International Journal of Humanities & Social Science Studies (IJHSSS)
A Peer-Reviewed Bi-monthly Bi-lingual Research Journal
ISSN: 2349-6959 (Online), ISSN: 2349-6711 (Print)
ISJN: A4372-3142 (Online) ISJN: A4372-3143 (Print)
Volume-IX, Issue-II, March 2023, Page No.96-113
Published by Scholar Publications, Karimganj, Assam, India, 788711
Website: http://www.ijhsss.com
DOI: 10.29032/ijhsss.v9.i2.2023.96-113

Landslide Disaster in Chittagong Hill Tracts Natural or Man-made Disaster?

Rostoma Begum Chaudhury
Assistant Professor and Head, Dept. of LAW, University of Information Technology and Sciences (UITS), Bangladesh

Abstract:

This study aimed to investigate the causes, impacts, and management of landslides in Chittagong Hill Tract (CHT), Bangladesh. The conceptual framework and research questionnaire were developed based on literature review. A mixed-method as well as qualitative and quantitative approaches was used to collect and analyze data. In qualitative approach including surveys, interviews, and field observations. The authors utilized structural equation modeling (SEM) technique through R software for testing the hypothesized relationships in quantitative part. The study found that landslides in CHT are caused by a combination of landslide severity including topographic characteristics and mitigation measures such as community-based landslide. Landslides have severe impacts on the environment, society, and economy of the region, including loss of lives, damage to infrastructure, and disruption of livelihoods. The study also revealed that the existing policies and regulations to manage landslides in CHT are ineffective due to poor implementation and lack of coordination among stakeholders. Based on the findings, several recommendations were made, including the need for sustainable land use practices, early warning systems, and community-based disaster risk reduction initiatives. The study concludes that a comprehensive approach is required to address the challenges of landslide management in CHT, involving the active participation of all stakeholders.

Keyword: Chittagong Hill Tract (CHT), landslides, landslide severity, land use of change and Structural Equation Modeling.

Susilo et al (2020) analysed the landslide in the Banaran region of Ponorogo Regency, on the landslides that happened on April 1st in the year 2017. In order to examine the catastrophe mitigation activities, their research was carried out to learn more about the subsurface conditions in the Banaran region. The Wenner-Schlumberger configuration of the geo-electric resistivity approach was employed. The three villages of Banaran, Bekirang, and Mendak were the locations taken for the research. With a track length of 410 meters and a separation of 10 meters, there are 12 resistivity measurement locations. The range of the observed resistivity was 1.42 m to 67.500 m. The local geological maps and the resistivity data suggested that the rocks in the Banaran area were made of volcanic breccia, andesite lava, clay, and tuff lapilli. The landslide region started between 8 and 35 meters below the surface, the slope's gradient and the material thickness both equal 400, supporting the possibility of a more dramatic landslide. The research area was extremely sensitive to a landslide, according to the results of the parameter score of the landslide-prone zones.

Istijono, Hakam & Ophiyandri (2016) conducted a study to identify the possibility of a landslide in the Maninjau region, and to ascertain the likelihood of a landslide in the Maninjau region, a literature analysis and field investigation were conducted. The physical and mechanical characteristics of the soil in the Maninjau region were covered by the field investigation, where landslides frequently occurred around Maninjau Lake. It was found that at Maninjau, landslides were more likely to occur on slopes greater than 40%. It was necessary to implement the action plan and early warning systems in landslide-prone areas in the region.

Purworini, Hartuti & Purnamasari (2021) outlined the sociocultural elements influencing evacuation decision-making. In-depth semi-structured interviews were employed in this exploratory research project to get the data, and using particular criteria, the purposive sample approach was also used to choose the informants. Twenty villagers who had experienced a catastrophe and eight employees of the Badan Penanggulangan Bencana Daerah (BPBD), Ponorogo, and Regional Board of Disaster Management of the Republic of Indonesia made up the informants. Thematic coding was finally used to analyse the data, and according to the findings of the coding analysis, sociocultural factors were among the main factors influencing people's decisions to evacuate during catastrophes. The norms, roles, language, leadership, regulations, routines, occupations, perceptions, family participation, as well as other behaviours displayed by individuals and the community, may all have an impact on how people make evacuation decisions in this research.

Rauteka & Pande (2006) dispelled the notion that landslides were primarily a problem during the monsoonal months, which were often seen after heavy rainfall, and that they could also occur during other seasons. As a result, disaster warning levels could not be lowered during the non-monsoonal season. The message also made an effort to pinpoint weathering processes that could result in slope failure in the absence of rain, opening the door to identifying comparable landslide-prone regions. Based on the author’s own field observations, the report covers two recent landslides that occurred following the cessation of the monsoon rains: the Uttarkashi landslide of September 23, 2003, and the Ramolsari landslide of March 30, 2005. The possible causes of the slides were discussed in the study, along with the effects of this unique pattern of landslides occurring during the non-monsoon season on the state's disaster management policy.

The results of the research indicated that the Uttarkashi landslide may have been induced by precipitation, but there was no evidence to support this theory for the Ramolsari landslide. This appears to have been started by slow, continuous, and difficult-to-monitor weathering processes.

Pande & Uniyal (2007) provided insight into the underlying causes and consequences of catastrophes in the Himalayan area of Uttarkashi in the north, and disasters like the

Uttarkashi Earthquake of 1991, the Bhagirathi River flash floods, and the destruction brought on by the Gyansu landslide were taken into account. The following methodology was employed: the precise geographic location of the various landslides was marked using a ‘Global Positioning System Receiver (GPS)’, landslide types were identified based on ‘activity’ (active or old), ‘debris flow slide and rock fall were marked based on the sliding material and slope condition’, the land use/land cover pattern of Varunawat Parvat, the vulnerability of the population, houses, and infrastructure. The Himalayan state of Uttaranchal had long experienced the wrath of nature. Natural disasters were happening more frequently now than in previous years, and in several areas of the state, earthquakes, landslides, cloudbursts, and flash floods have seriously damaged both people and property. The Himalayan orogenic belt was susceptible to natural processes and was tectonically active. Anthropogenic activities such as uncontrolled slope cutting for construction activity, blasting of highly jointed rock mass for road building, and unplanned disposal of the slope-cut rubbish material all contributed to the fragility of this belt.

Uniyal (2008) gave a debate on the prognosis and mitigation of large landslide zones with an in-depth case study on the progression of the sliding events in VarunavatParvat in Uttarkashi, India, the reactions of the populace and the authorities, and the variables that caused the sliding events has been provided for the prediction and mitigation of big slide zones. The prediction and mitigation techniques mentioned were based on field research, satellite image analysis (of pre- and post-landslide period photos), learning, and engagement with village elders in landslide hazard-prone Himalayan terrain, which monitored mass wasting zones. The study concludes that slope cutting for road or building construction should be kept to a minimum in Himalayan settlements like Uttarkashi, which was located in a region with fragile rocks, complex tectonics, seismic activity, and unstable hill slopes that were prone to cloud bursts and old slide zones.

Pande (2006) aimed to explain how mass movements and landslides were frequent occurrences in the Himalayan region. In terms of fatalities and substantial harm to roads, houses, woods, plantations, and agricultural fields, the effects have recently gotten worse. The study was based on information regarding numerous landslides in Uttaranchal, India, gathered through fieldwork and secondary sources. Intensive building activity and unstable natural factors have joined in recent years to create enormous and complicated issues that have never been seen before. Most of the instability issues have never been seen before due to the implementation of several hydroelectric projects, large-scale construction of dams, roads, tunnels, buildings, towers, ropeways, tanks, and other public utility works, as well as indiscriminate mining and quarrying.

Singh (2010) performed a study to create an advanced low-cost, accessible, environmentally friendly, and ecologically sustainable method of managing and preventing landslide disasters. The study comprised a thorough analysis of secondary source material and was based on in-depth investigation and field observations of several landslide management efforts over the previous 10 years. By using contemporary science and technology, as well as adopting the required actions and safety precautions at the appropriate times and locations, landslide management seeks to enable and, to the extent feasible, expedite the continuous process of development on a sustainable basis. Even in the most industrialized nations, inadequate financial resources have made it difficult to control landslides. An environmentally sustainable, extremely cost- and time-effective solution to the slope instability issues in steep and hilly environments is provided by bioengineering.

Research Gap: From the compilation of the past literature, it can be seen that landslides and other similar disasters were not only natural but also man-made in some instances, due to the effects of urbanization of the area around the vicinity, and also through the effects of climate change. Another important factor to mention is there was no research done on landslide disasters within the context of Bangladesh, especially in the hill tracts of Chittagong. Therefore, the main aim of this research is to identify key determinants that influence the frequency and the causes of natural and artificial landslide disasters in those specific regions and also suggest ways to mitigate the effects of these occurrences for the safety of its local people.

Land Use Change: Land use change refers to the alteration of the biophysical environment due to human activities, including the conversion of natural ecosystems, such as forests or grasslands, to urban or agricultural land. The drivers of land use change include population growth, economic development, changes in land tenure systems, and government policies. The effects of land use change on the environment are complex and can have both positive and negative impacts, including soil erosion, loss of biodiversity, and changes in the water cycle. The study by Rahman et al. (2020) assessed the effects of land use/land cover changes on soil erosion in the Chittagong hill tracts region of Bangladesh. The authors found that the conversion of forest land to agriculture and urban land use has led to an increase in soil erosion rates in the region. The study also identified the need for sustainable land use management practices to mitigate the adverse effects of land use change on soil erosion. Another research by Rani et al. (2021) investigated the impact of land use and land cover change on water resources in a mountainous watershed of northwestern India. The study found that the conversion of forest land to agricultural land use has led to a significant decrease in water yield in the region. The authors identified the need for effective land use planning and management practices to ensure sustainable use of land and water resources in the region.

H1. Land use change has positive impact on increases the risk of landslides in the Chittagong hill tract

Landslide Severity: Landslide severity refers to the degree of damage or destruction caused by landslides. The severity of landslides is influenced by various factors such as the topography of the area, rainfall intensity, soil type, and land use changes. Uddin et al. (2021) conducted a study in the Chittagong hill tracts region of Bangladesh to map the landslide susceptibility using machine learning algorithms. The authors concluded that the study area is highly susceptible to landslides, and the severity of landslides is influenced by the slope, aspect, and elevation of the area. Hassan et al. (2020) analyzed the topographic characteristics of landslides using GIS and remote sensing in Chittagong hill tracts, Bangladesh. The study found that the majority of landslides in the area occur in steep slopes, and the severity of landslides is influenced by slope angle, slope aspect, and curvature. The authors also suggested that forest cover and vegetation density can reduce the severity of landslides by increasing soil cohesion and reducing surface runoff.

H2. The landslide severity has positive impact on rise the landslides in Chittagong till tract

Mitigation Measures: Mitigation measures refer to the actions taken to reduce the risk and impact of landslides on human lives and properties. In the context of the Chittagong hill tracts region of Bangladesh, Hasan et al. (2021) conducted an analysis of landslide occurrences and mitigation measures. They found that landslide occurrences are primarily influenced by topographic features, such as slope angle and elevation, and land use changes. The authors suggested that effective mitigation measures should focus on identifying the high-risk areas, providing early warning systems, and conducting public awareness campaigns. In a similar vein, Siddique et al. (2020) focused on community-based landslide risk reduction initiatives in the Chittagong hill tracts. The study emphasized the importance of community participation in identifying and managing landslide risks. The authors highlighted the need for capacity building, knowledge transfer, and stakeholder engagement to effectively implement mitigation measures. They suggested that community-based approaches should be integrated with governmental policies and regulations to promote sustainable and long-term risk reduction.

H3. The mitigation measures have positive impact on increase the risk of landslides in Chittagong Hill Tract

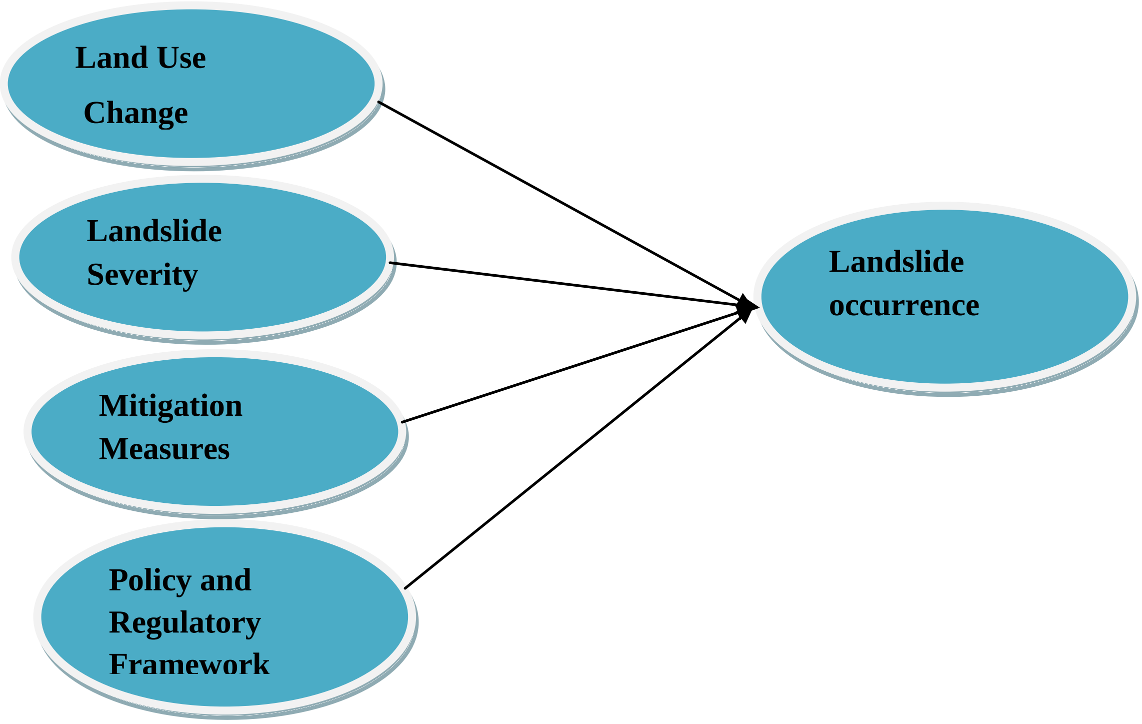
Policy and Regulatory Framework: The variable of policy and regulatory framework refers to the laws, regulations, and guidelines set by government institutions to manage and regulate activities that have an impact on landslides. The policy and regulatory framework aims to reduce the risk of landslides and ensure the safety of individuals and communities living in landslide-prone areas.

The study by Islam et al. (2018) focused on the policy and institutional issues related to landslide risk assessment and management in the Chittagong Hill Tracts of Bangladesh. The research examined the existing policy and regulatory framework and identifies gaps and challenges in implementing effective landslide risk management strategies. Similarly, the study by Hossain et al. (2020) assessed landslide risk in the Chittagong Hill Tracts area of Bangladesh and highlights the importance of effective policies and regulations in reducing the risk of landslides. The research evaluated the effectiveness of the existing policy and regulatory framework in managing landslide risk and suggests improvements to enhance the effectiveness of landslide risk reduction strategies.

H4. Policy and regulatory frameworks have positive impact on rise landslide risk management in Chittagong Hill Tract

Landslide Occurrence: Landslide occurrence refers to the frequency and distribution of landslides in a particular area. In geology, a landslide is defined as the sliding down of a mass of earth or rock from a mountain or cliff. The occurrence of landslides can be influenced by several factors, including geological and topographical features, land use changes, and climate variability. The study of landslide occurrence is essential for understanding the risks and hazards associated with landslides, which can cause significant damage to infrastructure, property, and human life. The two studies provided in the bibliography, Alam et al. (2020) and Hossain et al. (2019), both focused on landslide risk assessment in different areas of Bangladesh, using geospatial technology and different models such as frequency ratio and certainty factor models. These studies aimed to identify areas with high susceptibility to landslides and to develop strategies for managing the risks associated with landslides.

Theoretical Model: The proposed theoretical framework is based on above hypothesis and literature review, is shown in Figure 1.



Objectives:

1. To identify the main causes of landslides in Chittagong hill tract, whether they are natural or man-made, and to determine their relative contribution to the occurrence of landslides in the area.
2. To determine the severity of landslides in different areas of the Chittagong hill tracts using remote sensing and GIS technologies.

3. To investigate the effectiveness of existing mitigation measures in reducing landslide occurrence and severity, and to propose new measures where necessary.
4. To evaluate the policy and regulatory framework related to landslide management in the Chittagong hill tracts and suggest improvements for better risk reduction and disaster management.
5. To develop recommendations for improving landslide risk management in Chittagong hill tract based on the findings of the study, and to suggest areas for further research in this field.

Research Methodology: The following items have been taken for the constructs of the study from different sources mentioned below and these items have been adapted for this study.

Construct	**Variables**	**Adapted From**
Land Use Change	LUC1: Land use change in the Chittagong Hill Tract region over time increase the risk of landslide. LUC2: Land use change in the Chittagong Hill Tract region driven by certain factors cause's landslides. LUC3: Land use change affects the incidence and severity of landslides in the region.	Rahman, M. A., Alam, M. J. B. & Hossain, M. S. (2020). Rani, R., Singh, A., Tewari, V. K. & Akhtar, M. K. (2021).
Landslide Severity	LS1: The severity of landslides in Chittagong Hill Tract depends on topographic characteristics. LS2: The severity of landslides in the Chittagong Hill Tract region affected by soil type. LS3: There are other factors besides topography and soil type that influence the severity of landslides in Chittagong hill tract.	Uddin, M. J., Shahid, S., Harun, M. B., & Rahman, M. A. (2021). Hassan, M. A., Islam, M. R., Akhter, G., & Rahman, M. M. (2020).
Mitigation Measures	MM1: Effective mitigation measures reduce the risk of landslides in Chittagong hill tract. MM2: Community-based landslide risk reduction initiatives are effective in Chittagong hill tract. MM3: The implementation of mitigation measures can be improved in the Chittagong hill tract region.	Hasan, M. R., Islam, M. A., & Hasan, M. M. (2021). Siddique, M. A. R., Ahmed, S., Islam, S., Islam, M. S., & Ahmed, S. R. (2020).

Policy and Regulatory Framework	PRF1: There are some policies and regulations currently in place for landslide risk management in Chittagong hill tract. PRF2: These policies and regulations are not much effective for managing landslide risk in Chittagong hill tract. PRF3: Changes be made to improve the policy and regulatory framework for landslide risk management in Chittagong hill tract.	Islam, M. A., Hassan, M. Q., & Ahmed, R. (2018). Hossain, M. S., Rahman, M. M., & Mohiuddin, M. (2020).
Landslide Occurrence	LC1: Natural factors contribute to landslide occurrence in the Chittagong hill tract region. LC2: Human activities, such as deforestation and construction, influence landslide occurrence in the Chittagong hill tract region. LC3: The impact of natural and human factors on landslide occurrence is mitigated in the Chittagong hill tract region.	Alam, M.S., Hassan, M.Q., Rashid, M.T. et al. (2020). Hossain, M.A., Hoque, A.K.M.M., Alam, M.J.B. et al. (2019).

Analysis and Discussion

Measurement of Model Assessment: Table 1 shows he construct names and the items representing each construct are LUC (land use change), LS (Landslide Severity), MM (Mitigation Measures), PRF (Policy and Regulatory Framework), and LC (Landslide Occurrence). The table 1 highlighted the factor loadings for each item, the communality value (i.e., the variance explained by the construct), the redundancy value (i.e., the proportion of the item's variance accounted for by other constructs), and the average variance extracted (AVE).

The factor loadings indicate the strength of the relationship between each item and its respective construct. For instance, the factor loading for item LUC1 is 0.84, which indicates a strong positive relationship between LUC1 and the LUC construct. Similarly, the factor loading for item LS1 is 0.64, indicating a moderate positive relationship between LS1 and the LS construct.

The communality value represents the amount of variance in each item that is accounted for by its corresponding construct. For instance, the communality for item LUC1 is 0.70, indicating that 70% of the variance in LUC1 is explained by the LUC construct. The redundancy expresses the proportion of an item's variance that is accounted for by other constructs. For instance, the redundancy for item LUC1 is 0, indicating that none of the variance in LUC1 is accounted for by other constructs. The AVE represents the average amount of variance in each item that is explained by its corresponding construct. For instance, the AVE for the LUC construct is 0.68, indicating that 68% of the variance in the LUC items is accounted for by the LUC construct. Overall, the results suggest that the constructs have good convergent validity, as the factor loadings are generally high, the communality is moderate to high, the redundancy is under criteria value, and the AVE is above the recommended threshold of 0.5.

Table 1: Factors Loading with Communality and Redundancy, Convergent Validity

Construct	Item	Factor Loading	Communality	Redundancy (P-value)	Average variance Extracted (AVE)
LUC					0.683
	LUC1	0.8364722	0.69968577	0.000	
	LUC2	0.8186360	0.67016487	0.000	
	LUC3	0.8246798	0.68009676	0.000	
LS					0.460
	LS1	0.6438664	0.41456400	0.000	
	LS2	0.5890566	0.34698769	0.000	
	LS3	0.7861506	0.61803284	0.000	
MM					0.534
	MM1	0.8525326	0.72681187	0.000	
	MM2	0.6142305	0.37727915	0.000	
	MM3	0.7047984	0.49674077	0.000	
PRF					0.469
	PRF1	0.3003941	0.09023661	0.080	
	PRF2	0.7768537	0.60350162	0.000	
	PRF3	0.8441487	0.71258704	0.000	
LC					0.411
	LC1	0.5256884	0.27634830	0.001	
	LC2	0.7629805	0.58213923	0.000	
	LC3	0.6109509	0.37326100	0.000	

Source: Authors' own calculation

Table 2 provides information on the reliability and internal composite reliability of the constructs measured in the study. Cronbach's alpha is a measure of internal consistency and indicates the extent to which the items within each construct are measuring the same underlying concept. The table shows the Cronbach's alpha values for the constructs range from 0.310 to 0.77. Generally, a Cronbach's alpha of 0.7 or higher is considered acceptable for research purposes, although the acceptable range can depend on the specific context and research question. Composite reliability (rho (A)) and composite reliability (rho(C)) are measures of internal consistency that take into account the factor loadings of the items on the constructs. The table shows that the composite reliability values rho (A) range from 0.31 to 0.77 and from 0.67 to 0.87 for rho(C). Both rho (A) and rho(C) are commonly used measures of internal consistency in structural equation modeling analysis. Typically, values of 0.7 or higher are considered acceptable for both measures. Variance Inflation Factor (VIF) is a measure of multicollinearity between the independent variables in a regression model. It assesses the degree to which the variance of the estimated regression coefficients is increased due to multicollinearity. The table shows that the VIF values range from 1.2 to 1.4, indicating that there is no serious multicollinearity issue among the independent variables in the model. Overall, the reliability and internal consistency measures presented in Table 2 suggest that the constructs have acceptable internal consistency and are measuring the same underlying concepts.

Table: 2 Reliability and Internal Composite Reliability (rhoA), (rhoC) and VIF

Item	**Cronbach's α**	**Composite Reliability rho(A)**	**Composite Reliability rho(C)**	**VIF**
LUC	0.769	0.772	0.866	1.373
LS	0.465	0.464	0.716	1.391
MM	0.560	0.611	0.771	1.446
PRF	0.446	0.547	0.698	1.209
LC	0.310	0.311	0.671	

Source: Authors own calculation

Table 3 shows the results of the discriminant validity analysis using the heterotrait-monotrait (HTMT) ratio. The HTMT ratio is a commonly used method for assessing the discriminant validity of constructs in SEM analysis. A HTMT ratio of less than 0.9 is generally considered to indicate adequate discriminant validity. The table shows that the HTMT ratios are all below the threshold of 0.9, except for LC, indicating that there is adequate discriminant validity among the constructs. Higher HTMT value observed for LC. However, except LC, even the highest value is still below the threshold of 0.9, indicating that there is no significant issue of discriminant validity. Overall, these results suggest that the constructs are distinct and are measuring different underlying concepts.

Table 3: Discriminant Validity (HTMT Ratio).

	LUC	**LS**	**MM**	**PRF**	**LC**
LUC	.	.	.	.	.
LS	0.600	.	.	.	.
MM	0.631	0.830	.	.	.
PRF	0.568	0.619	0.657	.	.

LC	0.658	1.068	1.102	0.729	.

Source: Authors own calculation

Table 4 shows the results of the discriminant validity analysis using the Fornell-Larcker criterion. This method involves comparing the square root of the AVE for each construct with the correlations between the constructs. If the square root of the AVE for a given construct is higher than the correlation between that construct and other constructs, then discriminant validity is established.In this table, the diagonal values in bold represent the square root of the AVE for each construct. The values outside the diagonal represent the correlations between the constructs. As we can see, the square root of the AVE for each construct is higher than the correlations between that construct and other constructs. For example, the square root of the AVE for the LUC construct is 0.826, which is higher than the correlation between LUC, LS, MM, PRF and LC. Overall, these results provide further evidence of discriminant validity among the constructs. The Fornell-Larcker criterion confirms that the constructs are distinct and are measuring different underlying concepts.

Table 4: Discriminant Validity (Fornell-Larcker Criterion: Correlation matrix of Constructs and Square Root of AVE (in Bold).

	LUC	**LS**	**MM**	**PRF**	**LC**
LUC	**0.827**				
LS	0.406	**0.678**	.	.	.
MM	0.426	0.472	**0.730**	.	.
PRF	0.354	0.285	0.330	**0.685**	.
LC	0.361	0.428	0.493	0.322	**0.641**

Table 5 shows the cross-loadings of the measurement model. Cross-loadings indicate the extent to which each item of a construct loads on other constructs, in addition to its own. The values in the table represent the factor loadings of each item on its own construct as well as on other constructs. Overall, the table suggests that the items have stronger loadings on their own constructs than on other constructs, indicating good discriminant validity. However, some items show moderate to high cross-loadings on other constructs. For example, LS1 has a cross-loading of 0.644 on the LS construct and a moderate cross-loading of 0.243 on the LC construct. Similarly, PRF2 has a high cross-loading of 0.777 on the PRF construct and a moderate cross-loading of 0.269 on the LC construct. Therefore, it may be necessary to consider these cross-loadings when interpreting the results, particularly when examining the relationships between constructs. Further investigation may also be required to determine the reasons for the cross-loadings and whether any modifications to the model are necessary.

Table 5: Cross Loadings of Measurement Model

	LUC	**LS**	**MM**	**PRF**	**LC**
LUC1	0.836	0.261	0.364	0.316	0.280

LUC2	0.819	0.380	0.314	0.269	0.286
LUC3	0.825	0.360	0.375	0.293	0.326
LS1	0.168	0.644	0.255	0.194	0.243
LS2	0.179	0.589	0.151	0.143	0.183
LS3	0.405	0.786	0.462	0.230	0.389
MM1	0.385	0.362	0.853	0.254	0.451
MM2	0.211	0.268	0.614	0.160	0.286
MM3	0.314	0.410	0.705	0.311	0.317
PRF1	0.116	0.131	0.154	0.300	0.053
PRF2	0.289	0.290	0.259	0.777	0.246
PRF3	0.284	0.173	0.266	0.844	0.283
LC1	0.012	0.291	0.238	0.103	0.526
LC2	0.358	0.299	0.427	0.269	0.763
LC3	0.246	0.248	0.242	0.217	0.611

Source: Authors own calculation

Assessment of Structural Model: The structural model evaluation tests the relationships between the latent constructs and provides evidence for the hypotheses in Table 6. Looking at the results of the hypothesis tests, we see that three of the four relationships between the latent constructs and LC are statistically significant. The path coefficients for LS and MM are positive and statistically significant, indicating that there is a significant direct relationship between LS and MM with LC. This suggests that individuals who exhibit higher levels of LS and MM are more likely to demonstrate a high level of LC. On the other hand, the path coefficient for LUC and PRF are positive but not statistically significant. This suggests that there is no significant direct relationship between LUC and PRF with LC. Overall, these findings suggest that LS and MM are important predictors of LC, while LUC and PRF are not significant predictors of LC in the context of the LC. These results have practical implications for individuals and organizations seeking to improve LC, as they can focus their efforts on developing LS and MM as a means of enhancing LC.

Findings

1. The severity of landslides has a significant positive impact on the risk of landslides in the Chittagong Hill Tracts. This finding supports hypothesis H2 and indicates that the areas with more severe landslides are at a higher risk of experiencing future landslides.
2. Mitigation measures have a significant positive impact on reducing the risk of landslides in the Chittagong Hill Tracts. This finding contradicts hypothesis H3 and indicates that the existing measures, such as slope stabilization, drainage systems, and early warning systems, are effective in reducing landslide occurrence and severity.
3. Overall, the findings of the study suggest that landslides in the Chittagong Hill Tracts are mainly caused by natural factors such as rainfall intensity, geology, and

topography, but human activities, such as land use change, also play a significant role in increasing the risk of landslides. The study recommends implementing effective policies and regulations, improving the existing mitigation measures, and conducting further research to understand the dynamics of landslides in the area.

	Table 6: Hypothesis Testing and Structural Model Evaluation				
	$LC				
	Estimate (Beta)	**Mean**	**Std. Dev**	**T stat**	**Pr(>|t|)**
Intercept					
LUC -> LC	0.1017037	0.09956766	0.08966028	1.134322	0.160
LS -> LC	0.2040352	0.20950911	0.07780121	2.622519	0.029
MM -> LC	0.3117755	0.31970941	0.06928106	4.500154	0.005
PRF -> LC	0.1244517	0.14014874	0.07692119	1.617912	0.090

Source: Authors own calculation

Table 7 shows the goodness-of-fit indicators for the structural model. The model has a Goodness-of-Fit Index (GFI) of 0.930, which is greater than the recommended value of 0.90, indicating a good fit between the observed data and the model. The Adjusted Goodness-of-Fit Index (AGFI) is 0.851, which is also greater than the recommended value of 0.80. The Normed Fit Index (NFI) is 0.921, which is above the recommended value of 0.90, indicating that the model is a good fit to the data. The Comparative Fit Index (CFI) is 0.956, which is greater than the recommended value of 0.90, indicating an acceptable fit between the model and the data. The Root Mean Square Error of Approximation (RMSEA) is 0.065, which is below the recommended value of 0.08, indicating a good fit. The Standardized Root Mean Square Residual (SRMR) is 0.051, which is below the recommended value of 0.07. Overall, the goodness-of-fit indicators suggest thJat the structural model is a good fit for the data, indicating that the

Table 7: Goodness-of-fit indicators for the structural model			
Fit indices	**Structural model value**	**Recommended value**	**References**
gfi	0.930	> .90	Hair et al. (2010)
agfi	0.851	> .80	Hu and Bentler (1999)
nfi	0.921	> .90	Bentler and Paul (1996)
cfi	0.956	> .90	Bentler and Paul (1996)

rmsea	0.065	< .08	Hu and Bentler (1999)
srmr	0.051	< .07	Hu and Bentler’ (1999)

Source: Authors own calculation

Figure 2 Bootstrapped model. As Figure 1 revealed that to evaluate each of two the variables (exogenous and endogenous) measured the hypothesised latent variable accurately. Statistically significant relationships between the latent constructs and the predictor variables. Specifically, the path coefficients for LS and MM are positive and statistically significant, indicating that there is a significant direct relationship between LS and MM with LC. The path coefficients for PRF and LUC are also positive but less statistically significant than LS and MM. Additionally, the R-squared value for LC is 0.318, indicating that the predictor variables collectively explain approximately 31.8% of the variance in LC. Overall, these findings suggest that there is a significant relationship between the predictor variables and the occurrence of landslides in the Chittagong hill tract. The results also highlight the importance of considering multiple factors (i.e. LS, MM, PRF, and LUC) when developing policies and strategies for landslide risk management in the region. In conclusion, the Landslide Disaster in Chittagong Hill Tracts is a complex issue that involves multiple factors. The findings of this study suggest that the occurrence of Landslide Disaster is influenced by LS and MM. Therefore, measures should be taken to address these factors to reduce the risk of Landslide Disaster in the area. The results of this study can be used to inform policies and practices related to disaster risk reduction and management in the Chittagong Hill Tract.

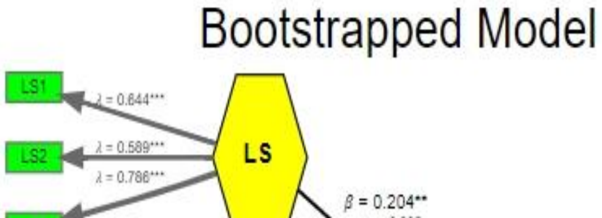


Fig-1

Fig-2

Conclusion: The Chittagong hill tracts region of Bangladesh is a highly susceptible area to landslides due to its steep topography, geological features, and land use changes. Land use change, such as the conversion of natural ecosystems to agriculture and urban land, has contributed to an increase in soil erosion rates, resulting in more severe landslides. The severity of landslides is also influenced by the topography of the area, including slope, aspect, and elevation. Mitigation measures such as identifying high-risk areas, providing early warning systems, and conducting public awareness campaigns, can help reduce the risk and impact of landslides on human lives and properties. Community-based approaches that involve stakeholder engagement, capacity building, and knowledge transfer can be integrated with governmental policies and regulations to promote sustainable and long-term risk reduction. The policy and regulatory framework also plays a vital role in reducing the risk of landslides in the Chittagong hill tracts region. The existing policy and regulatory framework should be evaluated and improved to enhance the effectiveness of landslide risk reduction strategies. Geospatial technology and different models such as frequency ratio and certainty factor models can be used to identify areas with high susceptibility to landslides and to develop strategies for managing the risks associated with landslides.

Managerial Implications of the study

1. Importance of land use planning and regulation: The findings suggest that land use change is a significant predictor of landslide occurrence and severity. Therefore, there is a need for effective land use planning and regulation to prevent or minimize the negative impact of land use change on landslide occurrence and severity.
2. Emphasis on mitigation measures: The study highlights the importance of mitigation measures in reducing the severity of landslides. Therefore, policy-makers and managers should prioritize the development and implementation of effective mitigation measures to reduce the risk of landslides.
3. Need for an effective policy and regulatory framework: The findings suggest that the policy and regulatory framework can significantly influence the occurrence and severity of landslides. Therefore, there is a need for an effective policy and regulatory framework that can support effective landslide disaster management in the Chittagong Hill Tracts.
4. Importance of cross-sectoral collaboration: The study highlights the need for collaboration between different sectors, such as land use planning, disaster management, and environmental protection, to effectively manage landslides in the Chittagong Hill Tracts.
5. Need for capacity building and awareness rises: The study emphasizes the need for capacity building and awareness rising among stakeholders involved in landslide disaster management in the Chittagong Hill Tracts. This can include training programs, awareness campaigns, and education initiatives that can equip stakeholders with the knowledge and skills necessary for effective landslide disaster management.

Reference:

1. Susilo, A., Fitriah, F., Sunaryo, Ayu Rachmawati, E.T. and Suryo, E.A. (2020), "Analysis of landslide area of Tulungsubdistrict, Ponorogo, Indonesia in 2017 using resistivity method", Smart and Sustainable Built Environment, Vol. 9 No. 4, pp. 341-360. https://doi.org/10.1108/SASBE-06-2019-0082.
2. Pande, R.K. (2006), "Landslide problems in Uttaranchal, India: issues and challenges", Disaster Prevention and Management, Vol. 15 No. 2, pp. 247-255. https://doi.org/10.1108/09653560610659793.

3. Singh, A.K. (2010), "Bioengineering techniques of slope stabilization and landslide mitigation", Disaster Prevention and Management, Vol. 19 No. 3, pp. 384-397. https://doi.org/10.1108/09653561011052547.
4. Uniyal, A. (2008), "Prognosis and mitigation strategy for major landslide-prone areas: A case study of VarunavatParvat landslide in Uttarkashi township of Uttarakhand (India)", Disaster Prevention and Management, Vol. 17 No. 5, pp. 622-644. https://doi.org/10.1108/09653560810918649.
5. Istijono, B., Hakam, A. and Ophiyandri, T.(2016), "Landslide hazard of Maninjau area", International Journal of Disaster Resilience in the Built Environment, Vol. 7 No. 3, pp. 302-312. https://doi.org/10.1108/IJDRBE-04-2014-0027.
6. Purworini, D., Hartuti, D.P. and Purnamasari, D. (2021), "Why is evacuation so difficult? Sociocultural aspects of landslide disaster in Ponorogo, Indonesia", Disaster Prevention and Management, Vol. 30 No. 2, pp. 137-148. https://doi.org/10.1108/DPM-04-2019-0123.
7. Rautela, P. and Pande, R.K. (2006), "Non-monsoonal landslides in Uttaranchal Himalaya (India): Implications upon disaster mitigation strategy", Disaster Prevention and Management, Vol. 15 No. 3, pp. 448-460. https://doi.org/10.1108/09653560610669927.
8. Hulathdoowage, N.D. and Hadiwattage, C. (2022), "Applicability of drywall technologies for disaster-induced housing reconstruction", International Journal of Disaster Resilience in the Built Environment, Vol. 13 No. 4, pp. 498-515. https://doi.org/10.1108/IJDRBE-01-2021-0001.
9. Pande, R.K. and Uniyal, A. (2007), "The fury of nature in Uttaranchal: Uttarkashi landslide of the year 2003", Disaster Prevention and Management, Vol. 16 No. 4, pp. 562-575. https://doi.org/10.1108/09653560710817048.
10. Rahman, M. A., Alam, M. J. B. & Hossain, M. S. (2020). “Assessment of the effects of land use/land cover changes on soil erosion in the Chittagong Hill Tracts, Bangladesh”. Catena, 193, 104582.
11. Rani, R., Singh, A., Tewari, V. K. & Akhtar, M. K. (2021). “Land use and land cover change and its impact on water resources in a mountainous watershed of northwestern India”. Journal of Environmental Monitoring and Assessment, 193(2), 1-25.
12. Uddin, M. J., Shahid, S., Harun, M. B. & Rahman, M. A. (2021). “Landslide susceptibility mapping using machine learning algorithms in the Chittagong Hill Tracts region of Bangladesh”. Geocarto International, 1-20.
13. Hassan, M. A., Islam, M. R., Akhter, G., & Rahman, M. M. (2020). “Analysis of the topographic characteristics of landslides using GIS and remote sensing in Chittagong Hill Tracts, Bangladesh”. Journal of Mountain Science, 17(8), 2069-2086.
14. Hasan, M. R., Islam, M. A. & Hasan, M. M. (2021). “Analysis of Landslide and Mitigation Measures in Chittagong Hill Tracts of Bangladesh”. Journal of Disaster Research, 16(3), 491-499.

15. Siddique, M. A. R., Ahmed, S., Islam, S., Islam, M. S. & Ahmed, S. R. (2020). “Community-based landslide risk reduction initiatives in Chittagong Hill Tracts, Bangladesh”. Landslides, 17(4), 1005-1017.
16. Islam, M. A., Hassan, M. Q. & Ahmed, R. (2018). “Landslide risk assessment and management in Chittagong Hill Tracts of Bangladesh: policy and institutional issues”. Landslides, 15(4), 695-704.
17. Hossain, M. S., Rahman, M. M. & Mohiuddin, M. (2020). “Assessment of landslide risk in the Chittagong Hill Tracts area of Bangladesh”. Journal of Environmental Management, 271, 111034.
18. Alam, M.S., Hassan, M.Q. & Rashid, M.T. et al. (2020). “Landslide susceptibility zonation using frequency ratio and certainty factor models in Bandarban, Bangladesh”. Environmental Earth Sciences, 79(16), 1-22.
19. Hossain, M.A., Hoque, A.K.M.M. & Alam, M.J.B. et al. (2019). “Landslide risk assessment of Chittagong Hill Tracts of Bangladesh using geospatial technology”. Geomatics, Natural Hazards and Risk, 10(1), 924-944.