Environmental Geological Assessments of Kawkhali Upazila, Rangamati, Bangladesh

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Abstract: Before starting any development planning, it is crucial to do environmental geological studies of the area. Kawkhali is an upazila in Bangladesh's Rangamati district that is steep and has stunning scenery. Environmental assessments of this Upazila have been made by analyzing environmental elements like landslide hazard, flash flood, riverbank erosion, gully erosion, surface and groundwater condition, land use and cover changes etc. The methods used in the study involved data collection from data processing, analysis and interpretation. Although they have some benefits in the form of flourishing biodiversity, landslides pose the greatest hazard to this area. They cause road and housing damage, blockages in streams and rivers, and erosion of land. Owing to its geographical location near the active Chittagong Myanmar fault zone, this area is also prone to earthquake risk. The rapid increase in population is causing an ongoing depletion of surface and ground water. Again, the increasing population requires more homes, a furniture road, and other amenities. As a result of these demands, the amount of forest and hill area is decreasing, which has a significant impact on the geo-environments. Hence, land use planning for this area should be done effectively to handle this scenario. In addition, hazards mapping needs to be done. Enhanced public awareness is also necessary.

Keywords: ***Environment, Kawkhali upazila, Geological Assessments, Land use and Land cover.***

Introduction

Environmental geology is the study of interactions between humans and their natural surroundings, focusing on how geological processes and structures above and below the Earth's surface influence human life—and how human activities, in turn, affect these systems (Nakić et al., 2017). Natural phenomena such as earthquakes, volcanoes, landslides, floods, and avalanches pose significant threats to human life and property, while the Earth's soil, water, mineral, and energy resources form the essential foundation of human existence (Geertsema et al., 2009; Perinçek, 2016).

Bangladesh is predominantly a plain country, with hilly areas mainly in the southeast and northeast. One of the most notable highland regions is Rangamati District, a popular tourist destination. Kawkhali Upazila, located within Rangamati and approximately 4 km from the district's main tourist area, covers around 700 square kilometers. The upazila's population, about 60,000, has doubled since 1981, with a current density of approximately 177 persons per square kilometer (District Statistics 2011, Rangamati, 2013). The Earth is constantly undergoing modification through sedimentological, hydrogeological, and geochemical processes, many of which are intensified by human activities. When such changes occur without proper geological assessment, environmental degradation follows. Understanding the geological causes and effects of these processes is therefore critical for sustainable environmental management.

In this context, a field program was conducted in Kawkhali Upazila during 2020–2021 to study its environmental geology. The study aimed to identify and assess geological materials and conditions that influence the area's environmental stability. As the population grows and development expands, resource exploitation is increasing (Ahmed and Rahman, 2020), gradually impacting the region's geo-environment. The findings are expected to support sustainable development planning and mitigate environmental risks in this rapidly evolving region.

Methodology

Environmental assessments were conducted by analyzing key environmental elements such as landslide hazards, flash floods, riverbank erosion, surface and groundwater conditions, and land use/land cover (LULC) changes. The study followed a systematic approach consisting of data collection, processing, analysis, and interpretation. Field data were collected during a one-month field campaign in 2021, supplemented by secondary information from published and institutional sources. Before fieldwork, a base map at a 1:50,000 scale was prepared, integrating geological and geomorphological data. Satellite imagery was also analyzed to identify landslides, rivers, ponds, streams, hills, and settlements.

Landslide assessment followed the standardized methods of Rickli (2001) and Rickli et al. (2008). For each landslide, parameters such as rupture surface length (Lr), width (Wr), and depth (Dr), along with displacement length (Ld) and width (Wd), were measured to calculate rupture areas and volumes. Because of irregular scar shapes, both maximum and mean diameters were considered for accuracy. Site-specific factors including topography, geology, and geomorphology were examined in detail. Geotechnical samples were collected from slope materials to determine mechanical properties. Each landslide site was georeferenced using a Global Positioning System (GPS) and mapped on the base map. Local and Indigenous knowledge was incorporated through interviews to identify historical and ancient landslide locations. Hydrogeological data was obtained from both institutional records and field surveys. Additional insights were gathered through focus group discussions (FGDs) with residents of landslide-affected areas. Geographic Information System (GIS) tools were employed for mapping, spatial analysis, and data validation. The field-verified landslide points were used to generate and confirm thematic hazard maps.

Land cover and its changes were analyzed using remote sensing techniques. Level-2 Landsat 8 OLI imagery with 30 m spatial resolution was used to detect changes between pre-disaster (15 March 2017) and post-disaster (6 February 2021) periods. The images, downloaded from the USGS Earth Explorer (https://earthexplorer.usgs.gov/), had less than 10% cloud cover, ensuring high-quality analysis. The Normalized Difference Vegetation Index (NDVI) was computed to assess vegetation and surface changes, providing insights into the spatial and temporal dynamics of land cover alterations in the study area. The NDVI can be calculated using surface reflectance of near-infrared (NIR) and red bands of Landsat 8 images. The expression of NDVI is as follows (Mohajane et al., 2018):

$$NDVI = \frac{NIR-Red}{NIR+Red} \quad (1)$$

Equation 1 represents the main formula for calculating NDVI for the Landsat 8 OLI images. NIR and Red correspondence to Band 5 and Band 4 respectively. In the raster calculator of ArcMap 10.8.1 platform, the following (equation 2) formula was used for defining NDVI values of the two years. The NDVI value is span from -1 to 1.

$$NDVI = \frac{Band\ 5-Band\ 4}{Band\ 5+Band\ 4} \quad (2)$$

A high NDVI value represents a high density of vegetation, while a low NDVI value indicates a low density of vegetation. The negative value of NDVI represents the water body. The result shows that the thematic map comparison of land use and land cover changes based on NDVI values over the two years. Six different classes were considered such as water, built up areas, barren land, shrubs and grass land, sparse vegetation and dense vegetation.

Conclusion

Landslides, floods, riverbank erosion, and earthquakes are major contributors to geo-environmental degradation in the study area. Rapid population growth, deforestation, and unplanned human activities have intensified resource depletion and environmental pollution. To promote sustainability, responsible resource use and eco-friendly technologies such as bioremediation, phytoremediation, and nano-remediation are vital. Hazard zonation and site evaluations support disaster risk reduction (DRR). Active involvement of local communities and experts is essential to address anthropogenic causes. Strict control of hill cutting, urbanization, and land misuse is required. The study's findings provide guidance for policymakers to ensure sustainable urban development and environmental protection.

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