rain is common during inter-monsoonal periods. Much of the rainfalls are received mainly during SW and NE monsoons.

The highest rainfall exceeds 5000 mm and the lowest is about 1750 mm. The average annual rainfall is 2820 mm in Peninsular Malaysia, but there is considerable temporal and spatial variation. The climate of the study area in Langat River is similar to the climate of Peninsular Malaysia which is equatorial-monsoon. (Chang, 1993)

2.2 Hydrological model

SWAT is a hydrological model of public domain used to simulate the quality and quantity of surface and ground water for different climate regimes and to predict the potential impacts of climate change on water resources. The model is based on the general daily water balance, which is used to simulate different hydrological processes.

$$SW_t = SW_0 + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw})$$

The model is based on the general water balance Equation, described by Neitsch et al. which is used to simulate different hydrological processes. Where SW_t and SW_0 are the final and initial soil water contents (mm), t is time (days), R_{day} is the amount of precipitation (mm), Q_{surf} is the amount of surface runoff (mm), E_a is the amount of evaporation (mm), W_{seep} is the amount of percolation and bypass flow exiting the soil profile bottom (mm), and Q_{gw} is the amount of return flow (mm).

2.2.1 Remote sensing

A short review of research indicates that there are many feedbacks shows good results of remote sensing in water resource. Currently, the data operationally are being used in precipitation estimation, soil moisture measurement for irrigation schedule, seasonal and short term precipitation and surface water inventories. In water resources predicting and monitoring, satellite images had been used widely we can retrieve gradually detect the changes of the surface condition. For example, major agricultural land use for crop such as rubber, oil palm and rice plantation can be mapped which including the urban settlement area and forest land through the satellite images

2.2.2 Watershed model

Watershed models can be divided into physical model and mathematical model. Watershed models are calibrated by comparing result of the simulation with existing records. Once the model were adjust to the known period data, additional period of stream flow as well as the water quality can be generated (Viessman et al., 1997).

2.2.2 Watershed delineation

The GIS delineation process starts with grid representation of topography called digital elevation model (DEM). The data that can be retrieve from DEM is a series of additional grid that produces represent various hydrologic characteristic of landscape from "hydrologic grids". A GIS can delineate watershed boundaries by identifying all location within a DEM that are uphill of an outlet.

2.3 SWAT (Soil Water Assesment Tools)

For that, SWAT was selected for its ability to simulate and forecast stream flow and assess the effect of land use changes on watershed runoff. (Santhi et al.2006). Modeling the interactions in aquifers throughout time it is important to understand where and how much recharge enters the system. (Henry 2015). SWAT is a watershed-scale distributed model, the first step in the model setup is watershed delineation into sub watersheds, each connected through a stream channel and further subdivided into HRUs with unique combination of soils, land uses, and management practices (Borah et al., 2006).

To define Hydrologic Response Units (HRUs), the model requires data on land use, soil type and slope. Watershed slope is derived from the digital elevation model using the Slope Spatial Analysis tool in ARC Map 10.1. Using the DEM file as the input raster, the tool translates the elevation into a slope projection using percent slope. This parameter will be used in SWAT Initial Watershed Delineation, Land Cover Classification from 2006 Thematic Mapper Land Cover Classes by Model Run to fill in the subsurface lateral water movement, flow accumulation and routing as well as sediment yield for each sub basin (Arnold, Srinivasan et al. 1998).

The modeling of the water balance in any hydrological model entitles following a detailed procedure to have results at the end of work, the steps followed while using the SWAT model (Y. Bouslihim et al., 2016)

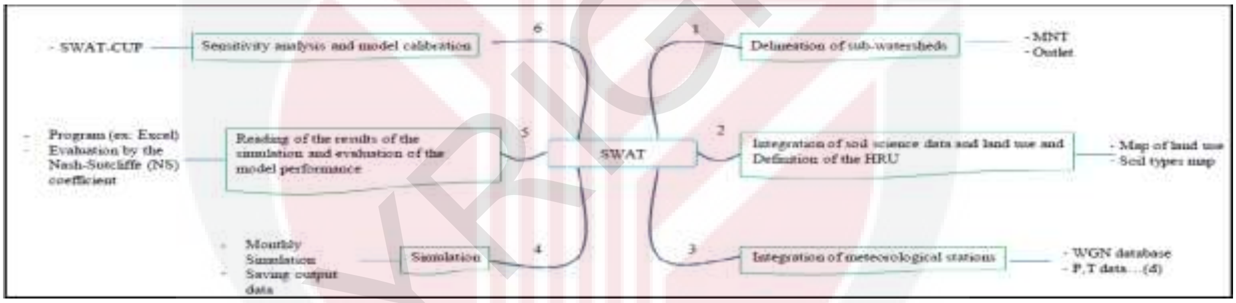

Figure 2.1: Schematic implementation of SWAT (Y. Bouslihim et al., 2016)

2.4 Groundwater recharges

An understanding of the recharge processes and natural recharge rate quantification are the prerequisites for efficient and sustainable groundwater resources management (Chand et al. 2005). Climate change and shifts in precipitation intensity will affect groundwater continuity, thus altering groundwater recharge. Groundwater recharge is an important variable for effective groundwater management especially in drought season with little recharges.

Groundwater resources drough season have been identified as under stress resulting from the imbalance between groundwater recharge and the combination of natural rates of discharge and groundwater withdrawals. Estimation of Recharge by Water Balance:

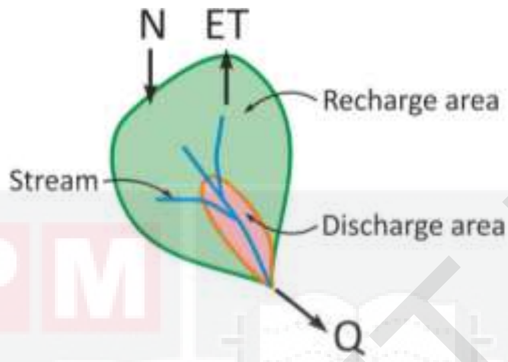

Figure 2.2 Recharge by Water Balance (Freeze & Cherry 1979)

$$N = ET + Q \pm \Delta S$$

Which is N is stand for precipitation, ET is evapotranspiration, Q is discharge and ΔS is change in storage. (Freeze & Cherry 1979)

2.4.1 Master recession curve (MRC)

The estimation of groundwater recharge using in situ data can be conducted using multiple approaches, including the water table fluctuation (WTF) method and the master recession curve (MRC) approach. Periodic recharge would occur during this natural recession decline as a result of intense precipitation events.

The MRC approach of is thus advantageous in our evaluation of recharge as the analysis accounts for natural and anthropogenic changes in groundwater hydrograph recessions over time. The MRC approach is an extension of the WTF method which estimates groundwater recharge as a function of water table height with respect to water table elevation which would occur in the absence of recharge (DH_t) and Sy is the specific yield. . Groundwater recharge for each time step t (R_t) is calculated by

$$R_t = S_y \times \Delta H_t \tag{1}$$

A limitation of the MRC approach is the estimate of the specific yield; thus, recharge was only estimated at wells for which a robust estimate of specific yield could be identified using a relation between streamflow and groundwater elevation. As described by, one may estimate specific yield (S_y) as

$$S_y = \frac{q}{\Delta h} \tag{2}$$

Where q represents the average streamflow during a hydrograph recession event as a depth per unit of catchment area and D_h represents the average decline in groundwater elevations during the streamflow hydrograph recession period. Extend the MRC approach to account for episodic recharge events. In that study, selected episodic recharge events from wells were used to estimate recharge (Nimmo et al., 2015).

2.5 SWAT simulation

Watershed hydrology simulation in SWAT features two major phases which are the land phase of hydrologic cycle and water or roting phase of hydrologic circle. The land phase of hydrologic circle depicted which control the amount of water, sediment, nutrient and pesticide loading into the main channel in eash sub basin.

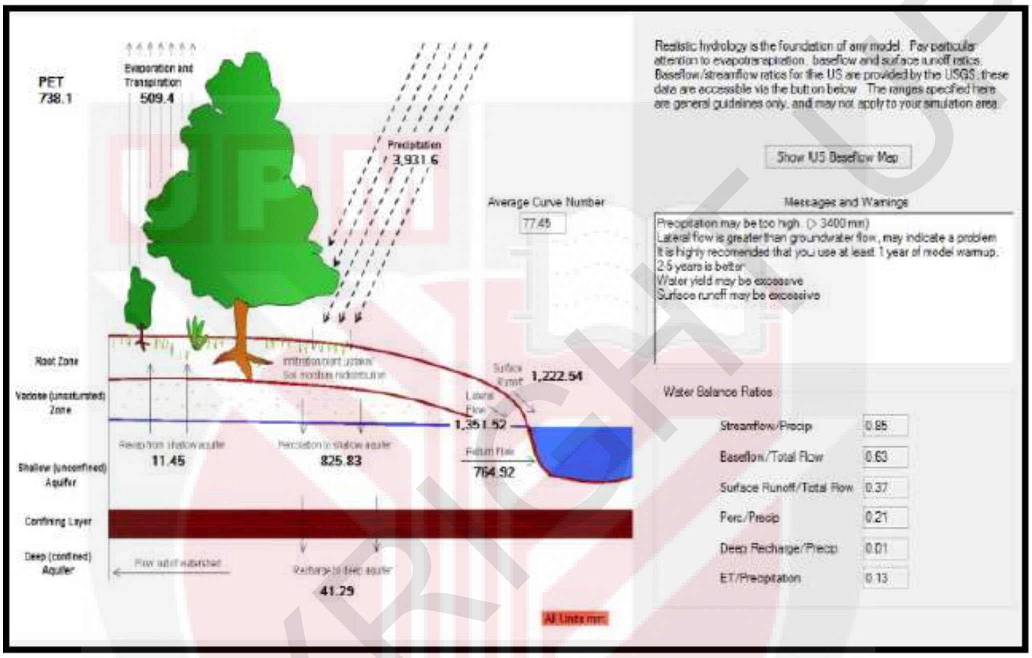

Figure 2.3: SWAT simulation (Nadia et al., 2016)

CHAPTER 3

METHODOLOGY

3.1 Procedure of study

Figure 1 shows the overview of step by step procedure for this study

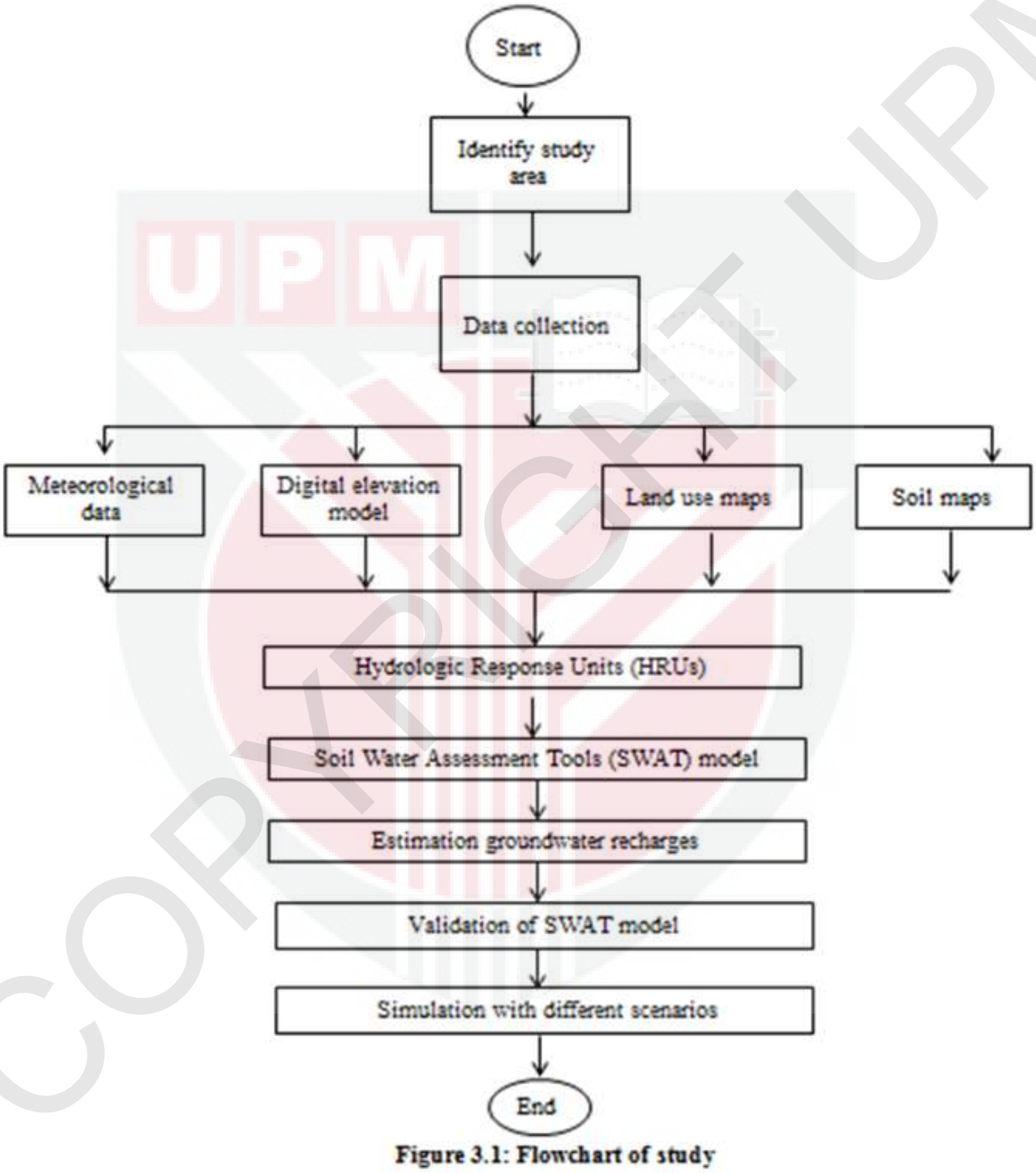

Figure 3.1: Flowchart of study

3.1.2 Study area description

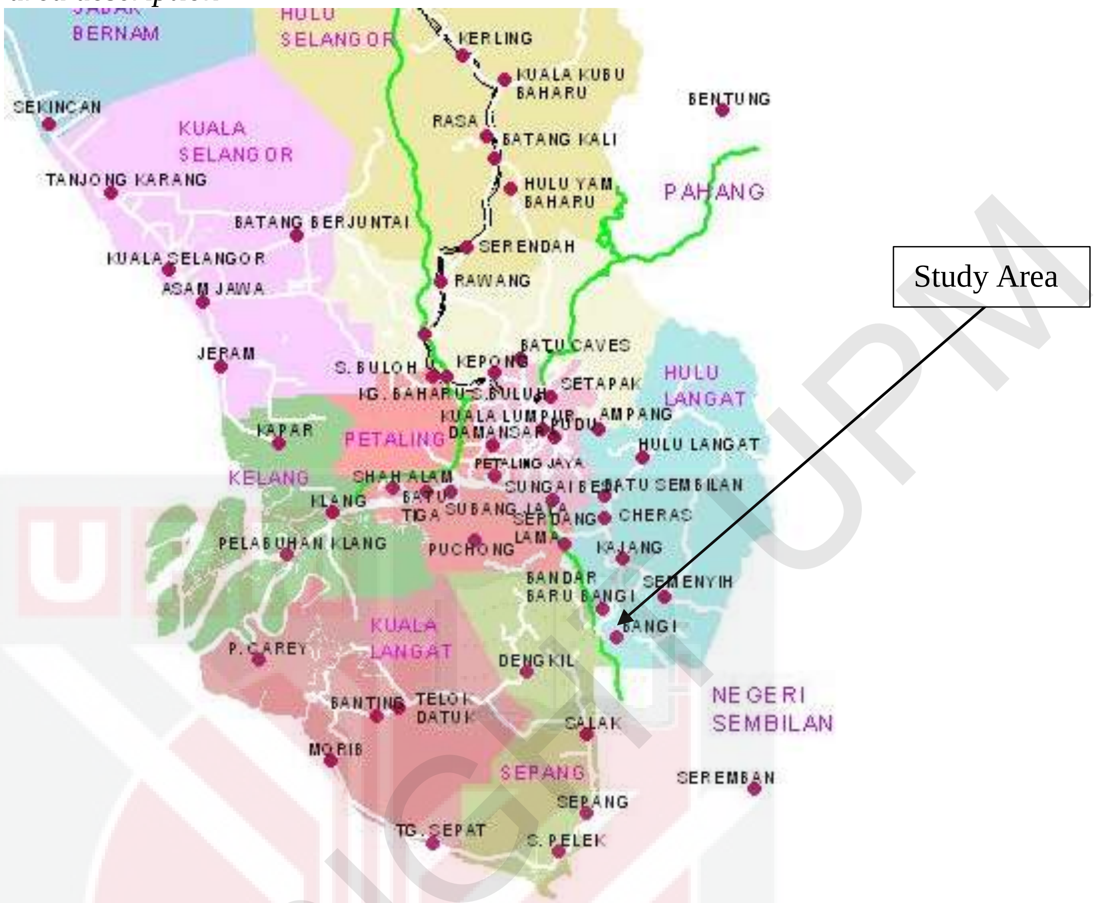

Figure 3.2: Jenderam Hilir, Dengkil, Selangor

The study area is located in Jenderam Hilir, Dengkil, Selangor as shown in Figure 1. The study area is situated in the Langat basin that has a total area of 2,100 km^2. The area comprises of 1,155 km2 hilly mountain terrain and 945 km^2 of coastal terrain. The main river that flows through the study area is the Langat River measured at 78 km long and has a catchment area of 2,100 km2. The main tributary of the Langat River consist of Semenyih River and Labu River.

3.1.2 The Langat River has a total catchment

The Langat River has a total catchment area of approximately 1815 km^2. It lies within latitudes 2^o 40’M 152” N to 3^o 16’M 15” and longitudes 101^o 19’M 20” E to 102^o 1’M 10” E. The catchment is illustrated in Figure 3.2. The main river course length is about 141 km mostly situated around 40 km east of Kuala Lumpur. The Langat River has a several tributaries with the principal ones being the Semenyih River, the Lui River and the Beranang River.

3.1.3 Climate of the Langat River Basin

Malaysia falls within the humid tropics (Chang, 1993) and has a climate which is equatorial and greatly influenced by both North East (NE) and South West (SW) monsoons. The monsoons typically bring heavy rainfall while convectional rain is common during inter-monsoonal periods. Much of the rainfalls are received mainly during SW and NE monsoons.

The highest rainfall exceeds 5000 mm and the lowest is about 1750 mm. The average annual rainfall is 2820 mm in Peninsular Malaysia, but there is considerable temporal and spatial variation. The climate of the study area in Langat River is similar to the climate of Peninsular Malaysia which is equatorial-monsoon. This climate is characterized by high average and uniform annual temperatures, high rainfall and high humidity. This climate has a dominant impact on the hydrology and geomorphology of the study area. Generally the study area experiences two types of season: the wet season in April to end of November, and a relatively drier period from January to March.

The rainfall for the west is differentiated on the basis of a double maximum occurring during the two inter-monsoon seasons in April and October to September, but the double minimum is prevalent during the two monsoons seasons. The highest intensity storms normally occur during the months of October, November, December and April. The driest month in the west is July, and February is the second driest month.

3.2 Data required

There are a few data that need to be collected before starting the modeling input. Firstly, Digital Elevation Model (DEM) gives the elevation, slope and defines the location of the streams network in a basin. Describes the topography and the geometry of the basin and sub-basins; it is extracted from the ASTER - GDEM satellite with a spatial resolution of 30 m.

Then, rainfall collection data from weather station rainfall indices to capture changes aspects of the rainfall distribution. Land use or cover map gives the spatial extent and classification of various land use or cover classes of the study area. The land use or cover data combined with soil cover data generates the hydrologic characteristics of the basin or the study area, which in turn determines the excess precipitation, recharge to the ground water system and storage in the soil layers. Soil map is use to determines the different types of soil in the study area; it is associated with all the information describing the physical and chemical properties of the soil. All data source were summarized in table 3.1.

Data requirements	Main data source
Digital Elevation Model (DEM)	Extracted from the SRTM - USGS satellite with a spatial resolution of 30 m.
Land use or cover map	Department of agriculture (DOA)
Hydrological Data Rainfall data Temperature Data Evaporation Data Stream flow	Department of irrigation and Drainage (DID), Malaysian Meteorological Services
Soil maps	Department of agriculture (DOA)

Table 3.1: Source of data required

3.2.1 Rainfall Data

Rainfall is the most important parameters in hydrologic design which the analyze using the data that we had retrieve from DID. The daily rainfall data were collected from the rainfall station around the study area was tabulate in the table 3.2. Supposedly the data duration needed is 30 years but some of years of data collected were missing.

Type of data	Rainfall station	Data duration
Rainfall	Jenderam Hilir	2008-2018

Table 3.2 Rainfall data collected

Preparation of annual maximum data series from the available rainfall data, rainfall series for different durations for example 1hour, 2 hour, 6 hour, 12 hour and 24hour is developed. Fitting the probability distribution by choosing suitable probability distribution is fitted to the each selected duration data series. Generally used probability distributions are Gumbel’s Extreme Value distribution. y_T values are calculated for different return periods using Gumbel’s distribution.

Intensity of rainfall is the rate at which rainfall occurs and is measured in term of depth per unit time and the common unit of measurement for intensity of rainfall is measure is in mm/hr. Trend analysis of Sungai Langat river basin has been analyze from the data collceted from department of Irigatin and drainage (DID) nearest station to study area which is Jenderaam Hilir rainfall station. Daily mean of rainfall were tabulate in table 3.3.

Month/Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Januari	0	82	217.5	63.5	290.5	162.5	56	170	173	445.5	259.5
Febuary	13.3	304	55.5	43.4	143	357.5	1	25	475.5	197	64.5
March	291.7	393	226.3	173.1	232.5	232.5	157	167	194	297	338
April	333.5	347.5	129.7	220	189.5	181	328.5	178.5	158	282.5	266
May	119.5	34.5	280	154.5	218.5	121.2	293.9	99.5	298	162	191
June	230	77	202.3	68.5	30	28.8	29.6	77	155.5	83	77.9
July	79.5	173	48.6	142.5	92.5	106	42	49.5	121	67.5	85.1
August	144.5	160.5	283.6	140	145	165.5	151.5	197	122	151	1.5
September	107.5	177	256.5	172	273	81	155.5	101	131.5	313	0
October	327.5	172	153.5	288	309	323	242.5	110.5	116.5	128.5	0
November	322.5	282	136.5	371.5	361	327.5	693.5	238.8	330.5	326	0
Disember	299.5	230	52	249.5	345	350	224	556.7	268	127.5	0
Mean	2269	2432.5	2042	2086.5	2629.5	2436.5	2375	1970.5	2543.5	2580.5	1283.5
Average	189.0833	202.7083	170.1667	173.875	219.125	203.0417	197.9167	164.2083	211.9583	215.0417	106.9583

Table 3.3 : Jenderam Hilir Rainfall data (DID, 2019)

3.2.2 Land used

Land use change is an important role that can effected in infiltration and evapotranspiration which involve in the processes of recharges are by rainfall that infiltrate into the cracks and crevices below the land's surface. Due rapid development will cause the changes in amount of infiltration rate. Deforestation, urbanization and others activities will cause alter in seasonal and annual distribution of stream flow. The process of land used maps, were digitize the area based on the cover or plants. The function of lines and polygon was used in ArcGIS to complete the process.

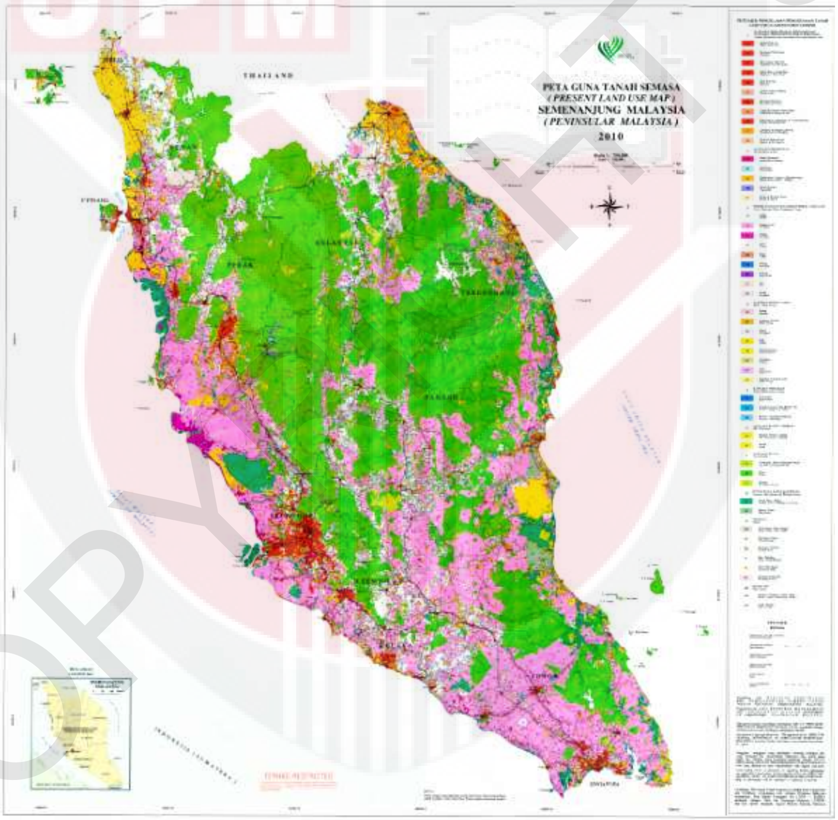

Figure 3.3: Land use maps (DOA, 2010)

3.3 Data processing for surface model

In preparing the data needed such as digital maps layers and database tables, GIS were used in this study. These processes involve in data projection and digitizing maps.

3.3.1 Digital maps

ArcGIS representing number of layers points, polylines and polygons. Most of layers were needed to create grid to fulfill the SWAT requirement such as watershed boundary, soil, land use and others. Other than that it needs information about the urbanization, gauging stations, weather station.

3.3.2 Grid map

Three main maps that required for processing is DEM, soil maps and land used maps to develop SWAT project files. Because it is physical based model, it is important for overlay all this information that can be relate spatially.

3.3.3 Digital Elevation Model (DEM)

This type of information was available various spatial resolutions which in these study was using 30 m resolution. It was recommended for watershed that had below 10,000 km^2. This layer was used to delineate sub basin within the study area and estimated surface parameter such as slope and length of flow path for each HRU.

3.3.4 Soil grid

The roles of soil in Arc SWAT were used to determine the soil properties such as soil texture, hydraulic conductivity, bulk density, water content were needed to make an input to the model.

3.3.5 Land use grid

Land used maps is important consideration and critical input for SWAT that effect the land flow, soil water storage and water demand for irrigation. Land use for Langat River

Basin grid layers mainly covered agriculture area such as Rubber plantation, urban areas, oil palm area and others. This process were completed by digitizing process using 2010 land used maps that had been retrieve from DOA.

3.3.6 Numerical data

Calculation such as means, variance, standard derivation and others were performed for the data using Excel 2007. The process data were transforming into organized GIS database table, which can be used to plot relevant graph for analysis purpose. Other than that several database table were also prepared to provide information needed by SWAT which listed in table 3.4.

No.	Database types	Fuction
1.	Location table -pcp.dbf	For specified raifall location
2.	Land use Loock up table	To specified the SWAT land cover or plant code to be modeled category in land used maps.
3.	Soil Look up table	Used to specified the type of soil to be modeled for each category in soil grid.
4.	Precipitation Data Table	Used to store daily precipitation.

Table 3.6: Information needed by SWAT

3.4 SWAT Database

These SWAT database were needed in order to run the model and can be accessed through 'Edit SWAT Database' in SWAT Arc Map. The SWAT database including user soils, user weather station and land cover or plant growth.

3.4.1 SWAT Database for Soil users

The User Soils database content the soil data in this project which the soil information were obtain from the UPM library and some research from soil report. The soil properties information shows the major types of soil were estimated is for Prang.

3.4.2 SWAT Database for Whether Station

This data contains the weather data needed by SWAT model. All necessary weather data in this project were obtained from the Department of Drainage (DID) Sepang.

3.4.3 SWAT Database for Land cover or Plant Growth.

The model came together with land cover or plant growth data for various crops. Changes on other land use have been made to fulfill the local condition.

3.5 The Arc SWAT model setup

The input for SWAT needs a lot of data to define the physical watershed representation. This including topography Digital Elevation Model, climate (daily measure statically weather data), soil and land use for your study area. The processing of data to generate model in this practical is typically divided into some steps as follow:

3.5.1 Watershed delineation

Sub-basin boundaries are created using the Arc Map watershed delineation toolkit and can be manipulated based on observed routing patterns, soil types and land uses.

3.5.2 HRU Definition; land use and soil database are required.

The Hydrologic Response Units (HRUs) were generated with the Arc SWAT interface in two stages. In the first stage, Arc SWAT intersects the GIS layers of the sub-watersheds, land use, soil and slope classes.

3.5.3 Write Input Table

SWAT requires mean recipitation value, maximum/minimum air temperature, solar radiation, wind speed and relative humidity. Values for all these parameters read from records of observed data or may be generated. From the figure 3.3, 3.4, 3,5 and 3.6 shows the value that had been input into the SWAT data.

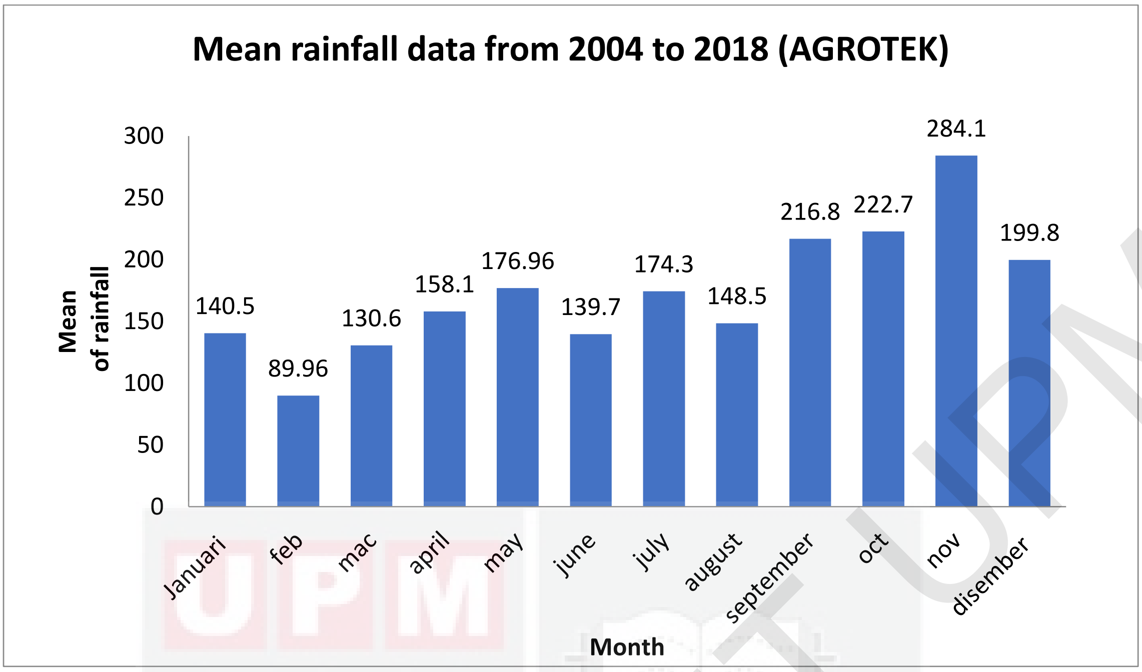

Figure 3.3 : Mean of rainfall data from 2004 to 2018 for Agrotek station

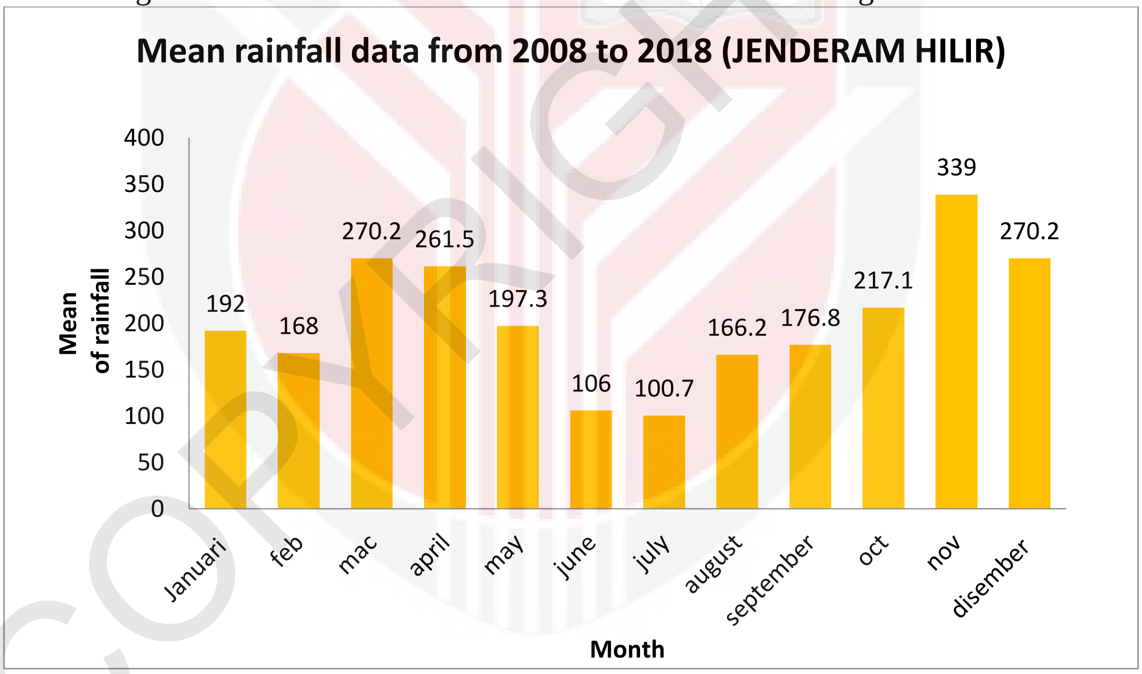

Figure 3.4 : Mean of rainfall data from 2008 to 2018 for Jenderam Hilir station

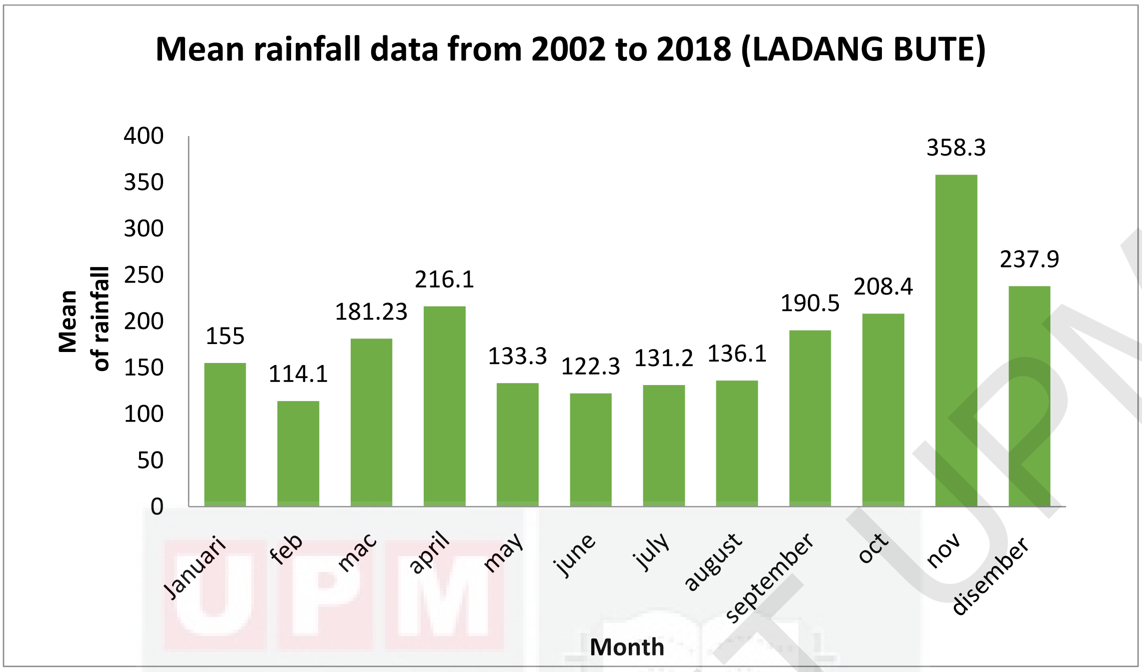

Figure 3.5: Mean of rainfall data from 2004 to 2018 for Ldg. Bute station

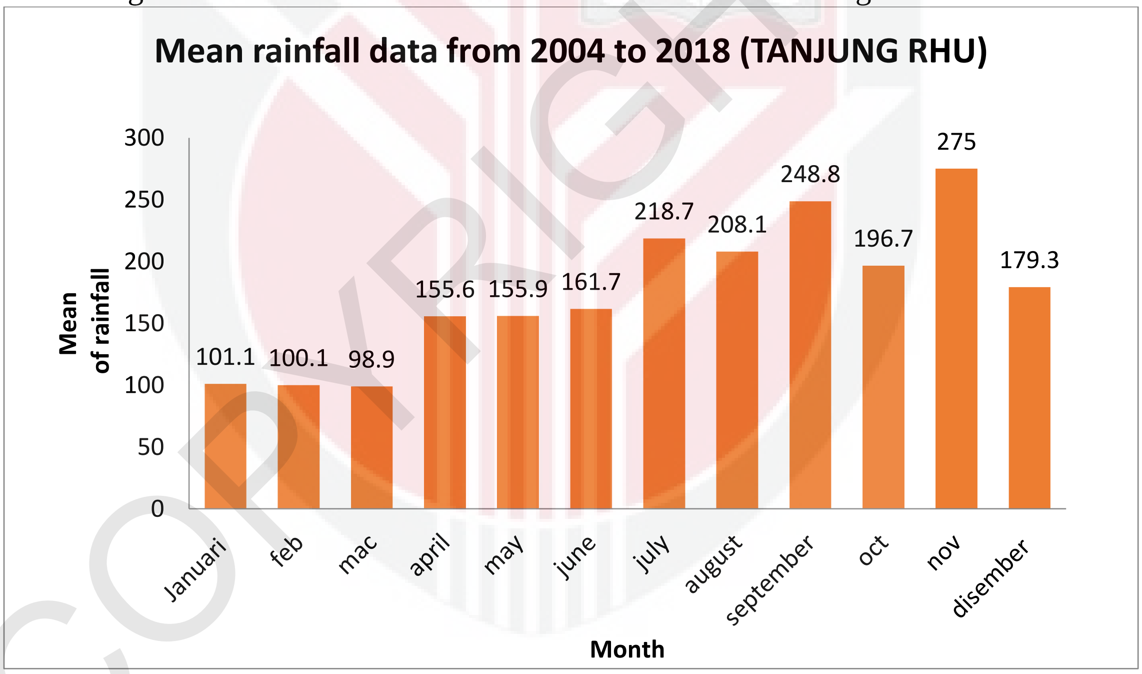

Figure 3.6: Mean of rainfall data from 2004 to 2018 for Agrotek station

3.6 SWAT Simulation

The simulation of the hydrological cycle is based on the water balance, which is carried out taking into account precipitation, evapotranspiration, surface, lateral and base flow and deep aquifer recharge. The hydrological cycle is calculated based on water balance, which is controlled by climate inputs such as daily precipitation and maximum or minimum air temperature. In these studies different situation will be input that is drought season and normal season. The SWAT model approch flowchart of hydrologic modeling in Langat River were shown in figure 3.7.

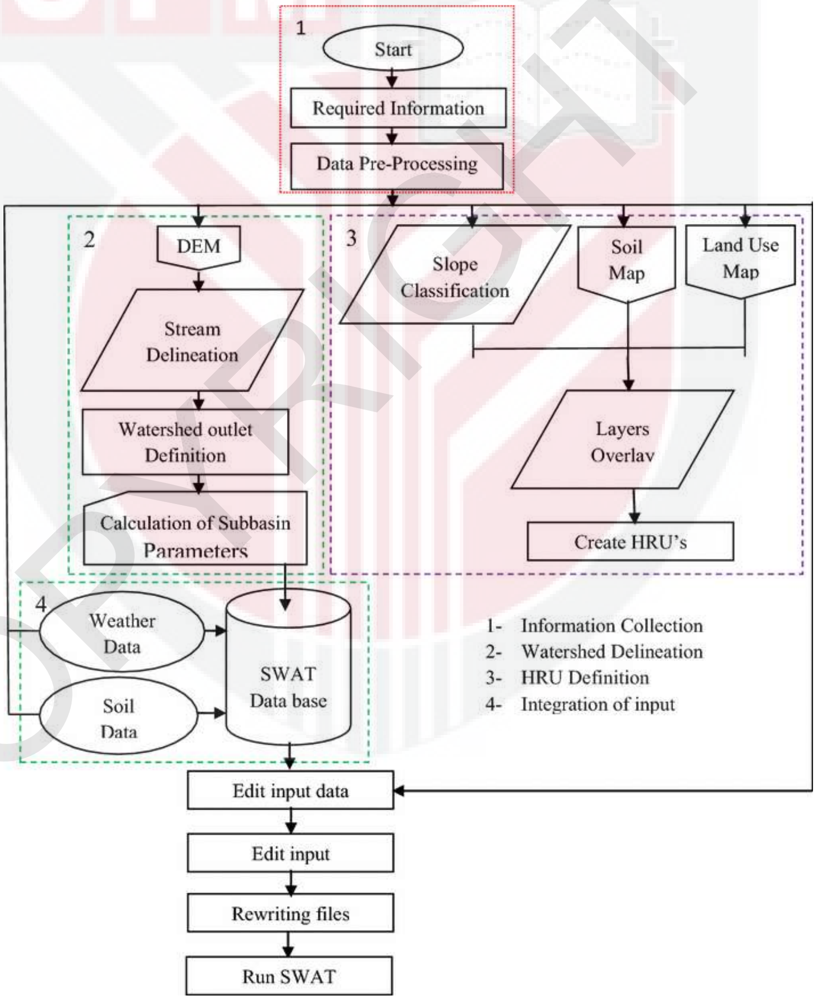

Figure 3.7: The SWAT model approch flowchart

CHAPTER 4

RESULT AND DISCUSSION

4.1 Data preparation

This process were completed by digitizing process using 2010 land used maps that had been retrieve from Department of Agriculture. The result show the produce maps Selangor area which before the studies area was define.

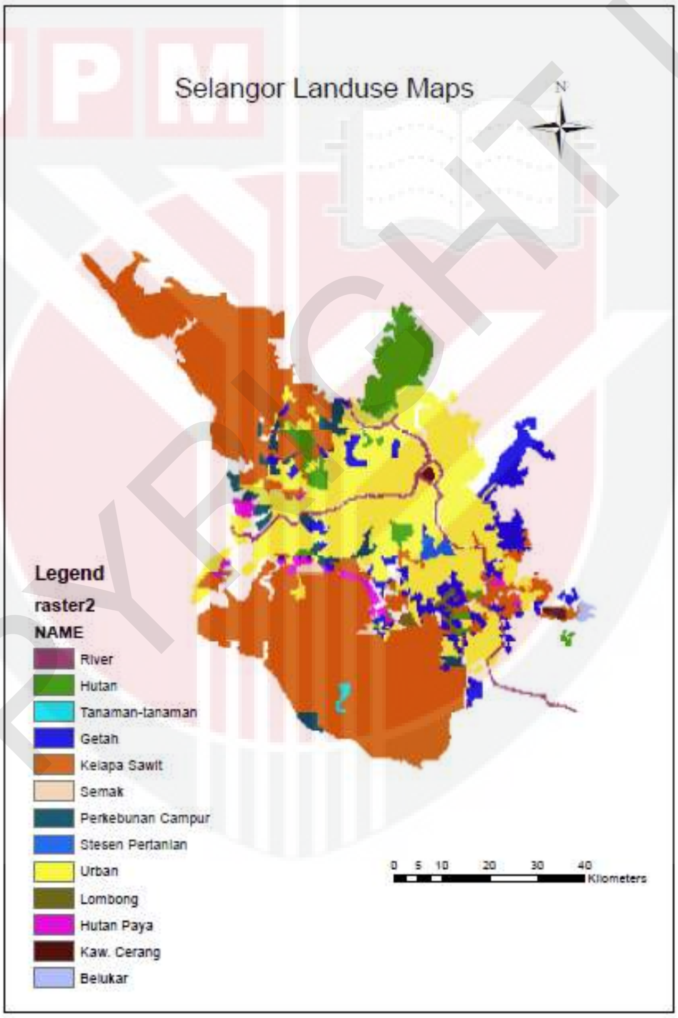

Figure 4.1: The land use maps

4.2 Land used classification

Land used reclassification were show the result of our covered land in our study area. The largest area that covers our study area is an urban area that might show resident areas. It has cover for 67.85% of areas show that more than half of the study area and it shows the blue color on the maps. Then, other than that agriculture activities were involved such as rubber 10.80 %, palm oil 16.83 % and other 4.52 %. Various land used categories and their coverage in the watershed are shown in table 4.2

LANDUSE	Code	Area [ha]	%Wat.Area
Rubber Trees	RUBR	537.4891	10.83
Oil Palm	OILP	837.2144	16.87
Agricultural Land-Generic	AGRL	225.0387	4.53
Residential	URBN	3364.3233	67.77

Table 4.1 Coverage of land used categories

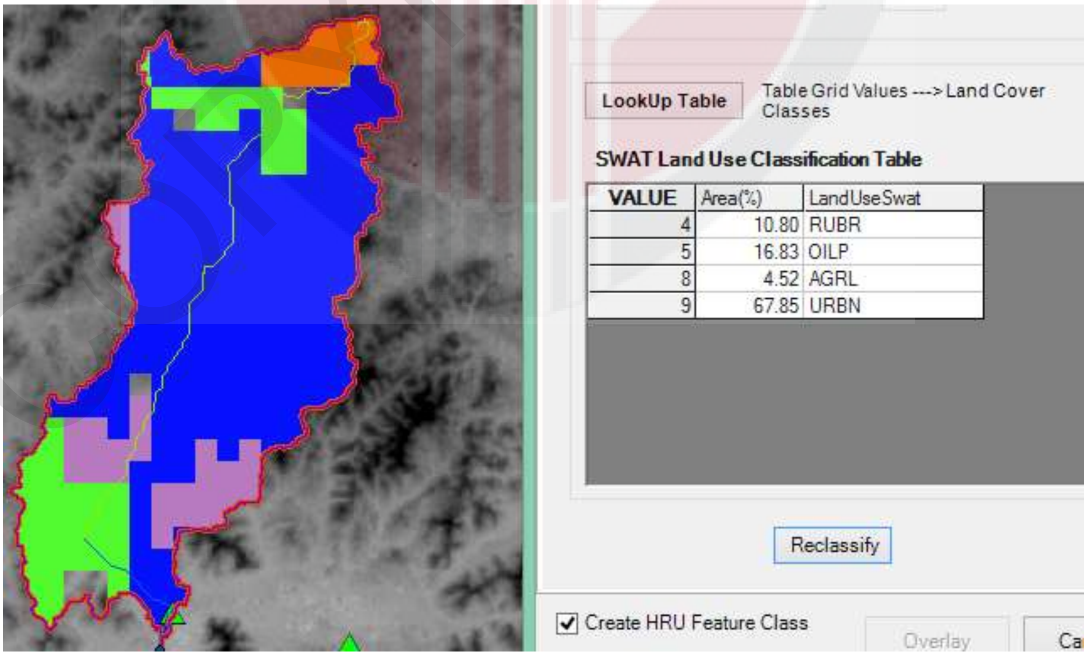

Figure 4.2 Reclassified land used

4.3 soil classification

Our soil type in our study area contains 4 type series of soil. The biggest area shows that it has Prang type series which in pink colors. Parameters that needed for knowing the soil type of soil series can give us the value of hydraulic conductivity, the storage and others. The soil map and the area were shown in table 4.4 and figure 4.5. After merging the soil type we had make the areas 100% of our study area called Jenderam Hilir 1.

Soil	Area	Percentage
Jenderam 1	4964.0654	100.00

Table 4.2: Soil area reclassifies

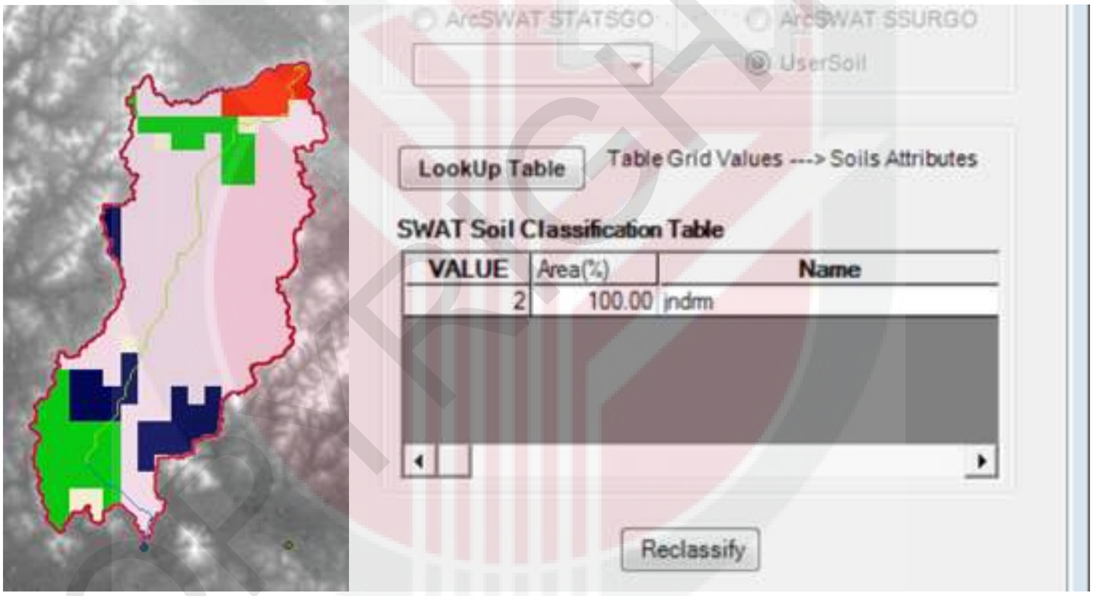

Figure 4.3: Soil reclassifies

4.4 slope classification

For areas steep land in the basin the slope is less than 20 % show in the figure in blue color. There is range of slope that had been set into three classes of slope. The slope has been divided into three classes as shown in figure 4.6 and it also differentiate by 3 colors that is blue, red and dark green.

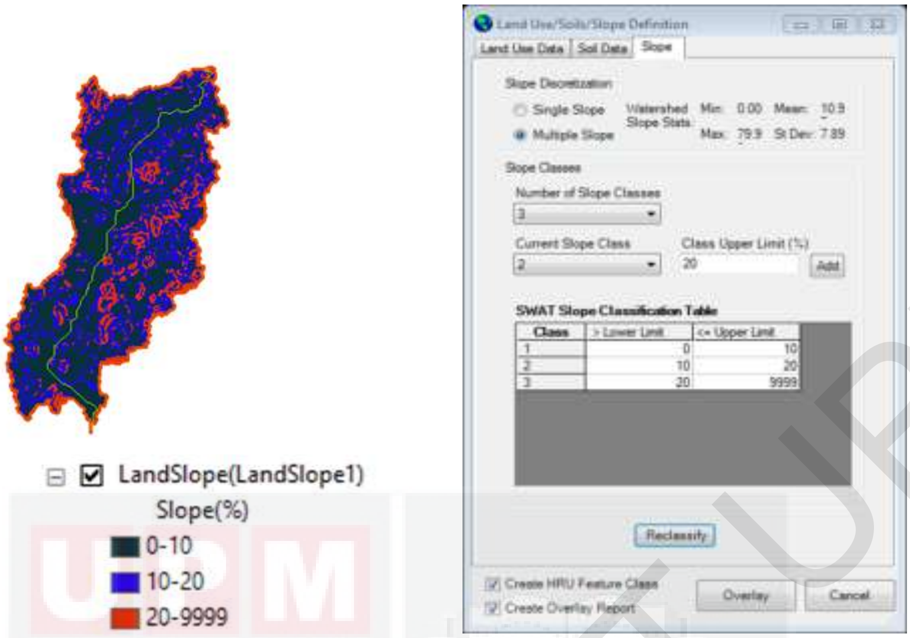

Figure 4.4 Reclassified slope

The HRU output files contain summary information such as coverage area; land used and soil type for each HRU in the river basin. Result from running SWAT produce several output files that are of great importance in this project. These results can be used as simulation to predict the groundwater recharge based on amount of precipitation that had been analyses for 10 years from 1 January 2008 to 1 December 2018. Based on the process of overlay the soil, land use and slope parameters, it will develop a condition of scenario that emits to the study areas and to observe the recharge value.

4.5 SWAT simulation

4.5.1 Normal condition scenario

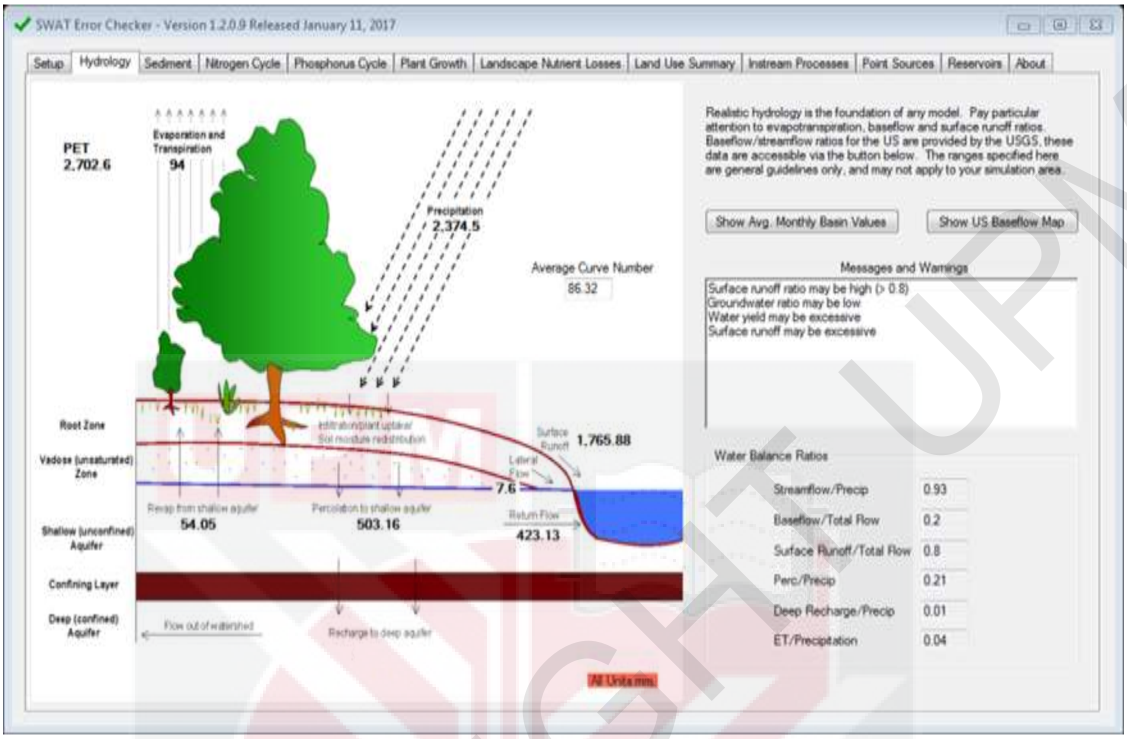

Figure 4.5 Simulation for normal condition

The average annual rainfall is 2820 mm in Peninsular Malaysia In our simulation the normal condition for normal condition 2,374.5 mm. From this simulation had been run based on the current condition of land used, slope and soil type. It shows the recharge that produce were 513.06.

4.5.2 Low Precipitation Scenario

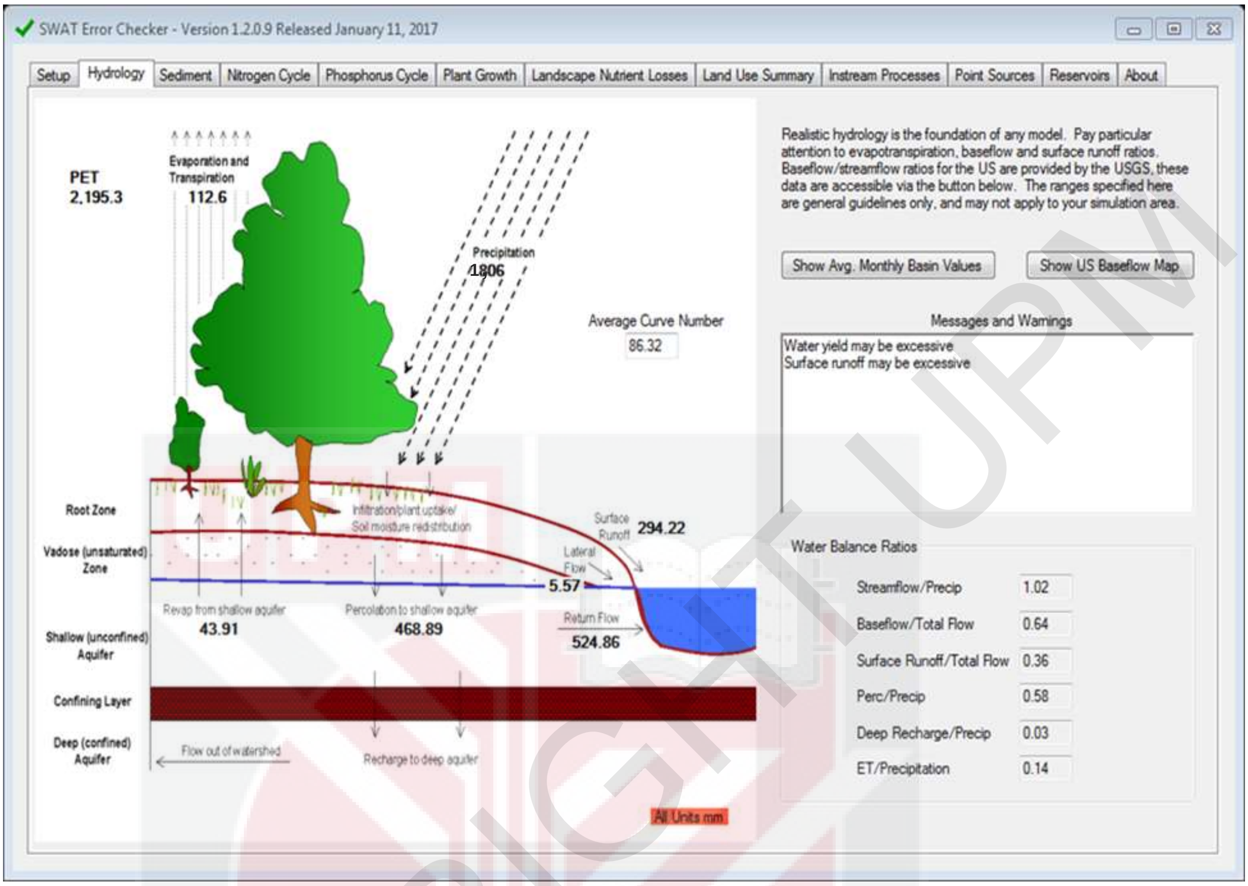

Figure 4.6 Simulation for extreme condition

Scenario condition	Precipitation	Recharge
Normal	2374.5	503.16
Low precipitation	1806.0	468.89

Table 4.4: Result of recharges

So, it shows that the decrease of recharge from normal to low precipitation condition base on rainfall intensity. Based rainfall intensity return period, the forecating for future predictio of rainfall can be evaluate. The changes of climate can be determine by comparing the precipitation prediction with the decreases of rainfall intensity in future cause by the climate change. Based on changing of rainfall the recharge become lower effected by the current landused, the soil type on-site and the different degree of slope that characterize the actual site.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, we had determined our hydrological regime of our study area by delineated watershed for Langat River and identify hydrologic response parameters of the area that is 4964.0654 hectare. This work process was completed by using integration remote sensing, GIS and hydrologic model to develop surface water model of the study area to determine groundwater recharge rate by using SWAT. Other than that, the groundwater recharge had been determined to analyses the recharge capacity based on changing the environment, for normal condition 2374.5mm have produce 513.06 recharges while for low precipitation that is 1806 mm will produce 468.69 recharges. That shows that the changes occur when the amount of rainfall were changing the recharge also will changes. It also takes many parameters to complete the evaluation. Based on study area the slope were between 10 to 20 percent sloping. The land used also take account cause it cover the land and takes time for the rainfall to infiltrate into the soil. The type of soil give the soil properties which it can affect the based on the sand, silt and clay contain in the soil. All of this parameter will produce the process of simulation on the impact of recharge based on the changes of amount of rainfall. Objective on evaluation of different situation which based on amount of rainfall was satisfies.

5.2 Recomendation

The recommendation that suggested improving our SWAT modeling is to predict the future rainfall event which can be used for SWAT input. Other than that, our project needs a further adjustment on input data to increase the accuracy of our SWAT modeling. We also had to make sure our data was calibrated for taking the model was considered the same as the actual condition of our study area. Some of the data were missing need to be interpolating to get the nearest data to the site and the soil properties were needed for future adjustment of actual value such as hydraulic conductivity, bulk density, storage, available water content and etc.

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