Probabilistic Seismic Hazard Assessment of the Central Himalaya and Its Adjoining Region

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1 Introduction

The central Himalaya is seismically one of the most active regions of the world due to continent-continent collision between the Indian and the Eurasian plates and presence of segments of major tectonic boundary thrusts, namely the Main Central Trust (MCT) and the Main Boundary Thrust (MBT). The surrounding region witnessed the Great Bihar-Nepal Earthquake of 1934 (M=8.1) and the Assam Earthquake of 1950 (M=8.6) and the recent Sikkim–Nepal Earthquake of 2011 ($M_{L=}$6.9). So, it is always important to study the seismic hazard assessment for the Himalayan region. Nepal is 800-km long and 200-km wide, with an area of about 147,000 km^2. In the present study, a probabilistic seismic hazard assessment (PSHA) of the region in and around the central Himalaya (Nepal) has been carried out. The information from the PSHA shall be helpful to devise an appropriate mechanism to mitigate disastrous effects of earthquakes. For this purpose, seismicity and tectonics of the region lying between latitude 26°0´N to 31°0´N and longitude 76° 5´E to 88°0´E has been considered for demarcating the seismotectonic sources.

2 Data and Methodology

In this study, earthquake data from International Seismological Center (ISC), U.K, National Earthquake Information Center (NEIC), USGS, USA and India Meteorological Department (IMD) have been used. In addition to global catalogues, some local catalogues prepared by Oldham (1883) and Iyengar (1999) are also considered. Appropriate global relations have also been used as given by Wason et al. (2012) and regional relations for conversion of body wave magnitude to moment magnitude (Das et al., 2013). Since PSHA is based on the assumption that seismicity follows Poisson process, it is essential to remove any non-Poissonian behaviour from earthquake catalogue. For this study the earthquake catalogue was analyzed and dependant events were removed based on Gardner and Knopoff (1974) approach considering 100 days time window (Musson 1999).

The central Himalaya and its adjoining region is divided into ten seismic source zones based upon the seismicity, tectonics of the region and focal mechanism. Magnitude of completeness (M_c) is one parameter defined as the lowest magnitude at which 100% of the events in a space-time window are detected (Woessner et al., 2005). For the present study, the Entire Magnitude Range Method (EMR) modified by Woessner et al. (2005) is adopted to estimate the magnitude of completeness. Maximum magnitude is defined as the upper limit of magnitude for a given seismic source zone or entire region. For the present study the non-parametric Gaussian (N-P-G) based estimator equation given by Kijko (2004) is used. Kijko's m_{max} Toolbox written in MATLAB has been used for the computation of maximum magnitude. Both historical and instrumental seismicity data has been used to determine m_{max}. Gutenberg-Richter recurrence parameters ('b' and 'a') values have been estimated for each source zone from the homogenized earthquake catalogue and the variations in the values of these seismicity parameters have been analyzed. Attenuation equation for shallow crustal earthquakes proposed by Boore and Atkinson (2008), Akkbar and boomer (2010), Ambraseys et al. (2005) has been used to calculate the spatial distribution of peak ground acceleration and 5% damped pseudo spectral acceleration (PSA). Standard procedure for PSHA has been adopted for this study and peak ground motion are estimated for 10% and 2% probability of exceedance in 50 years at the bed rock level.

3 Results

The seismic hazard parameters obtained from catalogue for a period from 1964 to 2011 are listed in Table 1, and further used for hazard analysis because return period based on instrumental seismicity data is found to provide reliable results. It is concluded that the M_c value valid for the Central Himalaya region can be considered to be 4.6 for the catalogue period 1964-2011. For 10% probability of exceedance in 50 years, the PGA values vary from 0.11g to 0.51g considering varying b-value, as shown is Fig. 1. In case of 2% probability of exceedance in 50 years, the PGA varies between 0.10g to 0.79g considering varying -values. For a return period of 475 years, the western part of Nepal is having higher hazard level from 0.41g to 0.51g and eastern part the PGA varies from 0.30g to 0.34g. Areas located to northeast have less hazard level.

Table 1, Seismic hazard parameters considering earthquake data after 1963.

Zone	M_c	a	b	beta	b error	beta coeff	lambda	m_{max} observed
1	4.1	3.32	0.8	1.84	0.03	0.07	1.10	6.8
2	3.9	1.93	0.84	1.93	0.00	0.00	0.05	5.6
3	4.4	4.43	0.98	2.26	0.03	0.07	1.31	6.5
4	4.4	4.38	0.92	2.12	0.22	0.51	2.15	7.5
5	4.4	4.23	0.91	2.10	0.15	0.35	1.68	6.5
6	3.8	2.52	0.67	1.54	0.50	1.15	0.94	6.0
7	4.3	4.44	1.06	2.44	0.27	0.62	0.76	7.0
8	4.6	5.54	1.14	2.63	0.12	0.28	1.98	8.3
9	4.5	5.58	1.26	2.90	0.18	0.41	0.81	6.7
10	4.5	6.21	1.33	3.06	0.13	0.30	1.68	7.1

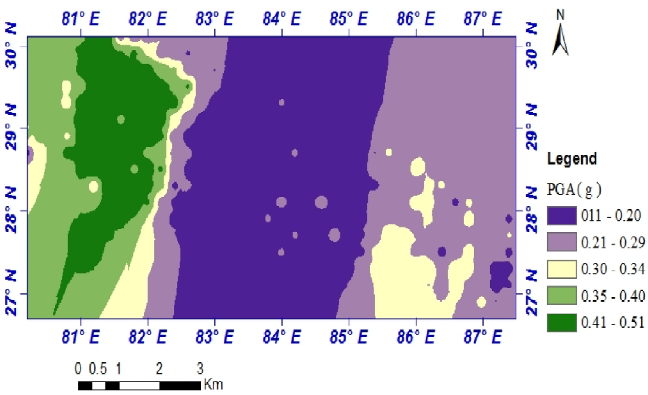

Fig 1. Peak ground acceleration for the return period of 475 years

4 Conclusion

M_c value valid for the Central Himalaya region can be considered to be 4.6 for a catalogue period of 1964-2011. For a return period of 475 years, the western part of Nepal has a higher hazard level from 0.41g to 0.51g and for the eastern part, the PGA varies from 0.17g to 0.26g. For a return period of 2500 yers, the PGA varies from 0.15g to 0.79g for entire Nepal, and higher PGA values are observed in the western part of Nepal.

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