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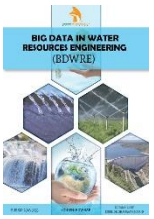

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RESEARCH ARTICLE

GEOSPATIAL ANALYSIS OF HYDROLOGIC RESPONSE UNITS OF FLOOD INUNDATION AT DIFFERENT SUB-BASINS PARAMETERS IN TERENGGANU WATERSHED, MALAYSIA

Mohammed Alkali[a], Ibrahim Sufiyan[a] and M.K. Dahiru[b]

[a]Department of Environment Management, Nasarawa State University Keffi, Nigeria
[b]Department of Geography Federal University Lafia
**Corresponding Author E-mail: ibrahimsufiyan0@gmail.com*

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ABSTRACT

Flood is one of the natural events in our environment. It destroys and displaces naturally existing structures found within the Hydrologic Response Units (HRUs). These include the Land Cover/Land use, Soil structure and the topography or the terrain. The method applied was the used of ArcSWAT to determine those flooded sub-basins by simply delineating the whole watershed into different sub-basin parameters. The result proves that what determines the flood influence was the area of the sub-basin that contained the HRUs not the HRUs itself. Once the sub-basin was inundated, the flooded streams within the sub-basins were calculated as flood impact. in this analysis 5 number of sub-basins were flooded in the watershed of Terengganu. Sub-basin number 3 has the highest flood impact with 14,699 hectares and sub-basin number 5 has the lowest total flood impact of 968.82 hectare.

KEYWORDS

Flood Impact, Inundation, Sub-basins, HRUs, Watershed

1. INTRODUCTION

Flood can be defined as a high water flow naturally or artificially from the river bank that dominates the surrounding areas to cause overflow (Lin et al., 2013). The high flow of water may extend over the floodplain and becomes a hazard to the society. Climate change becomes the dominant factor in a situation like a flood event. When a flood occurred, it might result in high risk of life, properties as well as the environment. Therefore, flood hazard can be viewed as a natural event that can disrupt day to day activities and hinder economic growth, create environmental pollution and outbreak of diseases. The application of geographic information system (GIS) will help in monitoring and evaluation, assessing and modeling, mapping hazard and mitigation, visualization and management.

Flood is one of the devastating hazard or disasters that Malaysia had been experiencing over the decades. However, there exist about 189 river basins most of which drained into the North China Sea, out of this the total number of rivers that are prone to flooding are eighty-five. The estimated areas liable to flooding and high vulnerability is approximately 29, 800 km^2 which are about 9 % of the total land area in Malaysia, and this is directly having an impact to about 4.82 people around 22% of the entire population in Malaysia. Eighty-six of these river basins are located in Peninsular Malaysia, 78 in Sabah and 22 in Sarawak. Most of the floods in Malaysia also occur due to sea level rise (Awang & Hamid, 2013).

Hydrologic Response Unit (HRU) is the smallest spatial unit of the model, and the standard HRU definition approach lumps all similar land uses, soils, and slopes within a sub-basin based upon user-defined thresholds (Kalcic et al., 2015).

The hydrologic response units (HRUs) are one of the components in the catchment or watershed studies that explain the relationship between the different hydrological units. The Arc SWAT interface was able to generate results of a particular watershed under investigation. In this study, the assessment of impacts of HRUs in different sub-basins parameters was carried out to determine the number of HRUs found in the flood risk zones.

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 coasts are been flooded (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 average level, while the monsoonal flood may last for a month or more (Ahmad et al., 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 spent large sum to control and manage flood disaster from 1926 to 2001 around 915 million Ringgit was estimated to be spent (Hassan et al., 2006).

2. MATERIAL AND METHOD

2.1 Sources of Data

The ArcSWAT-2012 requires meteorological data for it to merely define the type of precipitation, temperature, humidity wind and solar radiation within the catchment area. The source of this data was from the Department of Irrigation and Drainage.

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Malaysian Hydrological Stations

Malaysia Department of Irrigation and Drainage	Data Types
1. Station 5129437, Sg.Telemong, Paya Rap Terengganu 2. Station 5130432, Sg, Terengganu, G. Tanggol Terengganu 3. Station 4930401, Sg, Berang, Menerong Terengganu 4. Station 5229436, Sg, Nerus, Kg. Bukit Terengganu	Daily Streamflow
1. Station 5029001, Rumah Paya Kemat, Terengganu. 2. Station 5331048, Sector, JPS, K. Terengganu 3. Station 5330046, Sek. Men.Kg. Gempoh,Terengganu 4. Station 5328043, Kg. Bukit Berangan K. Terengganu. 5. Station 5230041, S.K. Kuala Telemong Terengganu 6. Station 4929001, Kg. Embong Sekayu, Ulu, Terengganu	Daily rainfall
1. Station 522936, Sg, Nerus, 2. Station 4930501, Kg. Berang, Menerong Terengganu	Daily suspended sediments

Source: Drainage and Irrigation Department Malaysia Tehrany et al, (2015)

3. Results and Discussion

3.1 Techniques of created Hydrologic Respond Units (HRUs)

ArcSWAT is hydrological software used in determining the sub-basins in Hydrologic Response units (HRUs). Hydrologic Response Units (HRUs) is mostly an analysis that described the pattern of Land Use/Land Cover, Soil and Slope definition in the whole catchment. It is also in this analysis that the entire HRU definition is calculated.

3.2 Technique for Data Analysis

All Malaysian Peninsular images data was converted using into appropriate coordinate system called Kertua or Rectified Skew Orthomorphic (RSO) Malaya meter for geometric correction of the georeferenced data.

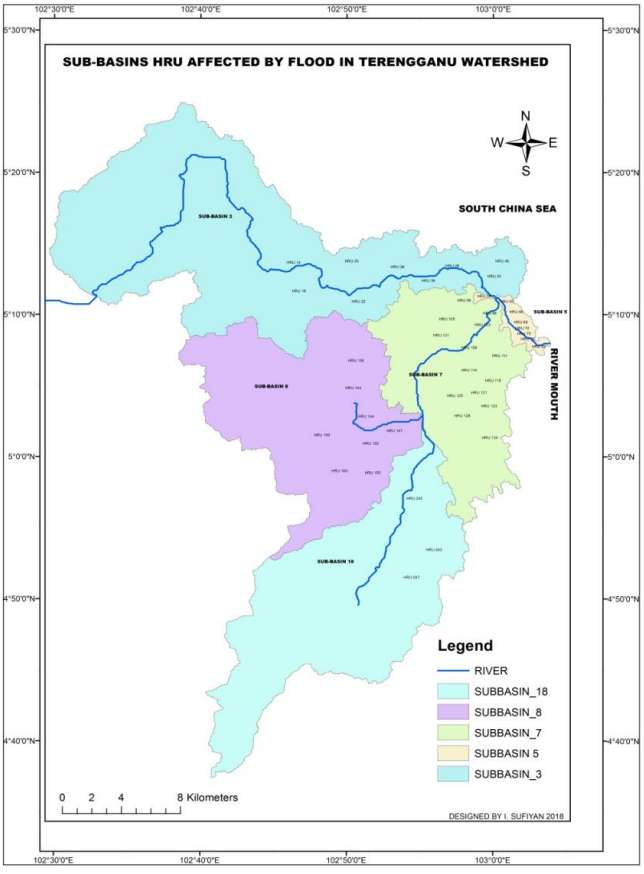

Figure 1: Number of HRUs found in different Sub-basins of Terengganu River catchment. Source: (ArcSWAT analysis 2017)

Flood frequently occurs in the catchment area of Terengganu. There is an issue of flash flood during the monsoon period around November to January most of the year. The flood along the river banks are mostly influenced by the high amount of the rainfall well over 2500mm to 3500mm per annum.

The total impact of flood from different Hydrologic Response Units were obtained as shown in Table below.

Table 1: Total flood impact of HRUs from different Sub-basins

No Sub-basins Flood	No. HRUs	Total flood Impact (Hectare)
3	9	14,699
5	8	968.82
7	14	13,994
8	8	8004.68
18	3	5804.24
Total	42	43,474.97

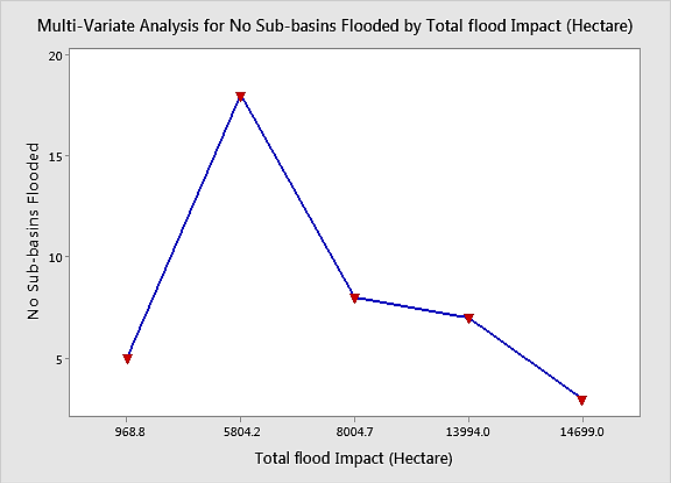

Figure 2: Number of Sub-basin Parameter influencing flood event

The flood impact was driven from the sub-basin with lowest HRUs, which is sub-basin 5, with total of 968.82 followed by sub-basin 18, 8, 7 and 3. In this Analysis, the biggest flood impact was found in sub-basin 3 and it's the largest among the rest. The high number of HRUs determines to the large extend the hydrologic event occurring in the sub-basin.

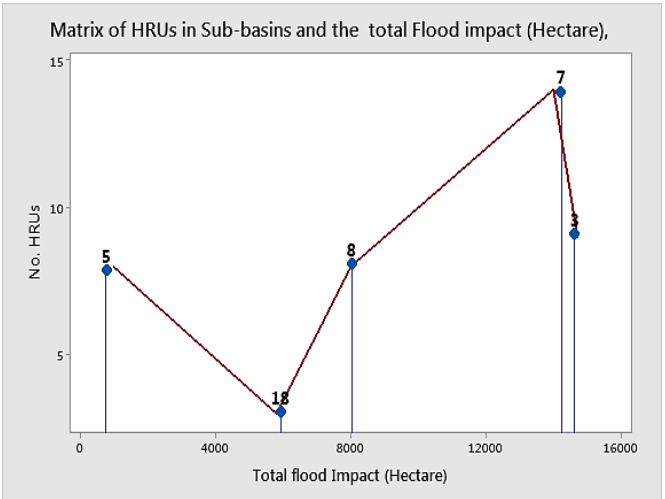

Figure 3: Number of HRUs in the Flooded Sub-basin Parameter

The result of this analysis has shown the least number of HRUs within the 5 flooded Sub-basins in the Terengganu watershed. The Sub-basin Number 18 has 3 HRUs, both sub-basin 5 and 8 has the same number of HURs, which is 8, while sub-basin 3 has 9 HRUs and sub-basin 7 has 14 HRUs.

However, base on this finding, the number of HRUs never determine the flood event, rather is the parameter of the Sub-basin always seen flooded. The HRUs which consist of the soil, land cover and slope were the all found within the sub-basins of a particular watershed.

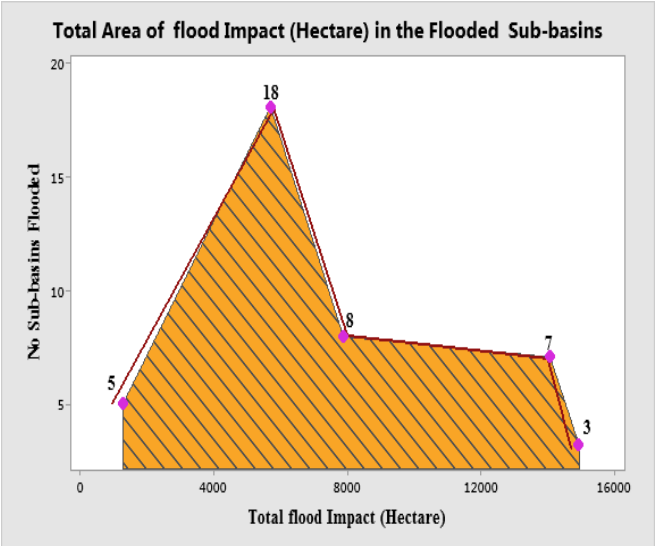

Figure 4: Total Sub-basins area flooded in Hectare

The shaded portion in Figure 4, describes the limit of the flood event in the sub-basin number 18 in the total flooded sub-basins.

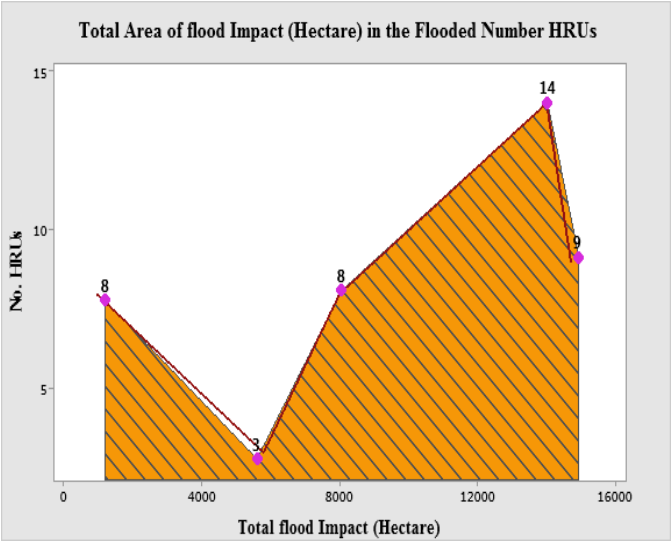

Figure 5: Total HRUs affected with the 5 Flooded Sub-basins in the Watershed

The shaded portion in figure 5 shows the highest peak of HRUs in the sub-basins with HRUs 14 being the limit from the 5 flooded sub-basins in Terengganu watershed.

The pareto chart summarized the total flood event in the flooded sub-basins in the Terengganu watershed. All the 5 sub-basins analysis was shown in figure 6.

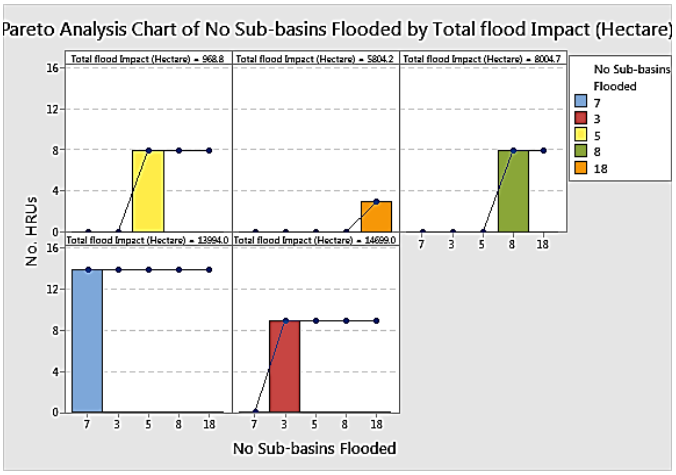

Figure 6: Pareto chart showing the characteristics of flood Sub-Basins

4. Conclusion

Among the 5 sub-basins that are vulnerable to high flood risk in Terengganu River catchment area, the most affected HRUs with high flood risk impacts are found in sub-basin 3 with 36,323 ha, followed by sub-basin 7 with 34,582 ha then sub-basin 8 with 19,750 ha, followed by the sub-basin 18 with 14,350 ha and the lowest impact are found in sub-basin 5 with 2,394 ha.

Recommendations

- It is necessary to know that flood occurs whenever water inundate the sub-basins in the low-lying areas within a watershed
- People who live near the flooded zones, should be careful for unexpected flash flood
- Malaysia government or any Agencies concern in places with flooded plains should lay emphasis and apply proper mitigation to remedies the flood situations.

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