LANDSLIDES IN HIMALAYAN MOUNTAINS: A STUDY OF HIMACHAL PRADESH, INDIA

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ABSTRACT

Landslide encompasses all varieties of mass movements consisting of different types of rock fall, topple and debris flow. The failure of shear strength or exceeding shear stress leads to down slope movement of surface material. These are short lived and suddenly occurring phenomena that cause considerable loss of life, widespread damages to infrastructure and facilities. The state of Himachal Pradesh is inherently prone to disasters, more so as it is a part of the Himalayan mountain system. Frequent natural disasters of varying intensity hamper the development of the state and strain the state exchequer.

This work explored the spatial and temporal dimensions of landslide in Himachal Pradesh with a focus on identifying critical zones of highly concentrated landslide activities. The results shows that slope failure activities show increasing trends and there is not only upward rise in annual and decadal frequency of landslides but the number of years with exceptionally high occurrence during each decade have also increased. The natural conditions including unstable steep slopes, weak rock structure and intense rainfall are main reasons for slope failure in the state. The vulnerability in these geologically young and unstable steep slopes has increased due to anthropogenic activity such as road construction and widening, communication facilities, expansion of settlements and other allied developmental activities, deforestation and changes in agriculture pattern.

Keywords
Landslides, Himalayas, Disaster, Risk and Vulnerability

1. INTRODUCTION

Landslide refers to down slope movement of surface material. Such phenomena result from several natural causes such as rainfall, seismic tremors, overburdening by rock material, removal of basal lateral support, loosened soil structure, blockage of drainage etc. as well as human induced/created causes. The term landslide encompasses all varieties of mass movements consisting of different types of rock fall, topple and debris flow (Varnes, 1984) etc. under the influence of gravity. The failure of shear strength or exceeding shear stress leads to down slope movement of surface material (Hyndman & Hyndman, 2009). Landslide is a short lived and suddenly occurring phenomena that cause considerable loss of life, widespread damages to infrastructure and facilities. However it may have had a long gestation period and the natural processes that result in a landslide may have been underway for a considerable time before the landslide actually occurs. Prolonged human activity of a detrimental nature may also lead to landslides.

The state of Himachal Pradesh is inherently prone to disasters, more so as it is a part of the Himalayan mountain system. The state has a long history of disastrous natural events (Chandel and Brar, 2010, 2011, 2012) and frequent natural disasters of varying intensity hamper the development of the state and strain the state exchequer (Planning Commission, 2005). This work explores the spatial and temporal dimensions of landslide as a disaster in Himachal Pradesh with a focus on identifying critical zones of highly concentrated landslide activities.

DATA SOURCE AND METHODOLOGY

In this work, landslide as a disaster has been discussed from historical and spatio-temporal perspectives. All available information on historical scenario has been presented using narratives from different sources. This is followed by spatio-temporal patterns of landslides for the period 1971-2009 for which continuous data has been compiled from daily news reports from newspaper ‘The Tribune’. The news reports from which the data on landslide events is compiled contain an element of locational bias in favor of areas of dense population or transport networks; it is likely that some events that occurred away from such areas were not reported and hence do not form a part of this analysis.

The focus of entire analysis is to understand the patterns of occurrence in terms of the spatial and temporal distribution, patterns of concentration, frequency, magnitude, impacts and identification of landslide prone zones. The discussion also takes into account the probable causes for disaster occurrence. This has been done in light of geo-physical, climatic and environmental conditions as well as the anthropogenic factors responsible for triggering such events.
RESULTS AND DISCUSSION

**Historical Perspective on Landslides in Himachal Pradesh**

Landslides have an established history in the state; however, the information on such disasters is very limited and restricted to the areas of population concentration or along the major transportation networks. The gazetteer of the Simla Hill State (Punjab Government, 1910) mentioned numerous landslides induced by an earthquake in 1803. These landslips blocked the river Satluj and river Giri and created huge dams. The bursting of dams led to large scale destruction in Bilaspur and Sirmaur districts. Apart from these events, some folk tales also corroborate the landslide activities in upper Beas River valley in Kullu. One such location is near village Bandrole, about 13 km, north of Kullu town, where according to a legend a massive landslide buried an entire village (Gardner, 2002). The records reveal that 1905 Kangra earthquake induced numerous landslides in the Beas river valley between Kullu and Manali (Punjab Government, 1926). Chander (1989) in his PhD thesis mentioned the occurrence of 33 landslides on Kalka-Rampur highway and 3 landslides on Mandi-Manali highway during 1935-1947. The Tribune, June 10, 1935 reported many landslides near Barog on Kalka-Shimla highway that isolated areas of Solan and Dharampur from the other markets and led to the shortage of food products. During late 1950s, two landslides occurred five and half kilometers south of Kumarsain in Shimla district on Shimla-Rampur highway, due to heavy rainfall (The Tribune, 4 & 5 June 1957); one in Shimla town near Jakh (The Tribune, 15 September 1957); and at various places on Kalka-Shimla highway (The Tribune, 18 September 1957). The Tribune, 11 June 1958, reported landslide near Aut in Mandi district along the Mandi-Manali highway in which road workers were caught under the falling mass of rock claiming two lives. Another landslide occurred in Kullu due to heavy rainfall (The Tribune, 19 July 1958).

A huge landslide occurred in 1963 on Bilaspur- Chandigarh highway at Gambhar in Bilaspur district: “Landslides in hills are common, but there is something unusual in the cave-in of a 2000-f. stretch of the recently-constructed Shimla Naglang Road in Himachal Pradesh. The “sunken” portion of the road settled at about 800 feet below its alignment... The site is 16 miles, 600 yards from Bilaspur, and few hundred yards from the bank of Gambheir, a tributary of the Sutlej, near Charole village... The mishap occurred on the night of April 1 shortly before midnight” (The Tribune, 9 April 1963). As per the news report, the truck drivers were stopped few hundred yards from village Charole by “a chunk of a hillock which had just started to fall... another landslide began in front of them”. A according to an eyewitness “we found ourself going down rapidly, but without any jerks... The movement was then stopped and they found themselves with two trucks on a badly battered track cut off from both sides of the road” (The Tribune, 9 April 1963). This apart, heavy rainfall during the monsoon of 1968 induced a huge landslide at Malling that destroyed one kilometer of road and washed out a bridge (The Tribune, September 1968).

A landslide killed 40 people and injured 16 at Matiana on Hindustan-Tibet (HT) highway in Shimla district in August 1989 (The Tribune, 6 Aug 1989). Another massive landslide killing over hundred people in Luggar-Bhatti area of Kullu district occurred in 1995. This landslide led to the accumulation of 200 m long and 100 m high debris. “... the landslide occurred at 9:45 a.m. in the morning when there was a rush of office goers and school children ... Labourers engaged by the PWD to clear the bank road leading to Manali were at work. Almost all labourers, most of whom were from Nepal, were buried... report said that a number of school children, who were walking atop the hill which slid down were buried” (The Tribune, 12 September 1995).

On 14th October 2004, nine labourers were buried alive and three injured in a huge landslide near Mulgi bridge at Basantpur in Shimla (The Tribune 15 October 2004). During March 2008 at least six persons were killed and eight injured in a massive landslide at Nehru Kund hill near Mandi. “At least six persons were killed and eight injured when a huge rock rolled down from the Nehru Kund hill on the Manali-Rohtang highway... The slide buried about 500 m stretch of the road along with a dozen improvised shops (khokas), one temple and four houses. Some vehicles, including car and motorcycles were also feared to have been buried” (The Tribune, 18 March 2008).

**Spatial Distribution and Concentration of Landslides**

**Landslide Hazard in Himachal Pradesh:** As per Government of India (2003), nearly 97.42 per cent of the total geographical area of the state is prone to landslide hazard. Over 14 per cent and 70 per cent area is liable to severe to very high and high risk of landslides. All the districts have over 90% area prone to landslide hazard except Una where it is about 80% of the total area (table 1). In severe landslide hazard risk category Kullu district (33.70%) with one-third area under this class tops the list followed by Chamba (33.28%), Solan (29.11%), Mandi (25.01%), Bilaspur (18.91%), Shimla (17.79%) and Kinnaur (13.73%).

**Spatio-Temporal Patterns:** The annual distribution of landslide events for the period 1971-2009 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.

<table>
<thead>
<tr>
<th>District</th>
<th>Severe to Very High Risk</th>
<th>High Risk</th>
<th>Moderate to Low Risk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Kullu</td>
<td>33.70</td>
<td>65.04</td>
<td>1.20</td>
<td>99.94</td>
</tr>
<tr>
<td>2 Chamba</td>
<td>33.28</td>
<td>60.11</td>
<td>5.11</td>
<td>98.90</td>
</tr>
<tr>
<td>3 Solan</td>
<td>29.11</td>
<td>58.53</td>
<td>8.22</td>
<td>95.86</td>
</tr>
<tr>
<td>4 Mandi</td>
<td>25.01</td>
<td>51.11</td>
<td>21.34</td>
<td>97.46</td>
</tr>
<tr>
<td>5 Bilaspur</td>
<td>18.91</td>
<td>73.73</td>
<td>7.27</td>
<td>99.91</td>
</tr>
<tr>
<td>6 Shimla</td>
<td>17.79</td>
<td>66.65</td>
<td>15.28</td>
<td>99.72</td>
</tr>
<tr>
<td>7 Kinnaur</td>
<td>13.73</td>
<td>78.39</td>
<td>7.88</td>
<td>100</td>
</tr>
<tr>
<td>8 Sirmaur</td>
<td>3.46</td>
<td>65.83</td>
<td>22.39</td>
<td>91.68</td>
</tr>
<tr>
<td>9 Kangra</td>
<td>2.19</td>
<td>65.91</td>
<td>19.91</td>
<td>90.07</td>
</tr>
<tr>
<td>10 Lahaul &amp; Spiti</td>
<td>0.93</td>
<td>85.62</td>
<td>13.43</td>
<td>99.98</td>
</tr>
<tr>
<td>11 Una</td>
<td>0.13</td>
<td>44.96</td>
<td>34.28</td>
<td>79.37</td>
</tr>
<tr>
<td>12 Hamirpur</td>
<td>0.00</td>
<td>77.36</td>
<td>18.55</td>
<td>95.91</td>
</tr>
<tr>
<td>HIMACHAL PRADESH</td>
<td>14.27</td>
<td>70.07</td>
<td>13.08</td>
<td>97.42</td>
</tr>
</tbody>
</table>


Table 2: Decadal Distribution of Landslides (1971-2009)

<table>
<thead>
<tr>
<th>Decade</th>
<th>Total Landslides</th>
<th>Per cent</th>
<th>Decadal Average</th>
<th>Landslide Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1971-1979</td>
<td>164</td>
<td>17.84</td>
<td>18.22</td>
<td>High landslide activity</td>
</tr>
<tr>
<td>2 1980-1989</td>
<td>62</td>
<td>06.75</td>
<td>06.20</td>
<td>Declined activities</td>
</tr>
<tr>
<td>3 1990-1999</td>
<td>219</td>
<td>23.83</td>
<td>21.90</td>
<td>Increase in landslide activities</td>
</tr>
<tr>
<td>4 2000-2009</td>
<td>474</td>
<td>51.58</td>
<td>47.40</td>
<td>Intensification over time &amp; space</td>
</tr>
<tr>
<td>Total</td>
<td>919</td>
<td>100</td>
<td>22.98</td>
<td></td>
</tr>
</tbody>
</table>
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 3: District-wise Decadal Distribution of Landslides (1971-2009)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events (per cent)</td>
<td>Events (per cent)</td>
<td>Events (per cent)</td>
<td>Events (per cent)</td>
<td>Decadal Total (per cent)</td>
</tr>
<tr>
<td>1 Shimla</td>
<td>50 (30.49)</td>
<td>9 (14.52)</td>
<td>55 (25.11)</td>
<td>95 (20.04)</td>
<td>209 (22.74)</td>
</tr>
<tr>
<td>2 Solan</td>
<td>38 (23.17)</td>
<td>7 (11.29)</td>
<td>31 (14.15)</td>
<td>62 (13.08)</td>
<td>138 (15.02)</td>
</tr>
<tr>
<td>3 Kinnaur</td>
<td>17 (10.37)</td>
<td>3 (4.84)</td>
<td>18 (8.22)</td>
<td>85 (17.93)</td>
<td>123 (13.38)</td>
</tr>
<tr>
<td>4 M andi</td>
<td>20 (12.20)</td>
<td>12 (19.35)</td>
<td>27 (12.33)</td>
<td>40 (8.44)</td>
<td>99 (10.77)</td>
</tr>
<tr>
<td>5 Chamba</td>
<td>4 (2.44)</td>
<td>6 (9.68)</td>
<td>26 (11.87)</td>
<td>49 (10.34)</td>
<td>85 (9.26)</td>
</tr>
<tr>
<td>6 Sirmaur</td>
<td>7 (4.27)</td>
<td>0</td>
<td>3 (1.37)</td>
<td>54 (11.39)</td>
<td>64 (6.97)</td>
</tr>
<tr>
<td>7 Kangra</td>
<td>4 (2.44)</td>
<td>5 (8.06)</td>
<td>10 (4.57)</td>
<td>38 (8.02)</td>
<td>57 (6.20)</td>
</tr>
<tr>
<td>8 Kullu</td>
<td>8 (4.88)</td>
<td>3 (4.84)</td>
<td>15 (6.85)</td>
<td>23 (4.85)</td>
<td>49 (5.33)</td>
</tr>
<tr>
<td>9 Bilaspur</td>
<td>12 (7.32)</td>
<td>2 (3.23)</td>
<td>19 (8.68)</td>
<td>7 (1.48)</td>
<td>40 (4.35)</td>
</tr>
<tr>
<td>10 Lahaul &amp; Spiti</td>
<td>2 (1.22)</td>
<td>1 (1.61)</td>
<td>7 (3.20)</td>
<td>12 (2.53)</td>
<td>22 (2.39)</td>
</tr>
<tr>
<td>11 Hamirpur</td>
<td>2 (1.22)</td>
<td>3 (4.84)</td>
<td>6 (2.74)</td>
<td>7 (1.48)</td>
<td>18 (1.96)</td>
</tr>
<tr>
<td>12 Una</td>
<td>0</td>
<td>11 (17.74)</td>
<td>2 (0.91)</td>
<td>2 (0.42)</td>
<td>15 (1.63)</td>
</tr>
<tr>
<td>Total (percent)</td>
<td>164 (100)</td>
<td>62 (100)</td>
<td>219 (100)</td>
<td>474 (100)</td>
<td>919 (100)</td>
</tr>
</tbody>
</table>

Source: compiled from The Tribune, 1971-2009

### Table 4: Seasonal Distribution of Landslide (1971-2009)

<table>
<thead>
<tr>
<th>Decade</th>
<th>Winter Jan-Mar</th>
<th>Pre-Monsoon Apr-Jun</th>
<th>Monsoon Jul-Sept</th>
<th>Post-Monsoon Oct-Dec</th>
<th>Total Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1971-1979</td>
<td>14 (08.53)</td>
<td>19 (11.59)</td>
<td>129 (78.66)</td>
<td>02 (01.22)</td>
<td>164 (17.84)</td>
</tr>
<tr>
<td>2 1980-1989</td>
<td>04 (06.45)</td>
<td>01 (01.61)</td>
<td>53 (85.49)</td>
<td>04 (06.45)</td>
<td>62 (06.75)</td>
</tr>
<tr>
<td>3 1990-1999</td>
<td>20 (09.13)</td>
<td>05 (02.82)</td>
<td>169 (77.17)</td>
<td>25 (11.42)</td>
<td>219 (23.83)</td>
</tr>
<tr>
<td>4 2000-2009</td>
<td>30 (06.33)</td>
<td>82 (17.30)</td>
<td>352 (74.26)</td>
<td>10 (02.11)</td>
<td>474 (51.58)</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>107</td>
<td>703</td>
<td>41</td>
<td>919 (100)</td>
</tr>
<tr>
<td>Per cent</td>
<td>07.40</td>
<td>11.64</td>
<td>76.50</td>
<td>04.46</td>
<td></td>
</tr>
</tbody>
</table>

Source: compiled from The Tribune, 1971-2009

**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.
Landslide Prone Areas/Zones: Landslide occurrence in Himachal Pradesh has a wide distribution but there are a few pockets where slope failure is rampant and recurrent (figure 2). These include Kalka-Shimla National Highway (NH-22); Shimla-Rampur-Peo and Malling-Samdo stretch on Hindustan-Tibet (HT) Highway; Swarghat-Bilaspur, Mandi-Aut patch and Kullu valley on NH-21; Gummajogindernagar-Palampur-Dharamsala Highway; Bilaspur-Shimla Highway; Dalhousie-Chamba area; Bharmaur valley and Holi area of Chamba district.

The Kalka-Shimla-Kinnaur highway is one of the most vulnerable stretches. The Parwanoo-Solan-Shimla section (zone A) along NH-22 is tectonically active, characterized by steep slopes, high relief, and very immature topography (Sharma & Kumar 2008). The area belongs to lower tertiaries, Krol nappe, Chail nappe, Jutogh nappe consisting of sandstone, limestone and shale that are highly deformed and the area is traversed by several faults such as Main Boundary Fault (MBF), Krol Thrust, Giri Fault, Chail Fault and Jutogh Thrust. The high slopes provide prospect for slope failure especially in monsoons that acts as a triggering agent. Landslides in and around Shimla town are the result of expanding urban spaces altering natural slopes. Theog-Shilaru-Matiana (zone B) area has unconsolidated bedrock material and sparse vegetation cover. The building activities have added to the problem of landslide occurrence. The Hindustan-Tibet highway between Rampur to Khab (zone C) follows sparsely vegetated steep slopes consisting of highly jointed
and weathered rocks belonging to the Wangtu Gneissic Complex, the Vaikrita Group and the Haimanta Group (Sharma, 1977; Tewari et al. 1978; Gupta and Shah 2008). Besides the range of lithology, this area has glacial, glacio-fluvial, fluvial and paleo-sorted material of Quaternary origin (Gupta et al. 1993) and several faults such as Karcham and Vaikrita thrusts. Landslide activity in this area is a result of weak structure and steep slopes. The increased frequency of landslides is attributed to shift in climatic pattern and escalating anthropogenic activity as evident from growing population, increased road length and alteration in land use (Gupta and Shah 2008). Landslide in Malling area (zone D) is the outcome of highly jointed, fractured and weathered schist and high water discharge due to snow melt during summer and alteration of slopes for transport networks.

The landslide activity in Swarghat-Bilaspur (zone E) stretch of National Highway 21 is related with the Main Boundary Fault (MBF) and Gambhar Thrust. The area consists of alternate beds of hard rocks and loose soil strata dipping towards the road alignment. This provides perfect conditions for slope failure during rainfall. The landslide activity in Pandoh-Aut section (zone F) of this highway is attributed to its complex geo-physical character. The rocks consist of limestone, dolomite, quartzite and schist. The area falls under a very tectonically active section known as Larji window. The highway in this section passes through a gorge aligned with the Maraur fault (Nagar & Rawat, 1989) which is cut across by Chail thrust at right angle near Larji. The rocks are highly jointed and fractured. The slopes are very steep and the beds are dipping inside the slope which are left overhanging along the road alignment (Chander, 1989) and thus are highly prone to landslides. The Kullu valley (zone G) due to increased pressure of growing population, tourism and hydro-power plants has steadily been undergoing road construction and allied activities which have amplified landslide frequency. The Manali-Rohtang-Khokasar (zone H) road passes through an area that has high local relief. The unconsolidated material is very susceptible to slides especially during summers and monsoons when the surface material is over saturated with moisture.

The Bilaspur-Shimla highway (zone I) passes through an area dominated by phyllites and rocks that are highly jointed. The slope cutting along the roads in this area accentuates the down slope movements of rocks particularly during rainy season. The Mandi-Kangra highway (zone J) is prone to frequent landslides in the Gumman-Jogindernagar section. This area dissected by several faults is known for salt mines which have softer unconsolidated material. This results in landslide activities. The concentration of landslides in Dharamsala area of Kangra district (zone J); Dalhousie-Chamba (zone K), Bhamaur (zone L), Holi and Pangi areas of Chamba district, relates to high relief and steep slope which are seismically very active and cut across by several major faults and local lineaments. The high intensity rainfall acts as triggering factor during monsoons. Apart from these areas, Kala Amb-Nahan area in Sirmaur (zone M), Hamirpur-Jangalberi-Sandhol area (zone N) and Chaupal & Rohru (zone O) areas are also prone to slope failure.

Landslide Impact on Human Life: Landslide hazard and its disastrous manifestations have an established history in Himachal Pradesh. There have been numerous devastating incidents of landslides claiming huge numbers of human lives alongside gigantic loss of property, infrastructure and livelihood in the state. The Matiana (Shimla) landslides (1989), Luggar-Bhatti (Kullu) slide (1995) and Nehru-Kund (Kullu) slide (2008) are some of the worst reminders of misery caused by such events. A total of 525 people were killed in last four decades due to landslides. During 1970s, there was only one year i.e. 1971 of towering deaths when 56 people lost lives to landslides. The number remained small till 1989 which witnessed 47 deaths. In the post 1990 period, the high frequency of deaths caused by landslides rose steadily with the years 1994, 1995 and 1998 combining to raise the number of casualties significantly. Even during the next decade 2000-2009, the deaths attributed to landslides remained quite high.

CONCLUSIONS:

The occurrence of landslides in Himachal Pradesh is a frequent and wide spread activity. Slope failure activities show increasing trends and there is not only upward rise in annual and decadal frequency of landslides but the number of years with exceptionally high occurrence during each decade has also increased. Landslide occurrence during last four decades has been very high in Shimla, Solan, Kinnaur and Mandi districts. The high intensity rainfall, particularly in monsoons, is one of the chief triggering factors for such incidents.

The trend during 1971-2009 shows that the number of people killed by landslides in the state has been on the rise particularly during 1900s and 2000s. It appears that the last decade 2000-2009 also experienced higher intensity rainfall as evidenced by increased cloudburst and flash flood activities in the state. During this period, a large number of destructive landslides occurred every year which not only accounted for considerable human lives lost but also disrupted transport and communication lines causing damage to settlements, agricultural land and natural vegetation. Among the 12 districts, Kullu and Shimla district are the most affected districts accounting for nearly half of the total deaths by landslides.

The natural conditions including unstable steep slopes, weak rock structure and intense rainfall are main reasons for slope failure in the state. However, the vulnerability in
these geologically young and unstable steep slopes has increased due to anthropogenic activity such as road construction, expansion of settlements and other allied developmental activities, deforestation and changes in agriculture pattern. This is particularly true for landslide prone areas of Kinnaur, Chamba, Shimla, Kullu and Lahaul & Spiti districts where large scale road construction and widening activities are under process to facilitate hydro-power projects and transportation facilities.

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