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Prevention and Mitigation of landslide hazard in Himachal Pradesh

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Abstract
The hills and mountains of Himachal Pradesh are liable to suffer landslides during monsoons and also in high intensity earthquakes. The vulnerability of the geologically young and no so stable steep slopes in various Himalayan ranges has been increasing at a rapid rate in the recent decades due to inappropriate human activity like deforestation, road cutting, terracing and changes in agricultural crops requiring more intense watering etc. The aim of the present research paper to highlight the major landslides in Himachal Pradesh and also focused causes, impacts and Prevention mitigation strategies for landslides reduction.

Keywords: Causes, Impacts, Prevention, Mitigation and Reduction

Introduction

Landslide

A landslide is the movement of large amount of soil, rocks, mud and other debris downward a slope. The movement is caused by the pull of gravity and occurs when a mountain side of hill side weakens and is unable to support its own weight. The amount of material that falls in a landslide can more slowly or quickly, and may travel a few feet (meters) or several miles (kilometers) before its stops. Some landslides move only a little each year, such movement may be irregular or it may happen at the same time each year, such as in the spring, where the snow melts.

Onset type and warning

Though they occur gradually, however sudden failure (sliding) can occur without warning. They may take place in combination with earthquakes, floods and volcanoes. There are no clearly established warnings in place indicating occurrence of landslide and hence difficult to predict the actual occurrence. Areas of high risk can be determined by use of information on geology, hydrology, vegetation cover, past occurrence and consequences in the region.

Elements at Risk

The most common elements at risk are the settlements built on the steep slopes, built at the toe and those built at the mouth of the streams emerging from the mountain valley. All those buildings constructed without appropriate foundation for a given soil and in sloppy areas are also at risk. Roads, communication line and buried utilities are vulnerable.

Typical Effects

Physical Damage: landslides destroy any thing that comes in their path. They block or bury roads, lines of communication, settlements, river flow, agricultural land etc. It also includes loss to agricultural production and land area. In addition physical effects such as flooding may also occur.

Casualties: They cause maximum fatalities depending on the place and time of occurrence. Catastrophic landslides have killed many thousands of persons, such as the debris slide on the slopes of Huascaran in Peru triggered by an earthquake in 1970, which killed over 18,000 people.

Landslide in Himachal Pradesh

The hills and mountains of Himachal Pradesh are liable to suffer landslides during monsoons and also in high intensity earthquakes. The vulnerability of the geologically young and no so stable steep slopes in various Himalayan ranges has been increasing at a rapid rate in the recent decades due to inappropriate human activity like deforestation, road cutting, terracing and changes in agricultural crops requiring more intense watering etc.

Table 1: Major Landslides in Himachal Pradesh

September, 1968	Himachal Pradesh	Active Maling slide 1 KM of road and a bridge washed out.
December, 1982	Himachal Pradesh	Near Solding Nallah 3 bridges and 1.5 KM length of road washed away
March, 1989	Himachal Pradesh	Nathpa, 500 mtr. Road section is frequently damaged during successive year
September, 1995	Himachal Pradesh	22 persons killed and several injured about 1 km road destroyed.

Table 2: Area under Landslide Hazard in Himachal Pradesh District

Distrit		Area under Landslide Hazard Risk (per cent)			Total
		Severe to Very High Risk	High Risk	Moderate to Low Risk	
1	Kullu	33.0	65.04	1.20	99.94
2	Chamba	33.8	60.11	5.51	98.90
3	Solan	29.1	58.53	8.22	95.86
4	Mandi	25.1	51.11	21.34	97.46
5	Bilaspur	18.1	73.73	7.27	99.91
6	Shimla	17.9	66.65	15.28	99.72
7	Kinnaur	13.3	78.39	7.88	100
8	Sirmaur	3.46	65.83	22.39	91.68
9	Kangra	2.19	65.91	21.97	90.07
10	Lahaul & Spiti	0.93	85.62	13.43	99.98
11	Una	0.13	44.96	34.28	79.37
12	Hamirpur	0.00	77.36	18.55	95.91
HIMACHL PRADESH		**14.7**	**70.07**	**13.08**	**97.42**

***Source*:** Government of India, 2003, Landslide Hazard Zonation Atlas of India

The annual distribution of landslide events for the period 1971-2016 displays the steadily rising trend in landslide frequency (figure 1) and 919 landslide events (table 2) were recorded in Himachal Pradesh. The distributional trends depict a slight decline from late 1970s till late 1980s; after this there is a rise in the frequency patterns. The intensification is not just in terms of the frequency of landslides, there has been an increase in the number of years that record a high number of events. The 1970s witnessed 164 incidents of landslides with an annual average of 18.22 events per year, which accounts for 18 percent of the total events that took place during 1971-2009. During 1980s landslide frequency was at an all time low as this decade accounts for about only 62 (6.7%)

Landslide events and annual average was just over 6 events per year. The decadal frequency in most of the districts has been on the rise after 1980s. In 1990s, 219 events (23.8%) at the annual average of about 22 events were recorded in the state. There was further increase in landslide events during 2000s (table 2) which recorded 474 landslides having annual average of 47 events per year, accounting for over 51 % of total events. 2010-2016 recorded 619 landslide events having annual average 73.70.

Table 3: Decadal Distribution of Landslides (1971-2016)

S.N.	Decade	Total Landslides	Per cent	Decadal Average	Landslide Character
1	1971-1979	164	17.84	18.22	High landslide activity
2	1980-1989	62	06.75	06.20	Declined activities
3	1990-1999	219	23.83	21.90	Increase in landslide activities
4	2000-2009	474	51.58	47.40	Intensification over time & space
5	2010-2016	567	73.50	68.77	Intensification over time & space

***Source*:** compiled from The Tribune, 1971-2016

The district wise distribution of landslides for the period 1971-2009 shows that there has been continual rise in landslide activities, particularly in post 1980 decades (table 3). During 1970s major landslide prone districts included Shimla (30.49%), Solan (23.17%), Mandi (12.20%) and Kinnaur (10.37) while in 1980s, Mandi (19.35%), Una (17.74%), Shimla (14.52%) and Solan (11.29%) were the most affected districts. During 1990s, Shimla (25.11%), Solan (14.15%), Mandi (12.33%) retained the status of being the most landslide prone districts while Chamba (11.87%) emerged as another landslide prone area. Similarly in 2000-2009, Shimla (20.04) was again the most landslide prone district. Kinnaur (17.93%), Solan (13.08%), Sirmaur (11.39%) and Chamba (10.34%) were other most landslide prone areas. Landslide occurrence during these 39 years exhibit that four districts, namely, Shimla, Solan, Kinnaur and Mandi account for more than 62 per cent of total landslide occurrences in the state. Shimla with 209 events

accounts for over 22.74 per cent of total landslides incidents followed by Solan (15.02%), Kinnaur (13.38%) and Mandi (10.77%).

Table 4: District-wise Decadal Distribution of Landslides (1971-2009)

Sr. No.	Districts	1971-1979	1980-1989	1990-1999	2000-2009	2010-16	Decadal Total (per cent)
		Events (per cent)	Events (per cent)	Events (per cent)	Events (per cent)	Events (per cent)	
1	Shimla	50 (30.49)	9 (14.52)	55 (25.11)	95 (20.04)	138 (24.33)	**347 (23.35)**
2	Solan	38 (23.17)	7(11.29)	31 (14.15)	62 (13.08)	54 (9.5)	**192 (12.92)**
3	Kinnaur	17 (10.37)	3(4.84)	18 (8.22)	85 (17.93)	87 (15.34)	**210 (14.13)**
4	Mandi	20 (12.20)	12 (19.35)	27 (12.33)	40 (8.44)	64 (11.28)	**163 (10.96)**
5	Chamba	4 (2.44)	6 (9.68)	26 (11.87)	49 (10.34)	53 (9.34)	**138 (10.77)**
6	Sirmaur	7 (4.27)	0	3 (1.37)	54 (11.39)	22 (3.88)	**86 (5.78)**
7	Kangra	4 (2.44)	5 (8.06)	10 (4.57)	38 (8.02)	61(10.75)	**99 (6.67)**
8	Kullu	8 (4.88)	3 (4.84)	15 (6.85)	23 (4.85)	31 (5.46)	**54 (3.63)**
9	Bilaspur	12 (7.32)	2 (3.23)	19 (8.68)	7 (1.48)	12 (2.11)	**52 (3.49)**
10	Lahaul & Spiti	2 (1.22)	1(1.61)	7 (3.20)	12 (2.53)	15 (2.64)	**37 (2.39)**
11	Hamirpur	2 (1.22)	3 (4.84)	6 (2.74)	7 (1.48)	28 (4.93)	**46 (2.48)**
12	Una	0	11 (17.74)	2 (0.91)	2 (0.42)	2 (0.35)	**17 (1.14)**
Total (percent)		**164 (100)**	**62 (100)**	**219 (100)**	**474 (100)**	**567 (100)**	**1486 (100)**

Table 5: Seasonal Distribution of Landslide (1971-2009)

Decade		Season Distribution			Total Per cent	
Winter Jan-Mar		Pre-Monsoon Apr-Jun		Monsoon Jul-Sept	Post- Monsoon Oct-Dec	
1	1971-1979	14 (08.53)	19 (11.59)	129 (78.66)	02 (01.22)	**164 (17.84)**
2	1980-1989	04 (06.45)	01 (01.61)	53 (85.49)	04 (06.45)	**62 (06.75)**
3	1990-1999	20 (09.13)	05 (02.28)	169 (77.17)	25 (11.42)	**219 (23.83)**
4	2000-2009	30 (06.33)	82 (17.30)	352 (74.26)	10 (02.11)	**474 (51.58)**
Total		**68**	**107**	**703**	**41**	**919 (100)**
Per cent		**07.40**	**11.64**		**76.50**	**04.46**

Seasonality of Landslide Occurrence

Intense and torrential rains are the principal cause of slope failure and majority of landslides in Himachal Pradesh occur during the monsoon season (table 4). During 1971-2009, 703 (76.50%) landslide events occurred during the monsoon season. The pre monsoon showers were also responsible for about 107 (11.64%) events of landslides while winter rains and snowfall during early months of the year cause over 7 per cent of total landslides.

Types of landslides

Falls: It happens due to the abrupt movements of masses of geologic materials, such as rocks and boulders that become detached from steep slopes or cliffs.

Topples: It happens due to the forward rotation of a unit or units about some pivotal point, below or low in the unit, under the actions of gravity and forces exerted by adjacent units or by fluids in cracks

Slides: In this types, rocks, debris or soil slide through slope forming material.

Spread: It usually occur on very gentle slopes or flat terrain.

Causes of Landslides

The major causes of landslides are

Rainfall and Snowfall

- The occurrence of heavy or continuous rainfall may lead to heavy landslides in the areas of steep slopes where National Highways and roads have been constructed.
- The Nashri area between BatoteRamban- Ramsu, and Banihal (Jammu and Kashmir) is frequently subjected to landslides. The landslides in this region are particularly severe during the rainy and winter seasons when the vehicular traffic is disturbed for several days.

Earthquakes and Volcanic Eruptions

- Earthquakes are the most important cause of landslides in the folded mountainous areas. In India, Landslides are more frequent in the folded mountains of the Tertiary Period, like the Himalayas.
- In the Kashmir valley, the earthquake of 1905 resulted into landslides in the lesser and the Greater Himalayas in which several thousand people lost their lives.
- Volcanic eruptions also trigger landslides in the mountainous regions.

Mining, Quarrying and Road cutting

- The continuous extraction of coal, minerals, and stones from the mines and quarries and the development of roads by cutting the steep slopes in the folded mountains create conducive conditions for the occurrence of landslides.
- Such landslides may be observed throughout the Himalayas and in the Eastern and Western Ghats.

Loading by construction of houses

- The unplanned growth of towns and cities in the hilly areas without testing soil and rocks in also an important cause of landslides.

Deforestation

- Deforestation and other human activities also induce landslides. Most of the landslides are small involving some blocks up to a few meters across. But some are large enough to cause a catastrophe. They may bury roads, buildings, and other structures.
- The adverse effect of landslides can be reduced by checking deforestation on mountain slopes, following building codes for such areas, and by avoiding the

construction of buildings on steep slopes.

Impact of Landslides

Short Term Impacts

Loss of Lives and Properties
Roadblocks, destruction of railway lines
Channel blocking due to rock – falls
Diversion of river courses due to landslides causing floods
Loss of natural Beauty

Long Term Impacts

Changes in the landscape that can be permanent
Loss of cultivable land
Environmental impact in terms of erosion and soil loss
Population shift and relocation of populations and establishments
Drying up of sources of water

Main Risk Reduction Strategies-Landslide

Hazard mapping will locate areas prone to slope failures. This will permit to identity avoidance of areas for building settlements. These maps will serve as a tool for mitigation planning, **land use** practices such as:

- Areas covered by degraded natural vegetation in upper slopes are to be afforested with suitable species. Existing patches of natural vegetation (forest and natural grass land) in good condition should be preserved.
- Any developmental activity initiated in the area should be taken up only after a detailed study of the region and slope protection should be carried out if necessary.
- In construction roads, irrigation canals etc. proper care is to be taken to avoid blockage of natural drainage.
- Total avoidance of settlement in the risk zone should be made mandatory.
- Relocate settlements and infrastructure that fall in the possible data of the landslide.
- No construction of buildings in areas beyond a certain degrees of slope.

Retaining walls can be built to stop land from slipping (these walls are commonly seen along roads in hill stations). It's constructed to prevent smaller sized and secondary landslides that often occur along the portion of the larger landslides.

Surface Drainage Control Works: The surface drainage control works are implemented to control the movement of landslides accompanied by infiltration of rain water and spring flows.

Engineered Structures with strong foundation can with stand or take the ground movement forces. Underground installations (Pipes, Cables etc.) should be made flexible to move in order to withstand forces caused by the land slide.

Increasing vegetation cover is the cheapest and most effective way of arresting landslides. This helps to bind the top layer of the soil with layer below, while preventing excessive run-off and soil erosion.

I**nsurance** will assist individuals whose homes are likely to be damaged by landslides or by any other natural hazards. For new constructions it should include standards for selection of the site as well as construction technique.

Community Based Mitigation

The most damaging landslides are often related to human intervention such as construction of roads, housing and other infrastructure in vulnerable slopes and regions. Other community based activities that can mitigate landslides are education and awareness generation among the communities, establishing community based monitoring, timely warning and evacuation system. Communities can play a vital role in identifying the areas where there is land instability. Compacting found locally, slope stabilization (procedures such as terracing and tree planting may reduce damages to some extent), and avoiding construction of houses in hazardous locations are something that the community has to agree and adhere to avoid damage from the possible landslides. This would also reduce the burden of shifting of settlements from hazardous slopes and rebuild in safe site as it is less practical to do in large scale.

Conclusion

The devastating landslides in Himachal Pradesh need more intensive scientific studies and engineering measures that are focused on the problem of landslides. As per the first step, it will be necessary to prepare zoning maps of landslides and rock fall prone areas through geological and geo technical studies. The landslide prone areas should be avoided while locating new settlement or buildings, and those, which are already occupied, should either be resettled or protective measures undertaken based on expert advice.

References

1. Govt of H.P. Revenue Department, Memorandum on damage due to flash flood, heavy rain monsoon, H.P. Govt. Press, 2001, 14.
2. Govt of H.P. Revenue Department, Memorandum on damage due to excessive rains, flash floods, H.P. Govt. Press, 2003, 8.
3. Govt of H.P. Revenue Department, Memorandum on damage due to excessive rains, flash floods, H.P. Govt. Press, 2005, 10.
4. Govt of H.P. Revenue Department, Memorandum on damage due to excessive rains, flash floods, H.P. Govt. Press, 2006, 12.
5. Govt of H.P. Revenue Department, Memorandum on damage due to excessive rains, flash floods, H.P. Govt. Press, 2007, 15.
6. Manual on National Disaster Management in India. M.C. Gupta, Vinod K. Sharma, L.C. Gupta, B.K. Tamini, NCDM, IIPA, New Delhi, march, 2001, 71.
7. Source: HTC, Kullu, 21 January, 2007, Hindustan Times, Chandigarh, January 21, 2007.
8. Source: HTC, Shimla, January 28, Monday, Hindustan Times 28 January 2007, Chandigarh, 2007.
9. Source: HTC, Kullu, June 8, Hindustan Times June 8, 2007 Chandigarh, 2007.
10. Source: Bhaskar News, Dainik Bhaskar, 26 July, Chandigarh, 2005.
11. Source: Express News Service Shimla, Kullu, Dharmshala, Oct. 7, 2005, Indian Express Chandigarh, Oct. 8, 2005.
12. Source: HT Correspondent, Hindustan Times, Saturday, July 01, Chandigarh, 2006.
13. Source: HT Correspondent, Hindustan Times, 14th. Nov, 2006, Hindustan Times Chandigarh 15th. Nov, 2006.
14. Source: Narendra Sharma, HT Correspondent, Jhokri

(Solan) Dec 2, 2006, Hindustan Times, Chandigarh Dec. 3, 2006.
15. Source: HT Correspondent, Shimla, May 2, 2007, Hindustan Times, Chandigarh, May 3, 2007.
16. Source: HT Correspondent, Nahan, Hindustan Times, Chandigarh, July 4, 2007.
17. Source: Revenue Dept, Deputy Commissioner office, Mandi, Hamachal Pradesh, 2000.
18. www.nih.ernet. In India National Institute of Hydrology perform tasks such as Ground Water Zone Mapping Land use, Salinity, Sedimentation, Soil erosion, Water logging etc.
19. MC Gupta, Vinod K Sharma, LC Gupta, BK Tamini. manual on Natural Disaster Management, IIPA, The Ministry of Agriculture, New Delhi, 2001, 75.
20. Prof. Anand S Arya, Anup Karanth and Ankush Agarwal, Hazards, Disaster and Your Community, A Primer Parliamentarians, Government of India, ministry of Home Affairs National Disaster Management division, New Delhi, 2004, 42.