RELEVANCE OF SOIL LANDUSE IN INFLUENCING FLOOD RISK IN MONSOON REGION OF TERENGGANU WATERSHED USING SWAT AND 3D

IBRAHIM SUFIYAN [a] ***RAZAK BIN ZAKARIYA*** [b]
[a b] *School of Marine and Environmental Sciences,*
Universiti MalaysiaTerengganu, 21030 Kuala Terengganu, Terengganu, Malaysia.
ajak@umt.edu.my

corresponding Author: *ibrahimsufiyan0@gmail.com*

ABSTRACT: different soil composition, nature and structures are relevent in water retention, infiltration and flow base on the terrian model or digital elevation model. This study concern about the water flow on top of different soils layers in Teregganu watershed. The effect of the climate change that provides disparities in different geographical regions has proven to affect water flow. The ArcGIS 10.3 and ArcSWAT2012 are used in prediction of flood risk zone. The soil of individual subbasin was categorized base on the simulation in a 3D environment. Flood risk analysis was done in Arcscence10.3, and the flood risk models are developed for management and planning.

Keywords: flood risk, modeling, simulation, soils, monsoon climate.

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1. Introduction

Terengganu River catchment flooding usually during the monsoon season. Peninsular Malaysia was located in the South China Sea. According to [1], SWAT contains climatic inputs such as daily precipitation, maximum and minimum temperature, relative humidity, solar radiation, and wind speed. 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 is relevant because it keeps the model dependent by allowing soil and land use heterogeneously equal. However, there is a limitation in simulating waterways of grasses because of the channel routing is not simulated at HRU level [2].

This study was aimed at deterning the relevance of land use such as soil types and sub-basins parameter to apply 3D simulations. The simulation lacates the flood riak zone within the Terengganu River catchement and produced models for mitigation, planning, and management.

The development of computer base technology in hydrological models made it easier and area of focus by researchers. Watershed delineation based on DEM (Digital Elevation Model) is the primary concern and key step [3]. The success and accurate watershed delineation is the precondition of the major hydrologic components of runoff, sediment and water quality modeling with excellent result. There are two important methods of watershed delineation in SWAT model.

One is the DEM-base method, base on the DEM of the study area and the second is the pre-defined method in which users can define the reaches and subbasins manually. But the best method adopted by many is DEM which has the high precision in slope terrains areas [4].

Watershed delineation is the especially based on the digital elevation models (DEMs) is one of the prerequisite to set up SWAT model. Attributes in GIS can be edited based on locations.

SWAT is a continuous time, physically based hydrological model. SWAT subdivides a basin into sub-basins connected by a stream network, and further delineates Hydrologic Response SWAT model, is a public domain model developed by a group of scientists from the USDA-Agricultural Research Services, USDA- Natural Research Conservation, and Texas A&M University. SWAT has been served as a virtual laboratory for testing the efficiency and effectiveness and marine technology, environmental and agricultural policies and pollution recently used in 90 countries. However SWAT provides useful tools that assisted the world in assessment of real time Hydrologic Respond Units (HRUs) The first version of SWAT was developed in the early 1990s and the first release version 94.2 [5], later published and report the first application of SWAT in the literature; [6] and [7]. The Soil and Water Assessment Tool or

According to [8] the main procedures in ArcSWAT setup includes the following

a. Firstly, the ArcSWAT extension in ArcGIS was selected
b. Next, the watershed delineation and HRUs was defined
c. The editing of SWAT database was optional

d. Then the weather data was defined
e. The default input files writer was applied
f. The SWAT was setup (required simulation period specification) and the SWAT was run.

Water is supplied to rivers from precipitation in the drainage basin (catchment area). Some of the precipitation is returned to the atmosphere by evaporation and evapotranspiration, but the remaining flows under the influence of gravity over the surface or through ground toward rivers. Overland flows are commonly subdivided into infiltration-excess overland flows (due to precipitation rate exceeding infiltration). The relative coarse weathered material tends to be most common in cold climate and steep slope. Clay (produced by chemical weathering) is numerous in humid climates. The organic material or contain make its maximum contribution to the sediment supply in a humid climate [9].

If there is N year of record, and the maximum annual discharge are ranked, the largest having rank m-1 and the smallest having rank m=N, then the probability of an annual flood of magnitude m is express as

$$P(x) = m / (N-1)$$

The mean return period of the flood event is

$$T = 1 / P(x)$$

And the cumulative probability is

$$f(x) = 1 - P(x)$$

Frequency distribution of extreme event such as the annual maximum discharge of a river is normally positively skewed.

River flow data are fundamentally essential in the management of water resources. Hydrometric data are required for river management and assessment. According to [10], the issue of global warming and climate

According to [11], GIS applications are applied because of the versatility of the resource over of time and space. Geographic Information systems are databases with a spatial component and ability to store and process data. However, the technology has potential to produce a map-like product for decision making. Data are stored in multiple files. Each file contains data in a coordinate system that identifies a position for each data point or entry. Most of the point data are characteristically stored as “attribute”. A database of individual files is developed and can be combined as an attribute such as topography, stream location, water or soil sampling.

2. Materials and Methods

2.1 Study Area

The study area covers most of the parts in Kuala Terengganu located at the approximate boundary of South China Sea from the North East, Kelantan to the west, Kuala Terengganu has an area of about 60528.1 Hectare and is the district in the state of Terengganu. Geographically the city 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 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.

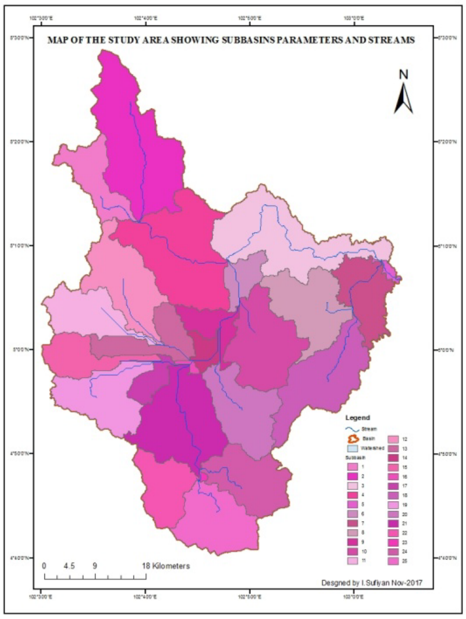

Figure 1: Study Area map

Detail studies about the major lakes in Malaysia show a different level of degradation, deterioration of clean water with good quality was reported in biggest natural and artificial lakes in Malaysia [12], especially in lake Chini [13], and also in lake Loagan Bunut [14].

2.2 Data Requirement

The different application uses 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

There are virtually 7 steps to be followed in the ArcSWAT data input for this studies. These are

Digital Elevation Model (DEM), Land cover image, Daily rainfall, Weather data, Soil data/map

Daily stream flow and Daily suspended sediment.

The SWAT dataset is compatible into ArcGIS (GRIDs) raster, text files (.txt format) and vector datasets called (shapefiles and feature classes).

These are needed to give full detail of the catchment area under study. 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. According to [15], 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 was 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 ArcSWAT that is the interface extension of ArcGIS.
e. The SWAT project setup that includes watershed delineation, HRU analysis, input weather data, and SWAT Database creation [16].

3.Results and Discusion

The soil is a loosed surface material found on the Earth surface which is developed in-situ. there are many impacts of soils that have contributed in the drainge basin, especially the local soils found at certain locations of the study area. Terengganu River catchment is characterised by the following local soils: Kuala Brang, Marang, Rudua, Telemong, Tok Yong, Peat and steepland. Each of these local soil has different characteristics of sturctures, porosity, water retention capacity, soil profiles, and many others. For the purpose of this study, 7 different local soils were discovered within the Terengganu catchment. The impacts of these local soils on individual subbasins are presented in table 1 the highest local soil in Terengganu is the Steepland with 69.85%.

According to the Malaysian Standard, Steepland (MS 1759 2015) SM 1001, these are land showing average slope exceeding 25 degrees. The soil is formed due to erosion and unsuitable for agriculture. It has a miscellaneous soil contain that soak little water drian from it. Peat (MS 1759 2015) GA 1200 this type of soil is derived from organic matter that contains organic matter and materials of about 50 to100 cm of the soil profile. It is also called Histosol. Tok Yong, (MS 1759-2015) SF 1366, this type of soil is formed from the alluvium recent riverine brown, fine sandy clay. It is characterized by well drian soil porous to water. Flooded zone with this type of soils has little time for flood water to drain away. It ia also called ultisol. Kuala Brang, (MS1759-2015) SF1154 this well drian soil is derived from brown shale and characterized by the rock fragment or saprolite.flood impacts are high on this type of soil because it allows water to drain quickly.

Rudua (SB 1022) is another type of local soil found in the catchment area of Terengganu. It is characterized by sandy beach rigdes in other word is called spodosols. Therefore, this soil is easily drained and wash away. Flood water does not retain for a longer time.

Telemong (MS1759-2004) SK 1041. This is sandy loam, yellow brown easily drained at low saturation. The soil is characterized by large pore spaces that soak water. For the flood impacts, this soil allows water to past through easily. This occupies areas of very high flood risk in the lower zones of Terengganu River catchment.

Marang (MS1759-2004) SF1193 is one of the fimily of fine siliceous loamy yellow Alik Tualembuts. It is richly developed from the iron- poor sandy shale. It is characterized by the pale yellow, olive, clay loamy subsoil, and fine sandy at the top [17].

3.1 Local Malaysian Soil Types Result

The soils classification was base on the USGS with default SWAT and has the ability to update local soil database. The

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local soils in the study area are edited base on the SWAT update from the existing soils of the world. Table 4.3 shows the result of the soil classification with total areas in hectares, acres as well as the total percent obtained during the analysis.

Table 1: Local Soil types result in the catchment of Terengganu

Soils	Area [ha]	Area[acres]	% wat. Area
Kuala Brang	35,604.8842	87,981.4491	12.43
Marang	26,762.6042	66,131.7330	9.34
Peat	47,32.3090	11,693.7721	1.65
Rudua	1,357.6481	3,354.8163	0.47
Steepland	200,117.6886	494,500.8145	69.85
Telemong	10,250.0178	25,328.3066	3.58
Tok Yong	7,682.1981	18,983.0956	2.68

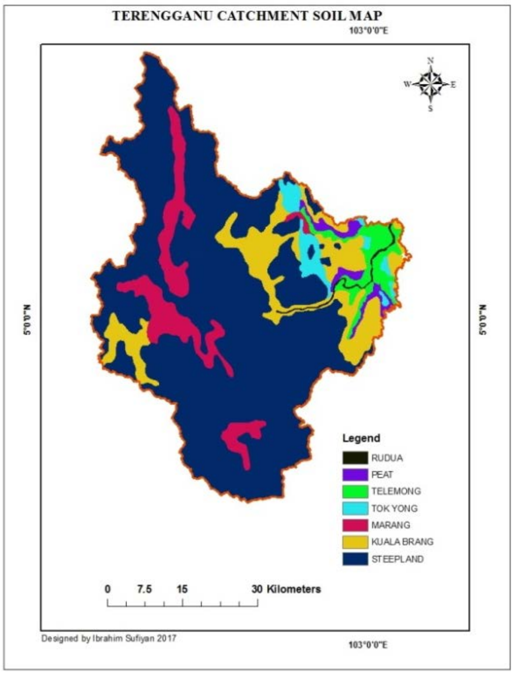

Figure 2: Digitized Soil map of Kuala Terengganu Catchment.

Figure 2 presents the digitized soil map of the Kuala Terengganu catchment. The Soils has the ability to absorb moisture and get cooler and hotter quickly. Depending on the temperature, the water retention capacity varies from equatorial wet climate to monsoon as well as arid and semi-arid environment. The predominant local soil in the Terengganu River catchment is steep and with the highest elevation; most of these areas around the steel and are flood risk-free zones.

3.2 Sub-basins flood simulation with Land Use/Cover Result

Table 2 below presents the SWAT output from one of the HRU result. The land cover plays an important role in controlling the climate as well as the water flow that causes a flood. The forest land cover for instance in the study area is the major predominant land cover. If some portion of the forest is removed the flood will inundate other areas occupying the lower elevations

Table 2: Land Use Results

Land use	Abbreviation	Area [ha]	Area[acres]	%wat. Area
Water Body	WATR	42,684.6541	105,475.9145	14.90
Residential-High Density	URHD	3,346.7332	8,269.9450	1.17
Orchard	ORCD	46.8465	115.7601	0.02
Rubber Trees	RUBR	11,981.4471	29,606.7548	4.18
Residential –Low Density	URLD	167.2060	413.1745	0.06
Oil Palm	OILP	13,251.0778	32,744.0757	4.63
Paddy	PADD	3,209.3467	7,930.4563	1.12
Grassland	GRSS	10.9008	26.9365	0.00
Forest-Evergreen	FRSE	211,809.1378	523,390.9698	73.93

Figure 3 depicts the land cover map of the Kuala Terengganu catchment. The legend below explains the different pattern of the land cover which includes forest, water, urban land use, rubber, paddy, orchard, oil palm and grassland. The Terengganu catchment was fully occupied by forest evergreen where most of the forest products are found. The model in figure 3 represented the forest evergreen as the predominant land cover in the whole of the study area.

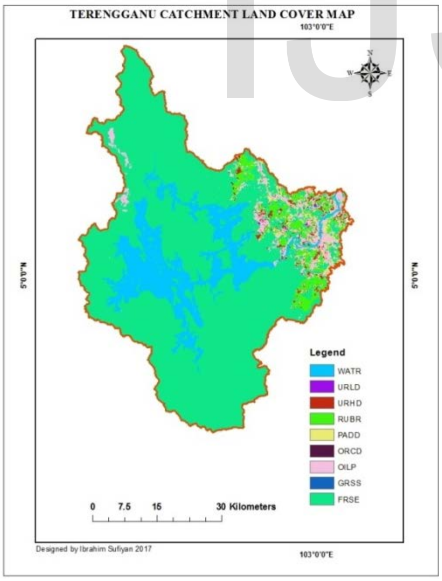

Figure 3: Land Use classification of Terengganu River catchment

3.3 Individual Subbasin Flood Risk Model

The figure 4 below was developed from both the ArcSWAT HRU and the 3D simulated model basically to append to it and show the munber of sub-basins parameters use for simulations in the Terennganu river catchment.

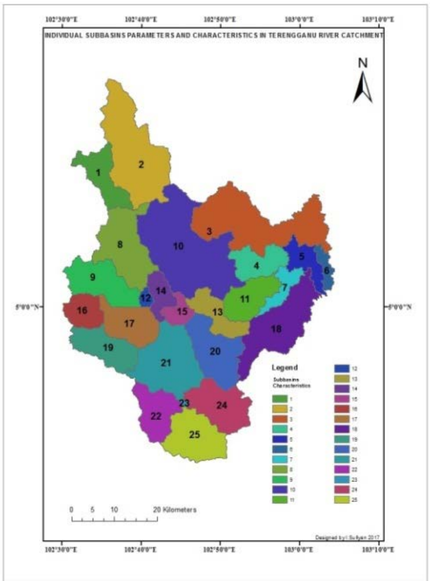

Figure 4 calculation of sub-basin parameters

There are about 25 subbasins in the study area. Each of which can stand at different GIS analysis to depict the magnitude of the flood risk. As illustrated in figure 4 above, the flood follows the degree of slope as determined by the digital elevation model

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(DEM) as indicated in the figure below.

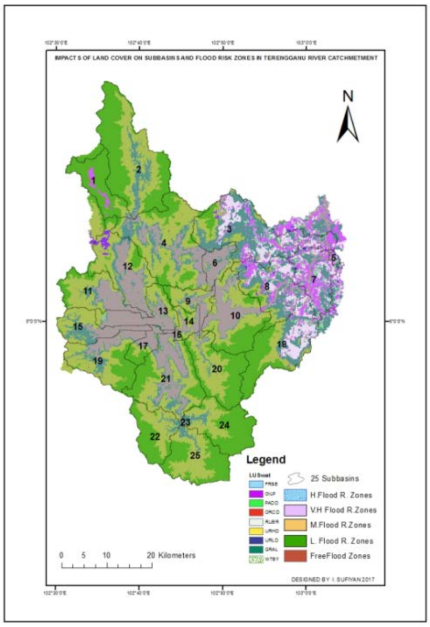

Figure 5: Simulated Flood risk zone on Sub-basin

both the slope and the flow direction in the Terengganu river catchment were explained fully in figure 5 and figure 6 respectively. For mitigation action, we can select and predict which subbasins in the catchment are highly substitutable and liable to flood at a point in time, depending on the intensity and duration of the rainfall.

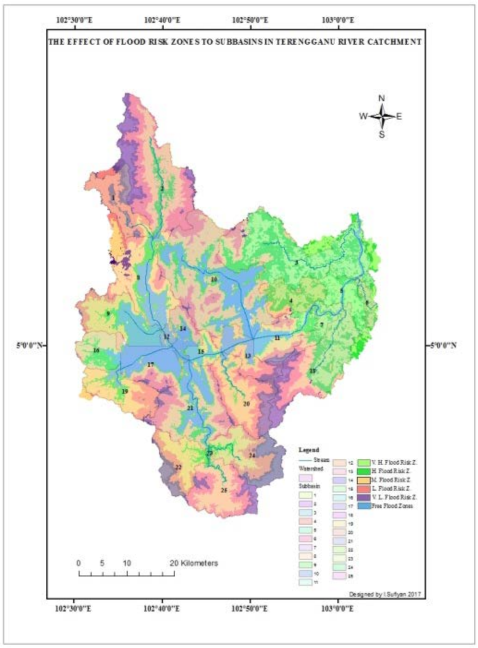

Figure 6: individual subbasins flood risk analysis of Terengganu River catchment

3.4 Impact of Malaysian local soils on flood simulation

Figure 7 presents the digitized soil map of the Kuala Terengganu catchment. The Soils has the ability to absorb moisture and get cooler and hotter quickly. Depending on the temperature, the water retention capacity varies from equatorial wet climate to monsoon as well as arid and semi-arid environment. The predominant local soil in the Terengganu River catchment is steepland with the highest elevation; most of these areas around the steepland are flood risk free zones.

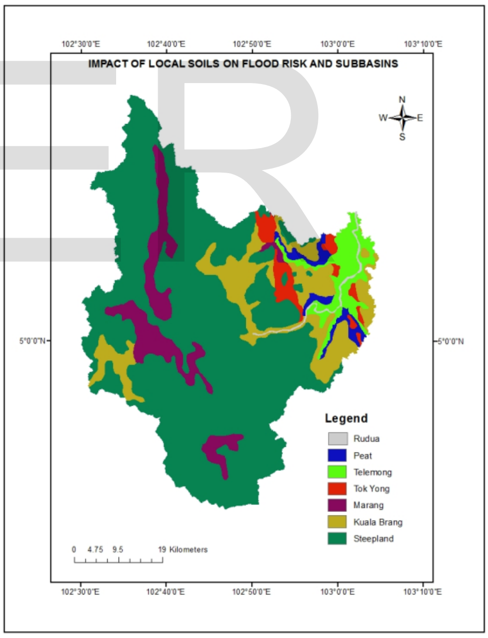

Figure 7: Digitized local Soils in Terengganu

And figure 8 is the simukation done base on the soils types found in the watershe, while figure 9 includes all the 3 variables (soil types,sub-basins and the flood risk zones) in the Terengganu watershed or river catchment.

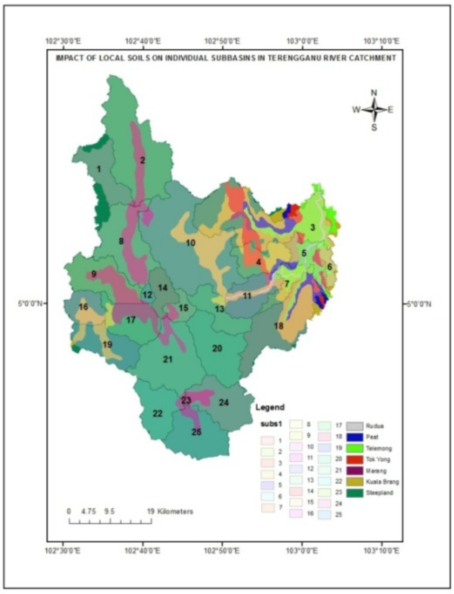

Figure 8: Simulated soil types and Sub-basins parameters

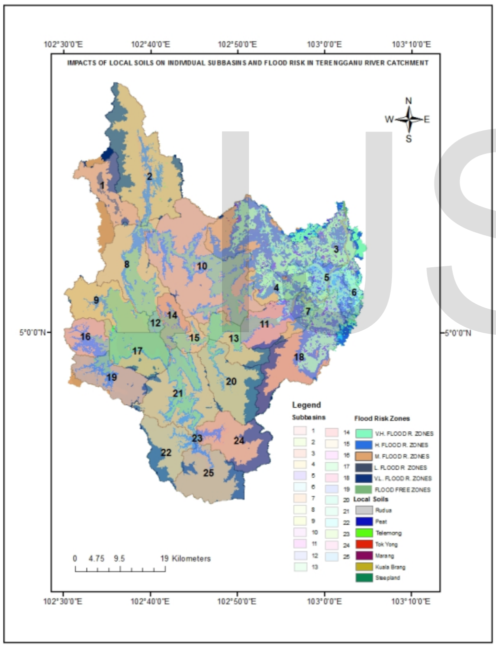

Figure 9: Simulated Flood risk zones with Soil types in Terengganu

3.5 3D Flood Model

The digital elevation model (DEM) of the study area was overlaid with the mask and the Terengganu river flow was considered as a base height. The figure 10 displays the 3D model developed from the ArcScene. At this point, the Z values are calculated in other to create the simulation. The real-time simulation is presented in figure 11 below. While the simulation was displayed, the purpose is to create a quick alert or warning through animation video perhaps all the areas prone to flooding will be easily identified and mitigation action can be applied.

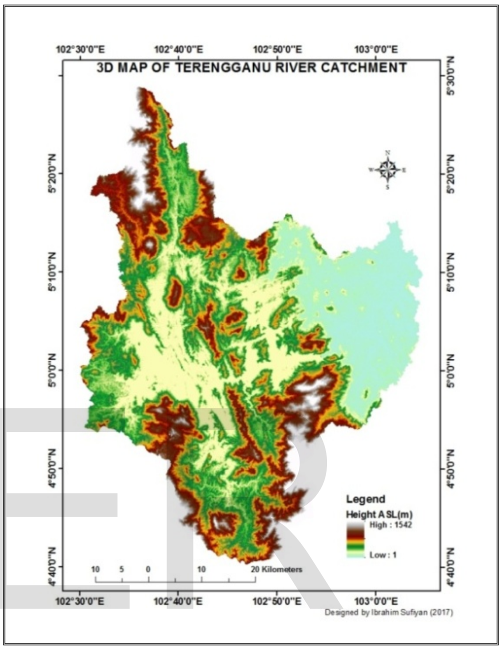

Figure 10: 3D Map of Flood Event of Terengganu River Catchment

3.6 Flood Simulation Model of Terengganu River Catchment

The 3D model in figure 4.12 presents the real-time 3D simulation with the blue color representing the water as it flows from the low gradient causing flood event that ranges from 1 to 2 meters of elevation while other zones from 2 to 3 meter will be flooded with increase in rainfall intensity perhaps two to three days of continues rain shower. If the water level increases then we expect flood occurrence within the Terengganu River catchment.Depending the climatic variation in the tropical monsoon regions

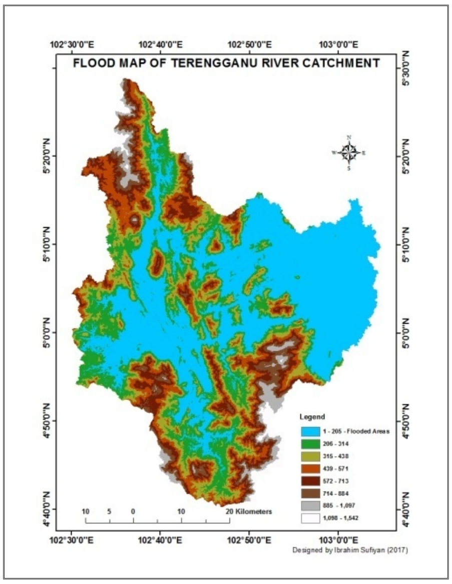

Figure 11: Flood Simulation Model of Terengganu River Catchment

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4.Conclusion

the Terengganu River catchment use to flood every monsoon season, the study found out the different subbasins parameters which were used to simulates the landuse of local soil in Terengganu catchment. Most of the flood were influenced by soils landuse due to the nature porosity and structure of the present localise soils types. The predominate soils type in Terengganu river catchment is steepland with 69.85% followed by the Kuala Brang with 12.43%. The flood risk zones were categorised base on the individual sub-basin parameter and the local soils types. The categories are from very high flood risk zones to flood risk free zones. The simulation also determines the soils types in subbasins 3,4,5,6 and 7 with high influence of Telemong, Kuala Brang and Tong Yong. The flood risk models can be used for planinig and management purposes.

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