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Geo-Physical Disasters In Himachal Pradesh, India: A Spatial Perspective

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ABSTRACT:

Disasters have a strong affinity for mountain environments. The geo-physical disasters such as earthquakes and landslides are more rampant in mountainous regions due to geo-physical complexities. However within the mountainous regions certain areas are more prone to frequent disasters than others. The state of Himachal Pradesh located in western Himalayas due to its location in seismically active zone and highly variable nature of monsoon rainfall is prone to disasters like earthquakes and slope failure. The area is also susceptible to avalanches. This paper explores the space-time dimensions of such disasters and their impacts on human population. It was found that seismic activity in the areas is highly variable temporally but spatially concentrated in few areas. The landslide activities show increasing trends overtime while avalanches are spatially restricted to the high altitudes in the northern and eastern areas of the state.

Key words: disaster, geophysical, Himalayan Mountains.

INTRODUCTION:

Mountainous regions for their physiographic complexities are inherently susceptible to geophysical disasters. The state of Himachal Pradesh located in the western Himalayas of India is prone to such disasters and has a long history of disastrous earthquake, landslide and avalanche events. The area is seismically active region (Chandra, 1992) and has undergone huge structural deformations throughout geological times causing large scale faulting and folding (Narula & Shome 1992; Arya 1992 and Mahajan & Kumar 1994). The high intensity rainfall during monsoon season (July-September) and heavy snowfall in some parts during winter months (December-march) provides suitable conditions for slope failure. Frequently occurring disasters and their impacts on human population, infrastructure and resources is one of the major problems that impedes the development of the state and strains the state exchequer (Planning Commission, 2005).

Methodology and data Sources: This paper analyse three major geo-physical disasters, namely, earthquake, landslide and avalanche from spatio-temporal perspectives for the period 1971-2009. However, some significant information on historical occurrence of these disasters has also been presented. The data for this study was collected from historical archives, gazetteers, daily newspapers and earthquake catalogues prepared by various scholars and organisations. By focusing upon the patterns of occurrence in terms of spatial-temporal distribution and impacts, an attempt has been made to highlight the areas highly prone to disasters. The discussion also takes into account the geo-physical, climatic and environmental conditions as well as the anthropogenic factors responsible for triggering such events.

DISCUSSION AND ANALYSIS

Earthquake: Himachal Pradesh has historically been prone to earthquake activities. The high seismic activity in the state is attributed to its situation in the main Himalayan seismic zone which is seismically the most active crustal zone of northwestern Himalayas (Narula & Shome, 1992). The state fall in very high seismic risk (Zone V) and high risk (Zone IV) zones. The earliest records on seismicity in the area can be traced from Varaha Mihira's (6th century A.D.) book Brihat Samhita that describes the occurrence of seismic activities in the area between Rivers Ravi and Chenab and in Kangra valley of Himachal Pradesh. Afterwards, a very little or no information exists on seismicity in the study area till the end of 18th century, (Chandel & Brar, 2010).

Seismic activities in the area during 1800-1900 A.D. can be traced from the work of eminent scholar Oldham who in his comprehensive catalog of Indian earthquakes mentioned at least 11 earthquakes in Himachal Pradesh from 1800 to 1869 A.D. (Oldham 1883; Chandel & Brar 2010). The earthquakes mentioned in the catalog were of moderate intensity (magnitude below 6). During 1900-1964, 21 earthquakes of varying magnitude occurred in the state. The most devastating event took place in the very beginning of 20th century on April 4th 1905. An earthquake of 7.8 magnitudes having an epicenter in Kangra area caused wide-spread damage in the state and claimed 20,000 human lives in Kangra area only (Punjab Government 1926, Bilham 2004 and Ambraseys & Bilham 2000). Other high intensity earthquakes were also recorded at Kullu in 1906 and Chamba in 1914, 1945 and 1947.

The catalogue prepared by the researcher for 1971-2009 shows that 514 earthquake events (table 1) took place in the state. 387 earthquakes were of low magnitude (below 4), 111 between 4-4.9 Mb, 15 between 5-5.9 Mb and only 1 event above magnitude 6 on Richter scale. A damaging earthquake event (6.2 Mb) occurred in January 1975 in Kinnaur district. In this year many other minor earthquakes were observed in the same area and claimed 55 lives along with huge loss of property. Another damaging event (5 Mb) in 1978 in Chamba district caused minor damage to buildings in Dharamsala and other parts of Kangra and Mandi districts. An earthquake of magnitude 5.5 Mb on Richter scale occurred on 26th April 1986 in Dharamsala area in which three people were killed and damage over Rs. 20 crore was estimated in Kangra district alone. During 1990s, a total of 100 earthquakes of low-moderate magnitude occurred in the state except Bilaspur, Hamirpur and Una districts. Majority events had epicenter in Chamba, Lahaul & Spiti and Mandi districts. There were 335 earthquakes of medium-low intensity (magnitude below 5.0) during 2000-2009. The majority of the seismic events during this decade had epicenter around Chamba and Kangra and Mandi districts.

Majority of the events were concentrated in Chamba, Lahaul & Spiti, Kinnaur, Mandi, Shimla and Kangra districts (table 2). The distribution of earthquake epicenters shows that 70 per cent earthquakes were concentrated around three districts only. Chamba district (34.05%) has highest concentration of earthquakes followed by Lahaul & Spiti (18.48%) and Kinnaur (17.51%) districts. The seismicity in the areas of Chamba, northwestern Lahaul & Spiti and northern Kangra district has a strong association with tectonic features such as Main Boundary Thrust (MBT) and some localized thrusts (Kumar and Mahajan, 1991; Mahajan

and Kumar, 1994; Srivastava et al., 1987). In eastern Kinnaur and southeastern Spiti seismic activity is attributed to the presence of a number of faults particularly around the Kaurik fault.

Landslide: Landslide hazard and its disastrous manifestations have an established history in the state. The gazetteer of the Simla Hill State (Punjab Government, 1910) mentioned numerous landslides induced by an earthquake in 1803 which blocked the River Satluj and River Giri leading to massive destruction in downstream areas. Some folk-lore corroborates landslide activities in upper Beas River valley in Kullu district near village Bandrole where a massive landslide buried an entire village (Gardner, 2002). 1905 Kangra earthquake induced numerous landslides in the Beas river valley between Kullu and Manali (Punjab Government 1926). There were 33 landslides on Kalka-Rampur highway and 3 landslides on Mandi-Manali highway during 1935-1947 (Chander 1989). One of the damaging landslides include 1963 event on Bilaspur-Chandigarh highway at Gambhar in Bilaspur district that damaged 2000 feet stretch of highway (The Tribune, 9 April 1963).

Since 1970, there has been increasing trend of landslide occurrence and 919 landslide events (table 1) were recorded in Himachal Pradesh. During 1970s the frequency was very high in 1971, 1973, 1976 and 1978. In the next decade, a decline was observed in response to rainfall deficit and prolonged drought conditions in the state. The high landslide activities were observed during 1990s and 2000s. During 1990s, six years experienced extreme landslide activities whereas during the decade 2000-2009 such events were noted in a total of seven years. In 1990s, 219 events at the annual average of about 22 events were recorded in the state. The figures increased to 474 landslide events with annual average of 47 events per year. The landslides during last 4 decades were concentrated in Shimla Solan, Kinnaur, Mandi and Chamba districts (table 2). These five districts, namely, Shimla (22.74%), Solan (15.02%), Kinnaur (13.38%) and Mandi (10.77%) and Chamba (9.25%) account for more than 71 per cent of total landslide occurrences in the state. There have been numerous devastating incidents of landslides (table 1.14) that claimed huge numbers of human lives apart from colossal loss to property and infrastructure in the state. The Matiana landslides (1989) in Shimla, Luggar-Bhatti (1995) and Nehru-Kund (2008) slides in Kullu district are some of the worst example. Nearly 525 people were killed during 1971-2009 and over 1/3 were killed during last 10 years only. In terms of human casualty, Kullu is the most affected where 142 people were killed by landslides followed by Shimla (119 people). Bilaspur, Mandi, Chamba, Kinnaur and Kangra were other major landslide affected districts in terms of human casualty.

TABLE 1: DISASTER EVENTS AND CASUALTY (1971-2009)

	YEAR	NUMBER OF EVENTS			NUMBER OF CASUALTY		
		Landslide	Avalanche	Earthquake	Landslide	Avalanche	Earthquake
1	1971	69	0	0	56	0	0
2	1972	11	1	2	3	2	0
3	1973	15	1	1	6	2	0
4	1974	3	0	1	2	0	0
5	1975	7	1	27	2	2	55
6	1976	17	0	10	3	0	0

7	1977	6	0	6	0	0	0
8	1978	26	2	2	5	6	0
9	1979	10	8	2	10	237	0
10	1980	6	0	3	0	0	0
11	1981	6	0	6	0	0	0
12	1982	1	2	3	0	7	0
13	1983	0	1	1	0	3	0
14	1984	1	2	1	3	11	0
15	1985	9	0	3	0	0	0
16	1986	1	0	3	0	0	3
17	1987	1	0	4	0	0	0
18	1988	31	1	1	1	0	0
19	1989	6	0	3	47	0	0
20	1990	9	0	3	12	0	0
21	1991	8	1	4	1	0	0
22	1992	23	1	4	1	9	0
23	1993	12	0	1	4	0	0
24	1994	32	0	1	31	0	0
25	1995	49	2	4	100	0	0
26	1996	26	1	6	2	6	0
27	1997	2	1	4	4	2	0
28	1998	35	0	8	28	0	0
29	1999	23	1	65	9	0	0
30	2000	80	0	109	21	0	0
31	2001	57	0	48	14	0	0
32	2002	13	4	43	7	3	0
33	2003	55	1	70	19	0	0
34	2004	14	0	21	22	0	0
35	2005	26	0	18	1	0	0
36	2006	42	3	10	21	0	0
37	2007	94	1	5	39	0	0
38	2008	75	6	7	48	11	0
39	2009	18	0	4	3	0	0
TOTAL		**919**	**41**	**514**	**525**	**301**	**58**
Source: Oldham (1883), Chandra (1992), Bilham (2004), The Tribune (1971-2009), IMD (1900-2005)							

TABLE 2: SPATIAL DISTRIBUTION OF GEO-PHYSICAL DISASTERS (1971-2009)

	District	Landslide Events	Landslide Casualty	Avalanche Events	Avalanche Casualty	Earthquake Events	Earthquake Casualty
1	**Shimla**	209 (22.74)	119 (22.67)	0	0	41 (7.98)	0
2	**Solan**	138 (15.02)	24 (4.57)	0	0	4 (0.78)	0
3	**Kinnaur**	123 (13.38)	32 (6.10)	15 (36.59)	16 (5.32)	90 (17.51)	55 (94.83)
4	**Mandi**	99 (10.77)	47 (8.95)	0	0	50 (9.73)	0
5	**Chamba**	85 (9.25)	34 (6.48)	4 (9.76)	3 (1.00)	175 (34.05)	0
6	**Sirmaur**	64 (6.96)	19 (3.62)	0	0	6 (1.17)	0
7	**Kangra**	57 (6.20)	28 (5.33)	0	0	32 (6.23)	3 (5.17)
8	**Kullu**	49 (5.33)	142 (27.05)	5 (12.20)	13 (4.32)	17 (3.31)	0
9	**Bilaspur**	40 (4.35)	49 (9.33)	0	0	1 (0.19)	0
10	**Lahaul & Spiti**	22 (2.39)	11 (2.10)	17 (41.46)	269 (89.37)	95 (18.48)	0
11	**Hamirpur**	18 (1.96)	16 (3.05)	0	0	2 (0.39)	0
12	**Una**	15 (1.63)	4 (0.76)	0	0	1 (0.19)	0
		919 (100)	**525 (100)**	**41 (100)**	**301 (100)**	**514 (100)**	**58**

Source: Oldham (1883), Chandra (1992), Bilham (2004), The Tribune (1971-2009), IMD (1900-2005)

Landslide prone sites represent strong association with geological weak, highly jointed and fractured structures that are tectonically active and characterized by steep slopes, high relief, and very immature topography. Such conditions provide opportunity for slope failure especially during erratic monsoons that acts as a triggering agent. Increased pressure of growing population, tourism and hydro-power plants has promoted rapid road construction and allied activities which have amplified landslide frequency (Chandel, Brar and Chauhan 2011; Kahlon, Chandel and Brar 2014) in the state.

Avalanche: This section provides a lucid account of avalanche occurrence in Himachal Pradesh. Avalanche is a major threat in the greater Himalayan areas of the state. Several incidents of a severe snow storm creating havoc in Rohtang Pass area of Lahaul & Spiti district in 1863 (Harcourt 1871) and series of avalanches in Kullu district (Punjab Government 1917) were recorded during 19th century. Chander (1989) mentioned 9 events of avalanches in Kullu valley during 1935-1947.

During the last 39 years, number of damaging avalanche events has struck the state. There were six devastating incidents of avalanche during 1971-1979 (table 1). Two porters got killed near Deo-Tibba at a height of 17,000 feet in an avalanche following heavy snowfall on 28 October 1972 while two climbers were killed in 1973 near Manali area and two more died at Arrang village of Lippa valley in Kinnaur district in 1975. The worst incident of avalanche occurred in the tribal district of Lahaul & Spiti in March 1979 in which, about 237 persons were killed (The Tribune, 12 March 1979; Government of Himachal Pradesh 2006). During 1980s, there were six incidents of avalanches, two in 1982, one in 1983, two in 1984 and one in 1988. These events claimed 21 lives out of which 11 were in Kinnaur, seven in Kullu and

three in Chamba district. The decades of 1990s witnessed 7 incidents, out of which five were in Lahaul & Spiti, and one each in Kullu and Kinnaur districts. These events claimed 17 lives, 15 in Lahaul & Spiti and 2 in Kullu district. The next decade (2000-2009) recorded 15 events of avalanches claiming 14 lives in the state.

The distribution of avalanches in the state is restricted to four districts of Kinnaur, Lahaul & Spiti, Chamba and Kullu (table 2). Lahaul & Spiti is the most vulnerable district where a total of 17 (41.46%) events have occurred during 1971-2009 while Kinnaur (36.59%) is the second leading district. Kullu and Chamba account for about 12 and 10 per cent, respectively. In terms of human lives lost Lahaul & Spiti district (41.46%) and Kinnaur (36.595%) are the worst affected districts. The locational distribution also shows that the most vulnerable areas include Chandra river valley from Koksar to Udaipur in Lahaul; Sangla valley, Karcham-Reckong Peo area and Tinku nullah in Poo area to Namgia in Kinnaur district. The occurrence is restricted to winter months of January to March. Although the occurrence and human impact of avalanches are lopsided and limited over time and space, the disastrous manifestation possibly will be colossal in light of the fact that the areas most vulnerable to avalanches are also the locations where large scale developmental activities in terms of infrastructure and tourism are taking place.

CONCLUSIONS:

Historical reconstruction and space-time dimensions of geo-physical disasters provide an understanding to disastrous manifestations and associated risk. From the records, it is evident that Himachal Pradesh has historically been prone to seismic hazard that has a strong association with the regional tectonic character. The seismicity is particularly high in the areas of Chamba, northwestern Lahaul & Spiti, northern Kangra, eastern Kinnaur and southeastern Spiti area. During the last century, earthquakes have taken the lives of more than 25, 000 people in Himachal Pradesh however, the major devastating earthquakes on record for the region such as 1905, 1975 and 1986, occurred before the population numbers grew substantially and much before the acceleration in efforts at infrastructure development. The occurrence of landslide in Himachal Pradesh is a frequent and wide spread activity; slope failure activities show increasing trends over the past decades. The number of years with exceptionally high landslide occurrence during last four decade has increased. Apart from high intensity monsoon rainfall, snowfall and western disturbances during winters, the landslide risk is also attributed to anthropogenic activities. This is particularly true for landslide prone areas of Kinnaur, Chamba, Shimla, Kullu and Lahaul & Spiti districts. Avalanche occurrence in the state has restricted spatial distribution and seasonal & temporal extent. Such events remain confined to northern and eastern parts of the state during winters when snowfall is perpetual.

The overall situation pertaining to geo-physical disasters i.e. earthquake, landslide and avalanche, clearly demonstrate the role of complex physiography and geo-tectonic settings in occurrence of these kinds of disasters in the state. However, the role of anthropogenic activities in aggravating the damage potential cannot be denied. The instability of hill slopes is a result of natural processes but the related human vulnerability is indeed a result of human interference and alteration of natural systems. The development of infrastructure, tourism and associated building activities, hydro-power generation and allied activities have been rampant

in the state for the last 20 years. Construction activity has been reckless as evidenced from haphazard building in the major cities and towns such as Shimla, Dharmashala, and Manali. It has largely ignored the hazards posed by seismicity. The sensitive zones comprising Chamba, Shimla, Kullu-Manali, Kinnaur and northern Kangra receive a very heavy influx of tourists throughout the year. Additionally, these areas have emerged as major hydro-power generation zones where a number of power projects are in various stages of construction. In such a situation, the vulnerability of human population and associated economic losses in the event of a high intensity earthquake would be very high.

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