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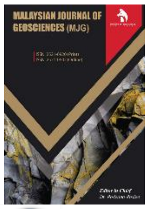

RESEARCH ARTICLE

3D MODELING AND ASSESSMENT OF FLOOD RISK ZONES USING GIS AND REMOTE SENSING IN CATCHMENT AREA TERENGGANU, MALAYSIA

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ABSTRACT

The application of 3D GIS has enabled better representation and visualization of flood events than previous 2D maps. Flooding is common in the Terengganu basin. Flash floods occur most of the year during the monsoon season, which lasts from November to January. Flooding along riverbanks is mainly affected by heavy rainfalls of 2500mm to well over 3500mm per year. This has significant impacts on environmental resources such as land use/land cover, local soil types and slopes. The study area of Kuala Terengganu was particularly affected by heavy rains and flash floods during the monsoon season. ASTER DEM resolution 5m converted to ArcScene 10.3 using ArcGIS 10.3 and 3D software. In recent years, flood monitoring methods have been developed that can predict water flow and associated risks and hazards. 3D visualization techniques include remote sensing such as satellite imagery and geographic information systems "GIS". and LiDAR modeling

KEYWORDS

Remote Sensing, GIS, Modelling, 3D, Watershed, Hydrology

1. Introduction

Flooding can be defined as natural or man-made flooding from a riverbank that dominates the surrounding area and causes overflow (Lin et al., 2013). Large amounts of water can spread across flood plains and become dangerous to society. In situations like flooding, climate change becomes the dominant factor. Flooding can pose significant risks to life, property and the environment. Flooding is one of the most devastating hazards and disasters Malaysia has experienced in decades. However, there are about 189 river basins, most of which drain into the North China Sea, of which the total number of rivers prone to flooding is 85.

The estimated flood prone and high-risk area is about 29,800 km2, or about 9% of Malaysia's total land area, which directly affects about 4.82 people, or about 22% of Malaysia's total population influence. Previous studies have shown promising results using SWAT as a hydrological model. SWAT was used in Taxes to calculate soil moisture in large river basins. (Narasimhan et al., 2005). SWAT was also used by used to model the effects of soil erosion and sediment loss (Betrie et al., 2011). In India, SWAT was used to simulate daily precipitation from 1951 to 2014 (Singh et al., 2014). Rain is a boon for Peninsular Malaysia with high forest cover (Sufiyan et al., 2018).

2. Methodology

The study area in Kuala Terengganu experienced heavy rains and flash floods, especially during the monsoon season. This study sought to address the issue of flood impacts based on digital image processing and the high multispectral resolution of satellite imagery and his GIS. The 5 m resolution of the ASTER DEM was obtained using the ArcGIS10.3 3D software Converted to ArcScene 10.3 (Pirasthe et al., 2018). In recent years, people have developed flood level monitoring methods that can predict water flow and associated risks and hazards. 3D visualization techniques include remote sensing such as satellite imagery and geographic information systems "GIS". LiDAR modelling. The recent application of 3D GIS has made it possible to better represent and visualize flood hazards than previous 2D maps (Wang and Xu, 2008).

3D computer graphics models allow users to simulate reality from a visualized perspective. ArcGIS techniques tend to create realistic animations of liquids, smoke, water, or pollutants in the environment. State of the art in remote sensing and geographic information systems (GIS) (Wylie et al., 2019). and developed a watershed depiction of the Kuala Terengganu River Basin. Flood mitigation measures require analytical watershed management combined with technological approaches to control flood risk and environmental hazards. The use of 3D in flood simulation development is of paramount importance, especially for rapid flood warnings and emergency assistance to flood victims (Winchell et al., 2007).

2.1 Study Area

The study area is located at upper left corner $5^{0}\ 30^{/}.40^{//}$ N, $102^{0}\ 23^{/}\ 15^{//}$ E and the lower right corner is $4^{0}\ 39^{/}\ 25^{//}$ N, $103^{0}\ 11^{/}\ 62^{//}$ E respectively. The bottom has a gentle slope gradually deepening toward the open of the South China Sea.

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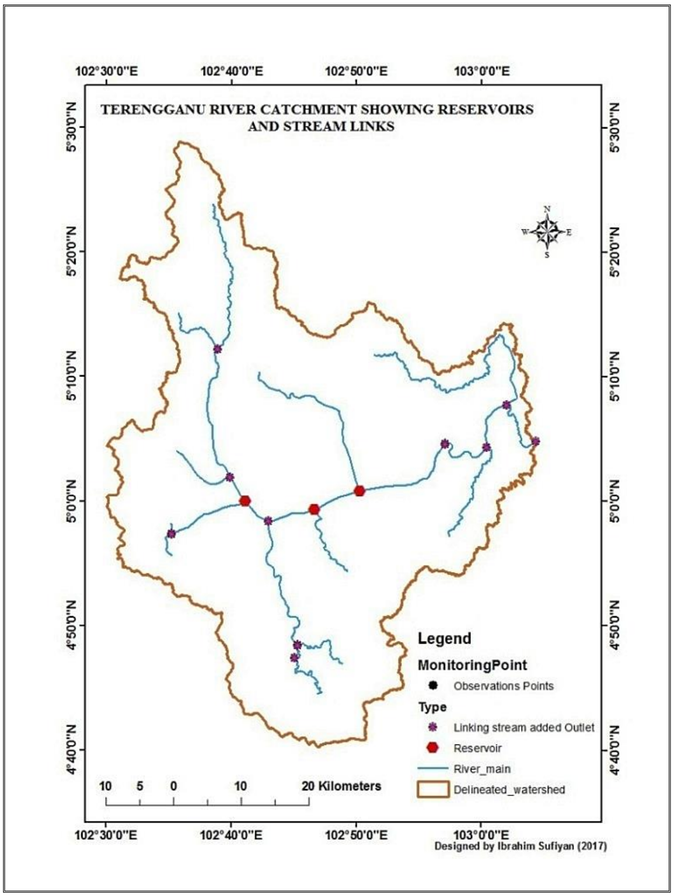

Figure 1: Map of the Study Area

3. Result and Discussion

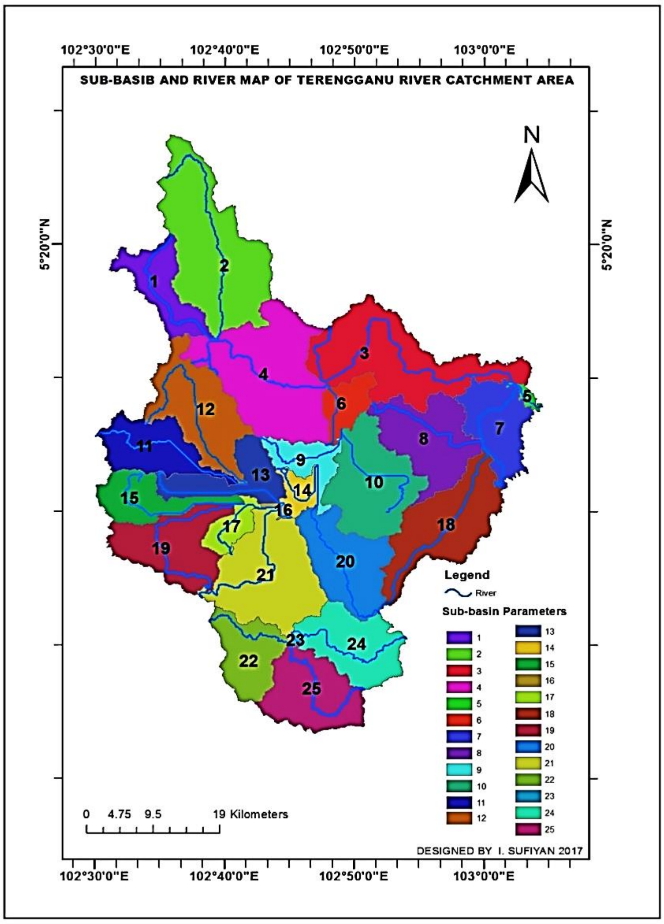

Figure 2: Terengganu River catchment Area sub-basins stream links and the main Rivers. Source: (ArcSWAT analysis 2022)

The temperature ranges from 23 °C to 32 °C on average, and the annual rainfall is approximately 3300 millimetres. During the northeast monsoon, which lasts from October to December, the catchment gets the most rain, while the southwest monsoon typically lasts from May to late September (Marganey at el., 2002). There are very few grasslands and a lot of evergreen forests in Malaysia. Rubber, palm trees, and timber can thrive in dense forests. The monsoon season is typically when floods occur (Tehrany et al., 2015).

The Hydrologic Response Units (HRU) consists 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, the following result is shown in Table 1, 2 and 3.

3.1 Land Use/Land Cover Analysis

Table 1 shows the SWAT output from one of the HRU results. Land cover plays an important role in controlling climate and flood-causing water flows. For example, forest cover is the predominant land cover in the study area. When part of the forest is cut down, floods inundate other lower elevation areas.

Table 1: Land Use/ Land cover Result from ArcSWAT Software

Land use	Abbreviation	Area [ha]	Area[acres]	%wat. Area
Water Body	WATR	42,685	105,476	14.90
Residential-High Density	URHD	3,347	8,270	1.17
Orchard	ORCD	46.8465	115.7601	0.02
Rubber Trees	RUBR	11,981	29,606	4.18
Residential – Low Density	URLD	167.2060	413.1745	0.06
Oil Palm	OILP	13,251	32,744.	4.63
Paddy	PADD	3,209	7,930	1.12
Grassland	GRSS	10.9008	26.9365	0.00
Forest-Evergreen	FRSE	211,809	523,391	73.93

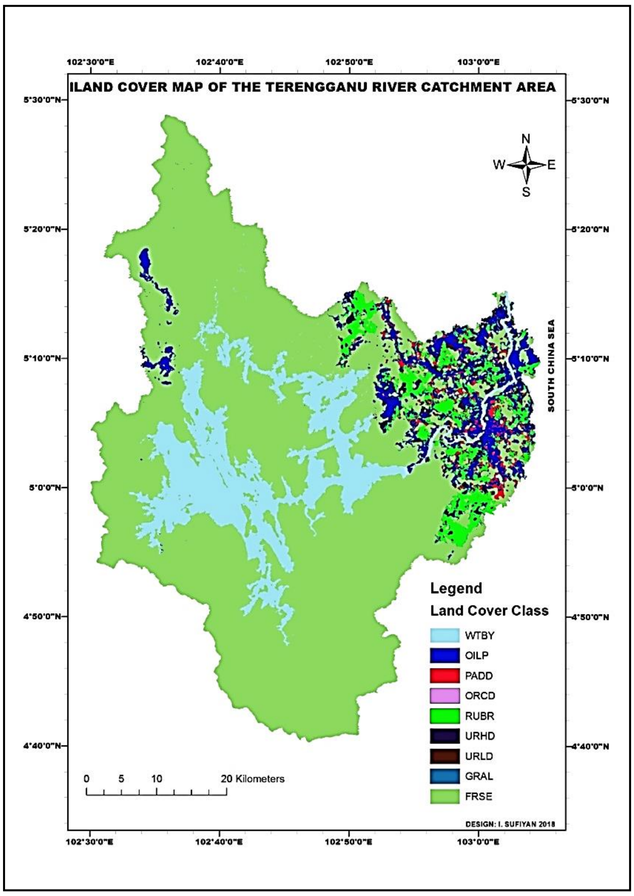

Figure 3: Land Cover classification of Terengganu River Catchment Area Source: (ArcSWAT analysis 2022)

Figure 3 View the land cover map of the Kuala Terengganu River Basin. The following legends represent different land cover patterns such as forest, water, urban land use, rubber, rice, orchard, oil palm, and grassland. The Terengganu River basin was completely occupied by evergreen forests where most forest products are found. The map shows that evergreen forest is the predominant land cover throughout the study area.

3.2 Local Soil Types Classification Results

Soil classification is based on USGS using standard SWAT and can update local soil databases. Local soils for the study area are created from existing soils around the world based on SWAT updates. Table 2 shows the soil classification results by total area (hectares, acres and total percentage) obtained during the analysis.

Table 2: Soil types result of Terengganu River Catchment Area

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	200,118	494,501	69.85
Telemong	10,250	25,328	3.58
Tok Yong	7,682	18,983	2.68

Figure 4 shows a digitized soil map of the Terengganu River basin. Soil absorbs moisture and cools or heats up quickly. Depending on temperature, water retention capacity varies from humid equatorial climates to monsoons to arid and semi-arid environments. The predominant local soils in the Terengganu River Basin are steep and at the highest altitudes. Most of these areas around the escarpment are flood-free zones.

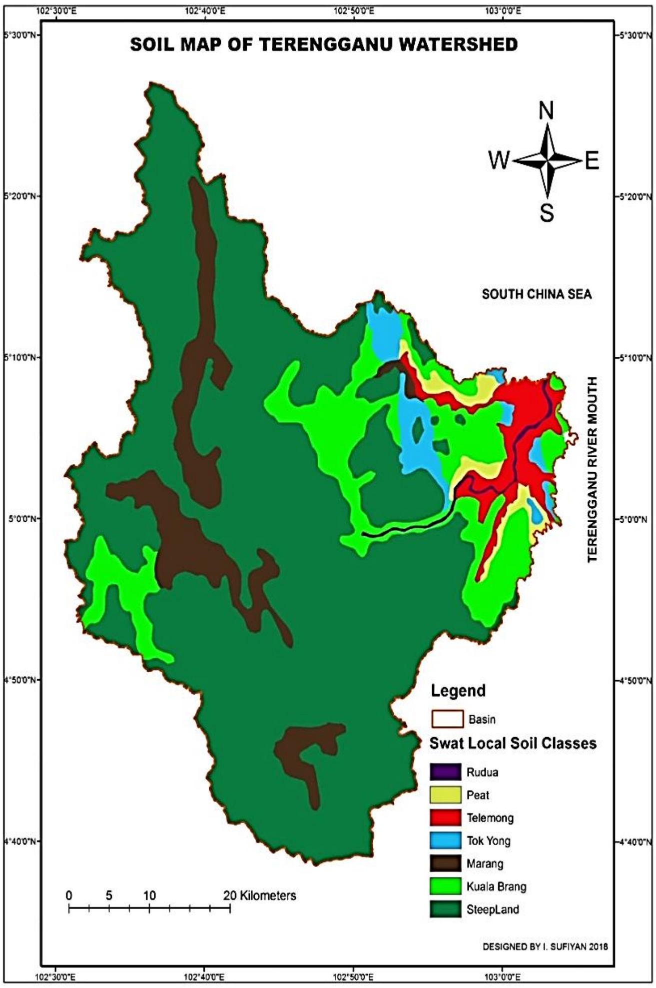

Figure 4: Soil Map of Terengganu River Catchment Area (Source: ArcSWAT analysis 2022)

3.3 Slope Analysis

Slope data obtained from the SWAT database were intrinsic evolution from 10/10/10 percent thresholds selected from HRU. Table 3 shows the total area results for each slope category in hectares and acres, explaining the slope percentages from 0-10 to 40 meters.

From Table 3 below, we can conclude that the area occupied by steep land cover of 66,130.4348 ha has the highest elevation and has the most significant percentage of about 23.08%. This justifies the results of the soil classification model in Figure 5, where steep land represents the most important space in the Terengganu River basin.

Table 3: Slope Results of Terengganu River Catchment Area

Slope	Area [ha]	Area[acres]	%wat. Area
0-10	62,168	153,620	21.699
10-20	59,974	148,199	20.933
20-30	543,93	134,407	18.985
30-40	43,843	108,337	15.302
40-9999	66,130	163,412	23.082

3.4 3D Analysis in ArcScene10.3

A 3D simulation was performed and the results were obtained in ArcScene 10.3 using a moving Z-value to indicate the elevation of the Terengganu river basin. Figure 5 is his 3D setup in the ArcScene10.3 environment to properly visualize the flood analysis scenario. A 3D flood model simulation with an underlying floating water mask was performed using a digital elevation model (DEM). Simulation is possible according to the altitude from low altitude to high altitude. ASTER Digital Elevation Models (DEMs) have the resolution required to display them in a 3D analysis mask.

3.5 Final 3D Flood Model of Terengganu Watershed

A digital elevation model (DEM) of the study area was overlaid with a mask and the Terengganu River was taken as the reference elevation. Figure 5 shows a 3D model created from ArcScene10.3. At this point, the Z values are calculated differently, and the simulation is created.

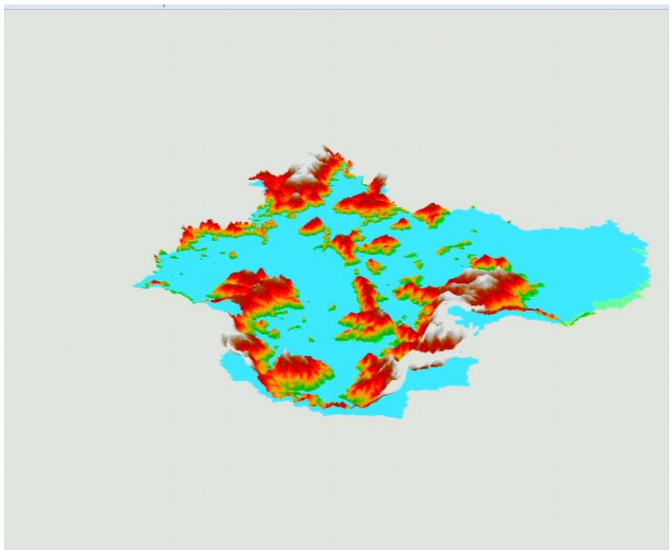

Figure 5: 3D flood Simulation of Terengganu Watershed

4. Conclusion

The 3D model in Figure 5 represents a real-time 3D simulation, with the blue color representing water running down a high slope. The most frequent type of flooding in these areas of Peninsular Malaysia is flash flooding. It occurs during the wettest period (monsoon) from November to late January, causing flood events reaching slopes of 1-6 m, flooding with increasing rainfall intensity, and lasting perhaps 2-3 days. Persistent showers will follow.

Recommendations

There are problems with inadequate drainage systems and clogged waterways. Draining debris from the drainage system is paramount to ensure that running water can easily drain into the main stream. Geographic Information System "GIS", Flood Maps are useful to some extent in flood risk assessment and management, flood protection, flood insurance estimation and coverage. Flood maps help provide flood alerts and warnings when flood levels reach certain hazard levels, especially freeboard. The positive aftermath of the flood in a river may form features significance to human activities land use/cover dynamics accumulated sediments improve fertile soils suitable for agriculture.

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