

Flood Risk Zonation for Karaj City Using Fuzzy Logic

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1. Introduction

Flood is one of natural hazard which ranks the most one just like earthquake and drought according to the report of the natural hazard program of the United Nations. Besides physical factors, and lack proper management will increase the flood potential. Therefore, in order to prevent flood damage it seems to be necessary to provide essential requirements before physical expansion of cities. Floods not only in developing country but also in developed country cause life and property damages. Such as these disasters was hurricane Katrina that had serious damages for the United States of America. Occurrence of several flood disaster in Karaj city during few last years, such as 31 March 2009 disaster flood that caused many life and property damages, indicate that flood researches are necessary for this area. Many studies had done by researchers related to flood in Iran and around the world. The flood map zonation for Helmand basin in Afghanistan was produced by using reverse engineered flood hazard (Hagen, et al., 2010). Another studies related to flood had done by (Sinnakaudan, et al., 2003, Hudson, et al., 2003, Wolski, et al., 2006, Baldassarre, et al., 2003). Hossain zadeh and Jihadi (2009) were studied the effects of physical urban expansion on drainage natural pattern and urban flood intensity of Mashhad city in Iran. By using HEC-HMS hydrological simulation method characters of flood were studied in Kiron plain in Iran (Amir Ahmadi, et al., 2011). The result of this research shows that it's not necessary to relate the characters of final flood to the pick flood sub basins. The flooding areas in Farahzad basin of Tehran, Iran were studied by using analytical hierarchy process (Ghanavati, et al., 2012).

2. Study Area

The Karaj as the fourth biggest city of Iran is situated between 35° 39' latitude north and 51° 10' east longitude in the Alborz province. This area has 1108m minimum altitude and 3239m maximum altitude. Yearly average precipitation in this area is 251mm and about 42 percent of them raining in winter season. Karaj city has moderate climate and its mean yearly temperature is 14.1 degree in centigrade scale. The Karaj plain is situated between Kane and Karaj river basin. So, the physical bed of this area was formed by deposited of fluvial cone of these rivers.

3. Material and Methods

In this research to identified areas of high risk flooding and high risk prone to flood,

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teen factors as: slope, profile curvature, plan curvature, precipitation, drainage density, distance to river, geology, geomorphology, land use and soil that affect flooding were used for preparing flood risk map of Karaj area. These data layers provide and extract by many sources such as geology maps of the area, satellite imagery, and data of climatology and hydrology stations. The fuzzy model was used to weighting each factor related to their effects on flooding.

Fuzzy model is based on fuzzy logic that used in fuzzy condition. According to fuzzy logic each member belongs to different sets but in different grade. Membership grades are between 0-1 and also zero and one themselves. The fuzzy theory has been developing from the beginning to now and has had different usages. This theory has been used widely in modeling the physical phenomenon, survey and classification. In the theory of exact set if we consider a set each member of the mother set is in the set or it isn't and we can define the below function for each set like(A).

$$\mu_A(x) = \begin{cases} 1 & , \text{If } x \in A \\ 0 & , \text{If } x \notin A \end{cases}$$

In this function each member of (A) set is attributed to (1) and the members out of the set are attributed to (0). A fuzzy set is represented by membership function. This function is indicating the member's grade of dependency by a real number between [0-1]. So, before executing the fuzzy model, membership function is determined for each layer (below table). By determining the functions to each layer, the value of each layer is located between [0-1]. As the area are having the most effect on flooding attributed to (1) and the areas having the less effect on flooding attributed to the less possible number or (0).

By using Arc GIS sum and product fuzzy operators on layers, the fuzzy sum and product maps are provided. To adjust the maximum and minimum values of risk, the gamma operator was used to provide the final map.

4. Result and Discussion

The final mapping flood risk is provided according to determine fuzzy membership for each layer and performing flood model based on Gama 0.9, 0.7 and 0.5. To find the most appropriate Gama for flooding map, between effective factors and the flood maps that provided by different Gama correlation were calculated using ArcGIS software(table No.1).

geology	distance to river	drainage density	precipitation	planimetric curvature	profile curvature	landuse	geomorphology	soil	slope	Gamma
-0.69	0.26	-0.2	0.78	0.06	-00.3	0.1	0.82	0.05	0.74	Gamma 0.9
-0.68	0.34	-0.24	0.76	0.09	-0.09	0.11	0.72	0.03	0.67	Gamma 0.7
-0.63	0.33	-0.21	0.67	0.11	-0.1	0.1	0.6	0.02	0.56	Gamma 0.5

According to the evaluations, the Gama 0.9 has the most correlation with effective factors and so Gama 0.9 was selected for providing the final flood map. Based on the natural fraction method, the final risk zonation flood map is classified in five categories from very high risk areas to very low risk areas.

5. Conclusion

According to the final flood map (Gama 0.9), the areas which caused the most flood situated in north eastern, north and east of Karaj city. These areas have slope between 30-75 % and precipitation between 600- 900mm. Their location is between 1500-3000m far from the rivers. The drainage densities of these areas are between 0-0.5. Also, the flat and low area such as valises, stream channels, terraces and flood plains have the highest potential for flooding. These landmarks are located mostly in western south and eastern south of the studied area. These areas have slope between 1-5 % and height between 1000- 1400m. Their location is between 0-1500m far from the rivers.

Key Word: Flood Risk Mapping, Fuzzy Logic, Flood Geomorphology, Karaj.

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