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ASSESSMENT OF VILLAGE-LEVEL FLOOD-AFFECTED AREAS IN THE GHED REGION OF SAURASHTRA, GUJARAT

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ABSTRACT

Floods are recurring natural disasters that significantly impact lives, property, and infrastructure, exacerbated by factors such as population growth, urbanization, and climate change. The *Ghed* region of Saurashtra in Gujarat, India, is particularly vulnerable to seasonal flooding due to its low-lying terrain and proximity to rivers. This study focuses on identifying and mapping flood-prone areas within the *Ghed* region, covering the Porbandar and Junagadh districts, to support the Gujarat government's rapid flood response and aid distribution, specifically through the "Krishi Rahat Package". Utilizing Synthetic Aperture Radar (SAR) data from Sentinel-1 satellites, processed on the Google Earth Engine (GEE) platform, flood-affected areas were mapped with high precision, overcoming cloud cover issues during the monsoon for the year of 2024. The analysis reveals that out of 123 villages in the *Ghed* region, 11 villages (Ghodadar, Sitana, Nanadiya, Ajak, Bagasara-Ghed, Sarma, Indrana, Padardi, Bhathrot, Vadala, and Balagam) in Junagadh and 9 villages (Kadachh, Rajpar, Gogan Bet, Balej, Amirpur, Revadra, Pata, Mander and Kadegi) in Porbandar are severely impacted, with over 50% of their area inundated. Conversely, 5 villages (Farangta, Nandarkhi, Talodra, Zariyavada and Kankasa) in Junagadh and 1 village (Navi Bandar) in Porbandar are minimally affected, with less than 5% of their area flooded. The spatial distribution of flood impact underscores the variation in vulnerability among villages, shaped by the region's topography and hydrology. This study offers valuable insights into the flood dynamics of the *Ghed* region, enabling more effective disaster management and planning. By identifying the most affected villages, this mapping serves as a crucial tool for prioritizing relief efforts, informing adaptive agricultural practices, and supporting long-term regional resilience strategies. The study also offers a timely, cost-effective solution for policymakers, crop insurers, and the Government of Gujarat (GoG) to address soil erosion and crop loss issues in the *Ghed* region at the village level.

***Key words*:** Flood, Ghed region, Sentinel-1, SAR, GEE, Disaster, Village, Porbandar, Junagadh

Introduction

Floods are a recurring event that result significant loss of life and extensive damage to livelihoods, property, infrastructure, and public services. The main causes of flooding include a sharp rise in population, rapid urbanization, increased developmental and economic activities in floodplains, and the impact of global warming (Jonkman, 2005). Globally, flood become widespread natural disaster in last two decades (Khosravi *et al*., 2016; Wani *et al*., 2022). In the last two decades, several urban and riverine flood events have been recorded in India resulting in widespread destruction (Wani *et al*., 2022). Out of the total geographical area (329 Mha) of India, more than 40 Mha area are susceptible to flooding (Rehman *et al*., 2024).

Over the past two decades, the scientific community has emphasized the potential of remotely sensed Earth Observation (EO) data for real-time flood mapping in flood monitoring applications (Matgen *et al*., 2011; Schumann *et al*., 2018). The advent of next-generation EO satellites, with enhanced spatial and temporal resolution, has significantly improved the accuracy and effectiveness of flood detection and monitoring capabilities (Domeneghetti *et al*., 2019).

Among various Earth observation datasets, Synthetic Aperture Radar (SAR) is particularly valuable for flood mapping due to its all-weather capability. Unlike optical remote sensing, SAR signals can penetrate cloud cover, making it indispensable for monitoring floods during heavy rainfall and overcast conditions. Disaster events like floods, earthquakes, and cyclones induce changes in the geometric and dielectric properties of surface features, which SAR backscatter can effectively detect. The distinct SAR backscatter from flooded versus non-flooded areas enables precise flood mapping (Schumann *et al*., 2015). Numerous studies have explored the effective use of SAR data for accurate flood monitoring and mapping (Kiage *et al*., 2005; Bonn *et al*., 2005; Long *et al*., 2014; Shen *et al*., 2019; Vanama *et al*., 2020; Mudashiru *et al*., 2021; Bhageerath *et al*., 2024).

In cloud-based platforms like Google Earth Engine (GEE), users can access and process large volumes of Sentinel-1 data directly in the cloud, eliminating the need for local downloads and processing (Gorelick *et al*., 2017). By leveraging Google's computational infrastructure, data is processed in parallel, significantly enhancing efficiency and unlocking new possibilities for users. In recent years, GEE has become widely adopted for numerous remote sensing applications (Kumar and Mutanga, 2018; Mandal *et al*., 2018). Many studies utilize the time-series Earth observation data available in the GEE catalog for applications such as Land Use Land Cover (LULC) change detection (Pande, 2022), crop acreage estimation (Liu *et al*., 2020), soil moisture assessment (Cho, 2024), land surface temperature (LST) analysis (Ermida *et al*., 2020), and more.

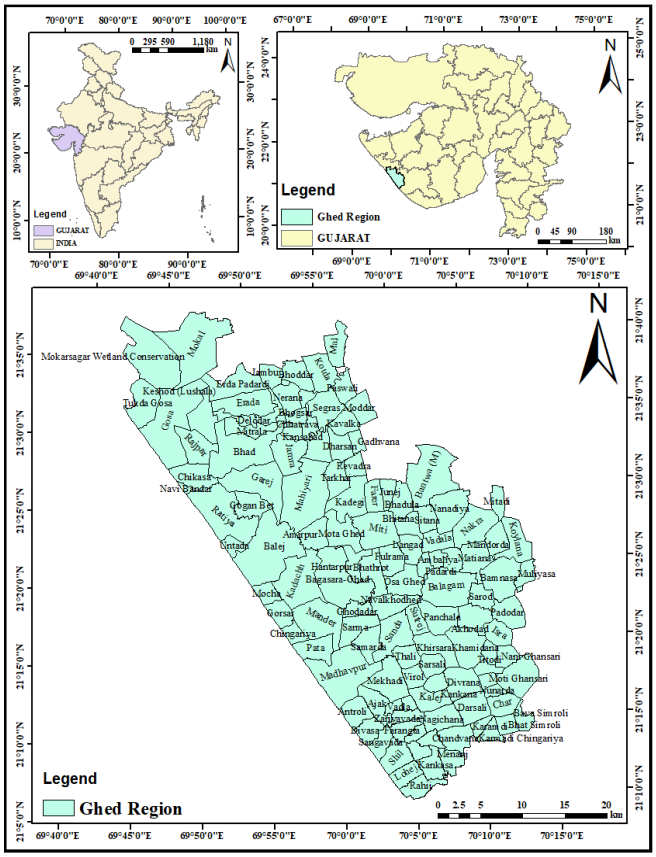

Fig. 1: Layout map of the study area.

The *Ghed* region is a low-lying area in the Saurashtra region of Gujarat, India, known for its unique geographic and ecological characteristics. Situated near the coastal plains, it is primarily a floodplain that experiences seasonal waterlogging due to monsoon rains, leading to rich alluvial soil deposits. This region is agriculturally significant, supporting crops like cotton, groundnut, and millet, but also faces challenges due to water stagnation. The *Ghed* area plays a crucial role in local ecosystems, providing habitats for diverse flora and fauna, especially in the wetlands that emerge during monsoons. It also includes several villages that rely on both farming and livestock for their livelihoods.

Considering the swift analysis and their adverse effects on agriculture, environment and human using microwave remote sensing data in Google Earth Engine (GEE) platform this research was carried out to demarcate the flood affected area at the village level to support the farmers from assistance given by the Government of Gujarat (GoI) under "Krishi Rahat Package" without much wasting of time in manual and labor-intensive survey.

Fig. 2: On site photograph of the flood event.

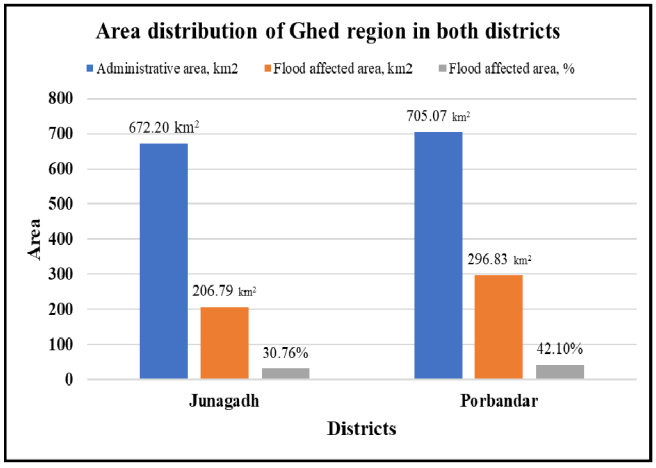

Fig. 3: Administrative and flood affected area of *Ghed* region in both districts.

Materials and Methods

Study Area

The *Ghed* region (Fig. 1), located in the Saurashtra region of Gujarat, India, is a distinct geographical area primarily situated along the coastal plains bordering the Arabian Sea. Positioned along the southwestern coastal belt of Saurashtra, its boundaries are not strictly defined but generally encompass areas between the coastal towns of Porbandar and Junagadh. It extends across latitudes 21°37'10.914"N to 21°13'8.519"N and longitudes 69°41'48.45"E to 70°12'11.861"E, covering an area of 1,377.27 km^2. The *Ghed* region comprises 123 villages across two districts, Junagadh and Porbandar, distributed among six tehsils: Porbandar, Ranavav and Kutiyana in Porbandar district, and Mangrol, Keshod and Manavadar in Junagadh district.

The name "*Ghed*" is derived from the Gujarati word "*Ghado*" meaning "pot" symbolizing how the region fills with water during the monsoon, leading to frequent flooding due to its low-lying terrain and rivers such as the Bhadar, Ozat, and Madhuvanti (Vargiya *et al*., 2022; Trambadia *et al*., 2023a; Trambadia *et al*., 2023b). This flat topography makes the region prone to waterlogging, with many areas remaining submerged during the rainy season. The flooding benefits agriculture by enriching the soil with nutrient-rich silt, creating highly fertile land after the water recedes, though it also presents challenges for settlements and cultivation. The climate is semi-arid, with hot summers, mild winters, and heavy monsoons that can exacerbate flooding. Agriculture is the mainstay of the *Ghed* region's economy, with crops like groundnut, gram, green gram, black gram, sorghum, sesame, cumin, cotton, peas, wheat, chickpea, and castor thriving due to the fertile conditions created by periodic flooding.

Sentinel-1 Data

Sentinel-1A, launched in April 2014, and Sentinel-1B, launched in April 2016, developed by the European Space Agency (ESA) as part of the Copernicus program, designed for all-weather radar imaging of the Earth's surface. These Sentinel-1 Synthetic Aperture Radar (SAR) images, captured before and during the flood event, were utilized in the study. The Sentinel-1 Ground Range Detected (GRD) images, accessed via the Google Earth Engine (GEE) platform, are preprocessed (Vanama *et al*., 2020) to provide terrain-corrected σ^o images with a 10 × 10 m pixel resolution. For validation, ground truth data points were collected during the flood using the NoteCam application (Fig. 2). A heavy rainfall event on August 25th in the upper part (Junagadh district) and in the *Ghed* region caused floodwaters to reach and spread across the *Ghed* area by August 26th - 27th, remaining for several days. Consequently, the flood analysis was done for the satellite passing date (August 28th, 2024) over the study region.

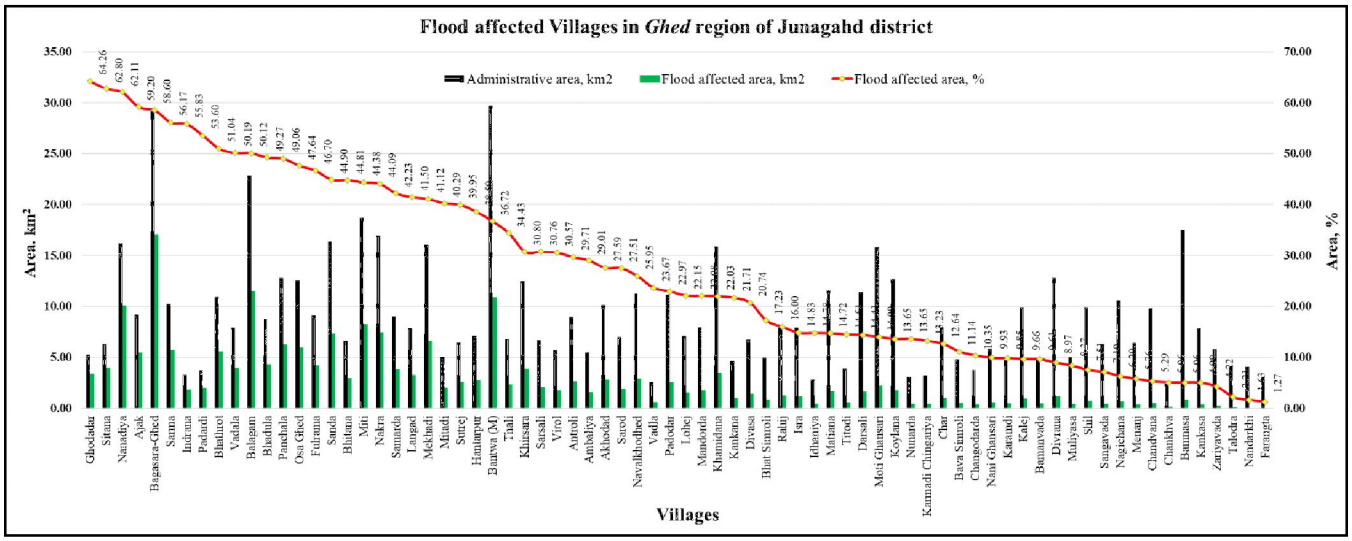

Fig. 4: Villages impacted by floods in the *Ghed* region of Junagadh district.

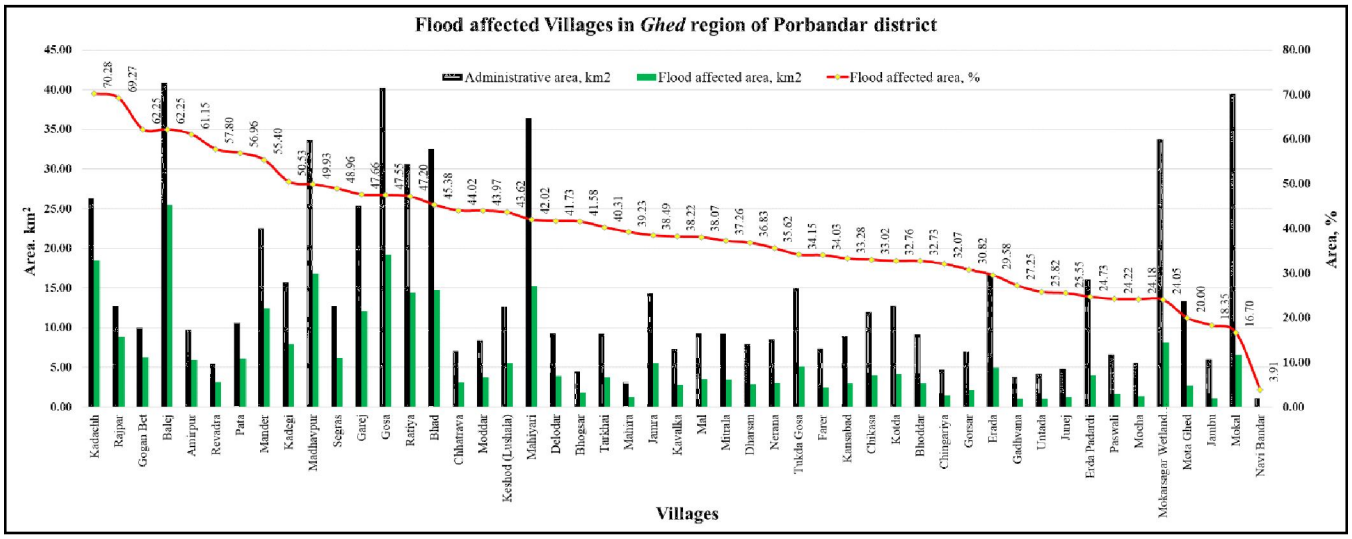

Fig. 5: Villages impacted by floods in the G*hed* region of Porbandar district.

Results and Discussion

The *Ghed* region primarily encompasses two districts: Junagadh and Porbandar. In Junagadh, there are 74 villages within the *Ghed* area, while Porbandar district includes 49 villages. The *Ghed* region covers an area of 672.20 km² in Junagadh district and 705.07 km² in Porbandar district. This year, flooding affected 206.79 km² (30.76%) of the *Ghed* area in Junagadh district and 296.83 km² (42.10%) in Porbandar district as shown in Fig. 3.

Fig. 4 & 5 presents a comprehensive analysis of the flood-affected areas across various villages in the *Ghed* region of Junagadh and Porbandar districts. It provides data on each village's total administrative area, the extent of flood-affected area in square kilometers, and the percentage of the village impacted by flooding. District wise detailed analysis of both the districts Junagadh and Porbandar is discussed herein.

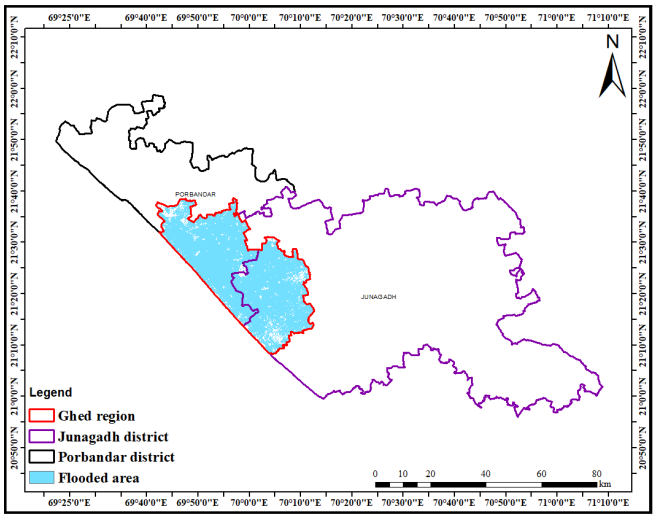

Fig. 6: Flood affected villages of the *Ghed* region covering both districts.

Flood Affected Villages in Junagadh District

In Junagadh district, the village name bagasara-ghed reported the largest flood-affected area at 17.10 km², while farangta had the smallest at 0.04 km² (Fig. 4). When assessed by percentage of area impacted, ghodadar had the highest flood impact at 64.26%, and farangta the lowest at 1.27%. Villages with over 50% of their area affected by flooding include ghodadar, sitana, nanadiya, ajak, bagasara-ghed, sarma, indrana, padardi, bhathrot, vadala, and balagam. Conversely, those with less than 5% of their area affected are kankasa, zariyavada, talodra, nandarkhi, and farangta.

Flood Affected Villages in Porbandar District

In Porbandar district, the village name balej reported the largest flood-affected area at 25.47 km², while navi bandar had the smallest at 0.04 km² (Fig. 5). When assessed by percentage of area impacted, kadachh had the highest flood impact at 70.28%, and navi bandar the

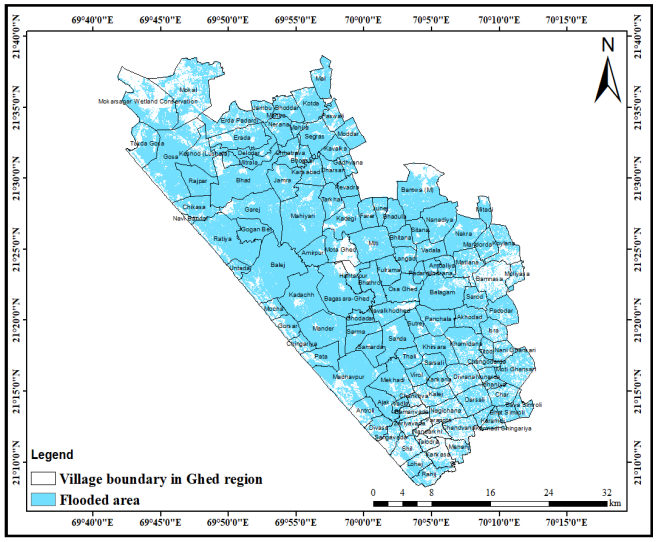

Fig. 7: Spatial distribution of flood at village level.

lowest at 3.91%. Villages with over 50% of their area affected by flooding include kadachh, rajpar, gogan bet, balej, amirpur, revadra, pata, mander and kadegi. Conversely, navi bandar had less than 5% of their area affected due to flood.

Spatial Distribution of Flood Affected Villages

Fig. 6 illustrates the geographical distribution of the *Ghed* region and the areas affected by flooding within the Junagadh and Porbandar districts in Gujarat, India. The flooded area covers a substantial part of both districts within the *Ghed* region, demonstrating the extent of flooding within this specific geographic zone. The boundary of the Junagadh district, Porbandar district and *Ghed* region is demarcated by different colors as shown in Fig. 6.

The variations in flood impact across villages reflect both the topographic and geographic diversity within the *Ghed* region, where low-lying areas experience higher susceptibility to waterlogging and extended inundation during the monsoon season. This flood-induced landscape transformation has direct implications for agriculture, infrastructure, and resource management in the district.

Fig. 7 presents a detailed overview of the villages in the *Ghed* region, highlighting the extent of flood-affected areas. The shaded regions clearly indicate that flooding has impacted significant portions of several villages, including ghodadar, sitana, nanadiya, ajak, bagasara-ghed, sarma, indrana, padardi, bhathrot, vadala, and balagam in the Junagadh district, as well as kadachh, rajpar, gogan bet, balej, amirpur, revadra, pata, mander, and kadegi in the Porbandar district. This illustrates the widespread impact of the recent flooding. Fig. 6 also identifies the least affected villages, such as farangta, nandarkhi, talodra, zariyavada, and kankasa in the Junagadh district, and navi bandar in the Porbandar district. In total, 11 villages in Junagadh and 9 in Porbandar are highly affected (with more than 50% of their area impacted), while 5 villages in Junagadh and 1 village in Porbandar are minimally affected (with less than 5% of their area impacted).

According to Times of India (TOI) report dated 25th July, 2024 since last couple of years *Ghed* region experienced heavy flood which cause heavy damage in this region that is why farmers have been demanding that Government of Gujarat provide a special package to farmers.

Conclusion

This study was conducted to identify and map flood-vulnerable areas within the *Ghed* region, which spans the Porbandar and Junagadh districts of Gujarat, India for the year of 2024. The *Ghed* region includes a total of 123 villages, with 74 located in Junagadh and 49 in Porbandar. The findings indicate that 11 villages in Junagadh and 9 in Porbandar are highly affected, with more than 50% of their area impacted by flooding, while 5 villages in Junagadh and 1 in Porbandar are minimally affected, with less than 5% of their area impacted. This study will assist to Government of Gujarat (GoG) to take the quick and timely decision to assist the farmers in the *Ghed* region for "Krishi Rahat Package". This rapid analysis is essential for understanding flood dynamics within the *Ghed* region and highlights the need for targeted flood management and adaptation strategies to support resilient agricultural practices and rural development in affected areas. This study is valuable for understanding the specific villages affected by flooding within the *Ghed* region. It highlights the widespread impact of the floodwaters across numerous villages, making it a useful tool for regional planning, disaster management, and flood mitigation efforts. The detailed labeling of village boundaries and names also aids in identifying the most affected areas, which can help prioritize relief and recovery resources.

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Conflict of Interest

The authors declare that they have no conflict of interest.

References

Bhageerath, Y.S., Babu A.S., Durga Rao K.H.V., Sreenivas K. and Chauhan P. (2024). Enhancing precision of flood estimation in EOS-04 SAR imagery: a statistical approach. *Geomatics, Natural Hazards and Risk*, **15(1)**, 2413910.

Bonn, F. and Dixon R. (2005). Monitoring flood extent and forecasting excess runoff risk with RADARSAT-1 data. *Natural Hazards*, **35**, 377-393.

Cho, Y. (2024). Study on the Possibility of Estimating Surface Soil Moisture Using Sentinel-1 SAR Satellite Imagery Based on Google Earth Engine. *Korean Journal of Remote Sensing*, **40(2)**, 229-241.

Domeneghetti, A., Schumann G.J.P. and Tarpanelli A. (2019). Preface: remote sensing for flood mapping and monitoring of flood dynamics. *Remote Sensing*, **11(8)**, 943.

Ermida, S.L., Soares P., Mantas V., Göttsche F.M. and Trigo I.F. (2020). Google earth engine open-source code for land surface temperature estimation from the landsat series. *Remote Sensing*, **12(9)**, 1471.

Gorelick, N., Hancher M., Dixon M., Ilyushchenko S., Thau D. and Moore R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, **202**, 18-27.

Jonkman, S.N. (2005). Global perspectives on loss of human life caused by floods. *Natural hazards*, **34(2)**, 151-175.

Khosravi, K., Nohani E., Maroufinia E. and Pourghasemi H.R. (2016). A GIS-based flood susceptibility assessment and its mapping in Iran: A comparison between frequency ratio and weights-of evidence bivariate statistical models with multi-criteria decision-making technique. *Natural Hazards*, **83(2)**, 947-987.

Kiage, L.M., Walker N.D., Balasubramanian S., Babin A. and Barras J. (2005). Applications of Radarsat 1 synthetic aperture radar imagery to assess hurricane related flooding of coastal Louisiana. *International Journal of Remote Sensing*, **26(24)**, 5359-5380.

Kumar, L. and Mutanga O. (2018). Google Earth Engine applications since inception: Usage, trends, and potential. *Remote Sensing*, **10(10)**, 1509.

Liu, X., Zhai H., Shen Y., Lou B., Jiang C., Li T., Hussain S.B. and Shen G. (2020). Large-scale crop mapping from multisource remote sensing images in google earth engine. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, **13**, 414-427.

Long, S., Fatoyinbo T.E. and Policelli F. (2014). Flood extent mapping for Namibia using change detection and thresholding with SAR. *Environmental Research Letters*, **9(3)**, 035002.

Mandal, D., Kumar V., Bhattacharya A., Rao Y.S., Siqueira P. and Bera S. (2018). Sen4Rice: A processing chain for differentiating early and late transplanted rice using time-series Sentinel-1 SAR data with Google Earth engine. *IEEE Geoscience and Remote Sensing Letters*, **15(12)**, 1947-1951.

Matgen, P., Hostache R., Schumann G., Pfister L., Hoffmann L. and Savenije H.H.G. (2011). Towards an automated SAR-based flood monitoring system: Lessons learned from two case studies. *Physics and Chemistry of the Earth*, Parts A/B/C, **36(7-8)**, 241-252.

Mudashiru, R.B., Sabtu N., Abustan I. and Balogun W. (2021). Flood hazard mapping methods: A review. *Journal of Hydrology*, **603**, 126846.

Pande, C.B. (2022). Land use/land cover and change detection mapping in Rahuri watershed area (MS), India using the google earth engine and machine learning approach. *Geocarto International*, **37(26)**, 13860-13880.

Rehman, S., Chaudhary B.S. and Azhoni A. (2024). Appraisal of flood susceptibility of Hooghly basin, India using Shannon entropy (SE) and fuzzy analytical hierarchy process (FAHP). *Environmental Earth Sciences*, **83(16)**, 1-20.

Schumann, G.J.P. and Moller D.K. (2015). Microwave remote sensing of flood inundation. *Physics and Chemistry of the Earth*, Parts a/b/c, **83**, 84-95.

Schumann, G.J., Brakenridge G.R., Kettner A.J., Kashif R. and Niebuhr E. (2018). Assisting flood disaster response with earth observation data and products: A critical assessment. *Remote Sensing*, **10(8)**, 1230.

Shen, X., Wang D., Mao K., Anagnostou E. and Hong Y. (2019). Inundation extent mapping by synthetic aperture radar: A review. *Remote Sensing*, **11(7)**, 879.

Times of India (TOI) report http://timesofindia.indiatimes.com\/articleshow/112000378.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Trambadia, N.K., Patel D.P., Patel V.M. and Gundalia M.J. (2023a). Flood inundation assessment in the data-scarce region using hydrodynamic models and google earth engine-A case of Ghed region, Ozat River basin, Gujarat, India.

Trambadia, N.K., Patel D.P., Patel V.M. and Gundalia M.J. (2023b). Development of a 2D hydrodynamic model for inundation assessment and flood early warning system: a case of depressed Ghed region, India. *Water Practice & Technology*, **18(10)**, 2469-2481.

Vanama, V.S.K., Mandal D. and Rao Y.S. (2020). GEE4FLOOD: rapid mapping of flood areas using temporal Sentinel-1 SAR images with Google Earth Engine cloud platform. *Journal of Applied Remote Sensing*, **14(3)**, 034505-034505.

Vargiya, D., Jethva B. and Pandya D. (2022). Identification of wetlands of international importance in Porbandar, Gujarat, western India during 2015-2021. *Wildfowl*, **72**, 132-151.

Wani, G.F., Ahmed R., Ahmad S.T., Singh A., Walia A., Ahmed P., Shah A.A. and Mir R.A. (2022). Local perspectives and motivations of people living in flood-prone areas of Srinagar city, India. *International Journal of Disaster Risk Reduction*, **82**, 103354.