Chapter 2

Natural Hazards in India

The Himalayas are the world's youngest fold mountains, are tectonically active, and sustain the largest global, non-polar glacial deposits. The Indo-Ganga-Brahmaputra basin, stretching parallel to the Himalayan arc, carries water and silt from wide catchments through the longest alluvial plain in the world. About 58% of the Indian landmass is prone to earthquakes and landslides of different magnitudes and about 12% of its geographical area (about 40 million hectares) is subject to riverine and flash floods of which about eight million hectares are susceptible to annual flooding. Thirty-five major urban centres with populations of more than half a million each are located in high risk, seismic zones where earthquakes of magnitude of six or above on the Richter scale are distinct possibilities. Parts of the northeast receive the highest rainfall in the world whereas parts of the northwest have the scantiest, just as some areas of the trans-Himalayas are among the coldest inhabited areas and part of the Thar Desert is among the warmest. This wide variation in rainfall and climate make many regions of India susceptible to hazards such as droughts, floods, hailstorms, cloudbursts, avalanches, and heat and cold waves that claim lives, livelihood, and property (Dhar Chakrabarti 2006).

States along the Bay of Bengal and the Arabian Sea are affected by about 80 per cent of all cyclones (and accompanying floods and storm surges) generated in the region. Despite many irrigation projects, 68 per cent of the arable land is drought-prone, half of it critically so with annual precipitations of less than 750 mm and consequently immense social (primarily health) and financial implications because of its impacts on agriculture and food production, diminishing access to safe water supplies, and negation of development achievements.

In addition to highly visible disasters are the 'normal disasters such as road accidents, infant and maternal mortality, water and air pollution, overexploitation of groundwater and arsenic poisoning , and the disaster of poverty that leads to malnutrition; none of these causing huge losses of life or considerable stress to the administrative and socioeconomic coping mechanisms, but which, nevertheless, as with natural disasters, affect the poor and marginalised severely and disproportionately. As disasters force the poor on to marginal lands and into increased penury, a vicious cycle ensues that requires an institutional mechanism to respond to not only one calamity, but a cumulative product of past circumstances and events as well. Attempts at hazard zoning have been made as a response to the increase in disasters in recent years.

The ferocity and impact of natural disasters in recent years has exceeded even the worst history. Disasters occurred in areas that had not been previously seen to be vulnerable to that particular disaster, or struck a traditionally vulnerable area with more intensity. In 2001 as a whole, India suffered 73.1% of all disaster-related deaths in Asia (IFRC 2002). Because of its sub-continental proportions and multiplicity of hazards faced, while one part of the country faces droughts, concomitantly another can be suffering from floods. Hence, vulnerability is of great concern. Some disaster events, for example, occur regularly: floods in the Ganga-Brahmaputra river systems occur every year, resulting in immense economic losses. There is an immediate need to put in place a mitigation or risk reduction system evolved from traditional coping mechanisms. Repetitive disasters should be considered within development planning itself, and their preparedness and mitigation implications should be taken into account in policy design.

Repeated disasters lead to substantial losses of hard-earned development gains as well as diverting development funds towards disaster relief. According to World Bank estimates, direct losses of public and private infrastructure in India have amounted to approximately $30 billion over the past 35 years (World Bank 2003). Since less than 25% of the events registered actually provide loss estimates, the official figures probably understate their true economic impact. According to the same study, 2.25% of the GDP and 12.15% of the national revenue were lost because of natural disasters from 1996-2001. This has serious implications for overall macroeconomic management and development planning. Table 1 gives an idea of the cost of disasters from 1996 to 2001.

Table 1: Disaster history by major hazards in India, 1996-2001

Hazard	No of events reported	No of deaths reported ('000)	People affected ('000)	Losses reported ($ million)	No of reports of loss submitted	% reported	Average loss per report ($ million)
Windstorms	15	14.6	25,213.7	5,619	15	100	374.6
Floods	29	8.9	150,980.3	2,928	18	62	162.7
Earthquakes	3	20.1	16,367.0	4,707	6	200	784.5
Drought	4	-	90,000.0	588	-	-	-
Other	24	5.9	356.9	-	3	13	-
Total	**75**		**282,917.9**	**13,842**	**-**	**56**	**329.6**

Source: World Bank (2003)

Floods

Flood disasters affect the largest number of people globally, accounting for 63% of the total number affected by disasters from 1992-2001. In the decade from 1992-2001, hydrometeorological disasters accounted for 64% of the decade's estimated damage from reported disasters (IFRC 2002). In India, between 1996-2001, floods accounted for 38.7% of all disaster events and 53.4% of the people were affected by floods.

The Indian weather is greatly influenced by the monsoon system. The country receives three quarters of its annual precipitation during the summer monsoon months between June to September. In terms of spatial variations, the areas carrying heavy riverine discharge are those that receive heavy precipitation during monsoons, thereby compounding the problem. The entire Indo-Gangetic plain and the northeastern states receive an annual precipitation of over 1,000 mm; in the lower Gangetic Plains, it is between 1,500-2,500 mm, while in upper Assam the annual average precipitation is over 2,500 mm. The Lower Gangetic Plain and Assam Valley are therefore heavy rainfall areas and most flood-prone.

The southwest monsoon during the months from June to October brings the maximum rainfall. Consequently the rivers are in spate and carry heavy discharge during this period, often resulting in floods, especially in the lower reaches. Flooding is aggravated by sediment deposition in the river channels, drainage congestion, and synchronisation of river floods with ocean tides along the coastal plains.

On average, the nation loses about Rs 100 million due to floods annually: the amount spent on relief and reconstruction results in a phenomenal loss of resources every year. Table 2 lists the principal flood-prone states,the damage figures from 1953 to 2004 are given in Table 3 and Box 1 gives a summary of flood facts for India.

Table 2: Principal flood-prone states in India

State	Flood-prone area as % of total area of the state	Flood-prone area of the state as % of the total flood-prone area of the country
Uttar Pradesh	32.61	19.4
Bihar	55.22	13.0
Assam	50.14	9.8
West Bengal	37.42	8.1
Orissa	10.34	4.0
Other States	6.92	45.7
Total	**12.17**	**100.0**

Table 3: Flood damage in India, 1953-2004		
Sector	**Annual average**	**Maximum (year)**
Area affected (million ha)	7.63	17.50 (1978)
Crop area affected (million ha)	3.56	10.15 (1988)
Population affected (million)	32.92	70.45 (1978)
Human lives lost (No.)	1,590	11,316 (1977)
Cattle lost (No.)	94,485	618,248 (1979)
Houses damaged (No.)	1,234,616	3,507,542 (1978)
Total damage (Rs million)	**18,052 (400 million US$)**	**88,645 (2000)**
Source: Central Water Commission		

Box 1: Flood facts – India

- According to EM-DAT (International Disaster database, OFDA/CRED) for 2004, India ranked fourth among the top 10, considering the number of casualties.
- In 2005, it ranked second among the top ten in the incidence of natural hazards.
- In the top 10 by number of affected, India ranks third after China and Bangladesh.
- Scrutiny of all natural disasters in India from 1900 – 2005 revealed the country suffered 160 floods, 21 droughts, and 24 earthquakes. The 160 floods killed 50, 964, left 9,034,230 homeless, and 675,252,850 affected.
- In 2004, the number of human lives lost due to floods was 1,275, in 1998 floods killed 2,889 people.
- The infrastructure loss in 2004 was estimated at Rs 1,896 crore while the area affected was 8,031 million hectares.

Source: Times of India, Mumbai, July 24, 2005

Flash floods in India

Flash floods are common in arid and semi-arid areas where rainfall occurs in short, intense storms. Mountain areas prone to thunderstorms, coupled with steep terrain and thin soils, result in high runoff within a short period of time and are very prone to flash floods. Increasing population, changing lifestyles, and rapid urbanisation in mountain areas mean human settlement and intervention in more hazardous areas. Along with flash floods, related hazards, including landslides and debris flows, are becoming more frequent and severe (Gruntfest and Hammer 2001). Table 4 lists the major flood disasters from 1953 to 2002.

Table 4: List of major flood disasters in India, 1953-2002					
Year	Population affected (million)	Area affected (million ha)	Crop area damaged (million ha)	Human lives lost (No)	Cost of total damage (Rs million)
1953	24.28	2.29	0.93	37	524
1954	12.92	7.49	2.61	279	573
1955	25.27	9.44	5.31	865	1027
1956	14.57	9.24	1.11	462	535
1957	6.76	4.86	0.45	352	234
1958	10.98	6.26	1.40	389	440
1959	14.52	5.77	1.54	619	862
1960	8.35	7.53	2.27	510	632
1961	9.26	6.56	1.97	1374	313
1962	15.46	6.12	3.39	348	950
1963	10.93	3.49	2.05	432	366
1964	13.78	4.90	2.49	690	666
1965	3.61	1.46	0.27	79	72
1966	14.4	4.74	2.16	180	884
1967	20.46	7.12	3.27	355	1555
1968	21.17	7.15	2.62	3497	2111
1969	33.22	6.20	2.91	1408	4044
1970	31.83	8.46	4.91	1076	2878
1971	59.74	13.25	6.24	994	6324
1972	26.69	4.10	2.45	544	1583
1973	64.08	11.79	3.73	1349	5690
1974	29.45	6.70	3.33	387	5689
1975	31.36	6.10	3.85	686	4717
1976	50.46	11.91	6.04	1373	8887
1977	49.43	11.46	6.84	11316	12019
1978	70.45	17.50	9.96	3396	14548
1979	19.52	3.99	2.17	3637	6142
1980	54.12	11.46	5.55	1913	8402
1981	32.49	6.12	3.27	1376	11965
1982	56.01	8.87	5.00	1573	16449
1983	61.03	9.02	3.29	2378	24916
1984	54.55	10.71	5.19	1661	19056
1985	59.59	8.38	4.65	1804	40593
1986	55.50	8.81	4.58	1200	37485
1987	48.34	8.89	4.94	1835	25697
1988	59.55	16.29	10.15	4252	46303
1989	34.15	8.06	3.01	1718	24053
1990	40.26	9.30	3.18	1855	13646
1991	33.89	6.36	2.69	1187	14883
1992	19.26	2.65	1.75	1533	33446
1993	30.41	11.44	3.21	2864	32824
1994	27.55	4.81	3.96	2078	17946
1995	35.93	5.25	3.25	1814	37023
1996	44.73	8.05	3.83	1803	21625
1997	29.67	4.57	2.26	1402	28311
1998	68.72	9.13	5.87	2758	58459
1999	25.66	3.98	1.76	576	21064
2000	40.07	4.94	2.88	2345	16602
2001	22.44	3.01	1.91	811	26247
2002	22.41	2.87	1.27	640	14888
Avg	**32.98**	**7.38**	**3.47**	**1560**	**13523**
Source: Prasad 2005					

Landslides

Landslides are a major hydro-geological hazard with regular occurrence in almost all hill regions such as the Himalayas, north-eastern hill ranges, Western Ghats, Nilgiris in the south, Eastern Ghats, and the Vindhyas in central parts. Heavy and prolonged rainfall due to tropical disturbances or convective storms is a common trigger for landslides. Little or no advance warning often hinders timely action. Table 5 gives information about the major landslide occurrences, their locations, dates, and impacts.

Table 5: Major landslides

Event	Location	Dates & time	Impact
Amboori Landslide	08°30'33"N and 77°11'15"E	20:30 and 20:45 hrs on 9 November 2001	38 lives lost, houses buried.
Malpa Rock Avalanche	30°01'55"N, 80°45'07"E Malpa Village in Kumaun Himalayas, on the right bank of the Kali River	00:25 hrs on 18 August 1998	210 killed including 60 pilgrims to Mt Kailash. Sudden detachment of rock mass with velocity as high as 30m/s. Village entirely destroyed by debris as high as 15m in some locations.
Marappalam Landslide	11°20'00"N and 78°49'00"E State Highway No 8, Mettupalayam-Ooty stretch	1200 and 1300 hours 11 Nov 1993	11 people killed, highway destroyed, railroad damaged, buried two buses with passengers, damaged buildings.
Nashri Landslide	33°06'15" N and 75°15'47"E, National Highway IA, from Jammu to Srinagar	First occurred in 1913, 20 times in 85 years	Blockage and disruption of national highway, primary connection to Srinagar.
Kaliasur Landslide	30°14'30" N, 78°55'50" E on the Hardwar-Badrinath Road	Repetitive occurrence 1920, 1952, 1963, 1964, 1965, 1969, 1970, 1971, 1972, 1985.	19 September 1969 most devastating slide- 300 m stretch of road dislocated vertically and laterally, severe damage to road structure.
Khuni Nallah Blockslide cum Rockfall	35°17'35" N and 75°07'48", National Highway IA, from Jammu to Srinagar between Ramban and Banihal	Almost annual feature	Steep gradient induces slides and rockfalls leading to destruction of vital bridges, communication network, and so on.
Snowdon Landslide	31°06'00" N and 77°12'00"E in Shimla, Himachal Pradesh	February 1971	Destruction of a six-storey medical college under construction
Great Alaknanda Tragedy	30°N to 30°47'00"N and 79°E to 79°47'00"E Along River Alaknanda and tributaries including Patalganga	1800 hrs on 20 July 1970	381 lives lost. Intense rainfall and cloudburst upstream resulted in breaching of the landslide dam and devastation downstream. Breaching of Rishiganga landslide dam, spate of landslides, damaged bridges, reactivation of old landslides, road subsidence, severe toe erosion, 9.1 million cu.m of silt and rock brought into Alaknanda.
Gangtok Siliguri Road	27°16'44"N and 88°35'30"E, National Highway 31A to Gangtok.	Several times since 1959. 1966 and 1972 were major occurrences	Floods of 1959 aggravated the slide. Massive road damage in July 1966 with destruction of protective measures. Intense rainfall and seismicity triggering factors
Sher-ka-Danda Landslide	29°24'00" N and 79°30'00"E at Nainital, Uttarakhand.	1867 and 1880	Permanently filled a portion of Naini Lake.
Source: BMTPC and CDMM 2003			

Earthquakes

Earthquakes strike without warning and cause widespread damage to various structures and systems. These can neither be predicted nor prevented in terms of their magnitude, place, and time of occurrence. Globally, between 1950- 1999, earthquakes constituted 29% of great natural catastrophes, with 47% of the fatalities, 35% of economic losses and 18% of insured losses (Munich Re Group 2002). The Himalayas are the most active seismic zone in the Indian subcontinent and have suffered over 650 recorded earthquakes of a magnitude of 5 and above in two centuries. Table 6 gives an account of earthquakes in the region from 1897 to 1993.

Table 6: Region-wise earthquake occurrence, 1897-1993

Seismic region	States	No of earthquakes of magnitude				Return period
		5.0-5.9	6.0– 6.9	7.0–7.9	8.0 +	
Kashmir & W Himalayas	J&K, HP, sub-mountainous Punjab	25	7	2	1	2.5-3 years
Central Himalayas	Uttaranchal, UP	68	28	4	1	1 year
North-east India	All NE states	200	128	15	4	< 4 months
Indo-Gangetic basin & Rajasthan	Rajasthan, Plains of Punjab, Haryana, UP and West Bengal	14	6	-	-	5 years
Cambay & Rann of Kutch	Gujarat	4	4	1	1	20 years
Peninsular India	Southern states including Lakshdweep	31	10	-	-	2.5 - 3 years
Andaman & Nicobar Is	A&N islands	80	68	1	1	<8 months
Source: NCDM 2001						

Based on the probable intensities and return periods, a seismic map of the country has been standardised in which the regions have been integrated into four seismic zones of various intensities. Zone 5 has been historically vulnerable to severe seismic activity of MSK IX and above. The high damage risk zone includes large areas of the Himalayan arc and its foothill regions. The state-wise zones are given in Table 7 and major earthquakes in Table 8.

Disasters like floods, landslides, and earthquakes are regular features, causing huge losses of life, property, and livelihoods. It is estimated that disasters result in annual average losses amounting to about 2.25% of the GDP (World Bank 2003). Preparedness measures involving all stakeholders are essential and must be integrated into national and subnational plans and implemented by raising public awareness.

Table 7: Classification of states according to seismic zones				
Seismic zone	Risk zone	Intensity		States
		MSK	Richter	
V	Very High Damage Risk Zone	IX	8+	Entire North East and parts of J&K, Himachal, Uttaranchal, Gujarat, Bihar and Andaman & Nicobar
IV	High Damage Risk Zone	VIII	7 – 7.9	Parts of J&K, HP, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Gujarat and Maharastra
III	Moderate Damage Risk Zone	VII	5 – 6.9	Parts of Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa, Madhya Pradesh, Chaaatisgarh, Rajasthan, Gujarat and Maharastra, Andhra, Tamil Nadu, Karnataka, Kerala and Lakshdweep
II	Low Damage Risk Zone	VI	- 4.9	Parts of Rajasthan, MP, Chaaatisgarh, Jharkhand, Orissa, Maharastra, AP, TN, Karnataka and Kerala

Table 8: Major earthquakes in India		
Year	Location	Magnitude (Richter)
1803	Kumaon Region	7.7
1819	Kutch	8.0
1869	Cachar, Assam	7.5
1885	Sopore, J&K	7.0
1897	Shillong	8.7
1905	Kangra, Himachal Pradesh	8.0
1906	Himachal Pradesh	7.0
1918	Assam	7.6
1930	Dhubri, Assam	7.1
1934	Bihar-Nepal	8.3
1947	Dibrugarh, Assam	7.8
1950	Arunachal Pradesh-China border	8.5
1952	Pondgo & Tango, North East India	7.5
1956	Anjar, Gujarat	7.0
1963	Badagaum (Koyna)	5.3
1966	Nepal-India Border	6.1
1967	Koyna	6.5
1988	Manipur-Burma	6.6
1988	Bihar – Nepal border	6.4
1991	Uttarkashi, Uttar Pradesh	6.6
1993	Latur, Maharashtra	6.3
1997	Jabalpur, Madhya Pradesh	6.0
1999	Chamoli, Uttar Pradesh	6.8
2001	Bhuj, Gujarat	6.9
2005	Jammu & Kashmir	7.6
Source: NCDM 2001; Singh et al. 2000		