

## Flood Susceptibility and Risk Assessment of Kolhapur District, Maharashtra, India: An Integrated GIS and Remote Sensing Approach Using Multi-Criteria Spatial Analysis

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### Abstract

Kolhapur district in southern Maharashtra, India, has experienced recurrent and increasingly severe flood events over the past two decades; the catastrophic 2019 flood alone displaced over 700,000 people and caused losses exceeding INR 8,000 crore. Despite this extreme vulnerability, a spatially explicit, district-wide assessment integrating flood susceptibility, hazard, and risk at a high resolution has remained a critical research gap. This study presents a comprehensive flood susceptibility and risk assessment for Kolhapur district using an integrated GIS and remote sensing framework. Flood susceptibility was modeled via multi-criteria spatial analysis integrating six conditioning factors: slope, rainfall, elevation, drainage density, land use/land cover (LULC), and soil type. These variables were derived from SRTM DEM, IMD gridded rainfall data, and multi temporal Landsat satellite imagery processed within Google Earth Engine (GEE). The Flood Susceptibility Index (FSI) was computed using a weighted overlay approach calibrated against historical flood inventory data. Flood risk was subsequently quantified by intersecting the FSI with high-resolution exposure layers—specifically population and urban density data derived from WorldPop and the Global Human Settlement Layer (GHSL).

The results indicate that the FSI across Kolhapur district ranges from 0.2 to over 0.9, with a dominant central tendency between 0.35 and 0.55. Flood risk reveals a highly concentrated spatial pattern: the urban core of Kolhapur city and adjacent, densely settled lowlands along the Panchganga River bear a disproportionate share of district-wide risk, exhibiting risk index values between 0.4 and 0.65 in the highest-vulnerability zones. Quantile-based classification identifies approximately 12% of the district as high-risk, heavily concentrated in the northern and central tehsils. Conversely, the southern and western zones—despite high susceptibility driven by intense Western Ghats rainfall—exhibit lower risk due to sparse population settlement. The non-linear relationship between flood susceptibility and flood risk, alongside the critical role of urban density as a risk amplifier, emerges as the central finding of this study. These outcomes provide the first high-resolution, spatially explicit flood risk map of Kolhapur district, offering a direct evidence base for proactive land-use planning, urban expansion zoning, and flood early warning system design.

### Keywords

Flood susceptibility, flood risk assessment, GIS, remote sensing, Kolhapur, Maharashtra, multi criteria analysis, urban flood, population exposure, Panchganga River.