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A STUDY ON FLOOD EXTENT IN FLOOD-PRONE AREAS OF JORHAT DISTRICT USING GEOSPATIAL TECHNIQUES

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ABSTRACT

Floods are the most frequent types of natural disaster. Assam with its vast network of rivers is prone to floods and soil erosion which has a negative impact on overall development of the state. The flood and erosion problem of Assam is different from the other states, if we consider the extent and duration of flooding and magnitude of erosion, which makes floods , the most acute and unique in the country. So,satellite-based flood assessment for extent and severity is a very crucial input before, during, and after a flood event has occurred. Though optical remote sensing data has been widely used for flood hazard mapping in the recent time Synthetic Aperture Radar (SAR) data is preferred for detecting inundated areas and providing reliable information during a flood event due to its capability to operate in all weather and day/night time. The present study is an attempt to use SAR data for showing the flood-prone areas of Jorhat District during the last five consecutive years and its impact on land-use and land cover change. Google Earth Engine (GEE) was used for implementing for processing Sentinel—1 SAR data and the flood areas identification. Flood events are common in the study area during the monsoon season due to high rainfall and its close proximity to the Brahmaputra River. Dual polarized (VV and VH) Sentinel-1 SAR images obtained for the entire monsoon period during the last five years were used to create inundation maps of the study area. The geospatial study of the flood provides the valuable information for flood privation and mitigation, disaster planning in the Jorhat District of Assam. Observations from Sentinel-1 SAR data using GEE can act as a powerful tool for mapping flood inundation areas at the time of disaster, and enhance existing efforts towards saving lives and livelihoods of communities.

Keywords: *floods, assessment, inundation, geospatial, GEE, Sentinel 1*

INTRODUCTION

Floods are amongst the most frequent natural disasters that cause significant damage and disrupts livelihood across the world. Every year floods occur in almost every country disrupting millions of people and property. Floods are common in Assam. The major reason for the floods in Assam is the river Brahmaputra, a huge and one of the largest rivers in India. In the past, these floods were advantageous for the state since they bring sediments with the water which ultimately make the land fertile. But in the last few years, the frequency and the intensity of these floods have been increased which makes them nothing but a devastating natural disaster. The immediate impacts of flooding include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions and has many environmental problems. Therefore, it is necessary to assess the flood risk in the flood affected area for making up the losses of flood. Flood Risk Assessment (FRA) is a methodology to determine the nature and extent of flood risk by analyzing potential flood hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. It is important to keep in mind, however, that many aspects of flood hazard and risk assessment require specific expertise and experience.

To prevent the occurrence of natural hazards such as floods, Remote Sensing and Geographic Information System technologies are being used as effective tools for risk assessment and hazard management. This technology provides effective and faster analysis than conventional survey methods. Remote Sensing systems are often used for flood risk mapping and have offered different levels of accuracy. However, since optical observations are limited in their validity by clouds, which are most common during floods, microwave SAR systems are preferred because they provide more efficient analysis due to their capabilities of penetrating the atmosphere.

The contribution of this research is that the use of satellites for monitoring flood risk overcomes the challenges provided by the hydrologically based model.

STUDY AREA

The Brahmaputra Valley in Assam is one of the most hazard-prone regions of the country, with more than 40% of its land (31.05 Lakh Hectares) susceptible to flood damage against the total land area of the state of 78.523 Lakh Hectares (Rashtriya Barh Ayog). This is about 9.4% of the country's total flood-prone area. Records show that average annual area affected by flood is 9.31 Lakh Hectares. The flood prone area of the country as a whole stands at about 10.2 % of the total area of the country, but flood prone area of Assam is 39.58 % of the area of the state. It signifies that the flood prone area of Assam is four times the national mark of the flood prone area of the country. (Govt. of Assam, Water Resources).Almost every year three to four waves of flood ravage the flood prone areas of Assam.The flood problem of the state is further aggravated due to flash floods by the rivers flowing down from neighbouring states like Arunachal Pradesh and Meghalaya.

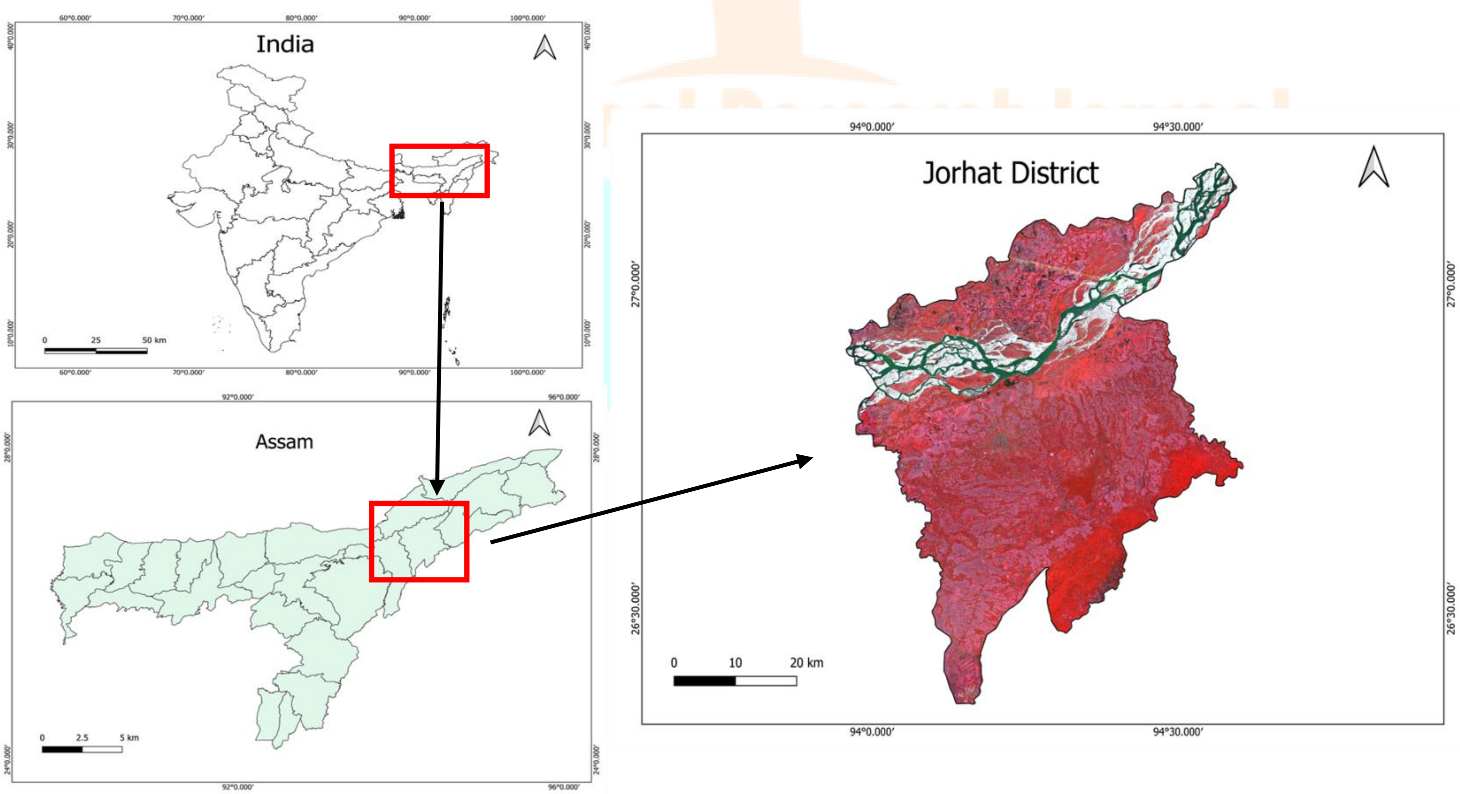
LOCATION AND EXTENT OF THE STUDY AREA

The district is situated between 26°20' N to 27°10' N latitudes and 93°57' E to 94°37' E longitudes and lies in the eastern part of the state of Assam .It is bounded in the north by the North Lakhimpur district, in the east by Sivasagar district, on the south and southeast by Nagaland state and in the west by Golaghat district of Assam.

Physiographically, the area can be divided into following geomorphic units viz.

i) Moderately steep hills,
ii) Upper piedmont,
iii) Lower piedmont,
iv) Interhill valley,
v) Gently sloping upland (dissected),
vi) Nearly level to very gently sloping plain
vii) Lower flood plain,
viii) Lower terrace,
ix) Upper terrace,
x) Active flood plain,
xi) Bars/ charlands,
xii) Miscellaneous land (Marshes and Swamps, water bodies)

The rainfall is well distributed throughout the year, though major portion of rainfall is received during March to September.



Map 1: Study Area map

OBJECTIVES OF THE STUDY

1) To use sentinel-1data to map flood risk areas
2) Mapping the extent of flooding in the flood prone areas of Jorhat District from 2017-2021
3) Identify the high flood risk areas over the study period
4) The maps prepared may be used for further planning and flood management for the study area.

DATABASE AND METHODS

Data acquisition and analysis was performed within the Google Earth Engine cloud-based platform (GEE). GEE is very efficient for the analysis of large datasets like satellite images because all the processing is done within the cloud infrastructure provided by Google. Other map creation and visualizations were executed in the QGIS. QGIS was used to create a map of flood extent layers for the 2017 and 2021 years.

A detailed overview identifying each major research phase with their required inputs and expected results is shown in the diagram below.

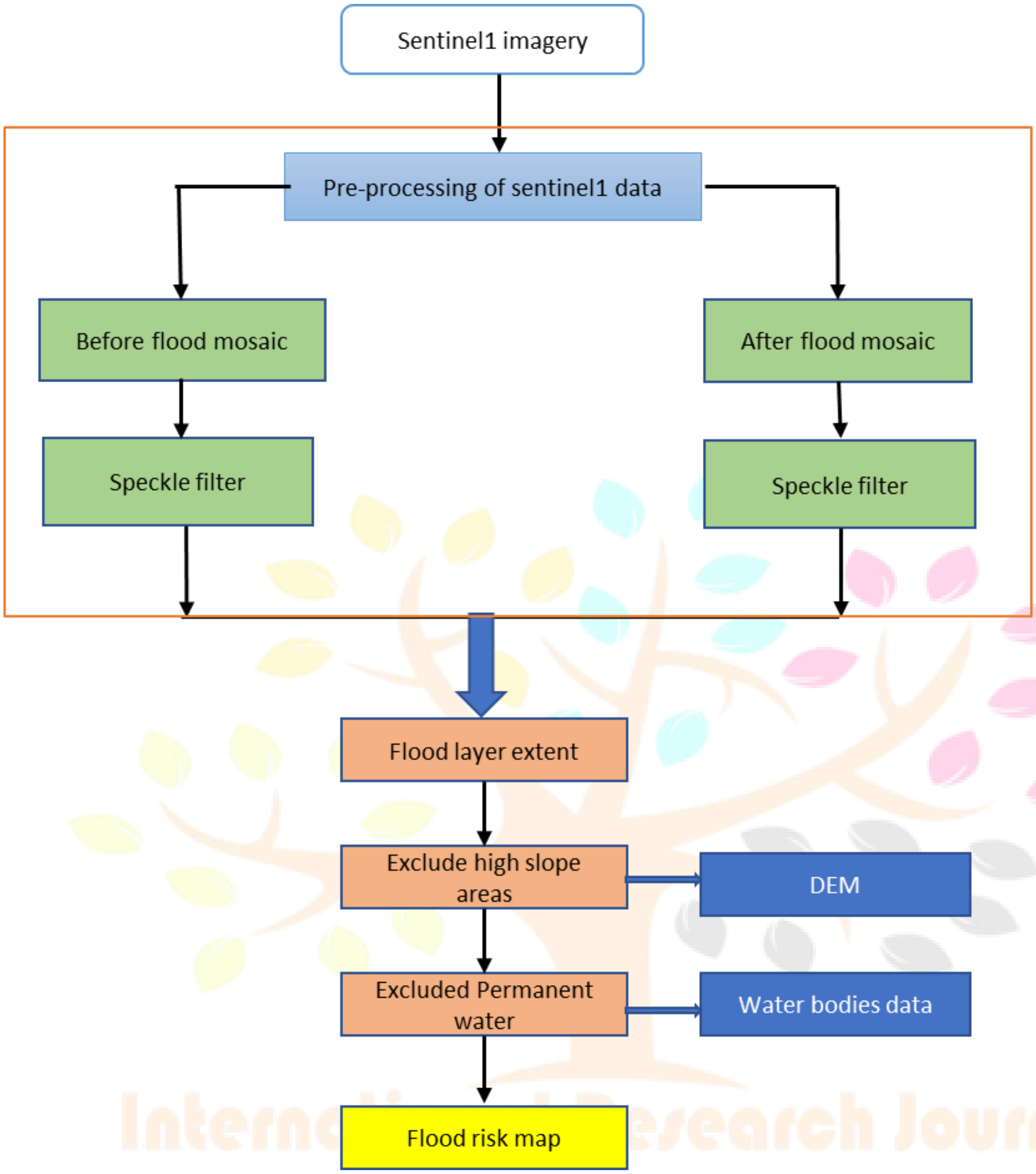


Fig1: Data Flow Chart

DATASETS USED, PRE-PROCESSING AND ANALYSIS

Sentinel-1 dataset based according to the flooding periods defined for this research, before and after flooding were downloaded for the pre-processing and analysis of flood risk mapping. This was done in Google Earth Engine. The data as provided within GEE (Sentinel-1 Level-1) is a Ground Range Detected (GRD) and therefore has a resolution of 10m. The instrument mode is Interferometric Wide Swath (IW). For this research, the image used was acquired in ascending mode pass direction due to the coverage of the study area which is located within the Ascending mode. The images were then clipped to the study area boundary. Information from the Sentinel-1 Level-1 Ground Range Detected (GRD) imagery in Google Earth Engine has already undergone some pre-processing steps including the application of orbits, border noise removal which removes low-intensity noise and invalid data on the scene edges, thermal noise removal, radiometric calibration which computes backscatter intensity using sensor calibration parameters, terrain correction and conversion of backscatter coefficient into decibels, among others. The only pre-processing steps applied were the smoothing filter to reduce the speckle-effects of radar imagery. For further study and analysis we used SRTM DEM of 30-m for extraction of elevation zones in Jorhat district. And to exclude permanent water bodies from the study area we used Global Surface water (seasonality) data to get the exact flooded areas of the study area. For the map visualization we used sentinel1 composite data as a base map for showing flood extent areas.

Table1: Showing Rainfall and Temperature (2017)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm per day)	2.0	2.44	3.73	8.17	10.48	15.1	17.12	10.67	10.5	6.97	0.27	0.07
Temperature (in °C)	18.41	20.94	22.27	25.8	27.27	28.74	28.63	28.88	27.87	26.02	21.58	19.05

Source: *https://power.larc.nasa.gov/data-access-viewer/*

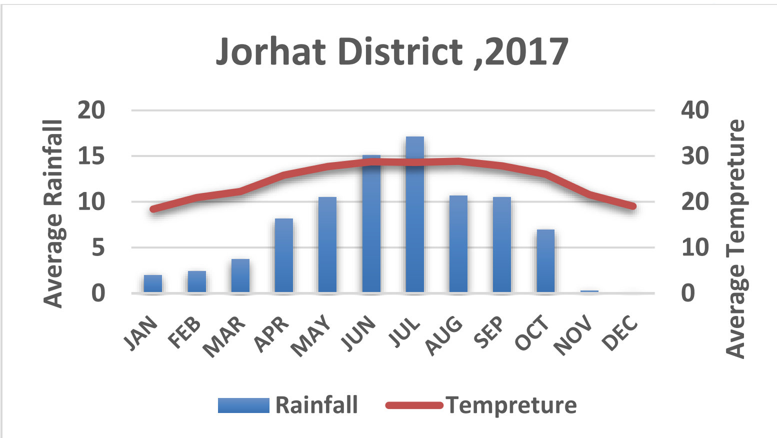


Fig2: Rainfall and Temperature Graph

Table2: Showing Rainfall and Temperature (2021)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (in mm per day)	0.34	0	1.7	1.82	9.56	13.76	10.49	12.22	5.19	3.76	0.26	0.27
Temperature (in °C)	16.87	19.58	23.14	26.50	28.05	28.28	28.84	28.23	28.55	26.36	20.20	18.05

Source: *https://power.larc.nasa.gov/data-access-viewer/*

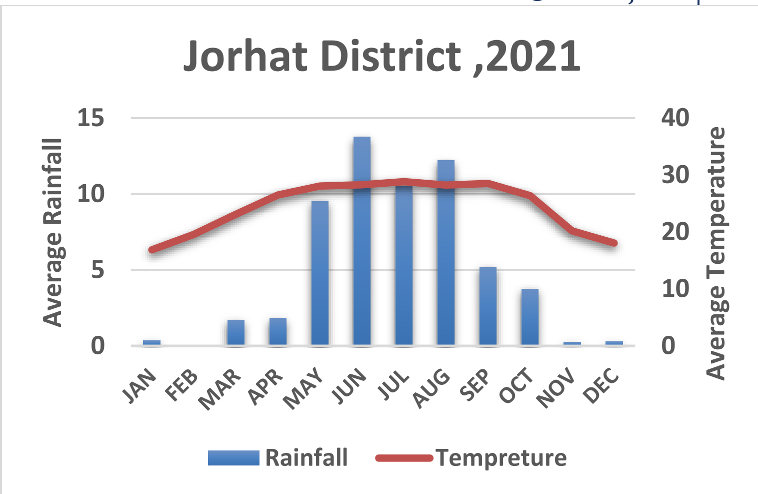
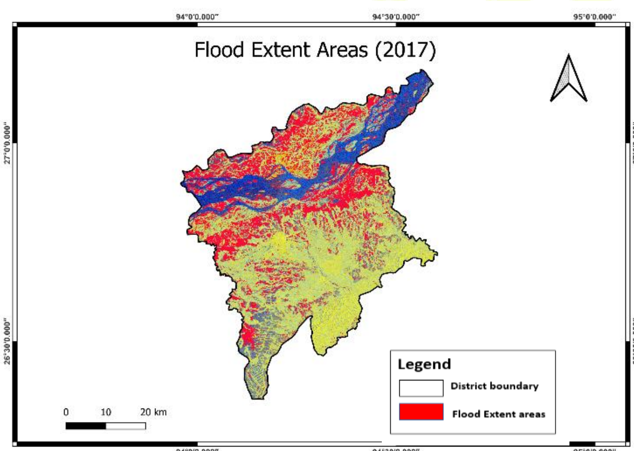


Fig3: Temperature and Rainfall graph (2021)

The above graphs show that there is some variability of rainfall and temperature between 2017 and 2021. The highest rainfall in 2017 was recorded in the months of June and July with 15.1 and 17.1. Whereas the highest rainfall in 2021 in the months of June and July were only 13.76 and 10.49. Because of less rainfall in 2021 than in 2017, the extent of flood areas in the study area were found to be less than in the previous year. There is slight variation in the temperature data of the study area.

RESULTS AND DISCUSSIONS



Map 2: Flood extent (2017)

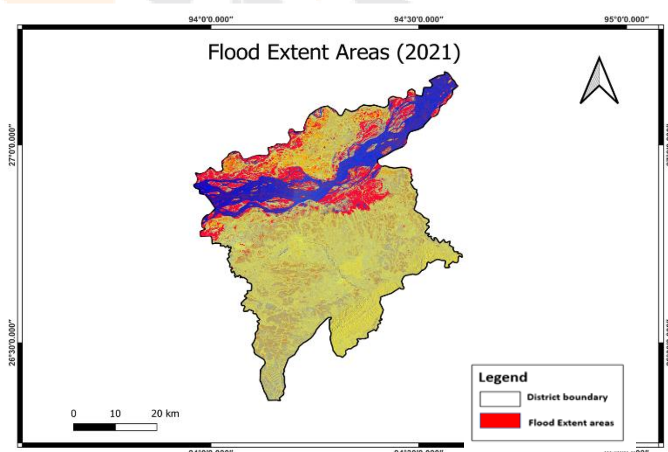


Fig: Flood extent (2021)

From the above table and flood extent maps of 2017 and 2021 it is clearly seen that amount of rainfall received in 2017 is quite higher in2017 hence the flood extent in some areas is high. Likewise, due to less amount of rainfall in 2021, the flood extent is lesser in those areas that were flooded in 2017. So, amount of rainfall received in a particular area can be regarded as the most important cause of flood in any area. The areas lying close to the Brahmaputra River is often flooded during the rainy season. Besides the low lying areas also gets flooded in rainy season.

Jorhat district is one of the highly flood prone zone in the state of Assam. Every year lakhs of people are affected by flood in Jorhat. Flood extent maps are generated using dual polarized sentinel1 SAR data in the year 2017 and 2021. Flood areas are observed from the SAR, since clouds are not interrupted in capturing information through SAR. To study the flood risk assessment, SAR is the most used in GIS and remote sensing analysis. Red color visualizes the yearly flood-affected areas of the Jorhat district.

Through this mapping procedure we can identify the high risk flood zones and it is also used for forecasting areas that are likely to be flooded due to high water level in a river.

CONCLUSION

It is noted that the impact of floods can be magnified by socio-economic development, encroachment on the floodplains and inadequate drainage management. Traditional knowledge of dealing with floods is also important to some extent as it offers site-specific knowledge and critical guidance to planners and decision makers. Flooding causes economic and livelihood losses especially in developing countries as the low-income earners have to undergo great stress. Due to floods the asset base of households are lost, communities and societies had to undergo the destruction of standing crops, dwellings, infrastructure, machinery and buildings, in addition to tragic loss of life. Despite the rich natural water resources, people living in these areas are poorer as compared to the rest of the country, and this is primarily due to the annual floods and related devastation. It becomes very difficult to maintain the day to day expenses, education of children amongst the flood disaster. The flood disaster increases poverty which sometimes led to migration of people from such areas. Flood and migration have direct relation as higher the flood, higher is the migration rate. It is important to note that floods impact different sections of society differently, and requires a thorough understanding of flood-related issues. Floods have adverse impacts such as the risk to life and property in the coming years, because floods are likely to be more frequent, and because increase in population is likely to result in more people settling in areas vulnerable to flooding. An increase in floods is likely to influence prevalence of water-related diseases and contaminate water sources whereas, the insufficient water for hygiene purposes during dry periods is likely to increase the risk of water-washed diseases. Given the projected changes in rainfall and precipitation, it is likely that there is going to be serious costs for communities and other sectors here. In view of the above, there is an urgent need for actions to assist communities and dependent sectors to adapt to floods. Therefore, the various water-dependent sectors like agriculture, fishery, industry, energy, navigation, and water supply and sanitation need proper planning and to cooperate all to work towards achieving a resilient State.

IMPLICATIONS OF THE STUDY

Flood risk management will only be effective if the public is involved. Risk reduction measures therefore need to be tailored to the highly differentiated awareness levels across and within countries. Stronger involvement of citizens may contribute to raising risk awareness and disaster preparedness, the local populations may provide knowledge that is fruitful for risk reduction efforts, and the involvement of the public may enhance the acceptance of risk management measures.SAR data provides complete coverage of cloud-covered areas with clear results in flood risk mapping. The use of SAR data for monitoring of flood extent areas provided us most useful information in identifying the flood areas and places, location and giving the early warning to the people to relocate and for wild life conservation organization to rescue the wild animals as well as the domestic animals in the flooded regions.

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