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Research Article

GIS-Based Flood Risk Assessment: A Case Study of Ashareef, East Nile District, Khartoum State, Sudan

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Abstract

Floods are a major risk in many parts of the world, leading to many risks to life in different fields. The use of modern technologies such as Geographical information system (GIS) reduces the harmful effects of these floods and manages the flood disaster. With the technological development of this age, the use of these techniques is becoming available, as using geographic information systems leads to positive results in managing flood crisis and reducing damage. This study applied Geographical Information System Technology in the spatial analysis of flood risks in Ashareef, East Nile state Sudan using geospatial technologies.

Keywords: Flood Hazards; GIS

Introduction

Floods are one of the most devastating disasters in many countries causing great human and economic loss [1]. The flood as one of the most natural disasters occurring in different countries affects these countries, both developed countries and developing countries. It results in many damages, including the loss of human lives and the destruction of infrastructure and financial loss, but can reduce these damages and work on Manage this disaster by providing accurate and timely information [2]. Floods are caused by the heavy rains on low altitudes and produce many of the hazards caused by this natural disaster, affecting various areas of life [3]. GIS is used and used to manage the flood disaster through the analysis of flood maps and the establishment of maps to assess damage caused by flooding [4-6]. Geographic information System (GIS) has been applied extensively to flood studies. GIS is a technological system that reflects all kinds of spatial data of the real world. It can input, output, store, search, display, analyze and be applied under certain support of software and hardware [7]. GIS can be used to map spatial distribution, and it enables ease of input, storage, analysis, management, output and integration, resulting in timely and appropriate decisions to reduce flood risk [8]. Geographic information systems can be used to predict places likely to be exposed to floods and also to assess the effects of floods. Flood studies rely on the use of GIS spatial models. Chapiet [9] proposed an artificial intelligence model, bagging-LMT, used in Haraz watershed in northern Iran. Remote sensing techniques were used in West Bengal, India [10]. Modern methods are used in the use of algorithms and induction systems [11] as well as genetic algorithms and differential evolution [12].

Statement of problem

Heavy rainfall lasting for a considerably longer duration often builds up excess water beyond which percolation can accommodate. This leads to a rise in the water level resulting in surface flow down the slope into nearby depressions. There is also a rise in the water-table due to prolonged infiltration arising long duration of rainfall. The resulting environment reduces the infiltration rate of the soil, increasing surface runoff and the potential flood occurrence. The development of industries and their expansion and the expansion of urban expansions without paying attention to the effects of this on the environment. Farming and other agricultural activities are increasingly being carried out on the flood plains. This leads to the loosening and disintegration of the resilient nature of the soil structure and texture in this area. Going by the above, it is therefore necessary and expedient for a study such as this to be carried out if the state is to avoid the associated problems of floods faced by many countries in the world.

This research seeks to answer the following question:

- How is GIS used to manage and overcome flood risks?

Aim and Objectives of the Research

The aim of this research is to apply Geographic Information System (GIS) in flood hazard management studies in Ashareef, East Nile state Sudan.

Literature Review

Many researchers have been interested in studying the flood disaster and its occurrence in different parts of the world and the consequences of this disaster.

Wu [8] considered on elements of surge immersion in Murray-Darling stream bowl in Australia. For this examination, they utilized time arrangement surge records and MOIDS symbolism. They utilized tallness surge insights for choosing genuine MOIDS symbolism to select the submerged area of surge. The utilization of hydrological and remotely detected immersion data, they created a spatiotemporal immersion outline, have the capacity to be extremely helpful to examine the ecohydrological attributes of the Murray-Darling waterway bowl.

Thilagavathi., *et al*. [1] utilized GIS to outline the surge peril inclined zones in the Papanasam Taluk and Qiang and Zhu (2009) demonstrated how height, hydrological conditions, precipitation power, soil and waterway arrange highlights can be utilized to make surge anticipating model in GIS, and presumed that rise was the most essential factor. In this way, when a territory is beneath a given point in tallness, it is probably going to fall inside the span of surge waters. To aggregate up, the writing audit demonstrates that GIS can be utilized to distinguish surge regions in the investigation zone. With its overlay capacities, capacity to store, control and investigate information, GIS can perform viable surge chance assurance for street arranging.

Sunyal and Lu [13] designed flood danger mapping which has vital components for appropriate land use making plans in flood inclined areas. It creates easily - examine, swiftly on hand charts and maps which facilitate the administrators and planners to identify areas of threat and priorities their mitigation/response efforts.

Venkata and Salt [14] tried to identify regions of risk and prioritize their mitigation/response attempt within the flood-danger regions in the Kosi River Basin, North Bihar, India in a GIS surroundings. data sets used on this examine have been: topographic maps, district level maps and census facts, DEM and digital remote sensing imagery. The primary choice elements taken into consideration inside the study location have been geomorphic capabilities, elevation, plants, land cowl, distance to lively channels and population density.

Balogun and Okoduwa [15] applied GIS to an assessment of flood risk in Benin, Nigeria. This was achieved by creating a digital database of selected variables such as relief, Land use, Land cover and soil strength. An overlay operation was carried out using the ArcMap 9.0 software. It was observed that areas with low soil strength, high intensity of land use and low relief are prone to low flood risk. Again, area with medium soil strength, medium intensity of land use and medium relief are exposed to moderate vulnerability to flood risk.

Study area

The study area lies in Khartoum state, east Nile locality. It is bounded by latitudes 15.6 and 16.6N and longitudes 32.7 and 33.6E. The average rainfall in the area is 161 mm. The targeted floods affected residential area lies at the bottom left corner of the study area and is called Al-shareef (Figure 1). It is bounded by an agricultural area in the north side, a highway in the south side, irrigation canals in the west side and an open area in the east side. Al-shareef area was affected by many rainfall disasters (Wikipedia, 2007), but the worst flooding hit the area in August 2013 [16].

Figure 1 : The study area with the main features the residential areas (RA), the agricultural areas (bounded green), the irrigation canals (blue), highways (black) and the Blue Nile river.

Methodology

The methodology adopted in conducting this study was three folds. Firstly, Google Earth satellite images and on-line GIS facilities were used to locate the study area and its main topographical features. Secondly, QGIS application program and its Plugin GRASS modules were used to derive the topographical and hydrological models of the study area using its SRTM90 digital elevation model. Thirdly, all the shape files required for the investigation were created by QGIS program. The topographical and hydrological models were integrated with the drainage network in the area and rainfall floods causes and future preventive measures were pointed out.

Results

The topographical and hydrological models of the study area are presented in figure 2 and 3 respectively. The topographical model indicated that the general slope of the study area is from the north east to the south west and the elevations ranged between 390 and 540m. The hydrological model demonstrated that there are six catchment areas (CA1-CA6), ranging in size from 10.109 to 1348.994 km^2 with a total area of 1631.316 km^2.

Figure 2: The topographical model of the study area.

Figure 3: The hydrological models of the area, showing draining areas (CAs), residential areas (RAs), irrigation canals (ICs), highways (HWs), agri. area (green).

Discussion

The hydrological model indicated that Al-shareef area is directly affected by catchment area CA1 which is too small to cause flooding disasters, even with the maximum rate of rainfall (300 mm, 2x the average rate, approximately). However, in some of the floods that hit the area (2016), the water level submerged the second-floor buildings in the area. This suggested that this area (Al-shareef) is indirectly affected by the other catchment areas in the study area. The topographical model indicated that the rainfall water coming from all the catchment areas in the study area was blocked by the topographical features in the area, mainly, the irrigation canals and the highways. Thus, the drained water has two options, either to pass these features and drain into the Blue Nile (the natural draining outlet in the study area) or to be blocked by these features, accumulate in large volumes and back up in the low lands in the area. This is true for the residential areas in the study area in general and Al-shareef area in particular. The reason for this is two-fold. Firstly, Al-shareef area lies in the lowest part of the study area (390m). Secondly, it is not far from the largest catchment area (CA2) and the latter is blocked by the irrigation canals and this forces the backing up water to accumulate in Al-shareef area (Figure 4) [17].

Figure 3: The outlet of CA2 blocked by the irrigation canals (IC) and Al-shareef close too it.

Conclusion

The effort made in this investigation clearly revealed that all the flood disasters that hit Al-shareef area in the past were caused by indirect floods related to the topographical features that are not provided with the proper drainage network to drain the rainfall water into the Blue Nile. Floods in the area can only be prevented by establishing a proper drainage network that is related to the rate of rainfall and draining areas. The results demonstrated the important role of the open sources of Geometics application programs and space data. The techniques used in this investigation can be adopted to solve the flooding problems associated with existing residential areas and apply flooding preventive measures for the future urban areas. GIS technology should be employed for effective and efficient flood management in the study area. That is the study proved GIS technology as tools which can be deployed in the assessment of flood risk in the study area.

Recommendations

- A GIS implementation strategy will help in effective and efficient flood hazard management.
- Other flood control measures can be integrated into field enterprise with GIS technology. E.g. financing, Emergency Response measure.

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