Water. Environ. Sustainability. 1 (3): 14-19, 2021

Forscher Publication

Water and Environmental Sustainability
ISSN: 2710-3404
DOI: 10.52293/WES.1.3.1419
Homepage: https://www.journalwes.com/

Research paper

Flood Impact Assessment Using HEC-RAS and GIS Techniques Dinder River, Southeast Sudan

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ARTIClE INFO

Keywords:
Flood impact assessment, HEC-Ras, Dinder River ,Sudan

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Received: 06 June, 2021
Accepted: 14 July, 2021
Available online: 30 Sep, 2021

ABSTRACT

Dinder River is largest tributary of the Blue Nile. It is seasonal river that flows from June to November and reaches its high peak in September. Frequently, the water level exceeds the normal height causing over bank flow and consequently floods. The floods generally ring about losses properties and crops close to river banks. This study is attempts to figure out the river flow behavior and find out the aerial extent of inundated lands in four flooding seasons. The investigated area is located in Sennar State, SE Sudan. Discharge data collected over the period from 2015 to 2018 and Digital Elevation Model (DEM) have been used to model the River flow regime, while land cover data was used to determine the affected LU/LC types in the area. HEC-RAS software was used to create 2D unsteady flow model in order to simulate Dinder River flooded area in four seasons. The largest flooded area extent in each season was used as input in GIS environment for further spatial analysis. Statistical computation for the affected area and consequent analysis revealed that: the affected urban area in 2018 was around 28.152km2, in 2017 was 29.205 km2, in 2016 was 16.531km2, and in 2015 was 10.422km2. Similar calculations were carried out for the other LU/LC types. According to the present study, the year 2017 witnessed the largest extent of flooding in the area.

Introduction

Natural disasters cause many countries to experience fatalities, injuries, damage to property, economic and social disruption. Disasters such as earthquakes, flash floods, volcanic eruptions, and landslides have always constituted a major problem in many developing and developed countries. The rapid growth of the world's population has escalated both the frequency and severity of the natural disasters (Lawal etal., 2012). The natural hazards kill thousands of people and destroy billions of dollars' worth habitat and property each year, flood disaster has a very special place in natural hazards. Floods are the costliest natural hazard in the world; river flooding has been one of the major natural hazards worldwide (Yahaya, 2008).

Disaster Relief Emergency Fund (DREF) reported that in the Mid-June 2017, torrential rains and flash flooding affected more than 70,535 people (approximately 14,000 households) across 8 states in Sudan namely Khartoum, Northern State, Sennar, Kassala, River Nile, Gezira, West Kordofan and White Nile states. According to the rapid assessment conducted by Sudanese Red Crescent Society, over 8,120 houses were destroyed and 5,987 houses partially damaged. A total of 2,868 latrines collapsed putting community at risk of water borne diseases. 30 public institutions mostly schools were also affected (IFRC, 2017).

Famine Early Warning Systems Network (FEWSN, 2018) expected that Sudan will witness a widespread flooding in 2018 season, leading to some slight crop production shortfalls, especially in the worst flood-affected regions in the eastern, northern, and western regions of the country.

In the year 2018, Floods affected people life and caused damages to their properties in Sudan. International Federation of Red Cross and Red Crescent Societies (IFRC) reported that over 45,000 people have been affected by flooding. This resulted in23 human deaths and 61 injuries; besides, more than 8,900 families have been homeless and they moved to live with their neighbors and relatives (IFRC, 2018).

There is no accurate records represent the damage in the Dinder area. However, Sky News (2018) presented outlet media of people describing the situation in their village during flood time (Photo 1).According to them; they have passed through difficult time. Actually they lost their properties and crops such as sesame and maize.

Fig. (1). Photograph showing the damaged villages during 2018 flood season.

It is evident that floods cause real problems. These problems could be solved through proper planning and detailed studies about flood prone areas. In this regards, determination of the flood vulnerable areas is an important issue for planning and management activities.

A lot of methods are used to find out the extent of the flood area and estimate the losses in the crops and properties. For instance, Marina et al., (2015) utilized HEC-RAS with HEC-GeoRAS extension in GIS to model of the flood prone area in middle and lower sector of the Pluton River.

The study area

Dinder River is largest tributary of the Blue Nile that originates from the Ethiopian Plateau west of the Lake Tana. It flows westwards, descends into the Sudanese plain, and joins the Blue Nile River below Sennar dam (Mohamed and Etuk, 2015). It represents a seasonal river that flows from June to November and reaches its high peak in September. The length of the river is approximately 750 km (Shahin, 2002). The river varies in width from 50 to 400m and in depth from 1 to 9 m (Elmoghraby and Abdu, 1985).

The study area is situated between longitudes: 33° 52′ 34 ″ and 34° 09′ 35″, and latitudes: 13°18′ 46″ and 13° 40′ 50″ (Fig. 2).

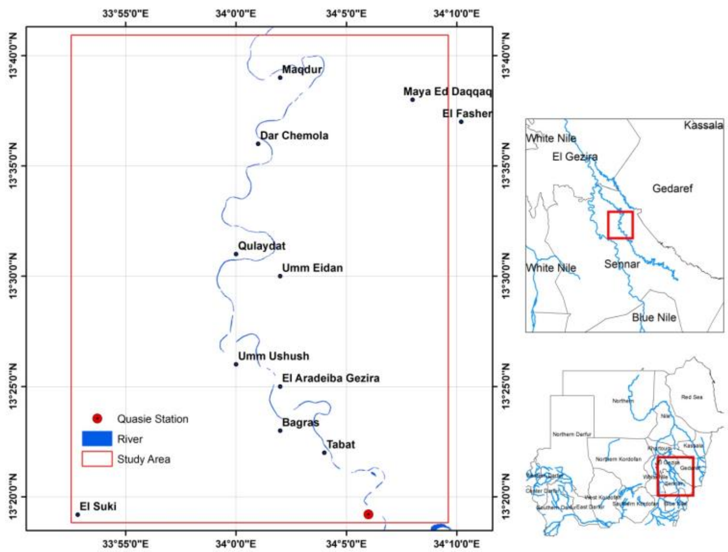

Fig. (2). A map showing the location of the study area

Methodology

Data types

Daily discharge data for Dinder River measured at Gwaisi station were offered by Ministry of Water Resources and Electricity. The data involve water level and discharge measurements for four seasons from 2015 to 2018.Land cover data for study area were obtained from Remote Sensing Authority (RSA) of the Ministry of Science and Technology, SRTM data with 90m spatial resolutions were obtained from the Earth Explorer of the USGS.

Methods

HEC-RAS software was used to create 2D unsteady flow model in order to simulate Dinder River flooded area in four seasons and find out the extent of inundated area in each season separately. Using discharge and DEM data, the modeling was conducted within the framework of HEC-RAS version 5.7.The inputs of such a model include the DEM data of area, specifications of the 2D follow through the drawing of the area of interest (Fig. 3), and unsteady follow data, where discharge data was used.

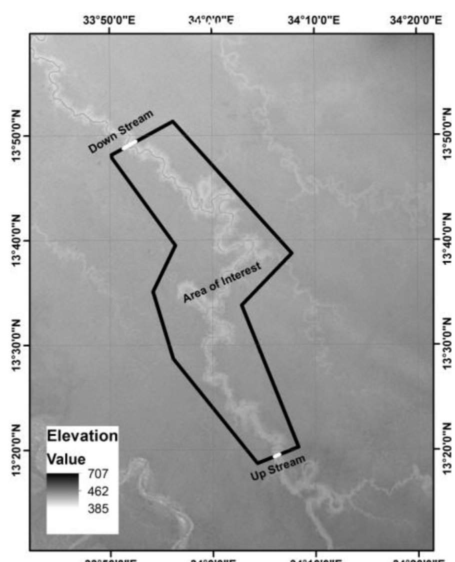

Fig. (3).Geometry data of the study area.

Results and discussions

The results of the unsteady flow modeling process, which was carried out to determine the extent of the flooded areas are presented in this section. Detailed accounts on the four modeled seasons (2015 to 2018) are provided in the following subsections:

Extension of inundated areas

The modeling process implemented in HEC-RAS included four steps: geometric data input was entered as being fixed for the different seasons (Fig. 3).The unsteady flow data in the form of discharge data was entered per cubic meter in the upstream, while the water level (per meter) was entered in the downstream. After all the inputs have been fixed, the model was run. The execution of this model resulted in the delineation of the flooded area in four seasons. In each season represent the extent of water every day during the season, after that the largest extent during each season was selected and exported, Figure (4-a, b, c, d) represent the largest extent in every year . The flooded area in season 2015 was found to be 330.642km^2; in 2016 571.039km^2; in 2107753.439km^2; and in 2108 accounts for 726.295km^2. These results were exported into the GIS environment for more analysis.

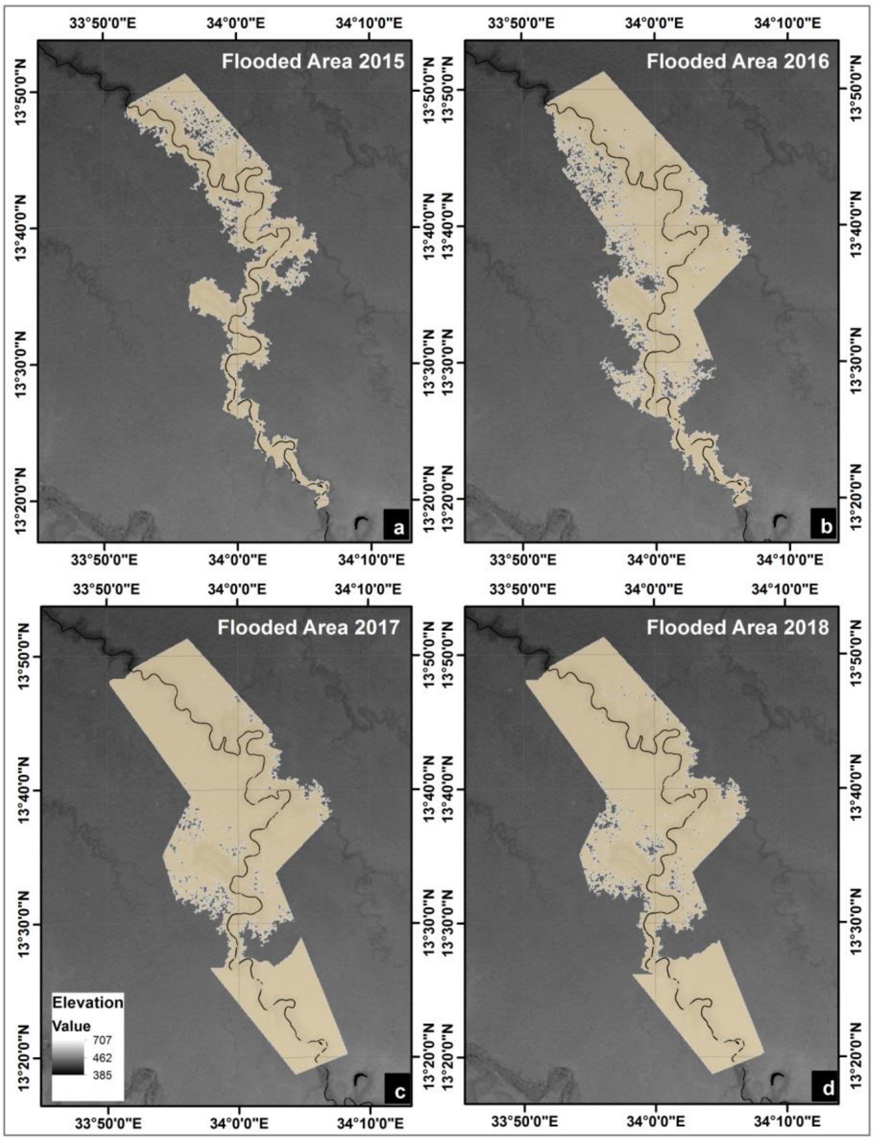

Fig. (4). Extension of inundated areas in the four seasons (2015-2018).

Land cover of study area

In order to determine the type of affected area in term of land use / land cover (LU/LC), a map showing the LU/LC classes was prepared. According to this map, dominant LU/LC type in the study area is agricultural land. The herbaceous land constitutes one of the wide spread land covers in the area. As well, there are residential areas distributed close to the river and among the agricultural land, with little presence of bare rocks.

The extensions of the flooded area in each season were extracted within the frame of the GIS and superimposed over the LU/LC map, described above. Accordingly, the LU/LC was cropped by the extension of the flooded area in each season separately. The result of this process is presented in Figure (5-a, b, c, d).

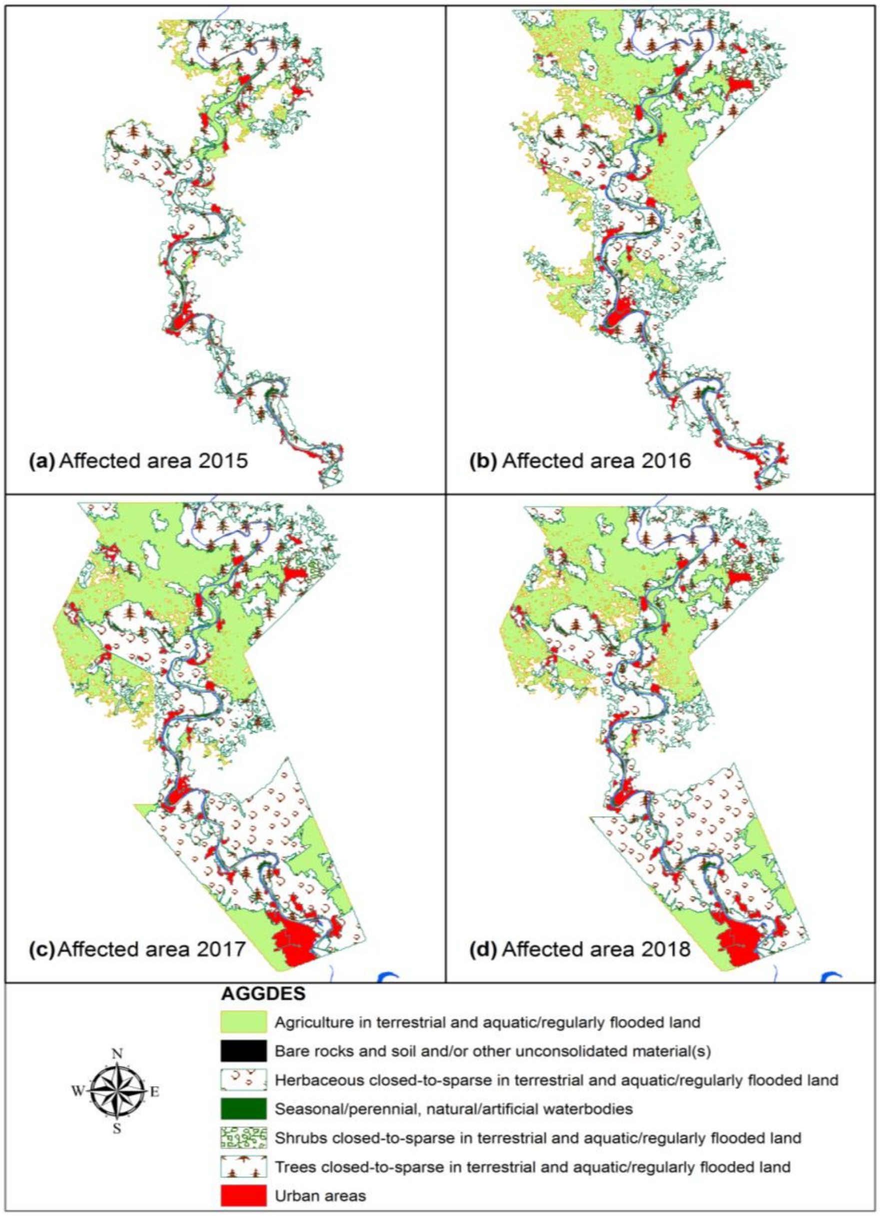

Fig. (5). Affected areas in the four seasons (2015-2018).

GIS environment was used in order to calculate the statistic of affected area for each year, in 2015, the damage agricultural area was found 19.78Km^2, while the residential area was found 10.442Km^2.In 2016, the damage agricultural area was found 106.919Km2, while the residential area was found 16.531Km^2.in 2017 , the damage agricultural area was found 168.531Km^2, while the residential area was found 29.205Km^2.In 2018, the damage agricultural area was found 150.770Km2, while the residential area was found 28.152Km^2.

Conclusions and recommendations

The extension of inundated area in 2017 was 753.439km^2; in 2018 726.295km^2; in 2016 571.039km^{2}and in 2015 was 330.642km^2 , the year 2017 represent the largest extent of flood area.

The investigated area was found to be occupied by LU/LC type, the dominant among which, is Agricultural area followed by urban area. Flooded agricultural land was found to be168.531Km^{2}in 2017; 150.770Km^{2}in 2018; 106.919Km^{2}in 2016 and 19.78Km^{2}in 2015, and urban area was found to be 29.205Km^{2}in 2017; 28.152Km^{2}in 2018; 16.531Km^{2}in 2016 and 10.442Km^2 in 2015, as well the year 2017 witnessed largest extent regard to agricultural area and the other type of LU/LC.

In this study problem have been faced which there is no accurate data, as well there is no precise statistic of loses in this area of study, the DEM was used has low spatial resolution (90m), the results have been carried out regard to low resolution have been considered as general results. Actually accurate data needed to enhance the result of this model in order to give detailed results, accurate data such accurate DEM and accurate data base data (visit the area, collect data, use indigenous knowledge ...etc).

This study highlight the problem of Dinder River flood which takes a place every year, it’s really a serious problem need to solve.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Elmoghraby, AI. & Abdu, AS. (1985): The dinder national park study area (Central Region): Institute of Environmental Studies, University of Khartoum, Sudan.

Famine Early Warning Systems (FEWSN) (2018): East Africa Season Monitor: https://reliefweb.int/sites/reliefweb.int/files/resources/EA_Seasonal_Monitor_2018_10_05_Final.pdf: [2019-11-3].

International Federation of Red Cross and Red Crescent Societies (IFRC) (2018): Emergency Plan of Action (EPoA) Sudan, Floods 2018:https://reliefweb.int/sites/reliefweb.int/files/resources/MDRSD026do.pdf: [2019-11-1].

International Federation of Red Cross and Red Crescent Societies (IFRC) (2017): DREF Final Report, Sudan floods https://reliefweb.int/sites/reliefweb.int/files/resources/MDRSD025dfr.pdf : [2019-11-1].

Lawal, D.; Mator, A.; Hashim, A.; Yusof, K. & Chandio, I. (2012): Detecting Flood Susceptible Areas Using GIS-based Analytic Hierarchy Process: International Conference on Future Environment and Energy, vol.28.

Marina, I.; Minea, I.; Oana, H. &Gh, R. (2015): The Use Of HEC-RAS Modeling In Flood Risk Analysis: AlexandruIoan Cuza University, Faculty of Geography, Romania.

Mohamed, T. & Etuk, E. (2015): Simulation of Monthly Flow for the Dinder River, SUDAN: Journal of Basic and Applied Research International: vol14 (4), 265-271.

Shahin, M. (2002): Hydrology and Water Resources of Africa, Kluwer Academic Publisher, New York.

Sky News (2018): Dinder River Affect buildings and crop land: *https://www.youtube.com/watch?v=i8h4vEmvguI* : [2019-11-05].

Yahaya, S. (2008): Multicriteria Analysis for Flood Vulnerable Areas in Hadejia-Jama’Are River Basin, Nigeria: ASPRS 2008 Annual Conference Portland, Oregon.