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Probabilistic Assessment of Earthquake Hazards in the North-East Indian Peninsula and Hindukush Regions

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Abstract—The Himalayan region is one of the most seismic prone areas of the world. The North-East (NE) Indian peninsula and the Hindukush regions mark the zone of collision of the Indian and Eurasian plates. The probability of the occurrence of great earthquakes with magnitude greater than 7.0 during a specified interval of time has been estimated on the basis of four probabilistic models, namely, Weibull, Gamma, Lognormal and Exponential for the NE Indian peninsula and Hindukush regions. The model parameters have been estimated by the method of Maximum Likelihood Estimates (MLE) and the Method of Moments (MOM). The cumulative probability is estimated for a period of 40 years from 1964 and is ranging between 0.881 to 0.995 by the year 1995, using all four models for the NE Indian peninsula. The conditional probability is also estimated and it is concluded that the NE Indian peninsula would expect a great earthquake at any time in the remaining years of the present century. For the Hindukush region, the cumulative probability has already crossed its highest value, but no earthquake of magnitude greater than 7.0 has occurred after 1974 in this area. It may attribute to the occurrence of frequent shocks of moderate size, as seventeen earthquakes of magnitude greater than 6.0, including four greater than 6.4, have been reported until 1994 from this region.

Key words: Earthquake hazards, NE Indian peninsula, probabilistic models.

Introduction

The term seismic hazard is used to denote the probability of occurrence of an earthquake with magnitude larger or equal than a particular value within a specified region and a given time span. The systematic evaluation of the seismic hazard is absolutely necessary for evaluation of the seismic risk and of great importance to the effort of earthquake prediction. Seismic hazard may be evaluated as a combination of probabilities determined from observations of various phenomena related to the occurrence of large earthquakes (AKI, 1981). One of the basic probabilities is based on the statistical analysis of the seismic history of the region under study. The term seismic history means the seismicity as reported by catalogue, excluding the short-term microseismic episodes and other premonitory seismic phenomena. In the past two decades a variety of approaches to complex

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physical problems have evolved. These generally involve numerical solutions of relatively simple models and often result in time distribution of earthquakes. It has been recognized that in some seismic regions earthquakes occur at fairly regular intervals. Although the occurrence of these events is not strictly a random process, a statistical approach to the analysis of earthquakes provides a reasonable basis for the seismic hazard assessment. The probabilistic models have been used for time dependent description of earthquake hazards along the plate boundaries in recent years.

It has been reported by a number of authors (e.g., MOGI, 1968; FEDOTOV *et al.*, 1970; KELLEHER *et al.*, 1974; UTSU, 1984 and RIKITAKE, 1976, 1991) that the great earthquakes tend to occur in an area which some tens or hundreds of years past experienced other great earthquakes. The present study is aimed to discuss the occurrence of great earthquakes for a country like India which experienced four great earthquakes of magnitude 8.5 and greater in the past, inflicting heavy casualties and economic loss. A remarkable industrial and economic development has also been achieved in several regions during recent decades. To overcome the natural disaster and damaging effect caused by the earthquakes, it is necessary to understand the hazard assessment of the area which may be estimated by the mean probability of the occurrence of a seismic event with a certain magnitude within a given time interval. In the present study, four probabilistic models, namely, Weibull, Gamma, Lognormal and Exponential distribution have been considered for the North-East (NE) Indian peninsula and Hindukush regions where the earthquakes occur repeatedly at a fairly regular time interval. The probability of occurrence of the next earthquake during a specified interval of time has been computed using each model. An earthquake catalogue covering almost 150 years data has been used for the purpose.

Tectonics and Geology of the Regions

The geological provinces of the NE Indian peninsula have been characterised by a series of north hading thrust as shown in Figure 1. The important thrust amongst these are the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT). The micro-continental areas of the NE Indian peninsula and Burma are represented by the Assam Plateau and Shan plateau, respectively. Garo, Khasi and Jaintia Hills together with the detached area of Mikir Hills form the Assam plateau which lies along the northeastern continuation of the Archaean rocks of Bihar, but is separated from the latter by the Ganges-Brahmputra valley alluvium. The Archaean rocks are represented by gneisses, schists and granites, having general NE-SW strikes. The eastern Himalaya, characterised by the NE hading Mishmi thrust, is a part of the collision boundary between India and Asia. The Burmese arc is characterised by a schuppen belt infested by SE hading thrusts, chief amongst which are the Naga and Disang thrusts. The outcome of the subduction of the Indian plate to the east is represented by these structures. The southern margin of the Shillong massif is characterised by an escarpment and the Danki fault which has been interpreted to have strike slip displacement by EVANS (1964). MURTHY *et al.* (1971) consider it as a reversed fault whereas MOLNAR (1987) interpreted it as a north hading thrust. The eastern margin is demarcated by the N-S Yamuna fault. There is a N-S graben between the Shillong massif and the Mikir Hills in the east along which the Kopili river flows north.

In the Hindukush region, numerous structures are of pre-Hercynian (mostly Caledonian, early Paleozoic), or Hercynian (Permian to Carboniferous age). However, these have been considerably affected by folding and faulting as a result of Alpine movements which are still taking place in the area. Figure 2 shows the tectonic map of the Hindukush and surrounding regions, indicating the major fault systems given by VERMA (1991).

The region fans out from a NE-SW direction, starting from the sourthwestern Pamir knot, into an ENE-WSW strike. The southern branch consists of highly complicated metamorphic rocks, whereas the northern branch consists of folded Mesozoic and predominantly Tertiary sediments (GANSSER, 1964). The well-marked bend in the course of the Hindukush and other mountains of central Asia has been attributed to the Punjab-Kashmir wedge which is believed to have produced syntaxial structures of the western Himalayas, pushing back the structures towards the north (KRISHNAN, 1965). The details of surface geology in the vicinity of the seismic zone indicate that a fracture zone striking NE-SW has separated the folded zone of Tertiary sediments to the north from the Palaeozoic structure towards the south.

Table 1

Great earthquakes in the North-East Indian peninsula (Source: CHANDRA 1978, KHATTRI 1987 and NOAA)

S. No.	Date	Lat. °N	Long. °E	Mag. (Mb)
1	Aug. 10, 1833	28.0	85.0	7.6
2	Dec. 10, 1846	26.0	93.0	7.5
3	May 23, 1866	27.7	85.3	7.6
	Jul. 07, 1869	28.0	85.0	7.3
4	—1885	25.4	90.0	7.3
5	Jun. 12, 1897	25.9	91.8	8.7
6	Jul. 08, 1918	24.5	91.0	7.6
7	Sep. 09, 1923	25.2	91.0	7.1
8	Jan. 15, 1934	26.5	86.5	8.4
9	Oct. 23, 1943	26.0	93.0	7.2
10	Jul. 29, 1947	28.5	94.0	7.9
	Aug. 15, 1950	28.5	96.7	8.7
11	Jul. 12, 1964	24.9	95.3	6.7

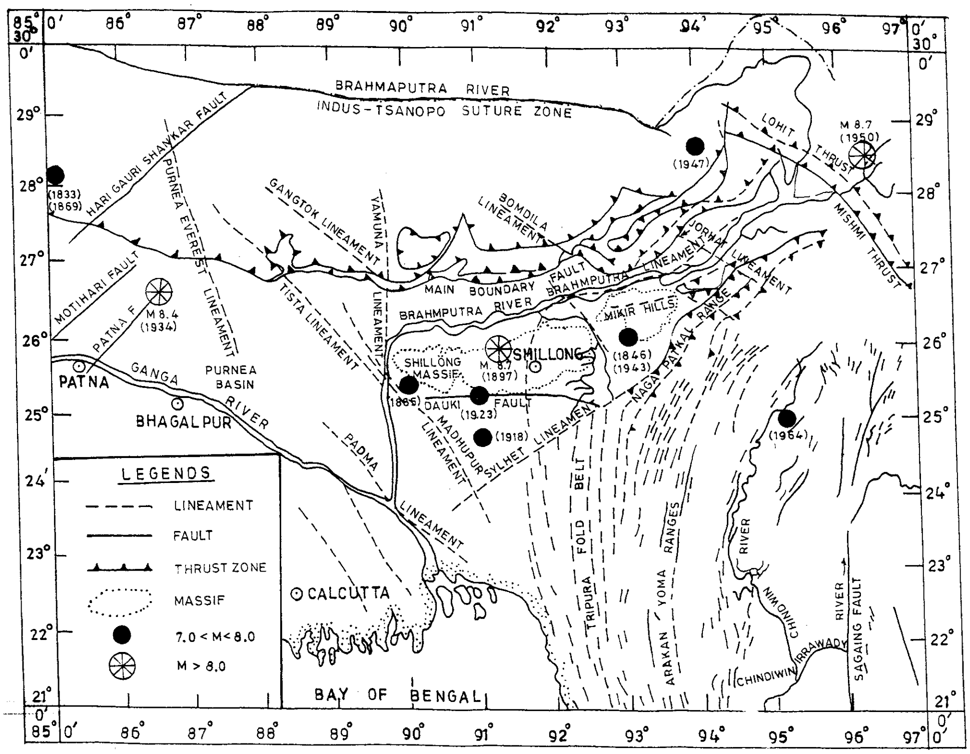

Figure 1
The geological setup of the North-East Indian peninsula and the epicentres of the great earthquakes listed in Table 1. (After KHATTRI, 1992, modified.)

Earthquake Data

The earthquake data set of magnitude >7.0, spanning the time interval from 1833 to 1964, have been used in the present study while more data are available before 1800 until 1341. However, we have carefully selected only time intervals for specific regions which provide as complete and unambiguous a description of characteristic earthquake activity as possible. For great earthquakes, it is difficult to guarantee completeness due to the length of the required historical record and also due to their size. The sources of data are the NOAA earthquake listing, CHANDRA (1978), KHATTRI (1987) and the Preliminary Determination of Epicentres (PDE) reports of the National Earthquake Information Centre, Boulder, Colorado, U.S.A.

Twelve great earthquakes are listed in Table 1 for the NE Indian peninsula. The epicentres of these earthquakes are shown in Figure 1. Three earthquakes of magnitude greater than 8.0 indicate the seismological importance of the region. Although the events of 1833, 1869 and 1934 occurred close to the Central part of the Himalaya, they have also been taken into account because of their size and damaging effect. After the great Assam earthquake of 1950, no earthquake of magnitude >7.0 has occurred to date, however, the event of 1964 has been selected to complete the data set as it is near the size of the great earthquake.

Table 2 shows the listing of earthquakes of the Hindukush region for the period of 1907 to 1974. The epicentres of these earthquakes are illustrated in Figure 2. The recurrence intervals range from 5–9 years. In the early period of this century the area was hit by two great earthquakes of magnitude greater than 8.0. After 1974, no earthquake of magnitude >7.0 was reported for this region.

Probabilistic Models and their Parameters

HAGIWARA (1974), RIKITAKE (1976, 1991), UTSU (1984) and NISHENKO and BULLARD (1987) have carried out probabilistic studies of the recurrence interval for great earthquakes mostly occurring at a number of subduction zones. UTSU (1984) compared four probabilistic models, using different distributions of time intervals, and concluded that the Lognormal model produces the best result in some cases, but the worst in others. The exponential probability model displays similar characteristics. The Weibull and Gamma models have given the intermediate results.

As per the recurrence studies carried out in the past, it is evident that such analysis is useful for evaluating, the probability of earthquake recurrence. In the present study, the intent is to analyse the recurrence intervals of the earthquakes listed in Tables 1 and 2, using the various models provided by UTSU (1984). The details of the models have been briefly described below.

Table 2

Great earthquakes in the Hindukush region (Source: CHANDRA, 1978)

S. No.	Date	Lat. °N	Long. °E	Mag. (Mb)
1	Apr. 13, 1907	36.5	70.5	7.0
	Oct. 23, 1908	36.5	70.5	7.0
	Oct. 24, 1908	36.5	70.5	7.0
	Jul. 07, 1909	36.5	70.5	8.1
	Jul. 04, 1911	36.0	70.5	7.6
2	Apr. 21, 1917	37.0	70.5	7.0
3	Nov. 15, 1921	36.5	70.5	8.1
	Dec. 06, 1922	36.5	70.5	7.5
	Oct. 13, 1924	36.0	70.0	7.3
4	Feb. 01, 1929	36.5	70.5	7.1
5	Nov. 14, 1937	36.5	70.5	7.2
6	Feb. 28, 1943	36.5	70.5	7.0
7	Mar. 04, 1949	36.0	70.5	7.5
8	Nov. 20, 1958	36.5	71.0	7.0
9	Mar. 14, 1965	36.3	70.7	7.6
10	Jul. 30, 1974	36.4	70.8	7.4

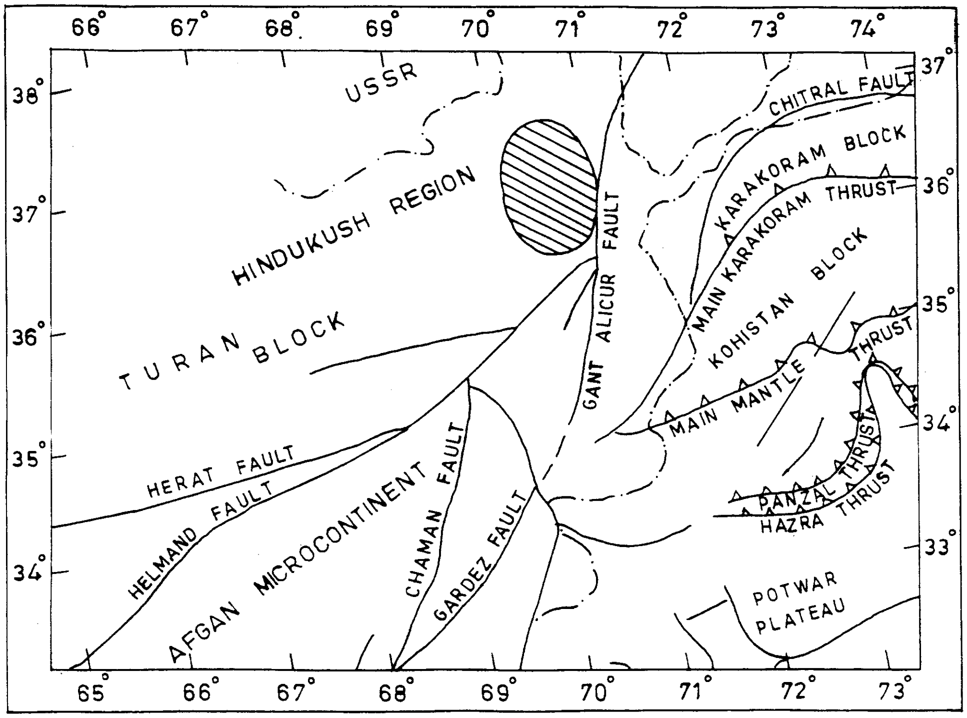

Figure 2
Tectonic map of Hindukush and surrounding regions. Hatched ellipse shows the region of the earthquakes listed in Table 2. (After VERMA, 1991 modified.)

1. Weibull Model

If T is the time interval in years between successive events with a certain $\omega(T)$ distribution, then

$$\omega(T) = \alpha\beta T^{\beta-1}\exp(-\alpha T^{\beta}) \quad \alpha > 0, \beta > 0 \tag{1}$$

where α and β are the model parameters.

$$\phi(t) = \exp(-\alpha t^{\beta}) \tag{2}$$

where $\phi(t)$ is the cumulative probability of the next earthquake that will occur at a time later than t, and t is the time measured in years from the last earthquake. If $p(\tau \mid t)$ is the conditional probability that the next earthquake will occur during the time interval between t and τ, then it is given as

$$p(\tau \mid t) = 1 - \exp[-\alpha\{(t+\tau)^{\beta} - t^{\beta}\}]. \tag{3}$$

Such a conditional probability is called the *Hazard rate* in quality control engineering.

2. Gamma Model

$$\omega(T) = \frac{k}{\Gamma(l)} (kT)^{l-1} e^{-kT} \quad k > 0, l > 0 \tag{4}$$

$$\phi(t) = \Gamma(l, kt)/\Gamma(l) \tag{5}$$

$$p(\tau \mid t) = 1 - \frac{\Gamma(l, k(t+\tau))}{\Gamma(l, kt)} \tag{6}$$

where k and l are the model parameters and other notations are the same as the Weibull model.

$\Gamma(x, y)$ represents the incomplete gamma function of the second kind, *i.e.*,

$$\Gamma(x, y) = \int_y^\infty e^{-u} u^{x-1}\, du. \tag{7}$$

3. Lognormal Model

$$\omega(T) = \frac{1}{\sqrt{2\pi}\sigma T} \exp\left\{-\frac{(\ln T - m)^2}{2\sigma^2}\right\} \quad m > 0, \sigma > 0 \tag{8}$$

$$\phi(t) = \Phi\left(\frac{\ln t - m}{\sigma}\right) \tag{9}$$

$$p(\tau \mid t) = 1 - \left\{1 - \Phi\left(\frac{\ln(t+\tau) - m}{\sigma}\right)\right\} \Big/ \left\{1 - \Phi\left(\frac{\ln t - m}{\sigma}\right)\right\} \tag{10}$$

Table 3

Model parameters for the North-East Indian peninsula (data listed in Table 1)

		I (all data)		II (excl. 1923)		III (1869–1964)	
Data set		MOM	MLE	MOM	MLE	MOM	MLE
Weibull	α	9.4×10^{-4}	8.7×10^{-4}	1.1×10^{-4}	1.0×10^{-4}	1.0×10^{-3}	0.9×10^{-3}
	β	2.59	2.62	3.28	3.29	2.66	2.68
	$\ln L$	−30.77	−30.79	−26.86	−26.92	−23.64	−23.67
Gamma	k	4.4×10^{-1}	4.2×10^{-1}	6.1×10^{-1}	5.8×10^{-1}	5.1×10^{-1}	4.9×10^{-1}
	l	5.819	5.514	8.901	8.427	6.102	5.844
	$\ln L$	−30.75	−30.75	−26.92	−26.91	−23.61	−23.61
Lognormal	m	2.493	2.479	2.625	2.617	2.399	2.386
	σ	0.398	0.447	0.326	0.357	0.390	0.431
	$\ln L$	−31.07	−30.93	−24.12	−24.05	−23.81	−23.72
Exp. Prob.	p		1.6×10^{-2}		7.8×10^{-3}		1.7×10^{-2}
	q		0.153		0.192		0.172
	$\ln L$		−31.42		−27.45		−24.23

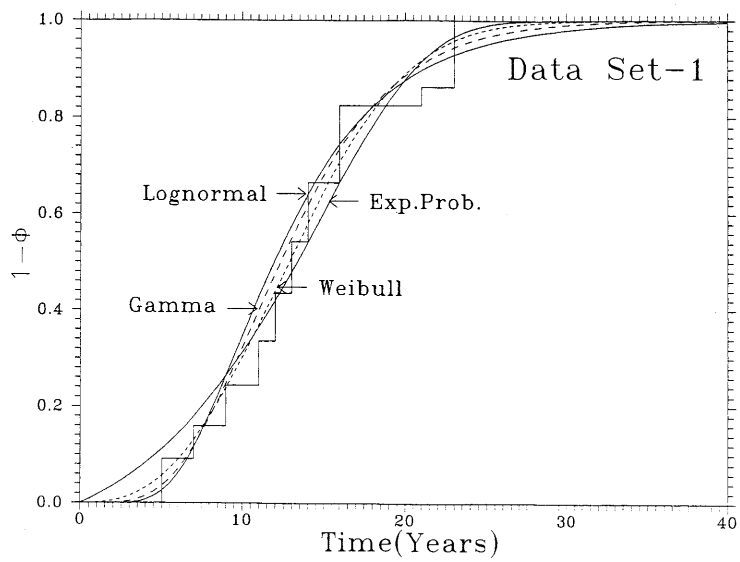

Figure 3
Cumulative distribution of Ti and the curves of $1-\phi(t)$ using the four models for the North-East Indian peninsula, Data set 1.

where m and σ are the model parameters and other notations are the same as above. $\Phi(x)$ represents the error integral given as;

$$\Phi(x)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x}\exp^{-u^2/2}\,du. \tag{11}$$

4. Exponential Probability Model

$$\omega(T)=p\cdot\exp\left\{\frac{p}{q}(1-e^{qT})+qT\right\}\quad p>0,q>0 \tag{12}$$

$$\phi(t)=\exp\left\{\frac{p}{q}(1-e^{qt})\right\} \tag{13}$$

$$p(\tau\mid t)=1-\exp\left\{\frac{p}{k}e^{kt}(1-e^{k\tau})\right\} \tag{14}$$

where p and q are model parameters and other notations are the same as above. The values of the parameters of these models, (α,β), (k,l), (m,σ) and (p,q) have been estimated by the method of moments (MOM) and the method of maximum likelihood estimates (MLE) except the method of moments for the exponential probability model as listed in Table 3. The logarithmic of likelihood function $L=\Pi_{i=1}^{n}\omega(T_i)$ has also been estimated. The actual process of obtaining the model parameters and logarithmic of likelihood functions are not presented here as these are well discussed by UTSU (1984).

Probability of Recurrence

If simple statistics of the recurrence interval for all the events is considered, it is realized that the model parameters represent a high probability of occurrence caused by an extremely short return period. For the long-term prediction, therefore, foreshocks, aftershocks activities and the closed events should be eliminated from the statistics. In this connection, a number of groupings are made for the earthquakes in Tables 1 and 2. After making proper data sets for the two regions, the probability of occurrence has been estimated with time intervals as described below.

1. North-East Indian Peninsula

The earthquake data for this region are given in Table 1. Ten recurrence intervals have been found between the period from 1833 to 1964. The model parameters estimated by MOM and MLE are listed in Table 3 for three selected sets of data. The first data set includes all the events of Table 1. The second data set excludes the event of 1923 as it is temporally very close to the 1918 event. The third includes all the events of 1869 to 1964. The parameter values are expressed using the time unit of years. As seen from Table 3, the parameters estimated by the two methods verge on each other.

The cumulative distribution of the observed time intervals for all the three data sets are shown in Figures 3, 4 and 5, respectively. The curves of

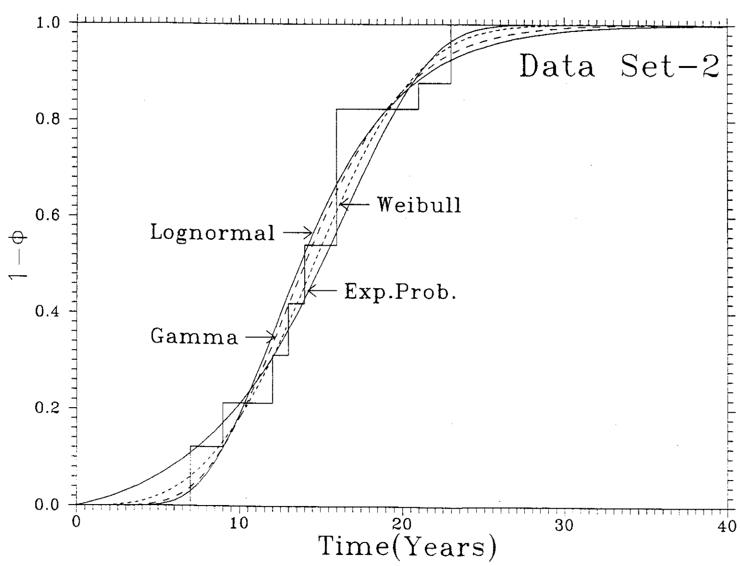

Figure 4
Same as Figure 3 for Data set 2.

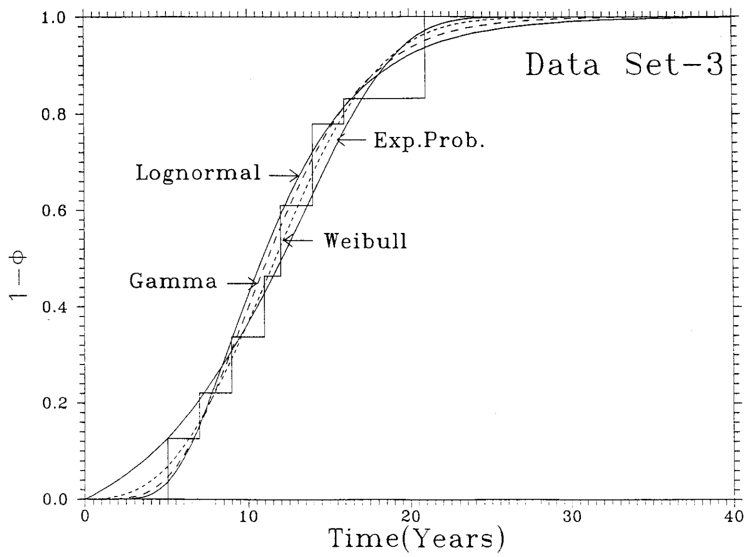

Figure 5
Same as Figure 4 for Data set 3.

$$1-\phi(t)=\int_0^t \omega(T)\,dT \tag{14}$$

for the four models on the basis of the parameters estimated by the maximum likelihood method are also drawn in the same figures. It is difficult to conclude which model fits the data best. Figure 3 indicates that the Weibull model seems to fit the actual distribution slightly better than the others. The next fit is the Gamma model. However, the Lognormal model gives the best fit at the extreme ends of the actual distribution. The logarithmic value of the likelihood function ($\ln L$) is estimated as -30.75 for the Gamma model, which is the highest, and the next highest is -30.79 for the Weibull model. The difference in the likelihood for the four models is too small (0.67) to recommend any argument as to which model is superior. It is clear from Figures 3, 4 and 5 that all the four models fit the actual distribution very well.

One of the interesting problems from the earthquake prediction point of view is to estimate the conditional probability of crustal rupture time in the near future, assuming that the rupture has not occurred in the past. The estimated values of the conditional probabilities, $p(\tau \mid t)$ for various combinations of t and τ from the equations (3), (6), (10) and (14) for all the four models are listed in Table 4 using the parameter estimated by the MLE method for the first data set. It is seen from the table that the Lognormal model gives the lowest value of probability for different combinations of t and τ and the Exponential model gives the highest. The probabilities for the Gamma and Weibull models fall between the two. The data sets 2 and 3 also display a similar pattern.

The changes in cumulative and conditional probabilities with time are shown in Figure 6, using data set 1 for the cases of $\tau = 5$ and 10 years, where time is measured from the last event. Examining this figure, it can be seen that the cumulative probability $\phi(t)$ reaches about 0.9–1.0 for the time period of 30–35 years after 1964. The conditional probabilities for a period of 5 and 10 years from 1995 also ranges between 0.59 to 1.0 as indicated by different models. As the mean value of the recurrence interval amounts to 13.1 years, for a value of t which is considerably larger than the mean value, the conditional probability for the Lognormal model increases to 15 years and then tends to decrease. Thus, it would not be unreasonable to expect a great earthquake in the North-East Indian peninsula at any time in the remaining years of the present century.

2. Hindukush

All the events in the region, between 36°–37° N and 70°–71° E are given in Table 2. It is clear from the table that maximum earthquakes occurred very near

Table 4

The conditional probability for North-East Indian peninsula as computed from the first data set (t and τ are given in years)

$t \Rightarrow$	0	5	10	15	20	25
$\tau =$			Weibull model			
2	0.005	0.079	0.197	0.331	0.464	0.586
4	0.032	0.193	0.398	0.589	0.740	0.847
6	0.090	0.331	0.581	0.769	0.886	0.950
8	0.182	0.481	0.731	0.882	0.955	0.985
10	0.302	0.624	0.842	0.946	0.984	0.996
			Gamma model			
2	0.000	0.081	0.230	0.329	0.389	0.427
4	0.012	0.214	0.442	0.568	0.637	0.678
6	0.064	0.374	0.617	0.731	0.789	0.823
8	0.170	0.533	0.748	0.838	0.881	0.904
10	0.315	0.671	0.841	0.905	0.934	0.949
			Lognormal model			
2	0.000	0.093	0.243	0.296	0.310	0.309
4	0.007	0.245	0.449	0.511	0.524	0.521
6	0.062	0.413	0.609	0.662	0.672	0.667
8	0.185	0.565	0.727	0.767	0.773	0.767
10	0.346	0.688	0.811	0.839	0.842	0.836
			Exponential model			
2	0.036	0.077	0.157	0.307	0.546	0.816
4	0.084	0.171	0.332	0.579	0.844	0.982
6	0.144	0.284	0.513	0.786	0.964	0.999
8	0.220	0.414	0.682	0.915	0.995	1.000
10	0.312	0.553	0.822	0.976	1.000	1.000

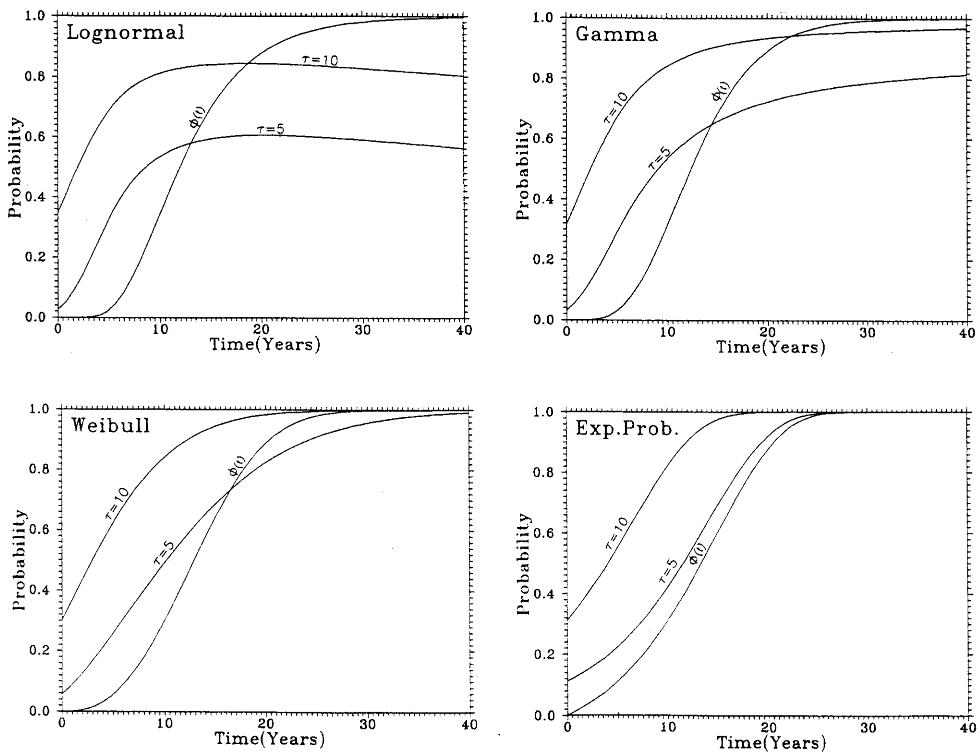

Figure 6
Cumulative $\phi(t)$ and conditional $p(\tau \mid t)$ probabilities for North-East Indian peninsula ($\tau = 5$, 10 years).

the same focal region. The model parameters estimated by the method of maximum likelihood for this region are listed in Table 5. The logarithmic of the likelihood estimated for this region gives the highest value for the Lognormal model and the next highest for the Weibull model. Figure 7 shows the cumulative distribution of the observed time interval (Ti) along with the probability curves for the four models. It is clear from this diagram that all the models yield the appropriate fit. Lognormal and Gamma models follow nearly the same pattern. The conditional probability for different sets of t and τ are given in Table 6. The curves for the conditional probability have also shown the similar pattern as for the NE Indian peninsula. The time for the occurrence of a great earthquake in the Hindukush region has already been passed, but no earthquake of magnitude greater than 7.0 occurred after 1974 (Table 6). The cause for nonoccurrence of a great earthquake in this region may be the frequent occurrences of the moderate size earthquakes which released the accumulated strain. The observed data indicate that seventeen earthquakes of magnitude greater than 6.0 and four earthquakes of magnitude greater than 6.4 have occurred in this region until 1994.

Table 5

Model parameters for the Hindukush region (data listed in Table 2)

		MOM	MLE
Weibull	α	1.94×10^{-6}	1.99×10^{-6}
	β	6.42	6.40
	$\ln L$	-15.03	-15.14
Gamma	k	4.18	4.01
	l	30.18	28.95
	$\ln L$	-15.32	-15.31
Lognormal	m	1.961	1.960
	σ	0.181	0.189
	$\ln L$	-13.71	-13.69
Exp. Prob.	p		9.7×10^{-4}
	q		0.864
	$\ln L$		-15.31

Discussion and Conclusions

The problem of earthquake prediction in terms of its size, place and time of occurrence attaches considerable importance. Multi-disciplinary approaches have

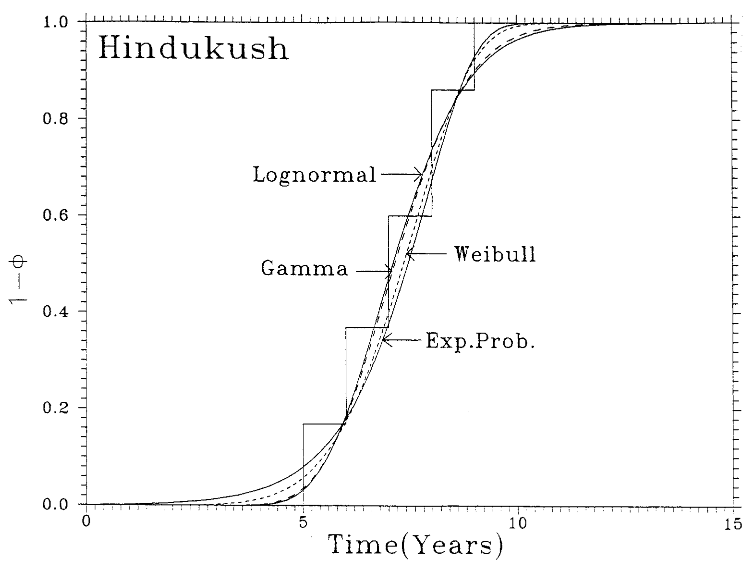

Figure 7
Same as Figure 3 for Hindukush region.

Table 6

The conditional probability for Hindukush region (t and τ are given in years)

$t \Rightarrow$	0	2	4	6	8
$\tau =$			Weibull model		
1	0.000	0.002	0.044	0.275	0.742
3	0.002	0.058	0.392	0.907	1.000
5	0.058	0.401	0.922	1.000	1.000
			Gamma model		
1	0.000	0.000	0.034	0.337	0.631
3	0.000	0.036	0.457	0.879	0.976
5	0.036	0.458	0.901	0.992	0.999
			Lognormal model		
1	0.000	0.000	0.031	0.349	0.604
3	0.000	0.032	0.470	0.872	0.961
5	0.032	0.471	0.896	0.987	0.997
			Exponential model		
1	0.002	0.009	0.047	0.240	0.786
3	0.014	0.075	0.355	0.915	1.000
5	0.080	0.373	0.928	1.000	1.000

been used earlier to deal with earthquake prediction related studies. In the present study, four distributions of extreme earthquake occurrences, namely Weibull, Gamma, Lognormal and Exponential distributions, have been presented to estimate the model parameters. These have been used to study the probabilistic assessment of earthquake hazards. The term earthquake hazard denotes the probability of occurrence of an earthquake ($M > 7.0$ in this case) during a specified interval of time within the specified region. UTSU (1984) applied these models for several seismic regions of Japan where large earthquakes occur repeatedly at fairly regular time intervals. He compared the models using different distributions of time intervals and suggested that all models seem to be acceptable. RIKITAKE (1991) also used the Weibull and Lognormal models to study earthquake hazard in the Tokyo area of Japan, and predicted that the probability of Japan's capital area being hit by a damaging earthquake is too high. NISHENKO and BULLARD (1987), who normalised recurrence intervals of large earthquakes with the mean interval for each earthquake province, analysed the recurrence interval distribution by the Lognormal and Weibull distributions and found the Lognormal to be the best. The investigations of the present study have been compared with the previous results and similar characteristics have been found. The logarithmic of the likelihood function has been estimated in order to test the best suitability of the models, but the difference in likelihood for the four models is too small to infer as to which model is the best.

The present study describes the estimation of parameters using the four probabilistic models for several sets of data. The great earthquakes of magnitude >7.0

have been selected for the NE Indian peninsula and Hindukush regions. On the basis of the earthquake catalogue covering about 150 years, the cumulative and conditional probabilities have been evaluated. One of the most important results of this study is that the probability of occurrence of a great earthquake in the NE Indian peninsula reaches 0.8–0.9 for the time period 30–35 years after 1964. It is concluded that the probability of the NE Indian peninsula being hit by a great earthquake in the foreseeable future is high. For the Hindukush region time has already passed for the occurrence of a great earthquake with high probability, and it is inferred that it may be due to the frequent occurrences of moderate size earthquakes in the area.

By comparing the models using different distributions of time intervals, it is found that all four models fit the actual distribution very well. The difference in the likelihood function ($\ln L$) for the four models is too small, thus it is not possible to present any argument as to which model is superior. It should be mentioned that the result of this paper is related to the assumption that the process of earthquake occurrence is temporally stable.

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