2. NATURAL HAZARD OCCURENCES IN INDIA

2.1 Earthquake Occurrences

India has a large part of its land area liable to wide range of probable maximum seismic intensities where shallow earthquakes of magnitudes of 5.0 or more on Richter scale, have been known to occur in the historical past or recorded in the last about 100 years. IMD has prepared a catalogue of all such known earthquakes which is continually updated. The largest earthquake magnitude in India has been 8.7 which had its origin in the Shillong Plateau in 1897. This and the 1950 quake of M = 8.6 in Sadiya region have been so intense that the rivers changed their courses, ground elevations got changed permanently and stones were thrown upward. A list of better known damaging earthquakes in India is given in *Table-1*.

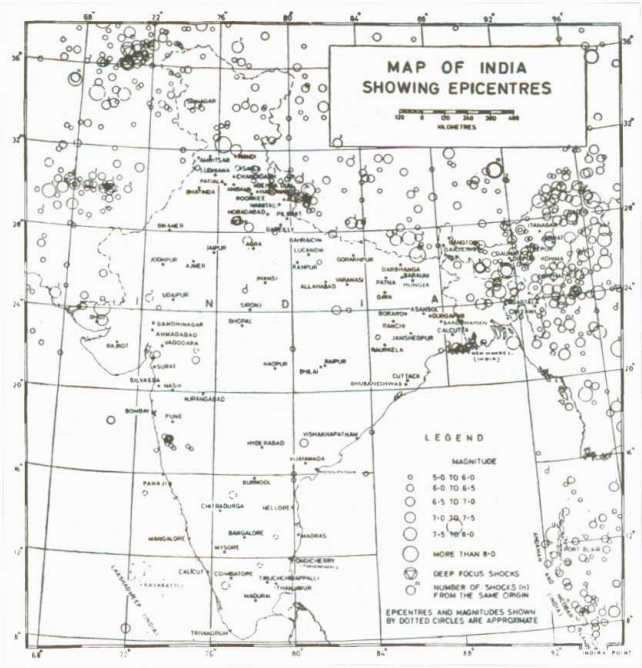

Fig.2: Epicentral Map - India
Source: Report (Part-I) of Expert Group set up by Ministry of Urban Development, 1998

Table 1: Some better known damaging earthquakes in India
Source: Report (Part-I) of Expert Group set up by Ministry of Urban Development, 1998

Year	Area	Date	(I.S.T) Time hr:m:s	Latitude degrees North	Longitude degrees East	Magnitude M	Max. MM Int.	Deaths
1819	Gujarat (Kutch)	Jan.16	Mid Night	-	-	8.0	XI	Many Thousand
1833	Bihar	Aug.26	-	27.5	86.5	7.7	XI	Hundreds
1897	Assam (Shillong)	Jun.12	16:36:-	25.9	91.0	8.7	XII	1600
1900	Kerala (Palghat)	Feb 8	-	10.7	76.7	6.0	-	
1905	Himachal Pradesh (Kangra)	Apr 4	06:20:-	32.5	76.5	8.0	XI	20000
1930	Assam (Dhubri)	Jul 3	02:33:34	25.8	90.2	7.1	IX	Many*
1934	Bihar -Nepal	Jan 15	14:13:26	26.6	86.8	8.3	XI	14000
1941	Andamans	Jun 26	-	12.4	92.5	8.0	X	Many
1943	Assam (NE)	Oct 23	22:53:17	26.8	94.0	7.2	X	
1950	Assam (NE)	Aug 15	19:39:28	28.7	96.6	8.6	XII	1500
1956	Gujarat (Anjar)	Jul 21	21:02:36	23.3	70.0	7.0	VIII	Hundreds
1956	Uttar Pradesh (Bullandshahar)	Oct 10	-	28.1	77.7	6.7	VIII	Many
1958	Uttar Pradesh (Kapkote)	Dec 28	-	30.0	80.0	6.3	VIII	Many
1960	Delhi	Aug 27	21:28:59	28.3	77.4	6.0	VII	
1963	Kashmir (Badgam)	Sep 2	07:04:32	33.9	74.7	5.5	VII	Hundreds
1966	Western Nepal	Jun 27	-	29.5	81.0	6.3	VIII	
1966	Uttar Pradesh (Moradabad)	Aug 15	-	28.0	79.0	5.3	VII	
1967	Nicobar	Jul 2	-	9.0	93.4	6.2	-	
1967	Maharashtra (Koyna)	Dec 11	04:21:19	17.4	73.7	6.5	VIII	200
1970	Andhra Pradesh (Bhadrachalam)	Apr 13	-	17.6	80.6	6.5	VII	
1970	Gujarat (Broach)	Mar 23	07:23:03	21.7	72.9	5.7	VII	
1975	Himachal Pradesh	Jan 19	-	32.5	78.4	6.5	VIII	
1988	Bihar - Nepal	Aug 21	04:39:10	26.76	86.62	6.6	VIII	1003
1991	Uttar Pradesh (Uttarkashi)	Oct 20	02:53:-	30.75	78.86	6.6	VIII	715
1993	Maharashtra (Killari)	Sep 30	03:55:47	18.07	76.62	6.3	VIII	7928
1997	Jabalpur	May 22	04:22:31	23.1	80.1	6.0	VII+	38

** Many will mean less than a hundred*

2.2 Cyclone Occurrences

Over the warm water (sea surface temperature greater than 26°C or 27°C) in the tropical ocean, little away from the equator within the belt of 30°N and 30°S, the occurrence of tropical cyclone is almost a world-wide phenomenon. However, their characteristics like frequency, intensity and coastal impact vary from region to region. But these have been the deadliest when crossing the coast bordering the north Bay of Bengal (coastal areas of Andhra Pradesh, Orissa, West Bengal and Bangladesh), mainly because of the serious storm surge problem in this area.

On an average, about 5-6 tropical cyclones form in the Bay of Bengal and the Arabian Sea every year, out of which 2 or 3 may be severe. More cyclones form in the Bay of Bengal than in the Arabian Sea. The ratio is 4:1. There are two definite seasons of tropical cyclones in the North Indian Ocean. One is from May to June and the other is from mid-September to mid-December. May, June, October and November are known for severe storms. The number of tropical cyclones during the period 1891 to 1990 is given in *Table-2*. The entire east coast is vulnerable to cyclones with varying frequency and intensity. Along the west coast, the Gujarat and Maharashtra coasts are more vulnerable compared to the southern part.

The El-Nino effect on weather is seriously being studied by Indian scientists and the outcomes of these studies will help in better communication of early warnings as well as preparedness planning.

Table 2: Observed number of cyclonic storms crossing the Indian Coasts, 1891-1990
Source: Report (Part-I) of Expert Group set up by Ministry of Urban Development, 1998

Degree Latitude	Arabian See Coast		Bay of Bengal Coast	
	All C.S	S.C.S. only	All C.S.	S.C.S. only
8 - 9	1	1	2	2
9 -10	1	1	4	3
10 - 11	2	1	13	4
11 - 12	2	2	7	4
12 - 13	-	-	15	8
13 - 14	2	1	11	4
14 - 15	-	-	10	7
15 - 16	-	-	11	4
16 - 17	-	-	18	4
17 - 18	1	1	7	2
18 - 19	3	1	12	4
19 - 20	1	1	23	3
20 - 21	6	3	34	8
21 - 22	8	4	95*	35*
22 - 23	3	0	X	X
23 - 24	3	2	X	X
TOTAL	**33**	**18**	**262**	**92**

*: These are upto Long. 90°E, hence, the number crossing Indian Coast upto about 89°E will be less
X : No sea coast here
Source : Cyclone Data 1891- 1990, IMD, G.O.I.
C.S. = Cyclonic Storm
S.C.S. = Severe Cyclonic Storm

Deaths in some major cyclonic storms around Bay of Bengal
Source: Report (Part-I) of Expert Group set up by Ministry of Urban Development, 1998

S.No.	Year	Country	Deaths
1.	1737*	Hoogly, West Bengal	300,000
2.	1779	Masulipatnam	20,000
3.	1787	Coringa, Andhra Pradesh	20,000
4.	1789	Coringa, Andhra Pradesh	20,000
5.	1822	Barisal/Backergunj	50 000
6.	1831	Balasore	22,000
7.	1833	Sagar Island	30,000
8.	1839	Coringa, Andhra Pradesh	20,000
9.	1864	Contai, West Bengal	50 000
10.	1864	Masulipatnam	30,000
11.	1876	Backergunj	200,000-250,000
12.	1885	False Point, Orissa	5,000
13.	1897	Bangladesh	175 000
14.	1942	Contai, West Bengal	15,000
15.	1960	Bangladesh	5,490
16.	1961	Bangladesh	11,468
17.	1963	Bangladesh	11,520
18.	1965	Bangladesh	19,229
19.	1970	Bangladesh	200,000
20.	1971	Paradip, Orissa	10,000
21.	1977	Chirala, Andhra Pradesh	10,000

Satellite image of 6th Nov. 1996 shows a cyclonic storm developed in Bay of Bengal and approaching the Godavri delta in Andhra Pradesh.
Source: Report (Part-I) of Expert Group set up by Ministry of Urban Development, 1998