Identification of flash flood susceptible zones in a highly complex topography and altitude dependent climatically sensitive Himalayan River Basin

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BACKGROUND & MOTIVATION: Flash floods in Uttarakhand

(Image source: https://timesofindia.indiatimes.com/city/dehradun/uttarakhand-house-swept-away-in-chamoli-flash-flood/articleshow/70637390.cms)

(Image source: https://sandrp.in/2018/07/21/uttrakhand-cloudburst-incidents-2018/)

Catastrophe

(Image source: Khanduri et. al., 2018)

(Image source: www.emeraldinsight.com/0965-3562.htm)

(Image source: https://sandrp.in/2019/12/11/uttarakhand-cloud-bursts-in-monsoon-2019-no-doppler-radars-six-years-since-2013-disaster/)

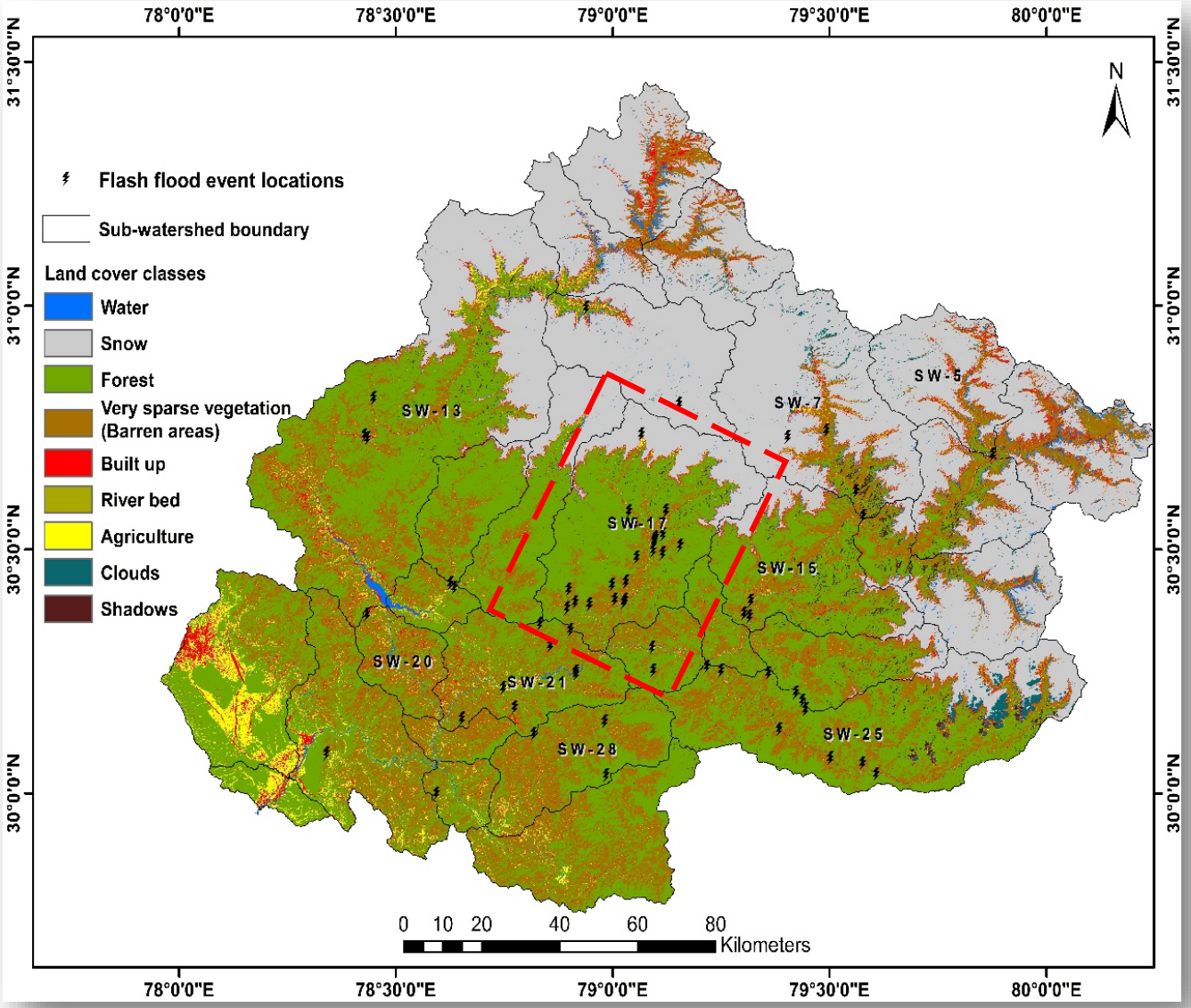
BACKGROUND & MOTIVATION: Why Mandakini River Basin?

Flash flood vulnerability zonation of Upper Ganga Basin (Singh & Pandey, 2021)

- Flash flood inventory was prepared
- MRB was a highly critical and vulnerable sub-watershed

Major challenges:

- There was no FF event location database available in public domain.
- Sparse weather monitoring infrastructure in the region and a sparse rain gauge network in the state.



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Flash flood susceptibility concept

- Flash Flood Susceptibility (FFS) concept reflects the likelihood of flash flood events occurring in an area based on local terrain, geographical and hydrometeorological factors.

- FFS modeling - constructive, feasible, and implicit solution for classifying an area into zones where future flash floods may occur, and efforts can be made to attenuate their consequences.

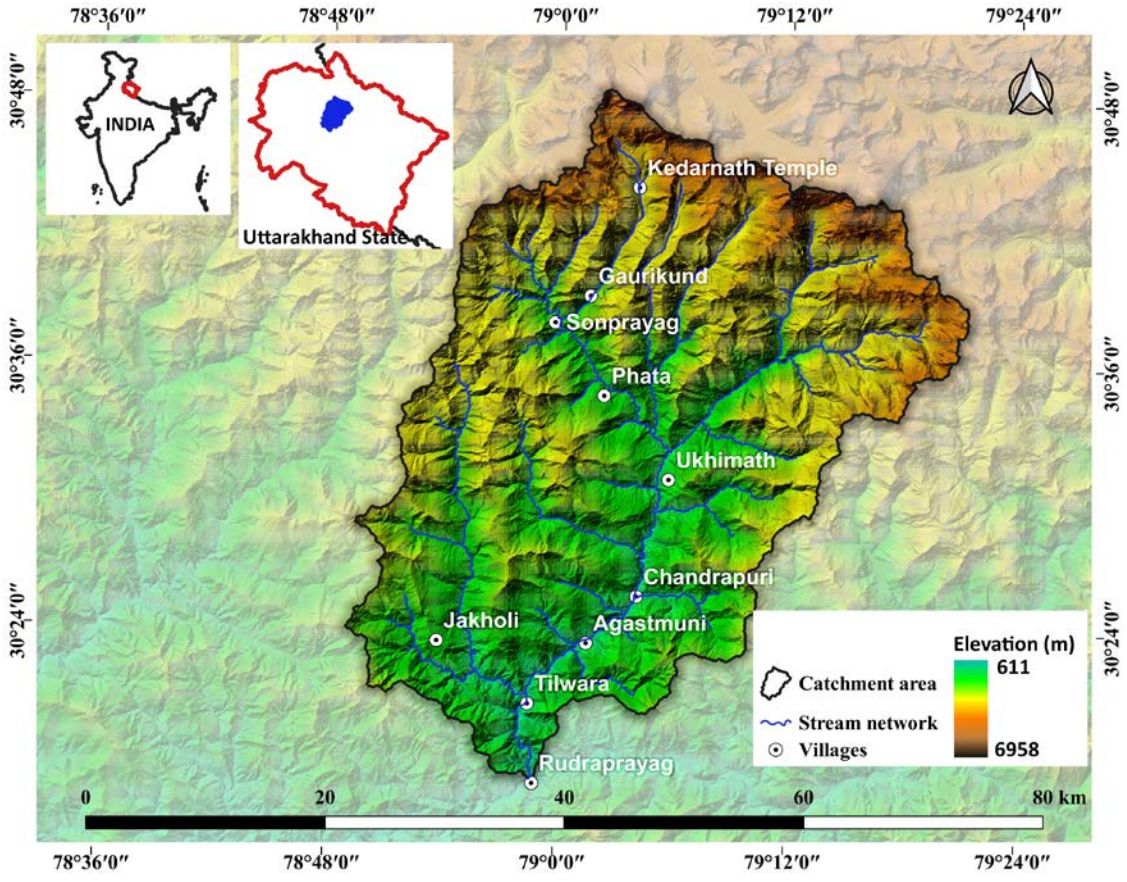
- The mainstay for the susceptibility assessment in this study is the selection and mapping of highly influential predictors to detect and appraise the specific areas prone to flash floods

STUDY AREA & DATA

Mandakini River Basin

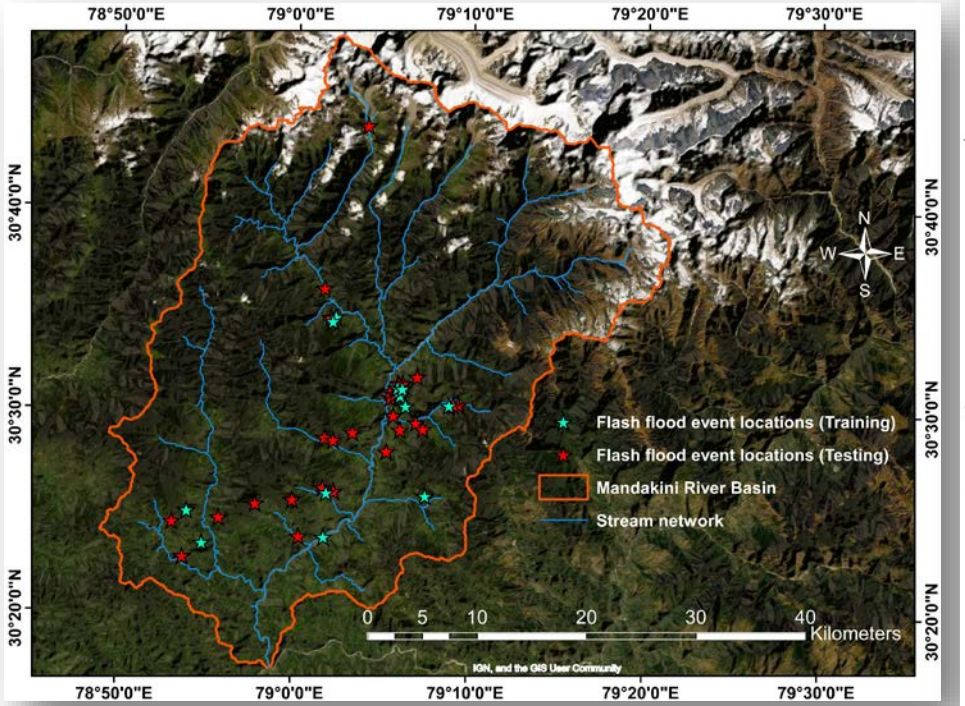
Geographical extent: **30◦17′0.69″N to 30◦48′ 50.58″N and 78◦49′1.30″ E to 79◦21′ 59.59″ E**

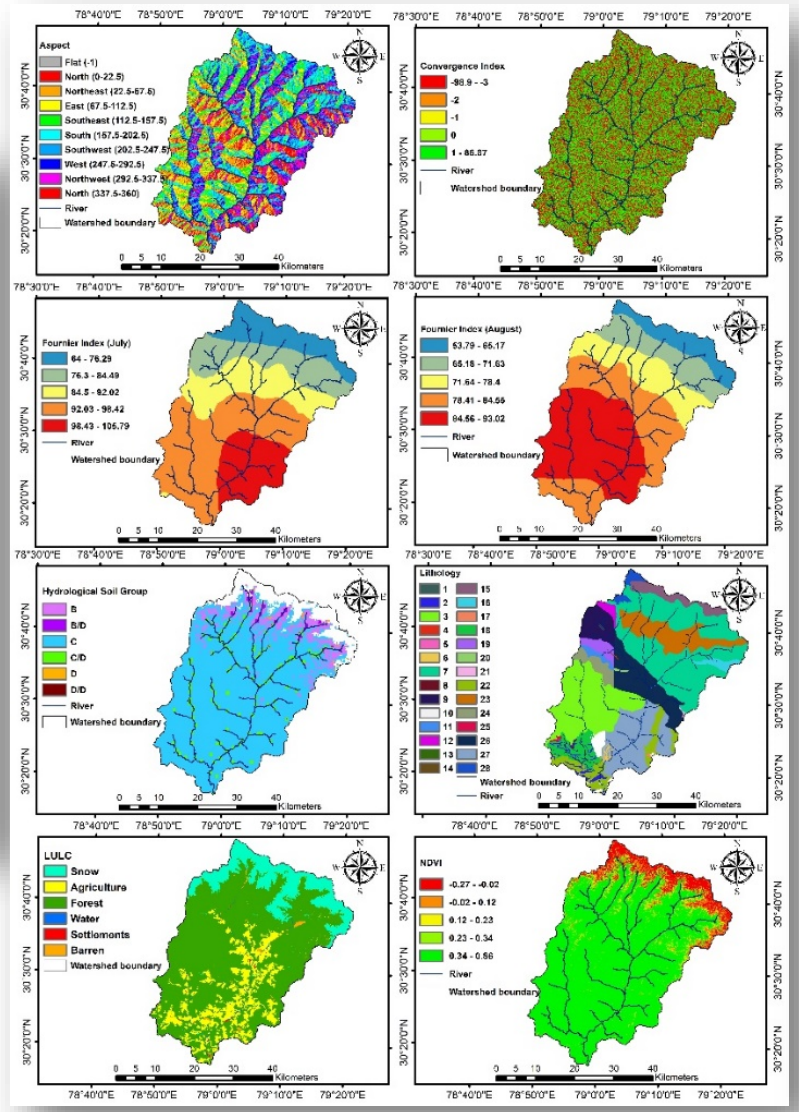
Area= **1642 sq. km.**

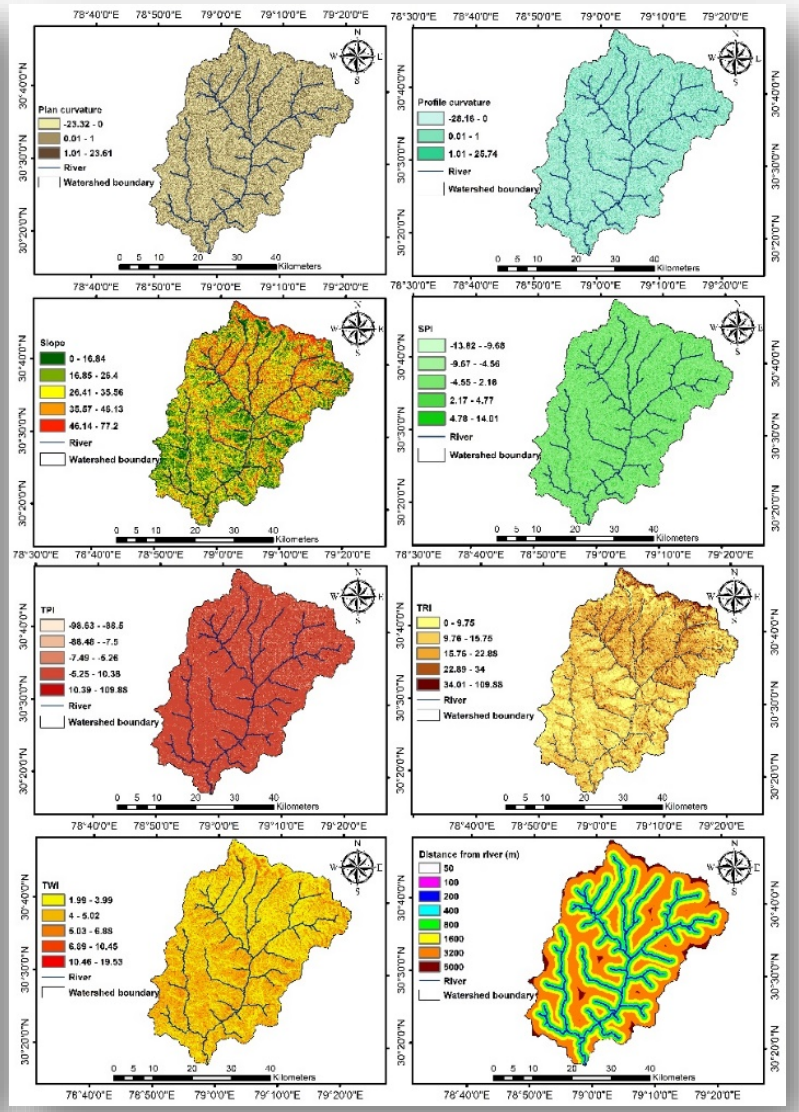


S. No.	Input data (Spatial resolution) [data source]	Conditioning factor (15)
1	SRTM-DEM (30 m) [https://search.earthdata.nasa.gov/]	(1) Aspect, (2) Convergence Index, (3) Plan curvature, (4) Profile curvature, (5) Slope, (6) Stream Power Index, (7) Topographic Position Index, (8) Topographic Roughness Index, (9) Topographic Wetness Index, (10) Distance from the river
2	Landsat 8 (30 m) [https://search.earthdata.nasa.gov/]	(11) NDVI, (12) LULC map
3	GPM IMERG (0.1° half-hourly rainfall data) [https://giovanni.gsfc.nasa.gov/Giovanni]	(13) Fournier Index map
4	HSG (250 m) [https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1566]	(14) HSG map
5.	Lithology [https://bhukosh.gsi.gov.in]	(15) Lithology

MAJOR INPUTS

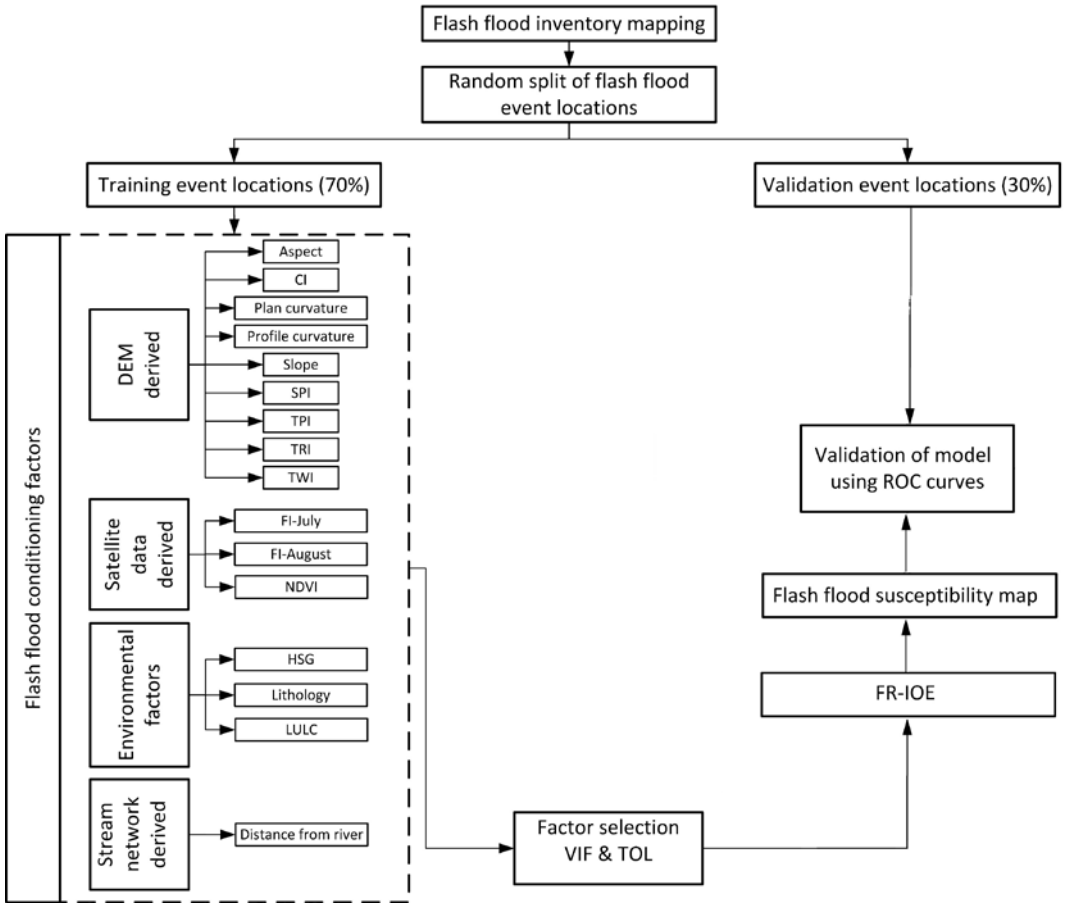






Gagandeep Singh & Ashish Pandey, "Hybrid ensemble modeling for flash flood potential assessment and susceptibility analysis of a Himalayan river catchment", in Geocarto International, Taylor & Francis, 2021 https://doi.org/10.1080/10106049.2021.2017007

METHODOLOGY



FR- quantifies the spatial overlap between the flash flood locations and the conditioning factor classes.

$$FR = \frac{\left(Np\left((LXi)/\left(\sum_{i=1}^{m} Np(LXi)\right)\right)\right)}{\left(Np\left((Xj)/\left(\sum_{i=1}^{n} Np(Xj)\right)\right)\right)}$$

class i; conditioning factor j;
Np(LXi): number of flash flood event locations in each class i of factor X;
Np(Xj): number of pixels within a conditioning factor Xj;
m: number of classes of each conditioning factor Xi;
n: number of conditioning factors in the study area.

IOE- is used for evaluating the uncertainty and instability of a system.
In this study, the entropy of flash flood events indicates the contribution of various conditioning factors in the occurrence of flash floods.

$$FFPI_{FR-IOE} = \sum_{j=1}^{n} FR_{ij} W_j$$

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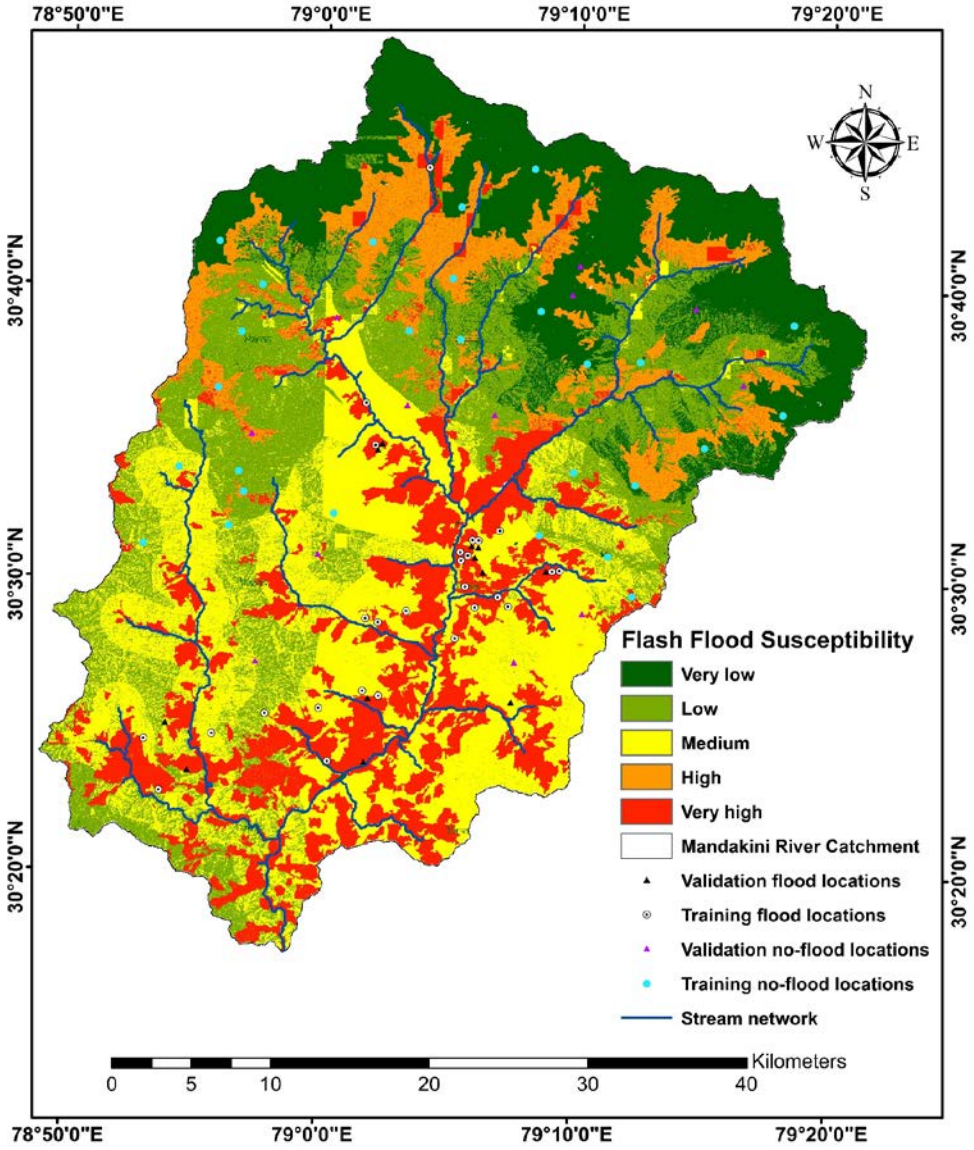
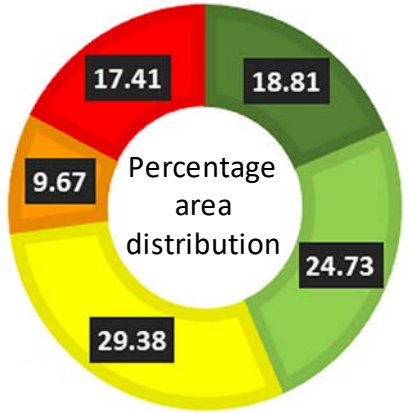
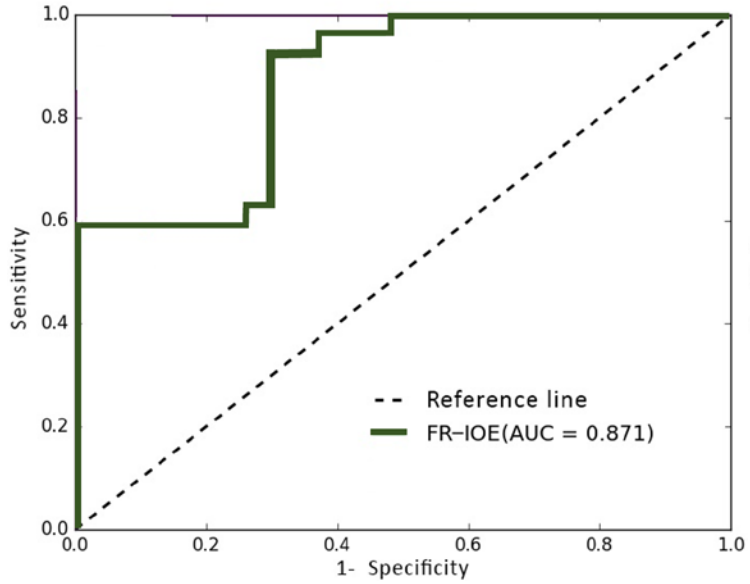
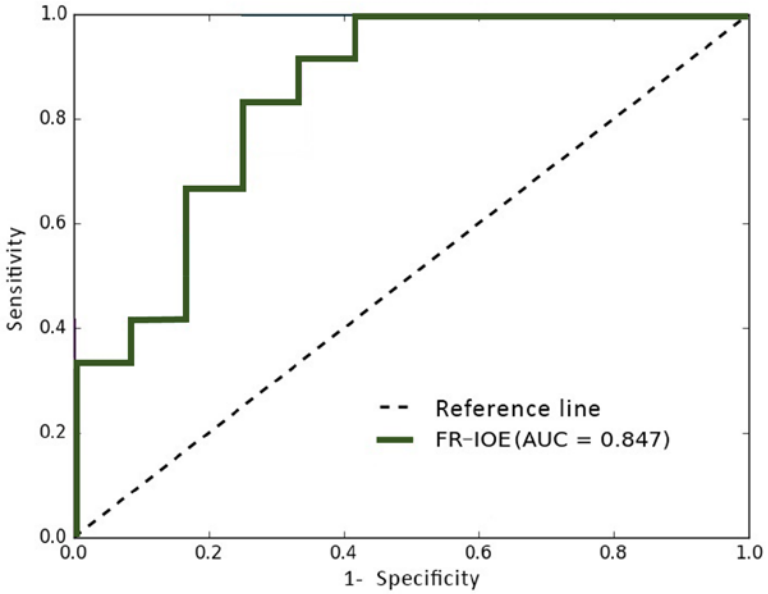
RESULTS







Success rate:
Training ROC



Prediction rate:
Testing ROC

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POTENTIAL APPLICATIONS/ SOCIETAL IMPACT

- The **methodology** can be adopted to identify flash flood susceptible areas in various vulnerable watersheds.

- Additionally, using the flash flood susceptibility map the decision-makers and local authorities can identify most susceptible towns and villages in the region and plan the future expansion accordingly.

- Preferences for construction and infrastructural development should be given to low and very low susceptible areas.

- Information can be beneficial for government agencies and implementation authorities viz. National/State Disaster Management Authority (NDMA/SDMA), National/State Disaster Response Force (NDRF/SDRF), Irrigation Department, City and Village Development Authorities, and other disaster mitigation agencies to frame guidelines and execute management plans to minimize life loss and property damage in flood-affected areas.

Article:

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Thank you!

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Please email any questions to Gagandeep Singh

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