Supplement of

Site Characterization vis-à-vis Probabilistic Seismic Hazard and Disaster Potential Modelling in the Himalayan and Sub-Himalayan Tectonic Ensemble from Kashmir Himalaya to Northeast India at the backdrop of the updated Seismic Hazard of the Indian Subcontinent

Sankar Kumar Nath et al.

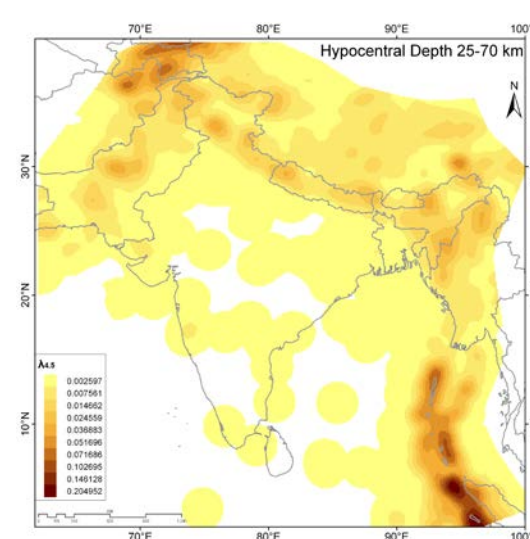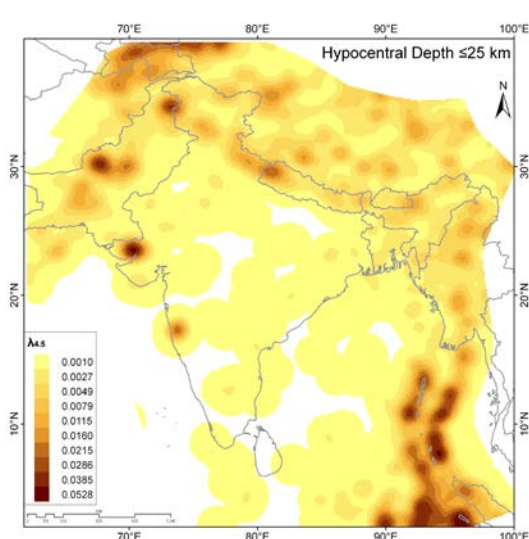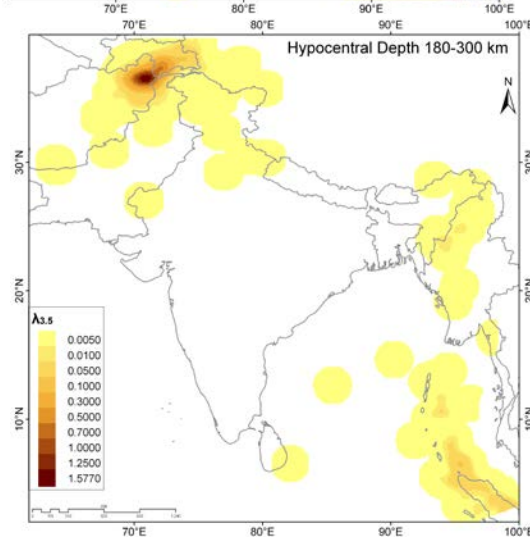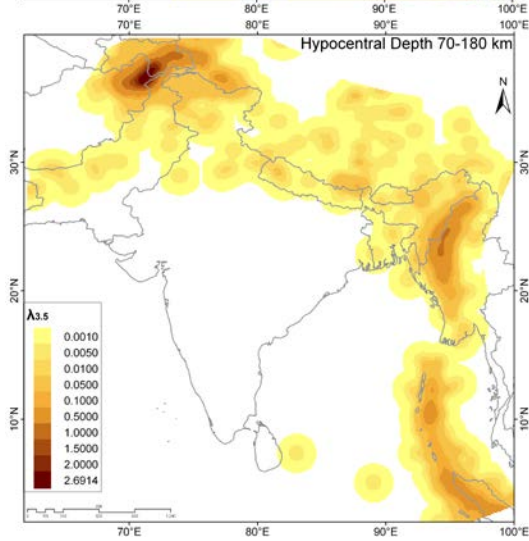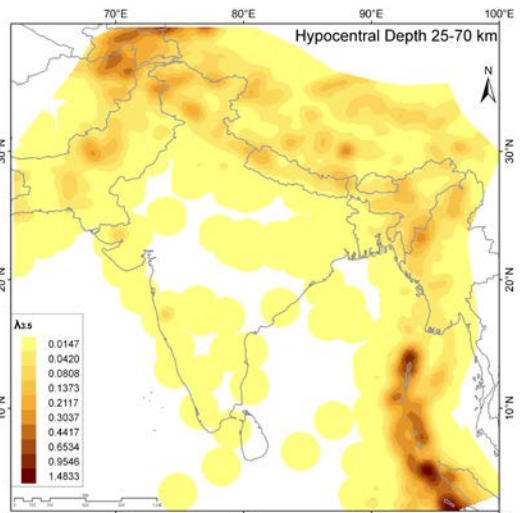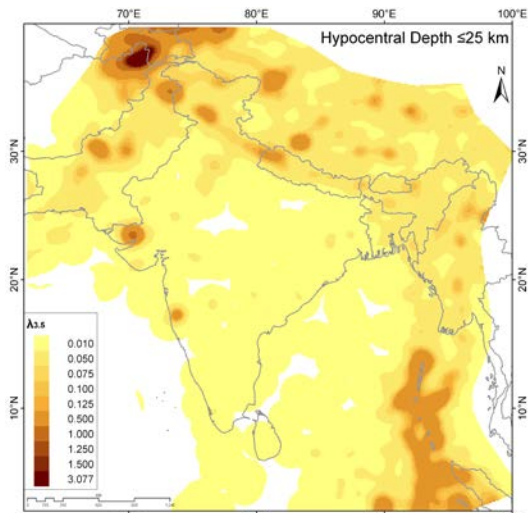*Correspondence to*: Sankar Kumar Nath (nath@gg.iitkgp.ac.in)

- Supplementary materials

  Figure S1 Smoothened gridded seismicity for the polygonal seismogenic sources of India and its surrounding region for the threshold magnitude of M_w 3.5, 4.5 and 5.5 at the hypocentral depth range of **(a)** 0-25km, **(b)** 25-70km, **(c)** 70-180km, and **(d)** 180-300km (After Nath, 2017).

  Figure S2 The annual activity rate versus magnitude for a group of active tectonic features inscribed in each polygonal areal seismogenic source at 0-25km focal depth level for threshold magnitudes of 3.5 (After Nath, 2017).

  Table S1. Selected Ground Motion Prediction Equations for PSHA of the Indian Peninsula predominantly comprising of eleven Seismogenic Tectonic Provinces shown in **Fig. 2** in the manuscript.

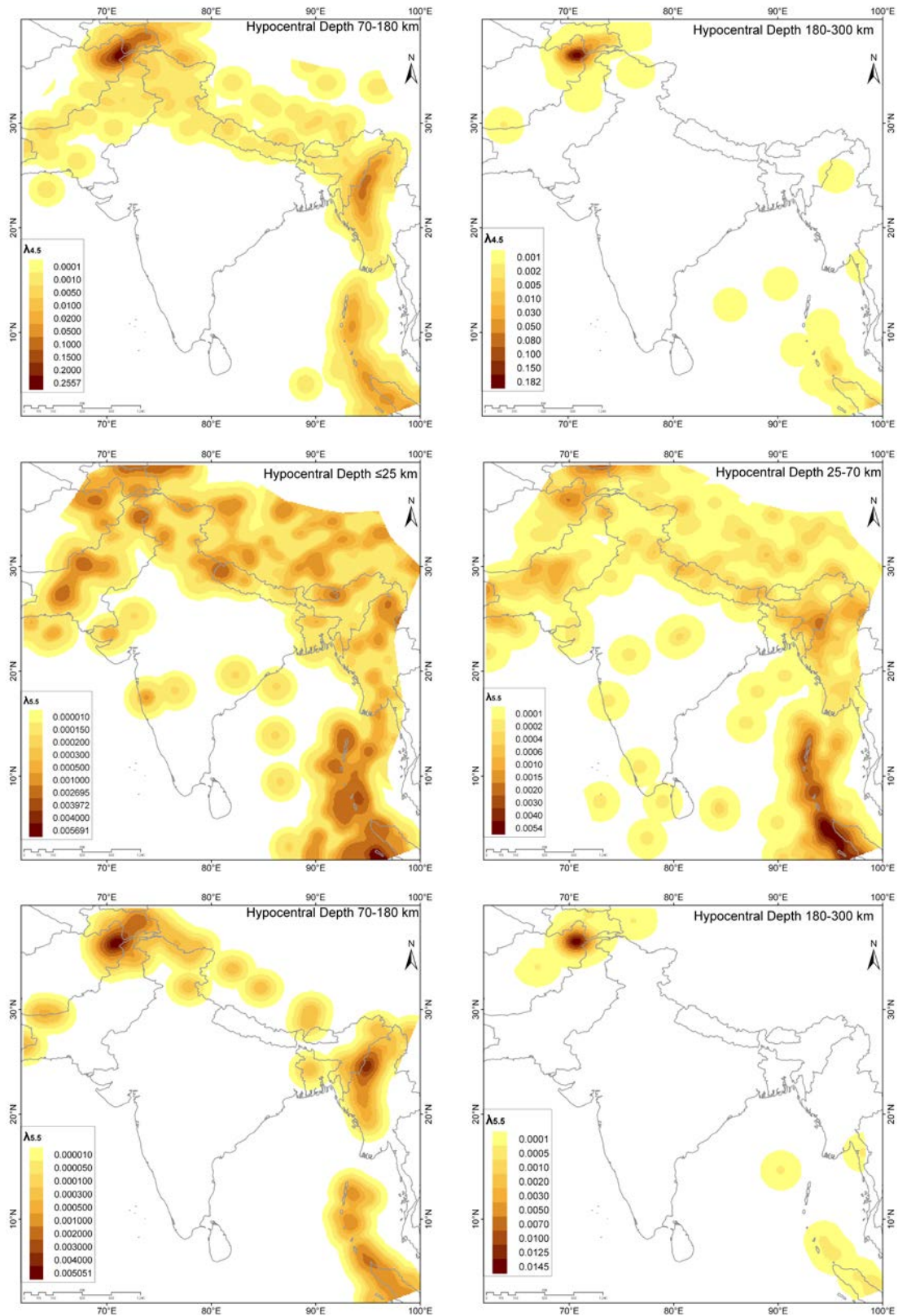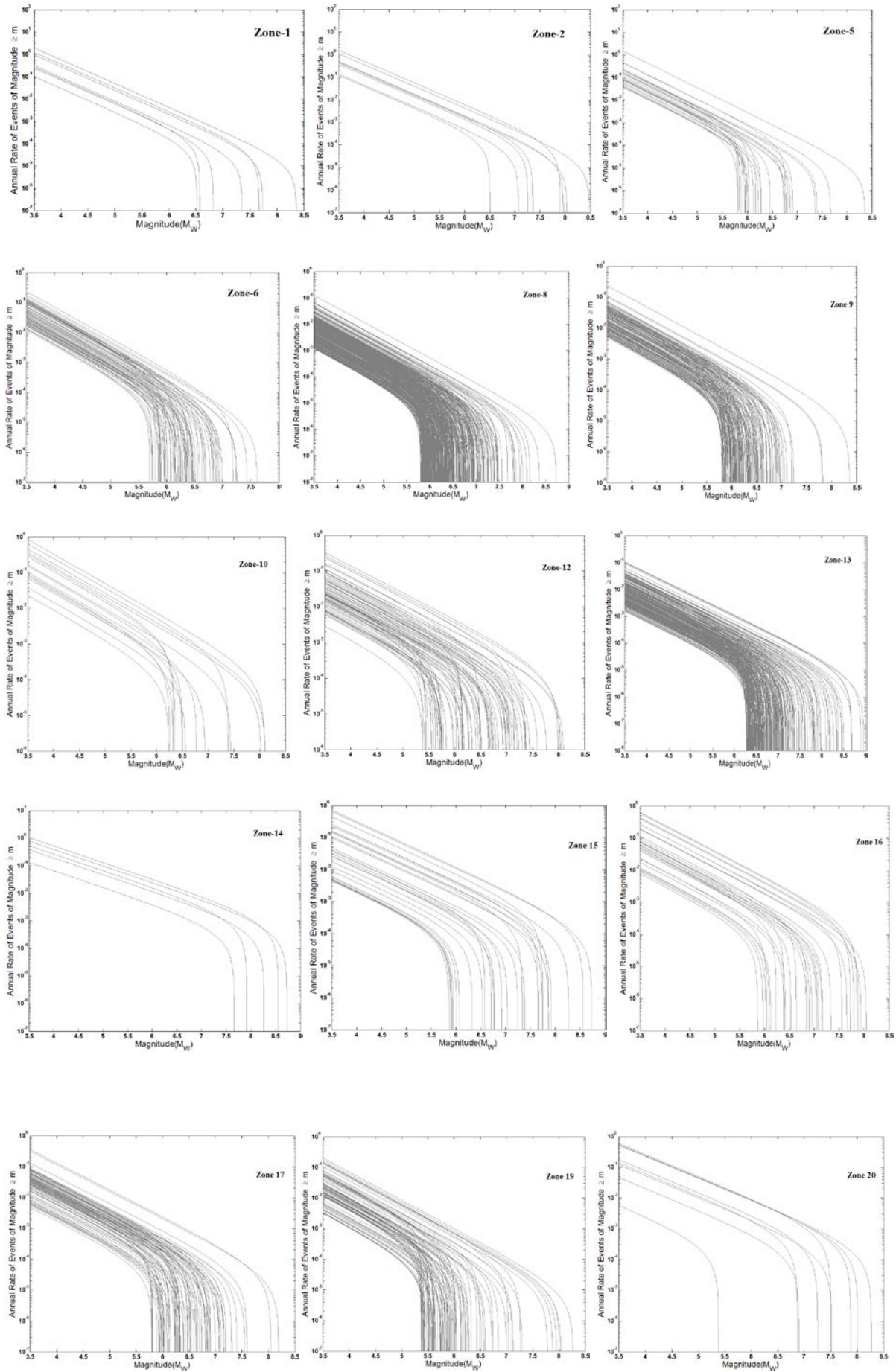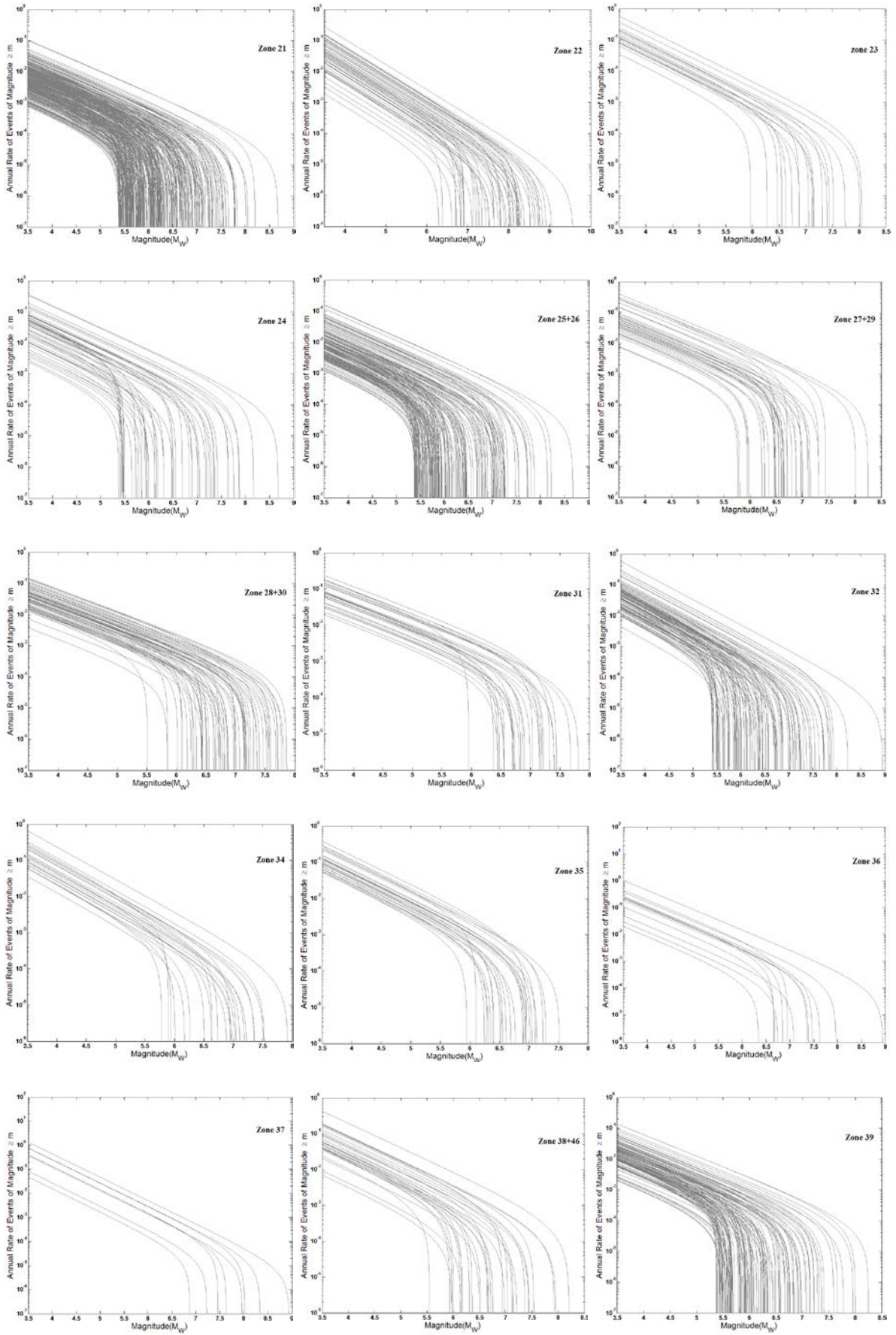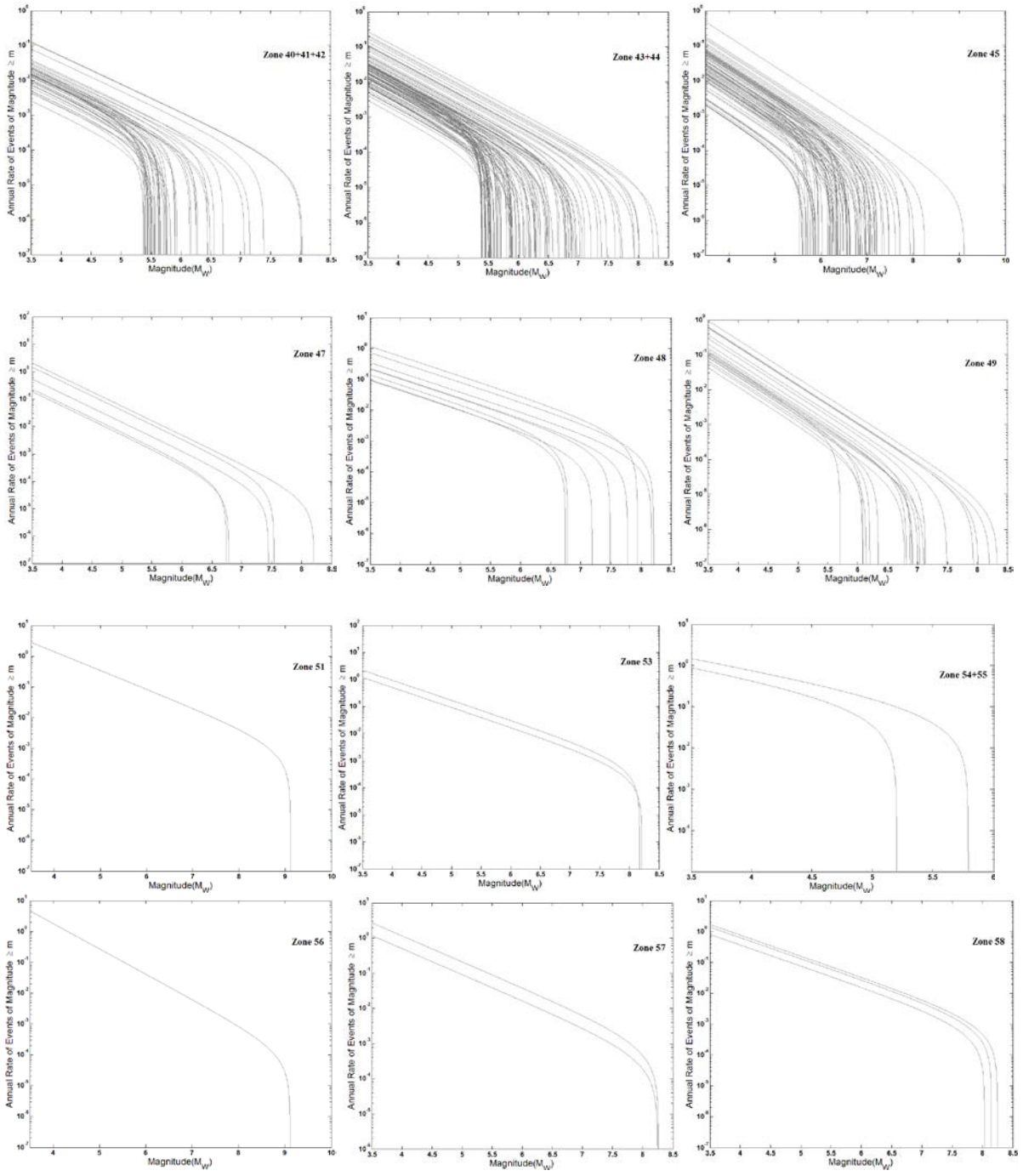**Figure S1** Smoothened gridded seismicity for the polygonal seismogenic sources of India and its surrounding region for the threshold magnitude of M_w 3.5, 4.5 and 5.5 at the hypocentral depth range of **(a)** 0-25km, **(b)** 25-70km, **(c)** 70-180km, and **(d)** 180-300km (After Nath, 2017).
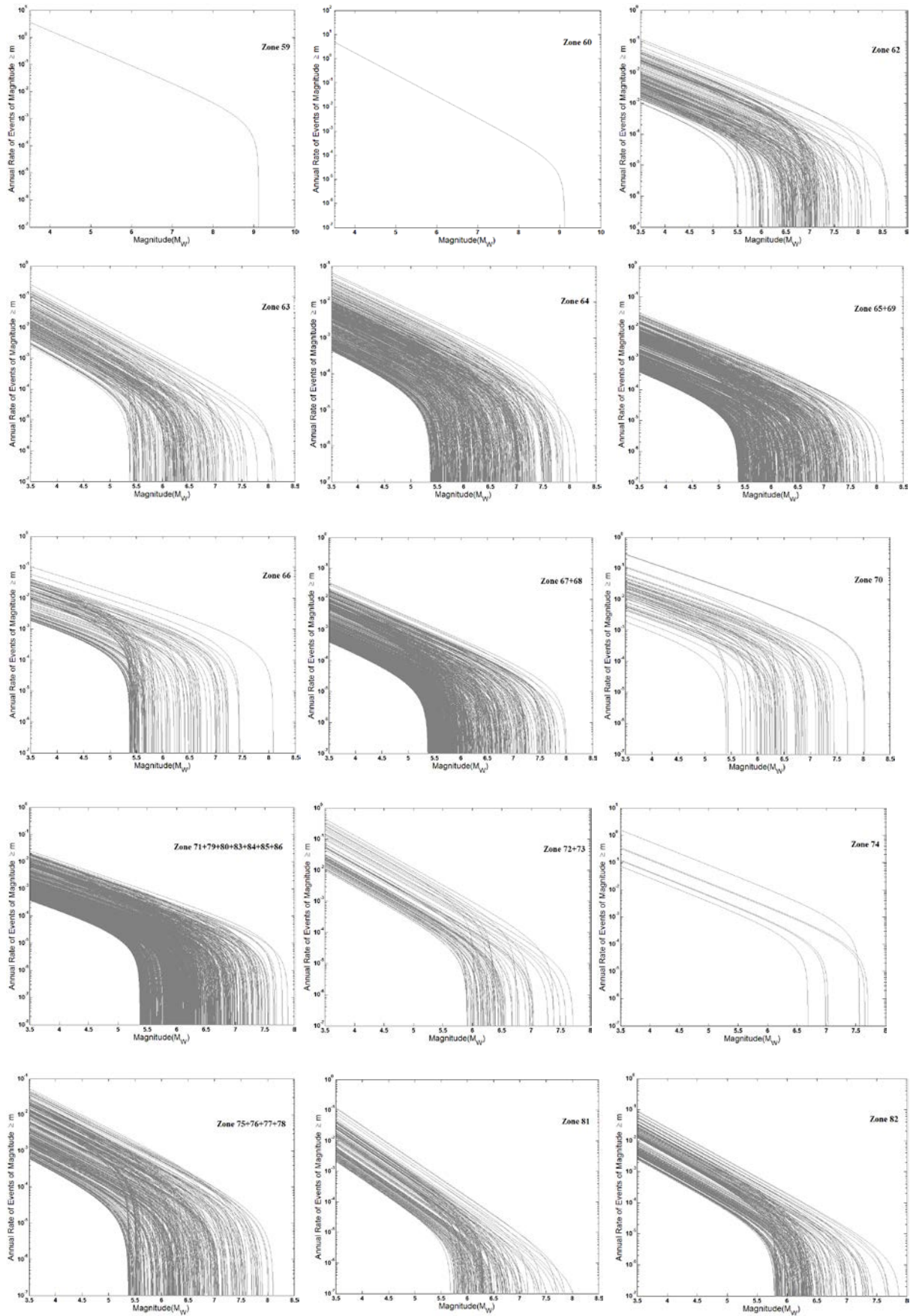
Figure S2 The annual activity rate versus magnitude for a group of active tectonic features inscribed in each

polygonal areal seismogenic source at 0-25km focal depth level for threshold magnitudes of 3.5 (After Nath, 2017).

Table S1. Selected Ground Motion Prediction Equations for PSHA of the Indian Peninsula predominantly comprising of eleven Seismogenic Tectonic Provinces shown in **Fig. 2** in the manuscript.

Seismogenic Tectonic Province	Seismogenic Sources	Global/Regional Ground Motion Prediction Equations (GMPEs)	Next Generation Attenuation (NGA) Models
Bengal Basin including Bangladesh	East-Central Himalaya	Sharma et al. (2009); Toro (2002); Campbell and Bozorgnia (2008)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Bengal Basin	Raghukanth and Iyengar (2007); Toro (2002)	Nath et al. (2014); Maiti et al. (2017); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Northeast India	Youngs et al. (1997); Campbell and Bozorgnia (2008); Nath et al. (2012) (Shallow and Deep crust)	Nath et al. (2009); Nath et al. (2012); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Indo-Gangetic Foredeep	Indo-Gangetic Foredeep	NDMA (2010); Abrahamson and Silva (2008); Raghukanth and Kavitha (2014)	Nath et al. (2019); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Central Himalaya	Anbazhagan et al. (2013); Sharma et al. (2009); Chiou and Youngs (2008)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Central India	Raghukanth and Iyengar (2007); Toro (2002); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Koyna-Warna Region	Central India	Raghukanth and Iyengar (2007); Toro (2002); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Kutch Region	Boore and Atkinson (2008); Sadigh et al. (1997); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Koyna-Warna Region	Raghukanth and Iyengar (2007); Sharma et al. (2009); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Western Ghat Region	Western Ghat Region	Raghukanth and Iyengar (2007); NDMA (2010); Hwang and Huo (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Eastern Ghat Region	Raghukanth and Iyengar (2007); NDMA (2010); Hwang and Huo (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Koyna-Warna Region	Raghukanth and Iyengar (2007); Sharma et al. (2009); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Eastern Ghat Region	Western Ghat Region	Raghukanth and Iyengar (2007); NDMA (2010); Hwang and Huo (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Eastern Ghat Region	Raghukanth and Iyengar (2007); NDMA (2010); Hwang and Huo (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Koyna-Warna Region	Raghukanth and Iyengar (2007); Sharma et al. (2009); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Kashmir Himalaya	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Sharma et al. (2012)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)

Northwest India including Nepal Himalaya	Northwest India	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Harbindu et al. (2014)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Hindu Kush Region	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Darjeeling-Sikkim Himalaya	Normal Fault	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); NDMA (2010); Toro (2002); Akkar and Bommer (2010); Lin and Lee (2008); Chiou and Youngs (2008); Zhao et al. (2006); Atkinson and Boore (2006); Abrahamson and Silva (2008); Campbell and Bozorgnia (2008)	Adhikari and Nath (2016); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Reverse Fault	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); NDMA (2010); Toro (2002); Akkar and Bommer (2010); Lin and Lee (2008); Chiou and Youngs (2008); Zhao et al. (2006); Atkinson and Boore (2006); Abrahamson and Silva (2008); Campbell and Bozorgnia (2008); Sharma et al. (2009); Nath et al. (2012)	Adhikari and Nath (2016); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Strike-slip Fault	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); NDMA (2010); Toro (2002); Akkar and Bommer (2010); Lin and Lee (2008); Chiou and Youngs (2008); Zhao et al. (2006); Atkinson and Boore (2006); Abrahamson and Silva (2008); Campbell and Bozorgnia (2008); Sharma et al. (2009); Nath et al. (2012)	Adhikari and Nath (2016); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Northeast India including Bhutan Himalaya	Eastern Himalayan Zone (EHZ)	Anbazhagan et al. (2013); Nath et al. (2012); Toro (2002)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Mishmi Block Zone (MBZ)	Nath et al. (2012); Youngs et al. (1997); Gupta (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Eastern Boundary Zone (EBZ)	Singh et al. (2016); Gupta (2010); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Shillong Zone (SHZ)	Nath et al. (2012); Youngs et al. (1997); Singh et al. (2016)	Nath et al. (2009); Nath et al. (2012); Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Central India	Central India	Raghukanth and Iyengar (2007); Toro (2002); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Kutch Region	Boore and Atkinson (2008); Sadigh et al. (1997); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Koyna-Warna Regiom	Raghukanth and Iyengar (2007); Sharma et al. (2009); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Kutch Region	Central India	Raghukanth and Iyengar (2007); Toro (2002); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Kutch Region	Boore and Atkinson (2008); Sadigh et al. (1997); NDMA (2010)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and

			Boore (2006)
	Koyna-Warna Region	Raghukanth and Iyengar (2007); Sharma et al. (2009); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
Kashmir Himalaya	Kashmir Himalaya	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Sharma et al. (2012)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Northwest India	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Harbindu et al. (2014)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)
	Hindu Kush Region	Anbazhagan et al. (2013); Raghukanth and Kavitha (2014); Youngs et al. (1997)	Nath (2017); Campbell and Bozorgnia (2003); Atkinson and Boore (2006)

Reference:

1. Abrahamson, N. and Silva, W.: Summary of the Abrahamson & Silva NGA ground-motion relations, Earthquake Spectra, 24(1), 67-97, https://doi.org/10.1193%2F1.2924360, 2008.

2. Adhikari, M. D. and Nath, S. K.: Site-specific next generation ground motion prediction models for Darjeeling-Sikkim Himalaya using strong motion seismometry, Journal of Indian Geophysical Union, 20(2), 151-170, 2016.

3. Akkar, D. S. and Bommer, J. J.: Empirical equations for the prediction of PGA, PGV, and spectral accelerations in Europe, the Mediterranean region, and the Middle East, Seismological Research Letters, 81 (2), 195–206, https://doi.org/10.1785/gssrl.81.2.195, 2010.

4. Anbazhagan, P., Kumar, A., and Sitharam, T. G.: Ground motion prediction equation considering combined dataset of recorded and simulated ground motions, Soil Dynamics and Earthquake Engineering, 53, 92-108, https://doi.org/10.1016/j.soildyn.2013.06.003, 2013.

5. Atkinson, G. M. and Boore, D. M.: Earthquake ground-motion prediction equations for eastern North America, Bulletin of the seismological society of America, 96(6), 2181-2205, https://doi.org/10.1785/0120050245, 2006.

6. Boore, D. M. and Atkinson, G. M.: Ground-motion prediction equations for the average horizontal component of PGA, PGV, and 5%-damped PSA at spectral periods between 0.01 s and 10.0s, Earthquake spectra, 24(1), 99-138, https://doi.org/10.1193%2F1.2830434, 2008.

7. Campbell, K. W. and Bozorgnia, Y.: Updated near-source ground-motion (attenuation) relations for the horizontal and vertical components of peak ground acceleration and acceleration response spectra, Bulletin of the Seismological Society of America, 93(1), 314-331, https://doi.org/10.1785/0120020029, 2003.

8. Campbell, K. W. and Bozorgnia, Y.: NGA ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5% damped linear elastic response spectra for periods ranging from 0.01 to 10s, Earthquake spectra, 24(1), 139-171, https://doi.org/10.1193%2F1.2857546, 2008.

9. Chiou, B. J. and Youngs, R. R.: An NGA model for the average horizontal component of peak ground motion and response spectra, Earthquake spectra, 24(1), 173-215, https://doi.org/10.1193%2F1.2894832, 2008.

10. Gupta, I. D.: Response spectral attenuation relations for in-slab earthquakes in Indo-Burmese subduction zone, Soil Dynamics and Earthquake Engineering, 30(5), 368-377, https://doi.org/10.1016/j.soildyn.2009.12.009, 2010.

11. Harbindu, A., Gupta, S., and Sharma, M. L.: Earthquake ground motion predictive equations for Garhwal Himalaya, India, Soil Dynamics and Earthquake Engineering, 66, 135-148, https://doi.org/10.1016/j.soildyn.2014.06.018, 2014.

12. Hwang, H. and Huo, J. R.: Attenuation relations of ground motion for rock and soil sites in eastern United States, Soil Dynamics and Earthquake Engineering, 16(6), 363-372, https://doi.org/10.1016/S0267-7261(97)00016-X, 1997.

13. Lin, P. S. and Lee, C. T.: Ground-motion attenuation relationships for subduction-zone earthquakes in northeastern Taiwan, Bulletin of the Seismological Society of America, 98(1), 220-240, https://doi.org/10.1785/0120060002, 2008.

14. Maiti, S. K., Nath, S. K., Adhikari, M. D., Srivastava, N., Sengupta, P., and Gupta, A. K.: Probabilistic seismic hazard model of West Bengal, India, Journal of Earthquake Engineering, 21(7), 1113-1157, https://doi.org/10.1080/13632469.2016.1210054, 2017.

15. Nath, S. K., Raj, A., Thingbaijam, K. K. S., and Kumar, A.: Ground Motion Synthesis and Seismic Scenario in Guwahati City—A Stochastic Approach. Seismological Research Letters, 80 (2): 233–242, https://doi.org/10.1785/gssrl.80.2.233, 2009.

16. Nath, S. K., Thingbaijam, K. K. S., Maiti, S. K., and Nayak, A.: Ground-motion predictions in Shillong region, northeast India, Journal of seismology, 16(3), 475-488, https://doi.org/10.1007/s10950-012-9285-8, 2012.

17. Nath, S. K., Adhikari, M. D., Maiti, S. K., Devaraj, N., Srivastava, N., and Mohapatra, L. D.: Earthquake scenario in West Bengal with emphasis on seismic hazard microzonation of the city of Kolkata, India, Natural Hazards and Earth System Sciences, 14, 2549–2575, https://doi.org/10.5194/nhess-14-2549-2014, 2014.

18. Nath, S. K.: Probabilistic Seismic Hazard Atlas of 40 Cities in India, © Ministry of Earth Sciences, Government of India, New Delhi, 457p, 2017.

19. Nath, S. K., Adhikari, M. D., Maiti, S. K., and Ghatak, C.: Earthquake hazard potential of Indo-Gangetic Foredeep: its seismotectonism, hazard, and damage modeling for the cities of Patna, Lucknow, and Varanasi, Journal of Seismology, 23(4), 725-769, https://doi.org/10.1007/s10950-019-09832-3, 2019.

20. NDMA.: Development of probabilistic seismic hazard map of India, Technical Report Published by Govt. of India, New Delhi, Working committee of experts (WCE), NDMA, 2010.

21. Raghukanth, S. T. G. and Iyengar, R. N.: Estimation of seismic spectral acceleration in peninsular India, Journal of Earth System Science, 116(3), 199-214, https://doi.org/10.1007/s12040-007-0020-8, 2007.

22. Raghukanth, S. T. G. and Kavitha, B.: Ground motion relations for active regions in India, Pure and Applied Geophysics, 171(9), 2241-2275, https://doi.org/10.1007/s00024-014-0807-x, 2014.

23. Sadigh, K., Chang, C. Y., Egan, J. A., Makdisi, F., and Youngs, R. R.: Attenuation relationships for shallow crustal earthquakes based on California strong motion data, Seismological research letters, 68(1), 180-189, https://doi.org/10.1785/gssrl.68.1.180, 1997.

24. Sharma, M. L., Douglas, J., Bungum, H., and Kotadia, J.: Ground-Motion Prediction Equations Based on Data from the Himalayan and Zagros Regions, Journal of Earthquake Engineering, 13(8), 1191-1210, https://doi.org/10.1080/13632460902859151, 2009.

25. Sharma, M. L., Harbindu, A., and Kamal: Strong ground motion prediction equation for Northwest Himalayan region based on stochastic approach, In: Proceedings of 15th World Conference of Earthquake Engineering, Lisbon, 2012.

26. Singh, N. M., Rahman, T., and Wong, I. G.: A New Ground-Motion Prediction Model for Northeastern India (NEI) Crustal Earthquakes, Bulletin of the Seismological Society of America, 106(3), 1282-1297, https://doi.org/10.1785/0120150180, 2016.

27. Toro, G. R.: Modification of the Toro et al. (1997) attenuation equations for large magnitudes and short distances, Risk Engineering Technical Report, 10, 2002.

28. Youngs, R. R., Chiou, S. J., Silva, W. J., and Humphrey, J. R.: Strong ground motion attenuation relationships for subduction zone earthquakes, Seismological research letters, 68(1), 58-73, https://doi.org/10.1785/gssrl.68.1.58, 1997.

29. Zhao, J. X., Zhang, J., Asano, A., Ohno, Y., Oouchi, T., Takahashi, T., Ogawa, H., Irikura, K., Thio, H. K., Somerville, P. G., Fukushima, Y., and Fukushima, Y.: Attenuation relations of strong ground motion in Japan using site classification based on predominant period, Bulletin of the Seismological Society of America, 96(3), 898-913, https://doi.org/10.1785/0120050122, 2006.