- Across all years, a consistent spatial pattern emerges: north Bihar is chronically flood-prone, with recurrent inundation driven by transboundary rivers and flat alluvial terrain.
- Seasonality map highlights Ganga, Gandak, Kosi, Son, and their tributaries—as zones of high water persistence (6–10 months), whereas, large portions of north and central Bihar show 3–6 months of water presence.
- East Champaran, Sheohar and Sitamarhi experience pronounced waterlogging, with depths of 12–15ft, 8-10ft and 3–7ft, respectively suggests a chronic drainage challenge.

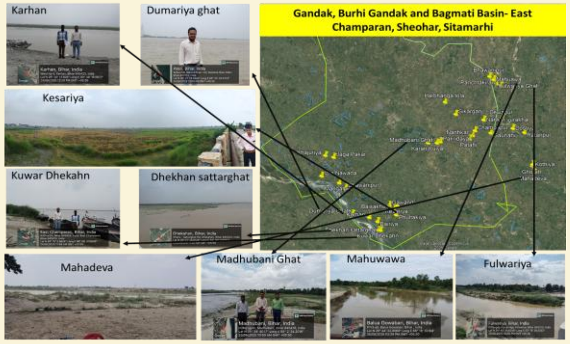

Fig. 4: Few glimpses of flood prone areas of East Champaran, Sheohar and Sitamarhi

- Intervention though Integrated Farming System (IFS) models across flood-prone blocks of East Champaran and Sheohar demonstrate site-specific adaptation, with farm sizes ranging from 5 katha to 40 bighas, integrating crops, livestock, fisheries, and horticulture to generate annual incomes from ₹30,000–40,000 in smallholder rice–goat systems to ₹10-15 lakh in diversified crop–fish–dairy models and in intensive fish-based systems. These models effectively transforming hydrological stress and prolonged waterlogging into sustainable livelihood opportunities.

Conclusion

This study demonstrates the effectiveness of Sentinel-1 SAR–based flood mapping (2017–2023), following UN-SPIDER protocols, and identifies that north Bihar is chronically flood-prone, with recurrent high-intensity inundation along the Kosi–Gandak–Burhi Gandak corridor. Persistent water seasonality and waterlogging in districts such as East Champaran, Sheohar, and Sitamarhi underline structural drainage constraints, while site-specific Integrated Farming System (IFS) models demonstrate that flood-induced hydrological stress can be transformed into climate-resilient livelihoods, generating good financial return per year depending on system intensity.

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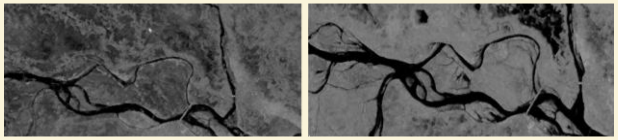
Spatio-temporal (2017-2023) Mapping of Flood Prone Areas of Bihar Using Sentinel-1A SAR Images: Implications for Climate-Resilient Farming



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Introduction

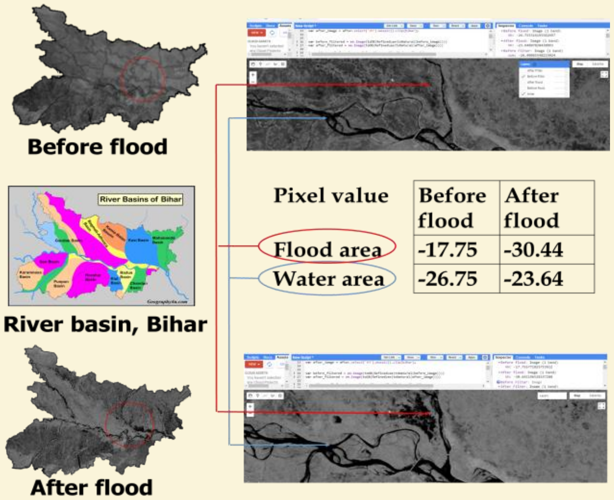
In recent decades, floods have become increasingly destructive due to increased impervious surfaces, climate change, and global warming. Remote sensing technologies have been widely used in risk analysis. In this study, mapping of flood-affected areas of Bihar is done using Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) with the Sendai Framework Terminology on Disaster Risk Reduction (United Nations, 2023) as a standard directly applicable to assessing flood impacts.

Materials and methods

Mapping of flood prone (2017-2023) areas of Bihar was done using Sentinel-1 Synthetic Aperture Radar (SAR) GRD: C-band image data. Pre and post flood images (VV and VH) were acquired at a spatial resolution of 10m, and interferometric width swath (IW) was used for mapping the flood prone areas following protocol provided by UN-SPIDER in Google Earth Engine (GEE) and ArcGIS (v10.8.2) environment. A pixel was classified as a flood pixel if the difference is more than the threshold value, while, a permanent water pixel is classified when the pixel value is less than the threshold value for that pixel.

Results

- Flooding primarily concentrates along major rivers such as the Kosi, Gandak, Burhi Gandak, Bagmati, Kamla, and Mahananda, with the northern districts consistently showing higher inundation extents.
- July and August shows a notable intensification of flood spread across multiple basins.



Pixel value	Before flood	After flood
Flood area	-17.75	-30.44
Water area	-26.75	-23.64

Fig. 1: Before and after flood condition of Bihar and associated changes in pixel values with occurrence of flood detected using Sentinel SAR 1 A, C band image

- Districts viz. Muzaffarpur, Supaul, Araria, Kishanganj, Sitamarhi, Saharsa, Khagaria, Araria, Gopalganj, and East/West Champaran demonstrate significant red (flood water) patches indicating peak flood expansion.

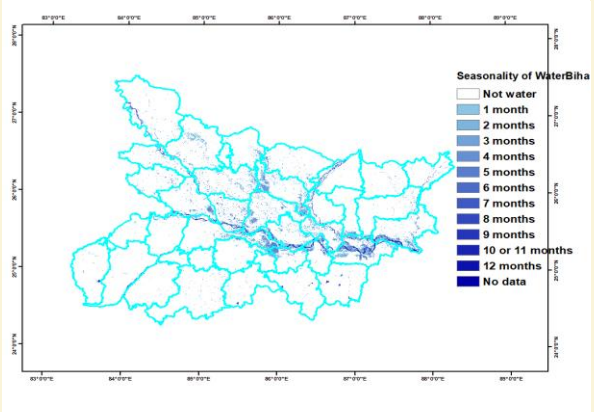


Fig.3 Seasonality water in Bihar. Deeper extent of blue colour show more water occurrence and longer duration of water inundation.

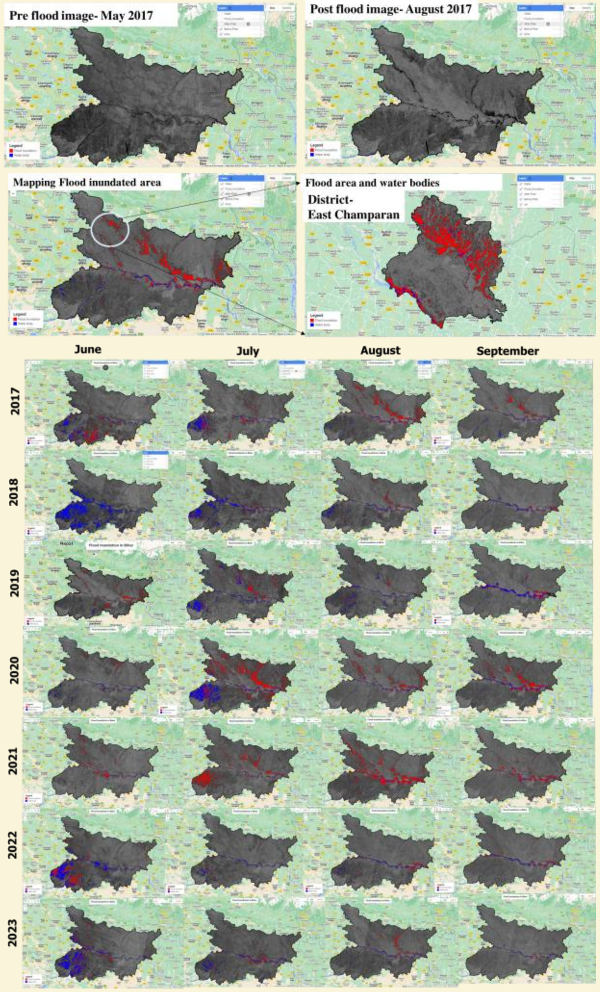


Fig 2: Spatial variability map of flood affected areas of East Champaran during and Bihar blue coloured pixels shows permanent/ seasonal water bodies.

- More than 1.13-1.60 lakh ha area in Bihar and 5900-9800 ha in East Champaran district were found high to very high flood-prone category respectively.
- The Kosi–Gandak–Burhi Gandak corridor displays maximum flood intensity, with widespread overbank flow.