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Impacts Of Individual Subbasins Flood Simulation In The Teregganu River Catchment Using 3d And Swat

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Abstract: *The issue of flood disaster in the tropicl environment is paramount coupled with the recent trend in climate disparisties. This study is concerned with the area around the Peninsular Malaysia; Kuala Terengganu. The coastal areas are experiencing flash flood during the heave monsoon. The application of Georaphic information system has proven to identify the flood risk zones at different degree of visualization. The ArcGIS 10.3, ArcSWAT 2012 and ArcScene 10.3 has been used to developed simulation and 3D modeling of the watershed. The elevation data was obtianed from ASTER DEM with high resolution for determining the slope and water flow. The model is use for flood risk zoning , animation, as well as mitigation for the future flood occurrences.*
Keywords: *3D, Subbasins , Flood, Modeling , GIS*

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I. Introduction

Modeling has become a major viable means for proper understanding of the reality. The Geographic Information System GIS as a technology of data acquisition, processing, storing and analyzing digital geospatial references and remotely sensed data is applicable to hydrologic science for depicting interrelationship with the environmental sciences according to (Khalid & Shafiai, 2015) was suggested to be an important alert for mitigation of flood. Calculation of flood hazard according to (Wade, Ramsbottom, Floyd, Penning-Rowsell, & Surendran, 2005) is based upon the following formula below;

Flood Hazard Rating (HR) = DX (V + 0.5) Where

V = velocity (m/s)

D = Depth (m)

DF = debris factor = (0, 0.5, 1 depending on probability that debris will lead to a significant greater hazard)

(Van Sickle & Johnson, 2008) 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. Land use/cover is two separate terminologies which are often used interchangeably (Dimyati, Mizuno, Kobayashi, & Kitamura, 1996). Land cover refers to the physical characteristics of earth’s surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g., settlements. While land-use refers to the way.

II. Flood Assessment in Terrngganu

Soil Water Assessment Tool (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 Units (HRUs) The first version of SWAT was developed in the early 1990s and the first release version 94.2 Engel and (Manguerra & Engel, 1998), later published and report the first application of SWAT in the literature; (J G Arnold, Williams, Srinivasan, King, & Griggs, 1994) and (Jeffrey G Arnold, Srinivasan, Muttiah, & Williams, 1998b). The Soil and Water Assessment Tool or 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 being 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 problems.

There are two categories of floods in Malaysia which has been classified by the Malaysian Drainage and Irrigation Department (Salahuddin, 2009), they are flash flood and monsoon floods. According to the two different perspective of floods, the hydrologic point of view is that flash flood is not intense for it only takes some few hours to return to normal level, while the monsoonal flood may last for a month or there about (Abd Manap, Firuz Ramli, & Redzwan, 2009).

The SWAT or Soil Water Assessment Tools is a physically base, continuous time calculation of hydrologic model Arnold (Jeffrey G Arnold, Srinivasan, Muttiah, & Williams, 1998a). It was designed to predict daily streamflow 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 (Galván et al., 2009), (Onuşluel Gül & Rosbjerg, 2010), (Stehr, Debels, Romero, & Alcayaga, 2008), (Thampi, Raneesh, & Surya, 2010), (Fukunaga, Cecílio, Zanetti, Oliveira, & Caiado, 2015), (Baker & Miller, 2013) respectively.

Water base services consider the increase in volume or quantity is of benefit in flood mitigation, decrease quantity beneficial as coined by (Brauman, Daily, Duarte, & Mooney, 2007), (Willaarts, 2012), (Banerjee, Bark, Connor, & Crossman, 2013).

There are two categories of floods in Malaysia which have been classified by Malaysian Drainage and Irrigation Department; these are a flash flood and monsoon floods and the areas around the coast are being flooding (Kemanusian, 2007). According to the two different perspectives of floods, the hydrologic point of view, the flash flood is not intense for it only takes some few hours to return to normal level, while the monsoonal flood may last for a month or more (Ahmad, Zani, & Hashim, 2015). Flood is one of the naturally occurring phenomena that affect Malaysia. The hazard and the risk go beyond a reasonable doubt. The Malaysian government sent large sum to control and manage flood disaster from 1926 to 2001 around RM 915 million was estimated to be spent (Hassan, Ab. Ghani, & Abdullah, 2006)

The attempt to employ modern techniques of software to determine better warning system, decision making as well as mitigation are however been incorporated based on hydrological model and Geographic Information System which was considered as the new technology of solving flood problems. Terengganu is located on the east coast of Peninsula Malaysia which is experiencing heavy rainfall during the Northeast monsoon occurs between October and March that has resulted in a flood in most of the Malaysia. But most of the coastal areas along the Eastern location including Terengganu were affected by coastal flooding, (Muhammad-Barzani, Ismail, & Rahim, 2007) Another flood event that concurrently happened in Malaysia, were in Johor, Pahang, Melaka and Negara Sembilan. It is important to identify land cover changes and their classification over time for easy comparison (Coppin, Jonckheere, Nackaerts, Muys, & Lambin, 2004). For instance, the forest land cover changes in Peninsula Malaysia.

III. Material and Methods

Study Area

Terengganu is located at the east coast of Peninsula Malaysia that has experience heavy rainfall during the North east monsoon which occurs between October and March that has resulted in flood in most of the Malaysia. But most of the coastal areas along the eastern location including Terengganu were affected by coastal flooding. (Kemanusian, 2007). Another flood event that concurrently happened in Malaysia, were in Johor, Pahang, Melaka and Negara Sembilan.

The study focuses on the flood mitigation in one of the flood prone region in Malaysia, Kaula Terengganu River Catchment. Kuala Terengganu was lied on Lat 5^0 4^I 18^{II}.767 to 5^0 3^1 15^{II}.938 N and 102^0 35^I 13^{II}.85 to 103^0 11^I 47^{II}.414 E located in the North-East part of peninsular Malaysia, with 1700sqkm wide. The study will examine the catchment and analyze the probability of modeling the flood event into flood map. According the report from of Drainage and Irrigation Department Malaysia (DID) stated that the volume of water rises to about 19.7m and exceeded the danger level of 19.5m during the flood in Terengganu.

Terengganu River (Sungai Terengganu) is originated from Lake Kenyir, it flows through the capital state of Terengganu and flows into the South China Sea. The Terengganu River catchment has occupied about 4,174sqkm. The basin comprises of more than 13 major tributaries the main Terengganu River drained into South China Sea. The basin is surrounded by highlands in the west undulating land in the south and in the north are flats low-lying lands. The river flows in the direction from west to east before emptying to the South China Sea. The Terengganu River Basin is composed of diverse relief. The area around the coastal plain are generally low-lying with about 75% of the catchment is on the steeply slope (mountainous) rising above 4031 meters above sea level. But the rest is virtually undulating hills and lowlands. The geologic formation is made up of granitic rocks, shells, predominated by sandstone, mudstone and siltstone (Roslan, Shamshuddin, Fauziah, & Anuar, 2010).

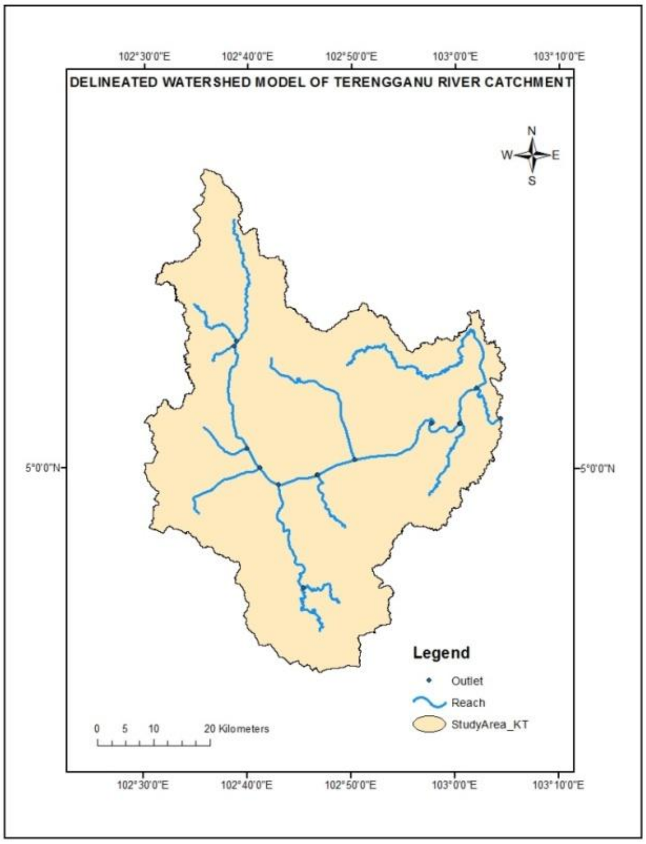

Figure 1: Location of the study area

Sources of Data and Input Required

1. Department of Irrigation and Drainage (DID)
a. Data of flood event in the study area (previously)
b. Digital Elevation Model data (DEM)
c. Stream flows data
d. Land cover/land uses data
e. Soil types

These are obtainable base on different location of the stations

2. Climate data from Malaysian Meteorological Department (MET Malaysia) from 2000-2015
3. Land cover images from Malaysian Remote Sensing Agency (MRSA)
4. Malaysian soil map was obtainable from online source European Digital Archives of soil maps (EuDASM) named Reconnaissance soil map Peninsular Malaysia 1968.

1. Maximum and minimum daily Temperature
2. Daily relative humidity
3. Daily solar radiation
4. Mean wind speed
5. Soil data
6. Digital Elevation Model (DEM)
7. Land cover images
8. Daily stream flows
9. Daily rainfall
10. Sediment suspended
11. Shape file of Terengganu catchment boundary

IV. Results and Discusion

Simulation validation of the 3D models can be done in the AcScene by using the layer keyframe with affirmative visibilty and choising the translation Z. This explain the parameter
at what scale and height the DEM data diplayed in figure 1 below.

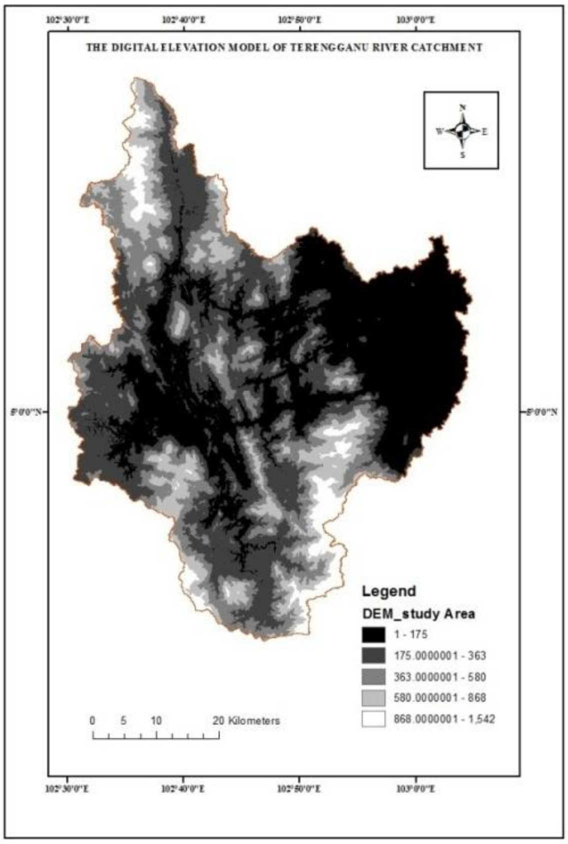

Figure 2: Digital elevation model (DEM) of the study area

The slope data was obtianed from the default in ArcSWAT. The slope is automatically generated base on the digiatal terrain model. The figure 3 below illustrates the slope according to the orientation of the catchment area. The flood follows the slope as it naturally allows water to flow depending on the gradient of the slope.

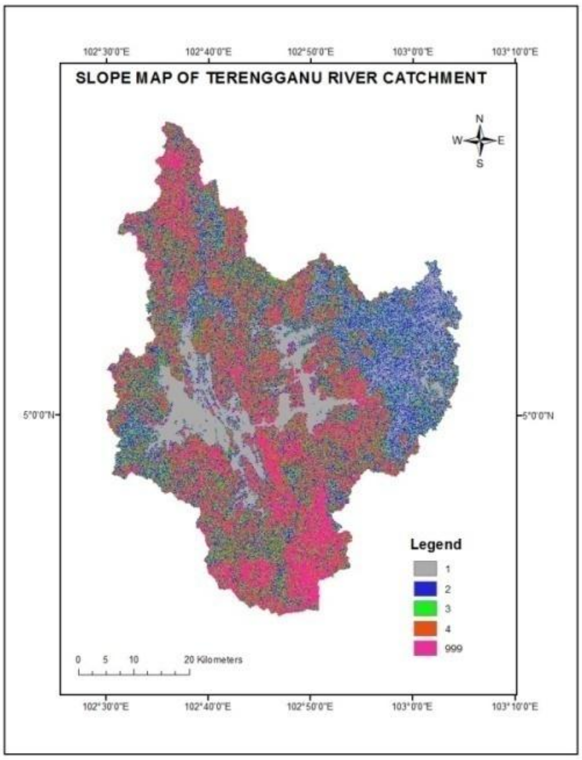

Figure 3: Slope oriention in Terengganu River catchment

Impacts individual Subbasins on Flood Risk Zones in Terengganu River Catchment

Comparing the impacts of hydrologic response units in Terengganu River catchment, the subbasins are different parameters. Different subbasins have different HRUs and that their impacts also vary at different levels for instance, subbasin number 1 might have different soil composition, land cover and slope gradient than subbasin number 2 and vice-versa.

The subbasins density as shown in the figure 4.50 displays the result obtained from the ArcSWAT. The subbasins are classifies into 5 classes; 1-5, 6-10, 11-15, 16-20 and 21-25. The impacts of the subbasins density can be analyze base on the lower slope density of very high flood risk zones near the South China Sea as we can see in the illustrated figure 4.50, subbasins number 3, 7 and 18 found on the very high flood risks zones.

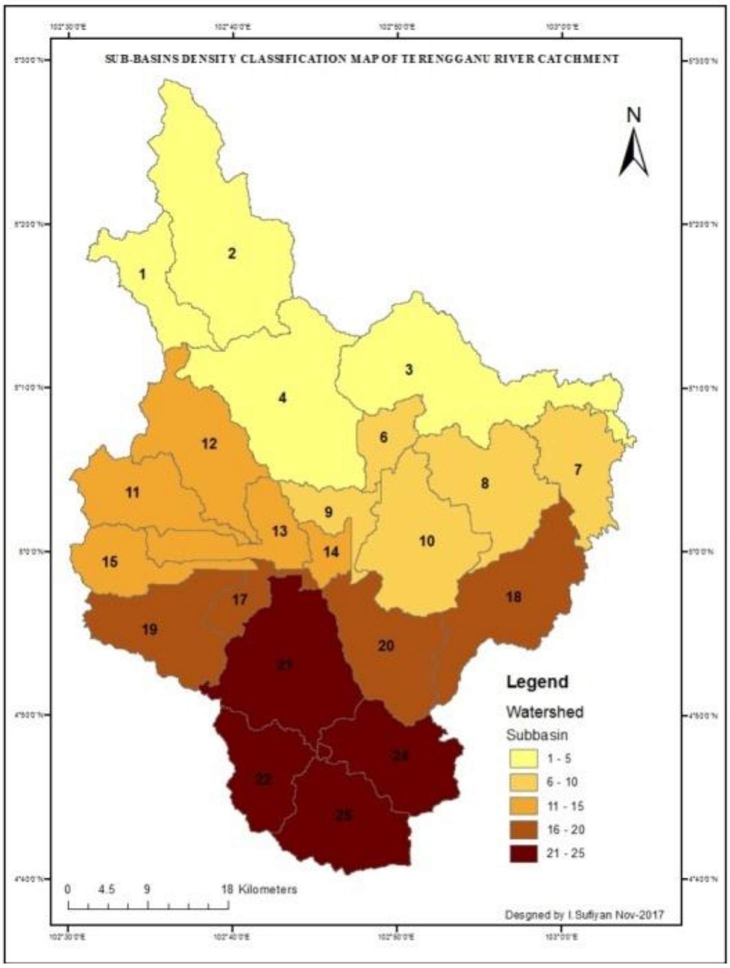

Figure 4: subbasins density of Terengganu river catchment

The individual subbasins parameters can be identifiable through the symbolized length of individual subbasins as shown in figure 4.51 below. The areas occupied by these subbasins vary from one another depending on the geographical locations sites and situations.

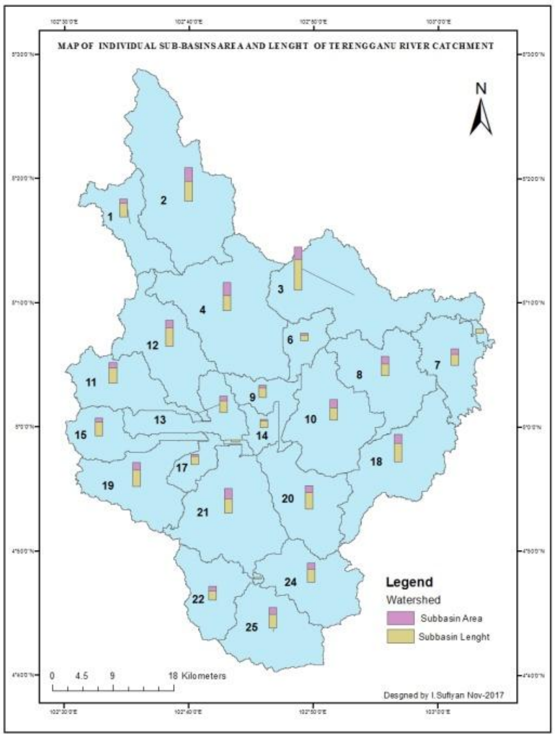

Figure 5: classification of subbasins base on length and area

The impacts would have to be on stream flow, soil structures, land cover density and receiving rainfall intensity. The results obtained from this study, have categorizes the individual subbasin in Terengganu River catchment refer to figure 4.52 and subsequence figures portrays below.

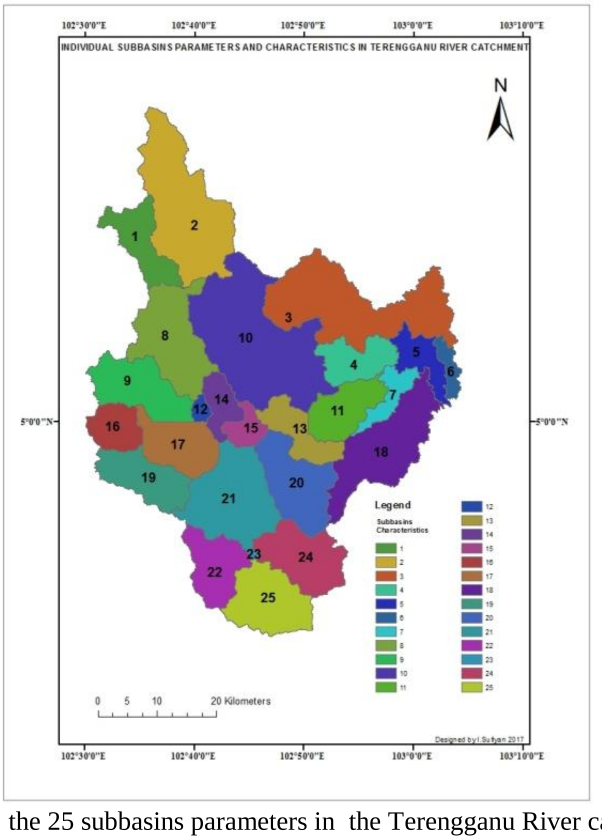

Figure 6: the 25 subbasins parameters in the Terengganu River catchment

The hydrologic response units (HRUs) of the Teregganu River display the charateristics patterns of the land ocver soil and slope of the area. The stream network and the sbbasins parameters are the output of the ArcSWAT that are use in the sumilation. The HRUs is responsible for the creation os subbasins parameters. The figure below explain the impact of flood simulations in individual subbasins found in the Terengganu River catchment.

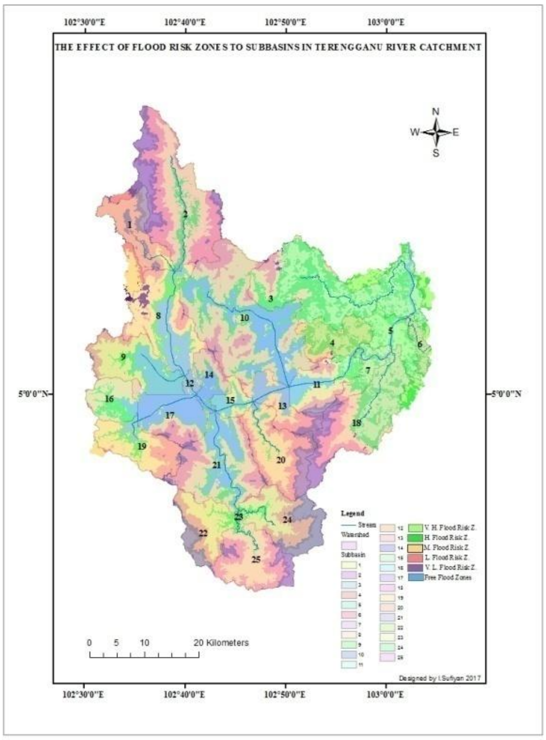

Figure 7: Individual subbasins parameters and their impacts

The model in the validation start from 0 to 60 the from 60 to 100 depending on the number of layers required for simulation as show in figure 8. But for the purpose of this study we have chosen the 0 to 100 as shown in figure 8.

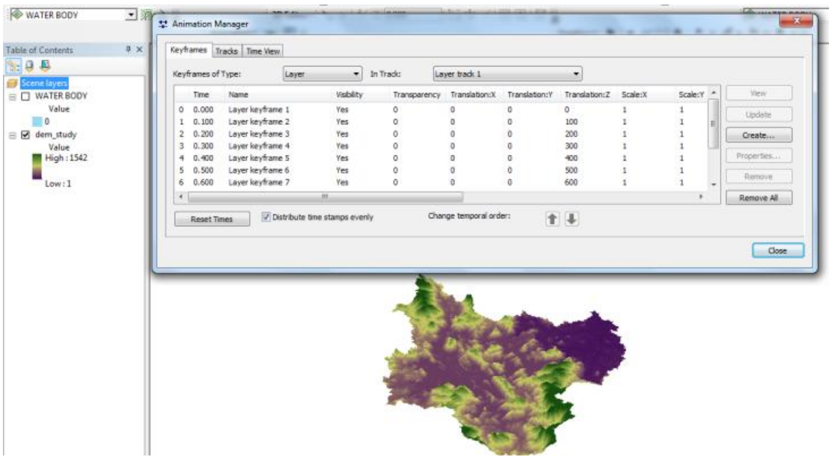

Figure 8: flood simulation validation

Time scale of simulation validation result in the animation manager starts from 0.000 to 0.125 and then to 0.250 at a maximum as shown in figure 9. The figure 10 below was set at the scale from 0.250 to 0.500. The final scale is validated from 0.500 to 1.000 shown in figure 11. The scale also detects the timing and viewing of the simulation at the real-time.

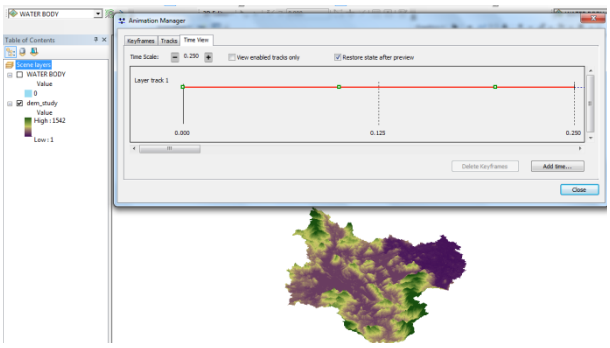

Figure 9: model validation from 0.125 to o.250 At 0.500

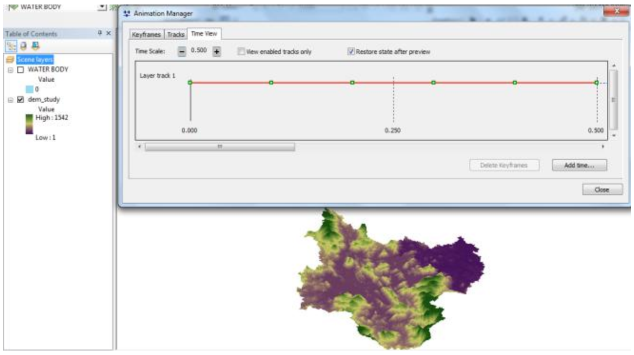

Figure 10: model validation from 0.250 to 0.500

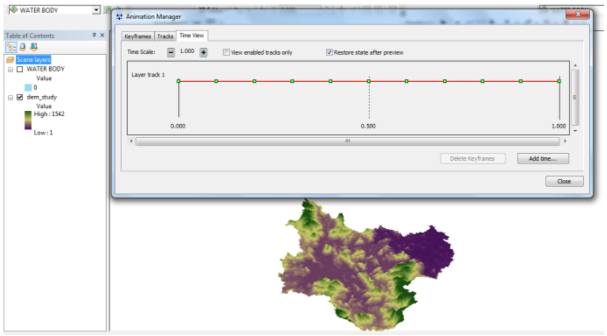

Figure 11: model validation from 0.500 to 1.000

3D – mask were loaded into the ArcScene (the new mask of the study area).
Set it on floating and choose the base height to have 3D view.
Digital Elevation Model DEM was also loaded into ArcScene , the Base Height was changed according to the data available in the study area.
Convert the DEM to 3D View; select the translation Z value base on the given elevation.

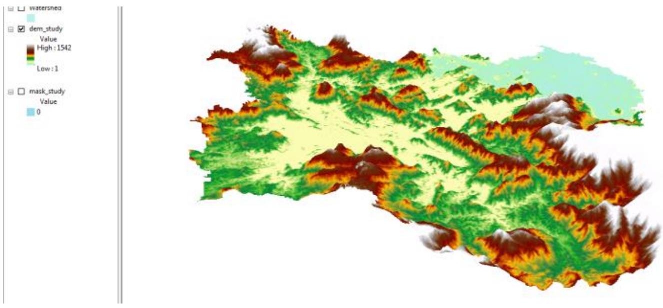

Figure 12: 3D Modeling of the catchment

Overlay the two shapefiles in 3D perspectives to allow the DEM to be visualized

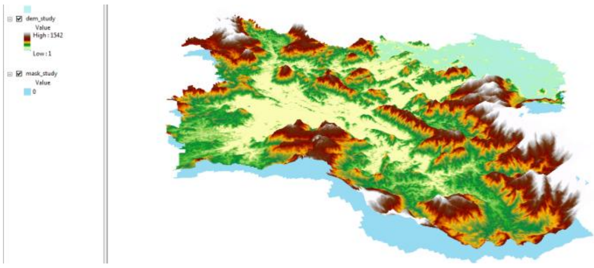

Figure 13: the Mask was set at floating for ready for simulation

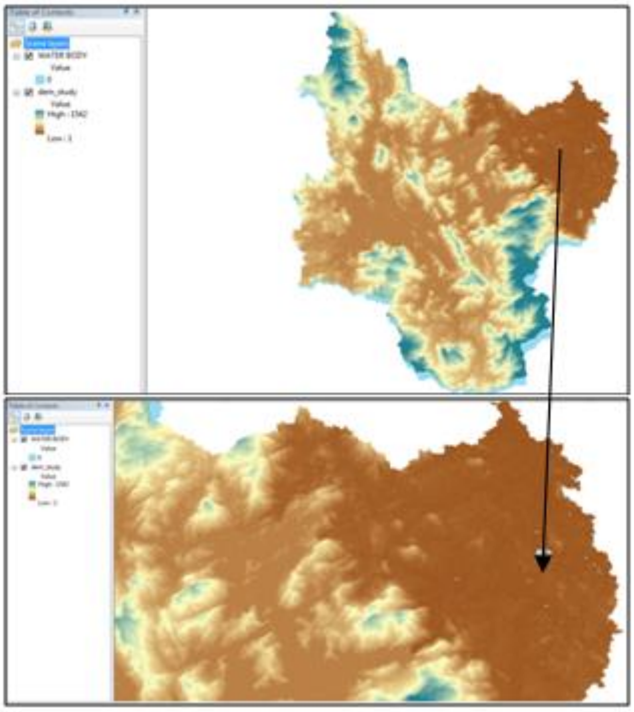

Figure 14: simulation at 2 meters

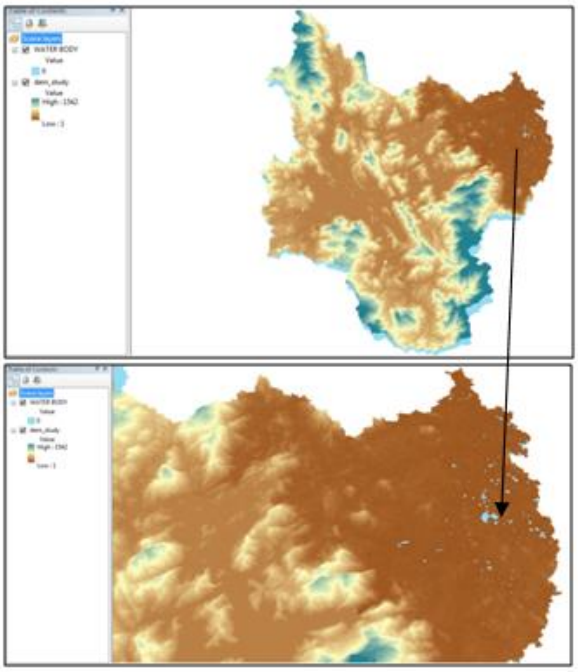

Figure 15: simulation done at 3 meters

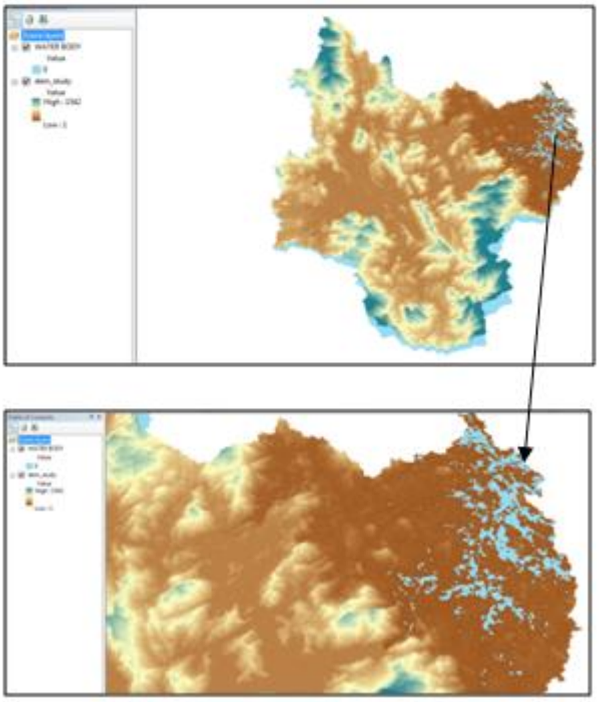

Figure 15: simulation done at 5 meters

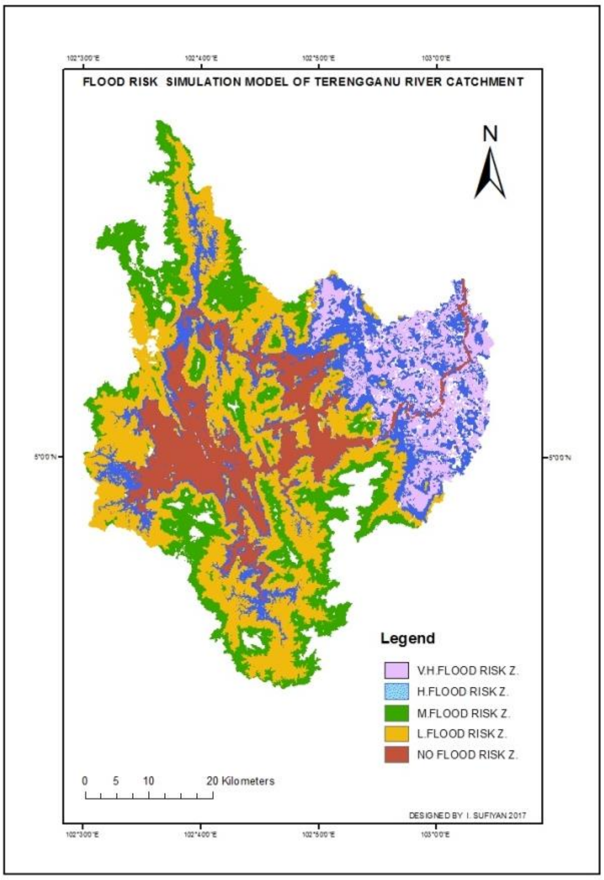

Figure 16. final flood risk simulation model of Terengganu River catchment

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The study was conducted in the Universiti Malaysia Terengganu under the juridiction of my supervisor Dr. Razak Bin Zakariya. Faculty of Marine and Envirnment Science.Deparment of Remote Sensing and GIS.

V. Conclusion

it is imporatant for every river catchment to have an accurate monitoring. This is because the study will help in different ways depending on the need assessment , management and mitigation. For the Terengganu River catchment we employ the use of Geoegraphic Information System (GIS) and Soil and water assessment tool (SWAT) to develop the flood risk models. The process had identified very high flood risk zones , moderate to low flood risk zones and to free- flood zones in the catchment area of Terengganu. The flood simulation also aids in physical or real-time simulation that can also be use as animation of the flood monitoring events

References

[1]. Abd Manap, M., Firuz Ramli, M., & Redzwan, G. (2009). The application of digital elevation model for the interpretation of Klang Valley geological structure. *Disaster Prevention and Management: An International Journal*, *18*(5), 504–510.

[2]. Ahmad, M., Zani, N. M., & Hashim, K. F. (2015). Knowledge sharing behavior among flood victims in Malaysia. *ARPN Journal of Engineering and Applied Sciences*, *10*(3), 968–976.

[3]. Arnold, J. G., Srinivasan, R., Muttiah, R. S., & Williams, J. R. (1998a). Large area hydrologic modeling and assessment part I: model development. *JAWRA Journal of the American Water Resources Association*, *34*(1), 73–89.

[4]. Arnold, J. G., Srinivasan, R., Muttiah, R. S., & Williams, J. R. (1998b). Large area hydrologic modeling and assessment part I: Model development1. Wiley Online Library.

[5]. Arnold, J. G., Williams, J. R., Srinivasan, R., King, K. W., & Griggs, R. H. (1994). SWAT: soil and water assessment tool. *US Department of Agriculture, Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, TX*.

[6]. Baker, T. J., & Miller, S. N. (2013). Using the Soil and Water Assessment Tool (SWAT) to assess land use impact on water resources in an East African watershed. *Journal of Hydrology*, *486*, 100–111.

[7]. Banerjee, O., Bark, R., Connor, J., & Crossman, N. D. (2013). An ecosystem services approach to estimating economic losses associated with drought. *Ecological Economics*, *91*, 19–27.

[8]. Brauman, K. A., Daily, G. C., Duarte, T. K., & Mooney, H. A. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. *Annu. Rev. Environ. Resour.*, *32*, 67–98.

[9]. Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., & Lambin, E. (2004). Review ArticleDigital change detection methods in ecosystem monitoring: a review. *International Journal of Remote Sensing*, *25*(9), 1565–1596.

[10]. Dimyati, M., Mizuno, K., Kobayashi, S., & Kitamura, T. (1996). An analysis of land use/cover change in Indonesia. *International Journal of Remote Sensing*, *17*(5), 931–944.

[11]. Fukunaga, D. C., Cecílio, R. A., Zanetti, S. S., Oliveira, L. T., & Caiado, M. A. C. (2015). Application of the SWAT hydrologic model to a tropical watershed at Brazil. *Catena*, *125*, 206–213.

[12]. Galván, L., Olías, M., de Villarán, R. F., Santos, J. M. D., Nieto, J. M., Sarmiento, A. M., & Cánovas, C. R. (2009). Application of the SWAT model to an AMD-affected river (Meca River, SW Spain). Estimation of transported pollutant load. *Journal of Hydrology*, *377*(3), 445–454.

[13]. Hassan, A. J., Ab. Ghani, A., & Abdullah, R. (2006). Development of flood risk map using GIS for Sg. Selangor Basin. *Proceeding 6th International Conf. on ASIA GIS, 9-10 Mac, UTM*, 1–11.

[14]. Kemanusian, F. (2007). Coastal Flood Phenomenon in Terengganu, Malaysia: Special Reference to Dungun" Muhammad Barzani Gasim," Jumaat H. Adam,"Mohd Ekhwan Hj Toriman," Sahibin Abd. Rahim and "Hafizan Hj. Juahir. *Research Journal of Environmental Sciences*, *1*(3), 102–109.

[15]. Khalid, M. S. Bin, & Shafiai, S. B. (2015). Flood disaster management in Malaysia: An evaluation of the effectiveness flood delivery system. *International Journal of Social Science and Humanity*, *5*(4), 398.

[16]. Manguerra, H. B., & Engel, B. A. (1998). HYDROLOGIC PARAMETERIZATION OF WATERSHEDS FOR RUNOFF PREDICTION USING SWAT1. Wiley Online Library.

[17]. Muhammad-Barzani, G., Ismail, B. S., & Rahim, S. (2007). Hydrology and Water Quality Assessment of the Tasik Chilli's Feeder Rivers, Pahang, Malaysia.

[18]. Onuşluel Gül, G., & Rosbjerg, D. (2010). Modelling of hydrologic processes and potential response to climate change through the use of a multisite SWAT. *Water and Environment Journal*, *24*(1), 21–31.

[19]. Roslan, I., Shamshuddin, J., Fauziah, C. I., & Anuar, A. R. (2010). Occurrence and properties of soils on sandy beach ridges in the Kelantan–Terengganu Plains, Peninsular Malaysia. *Catena*, *83*(1), 55–63.

[20]. Salahuddin, J. S. (2009). River sand mining management guideline. *Ministry of Natural Resources and Environment. Department of Irrigation and Drainage Malaysia. Department of Irrigation and Drainage (DID)*, 1–47.

[21]. Stehr, A., Debels, P., Romero, F., & Alcayaga, H. (2008). Hydrological modelling with SWAT under conditions of limited data availability: evaluation of results from a Chilean case study. *Hydrological Sciences Journal*, *53*(3), 588–601.

[22]. Thampi, S. G., Raneesh, K. Y., & Surya, T. V. (2010). Influence of scale on SWAT model calibration for streamflow in a river basin in the humid tropics. *Water Resources Management*, *24*(15), 4567–4578.

[23]. Van Sickle, J., & Johnson, C. B. (2008). Parametric distance weighting of landscape influence on streams. *Landscape Ecology*, *23*(4), 427–438.

[24]. Wade, S., Ramsbottom, D., Floyd, P., Penning-Rowsell, E., & Surendran, S. (2005). Risks to people: developing new approaches for flood hazard and vulnerability mapping.

[25]. Willaarts, B. (2012). Linking land management to water planning: estimating the water consumption of Spanish forests. *Water, Agriculture and the Environment in Spain: Can We Square the Circle*, 139–151.

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