Flood Susceptibility Assessment for Coastal Villages of Southern Tamil Nadu: An Integrated GIS and AHP Approach

Aswin S.K.[1,2], Stephen Pitchaimani V.[1*] and Antony Alosanai Promilton A.[1]
1. PG & Research, Dept. of Geology, V.O. Chidambaram College, Thoothukudi, Tamilnadu, 628008, INDIA
2. Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu. 627012, INDIA
*stephen.geo@voccollege.ac.in

Abstract
Floods are among the most devastating natural disasters globally causing significant loss of life, property damage and economic disruption across communities. This study presents a comprehensive flood susceptibility assessment of the coastal villages from Mookkaiyur to Tharuvaikulam in Southern Tamil Nadu, India, using an integrated approach combining remote sensing, Geographic Information Systems (GIS) and the Analytical Hierarchy Process (AHP). Ten critical parameters: geomorphology, rainfall, slope, Topographic Wetness Index (TWI), land use/land cover, soil type, lithology, Normalized Difference Vegetation Index (NDVI), distance from river and distance from road, were analysed to develop a detailed flood susceptibility map of the region. The study area spanning approximately 320 sq. km was evaluated using various data sources including SRTM DEM, Landsat-8 imagery and meteorological data. The AHP method assigned appropriate weightages to these parameters ranging from 18 for geomorphology to 6 for NDVI.

The resulting flood susceptibility map reveals that 26.76% of the study area falls under medium susceptibility, while 35.15% exhibits high to very high susceptibility to flooding. The analysis identified that areas with very low slopes, high rainfall and flood-prone geomorphological units combined with poor drainage characteristics of Vertisols and black clay lithology are particularly vulnerable to flooding. This study provides crucial insights for flood risk management and urban planning and may be effectively applied to similar coastal regions for comprehensive flood risk assessment.

Keywords: Flood susceptibility, AHP, GIS, Remote sensing, Multi-criteria analysis, Natural hazard assessment

Introduction

Extreme natural disasters have become increasingly frequent and severe worldwide leading to substantial socio-economic losses and environmental degradation that challenge sustainable development goals[12]. The impacts of these disasters are especially severe in developing Nations where resource constraints and vulnerable infrastructure intensify the effects, necessitating robust disaster risk reduction strategies and early warning systems[20]. Floods are among the most devastating and costly natural disasters that pose significant threats to human lives, infrastructure and economic activities across the globe[22]. According to the United Nations Office for Disaster Risk Reduction (UNDRR), floods accounted for approximately 40% of all natural disasters worldwide between 2000 and 2019, affecting more than 1.6 billion people and causing substantial economic losses exceeding 660 billion[15].

The impacts of floods are multifaceted ranging from the immediate loss of lives and destruction of property to long-term consequences such as the disruption of essential services, displacement of communities and the spread of waterborne diseases[2]. In recent decades, the compounding effects of climate change, urbanization and unsustainable land-use practices underscore the urgent need for effective flood-risk management strategies across the globe that have exacerbated the frequency and intensity of flood events[16]. Climate change is expected to intensify the hydrological cycle, leading to more extreme precipitation events and increased risk of flooding in many regions, while rapid urbanization has resulted in the expansion of impervious surfaces, altering natural drainage patterns and reducing water infiltration[11].

In India due to its vast geographical expanse and diverse topography, it is particularly vulnerable to floods. According to the National Disaster Management Authority (NDMA), floods account for a significant share of the total disaster related losses in the country affecting an average of 7.5 million hectares of land annually[4]. The countries monsoon climate coupled with the presence of numerous rivers and their tributaries contributes to the high risk of flooding especially in low-lying areas and coastal regions. Tamilnadu has witnessed several devastating flood events in recent years. The State's coastal location, flat terrain and the presence of major river systems such as the Cauvery, Palar, Vaippar and Thamirabarani make it particularly susceptible to floods[1]. The December 2023 floods in Tirunelveli, Thoothukudi and Ramanathapuram district triggered by unprecedented rainfall resulted in widespread inundation, loss of life. Severe damage to infrastructure highlights the importance of flood risk mapping[6].

In addressing these challenges, flood susceptibility mapping has emerged as a crucial tool for disaster risk reduction. By integrating various environmental and anthropogenic factors, these maps provide essential spatial information about areas prone to flooding[20]. Recent technological advances in remote sensing and Geographic Information Systems (GIS) have significantly enhanced the capability to develop accurate flood susceptibility maps enabling more precise identification of high-risk areas and facilitating informed decision-making in urban planning and disaster preparedness[14].

The growing body of research in flood susceptibility mapping, particularly studies conducted in the past three years, demonstrates the effectiveness of integrating multi-criteria decision models with geospatial techniques[3,19]. These studies have achieved notable accuracy levels, with recent work reporting success rates between 80-87% in predicting flood-prone areas across various geographical contexts[10,13]. There remains a need for region-specific studies that account for local geographical characteristics and changing climate patterns, particularly in rapidly urbanizing coastal areas like Tamil Nadu.

The primary objective of this study is to develop a comprehensive flood susceptibility map for the coastal villages from Mookkaiyur to Tharuvaikulam, Southern Tamilnadu by integrating remote sensing (RS) data, geographic information system (GIS) techniques and the analytical hierarchy process (AHP) method. It aims to identify and to analyse key factors influencing flood susceptibility such as topography, land use/land cover, soil characteristics, rainfall patterns and drainage network characteristics, using RS and GIS data.

The AHP method is employed to assign appropriate weightings to these factors based on expert knowledge and pairwise comparisons. The weighted factors will then be combined using GIS-based multi-criteria decision analysis techniques to generate a detailed flood susceptibility map. The resulting map provides a valuable decision-support tool for flood risk mitigation, urban planning and disaster management efforts in the region.

Study Area

The study area lies at 8° 56’ 0” N and 78° 8’ 6” E along the southeastern coast of Tamil Nadu, India, spanning approximately 320 sq. km. across the Thoothukudi and Ramanathapuram districts bordering the Bay of Bengal. The region experiences a semi-tropical coastal climate with temperatures ranging from 24.7°C to 37.7°C and high humidity levels between 76-83%. Notably, the area’s elevation ranges from -12 to 24 meters above mean sea level making lower-lying areas particularly vulnerable to flooding shown in fig. 1. The region receives an average rainfall of 827 mm (2010-2023), with precipitation patterns influenced by both monsoons and cyclonic activities in the Bay of Bengal.

Two major river systems, the Vaippar and Gundar, traverse the coastal landscape before forming estuarine environments where they meet the sea. These river mouths are critical zones for potential flood events during heavy rainfall or storm surges. The hydrogeological setting is characterized by freshwater availability at shallow depths of 5 to 10 meters, which can be significantly impacted during flood events, affecting water security in coastal villages.

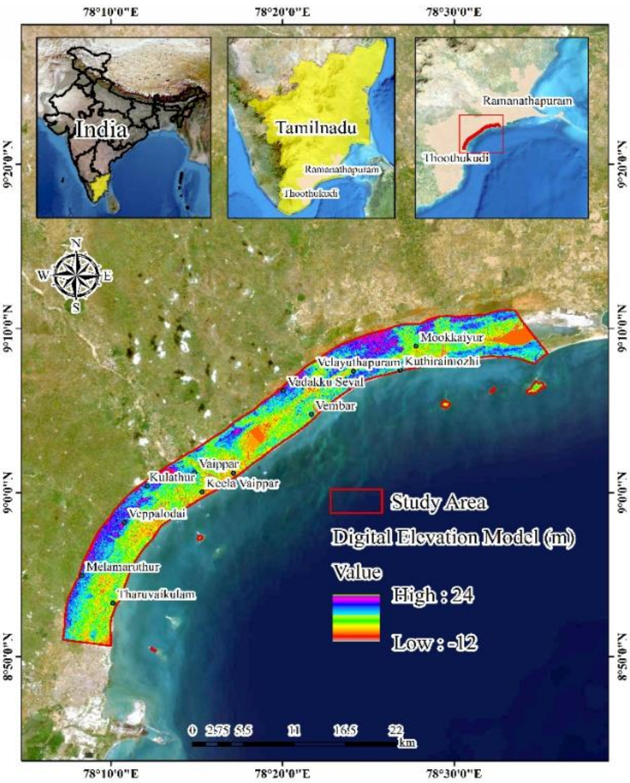

Fig. 1: Spatial distribution of elevation (m above mean sea level) in the study area

Material and Methods

Remote Sensing and GIS: The study utilized ten thematic layers processed through ArcMap 10.8 incorporating diverse spatial datasets at 30-meter resolution. SRTM digital elevation model provided the foundation for deriving topographic wetness index (TWI) and slope parameters[9]. Rainfall data from Indian Meteorological Department was spatially interpolated for precipitation analysis[7]. Land Use/Land Cover classification was performed using ESRI Sentinel-2 land cover explorer, categorizing urban areas, agricultural lands, forests and water bodies[10,23]. Landsat-8 satellite imagery was employed to calculate NDVI using near-infrared and red bands[17].

Additional parameters included soil characteristics from ICAR-NBSS&LUP database and proximity analyses (distance from river and road networks) derived from Open Street Map data[24]. Geology and geomorphology were obtained from Bhukosh GSI platform[19]. All parameters underwent geometric and radiometric corrections and were standardized to a uniform coordinate system to ensure analytical consistency in the flood susceptibility assessment[10].

Analytical Hierarchy Process (AHP): The analytical hierarchy process (AHP) was employed to assign weights and ranks to the ten thematic layers and their sub-parameters[7]. Following multi-criteria decision-making methodology, a hierarchical structure was established with flood susceptibility mapping as the primary goal, followed by thematic layers as criteria and their sub-parameters. Pairwise comparison matrices were developed using Saaty's fundamental scale (1-9), comparing each element's relative importance. The consistency evaluation yielded a λ value of 11.202, resulting in a CI value of 0.134. With an RI value of 1.49, the calculated CR value was 0.090, falling within the acceptable threshold (≤0.1). The Eigen vector method was then applied to calculate the final weights and ranks for all thematic layers and their sub-parameters, with higher weights indicating greater importance in flood susceptibility determination.

Flood Susceptibility Mapping: The assigned weights were integrated into the GIS environment, where the weighted overlay analysis was performed. Each thematic layer and its sub-parameters got multiplied by their respective weights and the resulting layers were summed up to generate the final flood susceptibility map, reflecting the combined influence of all factors and their relative importance is given in table 1. The weighted overlay tool was used for flood susceptibility mapping in ArcMap 10.8 by the equation:

$$\text{FSI} = \sum_{i-1}^{n} \text{WiRi}$$

where FSI is Flood Susceptibility Index, n is no. of parameters, W is Weightage of each parameter, R is Rating of each parameter, i is Parameter. The methodology flow chart is shown in fig. 2.

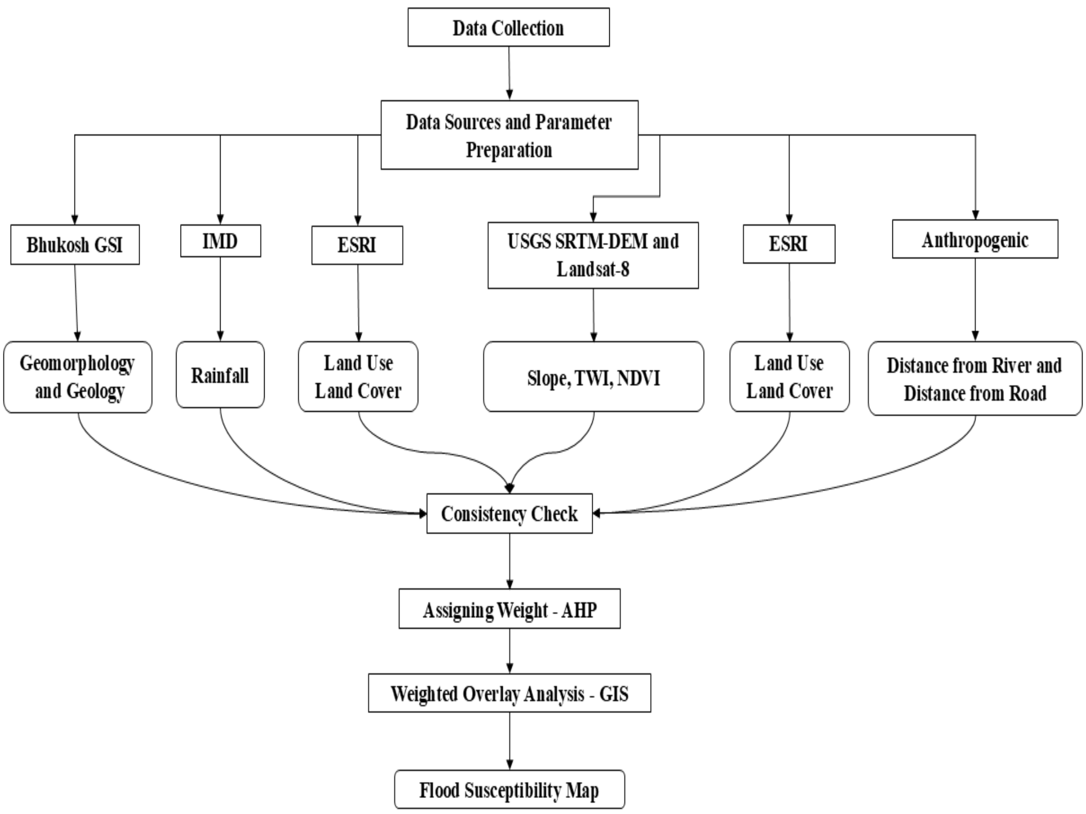

Fig. 2: Methodology Flow chart for Flood Susceptibility mapping

Table 1
Relative weights and rating of flood-influencing parameters

Parameters	Class	Area	Percent	Range	Rating	Weightage
Geomorphology	Active Flood Plain	15.42	4.97	Very High	5	18
	Aeolian Sand Dune	1.92	0.62	Very Low	1	
	Aeolian Stabilized Dune	0.11	0.04	Very Low	1	
	Older Coastal Plain	131.32	42.35	Medium	3	
	Pediment Pediplain complex	14.42	4.65	Low	2	
	River	2.35	0.76	Very High	5	
	Salt Pan	40.11	12.93	High	4	
	Water Bodies	18.28	5.9	Very High	5	
	Younger Coastal Plain	86.17	27.79	High	4	
Rainfall (mm/yr)	628 - 768	24.57	7.7	Very Low	1	12
	768 – 869	62.98	19.73	Low	2	
	869 – 954	96.33	30.18	Medium	3	
	954 – 1038	94.71	29.67	High	4	
	1038 - 1194	40.57	12.71	Very High	5	
Topographic Wetness Index	4.70 – 7.94	145.31	46.04	Very Low	1	11
	7.94 – 9.76	64.99	20.59	Low	2	
	9.76 – 11.79	55.2	17.49	Medium	3	
	11.79 – 14.41	39.12	12.39	High	4	
	14.41 – 20.93	10.99	3.48	Very High	5	
Land use Land cover	Water bodies	32.23	10.07	Very High	5	10
	Forest/Trees	7.2	2.25	Very Low	1	
	Crops/Farm land	0.49	0.15	Medium	3	
	Flooded Vegetation	87.52	27.35	Very High	5	
	Built Area	29.31	9.25	High	4	
	Bare Ground	21.54	6.73	High	4	
	Range Land	141.42	44.19	Low	2	
Slope (degree)	0 – 1	150.26	47.6	Very High	5	11
	1 – 2	105.65	33.47	High	4	
	2 – 4	54.71	17.33	Medium	3	
	4 – 10	4.99	1.58	Low	2	
	>10	0.03	0.01	Very Low	1	
Normalized Difference Vegetation Index	-3036 to -0.0002	30.76	9.62	Very High	5	6
	-0.0002 to 0.0998	32.86	10.27	High	4	
	0.0998 to 0.1837	101.03	31.59	Medium	3	
	0.1837 to 0.2612	103.03	32.21	Low	2	
	0.2612 to 0.5194	52.18	16.31	Very Low	1	
Lithology	Black clay (active tidal flat)	65.53	20.56	Very High	5	8
	Black clayey sand (tidal channel bar)	0.35	0.11	High	4	
	Black silty clay (active flood plain)	2.81	0.88	Very High	5	
	Brown fine sand (palaeo beach ridge)	61.28	19.23	Low	2	
	Brown silt (active levee)	0.46	0.15	Medium	3	
	Brown silty clay (Palaeo tidal flat)	70.33	22.07	High	4	
	Coarse sand with rock fragments (Active channel)	3.01	0.94	Medium	3	
	Sand (Channel bar/ point bar)	0.19	0.06	Low	2	
	Sand (Terri dune)	109.11	34.24	Very Low	1	
	Sand with coral (coral islands)	1.12	0.35	Very Low	1	

	Silty clay (Tidal channel)	4.45	1.4	Very High	5	
Soil Type	Alfisols	7.57	2.4	Medium	3	**10**
	Entisols	73.12	23.19	High	4	
	Forest unsurvey	6.14	1.95	Low	2	
	Inceptisols	2.57	0.82	High	4	
	Reserve forest	43.4	13.77	Low	2	
	Vertisols	182.54	57.88	Very High	5	
Distance From River	0 – 1480	88.05	27.55	Very High	5	**7**
	1480 – 3141	82.71	25.89	High	4	
	3141 - 4849	77.45	24.24	Medium	3	
	4849 – 7270	56.87	17.8	Low	2	
	7270 – 11365	14.45	4.52	Very Low	1	
Distance From Road	0 – 350	143.24	44.85	Very High	5	**7**
	350 – 910	93.39	29.41	High	4	
	910 – 1630	54.09	16.93	Medium	3	
	1630 – 2700	24.29	7.6	Low	2	

Results and Discussion

Spatial Distribution Flood Parameters: The geomorphological and hydrological parameters significantly influence flood susceptibility across the study area. The geomorphological analysis reveals nine distinct units (Fig. 3a and b) with active flood plains (4.97%) and rivers (0.76%) receiving the highest susceptibility rating of 5, while Aeolian Sand Dunes (0.62%) received the lowest rating[5]. Rainfall distribution shows five distinct zones (Fig. 3c and d) with the highest rainfall areas (1038-1194 mm/yr) covering 12.71% assigned maximum susceptibility rating. The lowest rainfall zone (628-768 mm/yr) spans 7.7%[21]. The Topographic Wetness Index (TWI) ranges from 4.70 to 20.93 (Fig. 3e and f), where the highest category (14.41-20.93) occupying 3.48% received maximum susceptibility rating, while 46.04% exhibits very low TWI values (4.70-7.94) with minimum susceptibility[3].

Land use and soil characteristics demonstrate varying impacts on flood vulnerability (Fig. 3g and h). The LULC analysis shows range land dominates (44.19%) with low susceptibility, while flooded vegetation (27.35%) and water bodies (10.07%) receive the highest susceptibility ratings[10,17]. Slope analysis reveals that 47.6% of the area has extremely gentle slopes (0-1 degrees), receiving the highest susceptibility rating, while only 0.01% has slopes exceeding 10 degrees (Fig. 3i and j)[8,17]. NDVI distribution indicates areas with sparse vegetation (-0.0002 to 0.0998) covering 10.27% receive high susceptibility ratings, while high NDVI values (0.2612 to 0.5194) cover 16.31% with minimum susceptibility (Fig. 3k and l)[18].

Lithological assessment reveals Sand (Terri dune) as dominant (34.24%) with low susceptibility, while black clay (20.56%) receives the highest rating due to low permeability (Fig. 4a and b)[10]. Soil analysis shows Vertisols dominating 57.88% of the area with maximum susceptibility, while reserve forest soils (13.77%) demonstrate low susceptibility due to enhanced infiltration capacity (Fig. 4c and d)[19]. Infrastructure proximity and anthropogenic factors significantly influence flood susceptibility patterns. The distance from river analysis reveals areas within 0-1480 meters (27.55%) receiving the highest susceptibility rating, decreasing systematically with distance to the lowest rating at 7270-11365 meters (4.52%) from rivers (Fig. 4e and f)[18].

Road proximity analysis shows areas within 0-350 meters (44.85%) to demonstrate highest flood susceptibility due to altered drainage patterns and impervious surfaces, while regions beyond 2700 meters (1.2%) receive minimum ratings (Fig. 4g and h)[5,9]. The comprehensive analysis of these ten parameters indicates that areas characterized by flat terrain, poor drainage, proximity to infrastructure and high rainfall are most susceptible to flooding, highlighting the complex interplay between natural and anthropogenic factors in determining flood vulnerability.

Inter-relation between Parameters: The intricate interplay between various flood-influencing parameters reveals complex relationships that enhance the understanding of flood susceptibility patterns. Geomorphological features fundamentally shape the topographic characteristics directly influencing slope conditions and TWI distributions across the landscape[9]. The Active Flood Plains which occupy 4.97% of the study area naturally exhibit low slope values (0-1°) and high TWI values (14.41-20.93), demonstrating how these parameters work in concert to create zones of heightened flood vulnerability[6].

The relationship between lithology and soil type further illustrates this interconnectedness where the predominant Vertisols (57.88%) correlate strongly with areas of black clay and brown silty clay lithological units collectively influencing the regions water retention and drainage characteristics[9]. This association becomes particularly significant during rainfall events as these soil-lithology combinations determine infiltration rates and surface runoff generation[10]. The spatial distribution of NDVI values shows a strong correlation with LULC patterns where higher NDVI values (0.2612-0.5194) correspond to forested areas and dense vegetation, while negative NDVI values align with water bodies and built-up areas demonstrating how these parameters collectively influence the landscapes hydrological response[18].

The anthropogenic parameters particularly distance from roads and built-up areas demonstrate significant correlations with altered drainage patterns and modified natural flow paths. Areas within 350 meters of roads, comprising of 44.85% of the study region, frequently intersect with zones of modified LULC and altered geomorphological characteristics creating compound effects on flood susceptibility[5]. This relationship becomes more pronounced in areas where road networks cross natural drainage paths or run parallel to river systems, potentially creating flood-prone zones due to the combined influence of multiple parameters[21].

The distance from rivers parameter shows a notable relationship with both geomorphological features and TWI values, where areas closest to rivers (within 1480 meters) typically exhibit higher TWI values and correspond to flood-prone geomorphological units[10]. This spatial correlation extends to rainfall patterns, where areas receiving higher annual precipitation (1038-1194 mm) often coincide with zones of high TWI values and flood-prone lithological units creating a compound effect that significantly increases flood susceptibility[6,19]. These interrelationships demonstrate how the parameters work effectively rather than in isolation creating a complex process of interactions that collectively determine areas flood vulnerability.

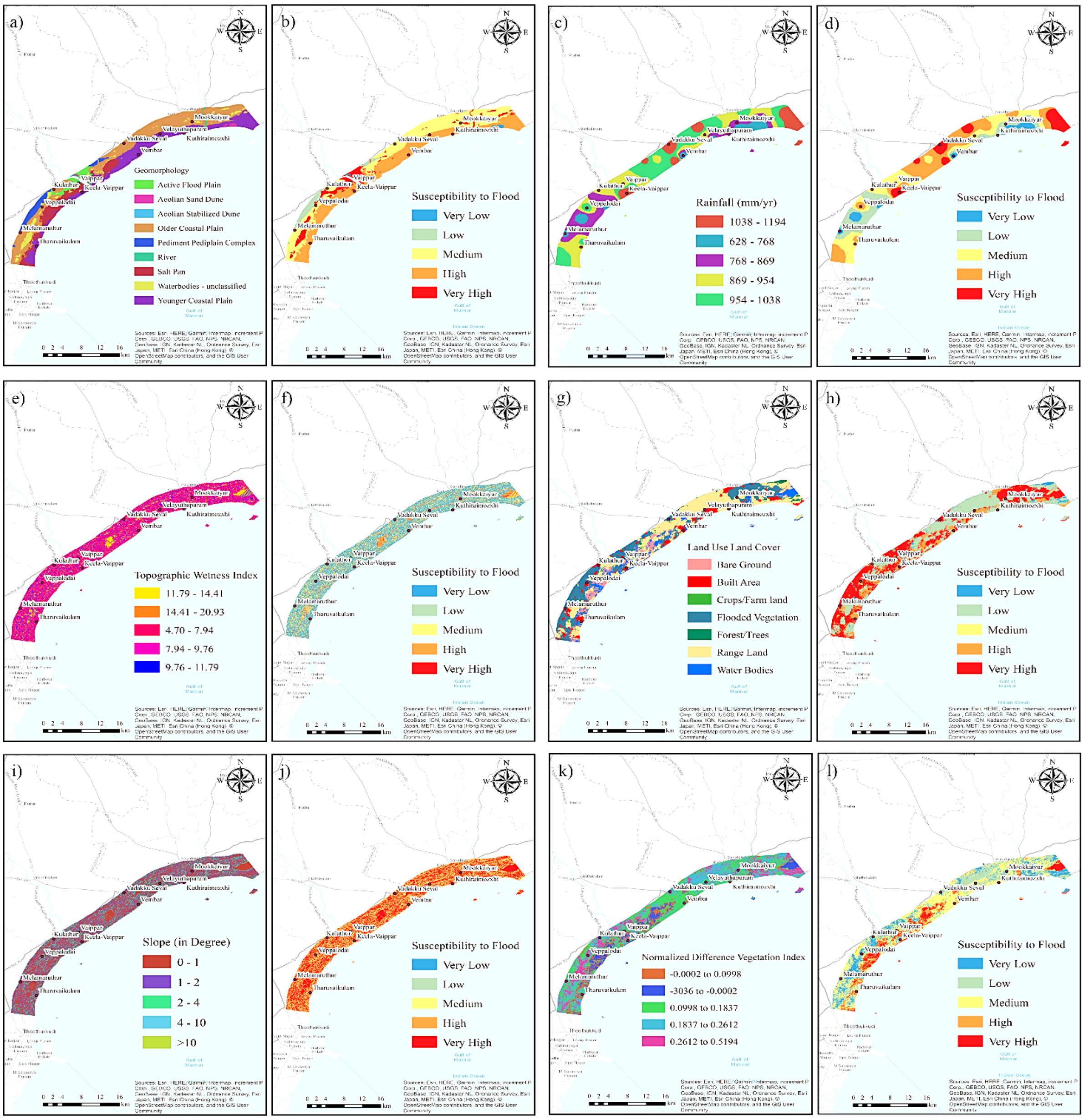

Fig. 3: Parameter and its Susceptibility to Flood (a and b) Geomorphology, (c and d) Rainfall, (e and f) Topographic Wetness Index, (g and h) Land use Land cover, (i and j) Slope in Degree and (k and l) Normalized Difference Vegetation Index

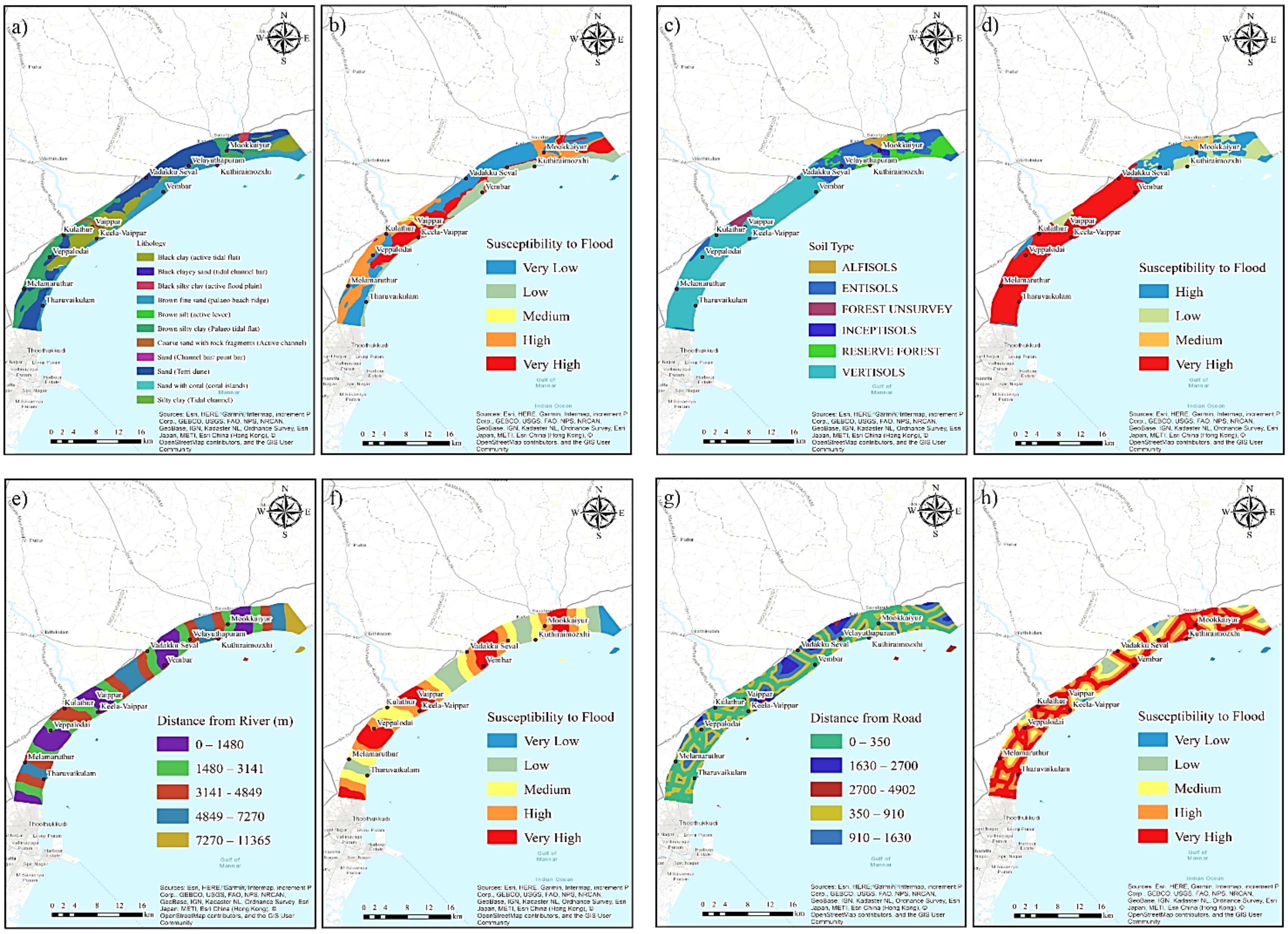

Fig. 4: Parameter and its susceptibility to Flood: (a and b) Lithology, (c and d) Soil type, (e and f) Distance from river and (g and h) Distance from road

Table 2
Classification of flood susceptibility zones with their respective area coverage in the study region

S.N.	Flood Susceptibility	Area (sq.km)	Percentage
1	Very Low	40.17	13.43
2	Low	73.77	24.66
3	Medium	80.02	26.76
4	High	69.2	23.14
5	Very High	35.91	12.01

Flood Susceptibility Map: The flood susceptibility mapping utilising ten influential parameters through weighted overlay analysis reveals a nuanced distribution of flood-prone areas across the study area shown in table 2 and fig. 5. The results indicate that medium susceptibility zones dominate the landscape, covering 80.02 km² (26.76%) of the study area, which aligns with the moderate ratings observed across multiple parameters, particularly in areas where the older coastal plain geomorphology intersects with intermediate rainfall zones (869-954 mm/yr) and moderate TWI values (9.76-11.79)[18,19].

These medium susceptibility zones often correspond to areas with balanced interactions between flood-promoting and flood-mitigating factors such as where moderate slope gradients (2-4°) coincide with intermediate distances from rivers and roads[6,9]. The low and very low susceptibility zones collectively account for 38.09% of the study area (113.94 km²), primarily occurring in regions characterized by flood-resistant features across multiple parameters[10]. These areas typically correspond to higher elevation zones with sand-dominated lithology (Terri dune - 34.24%), steeper slopes (>4°) and higher NDVI values (0.2612-0.5194), indicating dense vegetation cover[8]. The spatial distribution of these lower susceptibility zones often aligns with areas farther from rivers (>4849 m) and roads (>1630 m) where natural drainage patterns remain relatively undisturbed[18].

The high and very high susceptibility zones together comprise of 35.15% of the area (105.11 km²) predominantly occurring where multiple flood-promoting factors converge. These highly susceptible areas strongly correlate with zones of very low slopes (0-1°), high rainfall (>954 mm/yr) and flood-prone geomorphological units such as active flood plains and water bodies[21]. The presence of Vertisols (57.88%) and Black clay lithology in these zones further enhances their flood susceptibility through poor drainage characteristics[8]. These high-risk areas frequently coincide with zones closest to rivers (<1480 m) and roads (<350 m) where anthropogenic modifications may compound natural flood susceptibility factors[9,18].

The distribution pattern of flood susceptibility classes demonstrates the complex interplay between various parameters where the final susceptibility rating of any given area is determined by the cumulative influence of multiple factors rather than the dominance of any single parameter[10]. The results particularly highlight how the convergence of unfavourable conditions across multiple parameters creates zones of heightened flood risk while areas with more balanced or favourable parameter combinations exhibit lower susceptibility to flooding[6].

Conclusion

This study demonstrates the effectiveness of integrating remote sensing, GIS and the analytical hierarchy process in developing a detailed flood susceptibility map for the coastal villages from Mookkaiyur to Tharuvaikulam in Southern Tamil Nadu. The analysis of ten critical parameters revealed that geomorphology (weightage 18), rainfall (weightage 12) and slope and TWI (weightage 11 each) are the most influential factors in determining flood susceptibility in the study area. The resulting flood susceptibility map indicates that 26.76% of the study area falls under medium susceptibility while 35.15% exhibits high to very high susceptibility to flooding.

The spatial distribution of flood-prone zones strongly correlates with areas characterized by very low slopes (0-1°), high rainfall (>954 mm/yr) and flood-prone geomorphological units such as active flood plains and water bodies. The presence of Vertisols and Black clay lithology in these zones further enhances their vulnerability through poor drainage characteristics. The study also highlights the significant role of anthropogenic factors, particularly in areas close to rivers and roads where human modifications compound natural flood susceptibility factors. This comprehensive flood susceptibility assessment provides valuable insights for local authorities and planners in implementing targeted flood mitigation strategies, developing emergency response plans and making informed decisions about future infrastructure development in the region.

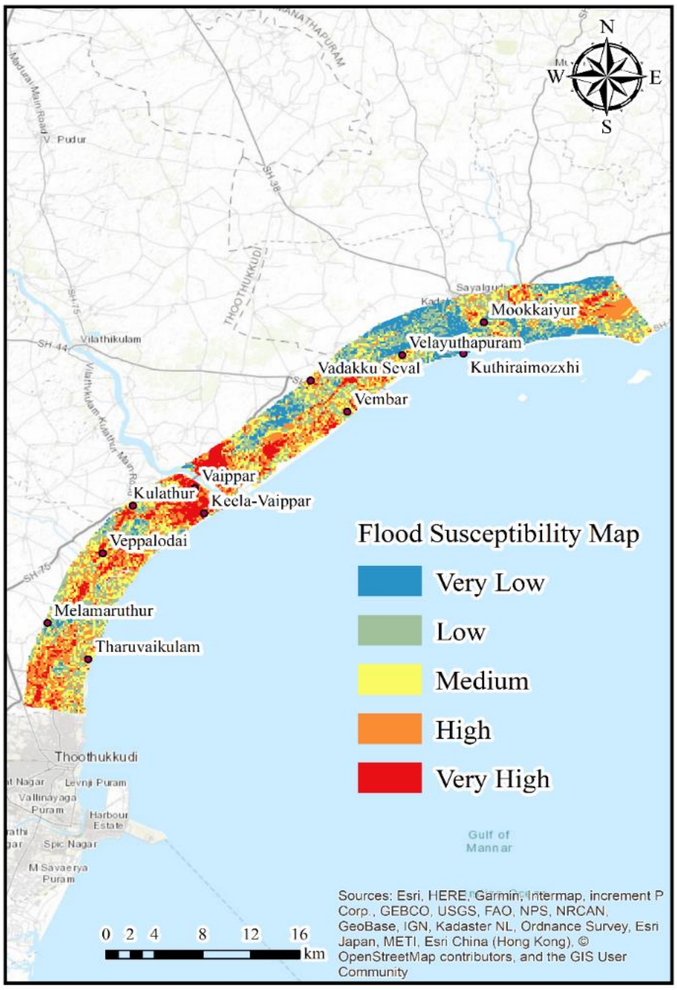

Fig. 5: Flood Susceptibility Map of the study area

The methodology employed in this study can be adapted for similar coastal regions, contributing to more effective flood risk management and disaster preparedness planning. This research directly benefits local communities by enabling them to better understand and prepare for future flood risks and also supports environmental conservation efforts through the identification of critical natural drainage systems and flood-prone ecosystems that require protection. The findings can guide sustainable land-use planning that balance community development needs with environmental preservation ultimately contributing to the region's long-term resilience against flooding.

References

1. Abijith D., Saravanan S. and Sundar P.K.S., Coastal vulnerability assessment for the coast of Tamil Nadu, India—a geospatial approach, *Environmental Science and Pollution Research*, **30(30)**, 75610–75628, https://doi.org/10.1007/s11356-023-27686-8 **(2023)**

2. Ahmad D. and Afzal M., Flood hazards and livelihood vulnerability of flood-prone farm-dependent Bait households in Punjab, Pakistan, *Environmental Science and Pollution Research*, **29(8)**, 11553–11573, https://doi.org/10.1007/s11356-021-16443-4 **(2021)**

3. Burayu D.G., Karuppannan S. and Shuniye G., Identifying flood vulnerable and risk areas using the integration of analytical hierarchy process (AHP), GIS and remote sensing: A case study of southern Oromia region, *Urban Climate*, **51**, 101640, https://doi.org/10.1016/j.uclim.2023.101640 **(2023)**

4. Charak A., Ravi K. and Verma A., Review of Various Climate Change Exacerbated Natural Hazards in India and Consequential Socioeconomic Vulnerabilities, *IDRiM Journal*, **13(2)**, https://doi.org/10.5595/001c.92642 **(2024)**

5. Dang K.B., Pham H.H., Nguyen T.N., Giang T.L., Pham T.P.N., Nghiem V.S., Nguyen D.H., Vu K.C., Bui Q.D., Pham H.N., Nguyen T.T. and Ngo H.H., Monitoring the effects of urbanization and flood hazards on sandy ecosystem services, *Science of The Total Environment*, **880**, 163271, https://doi.org/10.1016/j.scitotenv.2023.163271 **(2023)**

6. Das S., Flood susceptibility mapping of the Western Ghat coastal belt using multi-source geospatial data and analytical hierarchy process (AHP), *Remote Sensing Applications: Society and Environment*, **20**, 100379, https://doi.org/10.1016/j.rsase.2020.100379 **(2020)**

7. Diriba D., Takele T., Karuppannan S. and Husein M., Flood hazard analysis and risk assessment using remote sensing, GIS and AHP techniques: a case study of the Gidabo Watershed, main Ethiopian Rift, Ethiopia, *Geomatics, Natural Hazards and Risk*, **15(1)**, https://doi.org/10.1080/19475705.2024.2361813 **(2024)**

8. Hossain Md. N. and Mumu U.H., Flood susceptibility modelling of the Teesta River Basin through the AHP-MCDA process using GIS and remote sensing, *Natural Hazards*, **120(13)**, 12137–12161, https://doi.org/10.1007/s11069-024-06677-z **(2024)**

9. Kader Z., Islam Md. R., Aziz Md. T., Hossain Md. M., Islam Md. R., Miah M. and Jaafar W.Z.W., GIS and AHP-based flood susceptibility mapping: a case study of Bangladesh, *Sustainable Water Resources Management*, **10(5)**, https://doi.org/10.1007/s40899-024-01150-y **(2024)**

10. Kumar R., Kumar M., Tiwari A., Majid S.I., Bhadwal S., Sahu N. and Avtar R., Assessment and Mapping of Riverine Flood Susceptibility (RFS) in India through Coupled Multicriteria Decision Making Models and Geospatial Techniques, *Water*, **15(22)**, 3918, https://doi.org/10.3390/w15223918 **(2023)**

11. Kurniawan T.A., Meidiana C., Goh H.H., Zhang D., Jiang M., Othman M.H.D., Anouzla A., Aziz F., Mahmoud M., Khan M.I., Ali I., Khan M.M.H. and Goh K.C., Social dimensions of climate-induced flooding in Jakarta (Indonesia): The role of non-point source pollution, *Water Environment Research*, **96(9)**, https://doi.org/10.1002/wer.11129 **(2024)**

12. Malešević-Perović L. and Ćorić B., Sustainable development and economic disasters, *Journal of Cleaner Production*, **434**, 140043, https://doi.org/10.1016/j.jclepro.2023.140043 **(2024)**

13. Moniruzzaman M., Thakur P.K., Kumar P., Ashraful Alam Md., Garg V., Rousta I. and Olafsson H., Decadal Urban Land Use/Land Cover Changes and Its Impact on Surface Runoff Potential for the Dhaka City and Surroundings Using Remote Sensing, *Remote Sensing*, **13(1)**, 83, https://doi.org/10.3390/rs13010083 **(2020)**

14. Munawar H.S., Hammad A.W.A. and Waller S.T., Remote Sensing Methods for Flood Prediction: A Review, *Sensors*, **22(3)**, 960, https://doi.org/10.3390/s22030960 **(2022)**

15. Palinkas L.A., Global Climate Change, Population Displacement and Public Health, Springer International Publishing, https://doi.org/10.1007/978-3-030-41890-8 **(2020)**

16. Pizzorni M., Innocenti A. and Tollin N., Droughts and floods in a changing climate and implications for multi-hazard urban planning: A review, *City and Environment Interactions*, **24**, 100169, https://doi.org/10.1016/j.cacint.2024.100169 **(2024)**

17. Rana S.M.S., Habib S.A., Sharifee M.N.H., Sultana N. and Rahman S.H., Flood risk mapping of the flood-prone Rangpur division of Bangladesh using remote sensing and multi-criteria analysis, *Natural Hazards Research*, **4(1)**, 20–31. https://doi.org/10.1016/j.nhres.2023.09.012 **(2024)**

18. Saranya A., Sivakumar V., Satheeshkumar S. and Logeshkumaran A., Assessment of Flood Risk in the High Rainfall Coastal Area of Cuddalore Taluk, Southeast India, Using GIS-Based Analytic Hierarchy Process Techniques, *Journal of the Indian Society of Remote Sensing*, https://doi.org/10.1007/s12524-024-01998-9 **(2024)**

19. Selvam R.A. and Antony Jebamalai A.R., Application of the analytical hierarchy process (AHP) for flood susceptibility mapping using GIS techniques in Thamirabarani river basin, Srivaikundam region, Southern India, *Natural Hazards*, **118(2)**, 1065–1083, https://doi.org/10.1007/s11069-023-06037-3 **(2023)**

20. Shabir F. and Nain M.Z., Unveiling extensive and intensive disaster risks: an in-depth analysis of Asia's vulnerability, *Environmental Hazards*, 1–20, https://doi.org/10.1080/17477891.2024.2358057 **(2024)**

21. Shawky M. and Hassan Q.K., Geospatial Modeling Based-Multi-Criteria Decision-Making for Flash Flood Susceptibility Zonation in an Arid Area, *Remote Sensing*, **15(10)**, 2561, https://doi.org/10.3390/rs15102561 **(2023)**

22. Tillihal S.B. and Shukla A.K., Flood Disaster Hazards: A State-of-the-Art Review of Causes, Impacts and Monitoring, *Advances in Water Resource Planning and Sustainability*, 77–95, https://doi.org/10.1007/978-981-99-3660-1_5 **(2023)**

23. Trambadia N., Patel D., Patel V.M., Gundalia M.J. and Bhargav A., Flood inundation mapping in "Ghed Topography" using hydrodynamic modelling and Google Earth Engine-A case of combined approach for flood assessment, *ISH Journal of Hydraulic Engineering*, **20**, https://doi.org/10.1080/09715010.2025.2479839 **(2025)**

24. Zhran M., Ghanem K., Tariq A., Alshehri F., Jin S., Das J., Pande C.B., Pramanik M., Hasher F.F.B. and Mousa A., Exploring a GIS-based analytic hierarchy process for spatial flood risk assessment in Egypt: a case study of the Damietta branch, *Environmental Sciences Europe*, **36(1)**, https://doi.org/10.1186/s12302-024-01001-9 **(2024)**.

(Received 19th January 2025, accepted 20th February 2025)