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Spatial and Temporal Assessment of Flood Affected Areas in Dhubri District of Assam Using RS&GIS

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ABSTRACT

The experiment was conducted during September to December 2024 at SCS College of Agriculture, AAU, Dhubri, Assam, India using secondary data collected from Sentinel-1A satellite 10-meter spatial resolution for study year 2019–2024. The objective of the study was to assess the spatial and temporal variability of flood inundation and submergence of agricultural land in the district using Remote Sensing (RS) and Geographic Information Systems (GIS). The flood incidents at block levels in the entire Dhubri district over the period of 2020 to 2024 were considered for the study. For this purpose, Sentinel-1 SAR imagery of the study area and the period were extracted using Google Earth Engine. Significant spatial and temporal variations in flood inundations were observed during the years from 2020 to 2024 in all the blocks under the Dhubri district. Birsing Jarua block emerged as the most vulnerable one, with flooded areas increasing from 19.24% in 2022 to 49.12% in 2024, leading to a two and half times rise in cropland inundation. Nayeralga, Mahamaya, and Chapor-Salkocha blocks also showed high vulnerability towards intensified flooding. Conversely, Rupshi, Bilasipara, and Golaganj blocks exhibited declining flood extents over the period of study. The study highlighted the need for block level integrated contingency plan in high-risk zones to mitigate future agricultural damage caused by flood in the district.

KEYWORDS: GIS, remote sensing, flood inundation, cropland, Dhubri

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

The Dhubri district, located in the westernmost part of Assam, India, is bordered by Bangladesh along the Brahmaputra River. It's mostly plain physiography features a few scattered hillocks, interspersed by various small and medium rivers and tributaries. The Brahmaputra, running east to west, forms much of the district's southern boundary, while the other rivers originate either from Bhutan in the north or the Garo Hills in the south, merging into the Brahmaputra downstream. This extensive fluvial network supplies an abundance of freshwater, rendering the district exceptionally suited for agriculture.

Over 85% of Dhubri's population primarily depends on cultivation, and the district boasts one of the highest cropping intensities in Assam at 203% (Ahmed et al., 2022). Rapeseed and mustard productivity are particularly notable, along with cultivation of rice, maize, toria, and seasonal vegetables (Ahmed et al., 2022). Much of this agricultural output is marketed to nearby districts and neighbouring states, including West Bengal and Bihar (Nath et al., 2021). However, the district's topography, while advantageous for year-round cropping, also predisposes the region to frequent flood events. Intense monsoon rainfall, typically between April and September, coincides with dam-water releases from bordering nations, often inundating riverbanks. Heavy rains in upstream areas combine with inadequate channel depths from prolonged siltation, increasing flood intensity across Dhubri's fluvial plains. The Char areas-riverine sandbars along the Brahmaputra-are among the most fertile yet most flood-prone agricultural zones (Nath et al., 2021).

To address the persistent flood challenges, studies worldwide have utilized Remote Sensing (RS) and Geographic Information Systems (GIS) to evaluate flood-affected areas and quantify resulting agricultural losses. In Germany, Tapia-Silva et al. (2011) estimated flood damage with NDVI-based classification, while Forster et al. (2008) highlighted the role of GIS-based models in reducing rural flood impacts. In India, Dutta et al. (2003) underscored the importance of accurate flood risk mapping for lowering crop damage, whereas Pantaleoni et al. (2007) leveraged Landsat imagery to detect flood-induced agricultural loss. Time-series MODIS data were employed by Mingwei et al. (2008) for pre-and post-flood crop identification, further highlighting the capabilities of RS techniques. Likewise, Borah et al. (2023) demonstrated how floods affect toria cultivation, and Chohan et al. (2015) applied RS and GIS for flood damage assessments along the Chenab River in Punjab. Rai and Mohan (2014) showcased the utility of these tools for flood risk zoning in Varanasi.

Recent approaches integrate machine learning with RS and GIS, enhancing flood risk assessments. Koley and Kumar (2024) demonstrated its application for maize and rice production in Himachal Pradesh, while Halder et al. (2023) emphasized large-scale flood hazard monitoring through geospatial analysis. Mehta and Rawat (2023) used optical and microwave sensors to observe flash floods in Assam's Cachar district, illustrating the adaptability of these methods for real-time flood monitoring.

Despite ongoing flood-induced losses in Dhubri, detailed spatial and temporal evaluations of impacted agricultural lands remain limited. This data gap hinders effective flood management and mitigation efforts, as accurate and timely information on flood extent is critical for resource allocation and policy-making. Therefore, the present study utilizes RS and GIS tools to document flood occurrences in Dhubri from 2020 to 2024. Satellite data are employed to measure flood-affected areas and specifically assess damage to cultivated lands. The analysis further explores flood patterns, reveals fluctuations in inundation trends, and identifies the most vulnerable blocks within the district. The objective of the study was to assess the spatial and temporal variability of flood inundation and submergence of agricultural land in the district using Remote Sensing (RS) and Geographic Information Systems (GIS)

2. MATERIALS AND METHODS

The experiment was conducted during September to December, 2024 at SCS College of Agriculture, AAU, Dhubri using secondary data collected from Sentinel-1A satellite 10-meter spatial resolution for study year 2019–2024.

2.1. *Study area*

Dhubri district (extending from 26°22' to25°28' N latitude and 89°42' to 90°12' E longitude), located in the south-western part of Assam, India, is the focal point of this study on flood occurrences and agricultural impacts from 2020 to 2024 (Figure 1). The study area encompasses nine blocks *viz*. Birsing Jarua, Nayeralga, Agomani, Bilasipara, Rupshi, Golaganj, Jamadarhat, Gauripur, and Mahamaya within the district.

2.2. *Methods*

We employed Sentinel-1A SAR imagery through Google Earth Engine (GEE) to map and assess the flood inundation and its effect on agriculture in the Dhubri district of Assam. The Ground Range Detected (GRD) product of the Sentinel-1A satellite provides data in the C-band dual-polarization channels (VH and VV) with a repeat cycle of 12 days (Pandey et al., 2022), which was used to extract the flood-inundated area for our study.The sensitivity of polarization on mapping accuracy is estimated using Vertical-Horizontal (VH) and Vertical-Vertical (VV) modes available with Sentinel-1 data. The result indicates

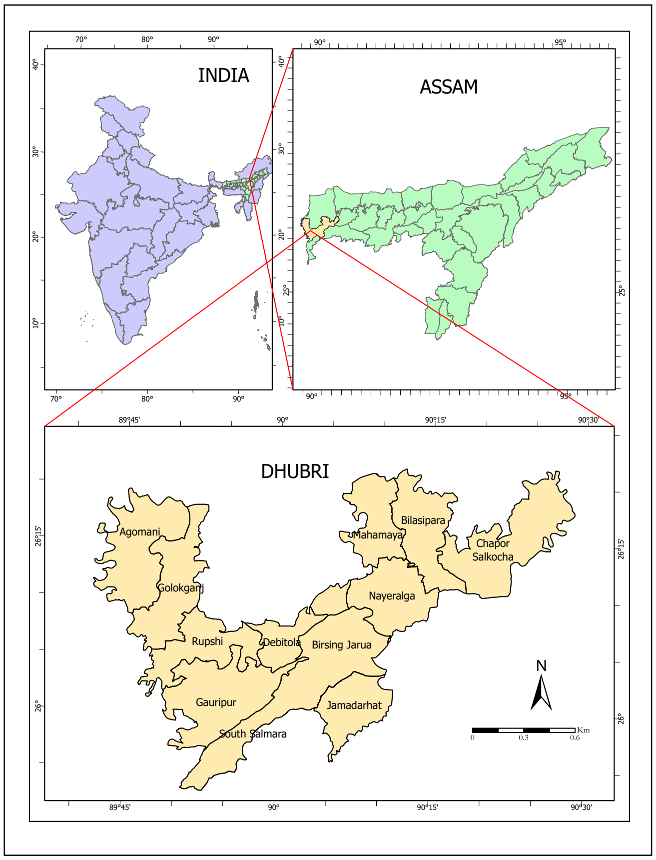


Figure 1: Study area

that VV mode of polarization provides better accuracy of 96% than VH mode (Kolanuvada and Ilango, 2022).

Prior to generating the flood maps, several pre-processing steps were applied to the Sentinel-1A SAR imagery, including thermal noise removal, radiometric calibration, speckle filtering, and terrain correction. These processes were carried out using the Google Earth Engine platform (Katiyar et al., 2019). A speckle filter with a 50 m smoothing radius was employed in this study (Ferreira et al., 2021). Terrain correction was also applied to address geometric distortions typical in SAR images, ensuring accurate spatial alignment and representation (Pandey et al., 2022). A threshold value of 1.25 was set and applied, whereby values greater than 1.25 were designated as 1, and those below 1.25 were designated as 0. The threshold value of 1.25 was selected through trial and error which can be adjusted to reduce the occurrence of false-positive or false-negative results. This method created a binary raster layer that represents potential flood magnitudes (Shinde et al., 2023). Temporal flood images were generated and pre-flood images were gathered and employed for comparison. These images were co-registered to align them spatially, ensuring accurate analysis. Speckle noise in the SAR images was reduced using the refined Lee filter, enhancing the clarity of the flood imagery (Amitranao et al., 2024).

Using a threshold-based masking approach, the flooded areas were identified and isolated (Chini et al., 2017). It was followed by updating the masked image for further refining the flood delineation. Subsequently, the final flood images were produced, providing clear visual identification of the flooded regions (Singh and Kumar, 2021; Manavalan et al., 2019). These images were used to estimate the block-wise temporal flood-affected areas.

World Cover 10 m 2021 product provided by the European Space Agency (ESA) was used to extract the agriculture area (Zhao et al., 2021). Year wise flood inundated area during the period considered for the study was calculated by masking the cropped area by overlyingwith the flood-inundated area (Mahdianpari et al., 2020; Dong et al., 2021).

3. RESULTS AND DISCUSSION

3.1. *Flood trends in the district*

From 2020 to 2024, Dhubri district experienced significant fluctuations in flood inundation and its impact on cropland. The flooded area peaked in 2020 at 40,523 hectares, affecting 35,582 hectares of cropland (24.68% of the total cultivated area of 144,152 hectares), while 2021 saw the lowest flooded area at 29,577 hectares, impacting 26,689 hectares of cropland (18.51%). A gradual increase in both flooded and affected cropland areas occurred from 2022 to 2024, witnessing 40,404 hectares flooded area in the year 2024, impacting 32,601 hectares (22.61%). The values in Table. 1show that the flood affected crop area ranged from 25790 ha to 39743 ha during the study period and its GIS analysis is shown in the Figure 2. Observing the steadily increasing extent of flood inundation during the study, it is felt that anearly warning system and suitable contingency plan comprising adoption of flood-escaping and tolerant crop varieties are the need of the hour.

Table 1: Year wise extent of flood inundation during the study period

Year	Flooded area (ha)	Food affected crop area (ha)	Flood affected cropland (%)
2020	40523	35582	24.68
2021	29577	26689	18.51
2022	29990	25790	17.89
2023	39012	32513	22.55
2024	49173	39743	27.57

3.2. *Block wise flood inundation of cropland during the study period*

The pattern of flood occurrence in Dhubri district during the year 2020 to 2024 demonstrates a significant spatial

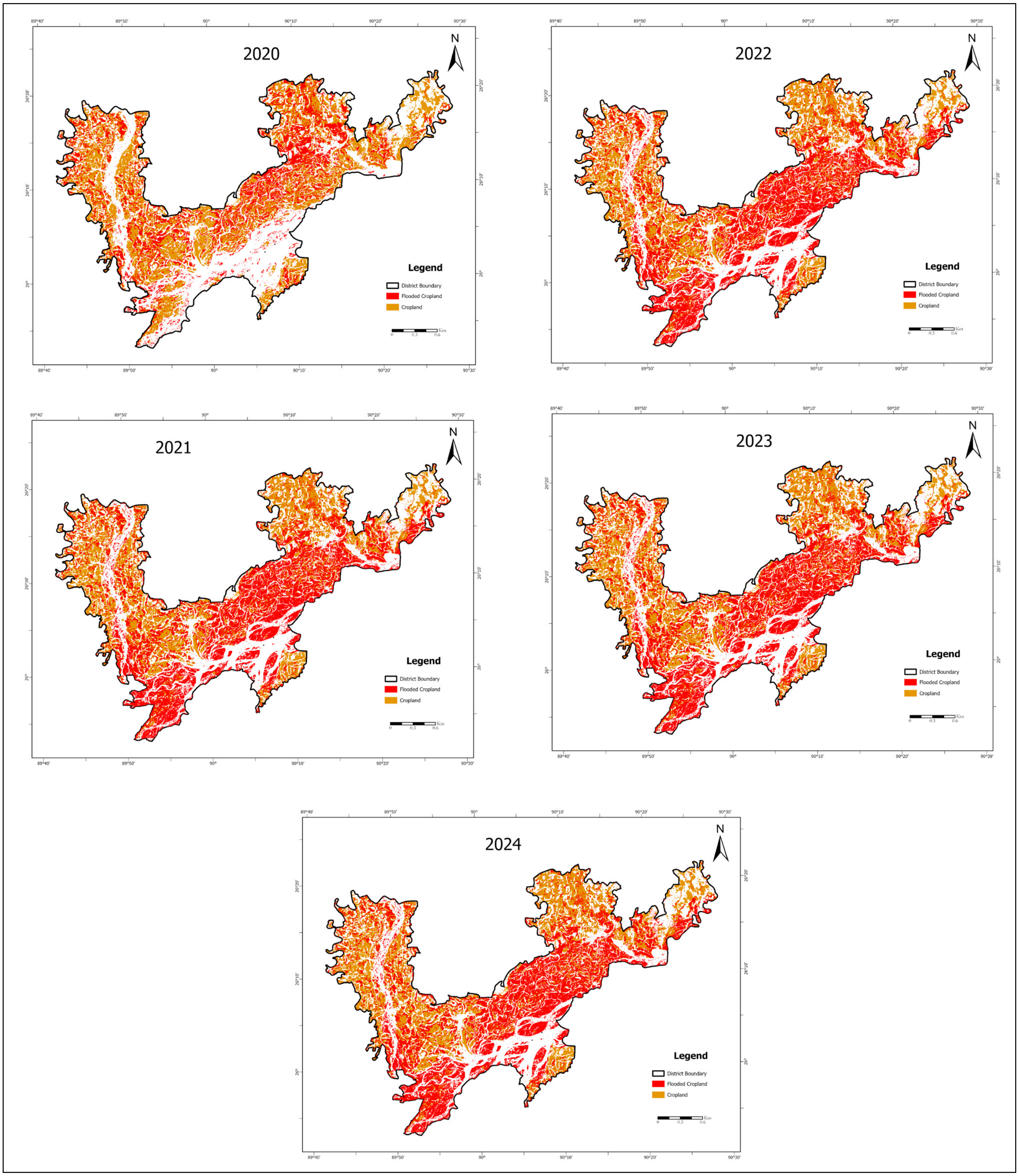
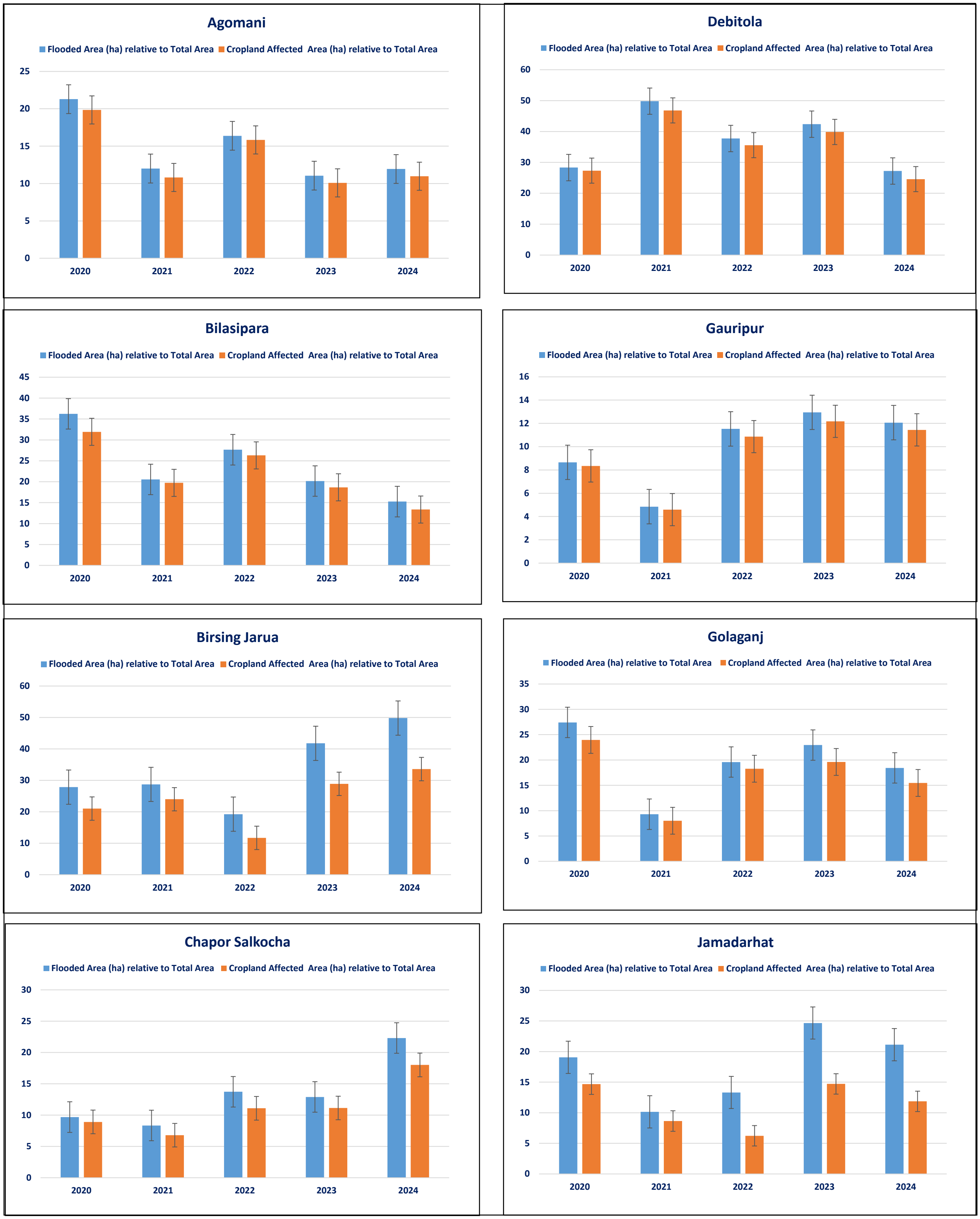


Figure 2: Max flood occurrence using Sentinel-1 SAR

and temporal variability (Table 2 and Figure 3). The analysis reveals that almost one-fifth of the cultivated area is inundated by the flood. The extent of total area inundated by flood increased sharply from 19.24% in 2022 to 49.80% in 2024 in the Birsing Jarua block. During the same period, this block experienced upward changes of 11.71% to 33.57% in the cropped area. In contrast, Rupshi, Bilasipara, and Golaganj blocks experienced a steady



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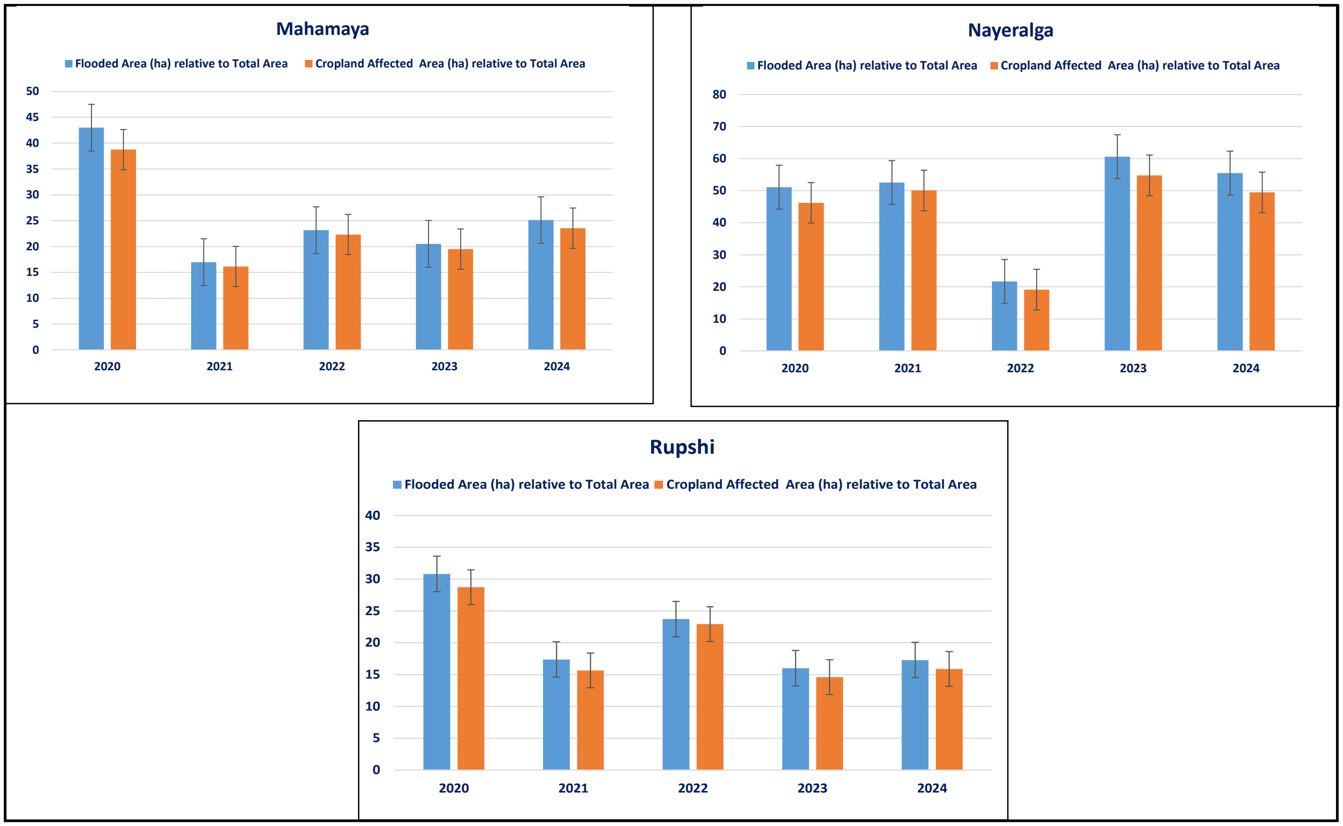

Figure 3: Changing flood pattern at different blocks of Dhubri district

Table 2: Flood inundation extent (ha) and cropland (ha) at block level during the period from 2020 to 2024

Block	2020		2021		2022		2023		2024	
	FI	CL	FI	CL	FI	CL	FI	CL	FI	CL
Agomani	3,563	3,321	2,009	1,809	2,742	2,651	1,850	1,688	1,999	1,837
Bilasipara	4,550	4,010	2,581	2,478	3,473	3,303	2,533	2,344	1,916	1,677
Birsing Jarua	6,758	5,098	6,968	5,822	4,670	2,843	10,134	7,011	12,084	8,146
ChaporSalkocha	1,865	1,717	1,607	1,309	2,644	2,136	2,484	2,146	4,296	3,469
Debitola	1,619	1,562	2,847	2,676	2,157	2,033	2,422	2,278	1,555	1,405
Gauripur	1,619	1,562	907	859	2,157	2,033	2,422	2,278	2,257	2,141
Golakganj	3,785	3,308	1,284	1,106	2,706	2,523	3,170	2,709	2,546	2,136
Jamadarhat	1,809	1,393	963	821	1,264	592	2,342	1,397	2,006	1,126
Mahamaya	5,236	4,720	2,068	1,966	2,821	2,718	2,499	2,375	3,058	2,867
Nayeralga	6,156	5,570	6,334	6,034	2,614	2,307	7,306	6,599	6,688	5,960
Rupshi	3,563	3,321	2,009	1,809	2,742	2,651	1,850	1,688	1,999	1,837

FI: Flood inundation (ha); CL: Cropland (ha)

decline in flooded areas and reduced agricultural damage during the said period of time. Again, it may be noted that Nayeralga block reported 60.60% flood affected area and 54.73% cropland inundation in the year 2023. The variable pattern of flood inundation among the blocks might be due to physiographical features, proximity to river system, climatic factors or changes in river hydrodynamics over the period of study.

3.3. Analysis of cropland affected by flood

As shown in Figure 4, the extent of cropland inundation followed similar pattern to that oftotal geographical area inundated by flood in every block. The Birsing Jarura block has shown the highest vulnerability with8,146 hectares of cropland inundated in the year 2024. On the other hand, with 1,837 hectares of cropland inundated in the Agomani block was least affected by flood in the same year. Notably, the Gauripur block also showed consistent crop losses, with a peak affected area of 2,278 hectares in 2023.

Figure 4: Continue...

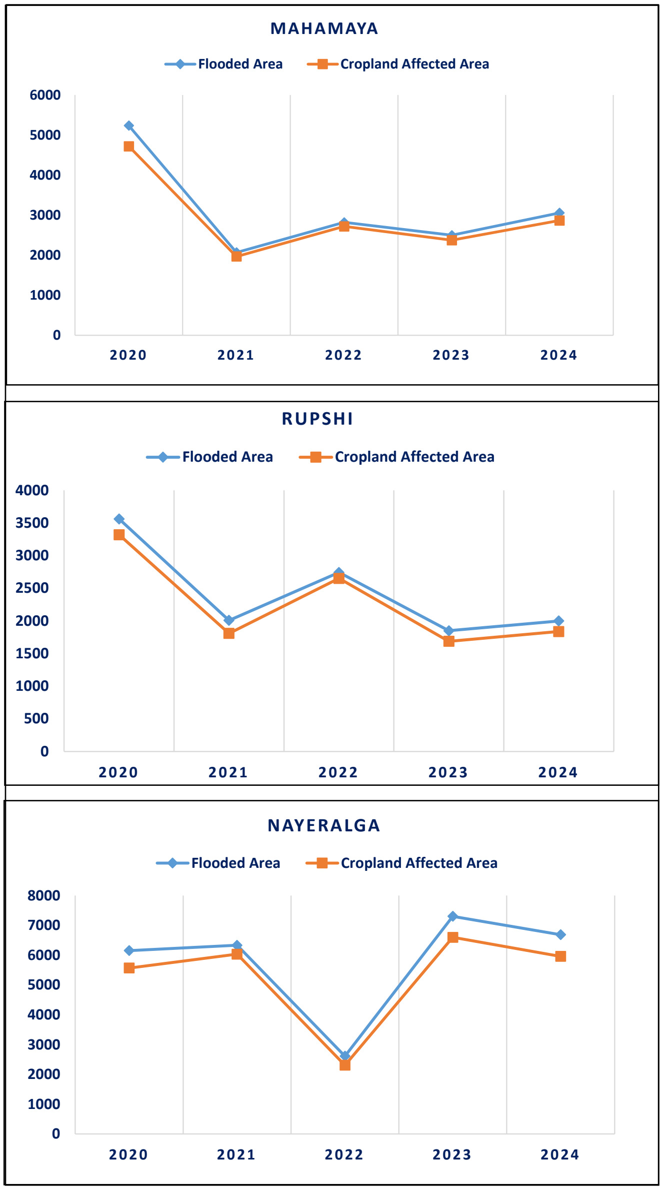

Figure 4: Flood affected crop areas vis a vis total area at block levels (2020–2024)

The study demonstrated that climatic variability and river hydrodynamic changes played significant roles in increasing flood intensity in Dhubri district, a 55-60% probability of increased third-quartile flood values and an over 80% probability of increased maximum flood values were reported by Apurv et al. (2015). Flood-affected areas and cropland damage steadily increased from 2022 to 2024, with BirsingJarua being the most vulnerable block. Prolonged water stagnation and inadequate drainage systems might lead to more crop losses. Pervez and Henebry (2015) observed that the streamflow in the Brahmaputra basin had been highly responsive to changes in precipitation, with flooding risks increasing during August–October due to higher rainfall and water yield.

Introduction of flood-tolerant crop varieties and improved embankments were found to reduce crop losses in blocks such as Rupshi and Bilasipara. Strategies suggested by Mohanty et al. (2020), including the use of early warning systems, had the potential to minimize the impact of flood on agricultural produces, if implemented effectively. Localized flood management plans, tailored to block-specific vulnerabilities, and active community participation proved essential for fostering long-term resilience. The findings emphasized the importance of integrating infrastructure improvements, resilient agricultural practices, and community-driven approaches to manage flood risks sustainably.

4. CONCLUSION

The flood trends in Dhubri during the study period from 2020–2024 show considerable spatial and temporal variability, exposing cropland vulnerability. Maximum flood-affected cultivated area was 24.68% in 2020, while the minimum was 18.51% in 2021.On the other hand Birsing Jarua block remains most vulnerable, with cropland damage rising from 19.24% in 2022 to 49.80% in 2024. In contrast, blocks like Rupshi and Bilasipara show declining flood impacts.

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