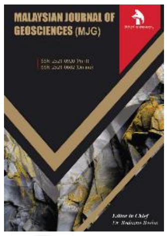
ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2521-0920 (Print)
ISSN: 2521-0602 (Online)
CODEN: MJGAAN

Malaysian Journal of Geosciences (MJG)

DOI: http://doi.org/10.26480/mjg.02.2020.90.95



CrossMark

RESEARCH ARTICLE

HYDROLOGIC ASSESSMENT OF FOOD USING SWAT AS GEOSPATIAL TECHNIQUES IN THE CATCHMENT AREA OF TERENGGANU MALAYSIA

Ibrahim Sufiyan[a], Magaji J.I[b], A.T. Ogah[b]

[a] Federal Polytechnic Nasarawa[1], Nasarawa State, Nigeria.
[b] Department of Geography, Nasarawa State University Keffi, Nigeria.
**Corresponding Author Email: ibrahimsufiyan0@gmail.com*

ARTICLE DETAILS

Article History:

Received 25 June 2020
Accepted 28 July 2020
Available online 13 August 2020

ABSTRACT

Risks and hazards are two important issues currently threatening humanity and the environment. Flood has claimed many lives and destroyed properties in Malaysia and Africa and Nigeria. It is global catastrophe. The application of geospatial science is, therefore, very important advantages that it offers solutions to flood. This stud uses of Advanced Space-borne Thermal Emission and Reflection Radiometer Digital Elevation Model (ASTER-DEM), and the Soil Water Assessment Tool (SWAT) in visualizing floods disaster risk. The whole catchment area of Terengganu has been delineated. The 25 sub-basins have been identified and the flood risk zones have been modeled. The complete watersheds are characterized by different sub-basins and Hydrologic Respond Units (HRUs) which can be viewed in 3D environment.

KEYWORDS

Geospatial technique, Floods, Watershed, HRU, Assessment.

1. INTRODUCTION

Flood is a hazardous natural phenomenon occurring in most of the world. Rainfall-triggered flow accumulation upstream to downstream overflow the river banks causing damages on the surface of the earth including human lives (Bronstert, 2003). Flood has been affecting human habitats creating anunsustainable environment. Among the various natural hazards, the flood is considered to be a devastating disaster with an extensive account of damages (Youssef et al., 2011). The current study about hazard events in many cities, towns, or villages cannot be overemphasizedbecause climatic conditions are not static. The presence of land covers as well as the geographical settings as great effects on the flood. There is a need to highlight the removal of vegetation cover or the types of land cover which may influence flooding, the soil, and water assessment tool will monitor the Hydrologic Response Units (HRUs) and the subdivision of the watershed sub-basins within the drainage basin of river Terengganu.

The continuous precipitation due to climate change is effectively considered in susceptible flood-prone areas inmost coastal regions (Bubeck et al., 2012). According to a study, there is an issue of excessive use of land cover by an anthropogenic factor for agriculture, urbanization as well as other benefits that change the topography (Dawson et al., 2006). We intend to develop a sustainable land cover system to reduce the rampant overuse of natural land cover through mitigating and create awareness to avoid a flood in the flood-prone areas within the scope of this study. The Geographic Information System (GIS) is the acquiring of spatial data. The river flow is high during the monsoon, and the water level overflow it banks. We need to get informed or be informed about the aftermath of flood event as quickly as possible, to assess the magnitude of the flood. Flood is a most severe hazard in Malaysia Watershed is also known as a basin or catchment, or simply an area delineated with a specified outlet point that emptied in a large body of water (Liu et al., 2003).

The 3D view can help in determining the water levels an extent to which the flood event will be analyzed. It also helps in displaying a real-time animation of flood events for proper visualization.The study can be useful in the assessment of impacts of HRUs developed from SWAT through ArcScene simulation. In another study, researchers also used GIS to determine flood management (Arnold et al., 2010). He further explained that flood eventscould be the resultant effects of the complex interaction of the natural system as a result of excessive rainfall flowing downstream. The component of the system involved rainfall event, topography, soil and channel characteristics. A flood event is as a result of such complex interaction within the watershed system.

The flood modeling are used for designing a flood risk map. However, there are various management practices in mitigating flood; this includes suitability of land cover practice, vegetation and forest conservation and other structural management. The investigation of multi-dimensional flood estimation was done using the artificial neural network with the design of modeling techniques. Various researchers have been analyzing flood mapping assessment in GIS gathered information concerning existing methods their views was the transformation of input factors into a single model using a differentapproach, weighing, computing, and interpolation techniques (Chau and Chan 2005; Mukerji et al., 2009). It means techniques acquired thorough knowledge base, quantitative techniques and data mining techniques are essential in map scaling (Meyer et al., 2009).

The objectives of this study are to evaluate flood by delineating the watershed and to categorize them into sub-basins so visualize the affected flooded areas. During the High flow period of monsoon, this can be

Quick Response Code	Access this article online	
	Website: www.myjgeosc.com	**DOI:** 10.26480/mjg.02.2020.90.95

Cite the Article: Ibrahim Sufiyan, Magaji J.I, A.T. Ogah (2020). Hydrologic Assessment Of Food Using Swat As Geospatial Techniques In The Catchment Area Of Terengganu Malaysia. *Malaysian Journal of Geosciences, 4(2): 90-95.*

achieved by setting the reference points or benchmarks of different land uses/ covers and the role played by the HRUs in the Terengganu catchment The 3D visualization can provide essential models for decision making in Terengganu as well as the entire catchment in Malaysia. The issue of flood disaster is a global phenomenon that requires attention in other to control life and properties. This study will be crucial in highlighting flood warnings and to people who are vulnerable to flood disasters.

The primary significance of this study is to alert people of the coming of the flood. Our communities are subjected to more flood vulnerability. Although flood is natural phenomena, human activities and human interventions have been affecting the ecosystem as well as wetland and the watershed in the drainage basins. The urbanization process, agricultural practices, and deforestation have considerably changed the situation in whole river basins.At the same time, exposition to risk and vulnerability in flood-prone areas has constantly being growing. Flash floods occurred quite rapidly (Toriman et al., 2009).

2. MATERIALS AND METHODS

2.1 Study Area

The study area is located at the upper left corner of 50^0 30^I.40^{II} N, 102^0 23^I 15^{II} E and the lower right corner is 40^0 39^I 25^{II} N, 103^0 11^I 62^{II} E respectively.The study focuses on flood mitigation in one of the flood-proneregions in the Eastern part of Malaysia Peninsula called Kuala Terengganu River Catchment. The Terengganu catchment has a total area of stream definition of 5,730.1452 (Ha) about 14,159.497acres. However, this study focuses on the tropical environment (rainforest zone) where there is excessive rainfall and the wet season is higher than the dry season. The terrain is undulating with tropical equitorial climate, rainfall is heavy (above 2500mm) tempersture almost high throughout the year. Relative humidity is high 80-90%. Intensive agriculture is employed with cultivation of rice and palm kernel (Marghany et al., 2002).

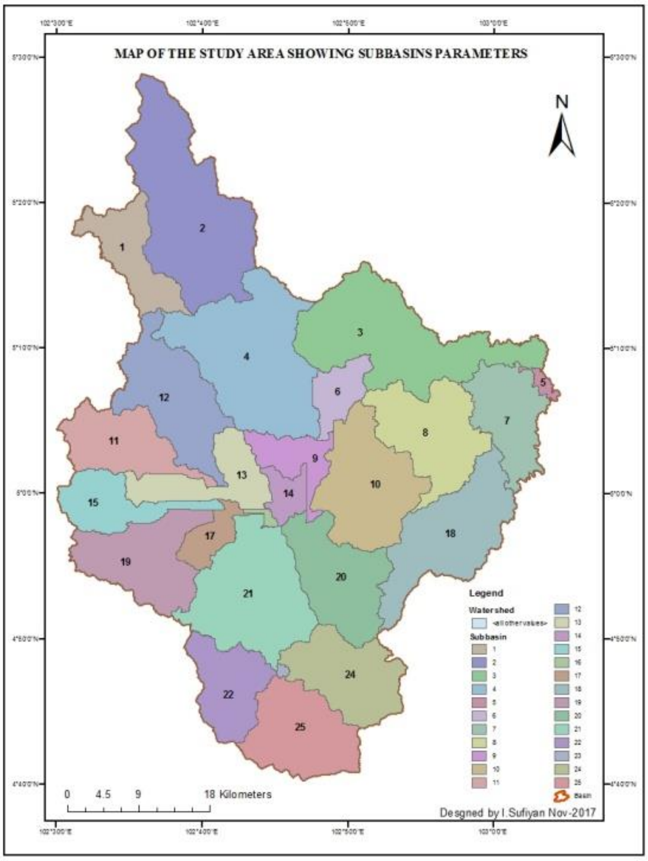


Figure 1: Map of the study area; Terengganu River Catchment Malaysia (2017)

The study flow chart in figure 2, explain the data collected including the ground survey, aquaring the satellite data and the inventory such as the digitised soil map. The Hydrolgic Response Units (HRUs) arease on the land cover, soil and slope of the study area. The simulation of the water or flood was done in ArcScene. The 3D was desined from the output in ArcScene

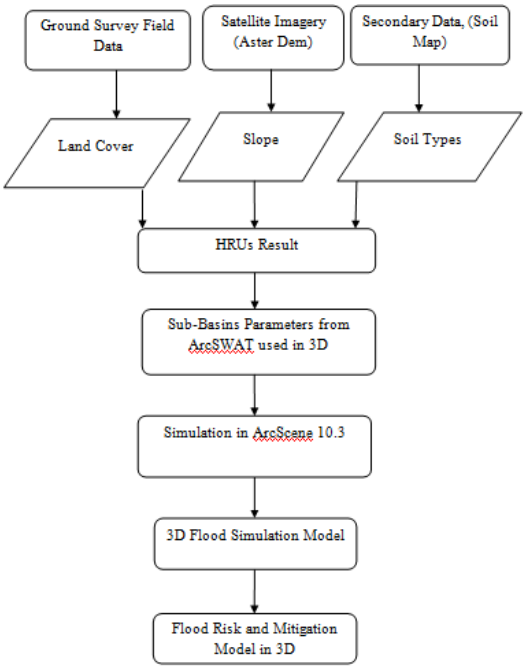


Figure 2: Flow chart of the study

Digital elevation model (DEM) is used to simulate the flow direction at a regular interval in ArcScene.

2.2 SWAT Data Sources

- → Department of Irrigation and Drainage (DID)
- → Data of flood event in the study area (previously)
- → The stream flows data These are obtainable base on a different location of the stations
- → Climate data from the Malaysian Meteorological Department (MET Malaysia) from 2000-2015
- → Land cover images from the Malaysian Remote Sensing Agency (MRSA)
- → Malaysian soil map was obtainable from online source European Digital Archives of soil maps (EuDASM) named Reconnaissance soil map Peninsular Malaysia 1968.

The input data for ArcSWAT includes the following: Required spatial datasets and Optional spatial datasets as show in Table 1.

Table 1: Data acquisition

Reqiured spatial Dataset	Optional spatial datasets
1. Digital elevation Model (DEM)	Weahther parameters
2. Land Cover	Daily rainfall data
3. Soil map/data	Daily streamflow
	Daily suspended sediment

2.3 SWAT Analysis

1. The Digital Elevation Model DEM was set up 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 result of the stream definition was obtained from 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. The Sub-basins parameters within the catchment area under study were also been calculated

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

3. RESULTS AND DISCUSSION

The result from the SWAT was obtained on 13th May 2017 at 05:29 pm with the total area of the watershed having 286,507.3500 hectares or 707,973.9872 acres. The total numbers of sub-basins obtained in Terengganu River catchment are 25 characterized by 305 numbers of Hydrologic Response Units (HRUs). The threshold from the SWAT output for this study was based on 10/10/10 percent as required by the software to get the model fit. There is a need to monitor the activities of the flood by applying the modern technology of Geographic Information System (Chan, 2015). The system will assist in mitigation and controlling flood. Many people died and lost their properties as a result of flooding.

3.1 SWAT Watershed Delineation Result

The figure below represents the delineated watershed of Kuala Terengganu Catchment. The boundary with brown color in figure 4 is the demarcation of the delineated watershed of the study area. The blue color is the main Rivers that flow toward the South China Sea. The green color is the minor streams in the sub-basins.

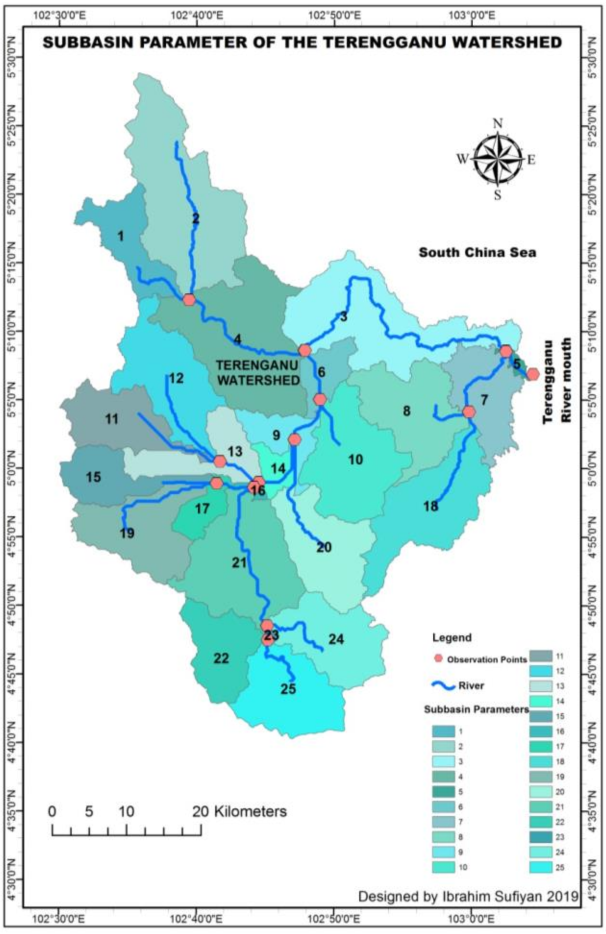


Figure 4: Delineation of the watershed and the main Rivers of Terengganu catchment

3.2 Stream Network and Reservoirs

The stream links are developed through the stream network. 10 stream links (small maron dots) are obtained from connectivity in SWAT by the junction where the watershed was delineated. Each stream link had been connected with the defined sub-basin. The 3 major reservoirs were identified within the watershed (the redish dots) aas shown in figure 5. A reservior is depression in the catchment where all the water drained toward it and empty into the South China Sea through the last dot that touches the watershed delineated boundary in the eastern direction. Refer to figure 4 the stream are emptied all through the Terengganu river Mouth.

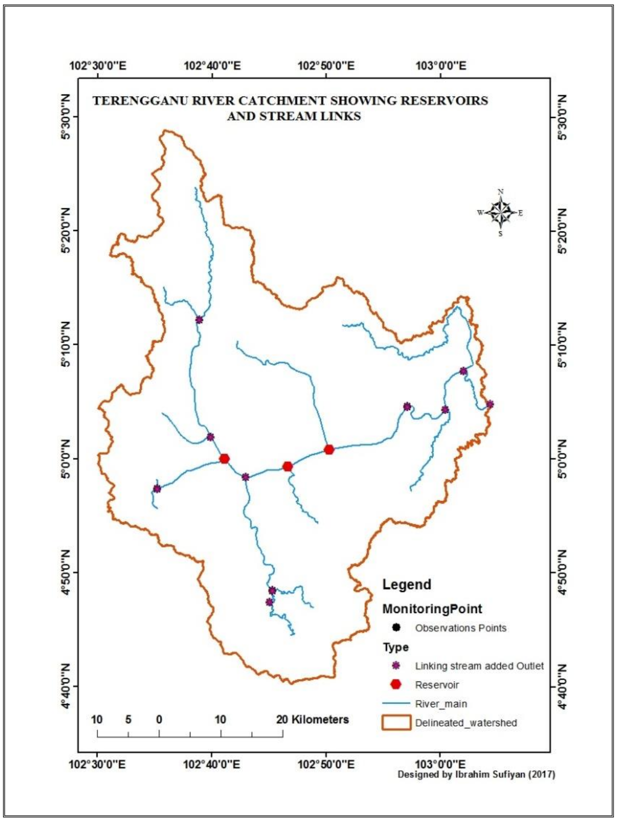


Figure 5: Stream Links and Reservoirs emptied into the South China Sea

3.3 Sub-Basins Parameter

There are about 25 different sub-basins in the study area created by the SWAT. Each of the sub-basins was characterized by a distinct parameter for easy classification and hydrologic analyses. Figure 6 shows the classified sub-basins in Kuala Terengganu catchment.

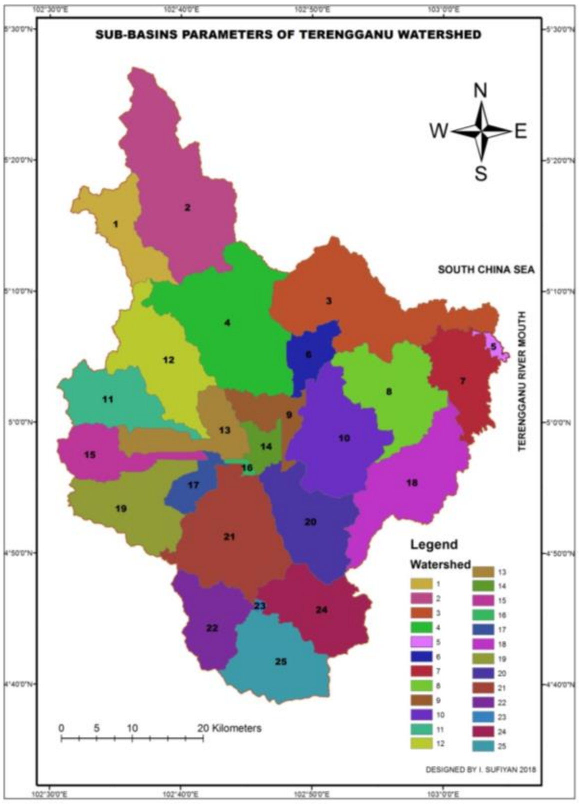


Figure 6: Sub-basins Parameters of Terengganu Catchment

The major Terengganu Rivers as shown in figure 7 are added connecting by the stream links to the watershed and the main rivers were appended to the whole catchment as in figure 4. Each of the sub-basins was defined by the water input and all the hydrologic response units.

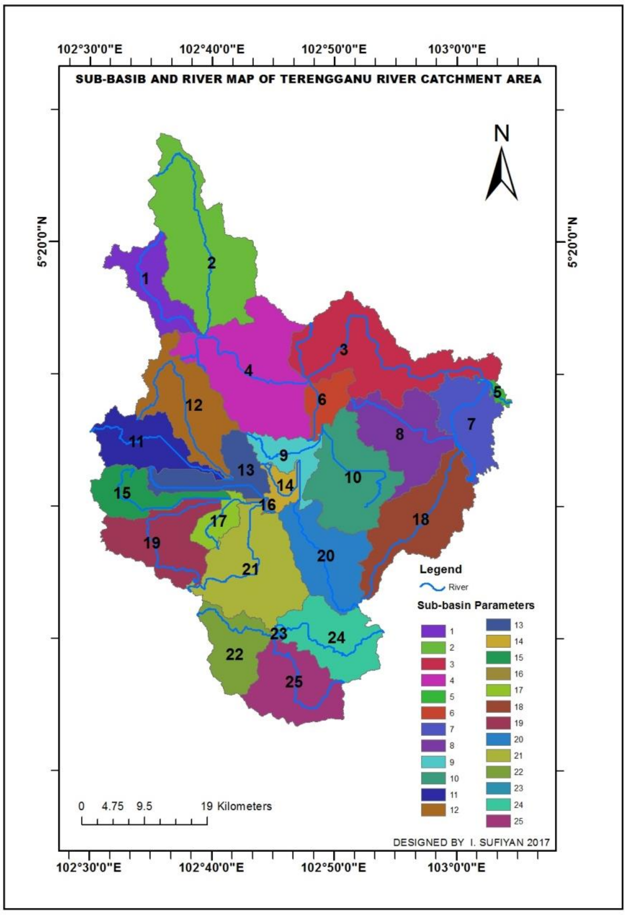


Figure 7: Terengganu Catchment Sub-basins Stream-links and the main Rivers

3.4 Hydrologic Response Units (HRUs)

The hydrologic response units (HRUs) results in consist of the land use, soil types, and the catchment slope. They are characterized by unique performance and distributions of the individual report within the catchment area. In this study, we can find out the following results as shown in tables 2, 3, 4 and 5 below.

3.5 Land Use/Cover Results

Table 2 below presents the SWAT output from one of the HRU results. 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. This has been mentioned in the study method flow in figure 2.

Table 2: Land Use Result

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 8 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 palmand grassland. The Terengganu catchment was fully occupied by forest evergreen where most of the forest products are found. The map in figure 8 has illustrated that the forest evergreen as the predominant land cover in the whole of the study area.

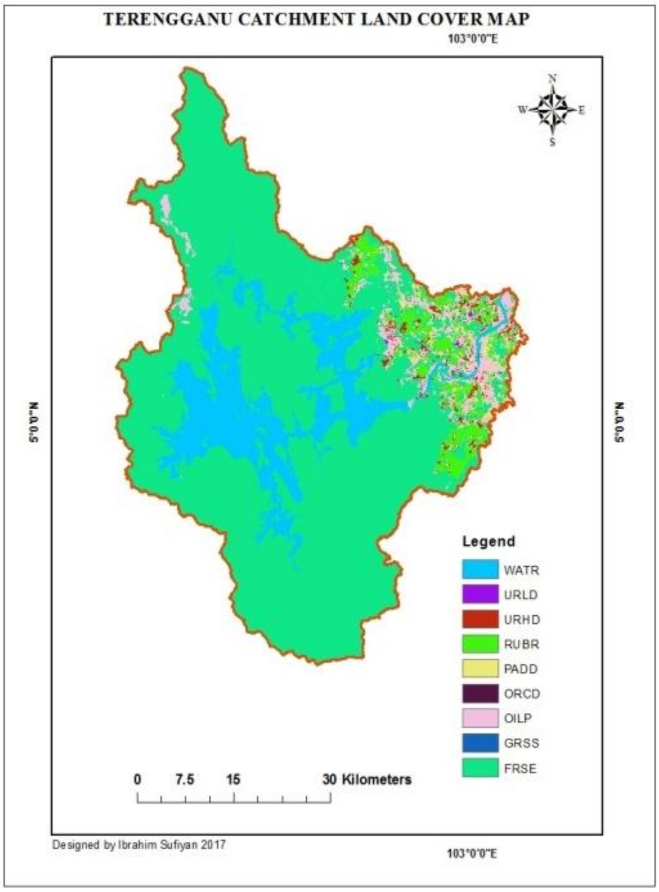


Figure 8: Land Use Classification ofTerengganu River catchment

3.6 Soil Types Classification Results

The soil classification was base on the USGS with default SWAT and can update the local soil database. The local soils in the study area are edited base on the SWAT update from the existing soils of the world. Table3 shows the result of the soil classification with total areas in hectares, acres as well as the total percent obtained during the analysis. All the local Malaysia soil name can be obtain in world soil classification book (European Digital Archives of soil maps (EuDASM).

Table 3: Local Soil types result

Soils	Area [ha]	Area[acres]	% wat. Area
Kuala Brang	35,605	87,981	12.43
Marang	26,763	66,132	9.34
Peat	47,32	11,694	1.65
Rudua	1,358	3,355	0.47
Steepland Soil	200,118	494,501	69.85
Telemong	10,250	25,328	3.58
Tok Yong	7,682	18,983	2.68
Total	286,508	707,974	100%

Figure 9 presents the digitized soil map of the Kuala Terengganu catchment. The Soil can 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 environments. 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.

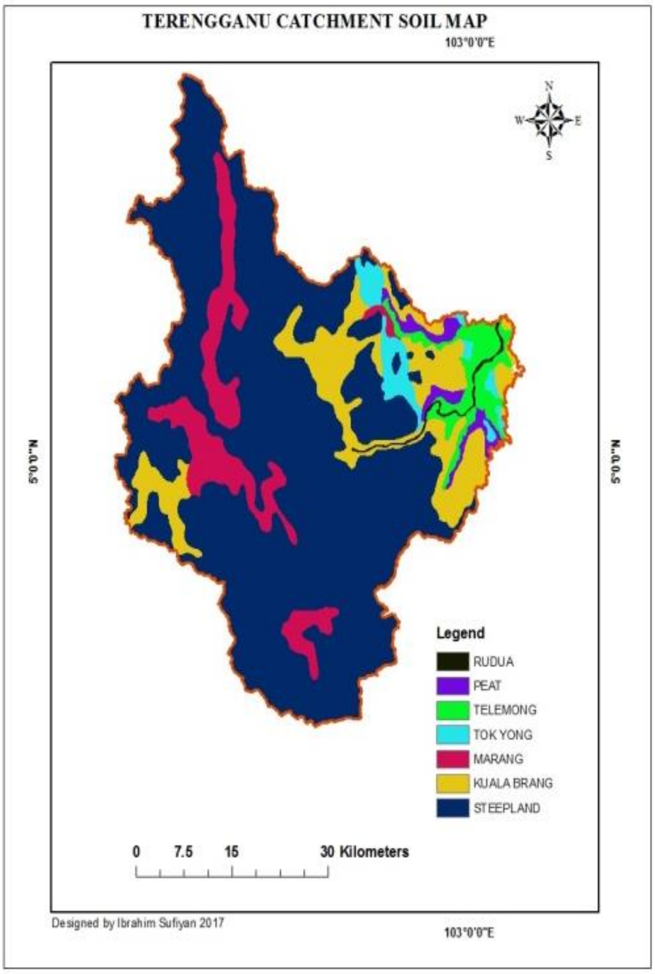


Figure 9: Soil map of Kuala Terengganu Catchment Area

3.7 Slope Analysis

The slope data derived from the SWAT database was an inbuilt developed from the chosen threshold of 10/10/10 percent from the HRU. Table 4 shows the result of total area from each category of slope in hectares and acres while taking cognizance of slope percent from 0-10 up to 40 meters above. From table 4 below, we can also conclude that areas occupied by the steepland land cover having the highest elevation and largestpercentage of 66,130.4348 hectares about 23.08%. This justifies the result obtained from the soil classification model in figure 9 with steepland representing the largest space in the Terengganu River catchment.

Table 4: Slope Results from Terengganu Catchment

Slope	Area [ha]	Area[acres]	%wat. Area
0-10	62,167.7600	153,619.6434	21.70
10-20	59,973.9917	148,198.7322	20.93
20-30	543,92.6797	134,407.0312	18.98
30-40	43,842.4838	108,336.9695	15.30
40-9999	66,130.4348	163,411.6109	23.08

Figure 10 below presents the elevation or slope map of the Kuala Terengganu catchment. The dark grey color depicts the lowest elevation that is 0-10 meters. The green color pattern is 10-20 meter slope, the blue color is between 20 -30 and lastly, the light grey color in the map represents the highest slope. Most of the flood event occurs near the open sea toward the outlet because of the low elevation.

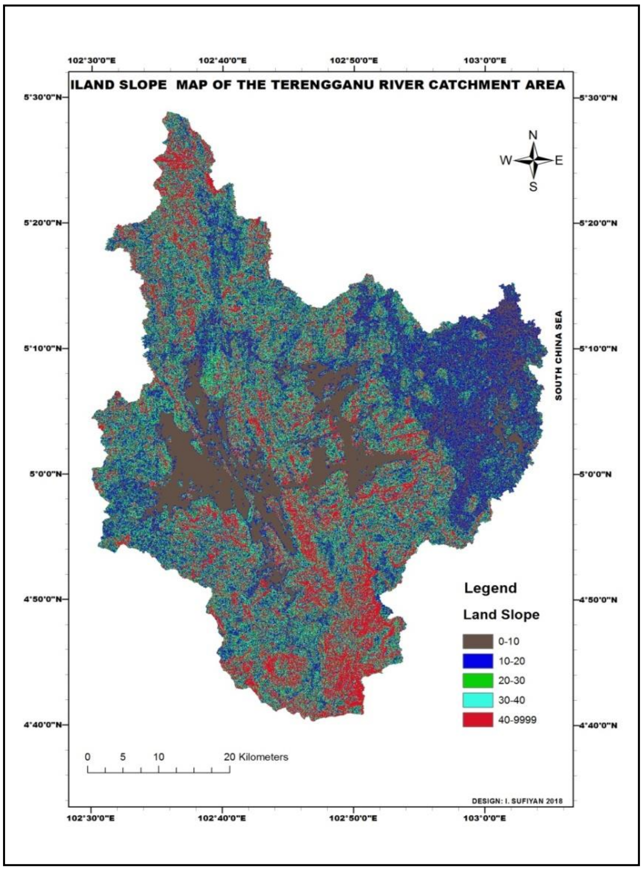


Figure 10: Slope model of KualaTerengganu River Catchment

3.8 Flow Direction

The water flow pattern and direction are from the highland to lowland. The flow was directed toward the river (Sungai) Terengganu outlet and empty into the South China Sea as shown in figure 10. The flow direction has vital relevance in terms of water flow and movement within the Terengganu catchment. Each flow direction has some counts. For example, flow direction number 1 has 604140 flow counts. However, the flow directions also follow the slope gradient into different outlets. The hydro-counts determine how big the sub-flow generates and the location of each flow as indicated in Table 5 below. According to this study the flow are in the same dirction.

Table 5: Flow Direction and Locations

Flow Direction ID	No of Flow	Locations
FLOWDIR 1	604140	102°48'36.532"E 5°0'39.423"N
FLOWDIR 2	286963	102°40'1.504"E 5°7'17.142"N
FLOWDIR 4	497406	102°40'2.652"E 5°4'7.508"N
FLOWDIR 8	270757	102°48'10.306"E 5°11'20.813"N
FLOWDIR 16	504052	102°51'45.044"E 5°1'17.089"N
FLOWDIR 32	293313	102°39'21.648"E 5°8'40.809"N
FLOWDIR 64	598457	102°49'54.499"E 5°1'34.916"N
FLOWDIR 128	305135	102°40'2.702"E 5°9'8.761"N

3.9 Geospatial Model of flood in the Catchment Area

The flood risk model shown in figure 11 below. The yardstick is to measure the magnitude of the flood risk in the catchment area of Kuala Terengganu. Here we arrived at the categories of flood risk from the highest risk to moderate and to no risk zones within the watershed. The flood risk map represents the risk zones that can be used for mitigation, planning and a warning to the public. The slopes to the lower course of the Terengganu River entered into the South China Sea through the major outlet at the lower DEM.

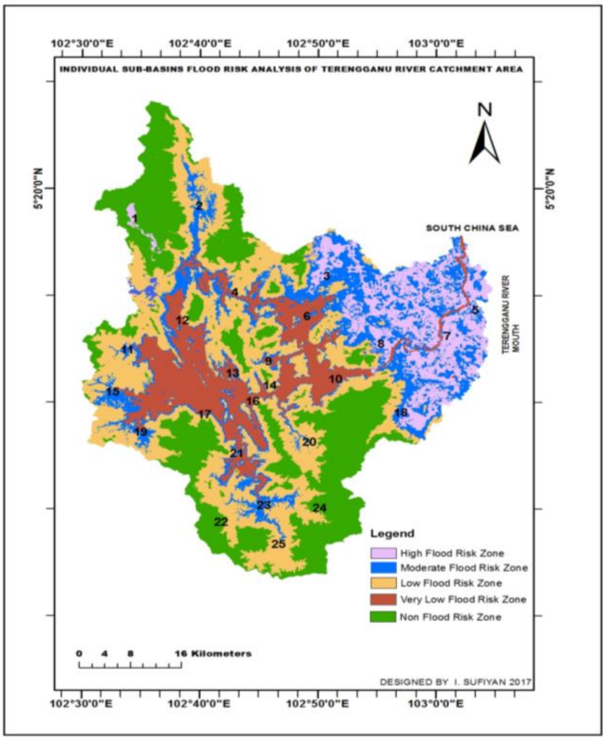


Figure 11: High and Low Flood Risk Map of TerengganuRiver catchment

3.10 Impact of Sub-basin Flood Risk Model

Figure 12 was developed from both the ArcSWAT-HRU and the 3D simulated model appended to it and shows which zone is severely affected by the flood. There are about 25 sub-basins 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 11 above, the water flow follows the slope. The slope and the flow direction with volume increase have determined the flood risk in the Terengganu river catchment. For mitigation action, we can select and predict which sub-basins in the catchment are highly substitutable and liable to flood at a point in time, depending on the intensity and duration of the rainfall.

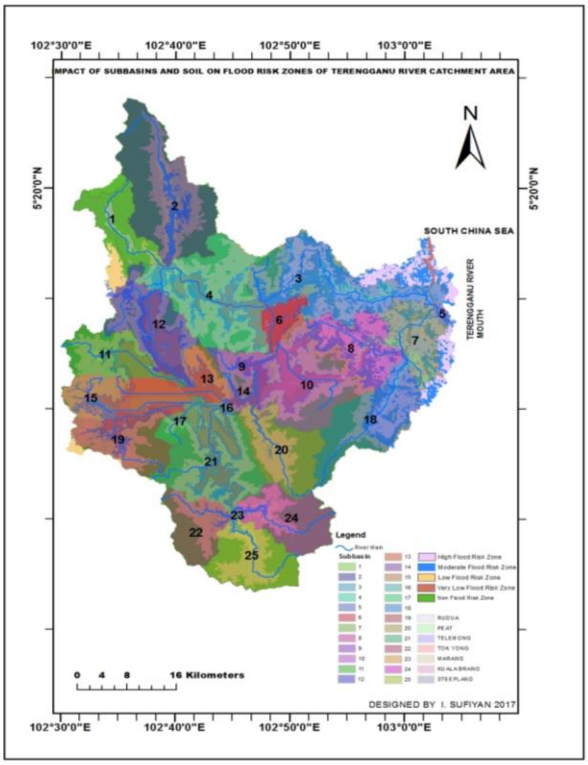


Figure 12: Impact of Sub-basins Flood Risk analysis of Terengganu River Catchment

4. Conclusion

The catchment area of Terengganu River was delineated with a total of 28, 6507.3500 (Ha) with 305 number of HRUs and 25 sub-basins refer to Table 1. There are about 3 major reservoirs right at the center of the catchment refers to figure 5 with 10 stream links connecting to the other streams. The land cover sustainability depends on the highest land use identified within the Terengganu catchment. In Table2, we arrived at the summary of land cover categories with forest land cover having 73.93%. The study finds out that every HRU has different characteristics especially the sizes of the sub-basins parameters which are used to determine the water flow for simulations of flood risk zones.

Generally, the local soils in the catchment area are summarized in table 3 with Steepland having 69.85 %, indicating that the soil formation is the highland type found in most of the tropical rainforest. There is a correlation between slope and the soil type found in Kuala Terengganu. The elevation from 40 meters and above is having the highest percent 23.08%, which interprets the steepness of the slope with characterized soil type of steepland in the catchment. The flow directions of almost all the streams are towards the lower slope as shown in figure 10. The slope values as indicated in the same model were drained from the Lake Kenyir and flows toward the North-East direction and enter into the South China Sea.

References

Arnold, J.G., Allen, P.M., Volk, M., Williams, J.R., Bosch, D.D., 2010. Assessment of different representations of spatial variability on SWAT model performance. Transactions of the ASABE, 53 (5), Pp. 1433–1443.

Bronstert, A., 2003. Floods and climate change: interactions and impacts. Risk Analysis, 23 (3), Pp. 545–557.

Bubeck, P., Botzen, W.J.W., Aerts, J.C.J.H., 2012. A review of risk perceptions and other factors that influence flood mitigation behavior. Risk Analysis, 32 (9), Pp. 1481–1495.

Chan, N.W., 2015. Impacts of disasters and disaster risk management in Malaysia: The case of floods. In Resilience and Recovery in Asian Disasters. Springer, Pp. 239–265.

Chau, K.T., Chan, J.E., 2005. The regional bias of landslide data in generating susceptibility maps using logistic regression: a case of Hong Kong Island. Landslides, 2 (4), Pp. 280–290.

Dawson, C.W., Abrahart, R.J., Shamseldin, A.Y., Wilby, R.L., 2006. Flood estimation at ungauged sites using artificial neural networks. Journal of Hydrology, 319 (1), Pp. 391–409.

Lau, C.L., Smythe, L.D., Craig, S.B., Weinstein, P., 2010. Climate change, flooding, urbanization and leptospirosis: fuelling the fire? Transactions of the Royal Society of Tropical Medicine and Hygiene, 104 (10), Pp. 631–638.

Liu, Y.B., Gebremeskel, S., De Smedt, F., Hoffmann, L., Pfister, L., 2003. A diffusive transport approach for flow routing in GIS-based flood modeling. Journal of Hydrology, 283 (1), Pp. 91–106.

Marghany, M., Ibrahim, Z., Van Genderen, J., 2002. Azimuth cut-off model for significant wave height investigation along coastal water of Kuala Terengganu, Malaysia. International Journal of Applied Earth Observation and Geoinformation, 4 (2), Pp. 147–160.

Meyer, V., Scheuer, S., Haase, D., 2009. A multicriteria approach for flood risk mapping exemplified at the Mulde River, Germany. Natural Hazards, 48 (1), Pp. 17–39.

Mukerji, A., Chatterjee, C., Raghuwanshi, N.S., 2009. Flood forecasting using ANN, neuro-fuzzy, and neuro-GA models. Journal of Hydrologic Engineering, 14 (6), Pp. 647–652.

Toriman, M.E., Hassan, A.J., Gazim, M.B., Mokhtar, M., Mastura, S.A.S., Jaafar, O., Karim, O., Aziz, N.A.A., 2009. Integration of 1-d hydrodynamic model and GIS approach in flood management study in Malaysia. Research Journal of Earth Sciences, 1 (1), Pp. 22–27.

Youssef, A.M., Pradhan, B., Hassan, A.M., 2011. Flash flood risk estimation along the St. Katherine road, southern Sinai, Egypt using GIS-based morphometry and satellite imagery. Environmental Earth Sciences, 62 (3), Pp. 611–623.