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To cite this article: B N Anis-Athirah *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **842** 012045

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Delineation of flood-prone areas using Digital Elevation Model (DEM) in Kuala Krai, Kelantan

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Abstract. Kelantan is one of the states that experience flood events annually including the Kuala Krai district. Flooding has a severe impact on roads, villages, farms, and people's livelihoods. Early detection of flood-prone areas is essential in detecting the specific area. This study aimed to map a flood-prone area based on evaluation of terrain characteristics include elevation, aspect, slope, contour and hill shade of the Kuala Krai area. The raster data of DEM with 50 m resolution and hydrological data were evaluated to create a potential flood map. A flood-prone map is created by overlaying terrain features with flood criteria of a gentle slope with contour < 250 m and degree of slope less than 10, flat surface in aspect and consideration of hill shade factors. The map was also supported by vector data of rivers network that cross the Kuala Krai area. 56% of the Kuala Krai area facing a moderate risk of flood occurrence, while 41 % of the areas are in a dangerous state and are predicted to be at a high risk of flood. This can be concluded that the areas with low elevation, adjacent to rivers, are the places where actions need to be taken by the experts to overcome the disaster in the future.

1. Introduction

The most prevalent hydrological disaster that happens in every country is flooding. In Malaysia, Kelantan is among the most common state facing flooding incidents, including in the Kuala Krai district. Kuala Krai is a region that is flooded nearly every year and had caused severe damages and losses of properties and life [1]. Annual heavy rainfall caused by the Northeast monsoon from November to March is the main cause of flooding. As stated by [2], that floods occur due to excessive rainfall and water catchment areas that are no longer afford water. However, many other factors could cause floods such as climatic change, uncontrolled land management and exploitation of land resources [3], improper drainage system, pollution, dam break [4] and terrain characteristics [5]. In recent years, much effort has been carried out to identify the flood risk areas through the use of hydrological and drainage data as well as technology-driven data. Besides traditional data capturing on the field, the detection of the flood-prone area can be calculated using the integration of remotely sensed data and Geographic Information System (GIS) technology that proved to be an effective method with less cost and workforce usage.

Detailed study on the topographic factors related to flood-prone areas in Kuala Krai is less to be known. The causes of potential flood occurrence can be measure physically by topographical factors such as slope, aspect, elevation, contour and hill shade attributes. It can be derived from a single DEM



Besides extracting the elevation of the study area, a 100 m intervals contour isoline was also delineated to show the form of the land surface in the Kuala Krai area. The hill shade was also extracted in a 3-dimensional representation of the terrain surface. It is a technique for visualizing a terrain determined by the combination of a light source, slope and aspect of the elevation surface. Integrating all primary terrain attributes with set criteria, a potential flood-prone area in Kuala Krai Kelantan is delineated. The result is also cross-checked with the hydrological data of rainfall and raster data on the river network acquired from open-source information. Figure 2 shows the process of data analysis adopted in this study.

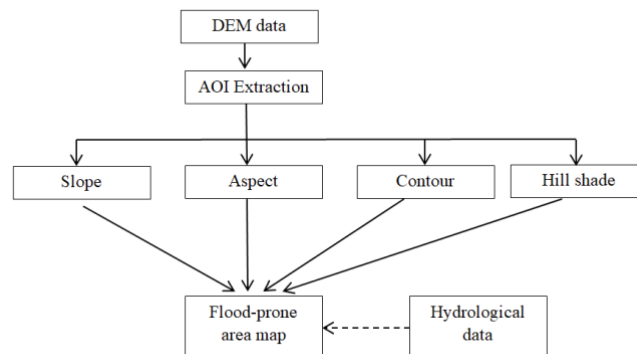


Figure 2. The framework analysis adopted in the study.

3. Results and Discussion

The analysis of topographical attributes extraction in Kuala Krai using DEM data is presented in Figure 3. Based on the analysis, the elevation of the study area is detected between 20 to 1860 m.

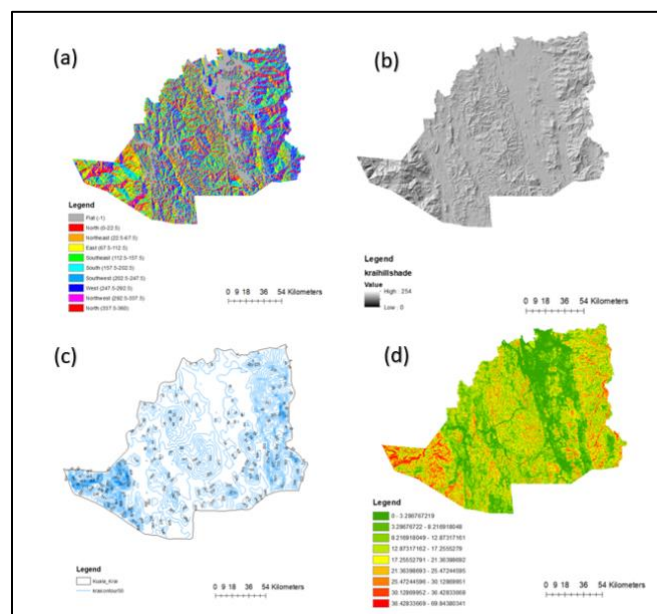


Figure 3. The terrain attribute of a) aspect, b) hill shade, c) contour and d) slope factors extracted from DEM data

By overlaying the topographic factors of aspect, slope, contour and hill shade that match the criteria of potential flood hazard, a flood-prone map was produced as shown in Figure 4.

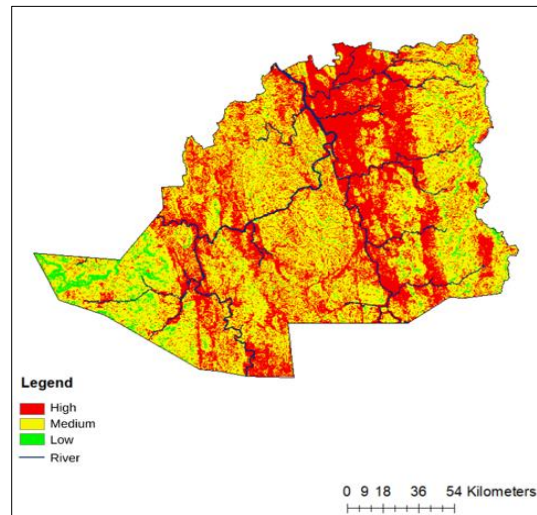


Figure 4. The flood-prone map of the Kuala Krai area.

The vulnerability of potential flood events in Kuala Krai was also categorized into three main categories named low (<50%), moderate (50-75%) and high (>75%) potential risk. Only 3% of the Kuala Krai area is categorized under low potential risk in experiencing flood occurrence. The remaining 56% of the area has medium chances of flood occurrence. 41% of the land is at a high risk to flood events as the area is on a flat surface, gentle slope, minimum terrain features and rivers that flow to this area act as rain catchment which leads to the flood occurrences. Table 2 show the susceptibility of flood occurrence based on topographical factor analyzed in this study.

Table 2. Susceptibility of flood-prone in Kuala Krai, Kelantan

Susceptibility Class	Risk (%)	Area Percentage (%)
Low	0 - 50	3
Moderate	50 - 75	56
High	> 75	41

The study had discovered the usefulness of DEM data and Spatial Analyst Tools in detecting flood-prone areas in Kuala Krai, Kelantan. However, additional data such as vegetation, weather and hydrological data, land use and land cover information are among the information that can support the accuracy of the analysis in the future. The output of this study may aid the related agencies in decision making to mitigate flood-related issues, land development and cultivate community awareness for early preparedness and action for flood prevention.

4. Conclusion

Based on DEM data, topographic variables such as slope, aspect, contour, and hill shade were analyzed to produce a flood-prone map of the Kuala Krai district. The results showed that 56% of the Kuala Krai area is at moderate risk of flood occurrence, while 41 % of the area will be in a dangerous state and predicted to be at a high risk of flood. It is due to the minimum terrain characteristics of gentle or lower slope, flat area and few river networks that flow into the area. By determining the specific location of flood-prone areas, the related agency can plan the protection method against

flooding and relocate community that faces a high risk of flooding as well as determine ideal areas for construction and redevelopment that are less prone to floods.

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