Geographical planning of space quarterly journal

Journal Hopepage: www.gps.gu.ac.ir

Golestan University

Research Paper

Determining the Flooding Points and Comparing it with Aq Qala Flood in 2019 and Estimating its Damage in the Agricultural Sector using Radar Images

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A R T I C L E I N F O

A B S T R A C T

Floods are one of the most important hazards that, depending on the intensity of rainfall and other factors, cause a lot of damage to urban and rural areas. Determining flood-prone areas for planning to prevent it and estimating the amount of damage for post-flood management is one of the main issues of flood planning. Nowadays, the use of radar data is one of the most recent and effective methods in flood study. It is possible to study the exact details of floods and determine the extent of their expansion so that it can be used in future planning. The current research is investigating the zoning and estimation of flood damage in the agricultural sector in the area of Aqqola city, where agricultural lands were damaged on a large scale in the flood of 2018. In this research, using the NDVI index of Sentinel 2 images (images from 1/3/2019 to 15/3/2019 as the first time and before the flood and images from 20/3/2019 to 20/5/2019 for the time It has been selected after the flood and after obtaining the NDVI index of Centile 2 images in the Google Earth Engine environment and combining it with the GFSAD system, the type of cultivation of the studied area was determined based on rainfed and irrigated, and using the cumulative flood zone layer, the areas affected by floods have been investigated according to the type of cultivation. The results showed that out of 100% of the available land, about 22.5% of its land has been flooded, and of this amount, about 15.5% of the rainfed land and the rest are irrigated land, and in the second part to estimate Flood-prone areas FHD model was used in the GIS environment, which determined the result of the flood-prone areas, and to validate it, a comparison was made with the cumulative flood area obtained from Sentinel 2 images, and the outputs showed complete matching.

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Extended Abstract
Introduction
Flood is one of the most prevalent environmental risks in the world and one of the environmental hazards that can harm human society, life, and property. One of the key problems in flood planning is predicting flood-prone areas so that planning can prevent it and assessing the damage to management after a flood.

Due to the climatic conditions, topography, and geomorphology in many areas, Iran is at risk of this natural disaster every year, so more than 80% of the cities of Iran are exposed to floods. Official statistics show that Golestan province has witnessed many floods. The floods caused heavy damage to infrastructures, buildings, and residential units, so the damage caused by this natural disaster remains in many rural and urban areas.

Today, the use of radar data is one of the newest and most effective methods in flood study. The exact details of the floods can be studied, and the extent of their spread can be determined so that they can be used in future planning. The study area is about 50 km from the Gorganrood River, which is located 18 km north of Gorgan. It is located at 36° and 58° latitudes and 54° and 16° longitudes. Based on the 2016 census, the number of Aqqala households was 9498, with a total population of 35,116 including the city of Aq Qala and 44 villages that were directly and indirectly affected by the floods in 2019. The average annual rainfall of Agh Qola is 330 mm, which has witnessed rainfall equal to one-third of its average annual rainfall in about four days from March 27 to April 2.

Methodology
In this research, the FHD model based on GIS software has been exerted to estimate flood-prone areas, and the result has been identified as flood-prone areas. To verify it, a comparison was made with the cumulative flood zone obtained from Sentinel 2 images. Images from 2019/3/1 to 2019/3/15 were selected for the first time before the flood, and images from 2019/3/20 to 2019/5/20 for the time after

the flood, and the results demonstrated complete compliance. NDVI index, Sentinel 2 images, and the GFSAD system combined with Google Earth's engine, the study area's cultivation types were determined based on rainfed and irrigated types using the cumulative flood zone layer, investigated the flooded areas.

Results and discussion
The image obtained from the difference between NDVI of the two time periods is shown the cumulative flood area in the study area, of which 89233.59 hectares, which includes the whole study area, 20204.91 hectares have been flooded. Of the 100 percent of the land in the study area, 22.40 percent has been flooded.

The highest amount of damage occurred in rainfed lands. Of the total 62.98% of the total rainfed arable lands, 18.78% have been flooded, and 5.85% of the 33.53% of the total irrigated agricultural lands have been flooded. In this study, the FHD model was used to validate the radar data. We compared the two study locations with the maps made from Sentinel 2's cumulative flood maps. Also, we investigated the second region in and around the city of Aq Qala to examine the accuracy of the model, which included two areas with two types of high-risk and low-risk classifications for floods as an indicator, the first area is in the northeast of the area, which shows a low-risk area.

Conclusion
Sentinel radar data provides the user with a high processing speed for checking during and after a flood, but research conducted before a flood is more crucial for crisis management.

The FHD tool can easily identify hazardous and safe areas based on the level of the riverbed and around the river. In places designated by the model as safe (east of the study area), the lowest flooding was recorded in 2019, And around the city of Aq Qala, which the model predicts the highest flood rate, the highest flood rate occurred in 2019. In the flood of 2019 in the study area, out of 100% of the existing

lands, about 22.5% of its lands were inundated of this amount, about 15.5 percent were rainfed lands, and the rest were irrigated lands. Radar data revealed that due to flooding in April 2019, 115 and 107 square kilometers of the study area were submerged on March 23 and 29, respectively.

Authors' Contribution

Authors contributed equally to the conceptualization and writing of the article. All of the authors approved thecontent of the manuscript and agreed on all aspects of the work declaration of competing interest none.

Conflict of Interest
Authors declared no conflict of interest.