Research Paper

Hydrogeomorphology, Vol. 10, No. 33, Winter 2003, pp (24-26)

Received: 2022.08.30
Accepted: 2022.11.14

Adaptive Flood Zoning of Cheshmeh Kileh Drainage Basin in Tonkabon, North of Iran

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1-Introduction

According to the international disasters database, the flood has the highest rank of causing financial and human losses, after drouth and earthquakes (The International Disasters Database, 2016). Over the last several decades, the flood has led to economic losses and many human casualties in different regions of the world (Guo et al., 2014: 955). According to the statistics from 1900 to 2015, floods have caused the death of 7 million people and 600 billion dollars in damages and still occur frequently with high intensity (Stefanidis & Stathis, 2013: 570; Stephane et al., 2013: 804). The importance of flood occurrence would be boosted due to the location of human settlements in hazardous areas. The establishment of population centers causes many risks in addition to increasing surface runoff production. The rate of damage by floods can be minimized by preventing and controlling this natural hazard using the following basic strategies. In this regard, the first step towards optimal management and developing strategies to deal with this natural hazard and reducing its outcome is to identify sensitive areas and zoning flood risk areas (Yang et al., 2006: 23). Flooding or hydrological behavior of basins includes multi-dimensional processes. Different factors have considerable roles in flood occurrence, such as climatic factors, geometric characteristics of the basin, land use, land cover, soil characteristics, and previous hydrological conditions (Reinhardt et al., 2018: 46). Primarily, flood magnitude and its recurrence over time depend on the rainfall intensity, the soil permeability, and topography (Mohammadi et al., 2019: 88).

In most of the past years, about 70% of the annual credits of the plan to reduce the effects of natural disasters and the headquarters of unforeseen events have been used to compensate for floods damages; increase of flood damages by 250% in the last five decades confirms this claim (Demir & Kisi, 2016: 6). In recent years, the combination of statistical models trough RS and GIS has received much attention from researchers. Considering the capability of valid recognition and better forecasting, predicting flood-

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prone areas with new combined methods is practical for flood studies. In general, no method is perfect for accurately predicting flood-prone areas.

2-Methodology

This study was carried out in 4 basic steps:

1. Preparation of the flood reference map (identification of the flood-prone locations in the drainage basin.

2. Extraction of spatial criteria affecting floods in the study area

3. Adaptive flood zoning based on WOE, FR SE models

4. Evaluation and comparison of the model performance by appropriate statistical indicators.

The studied factors were altitude, slope, soil, topographic moisture index (TWI), distance from the river, geology, land use, waterway density, vegetation density index (NDVI), and rainfall (Tehrani et al., 2015: 98). Each of the factors was prepared in the form of a raster map with a pixel size of 10 meters. It should be noted that the layers were classified according to the region's conditions and expert opinions. 70% of the flood zone area was used for modeling, and 30% of the area was used to measure the reliability of the models. The data sources used in this research have been mentioned in Table 1.

Table (1): Data sources used in the research

Scale	Reference	Data
1.25000	Armed Forces Mapping Organization	Topography map
1.100,000	Mapping Organization of Iran	Geological map
30*30	Earthexplorer.usgs.gov	Landsat 8 satellite image (2018)

3- Results and Discussion

In this research, Shannon entropy, witness weight, and frequency ratio models were used to prepare the flood zoning map of the study area. The final designed maps by implementing the three models were classified into 3 low-risk, medium-risk, and high-risk categories (Figure 4). In this research, 70% of the flood zone area was used for modeling, and 30% was used to measure the reliability of the models using the ROC curve. The low flood zone covers 687, 802, and 785 square kilometers of the study area in the SE, FR, and WOE models, respectively, which is equivalent to 73%, 86%, and 84% of the region area. In the medium-risk class with high flood potential in the Shannon

model, the witness frequency and weight ratio cover 59, 18, and 18 square kilometers, respectively, equivalent to 6%, 2%, and 2% of the area. In the high-risk class in the Shannon model, the ratio of frequency and weight of the witness covers 184, 110, and 127 square kilometers, respectively, which is equivalent to 19%, 11%, and 13% of the area of Cheshmeh Kileh.

4-Conclusions

Among the different methods for preparing flood zoning maps, statistical methods are considerable due to their simplicity and acceptable accuracy. This research used three methods of Shannon's entropy, witness weight, and frequency ratio to prepare a flood zoning map of Cheshmeh Kileh. The final maps from implementing the three models were classified into low, medium, and high sensitivity classes. According to this map, it can be seen that the outlet of the Cheshmeh Kileh basin is in the high flood risk class. The calculated highest accuracy (AUC) was observed in the frequency ratio model (0.80), the weight of the witness (0.72), and Shannon's entropy (0.68), respectively.

Keywords: Flood, Frequency ratio (FR), Weight of witness (WOE), Shannon entropy (SE), Cheshmeh Kileh, North of Iran.

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