Chapter 2

Natural Hazards in Nepal

Unstable steep slopes and fragile geological formation of a young mountain range along with heavy monsoon rainfall make Nepal one of the most hazardous areas in the world. Because of its topographical variation and geological characteristics, together with torrential rain during the monsoon season, the country frequently experiences landslides, debris flows, floods, and earthquakes. These phenomena not only cause loss of life and property, they also pose severe threats to physical infrastructure, and disrupt social and economic development.

Floods, landslides, and earthquakes of great magnitude are natural hazards, but their impacts are exacerbated by lack of preparedness and absence of measures for mitigating their impacts. Natural disasters are serious events, disrupting the functioning of a community and causing widespread hardship. They contribute significantly to the total annual loss of life and damage to property in Nepal. Geographically, the nature of damage caused by floods varies according to area. In the high mountains, heavy landslides and mudflows are the main cause of damage. Landslides often sweep away whole villages. The mudflows cover terraced land with boulders and debris damaging standing crops rendering the fields useless for agriculture until massive efforts are made to reclaim them.

In the foothills and floodplains of the river valleys, floods often deposit coarse sediment over the adjoining floodplain damaging standing crops and converting the land into an infertile land mass. River banks in such areas are subjected to severe bank erosion and loss of soil, which in turn provides more sediment for the river to deposit downstream.

Most river systems along the Nepal-India border have wide floodplains which are frequently inundated, damaging crops and nearby settlements. The problem of inundation in these areas is often aggravated by construction of roads, embankments, bridges, and barrages in India. On a temporal scale, damage caused by floods is confined mostly to the four monsoon months June to September, when more than 80% of the total annual precipitation occurs.

Damage to life, livelihoods, and infrastructure can be attributed to several factors: landslides, slope failures, and debris flow caused by dense precipitation are among them. The structural causes include inadequate design provisions and inadequate use of flood data in designing riverine infrastructure, poor protection measures, and inadequate maintenance of protection infrastructure and hydraulic structures; non-structural causes include unregulated economic activities in flood-prone areas, lack of flood-warning systems, and inadequate preparation in disaster management.

In Nepal, earthquakes are common because of the presence of major fault lines along the Himalayan mountain range, which are a result of the collision of the Indian tectonic plate with the Eurasian plate. However, unlike floods and landslides, severe earthquakes do not occur annually; still, when they do occur, they cause great losses to the community and to the nation.

Not all hazards turn into disasters. Risks, hazards, and preparedness are the key factors that determine whether or not a hazard becomes a disaster. If there is no risk to human life and property, even though the area is extremely hazardous, there will be no disaster; e.g., a large-scale landslide in an uninhabited area poses no risk to human life and property although the area may be extremely hazardous.

Floods and flash floods in Nepal

Floods are a common phenomenon every year in Nepal. There are more than 6,000 rivers and rivulets nationwide. Among these, snowfed rivers, such as the Koshi, Narayani, Karnali, and Mahakali, are perennial rivers. They originate from the Himalayas and, after descending from the hills, flow through the Terai plains. During the monsoon (June-September), these rivers swell and cause damage to the communities residing within their floodplains. In Nepal, flood preparedness activities generally begin with the advent of mid-monsoon rains. Preparedness for flooding along the Koshi River at Chakraghatti, 10 km downstream from the Chatra irrigation intake, is presented in Figure 1.

During the monsoon, rivers originating from the Mahabharat range; viz., the Kankai, Kamala, Bagmati, West Rapti, and Babai, also cause a great deal of damage in the communities residing within their floodplains in the Terai region.

Rivers originating from the Siwalik range have little water flow during the dry season, and some of them are almost dry. Notwithstanding, they are sometimes responsible for flash flooding during the wet season, causing extensive damage to the communities residing in the Terai plains.

Floods are caused by natural phenomena but may be increased by human intervention.

DWIDP

Figure 1: Preparing for flood mitigation along the Koshi River

Natural

- Intense rainfall
- Landslides and glacial lake outburst floods (GLOFs)
- Co-incidence of snow and glacial melt with monsoon precipitation
- Synchronisation of peak flow of rivers

Human intervention

- Land-use changes
- Drainage congestion caused by uncoordinated development activities
- Dam failure

These factors, individually or in combination, cause floods. The intensity or magnitude of flooding depends considerably on the location and pattern of occurrence and synchronisation of these factors.

Floods in Nepal can be classified broadly into the following two categories.

Riverine floods

Rainfall during the monsoon season is caused by the influence of both the south-east and south-west monsoon, characterised by dense rainfall during the four months from June to September, contributing about 80% of the annual rainfall. Widespread and intense monsoon rainfall causes floods and associated damage. Often anthropologic factors exacerbate an already occurring flood. These factors are associated most often with the promotion of hydraulic surcharge in water levels. They include the presence of natural or man-made obstructions in the flood path such as bridge piers, floating debris, weirs, barrages, and embankments restricting the flow path.

Riverine floods from the major rivers generally rise slowly in the southern Terai plains and the period of rise and fall may extend up to 12 to 24 hours or more. Inundation of large areas because of overflowing river banks causes extensive damage. The flood water erodes the banks, causing permanent damage to the adjacent agricultural land. Typical river bank erosion following the monsoon flooding along the West Rapti River is shown in Figure 2.

As long as the river water is contained within its regime and its banks, flooding is of normal proportions. Riverine floods combined with a sudden outburst of clouds, localised in nature, with incessant rain for days together, cause disastrous floods.

Highly localised rainfall of long duration in the monsoon season often generates water volumes in excess of local drainage capacity, causing localised flooding. The congestion of drainage by infrastructure such as roads, embankments, and bridges, often exacerbates the situation. This type of flood is common in the southern Terai belt, inner Terai, and in the valleys.

DWIDP

Figure 2: Typical bank erosion caused by riverine flooding along the West Rapti River, Dang

Flash floods

Flash floods are severe floods that occur with little or no warning. They are characterised by little time lapse between the start of the flood and peak discharge. Floods of this type are particularly dangerous because of the suddenness and speed with which they occur. They are triggered by extreme rainfall, glacial lake outbursts, or the failure of dams – whether man-made or caused by landslides, debris, ice, or snow. Flash floods can have devastating impact hundreds of kilometres downstream, yet the warning time available is counted in minutes or, at the most, hours. For instance, water flow in the rivers in the Siwalik range in southern Nepal are characterised by a sharp rise of flood water followed by a rapid recession, often causing high flow velocities. The ensuing floods damage crops, property, lives, and livelihoods.

Damming of a river by a landslide is a potentially dangerous situation. Such a blockage of the river flow is more common in narrow valleys where the slopes are steep on both sides of the river. Landslide dams will eventually collapse, causing heavy downstream flooding resulting in loss of life and property.

There have been several cases of landslide damming along the rivers of Nepal in the past. In 1985, such a landslide blocked the flow of the Trishuli River, creating a landslide dam. This dam eventually collapsed resulting in a flash flood that caused heavy damage to the Trishuli hydropower plant and settlements downstream. Fortunately, the formation and development of a landslide dam are relatively easy to monitor and therefore allow for better preparedness.

Glacial lakes are common in the high altitude areas of the country. These lakes often contain huge volumes of water. The lakes are dammed behind moraine ridges which may be more or less stable depending on the amount of ice within these ridges; and their unstable condition may lead to a breakage of the dam, creating a glacial lake outburst flood (GLOF) with the potential to cause great damage downstream.

The main characteristics of the GLOF phenomenon are given below (Xu et al. 2006).

- GLOFs are caused by the sudden bursting of glacial lakes that are either ice-dammed or moraine-dammed.
- Moraine-dammed lakes generally breach by overtopping or by piping whereas ice-dammed lakes drain underneath the ice.
- The flood surge can propagate hundreds of kilometres downstream from the glacial lake.
- Sediment loads during a GLOF are exceptionally high.

Altogether 2,315 glacial lakes have been identified in Nepal and, about 14 GLOFs are recorded to have occurred between 1935 and 1991 in Nepal. In total, 20 glacial lakes have been identified as being potentially dangerous at present.

Major floods in Nepal

The 1978 flood in the Tinao Basin, the 1980 flood along the Koshi River, the 1985 cloudburst and outburst of the debris dam in the Tadi River Basin, the 1987 flood in the Sunkoshi Basin resulting in the submergence of the central and eastern Terai by up to one metre, and the 1989 cloudburst affecting the Central region – some areas of Chitwan and the Western region – the inner Terai, and Butwal and the Parasi areas are among the major floods recorded in Nepal.

The devastating flood that occurred from July 18-20, 1993, in the Central Region surpassed all the floods mentioned above in terms of its ferocity and the damage it caused to the national economy. It caused heavy destruction of life and property, made thousands of people homeless, and destroyed standing crops spread over thousands of hectares of lands. Forty-four districts were affected.

Some 1,336 people lost their lives in that disaster. About half a million people from 73,000 households were affected. Several important bridges on the Prithvi and Tribhuvan highways (seven on the Prithvi Highway alone) were washed away by heavy flooding along many rivers, isolating Kathmandu Valley from the rest of the country. Another setback included the closing down of the Kulekhani 1 and 2 power stations because of damage to the penstock pipe. Bagmati, Manusmara, and Rapti irrigation projects and several farmer-managed irrigation projects were either damaged or washed away by the torrential rain. The total loss in terms of physical destruction was estimated to be Rs 5 billion (see Table 1).

In Nepal, flood disasters induced by glaciers have come into prominence with the GLOF that occurred following the collapse of the moraine dam on the Dig Tsho Lake at the head of the Dudh Koshi River on August 4, 1985. Such occurrences might have been taking place at different intervals in the past in many river basins with glaciers at their head waters within Nepal and beyond, but the flood that occurred on the Dudh Koshi River caused devastation unlike any encountered before. It completely swept away the almost completed Namche hydropower plant leaving no trace of it, damaging roads, bridges, cultivated land, and houses as it surged forward along a destructive course.

A similar event occurred in 1981 on the Bhote Koshi River (Poiqu River in Tibet) with the outburst of the Zhangzangbo glacial lake located in Tibet. Downstream in Nepal, the ensuing flood discharge of 16,000 m^3/sec (Daoming 1988) destroyed the Friendship Bridge bordering Nepal and the Tibet Autonomous Region of China; and it damaged a large stretch of the Arniko highway, the Bhote Koshi hydropower plant, and a large area of cultivated land in Nepal. These events signalled the impending dangers of GLOFs to the Nepalese government and highlighted the importance of transboundary dialogue for mitigating GLOF events. Tsho Rolpa glacial lake (Figure 3) was on the point of bursting in 1997. However, with the completion of the 'Tsho Rolpa GLOF Risk Reduction Project' in 2000, the lake was contained.

Table 1: **Details of Loss and Damage from Floods, Landslides, Avalanches, Earthquakes, and Other Disasters (1983-2004)**

Year/Types	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	
Floods & Landslides	293	263	420	315	391	328	680	307	93	71	1336	
Fire	69	57	52	96	62	23	109	46	90	97	43	
Epidemics	217	521	915	1101	426	427	879	503	725	1128	100	
Windstorms, Hailstorms & Thunder bolts	0	0	0	0	2	0	28	57	63	20	45	
Earthquakes	0	0	0	0	0	721	0	0	0	2	0	
Avalanches	0	0	0	0	0	14	20	0	0	0	0	
Stampedes	0	0	0	0	0	71	0	0	0	0	0	
Total	**579**	**941**	**1387**	**1512**	**881**	**1584**	**1716**	**913**	**971**	**1318**	**1524**	
Estimated Loss million Rs	240	49	23	23	2005	6099	4172	139	43	52	5189	
Year/Types	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Total 1983 to 2004**
Floods & Landslides	49	203	258	78	276	209	173	196	441	232	131	6843
Fire	43	73	61	45	54	46	53	26	14	16	10	1185
Epidemics	626	520	494	947	840	1207	141	154	0	0	41	11912
Windstorms, Hailstorms & Thunder bolts	47	34	75	44	23	22	26	41	6	62	10	605
Earthquakes	0	0	3	0	0	0	0	1	0	0	0	727
Avalanches	0	43	4	9	0	5	0	0	0	0	0	95
Stampedes	0	0	0	0	0	0	0	0	0	0	0	71
Total	**765**	**873**	**895**	**1123**	**1193**	**1489**	**393**	**418**	**461**	**310**	**192**	**21438**
Estimated Loss million Rs	184	1933	1579	410	1230	509	1141.5	526.55	525.56	989.93	341.09	27403.63

Sources: 1. Ministry of Home Affairs 2. Department of Water Induced Disaster Prevention

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Figure 3: Tsho Rolpa glacial lake 'sans danger'

Landslides in Nepal

Landslides are very common in the hills and are one of the main natural hazards; they occur mostly during monsoon season. Heavy rainfall in the hills saturates the soil and erodes shear strength, triggering a landslide. Infrastructure such as roads and irrigation canals, built without proper protection measures can trigger landslides in the hills. Landslides cause loss of human life and damage to property. They cause damage to infrastructure and agricultural lands and constant fear and trauma to the people living in and around the area. Several landslides occur every year in Nepal; many go unnoticed, and only those causing loss of human life and damage to property come to public attention. The categorisation of a landslide as simple or disastrous depends upon the extent of damage it causes to the community.

The Department of Mines and Geology (DMG) carried out landslide mapping for some years in the 1980s, and the results are available as unpublished technical reports in the form of raw data. At present, modern tools for landslide hazard mapping and landslide hazard assessment are available, and they should be applied according to the needs of the structures proposed.

In the Himalayan region, damage caused by landslides is estimated to cost more than US $ 1 billion in economic losses and landslides cause more than 200 deaths every year, which accounts for about 30 per cent of the total losses from landslides worldwide (Li 1990).

Tsho Rolpa glacial lake: successful prevention of an impending natural disaster

Tsho Rolpa glacial lake was much in the news during the mid-1990s with the imminence of glacial lake outburst flood (GLOF). This is how a timely measure saved the day: a success story follows (DHM 2001).

There are many glaciers along the stretch of the Himalayan range and many of these glaciers have glacial lakes. Tsho Rolpa glacial lake, at an altitude of 4,580 masl, is the largest glacial lake in Nepal. It is located 110 km north-east of Kathmandu in the Rolwaling Valley.

The 3.3 km long Tsho Rolpa glacial lake with a maximum depth of 132m is dammed by a 150m high, unconsolidated moraine formation. It is swelling yearly with the melting of the Trakarding glacier. Its estimated volume was put at 90 to 100 million cubic metres of water in 1999. Several past studies of the Water and Energy Commission Secretariat (WECS) and Department of Hydrology and Meteorology (DHM) on Tsho Rolpa had stressed the possibility of a glacial lake outburst flood (GLOF) because of the huge volume of water stored in the lake and water seepage through the dam and the small outlet and freeboard of the dam. The lake would already have reached the critical breaching stage had no immediate measures been taken to lower the lake level. If the moraine dam had collapsed, some 30-35 million cubic metres of water would have been released and the resulting flood would have caused serious damage up to a distance of 100 km downstream, threatening human life, villages, farmland, bridges, foot-trails, roads, and the 60 MW Khimti hydropower plant and other infrastructure.

With the objective of lowering the lake level to reduce the risk of a GLOF, the Nepal-Netherlands' Association installed one trial siphon with the use of a pipe at the Tsho Rolpa Glacial Lake in 1995. Five additional siphons were installed in 1997 using government resources. Although the siphons worked during normal periods, they required heavy maintenance and additional siphon pipes at other times to keep the water at safe levels.

Sensing the imminent danger, the government, with a World Bank loan, established an early warning system (EWS) in 17 villages along the Rolwaling Khola and Bhote/Tama Koshi downstream from Tsho Rolpa to warn people in case of a possible GLOF from Tsho Rolpa Lake.

During the 1997 field investigation, DHM found that a GLOF from Tsho Rolpa was imminent if necessary timely measures were not taken. A project formulation team visiting the site recommended lowering the level of the lake by three metres by cutting out an outlet in the terminal moraine to reduce the risk of a GLOF.

The Netherlands government agreed to fund the Tsho Rolpa GLOF Risk Reduction Project through a grant agreement between the governments of Nepal and the Netherlands in August 1998. The project constructed an open channel to lower the lake by at least three metres. The project was implemented by DHM staff and was realised on June 24, 2000, with the achievement of a three-metre drawdown on the lake level. This is a success story about how measures taken in time prevented a catastrophe from happening. DHM should continue to constantly monitor the Tsho Rolpa glacial lake now and in future and carry out necessary measures to prevent the lake from bursting out when it poses a danger.

The Department of Water Induced Disaster Prevention (DWIDP) has constructed check dams and landslide protection works for specific sites in the country to control debris flow and landslides. The check dams and landslide protection works built by the DWIDP in the Mugling-Narayanghat section and at Jhyalbas along the Giruwari River are shown in Figures 4 and 5. These were implemented by the DWIDP under the Water Induced Disaster Prevention Project (WIDPP) financed by JICA and hailed as very successful by the community. Several such projects have been completed at the special request of communities and with their full participation.

Landslides can be induced by either natural or human factors, or both. Some natural factors that contribute to landslides are high relief or steep slopes, unstable geology, and concentrated rainfall. Human factors can be deforestation, improper land use and construction, and agricultural activities on hill slopes. Additional factors causing landslides are removal of lateral support, surcharge loads, transitory stress caused by earthquakes or blasting, and factors causing low shear strength such as weak soil, high pore-water pressure, and so on. Earthquakes and heavy rainfall are the landslide triggers in most cases.

Landslides often give rise to debris flows. A debris flow has enormous energy which causes widespread damage to physical structures like bridges and hydroelectric power stations on its way downstream. The aggraded river bed caused by the continuing debris flow at the Lothar River crossing is shown in Figure 6.

DWIDP

Figure 4: Check dams built by the DWIDP in the Mugling-Narayan Ghat section to prevent debris flow

DWIDP

Figure 5: Landslide protection work undertaken by the DWIDP at Jhyalbas along the Giruwari River

DWIDP

Figure 6: Aggraded river bed caused by debris flow at the Lothar River bridge site

Major landslides

On August 1, 1968, a huge landslide dammed the Budhi Gandaki River at Labu Besi in central Nepal for 29 hours and created a 60-metre deep lake. When it breached, the debris flow and flood washed away most of the houses and bridges downstream. Arughat Bazaar was the most affected with heavy loss of life and property (Sharma 1990).

A huge landslide at Darbang dammed the Myagdi Khola for some time on September 20, 1988, and the subsequent flood after breaching claimed many lives and caused extensive damage to property. A similar landslide at the same site had buried Darbang Bazaar some 62 years before, killing about 500 people (Yagi et al. 1990).

Earthquakes in Nepal

Nepal is vulnerable to earthquakes because of its location in a tectonically active zone. The presence of three main fault lines: the Main Central Thrust (MCT) at the foot of the Greater Himalaya joining the midland mountains, the Main Boundary Fault (MBF) at the junction of the Lesser Himalaya, and the Siwaliks and the Himalayan Frontal Fault south of the Siwaliks, each running east to west, are the main causes of earthquakes of small and great magnitude in Nepal. These fault lines are a result of the movement of the Indian plate under the Eurasian plate.

The Department of Mines and Geology (DMG) records micro-seismic events through its two independent recording centres: the National Seismological Centre (NSC), Kathmandu, and the Regional Seismological Centre (RSC), Birendranagar. The NSC in Kathmandu records data from twelve stations installed between Pyuthan in the west to Taplejung in the east. The Regional Seismological Centre in Birendranagar in Surkhet district records tectonic events through eight telemetric stations in the far-western and mid-western regions. The National Seismological Centre (NSC) in Kathmandu is the data processing and interpretation centre. The recorded seismic data are processed and presented in the form of regular bulletins, and these are also used by the International Seismological Centre. The vibrations of the earth are continuously recorded by seismometers and transmitted to receiving or relay stations. The network has the capacity to record any seismic event of a magnitude as low as two on the Richter scale in any part of the country.

Earthquakes of major consequence were reported in 1255 AD, 1810 AD, 1866 AD, 1934 AD, 1980 AD, and 1988 AD in Nepal. The earthquake in 1934, which also hit Kathmandu Valley, was in the order of 8.4 on the Richter scale. It did great damage to Kathmandu Valley with the loss of more than 8,500 lives and partial collapse or complete destruction of 38,000 buildings. The devastation caused to the Durbar Square in Bhaktapur by the 1934 earthquake is shown in Figure 7.

Department of Mines and Geology

Figure 7: Bhaktapur Durbar Square before and after the 1934 earthquake

The earthquake in 1980 measured 6.5 on the Richter scale and its epicentre was in Bajhang in far-western Nepal. It claimed 178 lives and about 40,000 houses were damaged. Similarly, the earthquake in 1988 measured 6.6 on the Richter scale and its epicentre was in Udaypur district in eastern Nepal. It caused a loss of 721 lives and damage to infrastructure. The recurrence interval for large earthquakes in Nepal is reported to be 75 years. There is now great concern in the Kathmandu Valley about the possibility of another earthquake of greater magnitude. Should it happen, there will most likely be colossal losses in terms of human lives and physical infrastructure because of the densely populated area and unsafe residential buildings constructed without taking seismic concerns into consideration (NSET 1999).

Despite the availability of knowledge about historical earthquakes and the continued geological research in the Nepal Himalayas (Bilham et al. 1994; Thapa 1988), public awareness of earthquake hazards and risks were minimal until some years back, and implementation of earthquake risk management efforts were almost non-existent. The earthquake in 1988 in Udaypur district brought about a great deal of consciousness in both government and non-government circles regarding earthquake preparedness and mitigation measures. As a result, many action plans and programmes have been introduced and implemented over the last one and a half decades.

The need for an organised approach to mitigating the effects of a future earthquake in the Kathmandu Valley was advocated by many organisations (Dixit 1991; Dixit 2005). Several initiatives were conceptualised and implemented. The following are major achievements since the 1988 earthquake event:

- Implementation of the 'Earthquake Affected Areas (Udaypur and Dharan areas) Rehabilitation and Reconstruction Project 1989-1994'
- Implementation of the 'National Building Code Development Project (1992-1994)' and the enforcement of a building code subsequent to its approval by the government on July 28, 2003
- Development of a broad-based 'National Action Plan for Disaster Management in Nepal' for the first time in 1996 by the Ministry of Home Affairs (MoHA)
- Implementation of the 'Kathmandu Valley Earthquake Risk Management Project (KVERMP)' 1997-2001

- The 'Study of Earthquake Disaster Mitigation in the Kathmandu Valley (SEDM)', 2001-2002
- Implementation of the 'Municipal Earthquake Risk Management Project (MERMP)', 2003
- Implementation of the 'Kathmandu Valley Earthquake Risk Management Action Plan Implementation Project (APIP)', 2000-2005

Kathmandu Valley Earthquake Risk Management Project (KVERMP) was implemented from 1997-2000 by the National Society for Earthquake Technology (NSET) in association with Geo Hazards International (GHI), USA. They carried out a loss estimation study for a possible repeat of the 1934 earthquake in modern-day Kathmandu Valley using earthquake loss models such as the Applied Technology Council's loss estimation model, ATC-13. The study covered the likely loss of human lives and the damage to existing infrastructure. A scenario document, entitled 'Kathmandu Valley's Earthquake Scenario', explaining the results of the loss estimation, was published in 1999 for the general public in both English and Nepali. The study estimated a minimum of 22,000 and maximum of 40,000 human deaths. NSET and Geo Hazards International, USA, also produced 'The Kathmandu Valley Earthquake Risk Management Action Plan' for managing earthquake risks in the Kathmandu Valley (Annex 2).

A detailed study on earthquake disaster mitigation (SEDM) in the Kathmandu Valley was carried out by Japan International Cooperation Agency (JICA) in collaboration with the Ministry of Home Affairs and several other Nepalese institutions. It provided a detailed assessment of seismic vulnerability and damage analysis for existing buildings and public facilities; and it also gave an account of lifeline networks, including human casualty figures, for different earthquake scenarios in 2001-2002.

Apart from the above, NSET-Nepal has carried out various projects and programmes on earthquake preparedness supported by internal and external agencies (Annex 3).

Major earthquakes

The great earthquake of June 7, 1255, damaged palaces, temples, and houses in the Kathmandu Valley and killed one-third of its population. The reigning monarch, Abhaya Malla, died six days after the earthquake as a result of injuries sustained during the event (Regmi 1965, cited in Bilham 1994).

The earthquake of August 26, 1833, destroyed 4,040 buildings, killed 414 persons, and injured many in the vicinity of Kathmandu where there were hundreds of additional fatalities: it also destroyed houses in the eastern villages. The fort at Chisapani in the Mahabharat range south of Kathmandu was damaged and landslides blocked the passes to Tibet. The Kamala River was dammed by a landslide which burst out four days after the event flooding the village of Baldeah, north of Darbhanga in the Terai (Bengal Hurkaru, 16 Sept., 1833 cited in Bilham 1994).