## 1.1 Risk & Its Assessment

**Risk** is the probability or severity of occurrence of a harmful consequence due to hazards.

**Hazard** is a situation that poses a level of threat to life health or environment.

**Disaster** is a natural or man-made hazard resulting in an event of substantial extent causing significant physical damage or distraction loss of life or drastic change in environment.

**Risk Assessment:** Qualitative and quantitative measurement of the potential loss of life, personal injury, economic injury, and property damage resulting from hazards.

**Risk assessment involves the following:**

- Hazard Identification
- Vulnerability Analysis
- Risk Analysis
- Emergency Plan

The main objective of this Risk Assessment (RA) study for the proposed ropeway is to identify the disasters due to natural causes, human caused occurrences & technical failures and to provide risk mitigating measures to reduce associated hazards.

### *1.1.1 Hazard Identification*

Aerial ropeway at Ralli Village will present a number of hazards to the general public, operating and maintenance staff. Ropeway will be liable to suffer from two types of disasters:

**Natural Disasters**

Natural disasters include earthquakes, landslides, rock falls, floods, storms, avalanche, lightening etc. Risk Analysis due to Natural Hazards is discussed in section 7.1.3 of this chapter.

**Human -caused occurrences**

Man-made occurrences include:

- Fire
- Electrical faults
- Technical faults like rope with broken wires in service, drive / return sheave shaft failure / tension system failure, mount assembly parts failure, over speeding of ropeway / brake failure, rollback, slippage / fall of cabin, entanglement of cabin, swinging of cabin resulting in fall of passengers outside cabin, cabin derailment at station etc.
- Security threats

Hazard analysis for the Natural & Man-made Disasters is discussed in the Table 7-1

Table 7-1 Hazard Analysis

| Hazards | Severity (1-5) | likelihood (1-5) | Severity x likelihood (1-25) (Hazards scoring 1-12 are less serious hazards & 13-25 are very serious hazards & need prior attention) |
|---|---|---|---|
| Natural hazard | | | |
| Earthquake | 5 | 2 | 10 |
| Landslides | 5 | 4 | 20 |
| Flood | 2 | 1 | 2 |
| Avalanche | 3 | 3 | 9 |
| Wind & cyclone | 2 | 2 | 4 |
| Cloud Burst | 5 | 1 | 5 |
| Drought | 3 | 1 | 3 |
| Man-made hazard | | | |
| Fire & explosion | 5 | 2 | 10 |
| Electrical | 3 | 5 | 15 |
| Technical/ Accident | 4 | 5 | 20 |
| Security | 3 | 1 | 3 |

### *1.1.2 Vulnerability Analysis*

As per the hazards analysis given in Table 7-1, the vulnerable areas during construction phase are mainly the immediate areas under construction.

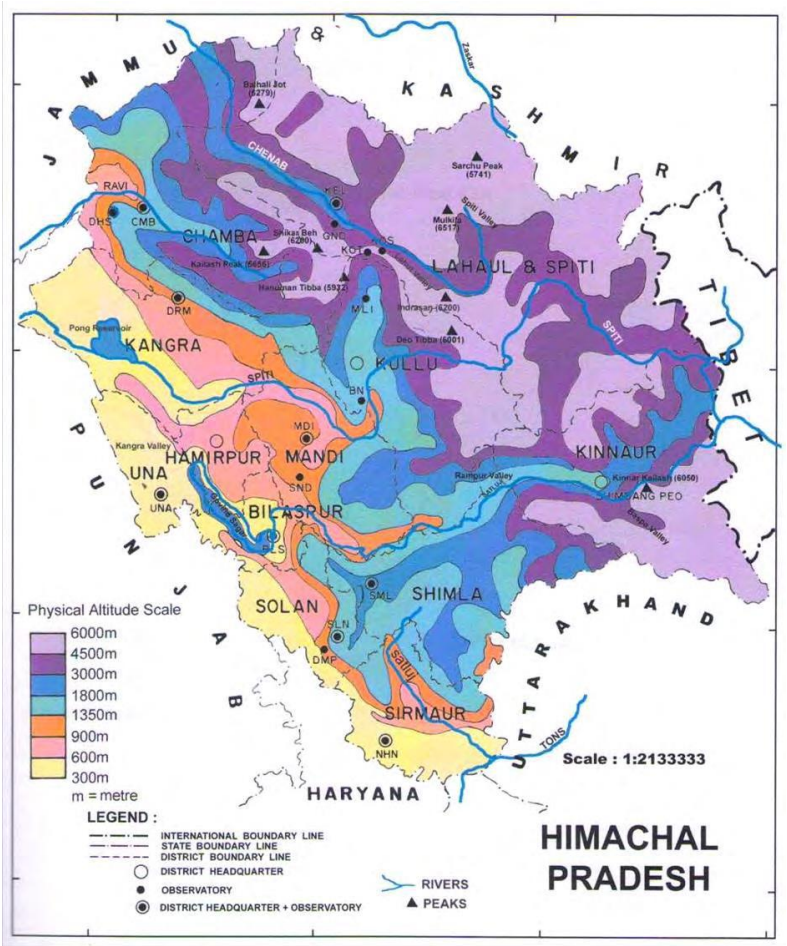
The vulnerability analysis during operation phase is given for natural as well as man-made hazards are shown in Table 7-2 & table 7-3 respectively.

Table 7-**Error! No text of specified style in document.**.1 Vulnerable locations/ areas for natural hazards

| Hazard | Vulnerability |
|---|---|
| Earthquake | Damage to Towers, Terminal Stations, Cable Cars |
| Landslides | Damage to Towers if slope stability is not maintained. |
| Flooding | Satluj River (due to cloud burst or excess rain) |
| Avalanche | As the project lies in a mountainous terrain, there is a risk of avalanches near the project site.<br><br>This can cause damage or burial of human and material. |
| Wind & cyclone | There are very moderate chances of wind & cyclone; this can cause damage to cable car. |
| Cloud Burst | Cloud burst can cause soil erosion, landslides and flooding on project site. It can cause damage to towers and terminal Stations |

Table 7-**Error! No text of specified style in document.**.2 vulnerable locations of different man-made hazards

| Hazard | Vulnerable Locations |
|---|---|
| Fire | Cable car, Terminal Stations, Control Room |
| Electrical | Cable Car, Transformer, Control room |
| Mechanical/ Accident | Cable car, Ropes, Terminal Stations, Ropeway Towers |
| Technical | Ropeway, Cable car, Terminal Stations |
| Security | Terminal Stations, Parking, Population at site |




**Geography of Himachal Pradesh**

## *1.1.3 Risk Analysis*

**Environmentally Induced Risks and Hazards**

**Natural Calamity Hazard Profile**

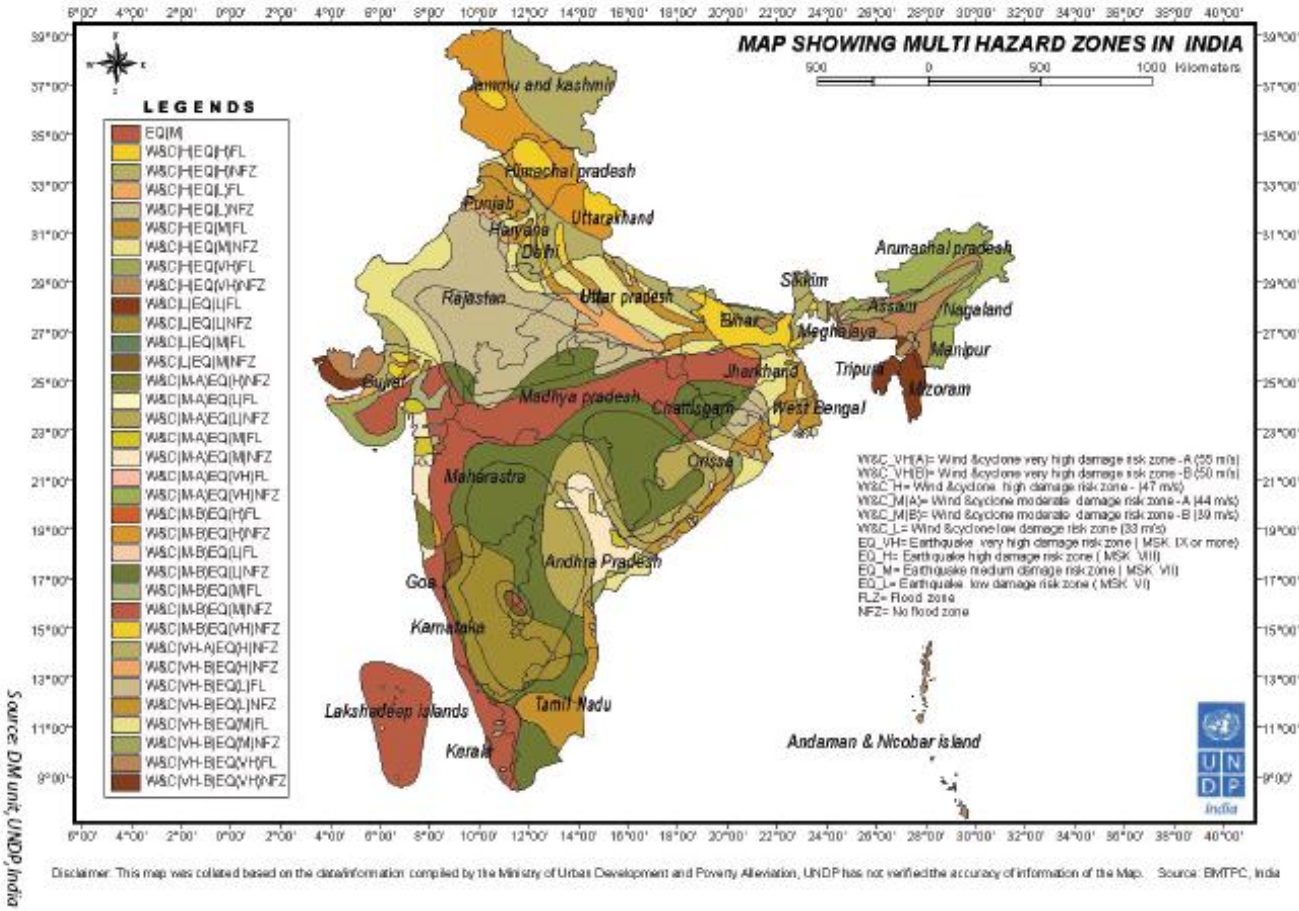
Hazard profile map of India (published by Home Ministry of India as a part of document 'Disaster Management Plan in India') is depicted in figure 7-1.

The region having project site is prone to following Hazards:

- Earth Quake
- Landslides
- Flooding
- Avalanche
- Wind & Cyclone
- Cloud Burst

Above findings are supported by profile map of India for earthquake, Landslides flooding and wind & cyclone as depicted in Fig. 7-1.

Figure 7-**Error! No text of specified style in document.**-1 Natural Calamity Hazard Profile of India




## Seismicity

As per fig. 7-3, the project site is located in seismic zone V which indicates highest risk zone. The last earthquake in the area was in the project district of Kinnaur and was of magnitude 6.8 on the Richter scale.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 mild earthquakes every year. Large earthquakes have occurred in all parts of Himachal Pradesh, the biggest being the Kangra earthquake of 1905.

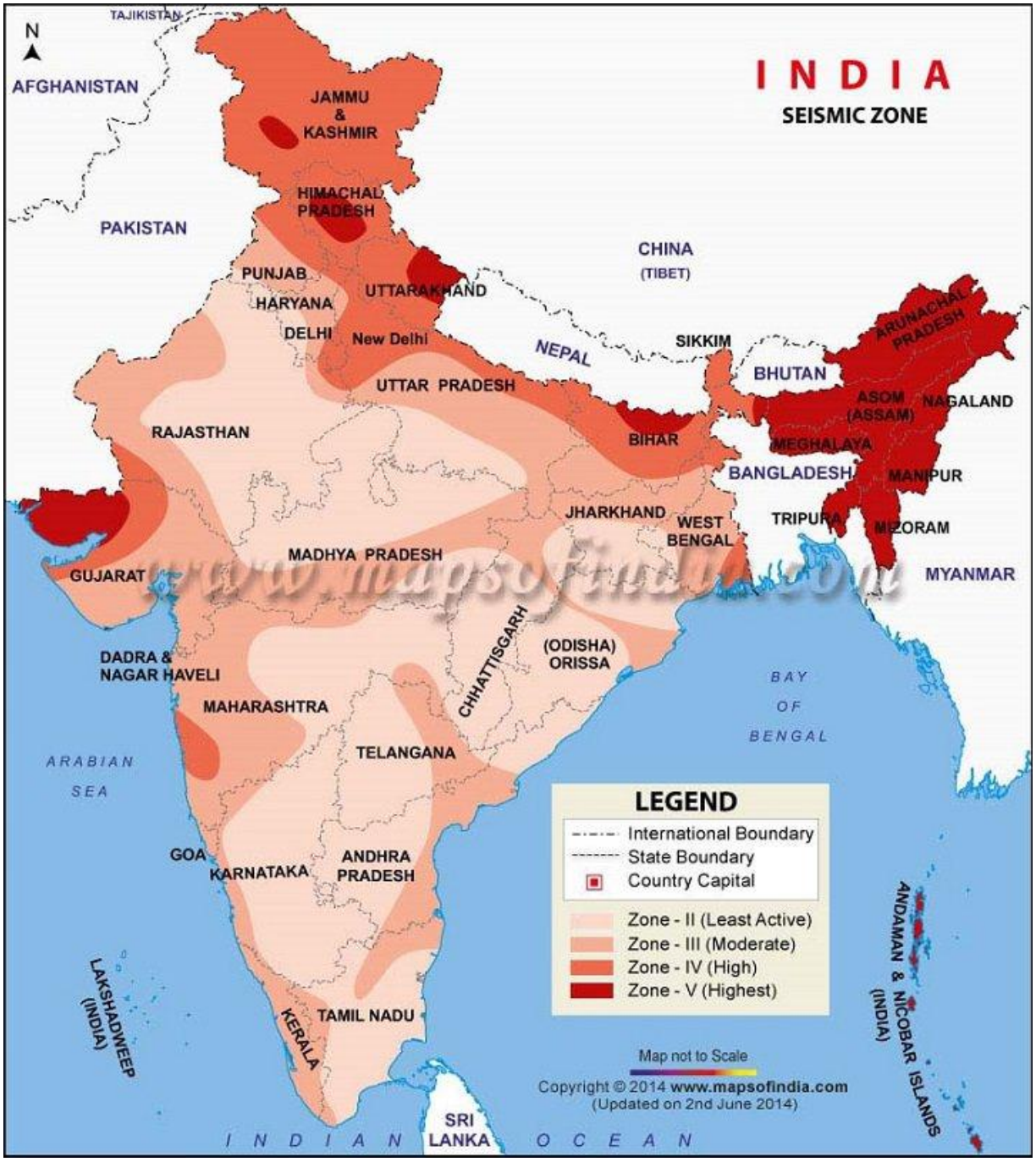
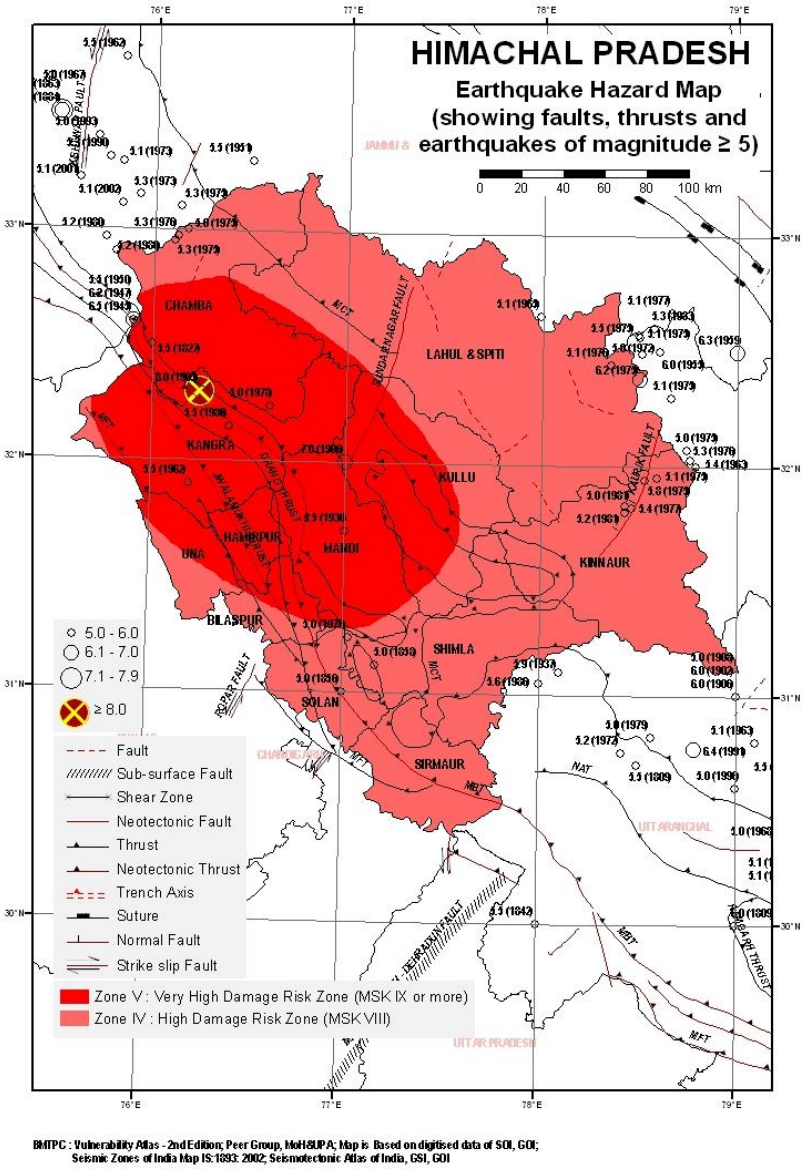



Figure 7-**Error! No text of specified style in document.**-2 Seismic Map of INDIA

Figure 7-3 Seismic Map of HIMACHAL PRADESH (Source: BMTPC Atlas of India)

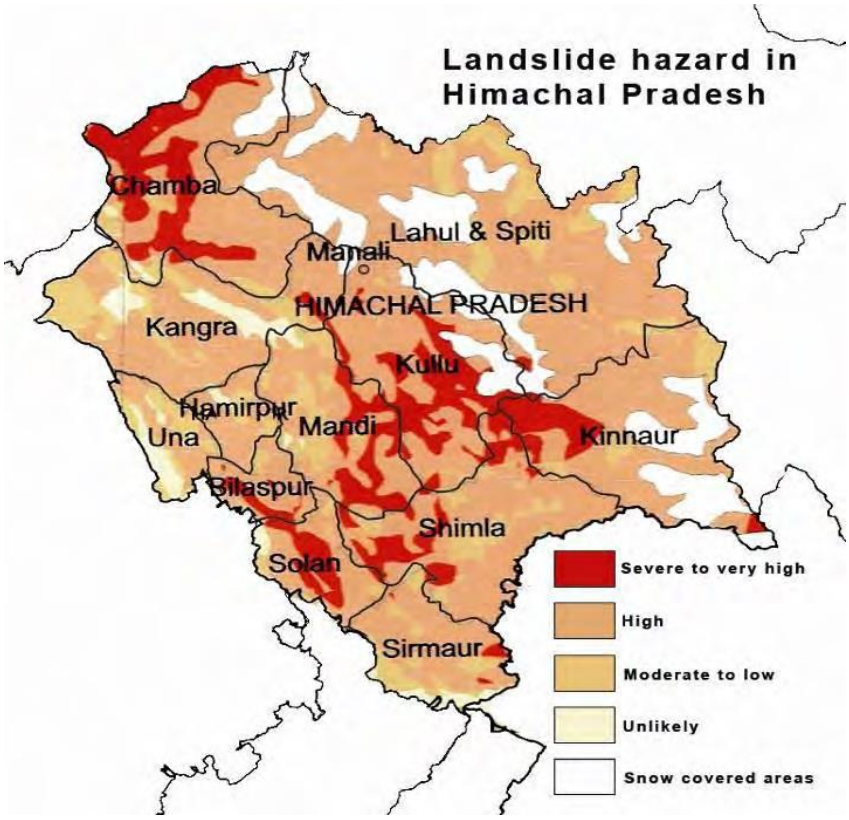



## Landslides

According to geological, topographical and climatic conditions of the area and human factors such as deforestation, unscientific road construction (blasting carried out for road cuttings), constructions of dams or reservoirs, housing schemes, roads, terracing and water intensive agricultural practices on steep slopes etc., implemented without proper environmental impact assessments have increased the intensity and frequency of 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. Landslides

may occur at the project site, if, slope stability is not maintained. District wise landslide vulnerability in the State is as follows.




**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 | 2120 | 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 |

Triggering of landslides is both a natural and anthropogenic phenomenon. 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, KhadraDhank, Thangi, Barua are some of the most common landslide that has affected the NH-22 in Satluj valley.

**Flooding**

The state is at high risk of floods, especially flash floods. Major causes responsible for floods and flash floods in the state of Himachal Pradesh may be –

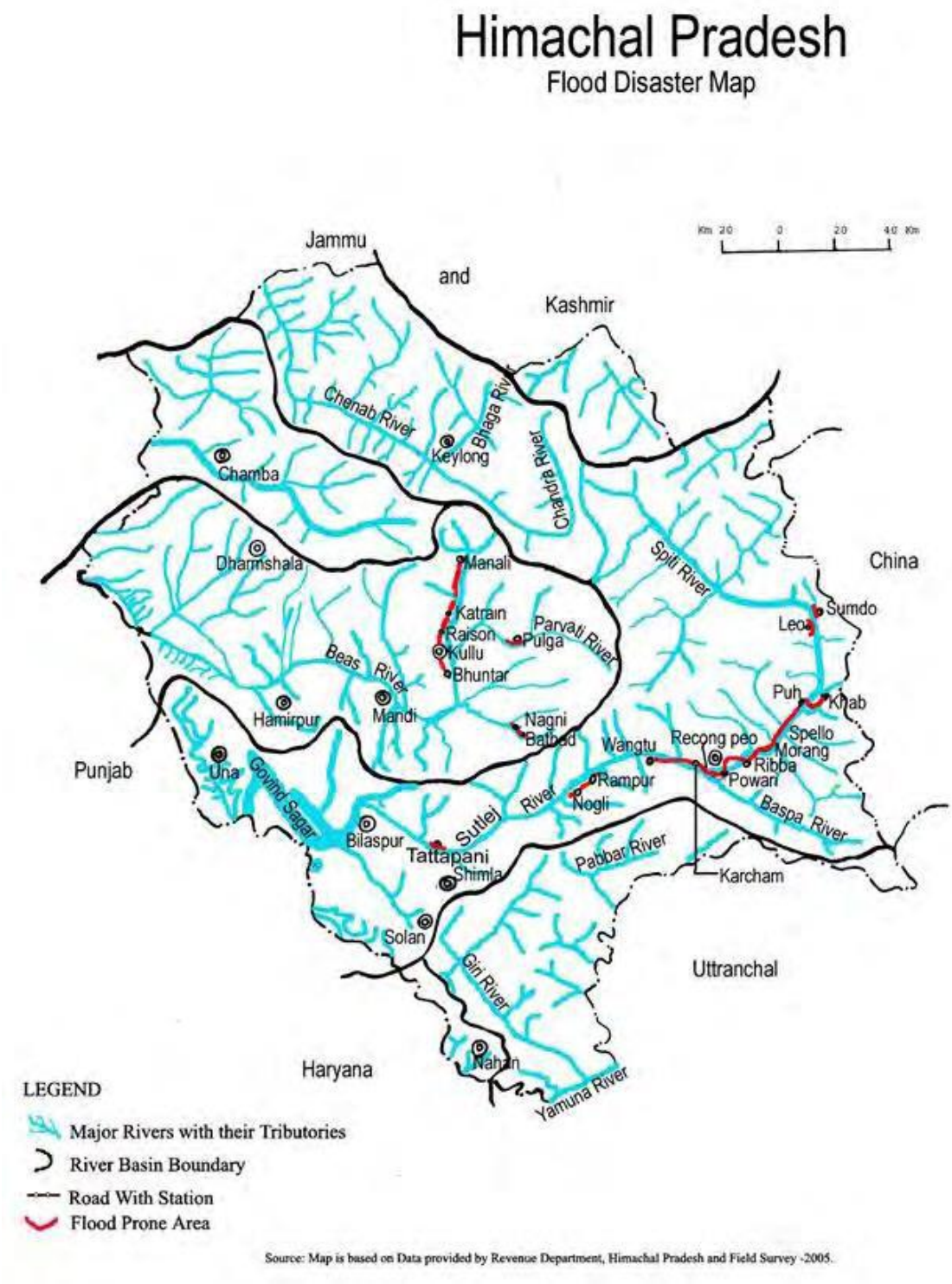
- Cloudburst in upper catchments of the river
- Excessive rainfall in the catchments
- Melting and bursting of glaciers due to global warming
- Sudden breach or failure of manmade or natural barriers
- Change of river course
- Landslides triggered due to slope failure or tectonic movements

Over 40 incidents of flash flood and cloud bursts occurred in Himachal Pradesh in the last 12 years.In August 1994, the Manimahesh cloudburst and flash flood washed away almost the entire length of Chamba-Bharmour road (62 km), over 50 people feared dead, and 2000 injured. The estimated loss was over 450 crore of Rupees. 1997 again saw a heavy flash flood in Maglad in Rampur tehsil of Shimla district. Some of the major flash floods reported in the State are as follows:

Figure 7-4 Flood map ofhimachal pradesh

**Major Flash Floods in Himachal Pradesh**

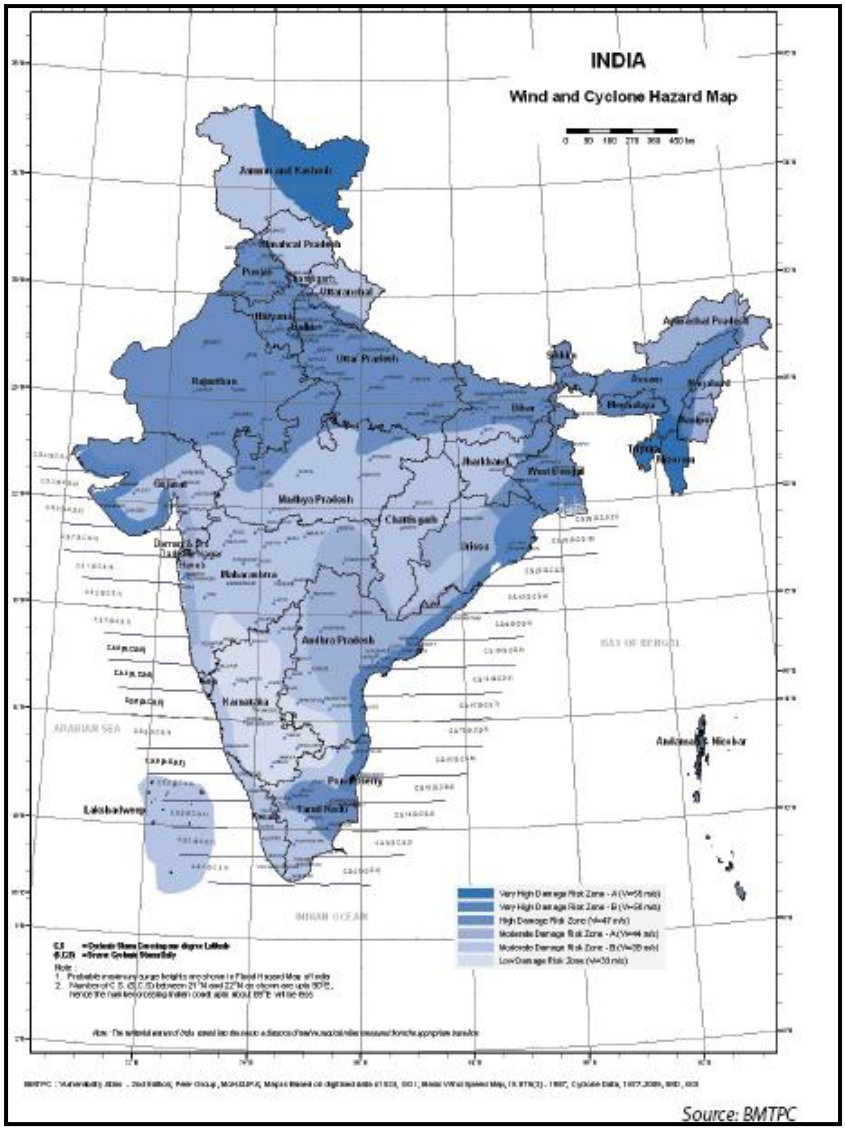
| Year | Location | Official Damage |
|---|---|---|
| July 2000 | Satluj River, Kullu, Mandi, Kinnaur, Rampur | 140 dead, 400 shifted, 12400 sq km. Affected |
| August 2001 | Chamba | 16 dead, 3010 sq km affected |
| July 2003 | Gadsa valley – Kullu | 35 dead |
| August 2004 | Satluj river, Kinnaur, Shimla, Kullu, Bilaspur | 3500 people and 56 villages evacuated |
| June 2005 | Parchu lake, Kinnaur, Rampur | 5 bridges damaged, 50 houses submerged |




**Wind & Cyclone**

The yearly distribution of tropical cyclones in the north Indian Ocean indicates large year to-year variations in the frequency of cyclonic disturbances and tropical cyclones, but no distinct periodicity. However, the trend indicates a slight decrease with time. The Cyclone hazard map of India as depicted in the Figure 7-4, gives the vulnerability map of hazard due to cyclone. As per this map, the project area falls under a zone where high wind & cyclone is seen.

Figure 7-5 wind & cyclone map of India




## 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 receive 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.

**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 | HP state affected | Road blockage for 40 days |
| September 1995 | HP state affected | Flood caused by melting of snow brought by avalanche |
| September 2001 | HP state affected | Devastated flood caused huge amount of damage |

**Cloud Burst**

Though not a regular phenomenon, cloudbursts lead to exceptionally heavy rainfall and sudden flash floods in the mountainous streams and rivers, leading to breaching of banks and overflowing of dams.

**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.

The tables below give the years of successive drought and years of severe drought in the state of HP when rainfall was less than 50%. Taking into consideration the above historical data and above criteria the areas falling in the districts of Kangra and Una between the years 1951-99 could only be termed as drought area. There is not a single district in the state which qualifies to be called as chronologically drought affected area. However, during the period 0f 49 years (1951-99) almost all the districts have suffered drought like situation Figure 2.8 shows the percentage of drought and years of successive drought for various districts with actual rainfall expressed as percentage of normal rainfall given in brackets against each district. Incident of wide spread drought was observed in the year 1972 and 2011.In the year 2011 in total 46.64 lakh human population and 0.88 lakh ha. cropped area was affected.

## Years of Successive Drought

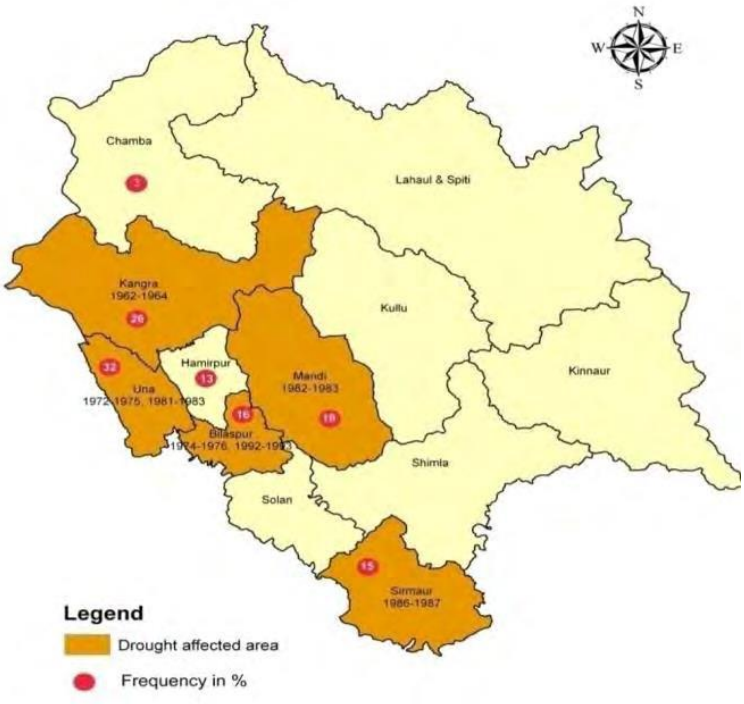
| Sr. No. | Districts | Years of successive drought |
|---|---|---|
| 1. | Bilaspur | 1974-75-76, 1992-93 |
| 2. | Kangra | 1962-63-64 |
| 3. | Mandi | 1982-83 |
| 4. | Sirmaur | 1986-87 |
| 5. | Una | 1972-73-74-75,81-82-83 |

*Source: Indian Meteorological Department (IMD)*

## Years of Severe Drought

| Sr. No. | Districts | Years of Severe Drought R/F < 50% |
|---|---|---|
| 1. | Bilaspur (37 %) | 1975 |
| 2. | Hamirpur (45 %) | 1974 |
| 3. | Mandi (44%) | 1983 |
| 4. | Sirmaur (48%, 41%) | 1979,1986 |
| 5. | Una (43%, 40 %) | 1975, 1981 |

*Source: Indian Meteorological Department (IMD)*




Areas affected by drought (1951-2000)

**Human Induced Risks and Hazards**

**Fire & Explosion:**

Since it is a ropeway project, fire can mainly cause due to electric spark in electrical room, fire in the surrounding forest area, fire in fuel storage places, etc.

The Fire & explosion can cause suffocation due to harmful gases generation & panic in people.

**Electrical:**

The ropeway will run on electricity & hence electrical current can pass through cable cars & wires due to inadequate insulation or accidently.

**Technical Failures/ Accident:**

As the ropeway consists of cable cars, ropes & big & heavy machineries, technical failures as discussed in Section 7.1.1 can cause risks to people working in the area during construction phase & people who will travel through the ropeway in operation phase.

**Consequences of the discussed hazards may result into accident.**

**Security Threat:**

War, crisis & terrorists can cause panic among public and staff.

## 1.2 Preventive Measures

**Natural Occurrences**

**Earthquake:**

The project will be situated in Seismic zone-II area. Special attention shall be given to the structural design of foundation, elements of masonry, timber, plain concrete, reinforced concrete, pre-stressed concrete, and structural steel. All applicable guidelines will also be followed in this regard to ensure safety of the building.

**Landslides:**

The area where ropeway is proposed is highly prone to landslides. Structural stability & safety is must to prevent ropeway damage due to landslides. Slope stability in the area shall be maintained at 450.

**Flooding:**

- Although the site is not prone to flooding & being at the highest peak & away from rivers, the probability of flooding is very less, proper designing of drainage system shall be done.
- All the waste water shall be disposed off to soak pits.
- Structures shall be built in such a way that no harm occurs to the people & structures due to flooding due to natural calamities.

**Man-made Occurrences**

**Fire and Life Safety:**

- Smoking must be prohibited.
- Electrical equipment must be explosion-proof to meet national electrical code requirements.
- Dry chemical extinguishers should be accessible for small fires. An adequate supply of handheld and wheeled types should be available.
- Hydrants should be strategically placed with adequate hoses.
- Small spills should be remediated with sand, earth, or other non-combustible absorbent material, and the area then flushed with water.

**Technical Faults & Accidents**

- The carriages will be provided with door lock which cannot be opened by the passengers.
- Carriage of each cabin shall be provide with 2 nos. detachable rope grips.
- The ropeway system will be provided with minimum of two braking systems- Normal/ Emergency Brake and Service Brake. The emergency brake shall be weight operated &thruster released brake which should be provided on brake ring fitted on drive sheave. The service brake shall be weight operator thruster released brake shall be provided on high speed brake drum coupling.
- In event of main power supply failure, the system should have full rated Diesel Generator to supply power to run drive motors.
- Standby diesel engine should be provided for each station to run ropeway at slow speed to rescue passengers from line in case of failure of main DC motor.
- Line safety devices should be installed on each trestle, holds down & pressure frames which immediately stop the ropeway in the unlikely event of rope derailment. This should comprise of electrical trip limit switch with attachment mounted on line sheave mount. In an accidental case, if the hauling rope comes out of line sheaves it should be automatically trip the ropeway by the actuation of limit switch through the attachment.
- Rope catcher will be provided on mount beams on line trestle, P.F. and Stations to arrest/ support the hauling rope in case of de-ropement.
- Emergency push buttons will be provided at stations to stop the ropeway, if required.
- The ropeway main drive motors to be tripped if:
  - Set rope speed exceed by 5 %
  - Wind speed exceeds the set limit
- The project shall be provided with anemometers to monitor the wind speed and to provide trip signals to main drive in case wind speed exceeds a pre-determined set speed.
- Each station will have a first-aid medical facility.

**Safety Planning**

- Safety Measures for Design Stage

**Information**

a) Obtain from the manufacturer, supplier or assembly contractor any drawings, manuals, other data and design verification, inspection and test certificates that are necessary to establish that the passenger ropeway has been designed, manufactured and installed in accordance with the relevant IS codes;

b) Obtain from the manufacturer, supplier or assembly contractor catalogues, drawings, manuals, specifications or other information required to ensure that all relevant in-service activities can be carried out safely;

c) Store this data at the place of work where the passenger ropeway is situated so that it is secure and readily available to all persons in that place of work and to any other person requiring access including equipment inspectors. This data shall be kept available for reference until disposal of the equipment.

**Supervision**

The ropeway operator will:

a) Personally, supervise the passenger ropeway and every specified activity or appoint a competent person to carry out this supervision;
b) Ensure that persons appointed are competent to carry out duties allocated to them;
c) Delegate to competent persons, appointed to supervise passenger ropeway, powers required to exercise supervision;
d) Ensure that the names of persons appointed to supervise a passenger ropeway are made known to any persons who carry out a specified activity or any other significant activity associated with that passenger ropeway.

**Erection and Commissioning Stage**

Assembly contractors of a passenger ropeway will ensure that it is erected, commissioned, tested and inspected in accordance with information which is complete and appropriate for safe erection, testing, inspection and commissioning.

Assembly contractors of ropeway will record every critical safety stage in the erection and commissioning of passenger ropeways.

**Inspection of Safety Related Components**

- Where the failure of a component will directly result in serious risk to passengers, such components should be given particular consideration when drawing up maintenance and inspection schedules. Such components include wire ropes, fixed and detachable rope groups, pylon structures etc.
- In addition to the inspections detailed discussed above, thorough examination of the ropeway by a competent person, preferably an independent third party, is recommended on an annual basis. The examination should be based on a scheme prepared by the competent person along with the ropeway controller and/or operator and take into account manufacturers' advice, past experience and all relevant standards and guidance material. Examinations cover all components and systems as discussed above and inspection of all structures and foundations

for signs of movement or failure. All significant defects need to be reported immediately to the operator and a decision made on what action to take with a full written report provided within a reasonable time.

- Static ropes need examination particularly where they may be subject to bending stresses, at rope terminations and where environmental conditions could cause deterioration. Haul ropes need examination for wear, lubrication, broken wires, corrosion and localized damage.
- Monitoring the internal condition of the haul and suspension ropes is a specialist area and requires trained and competent people. Non-destructive (NDT) methods, such as magnetic induction, should be used if possible. In addition, the competent person might consider it necessary to carry out an internal examination on some occasions. To monitor any deterioration in the rope and determine examination intervals, records of all examinations need to be kept. All ropes likely to be examined by NDT methods in service should be examined at the start of their service life to provide a datum for subsequent comparisons.
- It is not possible to have all safety related components examined each year, so a sampling strategy needs to be used so that all components are thoroughly examined over a set period which is determined by the competent person. The set period is recommended to be no greater than five years. Components examined in this way include:

1. Clamping devices (including fixed and detachable grips) dismantled into their separate parts;
2. Load bearing parts associated with chairs or cars;
3. Bolts and other fasteners from the critical components such as anchor bolts and shear frame
4. Pins found on support towers; and
5. Foundations and structures concerning the ropeway.

- It is unlikely that one individual will be competent to carry out thorough examinations on all parts of the installation. For example, the examination of ropes is a specialized skill. It is up to the controller to establish that the competent person has the necessary skills and facilities to carry out the thorough examinations for which they are employed. It should be noted that thorough examination by a competent person is not a substitute for regular planned maintenance. Testing, inspection and thorough examination only form part of a maintenance scheme, which is covered in the next section.

**Safety of Employees**

- Operating procedures should ensure the safety of staff involved in operation, inspection, examination, testing, maintenance and repair work and in emergency procedures. Safe access should be provided. Permit-to-work schemes and power isolators which can be locked in the off position should be provided when necessary. Staffs need to be fully conversant with permit-to-work schemes or other similar systems.
- Operations involving the construction, structural alteration, demolition or repair of the structure of a ropeway may be subject to the Construction Regulations.

- **Safety Measures for Operation Stage**

**General**

The operator of the ropeway will ensure that:

a) a display is placed in a conspicuous location for the operator at the main drive station stating the approved limiting conditions such as total number of cabins, capacity of each cabin, minimum spacing between cabins, maximum line speed and operating limiting wind velocities;
b) The ropeway has a valid certificate of inspection.
c) The ropeway is operated safely and within their design limits.
d) All safety devices are in working condition.
e) The operation is in accordance with relevant operating manuals/procedures.
f) All operating procedures relating to ropeway are kept under regular review, improved and updated whenever possible, and implemented by competent persons.
g) Security guard with hand held scanner and metal detector will be proposed at the entry of the LTP.

Further the ropeway project shall be thoroughly inspected by a Chief Ropeway Inspector before opening it for public use. After the clearance, the ropeway project shall commence.