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Landslide Hazard in Darjeeling Himalayan Region and Its Management: A Study of Geographical Perspective

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ABSTRACT

Landslide is a recurring natural phenomenon observed in mountainous terrain of Darjeeling Himalaya. It is the most pervasive of natural hazards that undermine the economic and cultural development of Darjeeling Himalaya. It brings a great loss of life and heavy damage to land and property. The main objective of the present study is to identify the causes of landslides, their impact and to suggest necessary measures to mitigate the hazard in the Darjeeling Himalaya. The findings of the present study reveals that it is neither possible to stop the landslides nor to completely eliminate their damages but it is possible to minimize the severity of the impact and the damage potential through several structural measures and settlement policy with strong public awareness.

Keywords: *Geo-environment aspects; critical areas; impacts; management*

INTRODUCTION

Landslides are the most recurring natural hazard which severely affect safety and security of inhabitants and forbid the sustainable development of the hilly areas. Due to some geological factors, unprecedented growth of population during the last few decades in the Darjeeling hill areas of West Bengal in India the problem of landslide has been very acute. The objective of the present study is to highlight the nature of landslide of the Darjeeling hilly area and to present an overview of its mitigation measures. The present study first explores the geo-environmental aspects of the Darjeeling hilly area that encourage the landslides in the area. After mentioning the critical areas of landslides the study proceeds with a description of past and present landslide disaster scenario. Later the study explains several landslide mitigation measures with emphasis on structural measures. The study concludes with some recommendations that are necessary for landslide problem.

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

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DATA BASE AND METHODOLOGY

The present study is based on secondary data generated through author's field survey. The relevant data were collected from 2.2.2015 to 8.3.2015 from the following sources:

i. National Disaster Management Authority, Ministry of Home Affairs, and Government of India and
ii. Annual Reports, NDM Division, Ministry of Agriculture.

For carrying out the present work a brief description of the geo-environmental aspects of the Darjeeling Himalaya has been drawn to have a picture of nature of landslide and their factors of the area. After highlighting it an analysis has been carried out about the spatial distribution of the landslides. A Critical Area Zonation map prepared by Basu(2000) examining the geology, soil, and climatic factors along with land use pattern has been put forward for better understanding of the landslide problem of the area.

Since landslide is the most pervasive and recurring natural hazard that undermine the socio-economic and cultural development of Darjeeling Himalaya a picture of landslide impact has also been highlighted in the present study. A detailed description of the landslide risk mitigation measures has been mentioned to cope with this natural hazard. However all the collected secondary data was systematically arranged and analyzed. On the basis of the secondary data and information, a full thorough literature review has been made by the researcher for the meaningful understanding of the problem of present study. The information collected from secondary sources has been verified with the field experience.

LITERATURE REVIEW

The study of landslide hazard and their management has become an important subject matter of social science. Landslide can snatch away a number of lives. So the scholars have directed their attention with great importance. Ghosh (1950) in his work points out the landslips problem of the Darjeeling Himalaya. Nautiyal (1951) presents a detailed geological report on the hill slopes stability in and around Darjeeling. Again Starkel (1972) explains in his work about the role of catastrophic rainfall in the shaping of the Lower Himalaya' (Darjeeling Hills). Bandopadhyay (1980) presents a description of slope stability of Toonsoong area, Darjeeling Town. Basu & Sarkar (1985) focuss on landslides at Tindharia region of Darjeeling Himalaya and their control. Sarkar (2010) describes geo-hazards of Sub Himalayan North Bengal. Ghosh, et al (2008) in his work highlights the regional distribution of disasters in West Bengal. Above all, the information gathered from the National Disaster Management Authority, Ministry of Home Affairs, and Government of India has been very useful in the present study.

Present study area

The Hill areas of Darjeeling district are located within the Lesser and Sub - Himalayan belts of the Eastern Himalayas. The area is bounded by the Sikkim Himalaya in the north, the Bhutan Himalaya in the east and Nepal Himalaya in the west. The southern foothill belt is demarcated by a highly dissipated platform of terrace deposits extending along the east west axis. The inner belt

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is defined by a ridgeline stretching from the Darjeeling Hill to the west and Kalimpong Hill to the east, overlooking the southerly flowing Tista valley in between. Prominent rivulets contributing to the Rammam - Rangit basin, dissipate the northern slope of Darjeeling Hills.

GEO-ENVIRONMENT ASPECTS THAT ENCOURAGE LANDSLIDES IN THE AREA

Weak Geological set up

The Darjeeling Hill area represents a unique geo- environmental perception. According to Mallet (1875) & Audent (1935) the tectonic units are found to be in the reverse order of stratigraphic superimposition and is represented by Siwalik and Gondwana systems. Towards the inner Himalayas, the thrusted sheets of Daling and Darjeeling group of rocks are found. The foothills of Himalaya are represented by Siwalik Group of sedimentary rocks which comprises of alternate sequence of soft immature micaceous sandstone, mudstone, claystone and pebble bed. In the north the Main Boundary Fault(MBF) separates it from the Gondwana Group of sediments. The north of Gondwana is techtono- stratigrahically represented by an assemblage low grade metamorphites, known as Daling Group.Geologically, the Daling rocks(phyllites, slates, schists feldspar etc.) and Damuda rocks((sandstones, shale etc) are susceptible to landslides(Sarkar,2010) since these are immature weak rocks.

Heavy rainfall

The amount of rainfall plays a very important role in causing instability of slopes. A very high intensity of rainfall within a short span of time is often common in Darjeeling hill areas. In respect of landslide hazards, the duration of rainfall is very important. Long duration along with heavy down pour may cause deeper infiltration and overland flow, which ultimately may result into the occurrence of landslides on weaker slopes. On an average 4198.8 mm of rainfalls in the southern slopes is observed. The records show some of the long continued down pour.

Table-1: Mean Annual rainfalls 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

Source:Sarkar et al.(2010)

Unstable geological structure

The trends of evolution or rising of young mountains is the basic reasons for frequent landslide hazards in the Himalayan region. This includes unstable geological structure, tectonic disturbances, parallel subsidence of Himalayan for deep of slopes.

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Rapid expansion of settlements

Rapid expansion of settlements and towns especially along the roads is one of the important causes of frequent landslide hazards in the hills. Multi storied buildings without proper planning along the roads and on the steeper slope increase the load on the already deteriorated slopes.

Demand for firewood & mining

In the rural and inaccessible high hills the demand for fuel wood is another important factor, which may be treated as an important cause for slope failure. Unscientific mining of low energetic coal seams and illegal felling of trees to meet the demand of firewood is practically unavoidable in the hills.

Critical areas of landslides

The main hazard prone areas of landslides can be mentioned as follows-

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 Subdivision,southernmost 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.

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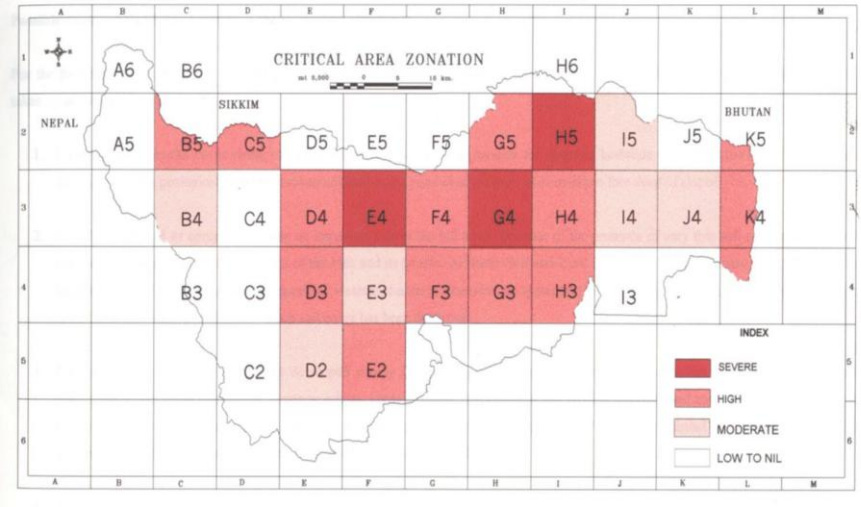

Source: Basu (2000)

IMPACT

Landslide is the most pervasive of natural hazards that undermine the economic and cultural development of Darjeeling Himalaya. From the available records (Griesbach, 1899-1900) it is found that the first recorded disastrous landslide occurred on September24, 1899, following unprecedented rainfall, causing the loss of 72 human lives only at Darjeeling town and widespread destruction of property. Many episodes of disastrous landslides occurred during the following years (Bandopadhyay, 1980; Basu & Sarkar, 1984, 1985,1987; Dutta, 1966;Ghosh 1950; Nautiyal, 1951, 1966; Roy & Sensharma,1967, 1986; Sarkar, 1990,1995).

In 1950(11th&12thJune)Darjeeling town area, Kalimpong, Mahanadi Paglajhora, Tindharia,Takdah and hill areas remain cutoff from rest of Bengal for five days. 127 lives lost and thousands of people were homeless. Again in 1980(3rd & 4th September) Rimbik, Lodhama,Bijanbari, Darjeeling, Sukhiapokri,Manebhanjan, Sonada Tindharia areas were severely affected by the landslides. Over 215 lives were killed & Rs. 100 milion properties were lost. The year of 1993(13th July) witnessed a number of landslides. Mongpoo area, Peshok, Pangkhabari, Mahanadi, Gayabari were affected and 15 human lives lost.

In 2009(26th May and 16th August) a series of landslides invaded the Darjeeling- Kurseong road and Kalimpong areas. 37 lives lost & massive destruction of animal and property, hills remain cutoff for a long period and 500 houses were destroyed.

In September of 2011, a shallow focus (The focal depth of the earthquake was 19.7 km according to USGS.) earthquake measuring 6.8 on the Richter scale with its epicenter near the India-Nepal border (27.73^{0}N, 88.08^{0}E, 68 km NW of Gangtok, Sikkim, India , shook the Northeast and large parts of northern and eastern India on 18hrs 10 minutes 47 seconds of 18-09-2011 and also in parts Nepal, Bhutan, Bangladesh and China. This destructive earthquake triggered 421 landslides of various sizes in Sikkim Himalayan region. These slides damaged roads and bridges and disrupted relief operations to towns and villages that were completely cut off, some for over three weeks.

ISSN NO.2395-0692
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The Sikkim Earthquake induced landslides damage and destroys a large number of homes and other structure, block roads and dam upriver and streams. Due to this earth quake the initial estimate of infrastructural damage in Sikkim was approximately Rs 10,000 crore ($22.3 billion), approximately 5–7 per cent of the total number of houses in Sikkim were damaged in varying degrees and Out of a total of 779 schools in the state, 682 school buildings were damaged. Most of losses and damages were happened mainly due to the earthquake and earthquake induced landslides.

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 correction,
- Proper land use measures,
- Reforestation for the areas occupied by degraded vegetation and
- Creation of awareness among local population.

Structural measures

Government emphasized on the actions that involve the construction of structures to reduce the landslide hazard. Such structures include dams, levees, floodwalls, retaining walls, channel maintenance sub-drains, soil reinforcement and safe rooms or shelters.

Drainage Corrections

The most important triggering mechanism for mass movements is the water infiltrating into the overburden during heavy rains and consequent increase in pore pressure within the overburden**.** Hence the natural way of preventing this situation is by reducing infiltration and allowing excess water to move down without hindrance. As such, the first and foremost mitigation measure is drainage correction. This involves maintenance of natural drainage channels both micro and macro in vulnerable slopes.

Proper land use measures

Government has also stressed on the effective land-use regulations and building codes based on scientific research. Through land-use planning, discourage new construction or development in identified hazard areas without first implementing appropriate remedial measures.

Afforestation

An afforestation programme has been planned in the area. Bounding of any sort using boulders etc. has to be avoided. The selection of suitable plant species is being done in such a manner that can stand the existing stress conditions of the terrain.

Public Awareness

Government has also emphasized on the awareness programme of landslide hazard. Public awareness is being propagated about signs that a landslide is imminent so that personal safety measures may be taken. Some of these signs include:

(i) Springs, seeps, or saturated ground in areas that have not typically been wet before.

(ii) New cracks or unusual bulges in the ground, street pavements or sidewalks.

(iii) Soil moving away from foundations, and ancillary structures such as decks and patios tilting and/or moving relative to the house.

(iv) Sticking doors and windows, and visible open spaces.

(v) Broken water lines and other underground utilities.

(vi) Leaning telephone poles, trees, retaining walls or fences.

(vii) Sunken or dropped-down road beds.

(viii) Rapid increase in a stream or creek water levels, possibly accompanied by increased turbidity (soil content).

(ix) Sudden decrease in creek water levels even though rain is still falling or just recently stopped.

Settlement policy

Drawing upon the Kerala study in parts of Western Ghat it has been felt that while permanent settlement should be avoided in high-risk zones, site selection even in moderately safe zones, especially in hilly edge regions should be made with caution. Diversion of stream channels in upper slopes, especially above settlement should strictly disallow. In hazard prone areas the existing natural drainage channels and hallows are to be meticulously maintained without any attempt at blocking, division or modification.

Findings

The present study provides an overview of the nature and mitigation measures of landslide disaster in Darjeeling Himalayan area. Landslides have a very detrimental effect on the population in different parts of India especially in the Northern Himalayan region by destroying crops, property, human and animal lives. The present study also reveals that it is neither possible to stop the landslides nor to completely eliminate their damages but it is possible to minimize the severity of the impact and the damage potential. Landslides have occurred in the past and will continue to occur in future in the area. Several mitigation measures like structural measures, drainage correction, proper land use measures, reforestation for the areas occupied by degraded vegetation and creation of awareness among local population can be fruitful for the area.

CONCLUSION

In conclusion it is important to say that people should aware much about the landslide hazards. They should not build settlements on the vulnerable areas. So it is very necessary to create a strong public awareness.

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