

Investigation of Landslides and Geoenvironmental Analysis in Rangamati and Adjoining Areas of Southeastern Hilly Districts, Bangladesh

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Abstract: Landslides that pose significant challenges to the development of Bangladesh have become a common threat, particularly in the southeastern region of the country. This study focuses on an area that stretches from Rangamati Sadar to Kawkhali Upazila, encompassing the surrounding regions of Rangamati District along the Chittagong-Rangamati National Highway. This research utilizes both fieldwork-based landslide inventory data and laboratory experimental analysis of slope soils to better understand disaster loss reduction strategies. A total of 40 landslides has been selected for this study, and 10 soil samples collected from different hills have been tested in the laboratory to characterize landslide slope materials. Field observations show that the slope materials primarily consist of sand, silt and clay. Laboratory test results indicate moisture content of soil samples ranging from 2.61% to 14.19%. The percentages of sand silt and clay-sized particles are 12-34%, 44-70% and 6-22%, respectively. Cohesion and friction angle values from the direct shear tests range from 2 to 24 kPa and 31 to 39 degrees, respectively. The low cohesion and steep slopes increase the likelihood of landslides. A landslide susceptibility map has been developed by integrating the landslide inventory with various factor maps using the Modified Frequency Ratio model. This map classifies the study area into different susceptibility categories: 9% high, 33% moderate, 41% low, and 18% very low landslide hazard-prone areas. The assessment indicates that the Chittagong-Rangamati National Highway and nearby areas in Rangamati District exhibit low vulnerability but face a high risk of landslides. Rainfall-induced landslides in the Rangamati District have increased significantly due to climate change, which has altered rainfall patterns. Besides geotechnical factors, other contributing causes of landslide hazards include extreme short-term rainfall and human activities such as hill cutting, deforestation and unplanned urbanization. This investigation will help the local authorities, stakeholders and policymakers in planning for landslide risk resilience.

Keywords: Geology, Landslides, Rainfall, Slope stability, Road, Rangamati, Bangladesh.

Introduction

Rangamati is the largest hilly district of Chittagong Hill Tracts of Bangladesh (Figure 1). Physiographically, the area is characterized by tight folds, ridges, wide valleys and cliffs. The study area was selected because of frequent landslides accountable for remarkable damage in recent years. On 13 June 2017, the area encountered extensive and dangerous landslides that caused 120 people to die, 227 injured, 1500 houses destroyed, and an enormous loss of economy. Chittagong-Rangamati National Highway Road was disconnected for about one week. In Manikchari, the road was partially damaged whereas in Sapchhori, about 60 m of the road collapsed and a temporary transportation structure was built for light vehicles (Ali et al., 2018; Rahman, 2020). The main focus of this investigation is to understand geoenvironmental conditions, landslide hazards and risk problems along the Chittagong-Rangamati National Highway Road and adjoining areas of the Rangamati District for proper risk management strategies.

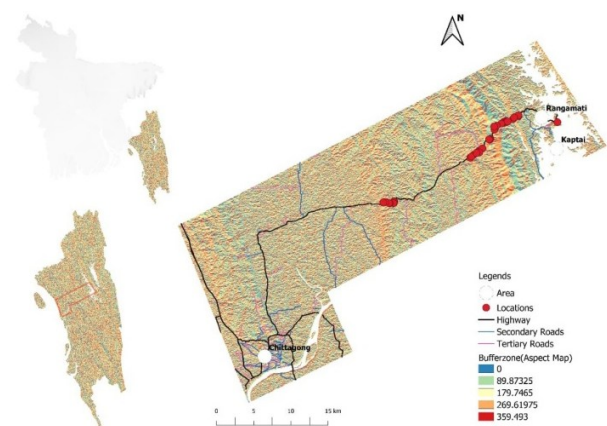


Figure 1, The study area location and landslide points along Chittagong-Rangamati National Highway Road and adjoining areas of Rangamati District.

Methodology

The study primarily relies on a fieldwork-based landslide inventory, collection of soil samples and secondary data analysis. The measurements of landslide dimensions (length, width, depth, etc) and slope angle were taken using the clinometers. Google maps and Geological maps have been used to find landslides in the field. GIS software was used to prepare inventory, susceptibility, vulnerability, hazard and risk maps. In this analysis, 40 landslides were mapped (Figure 2). Rainfall data was collected from the Bangladesh Meteorological Department (BMD) and Statistical Yearbook Bangladesh (2021). The soil samples were collected from the main body and sliding mass of the hill during field investigation. Collected soil samples were tested in the laboratory to determine the engineering properties following the ASTM standards.

The regional geology of the study area is mainly comprised of clastic sedimentary rocks from the Miocene to Holocene. The stratigraphic boundaries are mainly based on lithological characteristics. There are five stratigraphic units: Alluvium, Dupi Tila Formation, Tipam Formation, Boka Bil Formation and Bhuban Formation.

The climatic condition of the study area is tropical to subtropical. Seasonal variations of temperature and rainfall are observed (Figure 3). Human-caused climate changes make the situation more vulnerable to landslide hazards. Due to climate change, sometimes excessive rainfall occurs and sometimes there is no rain.

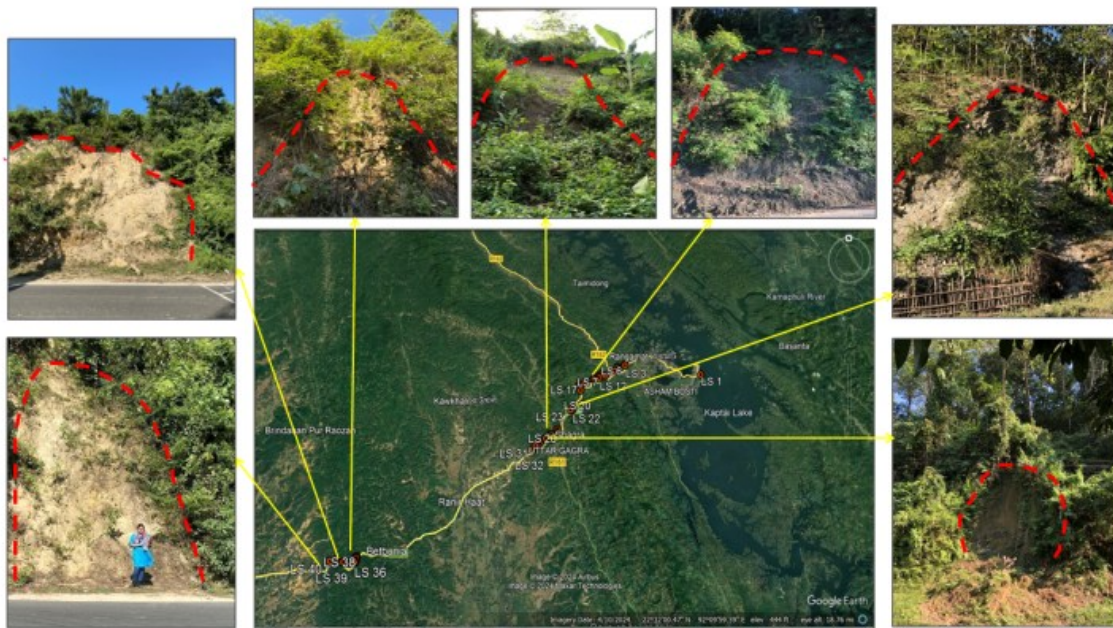


Figure 2, Landslide locations with images along Chittagong-Rangamati National Highway Road.

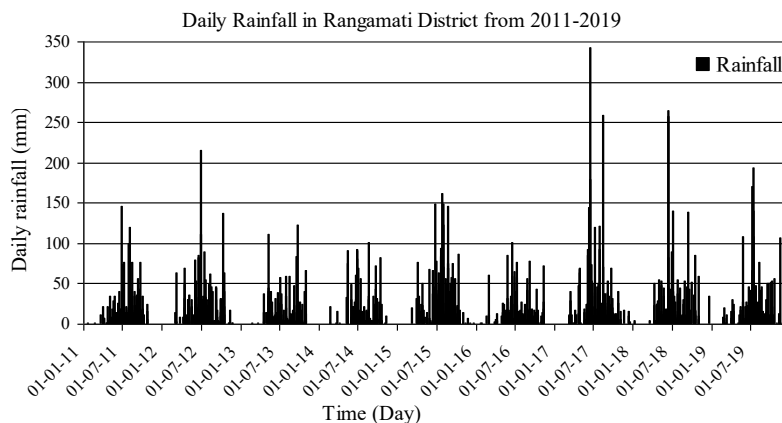


Figure 3, Daily rainfall (mm) in Rangamati District from 2011-2019.

Laboratory investigation was performed at the Engineering Geology Laboratory of the Department of Geology at the University of Dhaka. A total of 10

sediment samples were selected to determine index properties and direct shear test. Laboratory test results show that landslides occurred in sandstone consisting

of silt and clay particles. The cohesion of sediment samples is comparatively low due to a higher percentage of sand and silt particles than clay size particles. Low cohesion values indicate a high probability of landslides. The slope angle is highly deviated from the internal friction angle of slope materials and consequently frequent landslides occurred in this area.

Landslide characteristics and causes

The landslides are shallow based on the field investigation. The materials are mainly debris and earth. Most of the landslides are fall and flow type. Some are rotational slides. The movement is related to slopes ranging from 200 to 400. The landslide ranged

from 6 to 20 m in length and 6 to 19 m in width. The slope angles range from 650 to 850 respectively. The primary cause of the landslide occurrence is heavy rainfall in a short period (Kamal et al., 2021; Mia et al., 2017). Human interferences such as cutting hills, deforestation, unplanned urbanization and agricultural activities cause the area to be more vulnerable to landslides.

A landslide inventory has been prepared (Figure 4) and a susceptibility map from nine landslide factor maps using Modified Frequency Ratio (MFR method (Figure 5). Landslide hazard, vulnerability and risk assessments were done; therefore, a final risk map is produced to provide important information to mitigate or prevent disaster in landslide-prone areas.

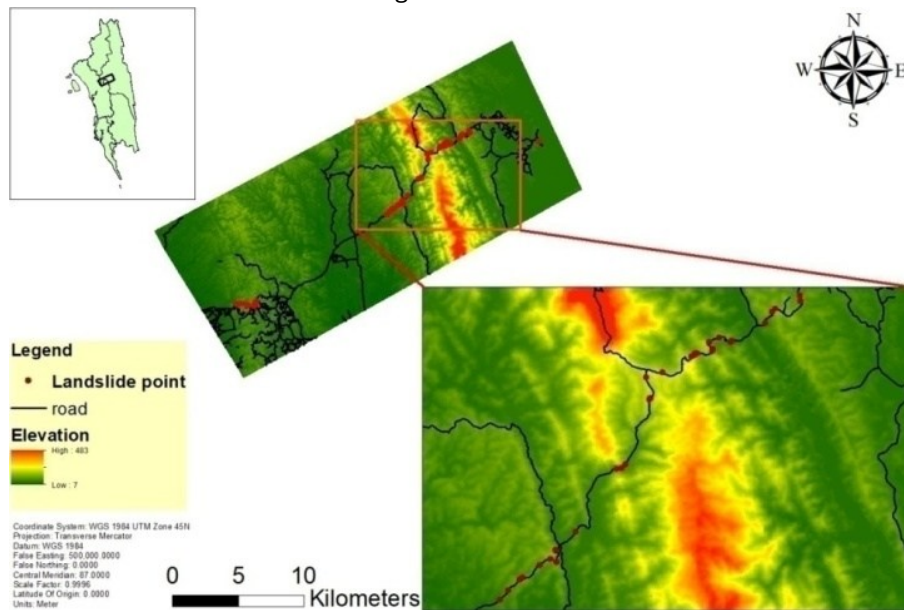


Figure 4, Landslide inventory map along Chittagong-Rangamati Highway Road and adjoining areas of Rangamati District.

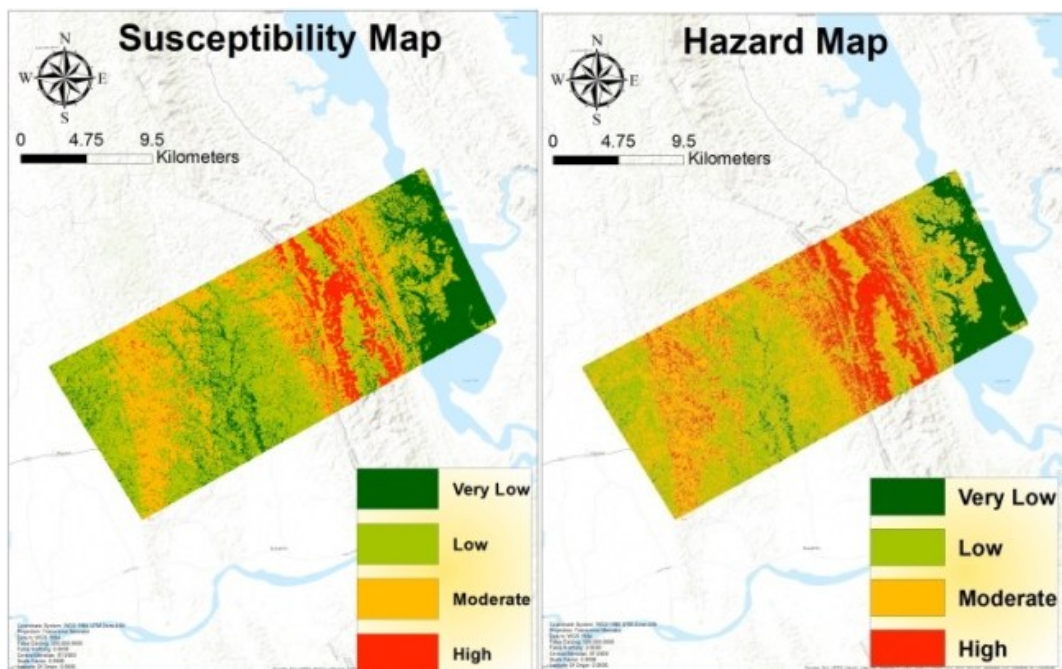


Figure 5, Landslide susceptibility map and hazard map of the study area.

Conclusion

In conclusion, landslide is one of the most serious hazards in Bangladesh. The findings reveal that seasonal rainfall pattern has greatly influenced the landslide occurrence in the area during monsoon period. Rock types and higher slope angles of hills are responsible for the pore water pressure in slope materials. High porosity and permeability, low cohesion, low friction angle and weathering characteristics of slope materials in the study area reflect a high probability of the occurrence of landslides.

To settle this problem, a multi-purpose approach should be taken jointly with proper planning. Some recommendations are made for the reduction of damage and loss by landslides in Rangamati District: i) Road alignment should be established in the competent rock strata to avoid slope instability ii) Slope angle should be <30° for road safety iii) Proper drainage structures should be built on slopes iv) Construction of adequate engineering structures v) Anthropogenic activities should be stopped vi) Necessity to develop early warning system and vii) make landslides awareness among people at the community level.

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