

## Abstract

In the present study Deterministic Seismic Hazard Analysis (DSHA) has been carried out for the states of Himachal Pradesh & Uttarakhand. Study investigates the seismicity data from the year 1963 to 2017 with  $M_w \geq 4.0$  in the region bounded by 29°N - 33°N latitude and 75°E - 81°E longitude have been taken from the catalogue of USGS and ISC. The study region is one of the most seismically active regions of western part of Himalaya, India and there are numerous major seismic faults present in this region. Eighty-nine seismo-tectonic sources in and around Himachal Pradesh & Uttarakhand were identified. Using an appropriate attenuation model the peak horizontal accelerations, peak vertical accelerations and ratios of peak vertical to horizontal accelerations were computed. For this purpose the study region was divided into grids of 0.5° by 0.5°. The estimated peak horizontal accelerations vary from 0.02g to 0.60g and peak vertical accelerations vary from 0.01g to 0.47g. The ratios of vertical to horizontal accelerations vary from 0.27 to 0.78. The PGA contour maps prepared for the region show that larger Peak Ground Accelerations are present in the region where there is a higher density of larger faults and vice versa.

**Introduction:** The local geological and soil conditions can profoundly influence all of the characteristics – amplitude, frequency content, and duration – of strong ground motion. Significant earthquake damage and loss of life has been directly related to the effect of local site condition in several recent earthquakes (eg., 1985 Mexico earthquake, 1989 Loma Prieta Earthquake, 1994 Northridge, 1995 Kobe Earthquake, and Bhuj earthquake 2001) which effects play an important role in earthquake resistant design [2]. Local site condition related damage are very essential component of a comprehensive assessment of seismic hazard and are attributed to geotechnical / geophysical characteristics of soil overburden closure to the ground. There is a clear role for geological and geotechnical data in evaluating the ground motions and in turn in the study of seismic hazard.

## Characteristics of Study Region:

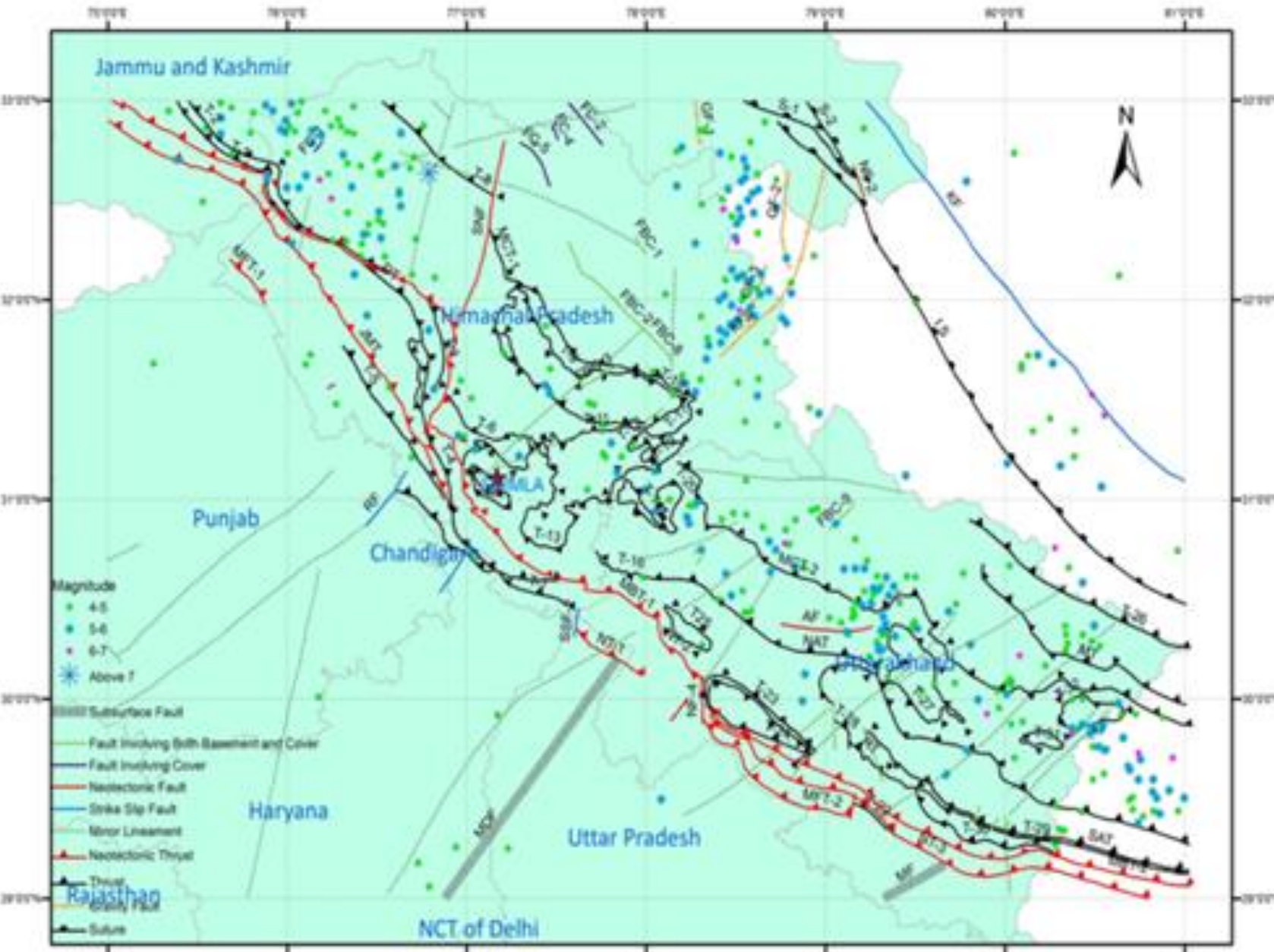


Figure 1 Seismotectonic map of the considered region (after [5]) in the study region

The frequent seismic activities observed in this region are due to ruptures at these thrust faults formed by the subduction of the Indian plate below the slow moving Eurasian plate [5]. Some of these prominent faults are the Main Frontal Thrust (MFT) [6], [7] the north-west-south-east trending Main Boundary Thrust (MBT) and Main Central Thrust (MCT) running parallel to Himalayas and other local transverse faults across the area. A highly devastating earthquake of magnitude 7.8 on the Richter scale occurred in 1905 within the study area

## Method of analyses

For conducting Deterministic Seismic Hazard Assessment eighty nine potential seismic line sources were delineated based on the major tectonic features mapped in the study area and observed seismicity patterns. The area was divided into small grids, each grid having a dimension of 0.5° latitude by 0.5° longitude. Center of each grid is taken as a site for the purpose of calculating ground motion parameter. The attenuation relationship developed by [1] has been used to compute both peak horizontal acceleration ( $a_h$ ) and peak vertical acceleration ( $a_v$ ). The expected ratios of peak vertical to peak horizontal accelerations ( $a_v/a_h$ ) have also been computed. The maximum value of peak horizontal and vertical accelerations computed at the center of each grid point, along with the ratio  $a_v/a_h$  and the source that has made maximum contribution.

## Computational Results

The contour maps showing the variation of peak horizontal accelerations ( $a_h$ ) and peak vertical accelerations ( $a_v$ ) are shown in Figures 2 and 3. Hence, this article presents an estimate estimated of peak horizontal accelerations varying from 0.02g to 0.60g (Figure 1) and peak vertical accelerations vary from 0.01g to 0.47g (Figure 3).

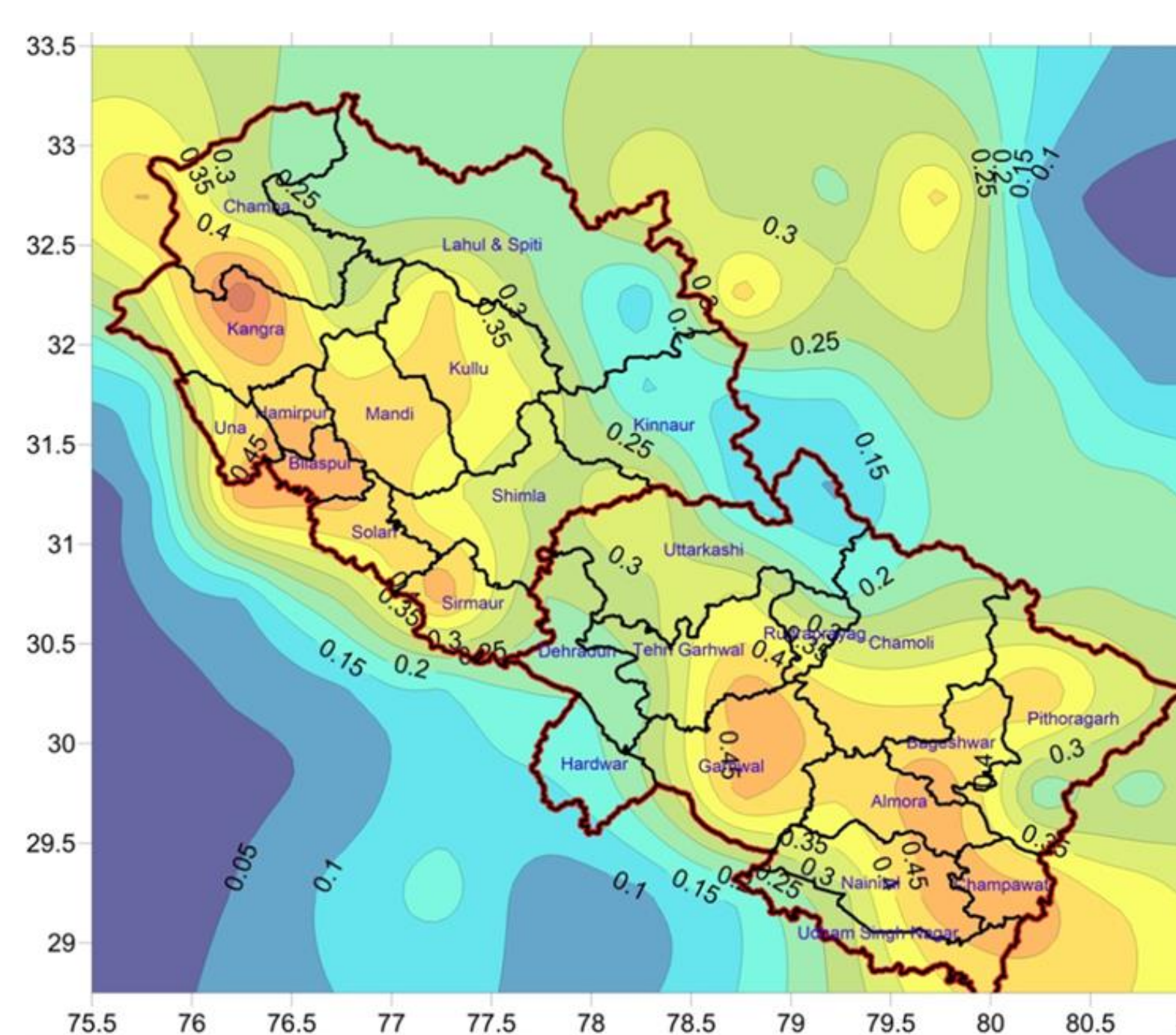
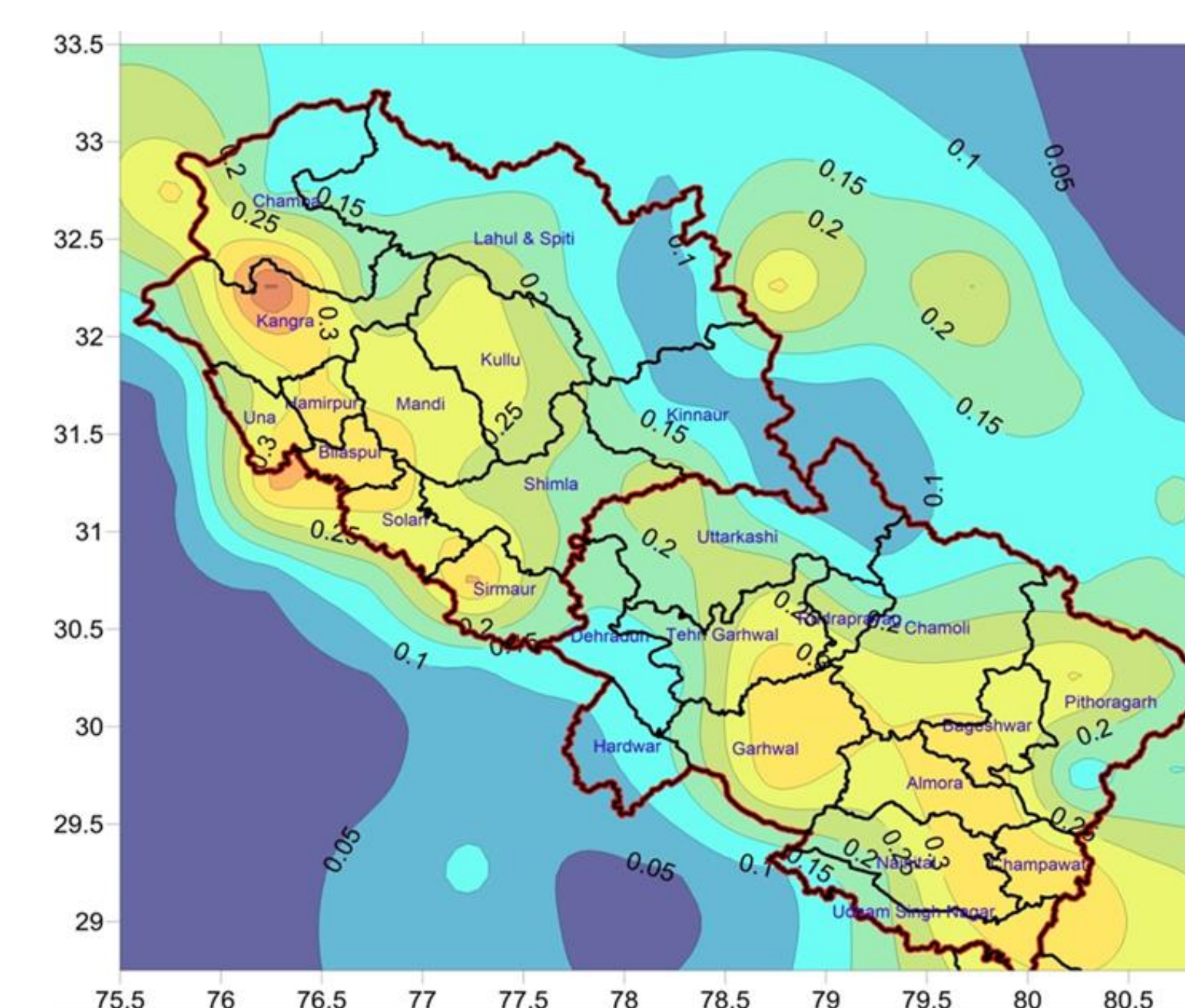


Figure 2. Contour map showing variation of peak horizontal accelerations in the study region



Contour map showing variation of peak vertical accelerations in the study region

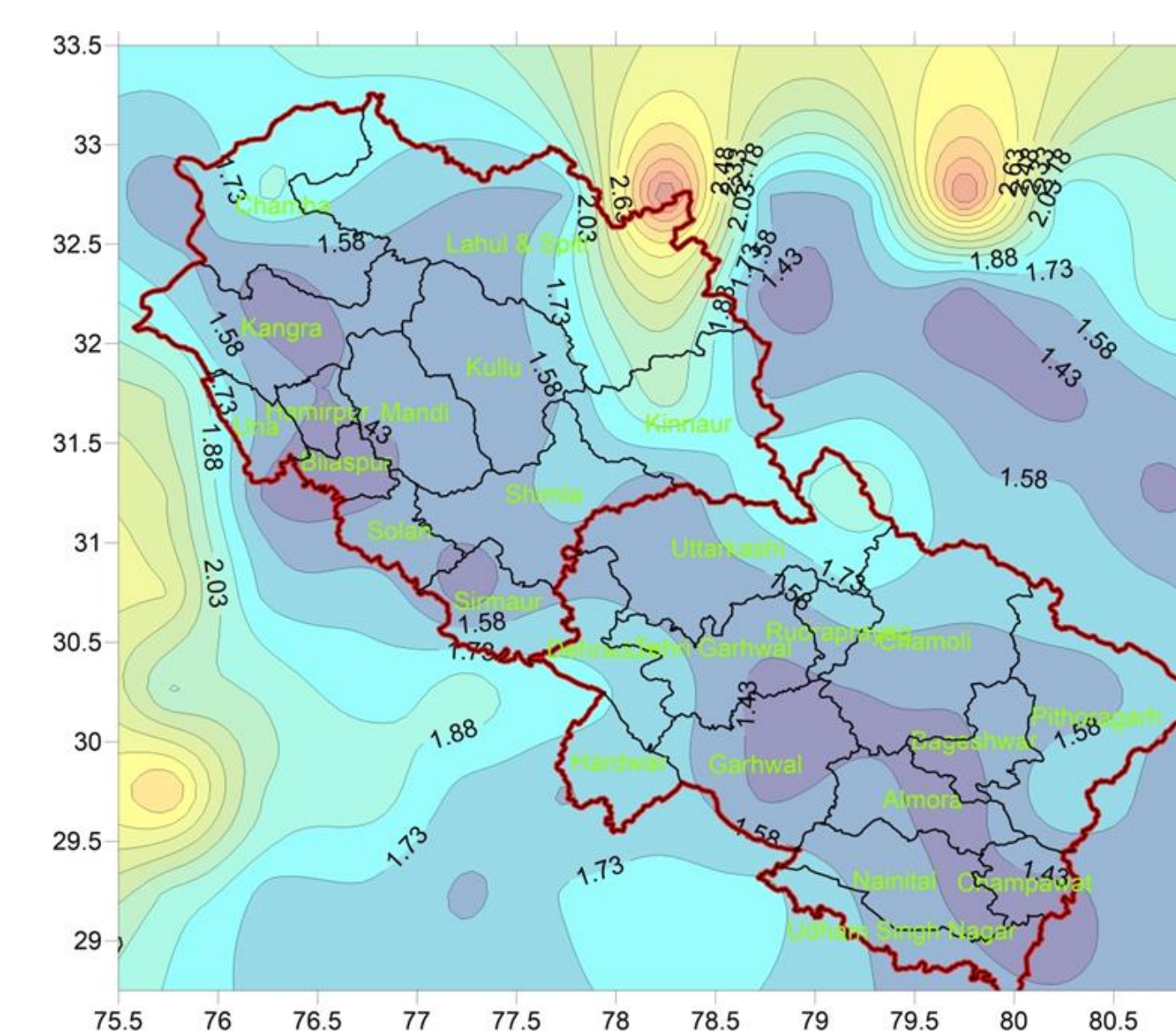


Figure 4. Contour map showing variation of ratio of Horizontal to vertical accelerations in the study region

## Discussion and Conclusion:

The ratios of horizontal to vertical accelerations vary from 3.60 to 1.28 (Figure 4). These estimates would be very helpful for future preparedness planning and even construction practices in the considered area. The PGA contour maps prepared for the region show that larger Peak Ground Accelerations are present in the region where there is a higher density of larger faults and vice versa. The values for Himachal Pradesh and Uttarakhand vary from 0.05g to 0.35g. These values are less than those obtained in the present study. The hazard map prepared by [4] is based on large sized source zones and uses different attenuation relationship and thus reflect the broader framework.

The values of accelerations may not be representative on local and regional scale as they have not considered the local and regional tectonic features.

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## REFERENCES

- [1] Abrahamson, N.A, Lithewiser, J.J., 1989. "Attenuation of vertical peak acceleration" Bulletin of Seismological Society of America; vol. 79, no.3: 549-567.
- [2] Arya, A.S., (1992). Possible effects of a major earthquake in Kangra region of Himachal Pradesh, Current Science, 62(1-2), 251-256.
- [3] Bhatia, S.C., Kumar, M.R. and Gupta, H.K. (1999), A probabilistic seismic hazard map of India and adjoining regions, Annali di Geofisica, 42:1153-1166.
- [4] Chandra, U. (1992), Seismotectonics of Himalaya, Current Science, 62 (1-2), 40-71.
- [5] G S I. (2000), "Seismotectonic Atlas of India and Its Environs". Geological Survey of India, SEISAT 5, 6
- [6] Valdiya, K.S., (1976). Himalayan transverse faults and folds and their parallelism with subsurface structures of north Indian Plains; Tectonophysics, 32, 353-386.
- [7] Valdiya, K.S. Rana, R.S. and Sharma, P.K., (1992). Active Himalayan Frontal fault, Main Boundary Thrust and Ramgarh Thrust in Southern Kumaun; Jour. Geol. Soc. India, 40, 509-528.