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Overview of Vulnerability Floods and Avalanche Hazard 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 floods and avalanche hazard in Himachal Pradesh and also describes the main risk reduction strategies during floods hazards. The universe of the study is very wide and vast. Therefore due to constraints of resources and time only floods and avalanche hazard in Himachal Pradesh & Main hazards Risk Reduction strategies for floods and avalanche 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.

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

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.

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. In India, data is

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 1.2: 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

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 – 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.

2. 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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