

Original Research Article**APPLICATION OF SWAT AND 3D ENVIRONMENT IN
FLOOD DETECTION SENARIO OF TERENGGANU
WATERSHED**

Abstract For many years, the River (Sungai) Terengganu watershed in Malaysia has been flooding and causing great problems to the inhabitants as well as the environment. This study uses the real-time simulation in ArcGIS 10.3 and 3D in ArcScene 10.3, and the variables obtained from the soil and water assessment tool SWAT such as the land use, soil and slope are the parameters measured to induce the flood. When certain portions of the Hydrologic response unit HRU; land use, soil or slope is changed due to temporal adjustment and climate change, then the model can predict zones of low, moderate and high flood risk. The 3D simulations appear to produce a visual model for decision-making, planning, management, and mitigation.

Keywords: Flood, Simulation, 3D GIS, Modeling, watershed

1. Introduction

Each time it floods the soil gets wet and increases in the nutrient. But the flood is one of the natural disasters that occur when river volume exceeds the limit of it banks thereby over flow over land and cause havoc. The regions in Peninsular Malaysia located near the coastal estuaries and bays are usually experiencing flood event during the monsoon period. According to [1] flood can be defined as a high water flow naturally or artificially from the river bank that dominates the surrounding area to cause overflow. Water is the basic units of life, if the quantity or

volume is too much it may be of fewer benefits to human as it can result in flood hazard and if it is a too merger in quantity may result in famine, drought, desertification and wilting of agricultural (farm produce). The Department of Irrigation and Drainage Malaysia (DID) is responsible for providing flood forecast and warning services to the public [2]. The short messages system (SMS) according to [3] was suggested to be an important alert for mitigation against flood to the communities because information about flood events will reach them effectively. Van [4] incorporated remotely sensed data

collection used in the recent trend in GIS application to watershed research as improved the concurrency of collected data as compared to the manual entries which are subject to errors. Improved database organization and storage had help in determining watershed segmentation; identification of drainage divides and channels networks. [5] are the view that making use of satellite data on water watershed over large land cover areas in the different ecosystem in Florida, Great Lakes, Washington, and Africa. [6] concluded that in Malaysia, converting land use from agriculture to the urban area increase the runoff rate. The general perceptions of the flood were seemed to have negative impacts.

1.1 Flood Management in Malaysia

The Department of Irrigation and Drainage (DID), It is the leading government agency responsible for flood management in Malaysia form in 1932. Its main function then was to manage floods in agriculture sector through the drainage system. Following the big flood of 1971, flood mitigation for urban and rural settlement is required and continues. The local authority was responsible for food security by providing flood forecasting service and warning through hydrological data, there are available records of a flood event in Malaysia started from 1926 till today.

Table 1: Flood Events on Selected Floods in Malaysia for the last 10 Year

Flood Event (year)	Place	Damage (RM million)	Deaths	Person Evacuated
1997	Kedah, Terengganu	NA	5	5,321
2000	Terengganu, Kelantan	7.1	NA	NA
2001	Pahang, Johor	NA	15	13,195
2002	Kuala Lumpur	NA	NA	NA
2003	Kuala Lumpur, Pulau Pinang, Kedah	NA	5	31,046
2004	Kelantan, Terengganu, Pahang	NA	17	17,080
2005	Kedah Perlis, Kelantan, Terengganu	240.1	14	99,405
2006	Johor, Negeri Sembilan, Melaka	NA	15	107,000
2007	Pahang, Kelantan, Johor, Kedah (Dec.)	316.1	22	36,143
2007	Kuala Lumpur (June)	NA	NA	NA

Source: [7] Drainage and Irrigation Department Malaysia (DID) Malaysian National Security Council.

The SWAT or Soil Water Assessment Tools is a physically based, continuous time calculation of hydrologic model [8]. It was designed to predict daily stream flow activities, nutrient losses, soil analysis and sediment yield in a watershed. Several studies previously showed and indicated a promising result using SWAT as a hydrologic model. These include, [9] [10], [11], [12], [13] respectively. The advent of Soil Water Assessment Tool (SWAT), in recent years, have tested several hydrological modeling through simulation and calibration of different spatial scale to investigate strategies in

planning and management of watershed [14].

1.2 Hydrologic Respond Units (HRUs)

The incorporation of HRUs non-spatial in SWAT has supported adaptation of virtually most of the watershed model. The recognition of size ranging from small field to entire river basins in HRUs within sub-watershed are relevant because it keep the model dependent by allowing soil and land use heterogeneously equal. However, there are limitation in simulating waterways of grasses because of the channel routing is not simulated at HRU level Arabi et al (2007)[15].

According to Monteith (1965)[16], SWAT contains climatic inputs such as daily precipitation, maximum and minimum temperature, relative humidity, solar radiation, and wind speed.

103° 1'56.06"E, Lat 5°21'27.38"N, Long 102°53'13.88"E. Terengganu has the largest population with a population of 406,317 in 2010. It was named to Kuala Terengganu with the title *Bandaraya Warisan Pesisir Air* (English: Coastal Heritage City) on 1 January 2008.

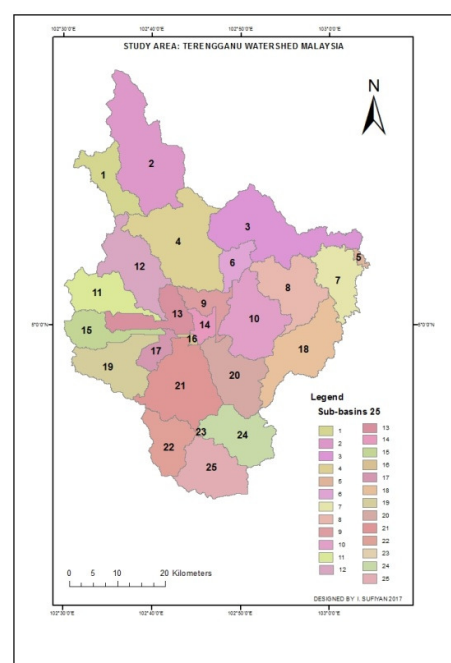


Figure 1: study area map

2. Materials and Methods

2.1 Study Area

Geographically the study area is situated at the estuary of Terengganu to the eastern part faces the South China Sea. The study area located at Lat 5°27'4.05"N, Long 103° 2'47.04"E Lat 5°16'51.43"N, Long 103°10'39.30"E, Lat 5°13'14.65"N Long

The image from the remote sensing data was acquired and is one of the prerequisite. The topographic data from was acquired through the use of digital elevation model (DEM) which has been received from Advanced Space borne Thermal Emission and reflection Radiometer (ASTER). Reuter et al (2009) [17]. The ASTER DEM for this study has a spatial resolution

of about 30 meter. Another rainfall data variable were computed from 2000 to 2010 and analyzed based on the catchment parameter. The ArcSWAT were used to simulate the result by inputting the available data from the weather, rainfall and soil. These techniques will ensure that the output data will be a model useful for further studies

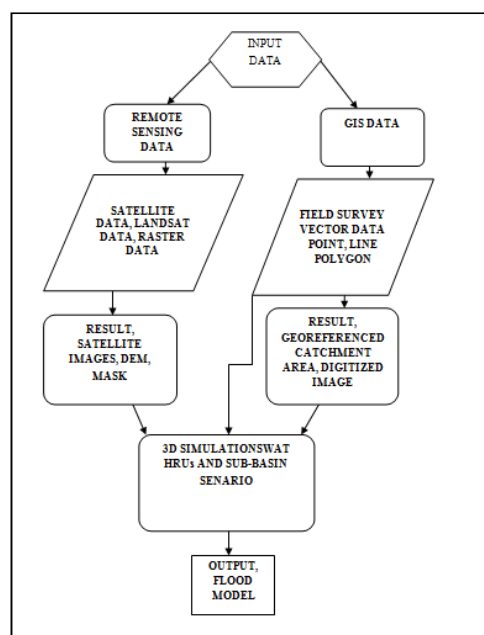


Figure 2: Flow Chart

2.2 Data Requirement

Different application use different data variable for modeling spatial data. This includes

1. ASTER DEM
2. Global Land use/Land cover data
3. Soil data
4. Weather parameter

All the datasets required for this study are transformed into the geodetic datum of coordinate transformation. The Malaysian projection system is formed within the geodetic survey of Ratified Skewed Orthomophic known as Kertau RSO. Accord to Wincell et al (2010)[18], there are two basics information of datasets to be supplied in the interface of ArcSWAT

- a. Required spatial datasets and
- b. Optional spatial datasets

The required spatial datasets entails the followings;

1. DEM
2. Land Cover
3. Soil map/data

The optional spatial datasets includes

1. Weather parameters
2. Daily rainfall data
3. Daily stream flow
4. Daily suspended sediment

2.3 Data Processing

The SWAT analysis were carried out in steps and logical coherent so that there will be consistence in the output data. The steps in this study involved the following;

- a. Ground survey (field data base on land surveying procedures) this include depicting the coordinate and transformation for land cover,

- land uses, soil mapping, physical features and residential locations.
- b. Flood mapping; map demarcation with output data as flood map of the study area.
 - c. Preparing ArcSWAT Input data which also involved the two basic datasets (require and optional datasets) such as the .tiff files, polylines. .txt files shapefiles and feature classes.
 - d. The main installation of ArcSWAT2012 that is the interface extension of ArcGIS 10.3.
 - e. The SWAT project setup that includes watershed delineation, HRU analysis, input weather data, and SWAT Database creation Santhi et al (2001)[19].

2.4 ArcSWAT Installation/Project Setup

The ArcSWAT is free open source GIS software which can be downloaded can be linked as an extension to ArcGIS, depending on the version compatible to it Winchell et al (2007)[18] The SWAT project setup was created using figure 3 below;

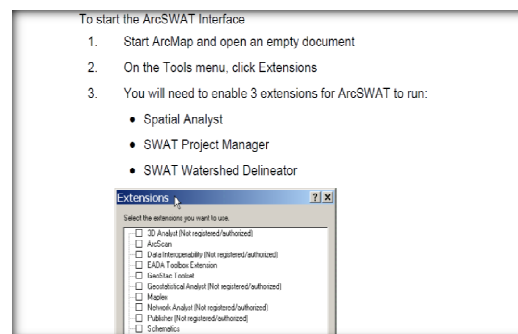


Figure 3: SWAT Interface

We can simple check those relevant extensions especially the ones that can be use for the simulation such as Spatial Analyst, SWAT Project Manager and SWAT Watershed delineator as show in the diagram below after the installation, the customized menu, the toolbar will then appear in the ArcMap window

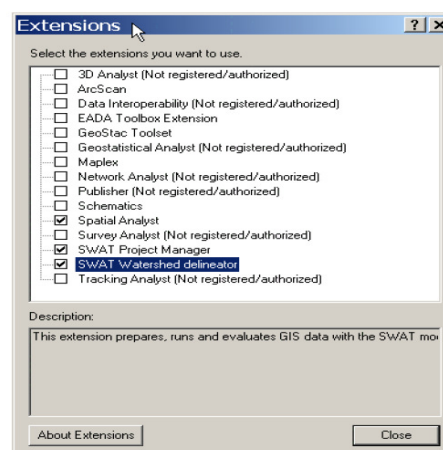


Figure 4: SWAT Extensions

The SWAT interface contains the entire variable that can be use for the hydrologic solutions. The tools are setup from the customized menu that can be appeared in the ArcMap window as seen below in figure 5.

The New SWAT Project can be selected to register the data from the drop down menu

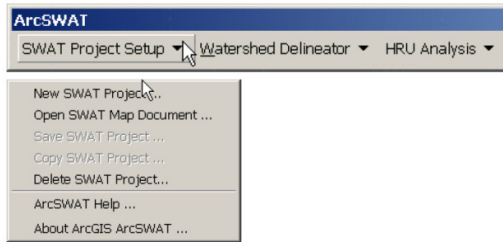


Figure 5: SWAT Project Setup

2.5 Watershed Delineation

Here the ArcSWAT will delineate the whole watershed of the area under study and give the the accurate reports in figures for all the watershed, we can also use the automatic watershed delineation

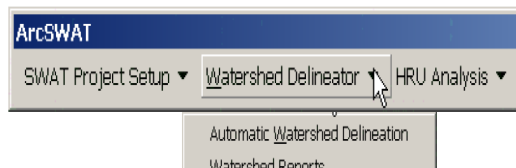


Figure 6: Watershed Delineation process

The River Terengganu can be delineated using SWAT analysis based on the required data which can be imported as explained in the watershed delineation interface. Each of the step are listed in numerical order below.

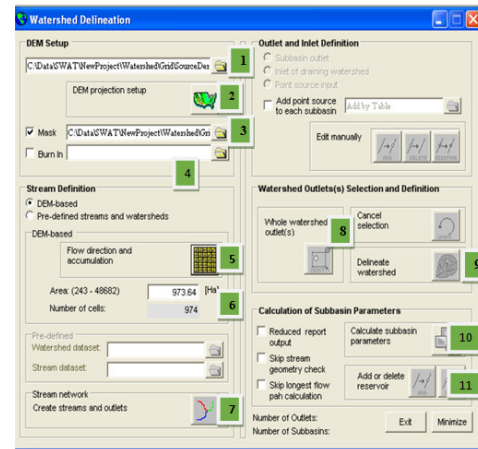


Figure 7: summary of SWAT Analysis Table

- (1) The Digital Elevation Model DEM was setup and loaded from the stored location in C drive from the computer
- (2) The DEM coordinate was transformed and setup
- (3) The Masked of River Terengganu was superimposed and loaded from the C drive
- (4) The Burn In was also defined and loaded
- (5) The River Flow direction and accumulation were calculated based on the DEM
- (6) The outcome or result of the flow accumulation was obtained of the total area in hectares and the calculated raster cells of the catchment.
- (7) Stream network and outlets were created
- (8) The whole watershed outlets from the Terengganu River mouth was formed

(9) All the watershed in the River Terengganu Catchment has been delineated

(10) Other Subbasins within the catchment area under study was also been calculated

(11) The selection of appropriate Reservoir was also done in the River Terengganu catchment.

2.6 Hydrologic Respond Units (HRUs)

Hydrologic Response Units HRUs is largely an analysis that described the pattern of Land Use/Land Cover, Soil and Slope definition. It is also in this analysis that the whole HRU definition is calculated then gives the reports.

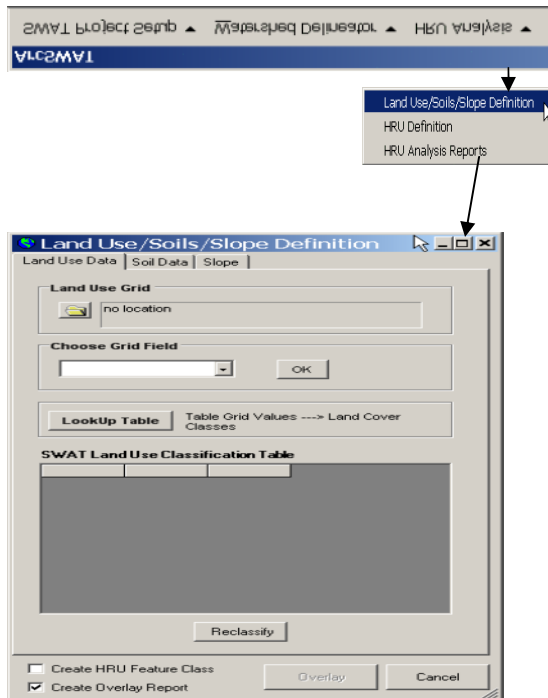


Figure 8: Hydrologic Response Units Analysis

Write Input Tables here the weather parameter will be inputted such as that rainfall, humidity sunshine wind can be written in the SWAT table. Mostly the user options are obtainable from weather station in a given area under study. For the purpose of this study we obtained data concerning weather parameters from Malaysian Department of Irrigation and Drainage (DID).

We can edit the use requirement data such as the Land Cover and Soil data base on the types and location of each individual parameter so that it will automatically updated in the SWAT database

2.7 SWAT Simulation

We can now select to run the SWAT, read SWAT output, set default simulation or enable manual calibration as well.

3. Result and Discussion

Most of the outputs data have shown are properly compared in the ArcSWAT and the satellites image data are recently acquired using Landsat. The major categories of marine ecosystem in Malaysia are obtained for the needs of sustainable coverage of the locations for management and development purposes. The table 2 and 3 below are the Marine ecosystem in Malaysia

Table 2: Peninsular Malaysia

Habitat	Area (Sq ²)
River and flood plain	9,111
Peat Swamps	4850
Mining Pools	164
Reservoirs	1600

Table 3: East Malaysia

Habitat	Area (Sq ²)
Rivers and Flood plain	8487
Peat Swamps	15150
Reservoirs	22

SWAT output results from the 6 different stations

For the purpose of this study, we focus on the slope data and the input flow from the daily and monthly precipitation output from 2 different stations in Kuala Terengganu as show in Table 4 and Table 5.

Table 4 Station 1 rainfall output in Kuala

Statistical Analysis of Daily Precipitation Data (1980 - 2010)						
Input Filename = 4929001.txt						
Number of Years = 31						
Number of Leap Years = 8						
Number of Records = 11323						
Number of Nodata values = 1298						
Month	PCP_MM	PCPSTD	PCPSKW	PR_W1	PR_W2	PCPD
Jan.	385.51	23.1799	4.4106	0.2963	0.8298	21.42
Feb.	221.07	22.8392	7.0879	0.2244	0.7170	13.45
Mar.	261.93	19.3347	6.1329	0.1951	0.7676	15.13
Apr.	200.10	12.1452	3.3128	0.2870	0.7189	16.06
May.	234.87	13.7350	3.2798	0.4069	0.6931	18.00
Jun.	190.95	12.4190	3.3892	0.3690	0.6144	15.23
Jul.	195.76	11.4448	3.6565	0.3443	0.7002	17.32
Aug.	231.45	12.0240	2.7927	0.4704	0.6964	19.55
Sep.	253.49	14.6622	4.7385	0.5144	0.7034	19.90
Oct.	273.34	15.2849	3.3537	0.3455	0.7259	21.42
Nov.	557.37	37.1827	4.6618	0.5073	0.8221	23.39
Dec.	817.03	46.2372	3.2069	0.4234	0.8363	23.84

PCP_MM = average monthly precipitation [mm]
PCPSTD = standard deviation
PCPSKW = skew coefficient
PR_W1 = probability of a wet day following a dry day
PR_W2 = probability of a wet day following a wet day
PCPD = average number of days of precipitation in month

Table 5 Station 2 rainfall output in Kuala Terengganu from SWAT

Statistical Analysis of Daily Precipitation Data (1980 - 2010)						
Input Filename = 5230041.txt						
Number of Years = 31						
Number of Leap Years = 8						
Number of Records = 11323						
Number of Nodata values = 34						
Month	PCP_MM	PCPSTD	PCPSKW	PR_W1	PR_W2	PCPD
Jan.	185.61	14.2660	4.5245	0.1909	0.6210	11.06
Feb.	111.52	13.5167	6.0771	0.1292	0.5179	6.29
Mar.	179.06	18.9010	5.9720	0.1098	0.5610	6.61
Apr.	96.15	9.8178	4.3316	0.1357	0.3684	5.52
May.	174.96	13.0755	3.3673	0.2173	0.4602	9.32
Jun.	165.19	12.4461	3.1271	0.2692	0.3780	9.39
Jul.	189.40	13.9009	3.1049	0.2518	0.3688	9.10
Aug.	231.39	15.6308	3.0414	0.2995	0.3531	10.32
Sep.	251.69	15.4873	2.4943	0.3584	0.4355	12.00
Oct.	289.15	17.0475	3.0047	0.3717	0.5128	13.90
Nov.	673.41	41.8015	3.1030	0.4095	0.6598	17.16
Dec.	686.83	39.8192	2.8810	0.3687	0.7260	18.84

PCP_MM = average monthly precipitation [mm]
PCPSTD = standard deviation
PCPSKW = skew coefficient
PR_W1 = probability of a wet day following a dry day
PR_W2 = probability of a wet day following a wet day
PCPD = average number of days of precipitation in month

SWAT Senario Result of 10 major sub-basins in Terengganu watershed. The sub-basins in the watershed has individual parameters. About 10 subbasins with unique values and senario were obtained as illustrated from Table 5 to Table 14. Looking closely at each sub-basin, they have different characteristics in terms of HRUs, land cover, soil and slope, the flood dectection defended upon the presence or absence of each Sub-basins morphology

Table 6: sub-basin 1

		Area [ha]	Area [acres]	%Wat Area	%Sub Area
SUBBASIN #	1	8,810.7300	21,771.7544	3.08	
LANDUSE:					
Water	WATR	60.6302	149.8203	0.02	0.69
OilPalm	OILP	808.2826	1,997.3067	0.28	9.17
Forest-Evergreen	FRSE	7,950.5746	19,646.2673	2.77	90.24
SOILS:					
MARANG		114.8641	283.8348	0.04	1.30
STEEPLAND		8,704.6233	21,509.5595	3.04	98.80
SLOPE:					
0-10		718.8238	1,776.2495	0.25	8.16
10-20		1,822.5097	4,503.5125	0.64	20.69
20-30		2,080.0754	5,139.9704	0.73	23.61
30-40		1,729.3572	4,273.3281	0.60	19.63
40-9,999		2,468.7213	6,100.3339	0.86	28.02

Table 7: Sub-basins 2

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	2	27,019.5300	66,766.6096	9.43	
LANDUSE:					
Water	WATR	164.1430	405.6055	0.06	0.61
Oil Palm	OILP	3.1531	7.7915	0.00	0.01
Forest-Evergreen	FRSE	26,878.9097	66,419.1297	9.38	99.48
SOILS:					
MARANG		3,939.7921	9,735.4231	1.38	14.58
STEEPLAND		23,106.4137	57,097.1036	8.06	85.52
SLOPE:					
	0-10	2,347.6411	5,801.1386	0.82	8.69
	10-20	5,411.6736	13,372.5160	1.89	20.03
	20-30	5,918.3367	14,624.5058	2.07	21.90
	30-40	5,157.8916	12,745.4080	1.80	19.09
	40-9,999	8,210.6629	20,288.9584	2.87	30.39

Table 8: Sub-basin 3

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	3	24,065.0100	59,465.8430	8.40	
LANDUSE:					
Water	WATR	174.5033	431.2063	0.06	0.73
Oil Palm	OILP	4,085.0163	10,084.2394	1.43	16.97
Paddy	PADD	995.6687	2,460.3470	0.35	4.14
Orchard	ORCD	11.8918	29.3853	0.00	0.05
Rubber Trees	RUBR	4,377.5367	10,817.1121	1.53	18.19
Residential-High Density	URHD	1,161.6134	2,870.4049	0.41	4.83
Residential-Low Density	URLD	39.1889	96.8378	0.01	0.16
Forest-Evergreen	FRSE	13,196.3935	32,608.9481	4.61	54.84
SOILS:					
KUALA BRANG		6,378.6938	15,762.0713	2.23	26.51
MARANG		788.3728	1,948.1087	0.28	3.28
PEAT		2,012.9588	4,974.1218	0.70	8.36
RUDUA		162.4313	401.3758	0.06	0.67
STEEPLAND		7,551.1179	18,659.1900	2.64	31.38
TELEMONG		3,214.2116	7,942.4775	1.12	13.36
TOK YONG		3,934.0263	9,721.1758	1.37	16.55
SLOPE:					
	0-10	6,005.0027	14,838.6620	2.10	24.95
	10-20	706.5223	1,943.2018	2.69	32.02
	20-30	4,643.2105	11,473.6053	1.62	19.29
	30-40	2,820.8810	6,970.5380	0.98	11.72
	40-9,999	2,866.1960	7,082.5137	1.00	11.91

Table 9: Subbasins 4

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	4	25,678.9800	63,454.0435	8.96	
LANDUSE:					
Water	WATR	4,416.7256	10,913.9499	1.54	17.20
Oil Palm	OILP	1.0811	2.6714	0.00	0.00
Forest-Evergreen	FRSE	21,269.8501	52,558.8631	7.42	82.83
SOILS:					
KUALA BRANG		3,466.2819	8,565.3558	1.21	13.50
MARANG		2,389.9832	5,905.7679	0.83	9.31
STEEPLAND		19,831.3918	49,004.3606	6.92	77.23
SLOPE:					
	0-10	4,152.8536	10,261.9089	1.45	16.17
	10-20	5,629.8702	13,911.6908	1.97	21.92
	20-30	5,783.8331	14,292.1408	2.02	22.52
	30-40	4,709.7866	11,638.1182	1.64	18.34
	40-9,999	5,411.3132	13,371.6255	1.89	21.07

Table 10: Sub-basin 5

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	5	717.2100	1,772.2618	0.25	
LANDUSE:					
Water	WATR	28.4683	70.3465	0.01	3.97
Oil Palm	OILP	214.5931	530.2702	0.07	29.92
Paddy	PADD	25.4052	62.7776	0.01	3.54
Orchard	ORCD	3.1531	7.7915	0.00	0.44
Rubber Trees	RUBR	79.0985	195.4565	0.03	11.03
Residential-High Density	URHD	115.9451	286.5062	0.04	16.17
Residential-Low Density	URLD	1.4414	3.5618	0.00	0.20
Grassland	GRSS	0.4504	1.1131	0.00	0.06
Forest-Evergreen	FRSE	89.9994	222.3929	0.03	12.55
SOILS:					
KUALA BRANG		245.8541	607.5178	0.09	34.28
RUDUA		23.3332	57.6574	0.01	3.25
TELEMONG		289.3673	715.0411	0.10	40.35
SLOPE:					
	0-10	256.0342	632.6734	0.09	35.70
	10-20	181.8005	449.2382	0.06	25.35
	20-30	72.7022	179.6507	0.03	10.14
	30-40	29.1890	72.1274	0.01	4.07
	40-9999	18.8287	46.5266	0.01	2.63

Table 11: Sub-basin 6

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	6	4,562.6400	11,274.5116	1.59	
LANDUSE:					
Water	WATR	3,008.5374	7,434.2462	1.05	65.94
Oil Palm	OILP	0.4504	1.1131	0.00	0.01
Forest-Evergreen	FRSE	1,546.9260	3,822.5316	0.54	33.90
SOILS:					
KUALA BRANG		3,270.4274	8,081.3896	1.14	71.68
STEEPLAND		1,285.4864	3,176.5013	0.45	28.17
SLOPE:					
	0-10	2,339.8934	5,781.9936	0.82	51.28
	10-20	781.4359	1,930.9673	0.27	17.13
	20-30	564.6807	1,395.3543	0.20	12.38
	30-40	376.8442	931.2008	0.13	8.26
	40-9,999	493.0596	1,218.3749	0.17	10.81

Table 12: Sub-basin 7

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	7	10242.1800	25308.9389	3.57	
LANDUSE:					
Water	WATR	464.5913	1,148.0284	0.16	4.54
Oil Palm	OILP	3,750.0637	9,266.5948	1.31	36.61
Paddy	PADD	1,251.8831	3,093.4657	0.44	12.22
Orchard	ORCD	19.0990	47.1945	0.01	0.19
Rubber Trees	RUBR	1,766.3839	4,364.8231	0.62	17.25
Residential-High Density	URHD	640.5360	1,582.7965	0.22	6.25
Residential-Low Density	URLD	71.7112	177.2020	0.03	0.70
Grassland	GRSS	10.4504	25.8234	0.00	0.10
Forest-Evergreen	FRSE	2,277.6416	5,628.1663	0.79	22.24
SOILS:					
KUALA BRANG		2,844.7547	7,029.5312	0.99	27.77
PEAT		1,210.1717	2,990.3947	0.42	11.82
RUDUA		419.9970	1,037.8337	0.15	4.10
TELEMONG		4,344.5640	10,735.6348	1.52	42.42
TOK YONG		1,432.8728	3,540.7003	0.50	13.99
SLOPE:					
	0-10	4,622.8503	11,423.2942	1.61	45.14
	10-20	3,642.9473	9,001.9049	1.27	35.57
	20-30	1,354.4049	3,346.8021	0.47	13.22
	30-40	410.2674	1,013.7912	0.14	4.01
	40-9,999	221.8903	548.3021	0.08	2.17

Table 13: Sub-basin 8

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN #	8	14,531.4900	35,908.0384	5.07	
LANDUSE:					
Water	WATR	571.8879	1,413.1635	0.20	3.94
Oil Palm	OILP	2,792.4128	6,900.1915	0.97	19.22
Paddy	PADD	669.0043	1,653.1431	0.23	4.60
Orchard	ORCD	11.4414	28.2722	0.00	0.08
Rubber Trees	RUBR	2,192.9575	5,418.9077	0.77	15.09
Residential-High Density	URHD	849.5436	2,099.2646	0.30	5.85
Residential-Low Density	URLD	54.8645	135.5729	0.02	0.38
Forest-Evergreen	FRSE	7,377.2453	18,229.5420	2.57	50.77
SOILS:					
KUALA BRANG		4,484.5630	11,081.5794	1.37	30.86
PEAT		833.0572	2,058.5280	0.29	5.73
RUDUA		498.8253	1,232.6223	0.17	3.43
STEEPLAND		4,821.7678	11,914.8294	1.68	33.18
TELEMONG		1,565.8448	3,869.2808	0.55	10.78
TOK YONG		2,315.2990	5,721.2196	0.81	15.93
SLOPE:					
0-10		3,901.5040	9,640.8115	1.36	26.85
10-20		4,394.0231	10,857.8507	1.53	30.24
20-30		2,459.8926	6,078.5175	0.86	16.93
30-40		1,566.1151	3,869.9487	0.55	10.78
40-9999		2,197.8223	5,430.9289	0.77	15.12

Table 14: Sub-basin 9

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN#	9	5,284.5300	13,058.3379	1.84	
LANDUSE:					
Water	WATR	1,485.7553	3,671.3756	0.52	28.12
Forest-Evergreen	FRSE	3,798.3516	9,385.9167	1.33	71.88
SOILS:					
KUALA BRANG		127.5667	315.2236	0.04	2.41
STEEPLAND		5,156.5402	12,742.0687	1.80	97.58
SLOPE:					
0-10		1,353.2337	3,343.9081	0.47	25.61
10-20		897.6513	2,218.1413	0.31	16.99
20-30		991.7948	2,450.7746	0.35	18.77
30-40		868.5524	2,146.2365	0.30	16.44
40-9,999		1,172.8746	2,898.2318	0.41	22.19

Table 15: Subbasin 10

		Area [ha]	Area [acres]	%Wat.Area	%Sub.Area
SUBBASIN#	10	16,547.5800	40,889.8976	5.78	
LANDUSE:					
Water	WATR	5,334.1065	13,180.8440	1.86	32.23
Oil Palm	OILP	4.6847	11.5760	0.00	0.03
Forest-Evergreen	FRSE	11,212.7138	27,707.1763	3.91	67.76
SOILS:					
KUALA BRANG		2,775.5660	6,858.5624	0.97	16.77
RUDUA		250.5388	619.0938	0.09	1.51
STEEPLAND		13,525.4002	33,421.9401	4.72	81.74
SLOPE:					
0-10		4,956.7218	12,248.3075	1.73	29.95
10-20		2,319.7134	5,732.1277	0.81	14.02
20-30		2,767.9084	6,839.6401	0.97	16.73
30-40		2,468.6312	6,100.1112	0.86	14.92
40-9,999		4,038.5301	9,979.4098	1.41	24.41

Flood map predicted flood event in Gong Badak area of Kuala Terengganu. Figure 9 showing below is the water height of 8 meters and elevation data of 9 meters.

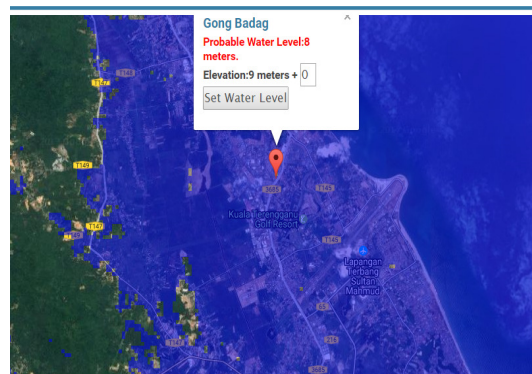


Figure 9: flooded areas in Kuala Terengganu

Most of the rivers in the catchment are of Terengganu took thies source from the upstream watershed drained into each sub-basin shown in figure 10.

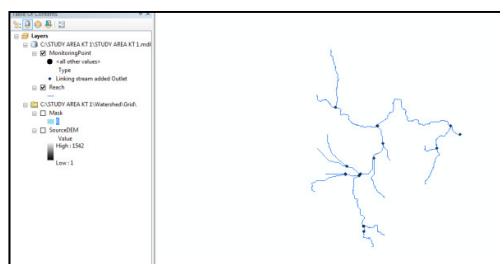


Figure 10: Main Rivers in Terengganu Watershed

The study are mask were generated based on the DEM obtained. Figure 11 is the afined model with the main rivers in the watershed

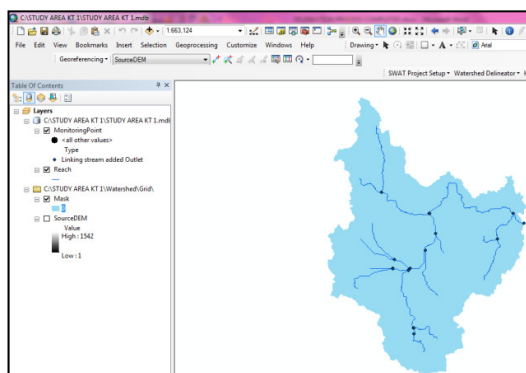


Figure 11: Study area Mask added to rivers

The result of the watershed delineation was illustrated in figure 12 showing the demarcation of the catchment area of Terengganu.

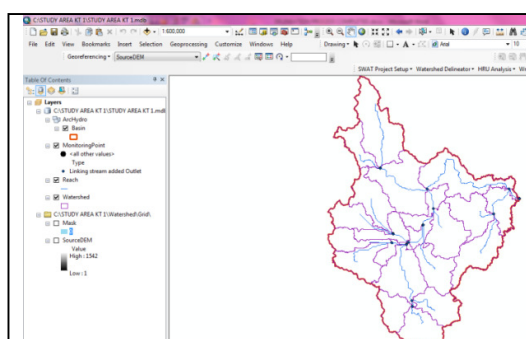


Figure 12: Delineation of Terengganu watershed completed

The result of the flood detection simulation and risk zones was modelled. Using 3D environment. In figure 13, each sub-basin has flood risk and can be using in engineering designs and urban planning.

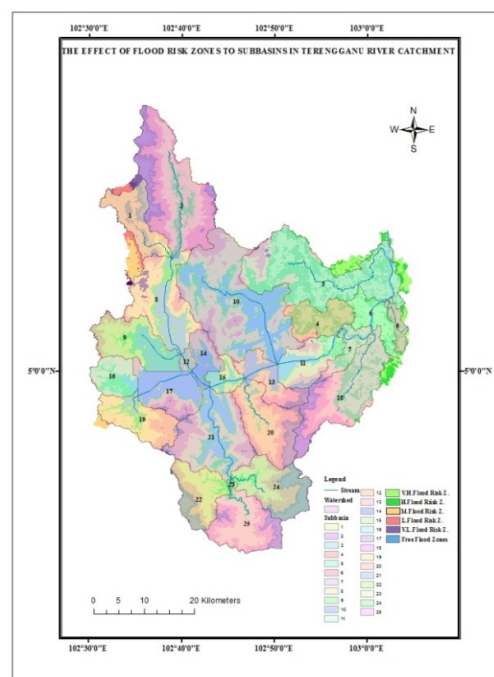


Figure 13: Sub-basin Flood risk and simulation in Terengganu watershed

The flood risk zoning is clearly indicates different senario.the figure 14 is the final model of flood detection which can be applied to management and planning, mitigation and prediction.

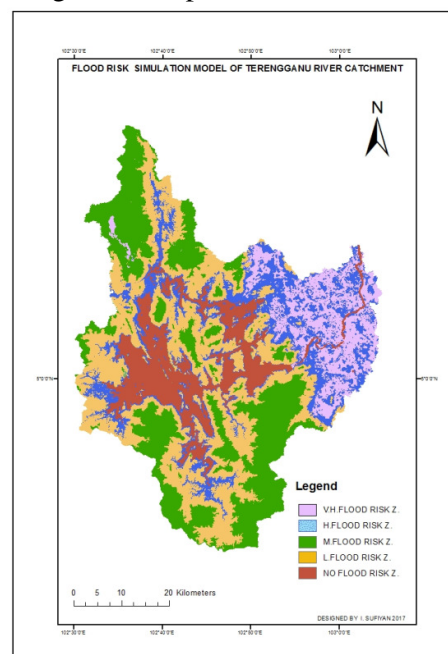


Figure 14: Flood Risk Zonning model

4. Conclusion

Geographic Information System GIS and Remote Sensing have contributed a lot to the development of hydrology in marine science. The main concern is the accuracy of data in scientific research and the availability of personale to handle the task. The application of Soil Water Assessment Tool (SWAT) has a tremendous benefit in simulating the prediction of most of the hydrologic problems such a flood prediction, water quality assessment, sediment load and sediment yield calculation, nutrient flow in the river, land use and land cover charges investigation and river flow and pollution control. SWAT is proven to be very efficient in modeling flood event in River Terengganu. The National Physical Plan (NPP) coordination of land development throughout the Peninsular Malaysia was introduced for sustainability in 2006. The idea is to promote establishment responsible for environmental monitoring and assessment needs. An important area of focus includes water catchment, central forest spine, reduce biodegradable diversity and minimize pollution and soil erosion.

All the environmental policies have impacts on other national plans such as National Forestry Policy (1978), National Policy on Biodiversity (1998), National

Energy Policy (1979), Third National Agricultural Policy (1998-2010), and National Energy Policy (1979). Other information on Dam and Reservoir was established in 1995 as well (NAHRIM 2005). All the 25 sub-basins are analyzed using the 3D simulations. But for the 10 Sub-basins have unique values for flood detection senario.

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