Overview of Vulnerability Natural Hazards in Himachal Pradesh

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Abstract: ***The state of Himachal Pradesh has been facing widespread and extensive damages almost every year because of natural hazards flood, cloud burst, flash floods, earth quake, landslides and droughts etc. which have been taking its toll of human lives, cattle heads, destruction of public utilities, roads, bridges, footpaths, culverts, landslides and washing away of drinking water supply and irrigation schemes and damage to public and private properties making a dependent into the already fragile economy of the state. The losses sustained are so serve that relief and restoration operations without adequate financial resources are not possible despite best efforts of the state to cope up with the emergent situation out of the available scanty resources. This paper focuses on analyzing natural hazards in Himachal Pradesh and also describes the main risk reduction strategies during natural hazards. The universe of the study is very wide and vast. Therefore due to constraints of resources and time only natural hazards in Himachal Pradesh & Main hazards Risk Reduction strategies for hazards will be study. In the present paper the data was collected through primary and secondary sources. The primary data has been collected by observation and field survey method. The Secondary data was collected from records, reports, relief manual, action plan and memorandum of the state revenue department and other department which are concerned with disaster management. Newspapers, magazines, journals, books, articles and website have been utilized.***

1. Introduction

Himachal Pradesh is situated in the lap of Himalayas the State of H. P lies between latitude 30°22 to 33°12’ N and 75°45’E to 79°4’E. It is surrounded on the south-east by the states of Uttarakhand, China on the east, Haryana on the south-west and J&K on the north. It is the geophysical setting of the state of Himachal Pradesh that controls and defines the meteorological characteristics and also has bearing on the occurrence and intensity of natural and manmade hazards. On account of the damage caused and widespread nature of hazards in the past this state can be called as one of the most unstable and hazards prone states of the country.

From south to north topographically and climatologically the setup of the State that define the type and intensity of multiple hazards can be visualized as follows:

Zone-I: Subtropical low-hill Shiwalik zone
This terrain is rugged with low mountains. Rainfall is between 800 to 1800 mm. The areas suffer from perpetual summer shortage due to high runoff. Valleys are generally narrow with few small flat areas where good agriculture is possible. Most of the streams are situated within narrow gorges and the terrain shows signs of rapid uplift in the recent past. The altitude ranges between 500 m and 1200 m above mean sea level.

Zone-II: Mid hill zone
The lesser Himalayas south west of the Dhauladhar range and valley areas of the Ravi and the Chenab rivers forms this zone It occupies 32 percent of the geographical area and 53 percent of the cultivated area of the state. Altitude ranges between 800 and 1600 m above mean sea level. The average annual rainfall is about 1800 mm.

Zone-III: Dry hill zone
The upper parts of the catchment of the Zone II constitute Zone III. This zone occupies 25 percent of the geographical area and 11 percent of the cultivated area of the state. Altitude ranges between 1600 and 2700 m above mean sea level. The annual rainfall ranges between 1000 and 1500 mm.

Zone-IV: Cold hill zone
The trans-Himalaya zone lying between Great Himalayas and Zanskar Ranges is a cold desert. Altitude is generally above 2700 m. Due to rain shadow of great Himalayas, the annual rainfall is less than 200 mm. This zone occupies 8 percent of the geographical area and 3 percent of the cultivated area of the state.

Seismic Vulnerability & Risk
Worldwide it is seen that out of hundred most deadly and hundred most expensive natural disaster of the 20th century, 25 and 15 events respectively were due to earthquakes (EM_Dat 2006). The seismic record for the past years coupled with continued occurrence of moderate to large earthquakes in the state of Himachal Pradesh render the state’s seismic vulnerability very high. Even though the earthquakes are generally considered to be rare low probability events with recurrence periods of the order of several decades, yet they pose extremely high risk.

The factors responsible for high seismic Vulnerability and risk are as follows:

32% of the total geographical area of the state falls in very high damaging risk and remaining 68% in high damaging risk zone.

High seismicity zones are also the areas of heavy concentration of population. Sample GIS based assessment suggest that very high vulnerable zone accommodates about 60% of the total population of the state followed by 38 in high vulnerable zone and only 3% population in low vulnerable comprising areas of Kinnaur & Lahaul Spiti districts. Another assessment made using the population potential for 109 tehsils and sub tehsil headquarters of the state suggest two highly vulnerable zones viz. Kullu-Mandi-Sundernagar Corridor and Palampur-Dharamshala-Kangra-Dehra Corridor. Areas surrounding Chamba, Nurpur, Hamirpur and Bilaspur have also been identified as highly vulnerable zones by this assessment.

Even though the intensity of past seismicity is more in districts of Chamba (33.63), Lahaul & Spiti (17.91), Kinnaur (16.82) and less in Kangra (7.05), Kullu (3.44), Hamirpur (0.36) yet the building topology coupled with density of population render the latter areas more risk pone than the former.

The house types mostly fall under Category A consisting of walls of clay mud, unburnt brick or random rubble masonry without any earthquake resisting features. The districts liable to the severest design intensity of MSK IX or more, also account for very high percentage of category A houses. Even category B houses as built in the state do not have the earthquake resisting features and are liable to severest damage under intensity IX and VIII earthquake.

Risk from impending earthquake can be gauged from the simulation scenario projected by Prof. Arya by taking into consideration the damage & loss caused by earthquake of 1905. Kangra earthquake having a Richter Scale magnitude of 8 caused 20, 000 human deaths, destruction of around one lakh houses and around 53000 animals and the earthquake was felt in an area around 41, 600 Sq. Km. Hypothetical recurrence of earthquake of magnitude 8 in the same area as in 1905 highlights the scenario by taking into consideration the Census data of 1991. The study projects that If all the 18, 15, 858 houses (1991) are without earthquake safety provisions the direct loss will amount Rs.51.04 billion, 65, 000 lives may be lost and about 399, 695 houses will be ruined completely. The trauma will be too great and cost of emergency relief will be exorbitant.

Zone-A: Very High Vulnerability Risk Zone

This zone constitutes areas falling in Zone-V as per seismic zoning map of India. With maximum concentration of population (60%), schools (59%) and heavy concentration of infrastructure the physical, social and economic vulnerability of this zone is very high. Most parts of districts Kangra, Mandi, Hamirpur, Kullu and Chamba constitute this zone.

Zone-B: High to Moderate Vulnerability & Risk Zone

Most parts of districts Bilaspur, Solan, Una, Sirmour, and Shimla & Kinnaur constitute this zone. Population concentration in this zone is as high as 38% of the total population and equal number of school concentration is observed in this zone. Vulnerability of urban centers in this zone like Shimla, Solan, Una, and Ponta Sahib is also relatively more. Over all the vulnerability &risk associated with this zone has been termed to be high.

Zone-C: Moderate to Low Vulnerability Risk Zone

This zone constitutes most parts of Lahaul & Spiti, northern parts of Chamba, Kullu, Kinnaur & Kangra districts where population concentration is as low as 3% of the total population. Even though the past seismicity suggests that seismic hazard threat in the Lahaul Spiti sector is relatively more but due to low density of population the associated vulnerability and risk is moderate to low.

Vulnerability to Climate Change

Recent flash floods occurred in the Satluj basin receiving its seasonal flow from snow melt and glaciers besides rainfall have added new dimension to the hazard vulnerability of river basins situated in the state of Himachal Pradesh. Intense and excessive rainfall resulting in cloud bursts coupled with rapid melting of snow and glaciers due rising temperatures has been identified as the main cause for the flash floods. One of the consequences of glaciers retreat that has been a cause of concern and worry to the people of Himachal Pradesh is the formation and expansion of glacial lakes high up in the mountains in the upper reaches of glacier-fed river systems. A glacier outbursts flood caused by moraine dammed lakes is a common feature in the glaciated terrain. In the world many events of such outbursts floods have been reported in the North America, Europe and in the Himalayas So far in the HKH region the bursting of such lakes have been reported from Manalsu region, Central Nepal and in Bhutan. However no systematic records of glacier lake outbursts from Indian Himalayas are available. In Himachal Pradesh more than 268 water bodies or wetlands have been mapped in areas above 3200 meter elevation. The melting of glaciers and snow fields in the state has reported to be on rise. Sometimes glaciers retreat melt water is blocked by glacier debris forming a lake behind the newly exposed terminal moraine. The formation of lakes due to glacier melting and damming by moraines and subsequently their bursting may lead to catastrophic discharge water pressure causing huge floods resulting in loss of precious lives and infrastructure. This phenomenon is known as GLOF i. e. glacial lake outburst floods.

As per the records available in Gazetteer, Lahaul & Spiti, “the Bara Shigri Glacier burst its bounds and dammed the Chandra, causing the formation of a large lake, which finally broke loose and carried devastation down the valley. The story runs that the people of Spiti posted guards in the Kunzam Pass to watch whether the water would rise high enough to flow across into Spiti. ”

Lakes in Himachal were found to be dangerous. The potentially dangerous lakes identified are located within four basins. i. e. five (5) in the Beas basin, five (5) lakes in the Chenab basin, one (1) in Ravi and three (3) lakes are located in Satluj basin. Similar inventory of moraine dammed lakes undertaken by H. P. State Council for Science, Technology and Environment and Space Applications Centre Ahmedabad for Satluj basin indicated the presence of 50 moraine dammed lakes and 5 supra glacial lakes with largest lake having an area of 1.053 sq. km and the smallest 0.002 sq. km. inventory in the Chenab basin suggest the presence of 17 moraine lakes and two supra lakes.

At times climate induced disasters resulting in response to intense long lasting rains could also trigger landslides, erosion and increased sediment yields in the drainage systems as the slopes in the upper catchment and in glacial topography are generally steep and unstable. Besides precipitation, the frequent seismic activity and permafrost thawing can also trigger landslides resulting in the damming of river channel forming lakes. These natural dams cause valley inundation upstream and when subsequently breached by lake water pressure results in flash floods or debris flows downstream causing heavy loss to life and property. This phenomenon is called LDOF. Recent event of Parechu lake outburst is one such event that has given new dimension to the possibility of lake formation due to geo-environmental factors. The satellite image analysis of August 2000 floods also showed the presence of huge water body or lake upstream in the Satluj basin before the flash flood took place. The cause of formation of these lakes is still a matter of conjecture whether landslide were triggered by natural slope failure or by deliberate human action, the fact remained that the lake disappeared immediately after the flash floods hit the Himachal part of Satluj basin. Huge infrastructure of hydropower projects located in different basins of the state in particular is at risk to the phenomena of GLOF & LDOF.

Risk Identification

As described in the previous section, the State of Himachal Pradesh is highly vulnerable to various natural and man induced disasters. This coupled with vulnerability factors like limited awareness on disaster risk reduction; inadequate preparedness and improper planning have contributed significantly to the increased risk to the people. It is certainly possible to reduce the potential impact of disasters by evolving appropriate preparedness, preventive and response plans. Risk identification and assessment constitutes the first step in developing the State plan.

Population at Risk

GIS based sample assessment indicates that about 54% of villages having 59% of population are located in highest vulnerable zone. Likewise about 41% villages with 38% population are located in the high risk zone and only 5% villages with 3% population in moderate to low risk zone. Hence 97% population in the state is located in high to very high seismic risk zone. This when viewed in conjunction with building topology and population density portrays very high risk scenario for the state requiring immediate attention.

Hydro Power Infrastructure at Risk

Besides buildings, factories, institutions, hydropower infrastructure which is considered crucial to sustain the country's economic growth is at risk. The state has identified potential of hydropower to the tune of 23, 000 MW and of which 6150 MW is operational. In terms of economics the investments in hydropower sector amounts more than 60, 000 crores in different basins of the state which is likely to increase to aggregate capacity of 12500 MW with an investment of Rs 1 lakh crore by the year 2022.

Apart from Mega projects 45 small hydro projects with an aggregate capacity of 177.55MW have been commissioned in various basins and by the year 2014 the small hydro development is expected to increase to 500MW. It is pertinent to note that apart from potential threat of floods the mega projects such as Pong Dam, Bhakra Dam, Pandoh Dam, Chemera, Parvati and Kol Dam are all located in highest vulnerable zone where seismic risk is also very high.

Table 1.1: River Basins and Hydropower Capacity

Name of Basin	Capacity (MW)
Yamuna	811
Satluj	10355
Beas	5339
Ravi	2952
Chenab	2973
Self / New Identified	570
TOTAL	23, 000

2. Brief Overview of Major Hazards

Seismic Hazard

The seismic sensitivity of the state of Himachal Pradesh is very high as over the years a large number of damaging earthquake has struck the state and its adjoining areas. Seismically it lies in the great Alpine Himalayan belt running from Alps Mountain through Yugoslavia, Turkey, Iran, Afghanistan, Pakistan, India, Nepal, Bhutan and Burma. Due to its location the state experiences dozens of mid earthquakes every year. Large earthquakes have occurred in all parts of Himachal Pradesh, the biggest being the Kangra earthquake of 1905. The Himalayan Frontal Thrust, the Main boundary Thrust, the Krol, the Giri, Jutogh and Nahan thrusts are some of the tectonic features that are responsible for shaping the present geophysical deposition of the state.

Table 1.2: District – wise Hazard Threat in Himachal Pradesh

District	Earthquake	Landslide	Floods	Avalanche	Drought	Cloud Burst
Kangra	VH	L	M	M	H	M
Chamba	VH	VH	H	M	M	H
Hamirpur	H	L	L	-	M	L
Mandi	VH	H	H	-	M	H
Kullu	VH	VH	H	H	M	VH
Bilaspur	H	M	L	-	M	L
Una	H	L	H	-	H	L
Sirmour	H	L	L	-	M	M
Solan	H	M	L	-	M	L
Kinnaur	H	H	H	VH	M	VH
Lahaul & Spiti	M	M	M	VH	M	H
Shimla	VH	H	H	M	M	H

The seismic vulnerability of Himachal Pradesh is primarily attributed to northward movement of Indian plate and to the major dislocation tectonic features such as MBF, MBT, Punjab thrust and MCT etc. Besides the longitudinal tectonic feature trending parallel to the Himalayas there are a large number of transverse fractures, faults that have been responsible for the seismic activity in the Himalayan region in general and Himachal Pradesh in particular. The Kinnaur earthquake of 1975 was associated with transverse Kauirik fault. In fact about 250 earthquakes with magnitude 4 and 62 earthquake having magnitude of 5 and above have impacted the state so far. It is also pertinent to note that the state of Himachal Pradesh is not only highly sensitive from the earthquake point of view but the risk has also grown many folds as the population and infrastructure have increased considerately over the last 20 years.

Chamba, Kullu, Kangra, Una, Hamirpur, Mandi and Bilaspur Districts lie in Zone V i. e. very high damage risk zone and the area falling in this zone may expect earthquake intensity maximum of MSK IX or more. The remaining districts of Lahaul and Spiti, Kinnaur, Shimla, Solan and Sirmour lie in Zone lV i. e. the areas in this zone are in high damage risk with expected intensity of MSK VIII or more. The spatial distribution and district wise history of past seismic events is given as below.

District – wise occurrence of Earthquakes (1800-2008)

S. No.	District	Number of earthquakes	Percentage of Total
1	Chamba	186	33.63
2	Lahhaul Spiti	99	17.90
3	Kinnour	93	16.82
4	Mandi	53	9.58
5	Shimla	49	8.86
6	Kangra	39	7.05
7	Kullu	19	3.44
8	Sirmaur	8	1.45
9	Solan	4	0.72
10	Hamirpur	2	0.36
11	Bilaspur	1	0.18
12	Una	0	0
	Himachal Pradesh	553	100

Source: SDMA Himachal Pradesh

The seismic record for the last 100 years coupled with continued occurrence of moderate to large earthquakes is an eloquent testimony of the seismic potential of the state of Himachal Pradesh. Even though the earthquakes are generally considered to be rare low probability events with recurrence periods of the order of several decades yet they pose extremely high risk to the society as much of the structural damage takes place within a few seconds. The past earthquake also indicates that the impact of earthquake was not uniform but varied from place to place on account of ground vibration and site amplification. Apart from the ground motion characteristics, the geotechnical properties and characteristics of soil and rocks plays an important role in controlling the structural damage during such events. The vulnerability of built up structures by following seismic codes prescribed from time to time to withstand the impact of such geophysical heterogeneities is highlighted by the building census and topology studies given by BMPTC.

Landslides

Landslide is the most common hazard in Himachal Pradesh, which causes immense risk to life and property. Almost every year the state is affected by one or more major landslides affecting the society in many ways. Loss of life, damage of houses, roads, means of communication, agricultural land, are some of the major consequences of landslides. The fragile nature of rocks forming the mountains, along with the climatic conditions and various anthropogenic activities has made the state vulnerable to the Landslides.

Table 1.4: District-wise area under Seismic Zones V and IV

S. No.	District	Area under seismic Zone V (%)	Area under seismic Zone IV (%)
1	Kangra	98.80	01.20
2	Mandi	97.40	02.60
3	Hamirpur	90.90	09.10
4	Chamba	53.20	46.80
5	Kullu	53.10	46.90
6	Una	37.00	73.00
7	Bilaspur	25.30	74.70
8	Lahaul & Spiti	02.14	97.86
9	Shimla	00.38	99.62
10	Solan	01.06	98.94
11	Sirmaur	Nil	100
12	Kinnour	Nil	100
	Himachal Pradesh	32.02	67.98

Source: SDMA Himachal Pradesh

Table 1.5: Impact of earthquake suffered by Himachal Pradesh in past 100 years

Date	Locations affected	Magnitude/ Intensity	Damage
4th April, 1905	Kangra	Magnitude 8.0	Approximate 19, 800 people died in Kangra District
28th Febuary, 1906	Shimla	Magnitude 6.5	26 people died, 45 severely injured
19th January, 1975	Kinnaur	Magnitude 6.8	60 people died, 2000 dwellings housing devastated
26th April, 1986	Dharmshala	Magnitude 5.5	6 people died, Extensive damage to buildings
April, 1994	Chamba	Magnitude 4.5	Area at risk was Chamba town
24March, 1995	Chamba	Magnitude 4.9	Fear some shaking, More than 70 percent houses faced cracks
July 1997	Sunder Nagar	Magnitude 5.0	Some part of Sunder Nagar affected

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Triggering of landslides is both a natural and anthropogenic phenomena. As in other parts of Himalayas the landslide activity in Himachal Pradesh also varies with altitude, geology and topography. Various geophysical factors such as steepness of slopes, saturation by heavy rains, melting snow and ice, rock vibrations, excess load from embankments, fills, waste & debris dumps change in water content, frost, change in vegetable cover and toe cutting by rivers and streams are some of the other natural factors influencing the occurrence of landslides. The vulnerability of course has increased many times in the recent past due to various developmental activities. Deforestation, unscientific road construction, terracing, water intensive agricultural practices, and encroachment on steep hill slopes are some of the anthropogenic factors that have contributed towards increased intensity and frequency of landslides. Jhakri, Pangi, Powari, Urni, Sholdan, Nichar, Khadra Dhank, Thangi, Barua are some of the most common landslide that has affected the NH-22 in Satluj valley.

Table 1.6: Landslide Vulnerable areas in Himachal Pradesh (District area in square Kilometres)

District	Severe to very high	High	Moderate to low	Unlikely	Total area
Bilaspur	216	842	83	1	1142
Chamba	2210	3829	351	70	6370
Hamirpur	0	851	204	45	1100
Kangra	123	3698	1233	557	5611
Kinnaur	868	4956	498	0	6322
Kullu	1820	3513	65	3	5401
Lahaul & Spiti	127	11637	1825	2	13591
Mandi	968	1978	826	98	3870
Shimla	893	3345	767	14	5019
Sirmaur	95	1805	614	228	2742
Solan	556	1118	157	79	1910
Una	2	678	517	311	1508

Floods

The state being in hilly terrain, the flood problem in the state is largely isolated in nature. The main problems are flash floods and bank erosion because of steep slopes of rivers and high river flows due to heavy rains are not an unusual phenomenon. As a result breaches in embankments and damage to various utilities like irrigation/flood control schemes and houses are also observed.

Flash floods in Satluj during rainy season of Year 2000

A natural calamity is of gigantic magnitude struck the Satluj Valley on the intervening night of 31st. July 2000. it led to an unprecedented rise in the water level of Satluj River from Tibetan plateau throughout the entire length of about 250 km up to Govindsagar lake. The rise in the level of water according to eyewitnesses was reported up to 60 feet above the normal levels. The flash flood was termed as the one that occur once in 61000 years. It is almost impossible to design technical specifications for all kinds of infrastructures to cater to such a rare incidence. It is obvious that such a natural calamities would cause unprecedented loss of human life, livestock, public and private property and would also erase from the surface and existing of physical infrastructure. It has led to extensive damage to about 200 km of road length, washed away 20 bridges and 22 Jhulas and badly damaged 12 bridges. About 1, 000 irrigation, sewerage, flood protection and water supply schemes have been considerably damaged and some of these have been completely destroyed.

According to preliminary estimates the damage has been estimated at about Rs 1466.26 crore.

Flash flood in Sutlej during rainy season of the Year 2005

A natural calamity of gigantic magnitude, due to sudden rise/breach of Parechu river in the Chinese territory struck the Sutlej valley on 26.06.2005. It, led to an unprecedented rise of water level of Sutlej river from Tibetan Plateau throughout the entire stretch of National Highway 22. The rise in water level was reported up to 15 meters above the normal level at some places. It led to extensive damage to about 350 hundred kilometers of road length from Samdo to Govindsagar/Bhakra Dam. Detail of damage is as under:

- 10 bridges, 11 ropeways washed away.
- 15 motor able bridges and 8 jeep able and foot bridges damaged/affected.
- 10 kms road between Wangtoo and Samdo washed away.
- 15 kilometer length of various patches in road between Wangtoo and Samdo has been damaged/affected.
- Various link roads originating from National Highways including certain NH/PWD roads between Sainj and Wangtoo have been damaged.
- Electrical lines including poles and towers, OFC Network, water supply schemes, sewerage system have also suffered serious damages.

Cloud Burst

It is a sudden occurrence and serve heavy rain and of very high intensity in a limited place. It creates a sudden flood in both plain and hilly areas, cause big landslides, brings down boulders and uproots trees, due to this, torrential rain shall occur in a limited area. Cloud burst because heavy damages in the flood prone plain area. Due to sudden rain or water flow, breaching of banks and over flowing of dams could happen.

Cloudburst in Himachal Pradesh

Himachal Pradesh has been facing widespread and extensive damages almost every year because of hazards and natural disaster. Cloudburst is one of the natural disasters which causes huge damages to the lives and property of the state. Cloudburst is a unique weather phenomenon which last for a short time in particular area which results in loss of lives of human being and animal as well as property and infrastructure of the state in that particular area.

Table 1.7: List of Major cloudbursts up to 2006 in different regions of Himachal Pradesh

Sr. No	Date of incident	Place of incident	District	Detail of loss
1.	29.09.1988	Soldan Stream	Kinnaur	32 people, 15 houses, an orchard, 25 km road bridge.
2.	08.07.1993	Nathpa Jhakri	Shimla	Loss to NJPC & NH 226 km long formed.
3.	August 1994-95	Mani Mahesh	Chamba	50 died, 62 km road, 2000 injured.
4.	Sept.1995	Beas River & southern slope of Rohtang	Lahaut Spiti & Mandi	Loss in several private and govt. Establishments
5.	11.08.1997	Andhra Khad, Chirgaon	Shimla	300 people died and loss to private & govt establishment.
6.	22.07.2001	Sainj & Jeeba Nallah	Kullu	40 farms, 2 bridges damaged.
7.	16.07.2003	Pullia Nallah	Kullu	90 people killed, loss to property

8.	08.08.2003	Kangli Nallah	Kullu	36 people killed, loss to property.
9.	08.07.2003	Rai Khad, Rampur	Shimla	Loss to crops & cattle.
10.	13.07.2003	Chunahan	Mandi	Loss to crops & real estate, cattle's
11.	20.07.2003	Balh Valley Gaggal	Mandi	Loss to crops & property.
12.	24.07.2003	Bahang	Kullu	2 people, house property.
13.	26.07.2003	Jhakri area	Shimla	Loss to NJPC, buried dead, a few went missing.
14.	27.07.2003	Dansa (Rampur)	Shimla	Damage to crops, apple orchards & land.
15.	02.08.2003	Lulani (Baijnath)	Kangra	5 killed, 18 families marooned.
16.	03.08.2003	Shilara (Rampur)	Shimla	Landslides.
17.	03.08.2003	Bhagsunath	Kangra	1 died, 2 injured.
18.	06.08.2003	Balh Valley	Mandi	Loss to crops and fertile land.
19.	07.08.2003	Kangni Nallah	Kullu	36 dead 20 stall reported missing.
20.	07.08.2003	Kotkhai	Shimla	Transport bus with passenger washed away, 15 had miracle escape.
21.	29.07.2004	Kothi Khokhan	Kullu	Loss to property.
22.	01.08.2004	Kothi Gulabh	Kullu	Killed, damage to Manali & Leh Highway.
23.	09.08.2004	Bassani	Kullu	22 labourer trapped, loss to Parvati Project.
24.	11.07.2005	Chopal	Shimla	40 cattle lost, valuable land washed away.
25.	18.08.2005	Bahan Godhiman, Karsog	Mandi	25 families affected & valuable land washed away.
26.	09.07.2006	Rampur, Sangla	Shimla, Kinnaur	Landslides.
27.	23.07.2006	Chopal	Shimla	Flash flood, bridge partially damaged.
28.	25.06.2006	Haripur	Chamba	Five mules & scooter washed away, landslides.

Glacial Lake Outburst Floods

Outside the polar region, the Hindu Kush-Himalayas contain the largest area in the world covered by glaciers and permafrost. The Himalayan region is intrinsically linked to global atmospheric circulation, hydrological cycle, bio-diversity and water resources. It has about 15, 000 glaciers which is nature's renewable storehouse of fresh water. The region is also the cradle of nine major river systems in Asia whose basins are home to over 1.3 billion people. However, in the face of accelerated global warming the glaciers in the Himalayan region are retreating/ melting at as higher rate of 30-60 meters per decade leading to accumulation of increasing amounts of water in mountain-top lakes.

As glaciers retreat, glacial lakes form behind moraine or ice 'dams'. Due to the inherent instability of such 'dams', the potential of sudden outbursts/ breaches is extremely high. Such outbursts can lead to a discharge of millions of cubic meters of water and debris in a few hours which can cause catastrophic devastation and flooding up to hundreds of kilometres downstream. Such flooding can lead to serious damage to life, property, agriculture, livestock, forests, eco-systems, the livelihoods of mountain communities heavily dependent on mountain eco-systems for sustenance, as well as precious socio-economic infrastructure/assets like hydro-power, electricity, communications, roads and bridges. All of these can induce forced migration and undermine the already meagre sources of livelihood of mountain people and downstream communities.

This phenomenon constituting a sudden discharge of a huge volume of water from such glacial lakes is known as **Glacial Lake Outburst Floods (GLOFs).** The frequency of such events is increasing in the HKH region since the second half of the 20th century (UNEP, 2003) due to the combined effects of climate change and deforestation. Satellite observation of the mountain top lakes in the region have revealed a steady increase in the size and volume of many of these glacial lakes at high altitudes, enhancing the possibility of a devastating outburst flood affecting sizeable populations and damaging precious socio-economic infrastructure and development assets in the Himalayan belt.

Over the years, countries in the region have built many high-value economic and infrastructure assets and the emerging threat from GLOFs has serious implications for their future development pathway.

Glacial Lakes in the Himalayas and Vulnerability

The Himalayan region is susceptible to a whole range of hydro-metrological, tectonic and climate-induced disasters. With warming in the Himalayas being higher than the global average (ICIMOD, 2007), climate-induced natural hazards are likely to be exacerbated, including severe glacial melting and the formation of glacial lakes.

Inventory of glaciers and glacial lakes has been and knowledge of GLOFs in the Himalayan region. Is being acquired by the technical and research institutions located in the Himalayan region like ICIMOD, Wadia Institute of Himalayan Geology, UNEP, G. B. Pant Institute of Himalayan Environment and Development, National Environment Commission (Bhutan) etc. . Regular monitoring and tracking of the size of these lakes has revealed that quite a few of them are expanding at an alarming rate due to accelerated glacial retreat and melting due to climate change impacts.

Himachal Pradesh, there are 2, 554 glaciers, with 156 glacial lakes, 16 of them are potentially dangerous.

There are quite a few reported events in Himachal Pradesh of GLOF/flash floods/river damming outbursts, the most notable being the Parechu outburst flood in Satluj Valley in 2005 which caused considerable damage to livelihoods, houses, roads, bridges, electricity generation and supply and to hydro-power plants downstream, in spite of timely early warnings and monitoring over a period of time. . The impact of such flash floods is further accentuated by the fact that the numerous distributaries of the Sutlej flow through narrow fragile valleys and *Khuds*, prone to constant landslides and mud flows.

Avalanches

Snow avalanches are the sudden slide of large mass of snow down a mountain. There are several factors, which can affect the occurrence of avalanche, including local weather, slope, atmospheric temperature, vegetation; terrain and general snow pack conditions. Different combinations of these factors can create low, moderate and extreme weather conditions. Most avalanches are very dangerous and cause huge loss of life and property. The temperature variation and wind speed are directly proportional to avalanches. As per the Snow & Avalanches study established on an average 30 persons are killed every year due to this disaster in the Himalaya.

Areas normally prone to Avalanches include
Region above 3500m elevation.
Slopes with inclination 30-45°
Convex slopes.
Slopes covered with grasses.

Higher reaches of Himachal Mountains receives considerable precipitation in the form of snowfall. The north western sector particularly receives maximum snowfall. In winter season the snowfall varies from 2 to 130cm in pre monsoon season, from 1-42cm and in post monsoon from 2 to 39cm. Annual amount of snowfall varies from 25 to 204cm and number of snowfall days from 6 to 77. Avalanches are common phenomena in the district of Kinnaur, Chamba & Kullu. In the past the only place where avalanches have caused destruction in Kangra District is the Bara Banghal area situated at an elevation of 8500feet above the sea level. The village which was located at the base of steep slopes and on the banks of Ravi River was destroyed many times by the avalanches in the past.

Table 1.8: Damage caused by Avalanches in past

Date	Location	Damage
March 1978	Lahaul and Spiti	30 people killed
March 1979	Lahaul and Spiti	237 people killed
1988	Shimla	Lahaul – Spiti, Kinnaur and Solan districts blocked
March 1991	Himachal Pradesh State affected	Road blockage for 40 days
September 1995	Himachal Pradesh State affected	Flood caused by melting of snow brought by avalanches
September 2001	Himachal Pradesh State affected	Devastated flood caused huge amount of damage

Drought

Drought is a long period with no or much less rainfall than normal for a given area. Meteorologically drought is defined as situation when the annual rainfall over any area is less than 75% of the normal. It is termed as moderate if rainfall deficit is between 25 to 50 % and severe if it is more than 50%. Area where frequency of drought is above 20% of the years examined is classified as drought area and areas having drought conditions for more than 40% of the years represent chronically drought affected area.

Table 1.9: Droughts in Himachal Pradesh

Year	Hilted area in H. P.	Total Loss in crore
1999	51 to 90% damage to crops in different part of state	234.87
2001	Chamba, Kangra, Solan, Bilaspur, Lahaul Spiti	299.17
2002	50% thrrougout the State	70.21

Main Risk Reduction Strategies (Flood)

Mapping of the flood prone areas is a primary step involved in reducing the risk of the region. Historical records give the indication of the flood inundation areas and the period of occurrence and the extent of the coverage. The basic map is combined with other maps and data to form a complete image of the flood plain. Warning can be issued looking into the earlier marked heights of the water levels in case of potential threat. In the coastal areas the tide levels and the land characteristics will determine the submergence areas. Flood hazard mapping will give the proper indication of water flow during floods.

Land use control will reduce danger of life and property when waters inundate the flood plains and the coastal areas. The number of casualties is related to the population in the area of risk. It's better to reduce the densities in areas where neighbourhoods are to be developed. In areas where people already have built their settlements, measures should be taken to relocate to better sites so as to reduce vulnerability. No major development should be permitted in the areas which are subjected to high flooding. Important facilities should be built in safe areas. In urban areas, water holding areas can be created in ponds lakes or low lying areas.

Construction of engineered structures in the flood plains and strengthening of structures to withstand flood forces and seepage. The building should be constructed on a elevated areas. If necessary build on stilts or platform.

Flood Control aims to reduce flood damage. This can be done by Flood Reduction by decreasing the amount of runoff by treatment like reforestation (to increase absorption could be a mitigation strategy in certain areas), protection of vegetation, clearing of debris from streams and other water holding areas, conservation of ponds and lake etc. Flood Diversion includes levees, embankments, dams and channel improvement. Dams can store water and can release water at a manageable rate. But failure of dams in earthquakes and operation of releasing the water can cause floods in the lower areas. Flood proofing reduces the risk of damage. Measures include use of sand bags to keep flood water away, blocking of sealing of doors and windows of houses etc. Houses may be elevated by building on raised land. Buildings should be constructed away from water bodies.

Community Based Mitigation

Sedimentation clearance, reforestation programme, dike and flood wall construction can be taken as part of the community based mitigation programme. The community can participate in flood fighting by organizing work parties to repair embankments, pile sandbags and stockpile needed materials. Farming practices have to be flood compatible, special varieties of seeds are available which can be harvested during the flood season. Houses constructed need to be flood resistant and multipurpose shelter should be constructed by the community. Banks of the earth can be raised and it can give shelter to the community as well as the livestock during the time of floods.

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.
Insurance 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.

Main Risk Reduction Strategies – Earthquakes
Engineered Structures (designed and built) to with stand ground shaking. Architectural and engineering inputs put together to improve building design and construction practice. Analyse soil type before construction and do not build structures on soft sail. To accommodate on weak soils adopt safety measures in design. Note: buildings built on soft soils are more likely to get damaged even if the earthquake is not particularly strong in magnitude. Similar problem persists in the alluvial plains and conditions across the river banks. Heavy damages are concentrated when ground is soft.

Follow Indian Standard Codes for construction of buildings. Enforcement of the byelaws including land use control and restriction on density and heights of buildings.

Strengthening of important lifeline buildings which need to be functional after a disaster. Upgrade level of safety of hospital, fire service building etc.

Public Awareness, sensitization and training programmes for architects, builders, contractors, designers, engineers, financiers, government functionaries, house owners, masons etc. Reduce possible damages from secondary effects such as like fire, floods, landslides etc. e. g. identify potential landslide sties and restrict construction in those areas.

Community Based Mitigation community preparedness along with public education is vital for mitigating the earthquake impact. Earthquake drill and public awareness programme.

Community based Earthquake Risk Management project should be developed and sustainable programmes launched. Retrofitting of schools and important buildings, purchase of emergency response equipment and facilities, establishing proper insurance can be the programmes under earthquake risk management project. A large number of local masons and engineers will be trained in disaster resistant construction techniques. A large number of masons, engineers and architects can get trained in this process.

Main Risk Reduction Strategies: Drought
Drought monitoring is continuous observation of rainfall situation, water availability in reservoirs, lakes, rivers and comparing with the existing water needs of various sectors of the society.

Water Supply Argumentation and conservation through rainwater harvesting in houses and farmers' fields increases the content of water available. Water harvesting by either allowing the run-off water from all the field to a common point or allowing it to infiltrate into the soil where it has fallen (in situ) (e. g. contour bunds, contour cultivation, raised bed planting etc.) helps increase water availability for sustained agricultural production. Expansion of irrigation facilities reduces the drought vulnerability.

Land Use based on its capability helps in optimum use of land and water and can avoid the undue demand created due to their misuse.

Livelihood planning identifies those livelihoods which are least affected by the drought. Some of such livelihoods include increased off – farm employment opportunities, collection of non-timber forest produce from the community forests, raising goats, and carpentry etc.

Drought Planning
The basic goal of drought planning is to improve the effectiveness of preparedness and response efforts by enhancing monitoring, mitigation and response measures. Planning would help in effective coordination among state and national agencies in dealing with the drought. Components of drought plan include establishing drought took force which is a team of specialists who can advise the government in taking decision to deal with drought situation, establishing coordination mechanism among various agencies which deal with the drought, providing crop insurance schemes to the farmers to cope with the drought related crop losses, and public awareness generation.

Public Awareness and Education
Education the masses on various strategies you learned above would, help in effective drought mitigation. This includes organizing drought information meetings for the public and media, implementing water conservation awareness programmes in the mass media like television, publishing and distributing pamphlets on water conservation techniques and agricultural drought management strategies like crop contingency plans and rainwater harvesting and establishing drought information centers for easy access to the farmers.

Watersheds: for water supply augmentation & conservation watersheds are geographic area where the water flows to a common point**.** To mitigate the drought impact**,** all kinds of soil and water conservation measures are taken up with the involvement of the local communities**.** This approach helped these areas to manage efficiently the soil**,** vegetation**,** water and other resources**.** By conserving scarce water sources and improving the management of soil and vegetation**,** watersheds have the potential to create conditions conducive to higher agricultural productivity while conserving natural resources**.**

Checkdams (Bhanadaras)

These are check dams or diversion weirs built across rivers, a traditional system found in Maharashtra, their presence raise the water level of the rivers so that it begins to flow into channels. They are also used to impound water and form a large reservoir where a bandhara was built across a small stream, The water supply would usually last for a few months after the rains.

Main Risk Reduction Strategies – Avalanche

Types of Control Measures
Avalanche control measures can roughly be classified into hardware and software types. Hardware measures are for the purpose of preventing avalanches or for blocking or deflecting avalanches with protective structures. Software measures provide safety by eliminating the probability of avalanches by removing show deposits on slope with blasting and by predicting the occurrence of avalanches by removing show deposits on slope with blasting and by predicting the occurrence of avalanches and recommending evacuation from hazardous areas.

Avalanche control structures: Avalanche control structures can be divided into two major types:

I. Prevention Structures
Prevention structures are provided to prevent the occurrence of avalanches major types are described below:
1) **Planting:** Avalanche prevention forest protect show cover form movement by resistance of tree trunks and branches, increase the stability of snow cover by uniformly distributing it and control quick changes in snow cover.
2) **Stepped Terraces:** Stepped terraces area provided for stabillising the snow cover on slope by reducing or dividing the sliding force of the snow cover with steps cut into dividing the sliding force of the snow cover with steps cut into the slopes. Steps are easy to construct at a reasonable cost but are not effective in controlling surface layer avalanches.
3) **Avalanche Control Piles:** Avalanche control piles are assemblies and single piles driven into slops in avalanche zones to control surface layer avalanches.
4) **Avalanche Control Fence:** Avalanche control fence is installed on slopes of avalanche zones to prevent full depth and surface layer avalanches.
5) **Suspended Fences:** These are used in steeps lopes or in areas where foundations cannot be properly installed because of poor ground conditions and useful in small area.
6) **Snow Cornice Control Structures:** These structures are installed at tops of mountains areas to prevent the development of snow cornices that can cause avalanche. These are two methods of prevention, one is a collector snow fence, which collects snow on the windward side of the top of the mountain, and the other is a blower snow fence which controls the development of snow cornice by blocking winds on the ridge.

3. Conclusion

The role of media, awareness and training in hazard management in Himachal Pradesh. needs to be addressed at priority. The role of media should be effective to inform and aware the community. Some time, it is observed that media creates panic during the hazard situation among the public and administration. So media should be trained skilfully in order to disseminate the information effectively. The NGOs, CBOs, VOs, Arm Forces, Home Guards, Police, Medicos Para Medical and other officials, Non officials' related to hazard management and community should be well trained to manage comprehend the situation. Community should be trained in the grass root level. Hazard awareness and training programmes are impossible for want of funds. It is necessary that the central govt. should help state govt. and administration by providing funds to these programmes.

Therefore, it can be said that govt. and administration both should make more efforts in the sense of media awareness and training to related hazard & hazard management system in Himachal Pradesh. Needless to say that in Himachal Pradesh many of NGOs', CBOs' and VOS' are playing very effective role for facilitating the government development & social programmes and the role whatever is played by them cannot be ignored particularly in the various fields such as literacy, Female foeticide, small savings, environmental fields, Agricultural fields, Small Scale industries etc. But so far in the concerned of hazard Management, their role is seen nowhere or it is very negligible. There may be many reasons behind it such as lack of interest, lack of fund, lack of interaction between govt. & administrator and lack of resources and training etc. whereas on the other hand Home Guards, Fire Service Man, Police and Para Military Forces, Red Cross Society and Rotary Clubs are playing effective role to handle the hazard situation. Thus, there should be an urgent need for interaction with Mahila Mandals, Youth Mandals, SHG, PTAs, Members of citizen councils, PRIS, Religious Organizations, Private organization and other Societies in hazards management system. The govt. and administration should give them training, resources, funds and other inventories to handle any hazards situation as they can play effective role in any hazard situation.

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