

Interactive comment on “Probabilistic seismic hazard analysis using logic tree approach – Patna District (India)” by Panjamani Anbazhagan et al.

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General Comment: - The Manuscript entitled “Probabilistic seismic hazard analysis using logic tree approach- Patna District (India)” presents a comprehensive PSHA study for one specific region in north India. Authors employ different alternatives for main PSHA-analyses components including, e.g., Mc, maximum magnitude, GMPE-set, zonation model, etc. to populate the epistemic logic tree. The study is confident, uses extensive local sources dataset and employs up-to-date PSHA analytical tools incorporated into the logic tree approach to treat the epistemic uncertainty. In general, I would recommend publishing present study in NHESS. Nevertheless, I would recommend “major revision” because of the two issues. Both issues deal with the art of presentation, so, I think, Authors could easily accommodate them. First- the

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manuscript has too many figures in the results section, namely 23! Some of them could be combined into one plot. For example, figures presenting PGA maps for the three approaches: ‘classical’, ‘areal seismic zone’ and ‘Frankel’ (Fig. 8a, 11a, 16a). Same for the deaggregation diagrams, and so on. Such a combination, if possible, would make presentation more structured and comparison between methods more evident. Alternatively, Authors may think of moving some figures into the supplementary material. The second issue is writing style. English is generally OK, but the writing style is somewhat sloppy. Especially in the beginning of the manuscript. Please read thoroughly statement-by-statement and put attention at clarity and correctness of the text. To avoid dubious statements like that on Page 2, Lines 10-11. Response: - The authors would like to thank the reviewer for his valuable comments which helped us in reviewing the manuscript. As per the suggestion figures have been combined and few has been used as supplementary material. The writing style has been also improved and the manuscript has been checked thoroughly statement-by-statement. Page 2 and line 10-11 has been revised. Change in the manuscript: In the absence of appropriate region-specific models of wave propagation, ground motion prediction models are generally used to determine the hazard value. Comment 1: - 1-17: tsunami Response: - It has been changed in the revised manuscript. Comment 2: - 1-18: Triggering tsunamis is nothing to do with ground shaking because tsunamis respond to residual, static deformation of the seabed, not to PGV or PGA. Response: - Tsunami has been removed in the revised manuscript. Comment 3: - 1-20: “subduction” Response: - It has been changed in the revised manuscript. Comment 4: - 1-20: I am not sure if you can call the India-Eurasia collision as “subduction zone” because the latter term commonly implies subduction of the oceanic lithosphere whereas in this case, we actually have continent-to-continent collision. Response: - The word “subduction zone” has been replaced by “continent-to-continent collision”. Change in the manuscript: Besides, many great events (2015, Nepal earthquake) have originated from continental-to-continental collision. Comment 5: - 2-6: Does aleatoric uncertainty include “randomness of ground motion prediction”? GMPE’s are derived by people,

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not by nature. Maybe, better to say that it includes randomness of wave propagation and site amplification? Response: - It has been changed as per the suggestion. The statement has been changed as follow Change in the manuscript: One is due to randomness of the nature of earthquake, wave propagation, and site amplification named as aleatory uncertainty while other is due to incomplete knowledge of earthquake process named as epistemic uncertainty. Comment 6: - 2-11: I do not see the logical connection between the sentence starting with “Generally, ground motion: : :.” and the next one. Logic tree is used to quantify all kinds of epistemic uncertainty, not only that related to GMPE’s. Please consider re-formulating these paragraphs. Response: - As per the suggestion this paragraph has been revised. It has been revised as follow Change in the manuscript: Epistemic uncertainty is due to improper knowledge about the process involve in earthquake events and algorithms used to model them. Hence, in this study, logic tree framework has been used to reduce the epistemic uncertainty in the final hazard value calculation. In the absence of appropriate region-specific models of wave propagation, ground motion prediction models are generally used to determine the hazard value. The uncertainty in GMPEs can be reduced by incorporating logic tree in the hazard analysis study. Comment 7: - 2-15: if weight is assigned, we cannot speak about “qualitative” assessment any more Response: - This word has been removed in the revised manuscript. Comment 8: - 2-21: “As per Bilham” – what is “per”? Response: - “As per” has been replaced with “similar to” Comment 9: - 2-28: “determined weighted mean”? Response: - Apology for the typo. This statement has been revised as below Change in the manuscript: Maximum magnitude has been determined using weighted mean considering three methods as increment factor on maximum observed magnitude, Kijko and Sellevoll (1989) and regional rupture characteristics (Anbazhagan et al. 2015b). Comment 10: - 2-31: “viz.” ? Response: - “viz.” has been replaced by “namely” Comment 11: - 3-7: what is “SSA”. Define explicitly before using abbreviation for the first time. Response: - “SSA” is seismic study area and it has been mentioned in the revised manuscript. Comment 12: - 3-8: an area cannot have only one single value of lon and lat. A point

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can, area – not. Response: - The statement has been changed as follow Change in the manuscript: The present study area has covered the longitude 84.6-85.65°E and latitude 25.2-25.8°N Comment 13: - 3-10: give reference to Figure 1 in the beginning of Patna region description Figure 1: source labels not readable I suggest adding a supplementary table describing individual faults. Or, alternatively, to extend Table S1 with additional parameters like position, rupture length. Response: - As per the suggestion, the refence of Figure 1 has been given in the beginning and Table S1 has been extended by providing the position (latitude and longitude of the end points), total fault length and rupture length. Comment 14: - 3-16/17: redundancy Response: - As per the suggestion the sentences are moved blow at relevant position. Comment 15: - 3-28: this sentence looks redundant. The whole paragraph is better to move to the beginning of the current chapter. Response: - As per the suggestion the whole paragraph is moved in the beginning of the paragraph. Change in the manuscript: Based on damage distribution map i.e. isoseismal map (1833 Nepal earthquake and 1934 Bihar-Nepal earthquake) and location of Main Boundary Trust, Main Central Trust and Himalayan Frontal Thrust (HFT), a radius of 500 km has been selected for present SSA. The detail study about selecting SA of 500 km is given in Anbazhagan et al. (2015a). Geographical information of India demonstrates that approximately 60 % of the land is highly susceptible to earthquakes (NDMA, 2010). The tectonic feature of SA has been compiled from the Seismotectonic Atlas (SEISAT, 2010) published by the Geological Survey of India (GSI, 2000). The seismotectonic map was developed by considering 500 km radius from Patna district boundary by considering linear sources (faults and lineaments) from SEISAT and published literatures (e.g. NDMA, 2010; Nath and Thingbaijam, 2012; Kumar et al., 2013). Separation of MBT and MCT has been done and all the faults along with MBT and MCT have also been numbered. Seismotectonic map for Patna District is shown in Figure 1. A brief description of seismicity and seismotectonics of SSA is given below. Comment 16: - 4-21: it is still worth to provide GR-expression with ‘a’ and ‘b’ parameters Seismicity parameters ‘a’ and ‘b’ are discussed in both Sections 3.1 and 3.2. That is why present Section

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titles look somewhat misleading. Consider renaming these sections, for example, according to the derivation approach: period of completeness (3.1) vs magnitude of completeness (3.2). Response: - Both the sections have been renamed as per the suggestion Comment 17: - 5-13: why M4.5 was finally accepted as Mc? This statement comes into contradiction with following statements where Authors accept M6-model to be their reference model. M6 has different Mc values for the two regions. Response: - Apology for the same. This statement has been removed as it's a typo error. Comment 18: - General Remark to Section 3.2: Authors employ 9 different methods to estimate 'a', 'b', and Mc. But finally accept only one model, M6, giving the corresponding logic tree node weight = 0.5. That means all other models were given zero weights despite some of them (M1,3,5) show results similar to M6. Authors should clearer justify why they do neglect all other 8 models. Response: - Nine methods have been used to check the variability in 'a', 'b', and Mc for the same study area. However as per Boomer et al. (2005) calculation effort increases dramatically with the inclusion of more branches in the logic tree. Therefore, Bommer et al. (2005) suggested avoiding using branches with slight differences between the options, in cases when those options result in very similar nodes. Hence only M6 has been used as M6 method is capable for M_c calculation as it synthetically maximises the available data and stabilises the M_c value. Change in the manuscript: According to Boomer et al. (2005) calculation effort increases dramatically with the inclusion of more branches in the logic tree. Therefore, Bommer et al. (2005) suggested avoiding using branches with slight differences between the options, in cases when those options result in very similar nodes. Hence only M6 has been used as M6 method is capable for M_c calculation as it synthetically maximises the available data and stabilises the M_c value. Comment 19: - 9-29: vulnerable? Response: - Apology for the typo. This word has been replaced. ===== END =====

Please also note the supplement to this comment:

<https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-328/nhess-2018-328->

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AC1-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2018-328>, 2019.

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