Flood Modelling & Analysis

Assignment-2

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Region of interest

We have chosen the city of Hyderabad as our area of interest for this assignment. Hyderabad experiences a tropical wet and dry climate, characterized by hot summers, moderate monsoons, and mild winters. The monsoon season (June to September) is crucial, bringing heavy rainfall that can lead to flooding, especially in urbanized areas.

Factors chosen

<u>Hydrological Factors</u>:

- Runoff
- Groundwater Levels
- Soil Organic Carbon Content

<u>Topological Factors</u>:

- Digital Elevation Model (DEM)

Land Use/Land Cover (LULC)

<u>Meteorological Factors</u>:

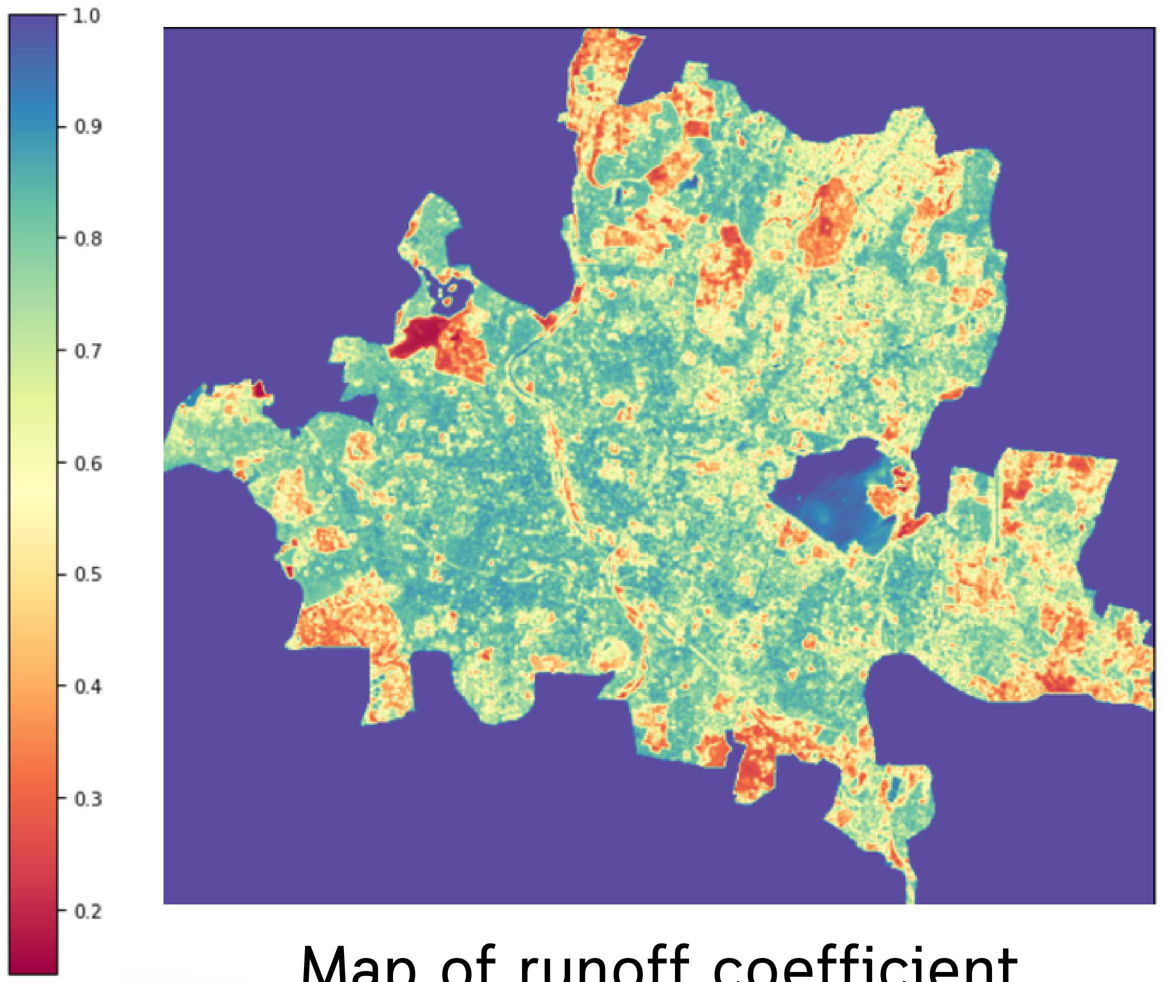
- Rainfall (also falls under hydrological)

<u>Socio-Economic Factors</u>:

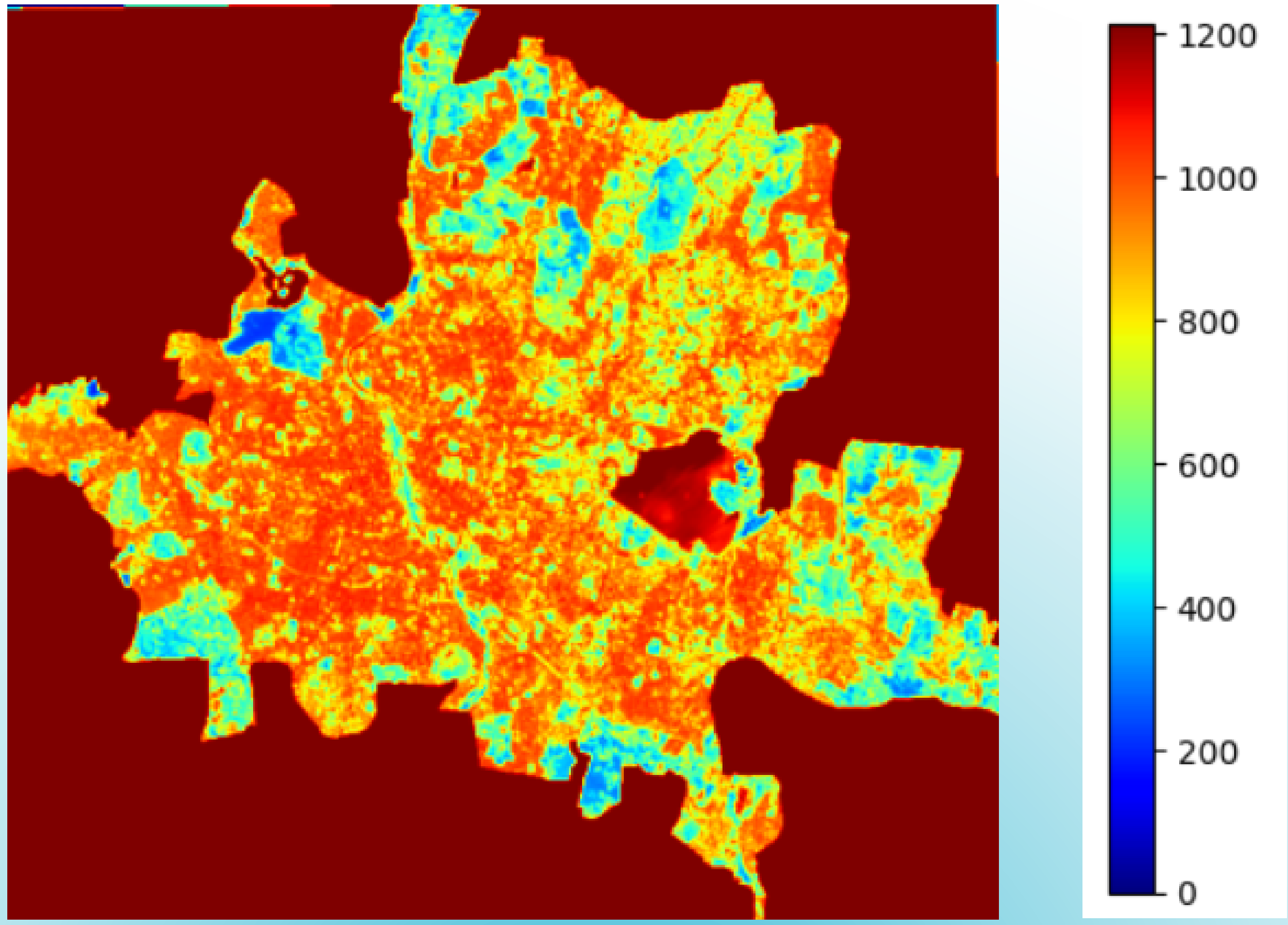
- Human Settlement and Built-Up Areas
- Poverty

Runoff Quantity

- The amount and intensity of rainfall determine the volume of water input, which is critical for predicting runoff and flood peak levels.
- Q=CIA (Rational formula)
- We estimated the runoff coefficient on the basis of **NDVI** values which provide info on vegetation cover.
- The runoff coefficient is inversely related to NDVI, as areas with higher vegetation cover (high NDVI) generally allow more infiltration and have lower runoff.



Map of runoff coefficient

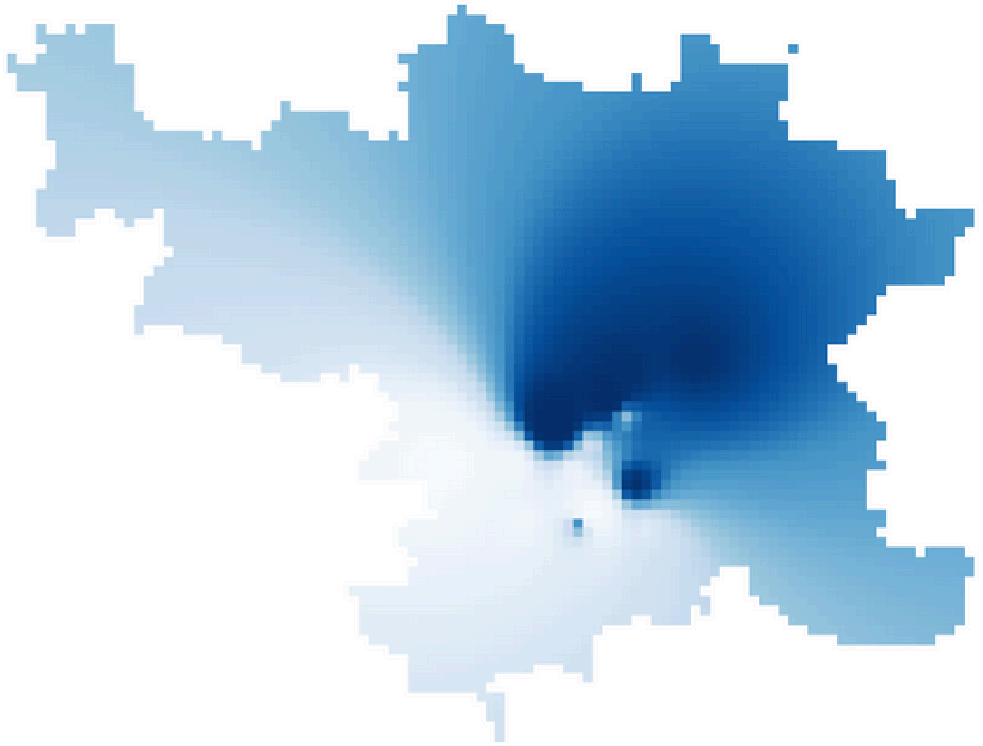


Map of runoff quantity/discharge

Rainfall

- We took rainfall data from various stations across hyderabad.
- Plotted them with their coordinates on the map.
- Interpolated the values using IDW method to have a better idea.

FINDINGS: central, north eastern parth has higher amount of rainfall throughout the year.



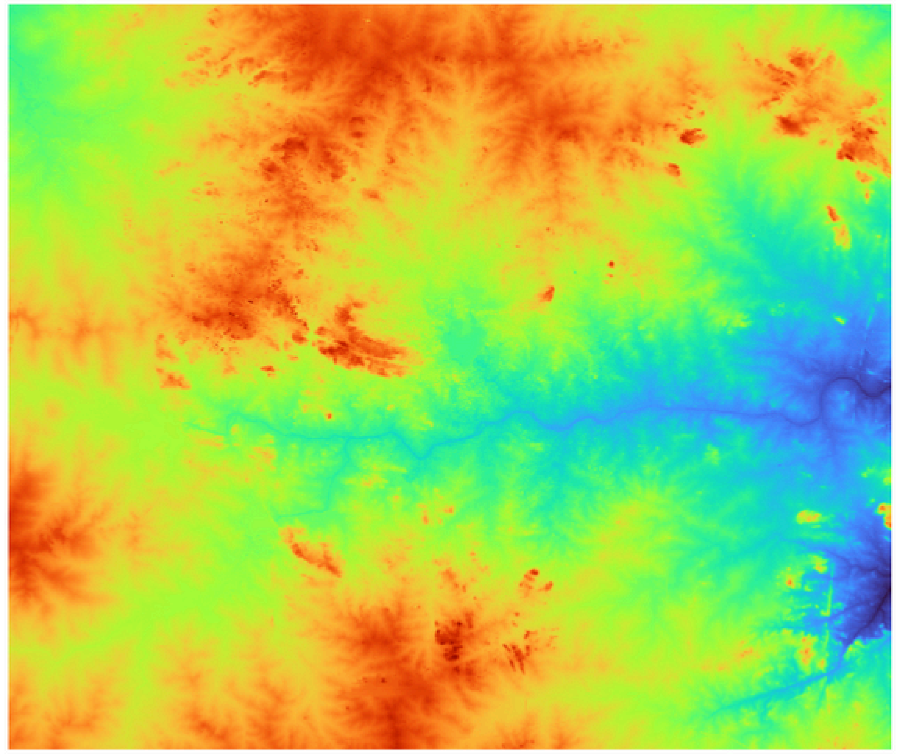
Interpolated map of Rainfall values

Value	Color	Label
696.114429...		696.1144
706.971175...		706.9712
717.827919...		717.8279
728.684664...		728.6847
739.541410...		739.5414
750.398154...		750.3982
761.254900...		761.2549

Digital Elevation Model

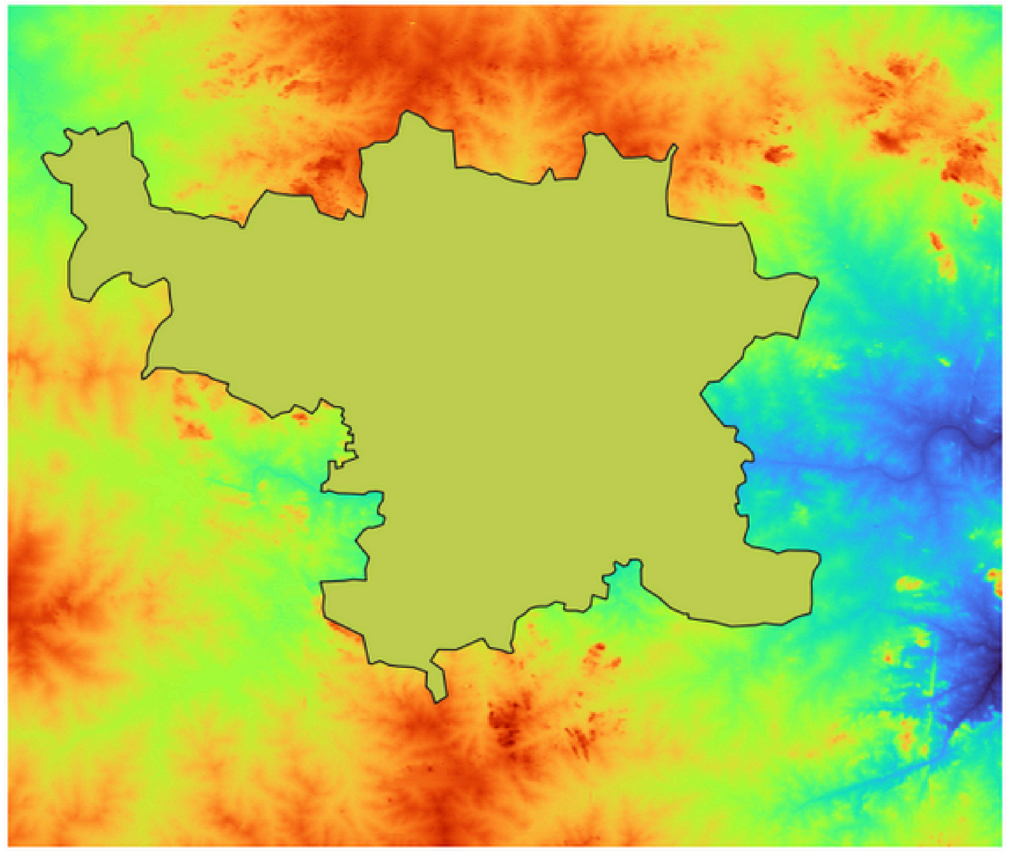
Digital Elevation Models (DEMs) are critical in flood modeling because they provide high-resolution information on terrain elevations, which directly influences water flow and flood behavior.

- Determining Flow Paths and Drainage Patterns
- Identifying Low-Lying and Flood-Prone Areas
- Slope and Gradient Calculation

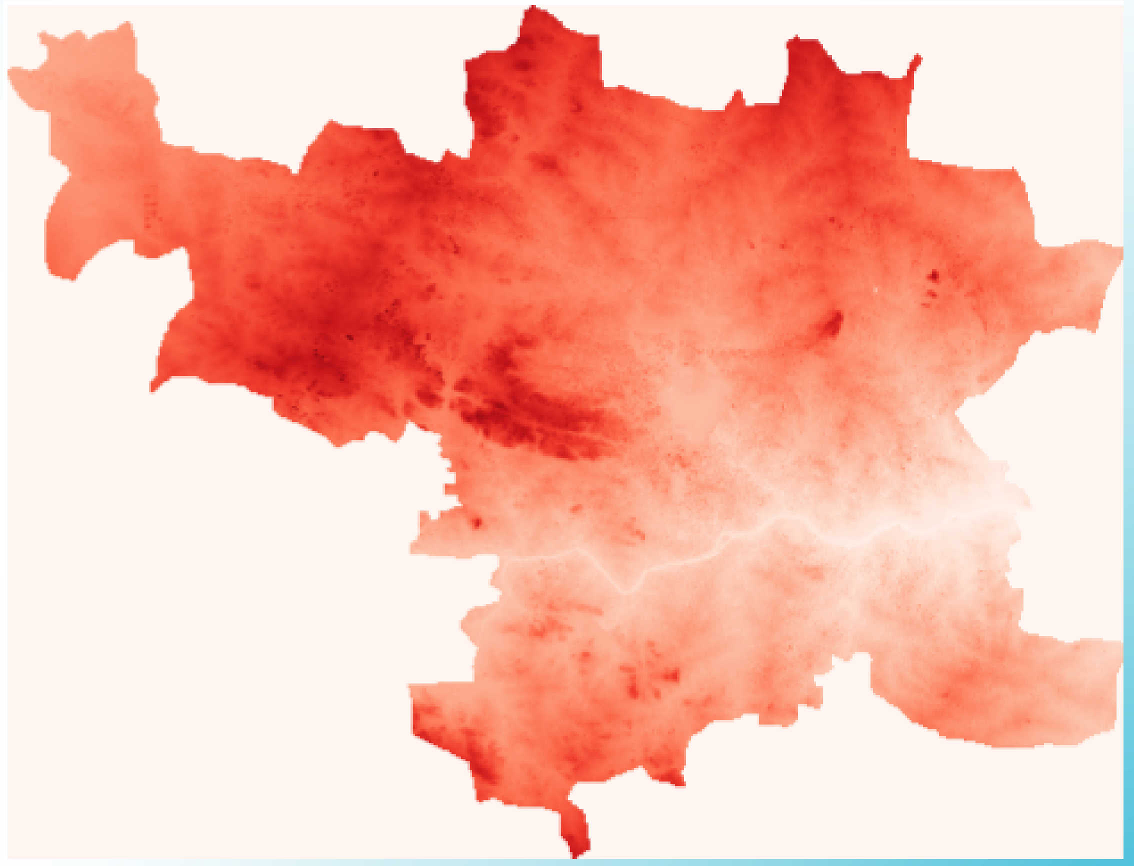


1) DEM of hyderabad and nearby districts

Value	Color	Label
0		0
165		165
330		330
494		494
659		659



2) DEM with the hyderabad boundary



3) DEM clipped to hyderabad boundary

Groundwater

- Groundwater levels play a significant role in flood modeling because they affect how much additional water the soil can absorb.
- When groundwater levels are high, the soil is often already near saturation, meaning it can absorb less rainfall. This results in more surface runoff, which can increase flood severity and duration.
- In areas where groundwater levels are low, there is more capacity for soil infiltration, which can reduce surface runoff and potentially mitigate flooding.
- For groundwater levels, we took data of various stations (telemtric and manual both) across hyderabad -> plotting-> idw interpolation.

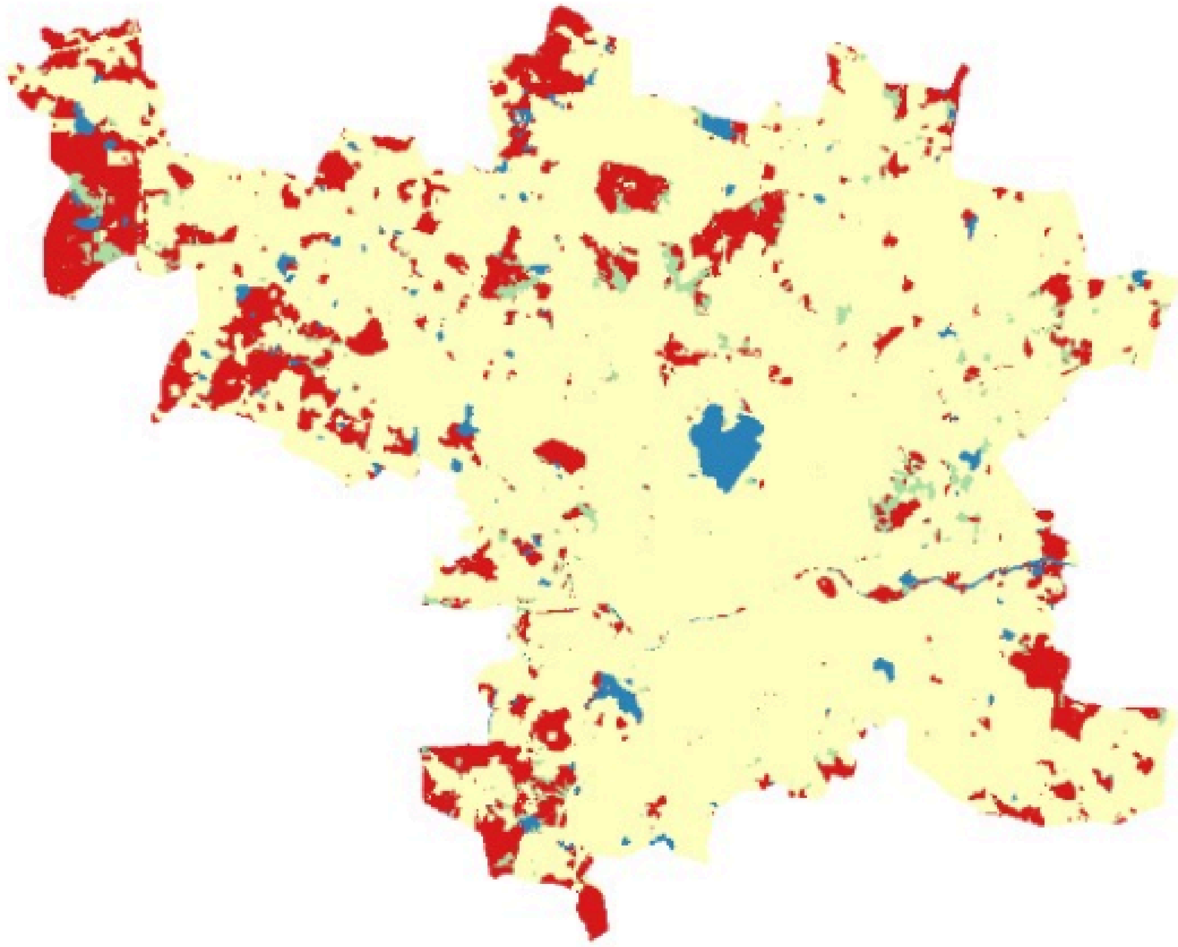
<u>FINDINGS</u>- central, north western regions have higher ground water levels (implying more saturated soil-> more surface runoff-> high chances

Value	Color	Label
2.8733933		2.8734
6.29911775...		6.2991
9.72484220...		9.7248
13.15056665		13.1506
16.5762910...		16.5763
20.0020155...		20.0020
23.42774		23.4277

Interpolated map of groundwater level values

Land use Land cover

- Purpose: LULC analysis helps determine flood susceptibility based on land type characteristics.
- LULC Categories:
  - Classified into water bodies, vegetation, urban areas, agricultural land, and barren land.
  - Categories ranked by flood susceptibility based on impermeability and runoff potential.
- Reclassification Process:
  - Assigned flood-proneness scores (1 to 5) to each land cover type.
  - Higher scores for impermeable surfaces (e.g., water bodies, urban areas).
  - Lower scores for permeable surfaces (e.g., vegetation).
- Raster Calculator Application: Used reclassified scores to generate a raster map of flood-prone areas.
- Color Scheme:
  - Blue = Highest flood risk (e.g., urban, water bodies)
  - Yellow = Moderate flood risk
  - Red = Lowest flood risk (e.g., vegetation)



Map of land use land cover of hyderabad region

Value	Color	Label
1		1.0000
2		2.0000
3		3.0000
4		4.0000
5		5.0000

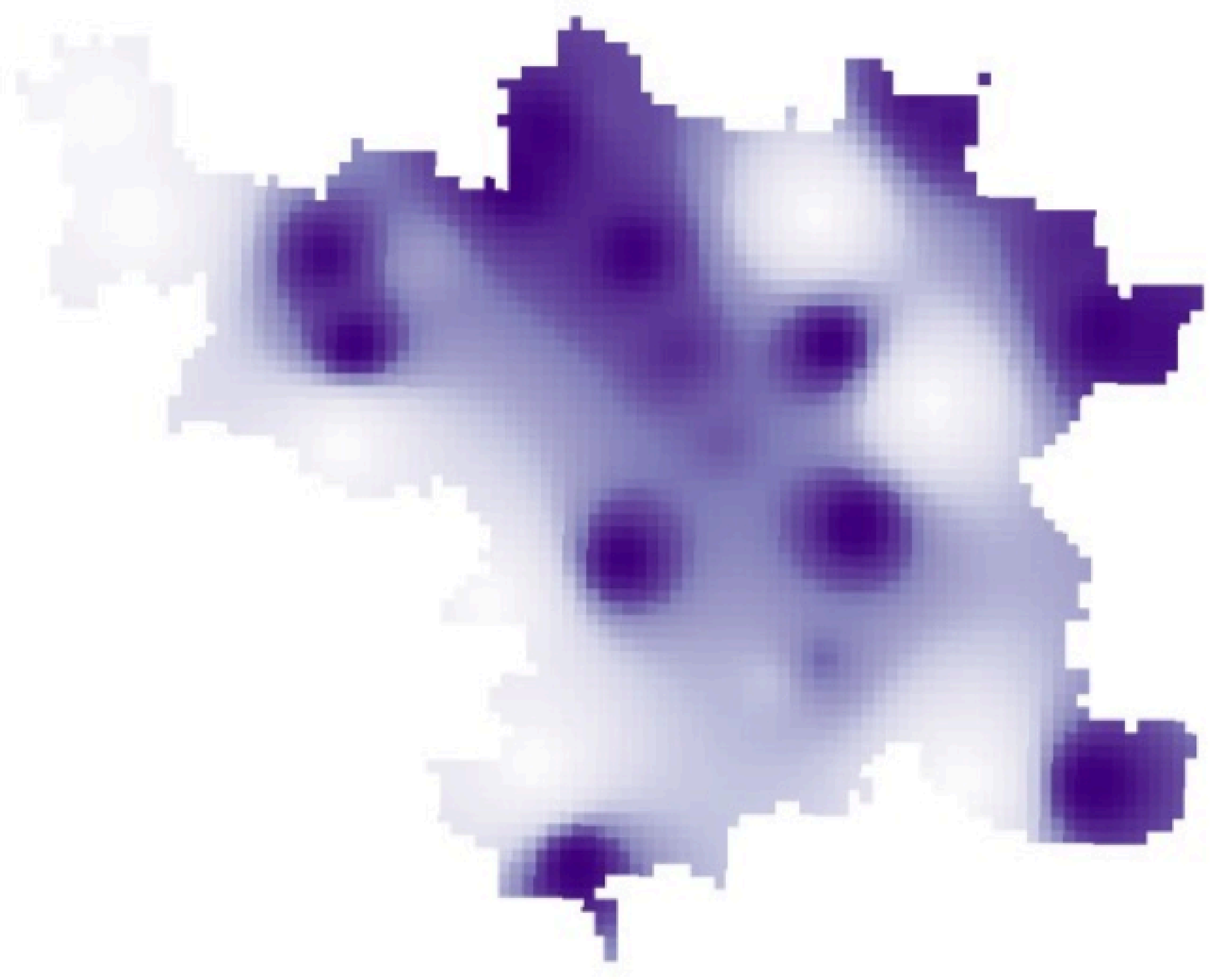
Human settlement

- Purpose:
  - High-density urban areas are more vulnerable to flooding due to impermeable surfaces (e.g., concrete, asphalt).
  - GHSL data aids in identifying flood-prone areas based on urban density.
- Data Interpretation:
  - High-density areas (darker shades in output) represent zones with substantial human infrastructure, prone to increased runoff and reduced water absorption.
  - Low-density areas (lighter shades) have more open spaces, allowing better water infiltration and lower flood risk.
- Color Coding in Output:
  - Light pink indicates low human settlement density.
  - Darker pink to violet represents higher human settlement and built-up density.
- Regions:
  - Central and western parts of Hyderabad exhibit high-density settlements.
  - Outskirts and green zones show lower settlement density, indicated by lighter colors.
- Impact on Flood Risk:
  - Densely populated urban zones increase flood risk, emphasizing the need for effective drainage systems.
  - This socio-economic layer helps in flood management planning by identifying high-risk zones requiring mitigation measures.

Value	Color	Label
0		0
2500		2500
5000		5000
7500		7500
10000		10000

Poverty

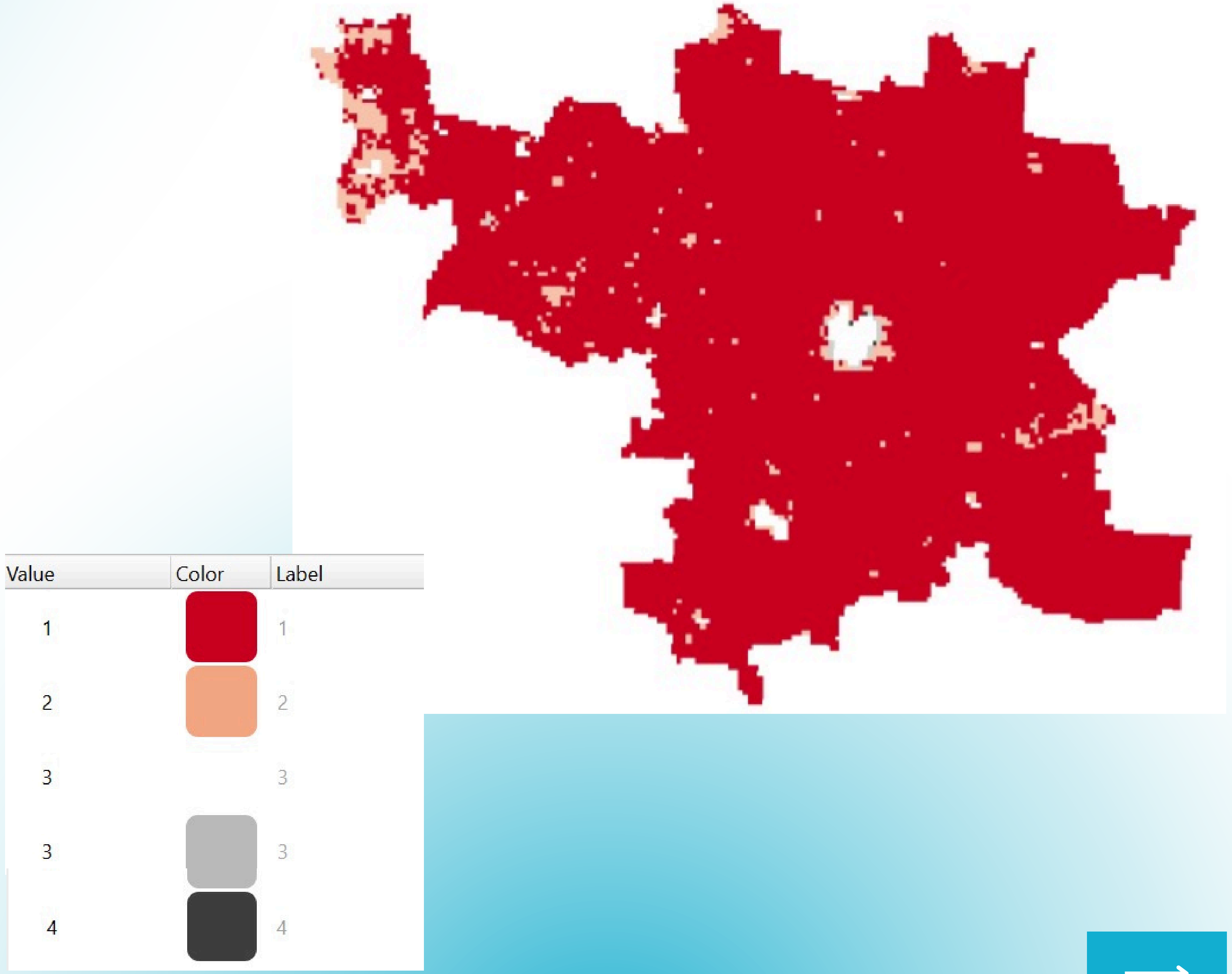
- Importance of Poverty in Flood Vulnerability:
  - Indirect Impact: While poverty doesn't cause flooding, it significantly increases vulnerability to flood impacts.
  - Poorer communities often lack robust infrastructure, insurance, and access to emergency services.
  - This leads to higher risks during floods and longer recovery times afterward.
- Spatial Interpolation:
  - Used Inverse Distance Weighting (IDW) method.
  - Created a continuous poverty distribution map to visualize poverty concentrations.
- Interpretation of Output Map:
  - Darker Areas: Indicate higher poverty levels.
  - Lighter Areas: Represent lower poverty levels.
- Regional Insights:
  - Higher Poverty Levels: Observed in the northern and eastern regions of Hyderabad.
  - Lower Poverty Levels: Found in central and southern regions.
- Overlay Analysis:
  - Combined poverty map with other flood-prone indicators.
  - Identified regions with both high flood susceptibility and high poverty.
  - Prioritization:
  - These areas are prioritized for targeted flood management and socio-economic support.



Value	Color	Label
0.1504957		0.1505
25.0817286		25.0817
50.0129615		50.0130
74.9441944		74.9442
99.8754272		99.8754

Soil organic carbon content

- Importance of Soil Organic Carbon:
  - Water Retention
  - Flood Mitigation
  - Low organic carbon content leads to faster runoff and higher flood risk, particularly in urbanized areas with impervious surfaces.
- Interpretation of Output Map:
  - Color Scheme:
    - Red Areas: Indicate regions with low organic carbon, implying high flood susceptibility.
    - Black Areas: Represent areas with higher organic carbon, suggesting lower flood risk.
  - Regional Insights:
    - Northern and Western Hyderabad: Dominated by low organic carbon content, leading to higher flood risk.
    - Central Regions: Display higher organic carbon levels, which implies better water retention and reduced flood risk.



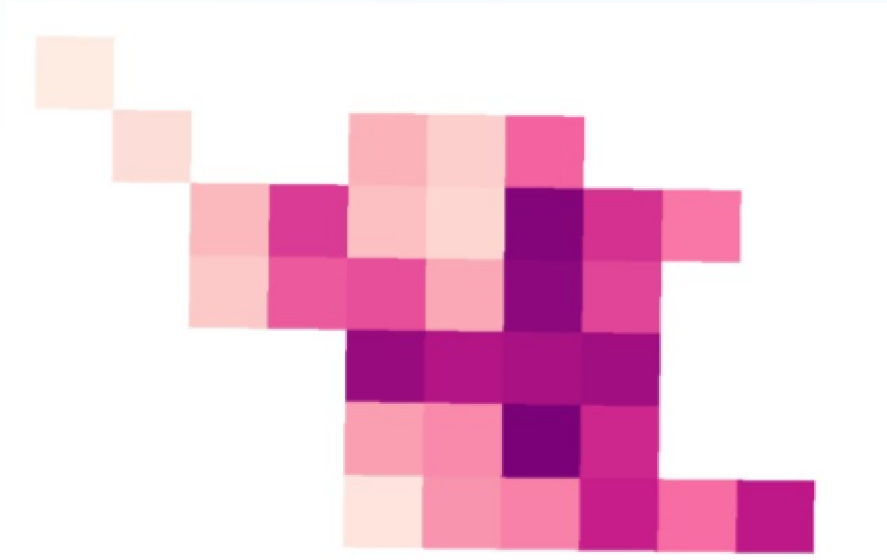
Weights assigned to different factors

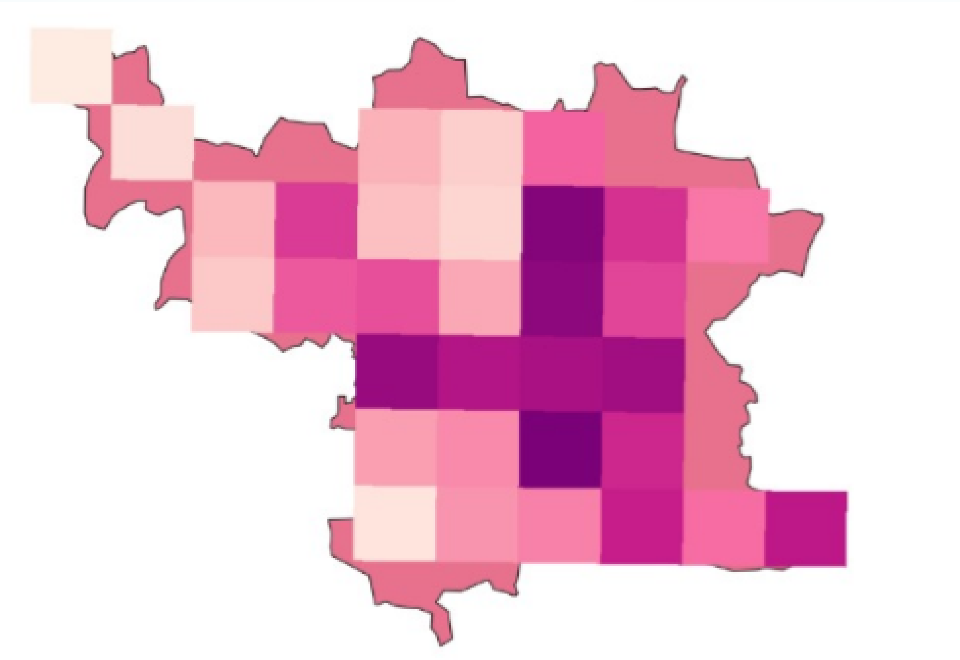
- Rainfall: 25%
- Groundwater: 10%
- DEM (Elevation): 15%
- Poverty: 5%
- Soil (Organic Carbon Content): 15%
- LULC: 20%
- Human Settlement and Built-Up Area: 10%

OUTPUT

- The Raster Calculator tool in QGIS was used to combine the spatial layers of selected flood-related factors, allowing us to create a weighted flood proneness map for Hyderabad. By assigning specific weights to each factor based on its influence on flood susceptibility, we achieved a composite representation of flood risk across the study area. Below formula was used to get the final output:

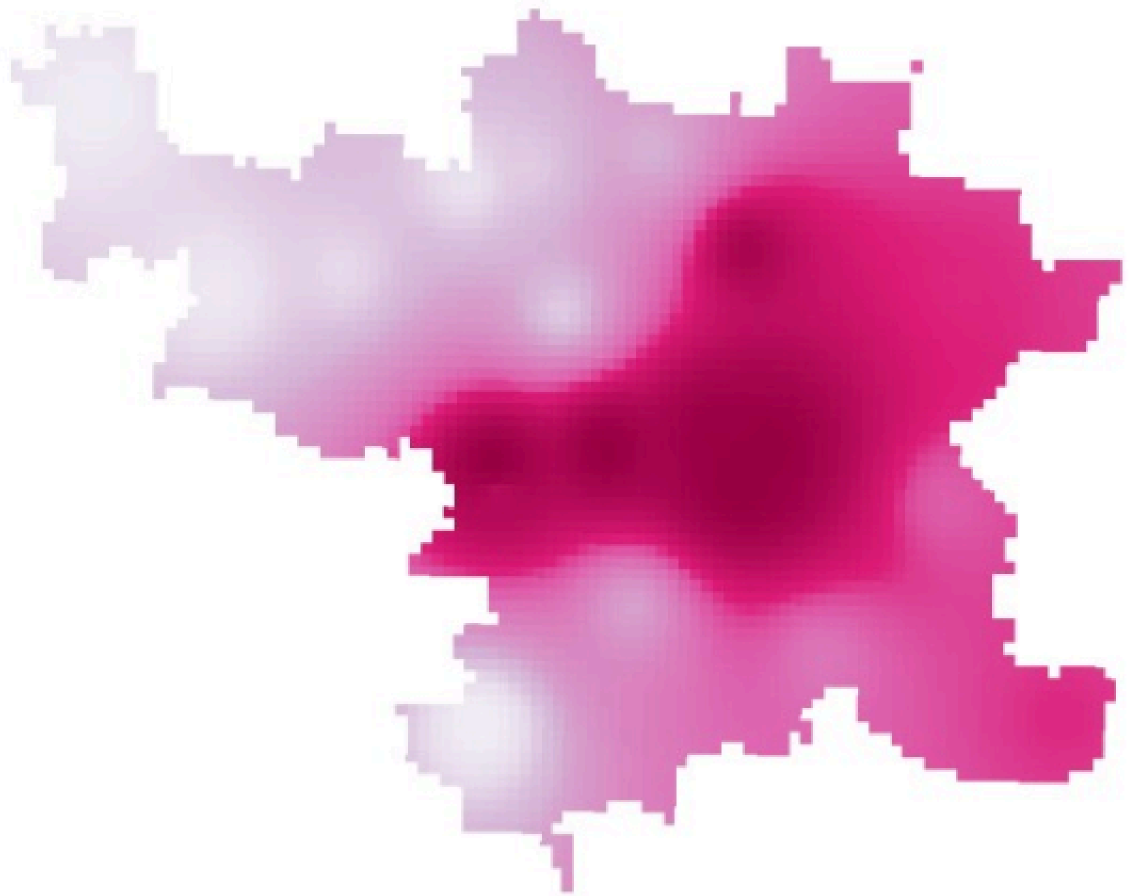
Flood Proneness = ("new_rain_idwclipped@1"×0.25) + ("new_gw_idwclipped@1"×0.10)+ ("dem_clipped@1"×0.15)+("Poverty clipped@1"×0.05)+ ("Raster Soil@1"×0.15)+ ("Red - Raster calculator@1"×0.20)+ ("Hyderabad settlement output@1"×0.10)





Value	Color	Label
262.9805908		262.9806
437.8488159		437.8488
612.717041		612.7170
787.5852661		787.5853
962.4534912		962.4535

OUTPUT



- After performing raster calculation, we interpolated the values with IDW interpolation method to get a smoother image throughout hyderabad by adjusting the resolution to the other layers and adjusting raster cell size for better quality.

<u>FINDINGS</u>: We can see that the central and north eastern region is more prone to floods which is in line with the outputs of every individual factor as well.

Value	Color	Label
10.0177975		10.0178
32.5006261		32.5006
54.9834547		54.9835
77.4662833		77.4663
99.9491119		99.9491

Related research papers

RAINFALL:

- Satellite Remote Sensing and GIS-based Multi-Criteria Analysis for Flood Hazard Mapping - Francesca Franci
- Flood Hazard Mapping Using Fuzzy Logic, Analytical Hierarchy Process, and Multi-Source Geospatial Datasets - Saeid Parsian (pg 4)
- Incorporating Probabilistic Approach into Local Multi-Criteria Decision Analysis for Flood Susceptibility Assessment - Zhongqian Tang
- Disaggregation of the Copernicus Land Use/Land Cover (LULC) and Population Density Data to Fit Mesoscale Flood Risk Assessment Requirements in Partially Urbanized Catchments in Croatia - Bojana Horvat
- Flood Vulnerability Assessment Using an Integrated Approach of Multi-Criteria Decision-Making Model and Geospatial Techniques - K. S. Vignesh

DEM:

- Satellite Remote Sensing and GIS-based Multi-Criteria Analysis for Flood Hazard Mapping - Francesca Franci
- Assessment of Flood Hazard Areas at a Regional Scale Using an Index-Based Approach and Analytical Hierarchy Process: Application in Rhodope-Evros Region, Greece - Nerantzis Kazakis
- Estimation of Flood Land Use/Land Cover Mapping by Regional Modelling of Flood Hazard at Sub-Basin Level: Case Study of Marand Basin - Seid Mohamad Mousavi
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GROUNDWATER:

- Satellite Remote Sensing and GIS-based Multi-Criteria Analysis for Flood Hazard Mapping - Francesca Franci

POVERTY:

- Predicting Flood Insurance Claims with Hydrologic and Socioeconomic Demographics via Machine Learning: Exploring the Roles of Topography, Minority Populations, and Political Dissimilarity - James Knighton
- Disaggregation of the Copernicus Land Use/Land Cover (LULC) and Population Density Data to Fit Mesoscale Flood Risk Assessment Requirements in Partially Urbanized Catchments in Croatia - Bojana Horvat

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- Estimation of Flood Land Use/Land Cover Mapping by Regional Modelling of Flood Hazard at Sub-Basin Level: Case Study of Marand Basin - Seid Mohamad Mousavi

HUMAN SETTLEMENT:

- Assessment of Flood Hazard Areas at a Regional Scale Using an Index-Based Approach and Analytical Hierarchy Process: Application in Rhodope–Evros Region, Greece - Nerantzis Kazakis
- Disaggregation of the Copernicus Land Use/Land Cover (LULC) and Population Density Data to Fit Mesoscale Flood Risk Assessment Requirements in Partially Urbanized Catchments in Croatia - Bojana Horvat

Thank you!!