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Integrating AHP and Remote Sensing Method for Landslide Susceptibility Mapping of the Coastal Cliffs in Southeastern Bangladesh

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Abstract: The study focused on the southeastern part of Bangladesh from Cox's Bazar to Teknaf, integrating the Analytical Hierarchy Process (AHP) and Remote Sensing (RS) techniques to develop a landslide susceptibility map. Ten conditioning factors—elevation, slope, aspect, curvature, soil type, land use/land cover, rainfall, drainage density, distance from road, and normalized difference vegetation index were produced from satellite imagery and secondary datasets. Analytical Hierarchy Process (AHP) was used to derive factor weights through pairwise comparison to evaluate susceptibility zonation. The resulting susceptibility map classified the area into 3 zones: low risk (35.34%), moderate risk (62.25%), high risk (2.40%) susceptibility. The findings highlight critical hotspots at Teknaf Upazila and moderate hotspot at the rest of Teknaf and Ukhia including the marine drive of coastal cliffs where mitigation and land-use planning should be prioritized. This integrated RS-AHP framework offers a cost-effective and scalable approach for hazard assessment in data-scarce regions like Bangladesh.

Keywords: ***Landslide susceptibility, AHP, Remote sensing, GIS, Coastal cliffs, Bangladesh.***

Introduction

Landslides are one of the most destructive natural hazards in Bangladesh, particularly in the southeastern hill tracts and coastal cliff areas. Coastal cliffs in Cox's Bazar–Teknaf belt are especially vulnerable due to marine erosion, deforestation, and unregulated construction (Shampa et al., 2023). Despite this, limited studies have systematically quantified landslide susceptibility in this costal cliff area.

Landslide Susceptibility Mapping (LSM) provides spatial prediction of areas prone to slope failure. Various approaches have been applied globally, among them, the Analytical Hierarchy Process (AHP) has gained prominence for integrating expert knowledge with multi-criteria decision analysis (Saaty, 1980).

Methodology

The methodological workflow involved three major steps: (1) preparation of conditioning factor maps, (2) application of AHP for factor weighting, and (3) integration in GIS for susceptibility mapping. AHP was conducted using Saaty's 1–9 scale, with experts ranking the relative importance of factors. The pairwise comparison matrix was normalized to derive weights, and the Consistency Ratio (CR) was calculated (<0.1 acceptable). The weighted linear combination method was applied in GIS to overlay all factor layers and generate the susceptibility map.

Table 1, Database of the current study.

Datasets	Parameters	Source	Scale	Classification method
Digital elevation model (DEM)	Elevation	USGS Earth Explorer	30m×30m	Natural break
	Slope		30m×30m	
	Aspect		30m×30m	
	Curvature		30m×30m	
	Drainage density		30m×30m	
Vector dataset	Soil type	Open-Source data	30m×30m	
	Distance from road		30m×30m	
NetCDF	Annual Rainfall		30m×30m	
Landsat TM Images	LULC	USGS Earth Explorer	30m×30m	Supervised classification.
	NDVI		30m×30m	

Results and discussion

The AHP analysis assigned the highest weight to elevation (26.20), followed by slope (12.38), NDVI (20.77), distance to road (11.065), aspect (10.14), curvature (5.42), soil type (5.42), drainage density (3.516), land use/land cover (3.09), and annual rainfall (1.97). The final susceptibility map categorized the study area into 3 susceptibility zones: low risk zone covers 90.98 km^2; moderate risk zone covers 160.22 km^2 and high zone covers 6.17 km^2.

The spatial distribution map reveals significant landslide-prone hotspots across Teknaf, Ukhia, and Ramu Upazilas, particularly along the coastal cliffs in the southeastern part of Bangladesh (Figure 1). The results are consistent with earlier studies in the Chittagong Hill Tracts and Cox's Bazar region (Ahmed, 2015).

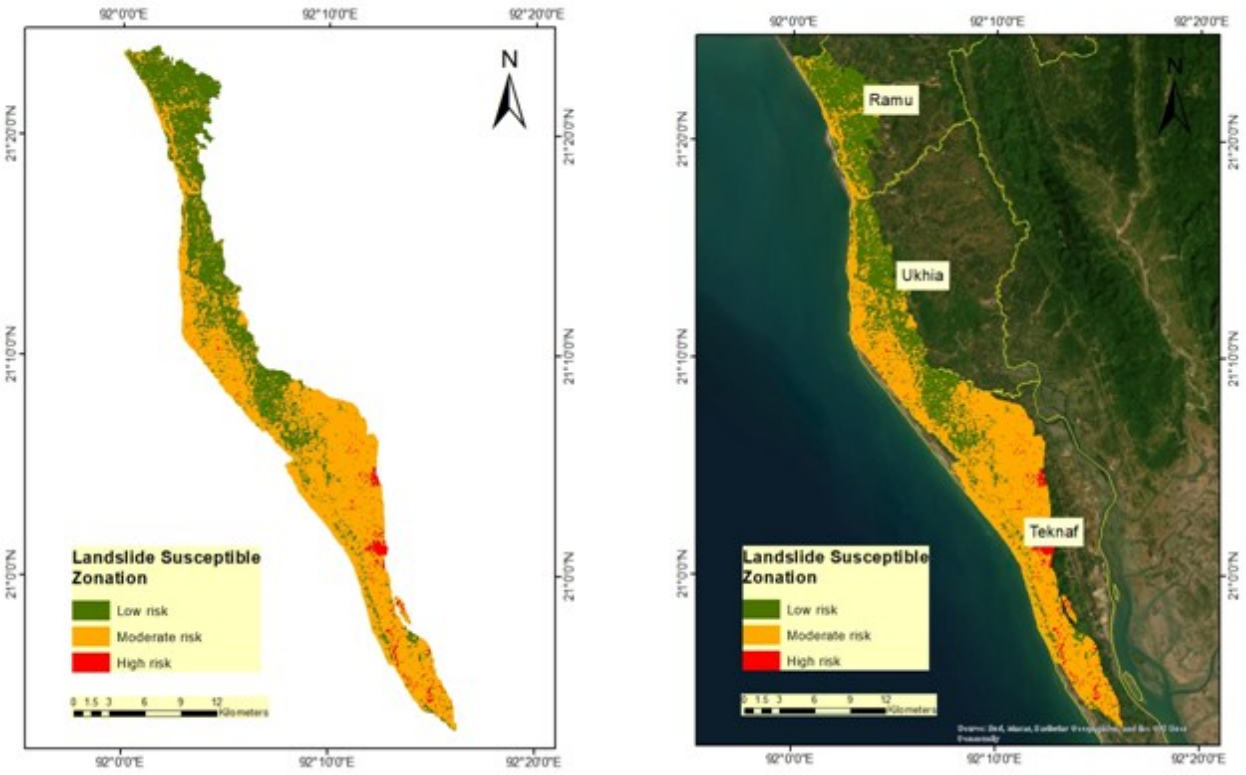

Figure 1, Landslide susceptibility zonation mapping.

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