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Occurrence of Landslide and Management in Darjeeling Himalayas

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Abstract – Landslide is a common natural phenomenon seen in mountainous territory of Darjeeling Himalaya. It is the most unavoidable of natural dangers that undermine the economic and social advancement of Darjeeling Himalaya. Landslides are the most across the board natural disaster in Darjeeling Himalaya which builds its spatial degree for quite a while. For a few natural causes and solid human effect on profoundly delicate and touchy slope ecological scene in type of deforestation, developments the natural security are quickened out. Natural elements like rainstorms, quake can trigger landslides. It brings an extraordinary death toll and substantial harm to land and property. The fundamental goal of the present examination is to distinguish the reasons for landslides, their effect and to propose vital measures to alleviate the risk in the Darjeeling Himalaya. The discoveries of the present examination uncovers that it is neither conceivable to stop the landslides nor to totally wipe out their harms however it is conceivable to limit the seriousness of the effect and the harm potential through a few basic measures and settlement strategy with solid open mindfulness.

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1. INTRODUCTION

Landslides are the most repeating natural risk which seriously influence wellbeing and security of occupants and disallow the maintainable improvement of the sloping regions. Because of some geographical elements, extraordinary development of populace amid the most recent couple of decades in the Darjeeling slope zones of West Bengal in India the issue of landslide has been intense. The target of the present examination is to feature the nature of landslide of the Darjeeling uneven territory and to display a diagram of its mitigation measures. The present investigation initially explores the geo-environmental parts of the Darjeeling bumpy region that empower the landslides in the zone. Subsequent to referencing the basic territories of landslides the examination continues with a depiction of over a significant time span landslide disaster situation. Later the examination clarifies a few landslide mitigation measures with accentuation on auxiliary measures. The investigation finishes up with certain recommendations that are vital for landslide issue.

Landslides are the huge type of natural disaster that causes the loss of properties and lives, particularly in the mountainous zones. The mountainous territories are portrayed by high vitality with insecurity and changeability of the majority. Landslide contrasts from the different mass development procedures and it is the development of the mass happens principally along a discrete disappointment surface. The inside unreformed plane slips the materials and breaks down the mass and further development incorporate the stream component. In India, the greater parts of the bumpy districts are portrayed with the landslide disaster. In the Himalayan locale, a few torrential slide zones are conspicuous, for example, Jammu Kashmir, Himachal Pradesh, Kumayun, Darjeeling and Sikkim and North-eastern uneven states. In the Himalayan lower regions where precipitation is noticeable, the event of landslides is noteworthy. The Darjeeling and Sikkim Himalaya are among the most helpless territories of landslides. The principle activating elements (barring topographical and geomorphological) of the landslide are substantial precipitation and seismicity. Generally, landslide disasters have been quickened by the few anthropogenic exercises in this locale. Be that as it may, to moderate or decrease the events of landslide, landslide vulnerability mapping of landslide risk alongside designing geomorphology are a portion of the post landslide activities.

As of late, in Darjeeling Himalaya, real landslides have happened in July-August, 1993 and May 2009 and in September 2011. Overwhelming precipitation has activated landslides at Mirik, Darjeeling, Kalimpong and Kurseong amid June-July, 2015, causes the loss of a few lives and properties. A few components might be in charge of the landslip. Consequently, the principle causing variables of the landslide have been talked about

dependent on some historical analysis with no factual or physically based model. This is in the organization of an educational report; hence, no examinations or evaluation was directed to gauge the impact and spatial attributes of the landslides in the investigation territory.

The Darjeeling Himalaya is a piece of Lesser Himalaya. The rise of the district ranges from 500 m to 2500 m above MSL as Figure 1. Because of differed geomorphology and neotectonic exercises, the locale is one of the exceedingly seismic tremor inclined zones. The fundamental shake kinds of the Darjeeling Himalayas are Pre-Cambrian high-grade gneiss and quartzite, high-grade schist phyletic and calc-silicate and quartzite. The real soils of this locale are portrayed by high grouping of iron oxide with the absence of mineral and natural supplements. The sedimentary shake of youthful collapsed mountain advances the dynamic disintegration in Darjeeling Himalaya. This district is profoundly powerless against landslides and the beginning of storm in the north India ordinarily finishes into gigantic high of the landslides. Landslides are likewise brought about by the seismic tremor stun. The tremor produced by the seismic tremor can irritate the fundamental structures of the uneven locale. The stun can disturb the fundamental parent body and thus landslide alongside the fall, droop, and the slide happens.

The anthropogenic exercises, for example, the informal employments of the incline for development, deforestation and the advancement of towns and the travel industry are likewise in charge of the expansion of the weakness of landslide in this locale. Sah and Bartarya have given a few reasons for the event of landslides in The Himalayan area. The causes are the dynamic powers (seismic tremors, neotectonic movement and so on.), an expansion of pore space because of high precipitation, the augmentation in inner weight because of synthetic and physical modification, and informal land use, mining and quarrying and so on.

1.1 History of Landslides in Darjeeling Himalayas

Darjeeling Himalayas has a place with the Eastern Himalayas ranges. This district is depleted by numerous streams and waterways, for example, Tista, Rangeet, Mahannda, Jaldhaka, Balason, Mechi, Lish, Gish, Murti and so on. The significant towns of this area are Darjeeling, Kalimpong, Kurseong and Mirik. This district is made out of delicate phyllite, schists, and gneiss and this locale are high powerless to a landslide. The events of landslides are noticeable from quite a while of history. According to the landslides records accessible, the sad landslide was happened in September 1899, in which 72 lives were lost in Darjeeling town. Kalimpong, Kurseong, Ghum, Tindharia of the Darjeeling Himalaya were additionally influenced by this disaster. In January of 1934, the event of the landslides is critical in Darjeeling, Ghum and Kurseong town. Enormous landslides were happened in June 1950, in which 127 lives were lost alongside the loss of a few properties including streets and Siliguri-Kalimpong railroads line. The influenced territories were Darjeeling town, Kalimpong, Kurseong, Happy Valley, Tindharia, Takdah. In another event of landslides, 667 lives were lost alongside the annihilation of a tea greenery enclosure and it happened on October 1968. The influenced zones of the landslide were Darjeeling town, Manpuri, Lebong, Kalimpong, Tista Bazar, and so forth. The Hill Cart Road and NH 31 of Darjeeling were seriously annihilated. Once more, Rimbik, Lodhama, Darjeeling Town, Bijanbari, Lebong, Ghum, Happy Valley were influenced by the landslides that happened on September 1980. In the slides around 215 individuals were lost alongside the few properties. Be that as it may, a few landslide disasters occurred in the time of 1991, 1993, 2003, 2004, 2005, and 2006. The majority of the slides happened in the Darjeeling Town, Kalimpong, Kurseong, Pulbazar, precipitation over the Himalayan lower region belt.

1.2 Landslides amid June-July, 2015

The landslides in the Darjeeling Himalayas are normal. Overwhelming precipitation set off the landslides at various places of Darjeeling Himalayas in June-July of 2015. The landslides happened for the most part in Darjeeling, Kurseong and Kalimpong sub-division of Darjeeling locale amid June-July, 2015. The primary influenced zones are Tingling and Soureni of Mirik, Nimki Dara, Sukhia Pokhari of Darjeeling, Lava, 11 miles (name of a place of Darjeeling District), 29 miles (name of a place of Darjeeling District), Pedong of Kalimpong. The all out loss of life came to up to 38 and a few people were misplaced. A few properties were lost, and streets were separated. The NH 55 that interface Siliguri and Darjeeling were separated as a scaffold washed away at Nimbujhora. The NH 10 were likewise detached the correspondence among Kalimpong and Lava. Numerous residential and global visitors were influenced for the separation of the interchanges. The landslides have disturbed the track of historical 'toy train' of Darjeeling Himalayan Railway and the Darjeeling Himalayas was disengaged in the rail organize over a month. Along these lines, because of the detachment of transportation and correspondence, the ordinary existence of the northern Darjeeling and Sikkim is disturbed. The shortage of the fuel gas and oil and diesel has expanded in this area. A gigantic measure of trash is dissipated all through the locale. It required investment of over a month to clean the trash and re-foundation of the customary correspondence. The traffic clog is a genuine picture as the a large portion of the vehicle couldn't experience the roadways (Figure 2).

The locale having steep incline is related with shake fall and flotsam and jetsam fall and is influenced much than the delicate slant. Despite what might be expected, in the valley side region, trash materials,

for example, bone and scree deposits hinder the streets and disengage the correspondence. The scree deposits likewise gather on the Tista, Rangeet, Mahananda, Jaldhaka, BalasonRiver, and so on. This amassing may additionally prompt glimmer flood with an overwhelming deluge in the upstream routine of the streams. Numerous specialists have distinguished a few foundations for the landslips. A few variables can be in charge of the ongoing landslides. The fundamental components for the landslide are, for example,

Figure 2: Landslides on different road stretches and on inhabited areas (Mirik) in Darjeeling Himalayas. Sources: Anandabazar Patrika and Bartaman (Bengali newspaper).

2. LITERATURE REVIEW

The investigation of landslide danger and their management has become a critical subject matter of sociology. Landslide can grab away various lives. So the researchers have coordinated their consideration with incredible significance. Ghosh (1950) in his work calls attention to the landslips issue of the Darjeeling Himalaya. Nautiyal (1951) presents a point by point land write about the slope inclines dependability in and around Darjeeling. Again Starkel (1972) clarifies in his work about the job of calamitous precipitation in the forming of the Lower Himalaya' (Darjeeling Hills). Bandopadhyay (1980) presents a portrayal of incline strength of Toonsoong zone, Darjeeling Town. Basu and Sarkar (1985) focuss on landslides at Tindharia district of Darjeeling Himalaya and their control Sarkar (2010) portrays geo-perils of Sub Himalayan North Bengal. Ghosh, et al (2008) in his work features the provincial dissemination of disasters in West Bengal. Most importantly, the data assembled from the National Disaster Management Authority, Ministry of Home Affairs, and Government of India has been valuable in the present examination.

3. OBJECTIVES OF THE PRESENT STUDY

The main objectives of the study are-

- To identify the causes of landslides in the Darjeeling Himalaya
- To assess the critical areas and impact of landslide disaster
- To suggest necessary measures to mitigate disasters

4. RESEARCH METHODOLOGY

The present examination depends on secondary information produced through creator's field study. The applicable information was gathered from 2.2.2015 to 8.3.2015 from the accompanying sources:

i. National Disaster Management Authority, Ministry of Home Affairs, and Government of India and

ii. Annual Reports, NDM Division, Ministry of Agriculture.

For doing the present work a short depiction of the geo-environmental parts of the Darjeeling Himalaya has been attracted to have an image of nature of landslide and their elements of the region. Subsequent to featuring it an analysis has been completed about the spatial appropriation of the landslides. A Critical Area Zonation map arranged by Basu(2000) looking at the topography, soil, and climatic factors alongside land use design has been advanced for better comprehension of the landslide issue of the zone.

Since landslide is the most unavoidable and repeating natural risk that undermine the financial and social improvement of Darjeeling Himalaya an image of landslide sway has additionally been featured in the present examination. A point by point portrayal of the landslide chance mitigation measures has been referenced to adapt to this natural danger. Anyway all the gathered secondary information was systematically organized and broke down. Based on the secondary information and data, a full careful literature audit has been made by the scientist for the significant comprehension of the issue of present examination. The data gathered from secondary sources has been confirmed with the field understanding.

- Present study area

The Hill territories of Darjeeling locale are situated inside the lesser and Sub - Himalayan belts of the Eastern Himalayas. The territory is limited by the Sikkim Himalaya in the north, the Bhutan Himalaya in the east and Nepal Himalaya in the west. The southern lower region belt is separated by an exceptionally dispersed stage of terrace deposits stretching out along the east west hub. The internal belt is characterized by a ridgeline extending from the Darjeeling Hill toward the west and Kalimpong Hill toward the east, sitting above the southerly streaming Tista valley in the middle.

Noticeable rivulets adding to the Rammam - Rangit bowl, disperse the northern slant of Darjeeling Hills.

5. GEO-ENVIRONMENT ASPECTS THAT ENCOURAGE LANDSLIDES IN THE AREA

5.1 Weak Geological set up

The Darjeeling Hill region speaks to a remarkable geo-environmental observation. As indicated by Mallet (1875) and Audent (1935) the structural units are observed to be in the invert request of stratigraphic superimposition and are spoken to by Siwalik and Gondwana systems. Towards the inward Himalayas, the thrusted sheets of Daling and Darjeeling group of rocks are found. The lower regions of Himalaya are spoken to by Siwalik Group of sedimentary rocks which includes interchange arrangement of delicate youthful micaceous sandstone, mudstone, dirt stone and stone bed. In the north the Main Boundary Fault (MBF) isolates it from the Gondwana Group of silt. The north of Gondwana is techtono-stratigrahically spoken to by a gathering second rate metamorphites, known as Daling Group. Topographically, the Daling rocks (phyllites, slates, schists feldspar and so on.) and Damuda rocks((sandstones, shale and so forth) are vulnerable to landslides(Sarkar,2010) since these are juvenile powerless rocks.

5.2 Heavy precipitation

The measure of precipitation assumes an imperative job in causing insecurity of slants. An extremely high power of precipitation inside a limited capacity to focus time is frequently regular in Darjeeling slope regions. In regard of landslide perils, the term of precipitation is critical. Long span alongside overwhelming storm may cause further invasion and overland stream, which at last may result into the event of landslides on more fragile slants. On a normal 4198.8 mm of downpour falls in the southern slants is watched. The records demonstrate a portion of the since quite a while ago proceeded deluge.

Table 1 Mean Annual rainfall in the southern slopes (around Paglajhora) of Darjeeling Himalaya

Rainfall recording stations	Mean annual rainfall in mm
Mahaldiram Tea Garden	4897.3
Victoria school	4257.9
Divisional Forest Office	4654.8
Goomti Tea Garden	3985.7
Lizzieur Tea Garden	3756.2
Goyabari Tea Garden	3641.0

5.3 Unstable geological structure

The trends of development or ascending of youthful mountains is the fundamental purposes behind regular landslide perils in the Himalayan locale. This incorporates temperamental topographical structure, structural unsettling influences, and parallel subsidence of Himalayan for profound of slants.

5.4 Rapid development of settlements

Quick development of settlements and towns particularly along the streets is one of the critical reasons for continuous landslide risks in the slopes. Multi storied structures without appropriate arranging along the streets and on the more extreme incline increment the heap on the as of now weakened slants.

5.5 Demand for kindling and mining

In the provincial and out of reach high slopes the interest for fuel wood is another imperative factor, which might be treated as a critical reason for incline disappointment. Informal mining of low enthusiastic coal creases and illicit felling of trees to fulfill the need of kindling is for all intents and purposes unavoidable in the slopes.

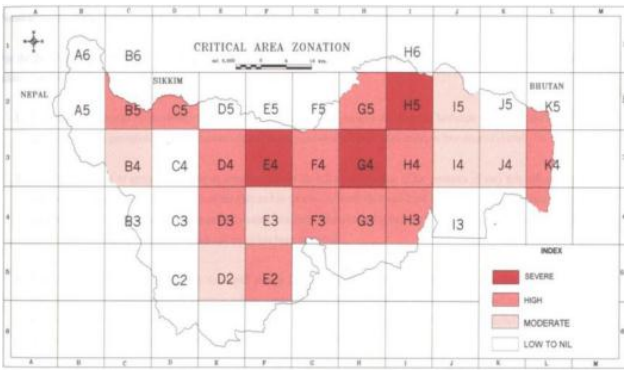
5.6 Critical regions of landslides

The primary risk inclined territories of landslides can be referenced as pursues

Table 2 Critical landslide prone areas of Darjeeling Himalaya

Level of Hazard prone areas	Hazard prone areas
Very high zone landslide prone area	This area lies in a small patch on the northern central part of the Darjeeling hills falling in Kalimpong subdivision
High zone of Landslide hazard	Darjeeling Sadar Subdivision on the right side of Teesta river and Kalimpong Subdivision of on the left bank of Teesta river
Moderately High zone of landslide hazard	Northwest- southeast below the high zone in Darjeeling and Kurseong Subdivisions
Moderate zone of Landslide hazard	The largest area of the Darjeeling hills where there remains a chance of at least one landslide/km2
Low zone of landslide hazard	Northwest corner of Darjeeling Sadar Sub-division, southern most end of the Kurseong Subdivision and southern part of the Kalimpong Subdivision

Prof. Basu (2000) after examining the geology, soil, and climatic factors along with land use prepared a Critical Area Zonation map. It appears from the map that the Grid no. E4 under Rangli-Rangliot block, G4 and H5 under Kalimpong II Block are the most landslide prone areas, where human intervention is high.



6. IMPACT

Landslide is the most unavoidable of natural risks that undermine the economic and social improvement of Darjeeling Himalaya From the accessible records (Griesbach, 1899-1900) it is discovered that the primary recorded terrible landslide happened on September24, 1899, after exceptional precipitation, causing the loss of 72 human lives just at Darjeeling town and boundless decimation of property. Numerous scenes of shocking landslides happened amid the next years (Bandopadhyay, 1980; Basu and Sarkar, 1984, 1985,1987; Dutta, 1966;Ghosh 1950; Nautiyal, 1951, 1966; Roy and Sensharma,1967, 1986; Sarkar, 1990,1995).

In 1950(11th&12thJune) Darjeeling town region, Kalimpong, Mahanadi Paglajhora, Tindharia, Takdah and slope territories remain cutoff from rest of Bengal for five days. 127 lives lost and a great many individuals were destitute. Again in 1980(third and fourth September) Rimbik, Lodhama, Bijanbari, Darjeeling, Sukhiapokri, Manebhanjan, Sonada Tindharia regions were seriously influenced by the landslides. More than 215 lives were executed and Rs. 100 milion properties were lost. The time of 1993(13th July) saw various landslides. Mongpoo region, Peshok, Pangkhabari, Mahanadi, Gayabari were influenced and 15 human lives lost.

In 2009(26th May and sixteenth August) a progression of landslides attacked the Darjeeling-Kurseong street and Kalimpong zones. 37 lives lost and gigantic devastation of creature and property, slopes remain cutoff for an extensive stretch and 500 houses were pulverized.

In September of 2011, a shallow center (The central profundity of the quake was 19.7 km as indicated by USGS.) seismic tremor estimating 6.8 on the Richter scale with its epicenter close to the India-Nepal outskirt (27.73^0N, 88.08^0E, 68 km NW of Gangtok, Sikkim, India , shook the Northeast and extensive pieces of northern and eastern India on 18hrs 10 minutes 47 seconds of 18-09-2011 and furthermore in parts Nepal, Bhutan, Bangladesh and China. This ruinous quake activated 421 landslides of different sizes in Sikkim Himalayan locale. These slides harmed streets and connects and upset help activities to towns and towns that were totally removed, some for more than three weeks.

The Sikkim Earthquake instigated landslides harm and demolishes an expansive number of homes and other structure, square streets and dam upriver and streams. Because of this world shudder the underlying appraisal of infrastructural harm in Sikkim was roughly Rs 10,000 crore ($22.3 billion), around 5– 7 percent of the complete number of houses in Sikkim were harmed in changing degrees and Out of a sum of 779 schools in the state, 682 school structures were harmed. The greater part of misfortunes and harms were happened primarily because of the seismic tremor and quake prompted landslides.

7. ROLE OF GOVERNMENT IN HAZARD MANAGEMENT

The Govt. of West Bengal has emphasized the following mitigational measures to tackle the landslide hazard in the present study area-

- √ Structural measures
- √ Drainage Corrections
- √ Proper land use measures
- √ Afforestation
- √ Public Awareness
- √ Settlement policy

8. FINDINGS OF THE STUDY

The present examination gives a review of the nature and mitigation proportions of landslide disaster in Darjeeling Himalayan region. Landslides have an extremely negative impact on the populace in various pieces of India particularly in the Northern Himalayan locale by devastating harvests, property, human and creature lives. The present investigation additionally uncovers that it is neither conceivable to stop the landslides nor to totally dispense with their harms yet it is conceivable to limit the seriousness of the effect and the harm potential. Landslides have happened previously and will keep on happening in future in the region. A few mitigation estimates like auxiliary measures, seepage adjustment, appropriate land use measures, reforestation for the territories involved by debased vegetation and making of mindfulness among neighborhood populace can be productive for the region.

9. CONCLUSION

In end say that individuals should mindful much about the landslide dangers. They ought not to manufacture settlements on the powerless territories. So it is important to make a solid open mindfulness. The Darjeeling Himalaya district is the most powerless against a landslide just as torrential slide, fall, and droop disaster. The essential impacts of the June-July landslide disaster are the disengagement of the streets, loss of lives, the breaking of extensions, and so forth. The general population has lost their home and endured homelessly and took covers that are given by state government. Therefore, the landslide disaster of 2015 triggers seriously the natural environment of the Darjeeling Himalayas. It is brought about by the natural wonders viz.

overwhelming heavy precipitation however the power and extent are upgraded by the anthropogenic exercises. An ongoing topographical review led for the Darjeeling Landslide by the Survey of India and the report says that the Nepal seismic tremor has a huge job in the event of the Darjeeling landslide. Notwithstanding, based on historical record it tends to be said that exceptional precipitation is the key factor for the June-July, 2015 landslide. As the formative action is expanded in the mountainous district, accordingly, the land use management is noteworthy to lessen the weakness of the landslides.

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