Response to Reviewers' comments, observations, and actions taken thereof while revising the Manuscript ID: nhess-2022-66 Titled "**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**" by Nath et al.

Response to the comments and observations of Anonymous Reviewer#1

Reviewer#1 Overall observation: The authors present several case studies on site characterization and PSHA of Indian cities. The paper is within the scope of the journal; however, the scientific quantity should be greatly improved in order to consider for publication. Considering the merits of the papers, I encourage the authors to consider the following comments to improve the manuscript.

Authors' Response: We feel encouraged by the words of appreciation of the Reviewer. We hereby provide point-by-point response to all the comments and suggestions made by the Reviewer and lay down the proposed actions to be taken thereof while revising the earlier version of the manuscript once asked to do by the Editorial board.

Reviewer#1: Abstract should be rewritten since the entire paragraph is superfluous.

Authors' Response: We tried to put up a marginally revised abstract (199 words) based on the suggestions made by the Reviewer, which now reads as follows:

"The Socio-economic Risk Map of India generated by integrating Population Density, Building Density, and Landuse/Landcover with IBC-compliant Probabilistic Surface PGA through Analytic Hierarchy Process places the entire tectonic stretch from Kashmir Himalaya to Northeast India together with Bhutan, Northwest India, Nepal, Indo-Gangetic Foredeep, Bengal Basin and Darjeeling-Sikkim Himalaya, in 'High' to 'Severe' Risk regime thus bringing in the essence of site-specific study in this ensemble. Hybrid surface and downhole Geophysical and Geotechnical measurements provided effective Shear wave velocity of soil/alluvium column (V_s^{30}) which classifies the Ensemble into 11 site classes viz. F/E, D4, D3, D2, D1, C4, C3, C2, C1, B and A with respective spectral site amplification of 6.2, 4.8, 4.2, 3.9, 3.3, 2.58, 2.2, 1.87, 1.81, 1.4 and 1.2 respectively at 0.73-8.5 Hz frequency range thus facilitating surface-consistent PGA varying between 0.06-1.99g that correlates well with those reported by others. The reported damage scenario on URM and RC buildings triggered by large historical earthquakes in each of the tectonic assemblages are seen to fit well within the, 'slight', 'moderate', 'extensive' and 'complete' damage states as assessed using capacity spectrum method on the prevalent building types for the surface-consistent probabilistic PGA through SELENA-based building damage modelling."

Further suggestions are welcome.

Reviewer#1: Please use modest language instead of overly romanticized phrases such as 'huge threats,' 'jolted time and again,' 'wreaked havoc', and many more.

Authors' Response: Very good suggestion. Appropriate technical and simple languages will replace the existing ones in the revised manuscript.

Reviewer#1: I think Indo-Eurasian subduction region is seismically highly active than peninsular India. Please check.

Authors' Response: Very true. **Figure 3** depicting the main shock distribution from the earthquake catalogue used in this study exhibits that major seismic events are concentrated along the Indo-Eurasian subduction region; on the contrary, the seismicity in the Peninsular India region is scanty. Also from the smoothened gridded seismicity models for the polygonal seismogenic sources of India and its surrounding region for the threshold magnitudes of M_w 3.5, 4.5 and 5.5 at the four hypocentral depth ranges used in the present study and shown in **Figure S1** in the electronic supplement exhibit higher seismic activity rate in the Himalayan belt as compared to that in the Peninsular shield region. The updated Probabilistic Seismic Hazard map of the Indian subcontinent at firm rock site condition for 10% probability of exceedance in 50years shown in **Figure 7(a)** also exhibits a higher hazard level to the tune of 0.45-0.95g in terms of Peak Ground Acceleration (PGA) distribution in the Himalaya and the Sub-Himalayan regions whereas the same in the Peninsular India shows a variation of 0.05-0.45g only.

Reviewer#1: Please check manuscript language thoroughly and write sentences in objective way, instead of long and curvaceous sentences.

Authors' Response: Noted. This will be taken care of while revising the manuscript once advised by the Editorial Board. A glimpse of which is given below.

"The collision between the Indian and the Eurasian plates caused huge tension in the crust, which is relieved occasionally by earthquakes along the plate boundary as well as intraplate faults and lineaments. The Vulnerability Atlas of India (BMTPC, 2019) mentions that more than 59% of the country's total land-cover is vulnerable to seismic threat. Unplanned urbanizations are fast emerging across the country to accommodate the burgeoning population………… Nath et al. (2017) developed a homogeneous M_w based declustered earthquake catalogue of Southeast Asia and the surrounding region considering earthquake recordings spanning over the period of 1900-2014. The uniform magnitude scaling in moment magnitude M_w in this catalogue is accomplished through correlating various magnitude types and then declustering the mainshocks from foreshocks and aftershocks and the mainshocks only retained as shown in **Figure 3** that depicts 64,153 mainshock events in the region, which has further been extended to the year 2018 for Seismic Hazard, Vulnerability and Risk Assessment of the region as performed here. ……….."

Reviewer#1: Line no. 39 requires a reference.

Authors' Response: As per the above suggestion, line no. 39 in the earlier version of the manuscript will be modified as follows and will be incorporated in the revised manuscript.

"The fatality counts in urban settlements due to future great Himalayan earthquakes have been envisaged to be around 150-200 thousand (Wyss, 2005; Bilham et al., 2001)."

Reviewer#1: The paper is excessively long and lacks justification for such a long discussion. I request the authors to focus straight on the objectives and related works.

Authors' Response: The observation has been noted and the text will be modified in the revised manuscript.

Reviewer#1: Authors note that they would like to use the results for India, Nepal, and Bhutan; however, they do miss some major contributions related to earthquake hazard and vulnerability especially from Nepal and Bhutan. Some references are:

https://www.sciencedirect.com/science/article/pii/S1631071317300718 https://www.tandfonline.com/doi/abs/10.1080/13632469.2020.1868362?src=&journalCode=ueqe20

For fatality/injury functions: https://www.sciencedirect.com/science/article/pii/B9780128210871000144

among others. There are hundreds of published literatures in the same field, at least for each section, from the same region, please try to synthesize some to juxtapose your work with the existing ones.

Authors' Response: Very good suggestion. The followings are our responses within the quotes (""), most of which including the diagram are intended to be included in the main body of the revised manuscript while the supportive tables will be incorporated in the electronic supplementary material of this manuscript.

"As suggested, we went for a rigorous literature review for all the sections of this manuscript and provide here section-wise comparative analyses.

A. Bedrock PSHA: In order to find out the reporting's of all the Probabilistic Seismic Hazard (PSH) related researches we browsed through the publications in Scopus journals, technical literatures, open file reports, online documentations etc. wherein we could come up with comparative clustering of the Probabilistic bedrock level PGA estimated by several researchers including the present study for 10% probability of exceedance with 475years of return period in 50years for more than 50 cities of which we appraise here the clustering of Kathmandu, Guwahati, Dhaka, Kolkata, Lucknow, New Delhi, Chandigarh and Srinagar located in the present tectonic ensemble from Kashmir Himalaya to Northeast India encompassing 6 tectonic blocks viz. Kashmir Himalaya, Northwest India, Indo-Gangetic Foredeep, Bengal Basin, Eastern Himalayan Zone and Northeast India together with Nepal, Bhutan and Bangladesh. The bedrock level PGA in the all these cities from the present study are seen to fit well within the cluster ranges extracted from all the researchers as given in **Figure 11** below.

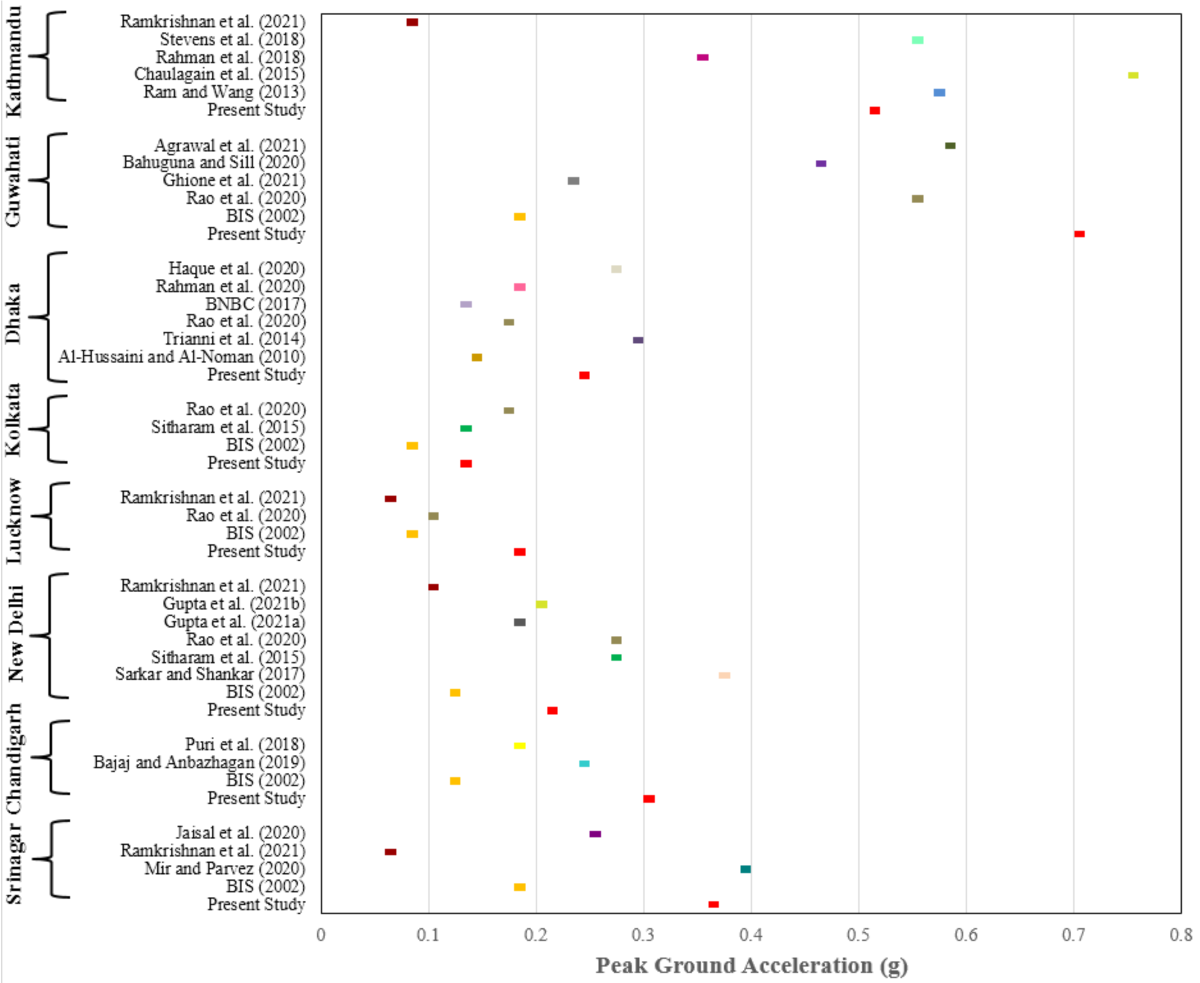


Figure 11. Comparative clustering of the Probabilistic bedrock level Peak Ground Acceleration estimated by several researchers including the present study for 10% probability of exceedance with 475years of return period in 50 years for the cities of Kathmandu, Guwahati, Dhaka, Kolkata, Lucknow, New Delhi, Chandigarh and Srinagar located in the present tectonic ensemble from Kashmir Himalaya to Northeast India encompassing 6 tectonic blocks together with Nepal, Bhutan and Bangladesh. The peak ground acceleration from the present study in all the cities are seen to fit well within the cluster ranges extracted from all the researchers.

Apart from this, we generated two **Tables S9** and **S10** where we presented a comparison of bedrock PGA values for 21 cities from India, Nepal, Bhutan and Bangladesh for both 10% and 2% probability of exceedance in 50years with 475years and 2475years of return periods respectively as extracted for aforementioned literatures, open file reporting's etc. and those from the present study. These two tables are intended to be incorporated in the electronic supplement of this manuscript. Our results presented in this manuscript find good agreement with many of the research reporting's as is evident from both the tables for both 475years and 2475years of return periods. The marginal variation of our probabilistic estimate and that by others are attributed to:

1. The consideration of 85 polygonal seismogenic Sources and 413 tectonic seismogenic sources inscribed within these polygonal seismogenic sources in the logic tree framework designed in the present study.
2. Usages of updated seismicity for the period 1900-2018 with three threshold magnitudes of M_w 3.5, 4.5 and 5.5 in the present study.
3. Inclusion of depth-wise variation of activity rates in the present study.
4. Region-specific maximum earthquake prognosis in the present study.
5. Selection of the hordes of Ground Motion Prediction Equations(GMPE) taken from all the local-specific researches totaling to about 197 of which there had been 68 Next Generation Spectral Attenuation models (NGAs) developed by Nath (2017) and Nath et al. (2021) as a part of the present research, there had also been global GMPEs from active and passive tectonic source regime considerations, all of whose weights and ranks have been determined through Log Likelihood (LLH) calculations and finally the same assigned on the Logic Tree Framework designed for PSHA in the present study.
6. Further, in the present study, we have used both the aleatory and epistemic uncertainties associated with magnitude, rupture distance and GMPEs for all the seismogenic provinces considered here.

Table S9. Comparison of Peak Ground Acceleration (PGA) for 10% probability of exceedance in 50years with 475years of return period from various literatures and present study.

Sl. No.	City Name	PGA(g) for 10% probability of exceedance in 50years with 475years of return period					Reference
		BIS (2002) [zone]	**GSHAP (Bhatia *et al.*, 1999)**	**Nath and Thingbaijam (2012)**	**Present Study**	**Other Studies**	
1	Amritsar	0.12 [IV]	0.00-0.05	0.20-0.25	0.17-0.18	0.18 0.20-0.35 0.12	Bajaj and Anbazhagan (2019) Rao et al. (2020) Mir and Parvez (2020)
2	Bhubaneswar	0.08 [III]	0.00-0.05	0.04-0.08	0.07-0.08	0.05-0.08 0.04-0.06	Rao et al. (2020) Scaria et al. (2021)
3	Chandigarh	0.12 [IV]	0.15-0.20	0.30-0.35	0.30-0.31	0.14-0.21 0.24 0.35-0.55	Puri and Jain (2018) Bajaj and Anbazhagan (2019) Rao et al. (2020)
4	New Delhi	0.12 [IV]	0.10-0.15	0.20-0.25	0.19-0.20	0.27 0.00-0.37 0.2-0.35 0.18 0.07-0.33 0.10	Sitharam et al. (2015) Sarkar and Shanker (2017) Rao et al. (2020) Gupta et al. (2021a) Gupta et al. (2021b) Ramkrishnan et al. (2021)
5	Guwahati	0.18 [V]	0.25-0.30	0.60-0.70	0.70-0.71	0.46 0.35-0.55 0.20-0.25 0.54-0.62	Bahuguna and Sil (2020) Rao et al. (2020) Ghione et al. (2021) Agrawal et al. (2021)
6	Kolkata	0.08 [III]	0.05-0.10	0.12-0.16	0.13-0.14	0.13 0.08-0.20	Sitharam et al. (2015) Rao et al. (2020)

7	Lucknow	0.08 [III]	0.05-0.10	0.16-0.20	0.16-0.17	0.08-0.13 0.06	Rao et al. (2020) Ramkrishnan et al. (2021)
8	Ranchi	0.05 [II]	0.075	0.12-0.16	0.05-0.15	0.04-0.06 0.13-0.20	Scaria et al. (2021) Rao et al. (2020)
9	Patna	0.12 [IV]	0.00-0.05	0.20-0.25	0.14-0.15	0.11-0.15 0.08-0.13 0.04	Anbazhagan et al. (2019a) Rao et al. (2020) Ramkrishnan et al. (2021)
10	Srinagar	0.18 [V]	0.20-0.25	0.08-0.12	0.36-0.37	0.22-0.27 0.39 0.06 0.35-0.55	Jaisal et al. (2020) Mir and Parvez (2020) Ramkrishnan et al. (2021) Rao et al. (2020)
11	Varanasi	0.08 [III]	0.05-0.10	0.08-0.12	0.10-0.11	0.09-0.11 0.05-0.08	Nath et al. (2019) Rao et al. (2020)
12	Dhaka		0.20-0.25	0.20-0.25	0.23-0.24	0.14 0.29 0.13 0.15-0.20 0.27 0.13-0.20	Al-Hussaini and Al-Noman (2010) Trianni et al. (2014) BNBC (2017) Rahman et al. (2020) Haque et al. (2020) Rao et al. (2020)
13	Chittagong		0.35-0.40	0.30-0.35	0.35-0.36	0.18 0.13 0.19 0.40-0.50 0.41	Al-Hussaini and Al-Noman (2010) Trianni et al. (2014) BNBC (2017) Rahman et al. (2020) Haque et al. (2020)
14	Jammu	0.12	0.10-0.15	0.30-0.35	0.33-0.34	0.17-0.22	Jaisal et al. (2020)

		[IV]				0.35-0.55	Rao et al. (2020)
15	Thimphu		0.25-0.30	0.25-0.30	0.35-0.37	0.55-0.60 0.20-0.35	Ghione et al. (2021) Rao et al. (2020)
16	Kathmandu		0.20-0.25	0.45-0.5	0.50-0.51	0.51-0.55 0.75 0.35 0.52-0.57 0.08	Ram and Wang (2013) Chaulagain et al. (2015) Rahman et al. (2018a) Stevens et al. (2018) Ramkrishnan et al. (2021)
17	Aizawl	0.18 [V]	0.40-0.45	0.50-0.55	0.54-0.56	0.35-0.55 0.15-0.20	Rao et al. (2020) Ghione et al. (2021)
18	Imphal	0.18 [V]	0.40-0.45	0.60-0.70	0.68-0.69	0.20-0.25 0.55-0.90 0.90-1.50	Pallav et al. (2012) Rao et al. (2020) Ghione et al. (2021)
19	Shillong	0.18 [V]	0.25-0.30	0.60-0.70	0.73-0.74	0.35-0.55 0.16 0.40-0.45	Rao et al. (2020) Baro et al. (2020) Ghione et al. (2021)
20	Gangtok	0.12 [IV]	0.25-0.30	0.30-0.35	0.36-0.38	0.43 0.35-0.55 0.55-0.60 0.08	Rahman et al. (2018a) Rao et al. (2020) Ghione et al. (2021) Ramkrishnan et al. (2021)
21	Agartala	0.18 [V]	0.35-0.40	0.25-0.30	0.28-0.29	0.20-0.35	Rao et al. (2020)

Table S10. Comparison of Peak Ground Acceleration (PGA) for 2% probability of exceedance in 50years with 2475years of return period from various literatures and present study.

Sl. No.	City Name	PGA(g) for 2% probability of exceedance in 50years with 2475years of return period			Reference
		Nath and Thingbaijam (2012)	Present Study	Other Studies	
1	Amritsar	0.25-0.40	0.40-0.42	0.25-0.3	Sitharam et al. (2015)
2	Bhubaneswar	0.08-0.20	0.17-0.19	0.09-0.14 0.01	Scaria et al. (2021) Huded and Dash (2022)
3	Chandigarh	0.35-0.70	0.60-0.61	0.24-0.4	Puri and Jain (2018)
4	New Delhi	0.25-0.50	0.42-0.43	0.22 0.51 0.00-0.64 0.32 0.12-0.37 0.18	Iyengar and Ghosh (2004) Sitharam et al. (2015) Sarkar and Shanker (2017) Gupta et al. (2021a) Gupta et al. (2021b) Ramkrishnan et al. (2021)
5	Guwahati	0.70-1.30	0.85-0.87	0.78 0.83-0.93	Bahuguna and Sil (2020) Agrawal et al. (2021)
6	Kolkata	0.16-0.30	0.30-0.31	0.23	Sitharam et al. (2015)
7	Lucknow	0.20-0.40	0.42-0.43	0.07-0.13 0.08	Sitharam et al. (2013) Ramkrishnan et al. (2021)
8	Ranchi	0.30-0.40	0.28-0.30	0.09-0.14	Scaria et al. (2021)
9	Patna	0.25-0.40	0.31-0.33	0.05-0.44 0.3-0.38	Anbazhagan et al. (2015) Anbazhagan et al. (2019a)

				0.08	Ramkrishnan et al. (2021)
10	Srinagar	0.30-0.40	0.58-0.60	0.69-0.70 0.37-0.47 0.08	Sana (2019) Jaisal et al. (2020) Ramkrishnan et al. (2021)
11	Varanasi	0.30-0.40	0.25-0.27	0.03	Raghucharan and Somala (2021)
12	Dhaka	0.50-0.60	0.39-0.40	0.30-0.40 0.55	Rahman et al. (2020) Haque et al. (2020)
13	Chittagong	0.70-0.80	0.49-0.51	0.9-1.0 0.84	Rahman et al. (2020) Haque et al. (2020)
14	Jammu	0.60-0.70	0.52-0.54	0.27-0.37	Jaisal et al. (2020)
15	Kathmandu	0.90-1.00	0.76-0.78	1.00-1.07 0.66 0.81-0.90 1.00 0.18	Ram and Wang (2013) Chaulagain et al. (2015) Rahman et al. (2018a) Stevens et al. (2018) Ramkrishnan et al. (2021)
16	Aizawl	1.00-1.10	0.72-0.73	0.13-0.20 0.22-0.32	Sil et al. (2013) Agrawal et al. (2021)
17	Imphal	1.30-1.40	0.97-0.99	0.3-1.1 0.14 0.32-0.42	Pallav et al. (2012) Das et al. (2016) Agrawal et al. (2021)
18	Shillong	1.40-1.50	0.87-0.88	0.24 0.73-0.83	Baro et al. (2020) Agrawal et al. (2021)
19	Gangtok	0.60-0.70	0.69-0.70	0.62 0.18	Rahman et al. (2018a) Ramkrishnan et al. (2021)

20	Agartala	0.50-0.60	0.45-0.46	0.20-0.27 0.42-0.52	Sil et al. (2013) Agrawal et al. (2021)

B. V_s^{30}:

In order to establish the authenticity of the measured/calculated **V_s^{30}** in the present study we made a comparative analysis of the same with those reported by others in several cities and urban centers of this tectonic ensemble and found an excellent match as is evident from **Table S11** given below which may also be incorporated in the electronic supplement of the main manuscript.

"**Table S11.** Comparison of effective shear wave velocity (V_S^{30}) variation from various literatures and present study.

Location	**V_s^{30} (m/s) Present study**	**V_s^{30} (m/s) Other studies**	**Reference**
Amritsar	257-370	180-360	Anbazhagan et al. (2019b)
New Delhi	220-360	230-350 270-565	Satyam and Rao (2008) Pandey et al. (2016)
Lucknow	204-391	230-470	Anbazhagan et al. (2013)
Patna	198-356	180-270	Anbazhagan et al. (2019b)
Varanasi	191-356	180-360 221-692	Anbazhagan et al. (2019b) Singh et al. (2021)
Kolkata	160-310	119-359	Nath et al. (2014)
Dhaka	114-291	127-320	Rahman et al. (2018b)
Chittagong	108-304	123-420	Rahman et al. (2016)
Jammu	250-470	340-390	Mahajan et al. (2012)
Chandigarh	180-360	210-290	Kandpal et al. (2009)
Kathmandu	112-368	366-490 148-298	Chen et al. (2017) Gautam and Chamlagain (2016)
Guwahati	102-300	180-760	Kumar et al. (2018)
Aizawl	320-620	360-760 200-950	Sil and Sitharam (2017) Rao and Ramhmachhuani (2017)
Shillong	248-760	275-375	Biswas et al. (2018)
Agartala	120-240	180-360	Sil and Sitharam (2017)
Srinagar	140-380	<180-360 139-451	Sana (2018) Zahoor et al. (2019)

C. Surface-consistent PGA:

A comparative study between the present surface-consistent PGA and those reported by others have also been undertaken for as many as 50 cities of which 14 significant city results have been tabulated in **Table S12** below which may also be incorporated in the Electronic supplement of the manuscript. It is evident that our result agrees to almost all the reporting thus establishing efficacy of the process protocol followed in our study.

Table S12. Comparison of Surface-consistent Probabilistic Peak Ground Acceleration (PGA) for 10% probability of exceedance in 50years with 475years of return period from various literatures and the present study.

Sl. No.	City Name	Surface-consistent PGA(g) for 10% probability of exceedance in 50years with 475years of return period		References
		Present Study	**Other Studies**	
1	Aizawl	0.6-0.8	0.60-0.70	Sitharam et al. (2015)
2	Ambala	0.20-0.40	0.299 0.30-0.40	Puri and Jain (2021) Sitharam et al. (2015)
3	Chandigarh	0.20-0.40	0.20-0.30 0.30-0.40	Puri and Jain (2018) Sitharam et al. (2015)
4	Gangtok	0.4-0.6	0.70	Sitharam et al. (2015)
5	Imphal	0.8-1.0	0.30-0.80 0.63	Pallav et al. (2015) Sitharam et al. (2015)
6	Itanagar	0.4-0.6	0.60-0.70	Sitharam et al. (2015)
7	Kohima	0.8-1.0	0.60-0.70	Sitharam et al. (2015)
8	Kolkata	0.20-0.40	0.17-0.25 0.30-0.40 0.39	Nath et al. (2014) Sitharam et al. (2015) Maiti et al. (2017)
9	Lucknow	0.20-0.40	0.10-0.40 0.26-0.29 0.20-0.30	Sitharam et al. (2013) Nath et al. (2019) Sitharam et al. (2015)
10	New Delhi	0.2-0.4	0.42 0.20	Sitharam et al. (2015) Iyenger and Ghosh (2004)
11	Panipat	0.20-0.40	0.145 0.20-0.30	Puri and Jain (2021) Sitharam et al. (2015)
12	Patna	0.20-0.40	0.22-0.24 0.20-0.30	Nath et al. (2019) Sitharam et al. (2015)
13	Srinagar	0.8-1.0	0.6-0.7	Sitharam et al. (2015)
14	Varanasi	0.05-0.20	0.14-0.17 0.20-0.30	Nath et al. (2019) Sitharam et al. (2015)

D. **Structural Impact Assessment in terms of Damage Potential Modelling and Human Casualty Assessment in cities of the seismogenic Tectonic Ensemble from Kashmir Himalaya to Northeast India:**

(i) **Building identification and classification following FEMA (2000) and WHE-PAGER (2008) nomenclature using Google Earth Imagery with due validation performed using Rapid Visual Screening, (RVS) on 25% samples of the entire ensemble and establishing user and producer accuracy and Kappa Statistics as enunciated below.**

The seismic resistant capability of a building is closely related to its structural type. The damage of a building depends on a number of factors including building type, building height, building age, building floor area, etc. In the present study, the building typology is classified based on the following image processing-cum accuracy assessment protocol given in **Figure S7.**

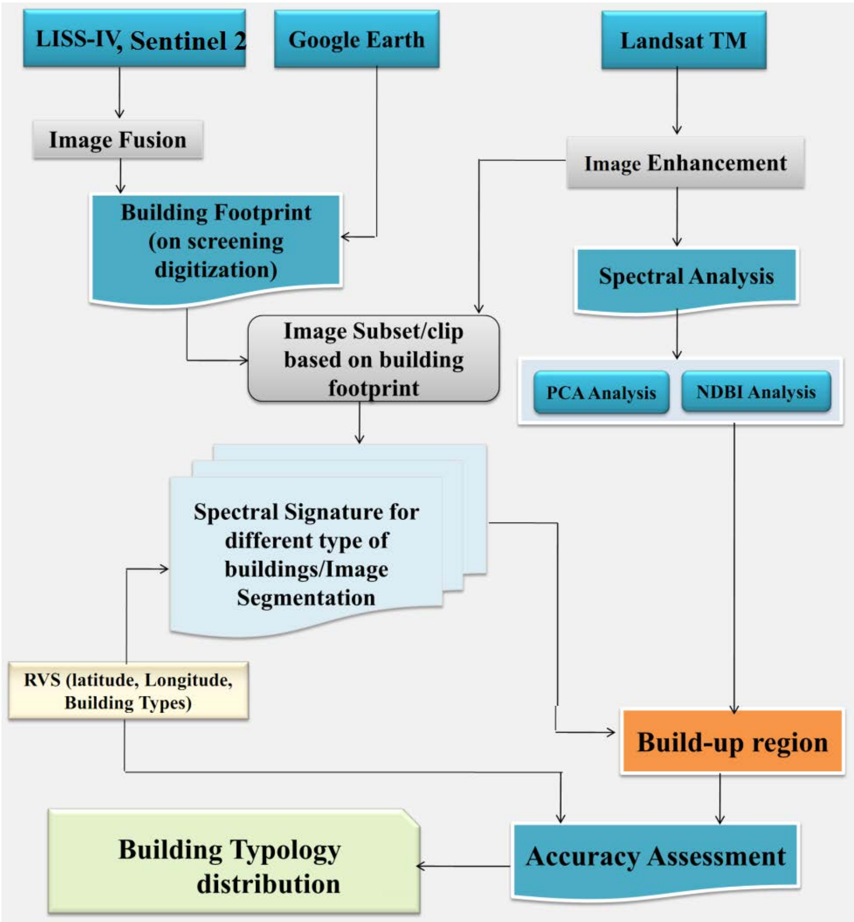


Figure S7. Building typology classification based on hybrid Remote Sensing and RVS processing.

These are further sub-classified using building height through the following protocol that uses Google Earth 2011 and Cartosat I Stereo Image shown in **Figure S8** to yield FEMA (2000) & WHE-PAGER (2008) nomenclature based building typology and those used in the present study for seismic structural impact assessment.

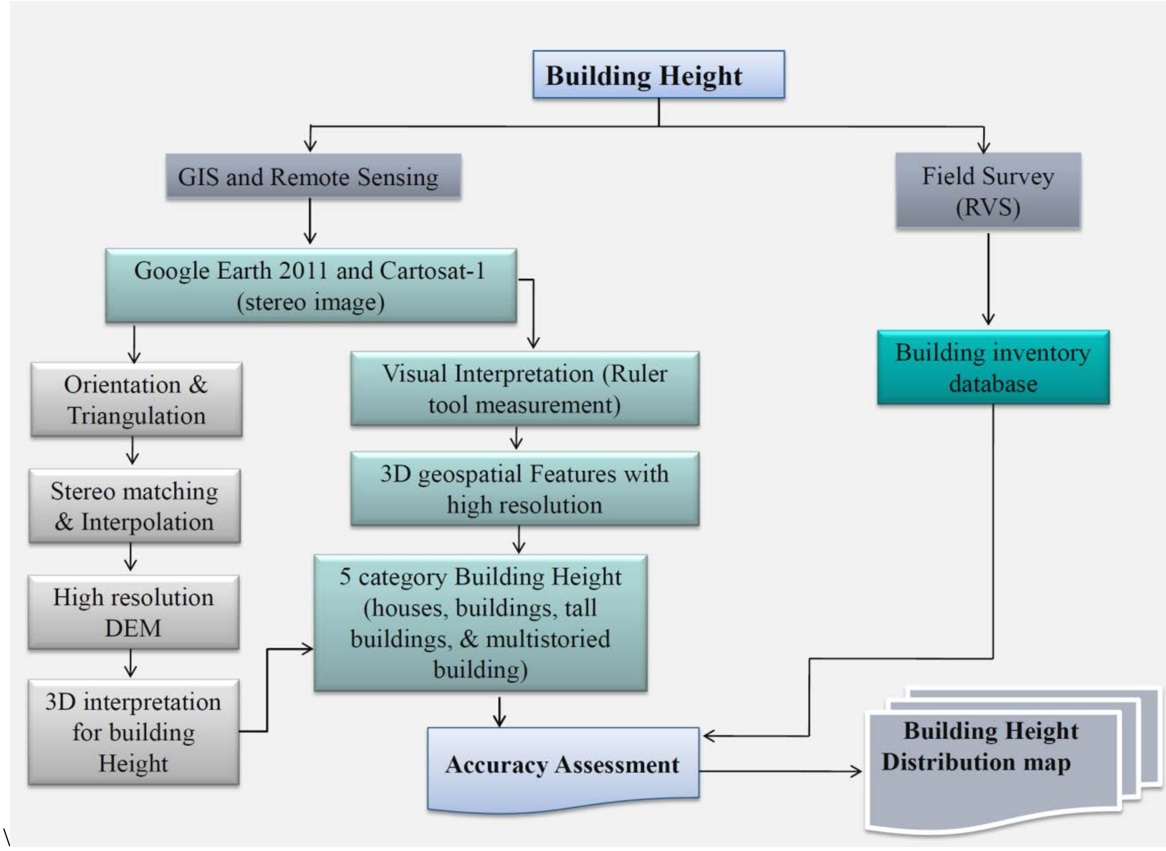


Figure S8. Building sub-classification protocol based on Building Height.

The most common way of representing the confidence level in the assessment of remote sensing data is in the form of computing an error matrix. It is based on the widely used accuracy assessment technique of statistical correlations between two data sets –one is the Rapid Visual Screening (RVS) of about 25-30% samples in the study region as shown in **Figure S9**, which we term as 'reference' and the other derived exclusively from remotely sensed data, which is termed as 'classified'. The correlation indicators used in the present analysis include "overall accuracy", i.e., the percentage of matched data between the 'reference' and the 'classified' data, "user's accuracy", i.e., the percentage of matched data in the 'classified' map, "producer's accuracy", i.e., the percentage of matched data in the 'reference' map.

In the present study, the structural vulnerability exposures derived from satellite imagery in case of building typology classified from Google Earth 3-D aspect, Sentinel 2, LISS-IV and Cartosat I for building height etc. are used as 'classified' data while those derived through Rapid Visual Screening from 25000 field survey locations in the ensemble being considered as 'reference' data have been used for the accuracy assessment of all the themes as given in **Tables S13** and **S14**.

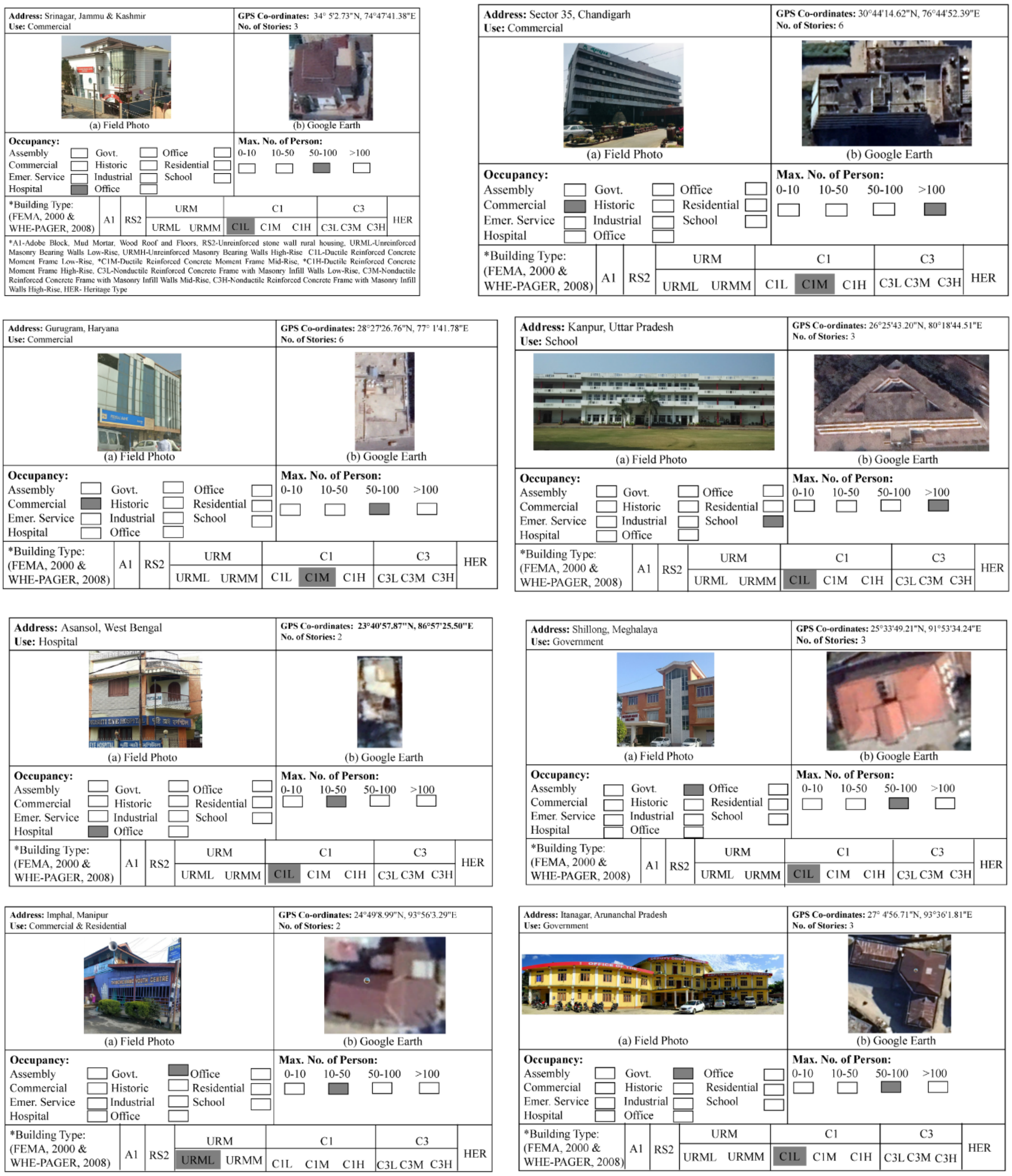


Figure S9. Rapid Visual Screening (RVS) survey for field and satellite imagery comparisons of existing building type and height in selected urban centers.

Table S13. Error matrix derived for building height.

Classified Building Height		RVS based Building Height (Reference data)						User's Accuracy (%)
		Houses	Buildings	Tall Buildings	Multistoried Buildings	Skyscrapers	Total	
	Houses (1 Floor)	205	47	0	0	0	252	81.34

	Buildings (2-4 Floors)	25	149	15	0	0	189	78.84
	Tall Buildings (5-8 Floors)	0	5	105	23	0	133	78.94
	Multistoried Buildings (9-10 Floors)	0	0	15	63	0	78	80.76
	Skyscrapers (>10 Floors)	0	0	0	0	10	10	100
	Total	230	201	135	86	10		
Producer's Accuracy (%)		89.13	74.13	77.78	73.26	100		
Overall Accuracy (%)								80.36

Table S14. Error matrix derived for building typology

	RVS based building typology (Reference data)													User's Accuracy (%)
Classified building typology		A1	RS2	URMM	URML	C1L	C1M	C1H	C3L	C3M	C3H	HER	Total	
	A1	15	4	1	0	0	0	0	0	0	0	0	20	75.00
	RS2	10	70	6	0	0	0	0	0	0	0	0	86	81.40
	URMM	5	17	100	20	0	0	0	0	0	0	0	142	70.42
	URML	0	3	43	189	8	0	0	0	0	0	0	243	77.78
	C1L	0	0	8	21	156	4	0	0	0	0	0	189	82.54
	C1M	0	0	0	2	31	120	9	0	0	0	0	162	74.07
	C1H	0	0	0	0	4	15	90	0	0	0	0	109	82.57
	C3L	0	0	0	0	0	0	10	107	2	0	0	119	89.92
	C3M	0	0	0	0	0	0	0	7	19	87	0	113	76.99
	C3H	0	0	0	0	0	0	0	0	7	63	0	70	90.00
	HER	0	0	0	0	0	0	0	0	0	0	5	5	100.00
	Total	30	94	158	232	199	139	109	114	96	82	5		

Producer's Accuracy (%)	50.00	74.47	63.29	81.47	78.39	86.33	82.57	93.86	90.63	76.83	100.00		
Overall Accuracy (%):													79.65

Finally, thus through RVS, Google Earth 3-D aspect, Sentinel 2, LISS IV and Cartosat I Imagery analyses we detected 11 model building types in the entire tectonic ensemble as tabulated in **Table S15.**

Table S15. Different model building types used in the present study (FEMA, 2000; WHE-PAGER, 2008).

Model Building Type	Description	Height	Stories
HER	Heritage building		
C1L	Ductile reinforced concrete frame with or without infill	Low-Rise	1 – 3
C1M		Mid-Rise	4 - 6
C1H		High-Rise	7+
C3L	Non-ductile reinforced concrete frame with masonry infill walls	Low-Rise	1 - 3
C3M		Mid-Rise	4 - 6
C3H		High-Rise	7+
A1	Adobe Block, Mud Mortar, Wood Roof and Floors	Low-Rise	1-2
RS2	Rubble stone masonry walls with timber frame and roof	Low-Rise	1-2
URML	Unreinforced masonry bearing wall	Low-Rise	1-3
URMM		Mid-Rise	3+

(ii) Generation of Damage Probability in the three tectonic territories viz. West-Northwest India, North-Central Himalaya and Northeast India including Nepal, Bhutan and Bangladesh

Damageability functions, defined as the probability of sustaining any damage are obtained by plotting damage probability against intensity or any other ground shaking parameters like PGA, PGV, PGD as had been worked out by Gautam et al. (2021) for stone masonry buildings in Nepal considering 1934 Bihar-Nepal earthquake of M_w 8.1, 1988 Nepal-Bihar earthquake of M_w 6.9 and 2015 Gorkha-Nepal earthquake of M_w 7.8 wherein 95-100% of this building type defined by FEMA (2000), WHE-PAGER (2008) as URM type had been projected to have been damaged for a GMPE predicted PGA value of 0.78g. Following suggestions from the Reviewer and taking clue from the works of Gautam et al. (2021) a rigorous literature survey has been conducted by us as detailed below and damage data have been collected as reported to have been inflicted by large and great Historical earthquakes in Nepal, Bhutan as suggested by the Reviewer and also extended the effort to the three seismogenic tectonic territories of the present ensemble viz. West-Northwest Himalaya, North-Central Himalaya and Northeast India and worked out damageability functions in all of them for three model building typologies viz. Adobe (A1), Unreinforced Masonry (URM) bearing structures and Reinforced Concrete (RC) structures in the ensemble.

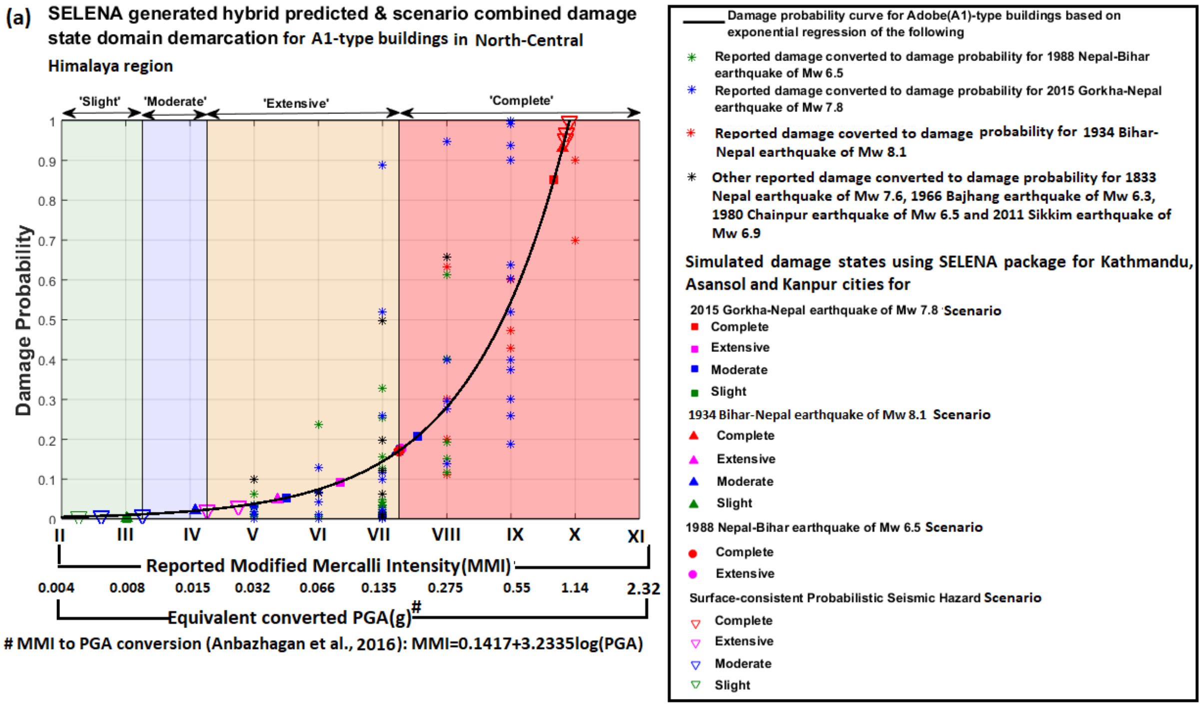
As we are all aware, the entire Himalayan belt frequently experiences major earthquakes due to continuous convergence of Indian plate beneath the Eurasian plate. Nepal, being centrally located in the belt, is worst affected. The number of buildings damaged during 1833 Nepal earthquake of M_w 7.6 is about 18,000 in the Kathmandu valley. The 1934 Bihar-Nepal earthquake of M_w 8.1 affected 200,000 buildings in the eastern mountains of Nepal and northern Bihar of India. 1966 Bajhang earthquake of M_w 6.3 damaged 7844 buildings in the western Nepal as reported by Bilham (1995), Pandey & Molnar (1988) and Chaulagain et al. (2018) for these earthquakes respectively. A1 and URM-type buildings were mostly prevalent in those regions at the time when the aforementioned earthquakes jolted those territories. 1980 Chainpur earthquake of M_w 6.5 is the only major event that occurred in the western section of the central seismic gap and Singh (1982) reported that approximately 32,186 buildings were damaged during that earthquake. The 1988 Nepal-Bihar earthquake of M_w 6.9 damaged about 70,000 buildings and triggered widespread liquefaction in eastern Nepal as documented by Gupta (1988) and Fujiwara et al. (1989). The recent earthquake damage statistics are available at the Nepal Disaster Risk Reduction Portal (http://drrportal.gov.np/). The 2011 Sikkim earthquake of M_w 6.9 and 2015 Gorkha-Nepal earthquake of M_w 7.8 have also been considered in the present study for structural impact assessment.

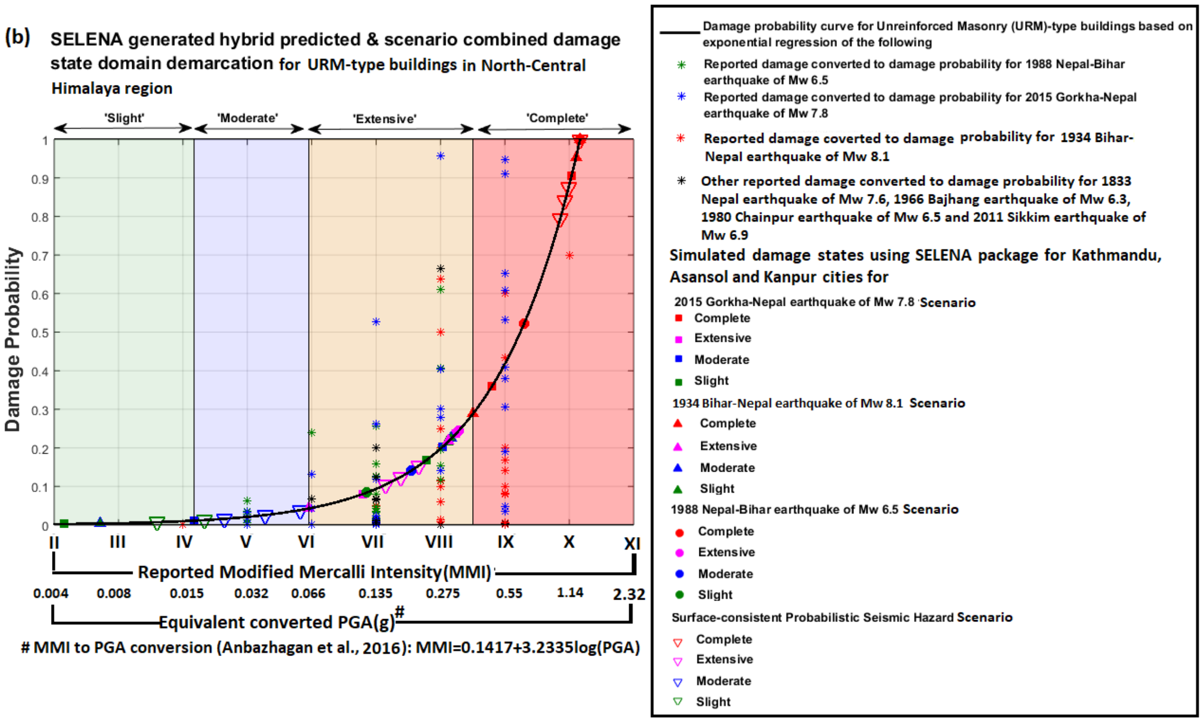
This work has been extended for the North-Central Himalaya region and it is found that Bihar and Uttar Pradesh of India have been remarkably affected by the same earthquakes. Dasgupta and Mukhopadhay (2015) has assembled all the reports and commentaries on 1833 Nepal earthquake of M_w 7.6 and it is reported that in the towns of Munger, Muzaffarpur, Arrah and Gorakhpur there had been building damages. There had been reporting of 149124 buildings in Bihar being damaged during 1988 Nepal-Bihar Earthquake of M_w 6.9. About 145 adobe-type buildings were damaged in Northern Bihar due to 2015 Gorkha-Nepal Earthquake of M_w 7.8.

The Northeast India region including Bhutan have repeatedly been struck by devastating earthquakes causing significant damage to life and properties. The District Disaster Management Department of the Government of Bhutan reported district-wise building damage due to past devastating earthquakes occurring in the region like, approximately 251 A1 and RC-type buildings getting damaged due to 2003 Paro earthquake of M_w 5.5, around 126 URM and RC-type buildings getting damaged due to 2006 Dewangthang earthquake of M_w 5.8 and about 5967 buildings getting damaged due to 2009 Bhutan earthquake of M_w 6.1. Chettri et al. (2021) presented an overview of seismic vulnerability of Bhutanese residential buildings and reported that 4950 buildings were damaged during 2009 Bhutan earthquake of M_w 6.1 and 7965 buildings were damaged during 2011 Sikkim earthquake of M_w 6.9. According to Gautam et al. (2022), 60% of all buildings in Bhutan were exposed to 2021 Sonitpur earthquake of M_w 6.4, among those 16 buildings collapsed, 541 buildings sustained major damage and 2277 buildings sustained minor damage. Halder et al. (2020) reported the extent of damage caused to buildings of various typologies by large earthquakes that occurred in Northeast India, amongst which 6727 mud-walled (Adobe-type) houses suffered partial to complete damage in the state of Tripura consequent upon 2017 Ambasa earthquake of M_w 5.7 while slight to moderate damage occurred to the houses due to the impact of 2016 Manipur earthquake of M_w 6.7 in Imphal, 2021 Sonitpur earthquake of M_w 6.4 in and around Sonitpur in Assam and 2011 Sikkim earthquake of M_w 6.9 in Sikkim. Damages have been reported by Debbarma et al. (2021) and Dey et al. (2022). The National Disaster Management Authority has reported maximum damage in North Sikkim region where 78%, 70% and 60% of A1, URM and RC type buildings have been damaged respectively due to 2011 Sikkim earthquake of M_w 6.9 while the West and East Sikkim also experienced considerable damage. According to Dutta et al. (2015), 2422 buildings have been damaged in Gangtok itself.

West-Northwest Himalaya has been jolted by numerous earthquakes from historic times. Mukhopadhyay and Dasgupta (2015) has compiled the extent of damage caused due to impact of large historical earthquakes in and around Kashmir and Kangra Valley viz. 1803 Garhwal earthquake of M_w 7.5, 1828 Srinagar earthquake of M_w 6.5 and 1905 Kangra earthquake of M_w 7.8. The Kinnaur and Lahul-Spiti districts of Himachal Pradesh were severely affected by 1975 Kinnaur earthquake of M_w 6.8 heavily damaging about 2000 houses in that around the region as reported by Singh et al. (1976) and Bhargava et al. (1978). The 1991 Uttarkashi earthquake of M_w 6.8 has rocked Garhwal Himalaya of Northern India with MM intensity of VIII causing complete collapse of 20184 houses and partially damaging 74714 houses (Arya, 1994). District-wise number of building damages has been documented in a report published by Geological Survey of India (GSI, 1992). Pandey (2013) reported that damage was observed in more than 64000 unreinforced masonry buildings as well as reinforced concrete frame structures. Himachal Pradesh State Disaster Management Authority (https://hpsdma.nic.in/) has reported that more than 70% houses developed cracks in the epicentral region during 1995 Chamba earthquake of M_w 4.9, maximum damage being experienced in Pilure-Baraur sector located 8-10 km northeast of Chamba town as reported by Mahajan (1998). Field observations after 1997 Sundernagar earthquake of M_w 4.7 in Sundernagar region and around Mandi district of Himachal Pradesh have been compiled by Thakur et al. (1997) reporting extensive damages to about 1000 adobe houses and developing small cracks in concrete structures. A report by Paul (2000) on 1999 Chamoli earthquake of M_w 6.5 has detailed the damages observed in the Chamoli region. Several such accounts have been collected regarding 2004 Dharamshala earthquake of M_w 4.9, 2005 Muzaffarabad earthquake of M_w 7.6, 2012 Jhajjar earthquake of M_w 5.1, 2013 Bhaderwah-Kishtwar earthquake of M_w 5.1 and 2019 Kashmir earthquake of M_w 5.6 with reporting of considerable damage to unreinforced masonry and reinforced concrete buildings prevalent in recent times. The 2005 Muzaffarabad earthquake of M_w 7.6, the worst ever earthquake that shook the Kashmir valley with its epicentre located 124 km to the west of Srinagar, caused widespread destruction and casualties (>50,000) in the region as detailed in Mahajan (2006). Kumar and Murty (2014) reported that about 450000 houses have been destroyed in Kashmir. Gupta et al. (2013) has compiled all the reports in context of 2012 Jhajjar earthquake of M_w 5.1 affecting the Haryana-Delhi border region depicting the damage patterns along with MM intensity variation of III-VI in the region due to this earthquake.

Based on the reported number of buildings damaged during impinging large, strong and great earthquakes against the total number of buildings actually existent in the same period extracted through remote sensing technique using the imagery data prevalent during that particular period Damage Probability has been calculated and plotted against the Modified Mercalli Intensity (MMI) for North-Central Himalaya, Nepal, Northeast India, Bhutan and West-Northwest India as presented in **Figures 22(a-c)**, **23(a-c)**, **24(a-c)**, **25(a-c)** and **26(a-c)** respectively for Adobe(A1), Unreinforced Masonry (URM) and Reinforced Concrete (RC) model building types for these tectonic territories in the ensemble. We invoked SELENA (Molina et al., 2014) package for assessing damage states of all 11 building types including A1, URM and RC type buildings for all the scenario earthquakes as well as the surface-consistent probabilistic seismic hazard in terms of surface level PGA(g) distribution in all these territories and ascertained the damage state domains for these three building types A1, URM and RC in all the territories and juxtaposed the same tectonic territory-wise on each of these diagrams as shown in **Figures 22, 23, 24, 25** and **26** depicting the four damage states viz. 'Slight', 'Moderate', 'Extensive' and 'Complete' for all the three model building types. It is evident from these diagrams that all building damages reported by till date for all the aforementioned earthquakes have been classified in the SELENA modelled four damage state domains in all the aforementioned tectonic territories, thus, bringing in a good agreement between the SELENA generated building damage state for A1, URM and RC-type buildings and damage probability distribution variation against Modified Mercalli Intensity and/or equivalent converted PGA(g) in all the three seismogenic tectonic territories including Nepal and Bhutan for all the scenario earthquakes as well as surface-consistent probabilistic seismic hazard distribution.





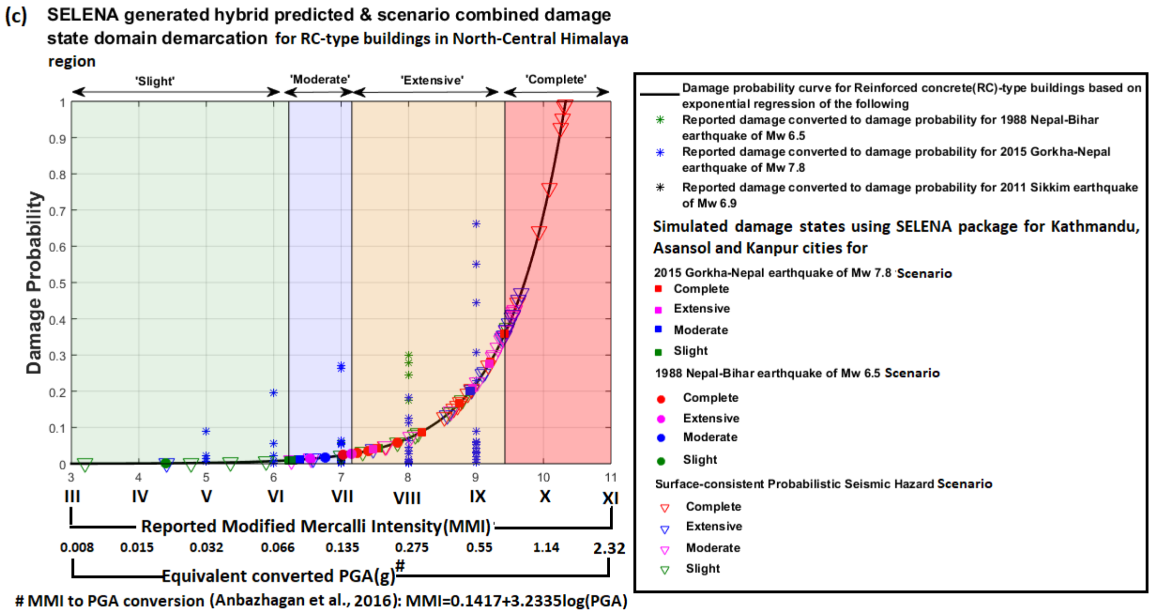
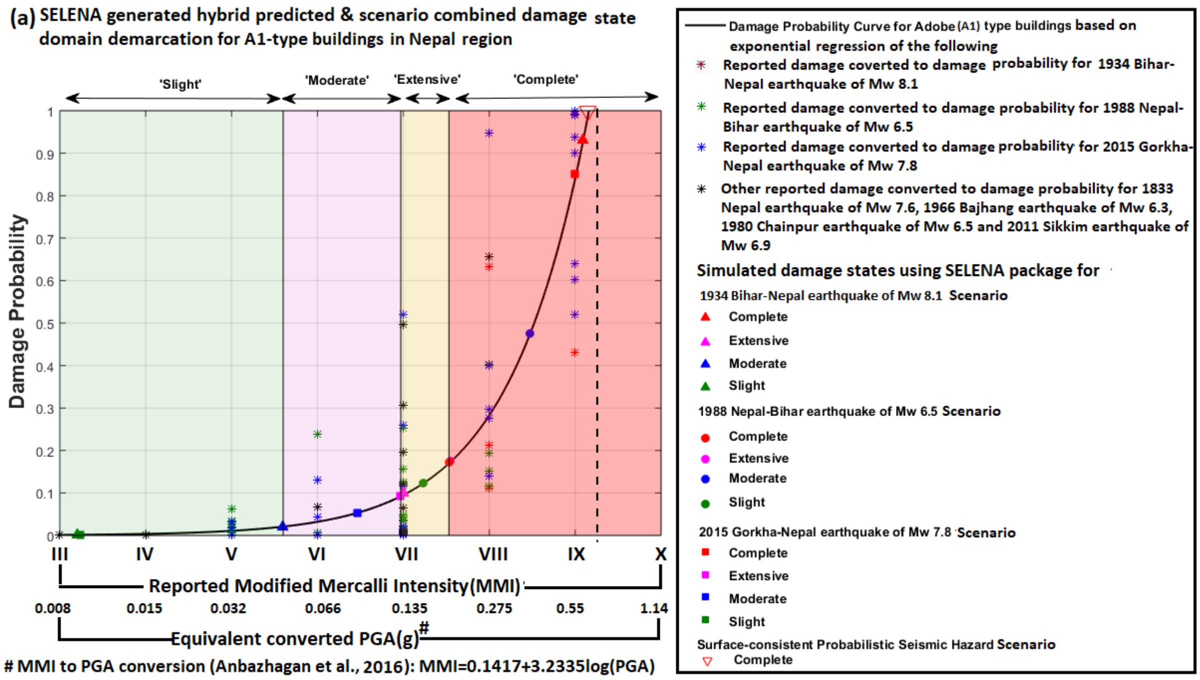
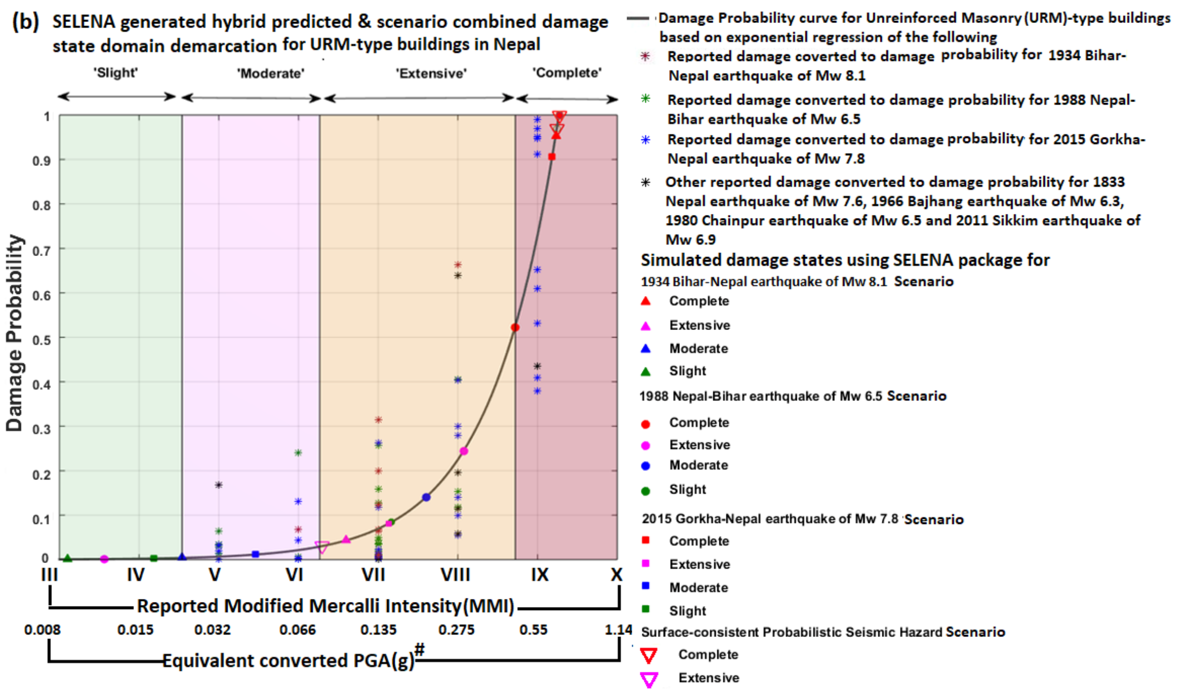


Figure 22. Damage probability curve for North-Central Himalaya region for (a) Adobe (A1), (b) Unreinforced Masonry (URM) and (c) Reinforced Concrete (RC)-type buildings based on exponential regression of reported damage converted to damage probability for different earthquake scenarios. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for three earthquake scenarios viz. 1934 Bihar-Nepal earthquake of M_w 8.1, 1988 Nepal-Bihar earthquake of M_w 6.9 and 2015 Gorkha-Nepal earthquake of M_w 7.8 and Surface-consistent Probabilistic Seismic Hazard scenario.





MMI to PGA conversion (Anbazhagan et al., 2016): MMI=0.1417+3.2335log(PGA)

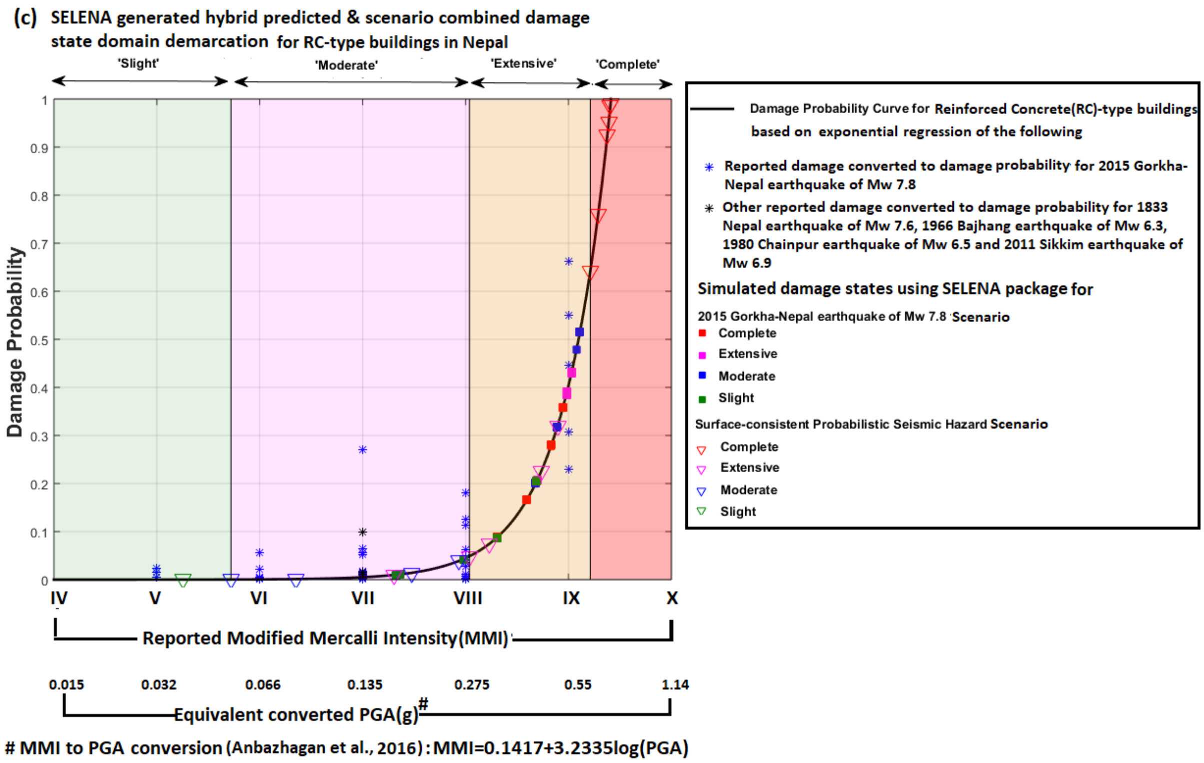
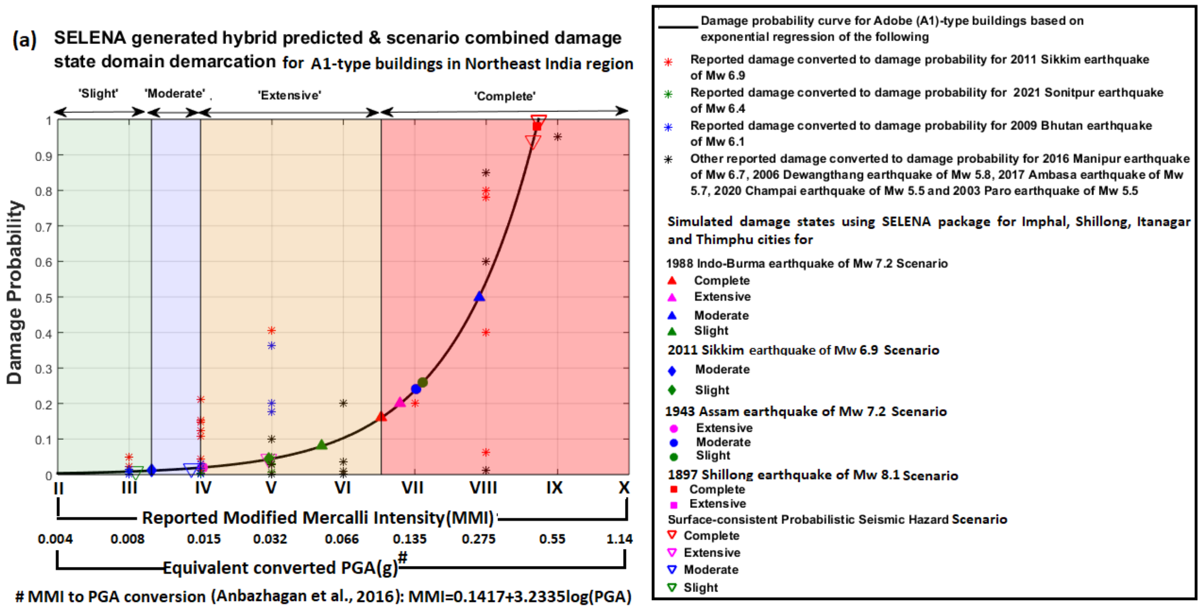
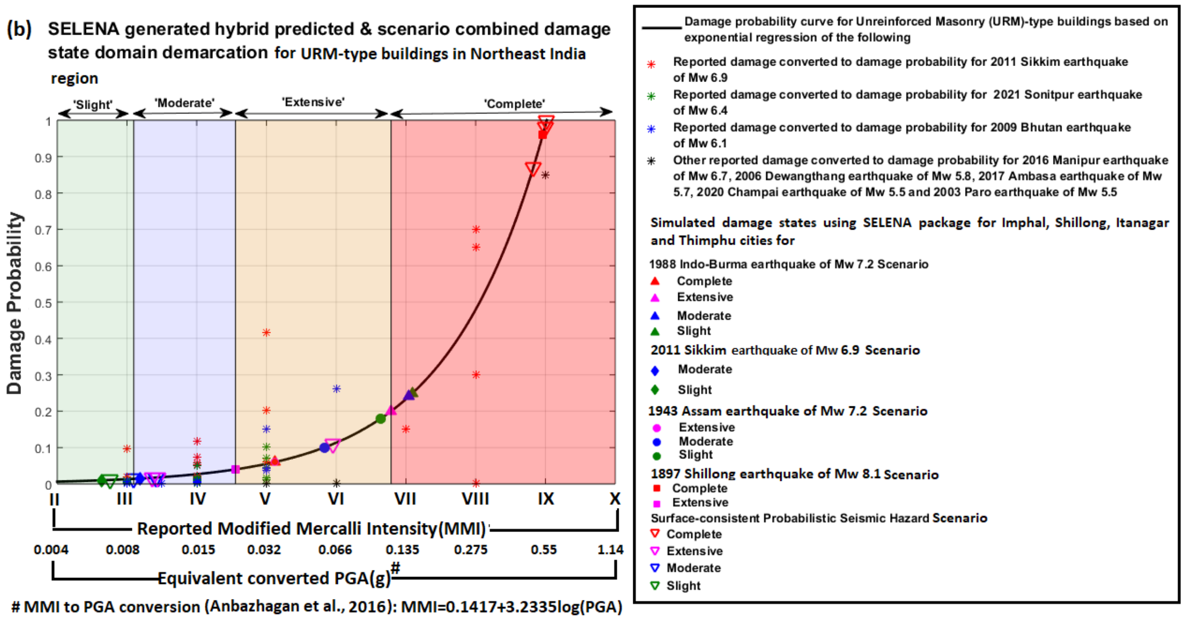


Figure 23. Damage probability curves for Nepal region for (a) Adobe (A1), (b) Unreinforced Masonry (URM) and (c) Reinforced Concrete (RC)-type buildings based on exponential regression of reported damage converted to damage probability for different earthquake scenarios. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for three earthquake scenarios viz. 1934 Bihar-Nepal earthquake of M_w 8.1, 1988 Nepal-Bihar earthquake of M_w 6.9 and 2015 Gorkha-Nepal earthquake of M_w 7.8 and Surface-consistent Probabilistic Seismic Hazard scenario.


(a) SELENA generated hybrid predicted & scenario combined damage state domain demarcation for A1-type buildings in Northeast India region
'Slight'
'Moderate'
'Extensive'
'Complete'
Damage Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
II
III
IV
V
VI
VII
VIII
IX
X
Reported Modified Mercalli Intensity(MMI)
0.004
0.008
0.015
0.032
0.066
0.135
0.275
0.55
1.14
Equivalent converted PGA(g)#
MMI to PGA conversion (Anbazhagan et al., 2016): MMI=0.1417+3.2335log(PGA)
Damage probability curve for Adobe (A1)-type buildings based on exponential regression of the following
Reported damage converted to damage probability for 2011 Sikkim earthquake of Mw 6.9
Reported damage converted to damage probability for 2021 Sonitpur earthquake of Mw 6.4
Reported damage converted to damage probability for 2009 Bhutan earthquake of Mw 6.1
Other reported damage converted to damage probability for 2016 Manipur earthquake of Mw 6.7, 2006 Dewangthang earthquake of Mw 5.8, 2017 Ambasa earthquake of Mw 5.7, 2020 Champai earthquake of Mw 5.5 and 2003 Paro earthquake of Mw 5.5
Simulated damage states using SELENA package for Imphal, Shillong, Itanagar and Thimphu cities for
1988 Indo-Burma earthquake of Mw 7.2 Scenario
Complete
Extensive
Moderate
Slight
2011 Sikkim earthquake of Mw 6.9 Scenario
Moderate
Slight
1943 Assam earthquake of Mw 7.2 Scenario
Extensive
Moderate
Slight
1897 Shillong earthquake of Mw 8.1 Scenario
Complete
Extensive
Surface-consistent Probabilistic Seismic Hazard Scenario
Complete
Extensive
Moderate
Slight


(b) SELENA generated hybrid predicted & scenario combined damage state domain demarcation for URM-type buildings in Northeast India region
'Slight'
'Moderate'
'Extensive'
'Complete'
Damage Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
II
III
IV
V
VI
VII
VIII
IX
X
Reported Modified Mercalli Intensity(MMI)
0.004
0.008
0.015
0.032
0.066
0.135
0.275
0.55
1.14
Equivalent converted PGA(g)#
MMI to PGA conversion (Anbazhagan et al., 2016): MMI=0.1417+3.2335log(PGA)
Damage probability curve for Unreinforced Masonry (URM)-type buildings based on exponential regression of the following
Reported damage converted to damage probability for 2011 Sikkim earthquake of Mw 6.9
Reported damage converted to damage probability for 2021 Sonitpur earthquake of Mw 6.4
Reported damage converted to damage probability for 2009 Bhutan earthquake of Mw 6.1
Other reported damage converted to damage probability for 2016 Manipur earthquake of Mw 6.7, 2006 Dewangthang earthquake of Mw 5.8, 2017 Ambasa earthquake of Mw 5.7, 2020 Champai earthquake of Mw 5.5 and 2003 Paro earthquake of Mw 5.5
Simulated damage states using SELENA package for Imphal, Shillong, Itanagar and Thimphu cities for
1988 Indo-Burma earthquake of Mw 7.2 Scenario
Complete
Extensive
Moderate
Slight
2011 Sikkim earthquake of Mw 6.9 Scenario
Moderate
Slight
1943 Assam earthquake of Mw 7.2 Scenario
Extensive
Moderate
Slight
1897 Shillong earthquake of Mw 8.1 Scenario
Complete
Extensive
Surface-consistent Probabilistic Seismic Hazard Scenario
Complete
Extensive
Moderate
Slight

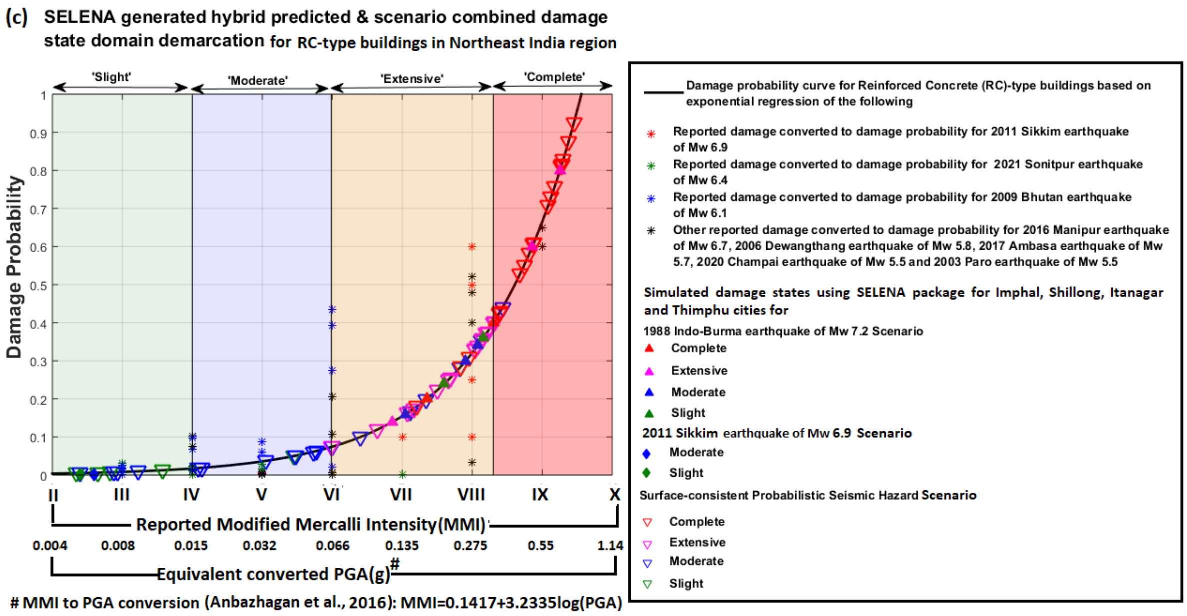
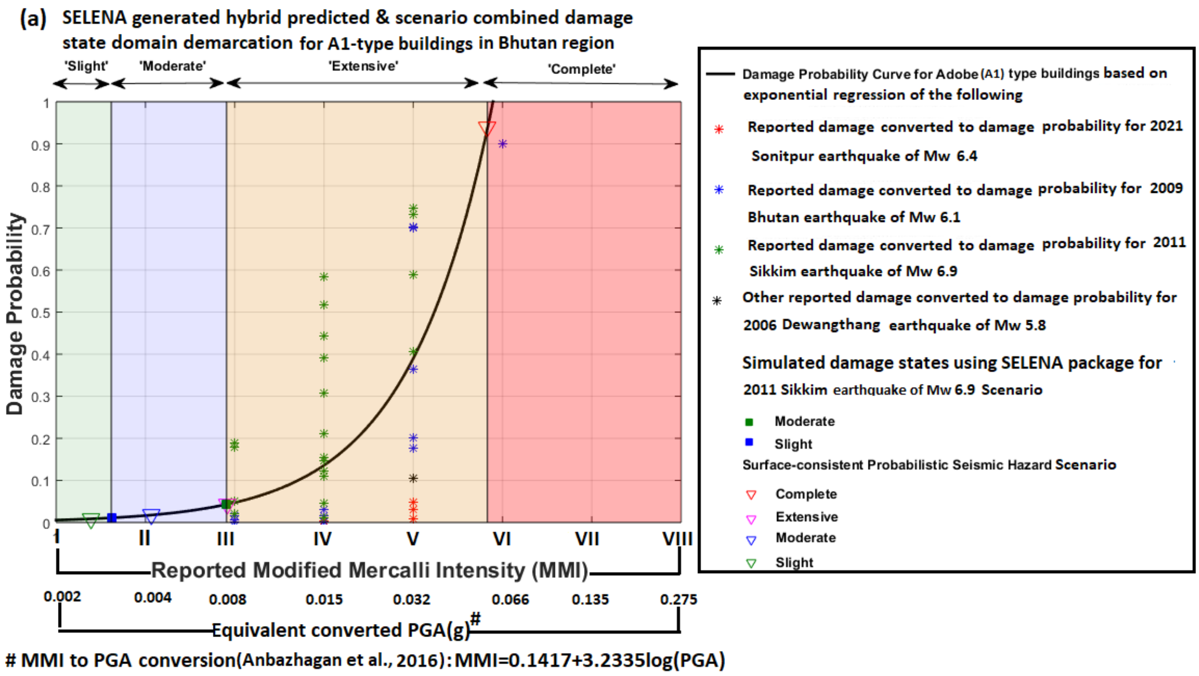
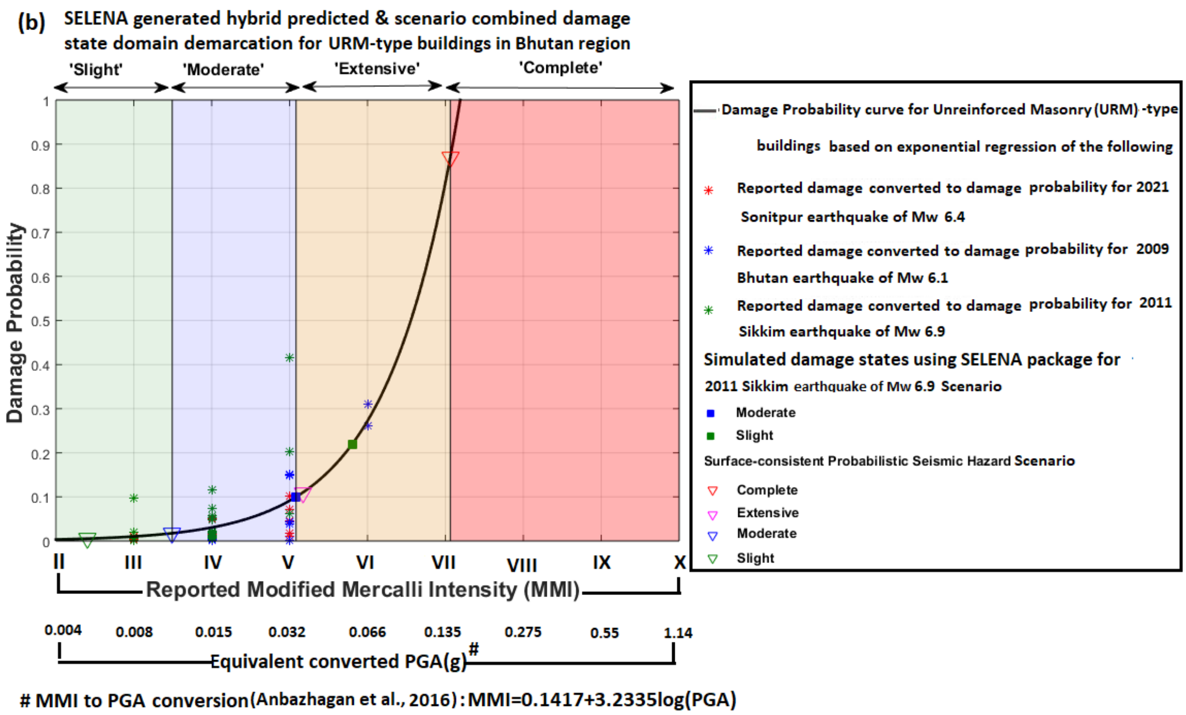


Figure 24. Damage probability curve for Northeast India region for (a) Adobe (A1), (b) Unreinforced Masonry (URM) and (c) Reinforced Concrete (RC)-type buildings based on exponential regression of reported damage converted to damage probability for different earthquake scenarios. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for Four earthquake scenarios viz. 1897 Shillong earthquake of M_w 8.1, 1943 Assam earthquake of M_w 7.2, 1988 Indo-Burma earthquake of M_w 7.2 and 2011 Sikkim earthquake of M_w 6.9 and Surface-consistent Probabilistic Seismic Hazard scenario.



(a) SELENA generated hybrid predicted & scenario combined damage state domain demarcation for A1-type buildings in Bhutan region
'Slight'
'Moderate'
'Extensive'
'Complete'
Damage Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
I
II
III
IV
V
VI
VII
VIII
Reported Modified Mercalli Intensity (MMI)
0.002
0.004
0.008
0.015
0.032
0.066
0.135
0.275
Equivalent converted PGA(g)#
MMI to PGA conversion(Anbazhagan et al., 2016): MMI=0.1417+3.2335log(PGA)
Damage Probability Curve for Adobe (A1) type buildings based on exponential regression of the following
Reported damage converted to damage probability for 2021 Sonitpur earthquake of Mw 6.4
Reported damage converted to damage probability for 2009 Bhutan earthquake of Mw 6.1
Reported damage converted to damage probability for 2011 Sikkim earthquake of Mw 6.9
Other reported damage converted to damage probability for 2006 Dewangthang earthquake of Mw 5.8
Simulated damage states using SELENA package for 2011 Sikkim earthquake of Mw 6.9 Scenario
Moderate
Slight
Surface-consistent Probabilistic Seismic Hazard Scenario
Complete
Extensive
Moderate
Slight



(b) SELENA generated hybrid predicted & scenario combined damage state domain demarcation for URM-type buildings in Bhutan region
'Slight'
'Moderate'
'Extensive'
'Complete'
Damage Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
II
III
IV
V
VI
VII
VIII
IX
X
Reported Modified Mercalli Intensity (MMI)
0.004
0.008
0.015
0.032
0.066
0.135
0.275
0.55
1.14
Equivalent converted PGA(g)#
MMI to PGA conversion(Anbazhagan et al., 2016): MMI=0.1417+3.2335log(PGA)
Damage Probability curve for Unreinforced Masonry (URM) -type buildings based on exponential regression of the following
Reported damage converted to damage probability for 2021 Sonitpur earthquake of Mw 6.4
Reported damage converted to damage probability for 2009 Bhutan earthquake of Mw 6.1
Reported damage converted to damage probability for 2011 Sikkim earthquake of Mw 6.9
Simulated damage states using SELENA package for 2011 Sikkim earthquake of Mw 6.9 Scenario
Moderate
Slight
Surface-consistent Probabilistic Seismic Hazard Scenario
Complete
Extensive
Moderate
Slight

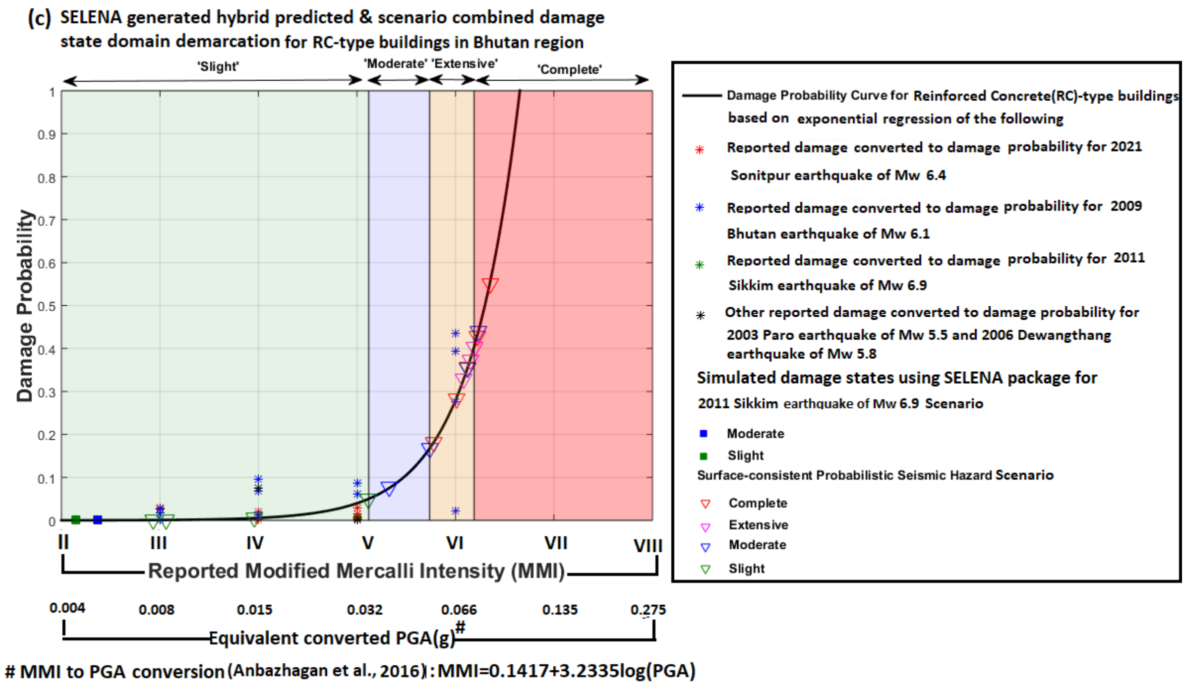
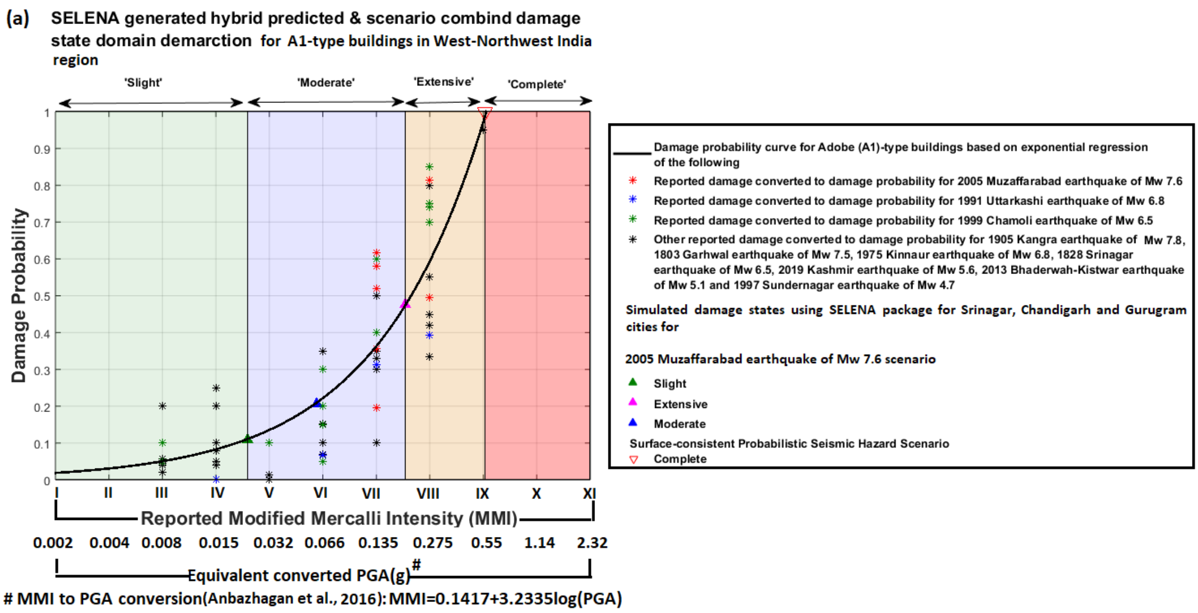
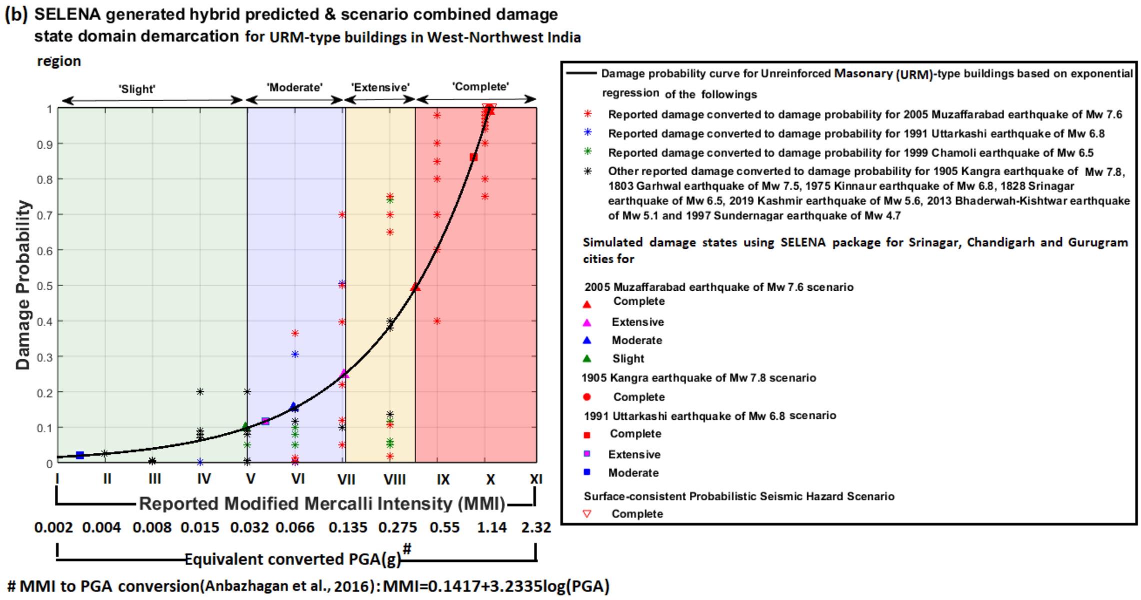


Figure 25. Damage probability curve for Bhutan region for (a) Adobe (A1), (b) Unreinforced Masonry (URM) and (c) Reinforced Concrete (RC)-type buildings based on exponential regression of reported damage converted to damage probability for different earthquake scenarios. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for the 2011 Sikkim earthquake of M_w 6.9 and Surface-consistent Probabilistic Seismic Hazard scenario.





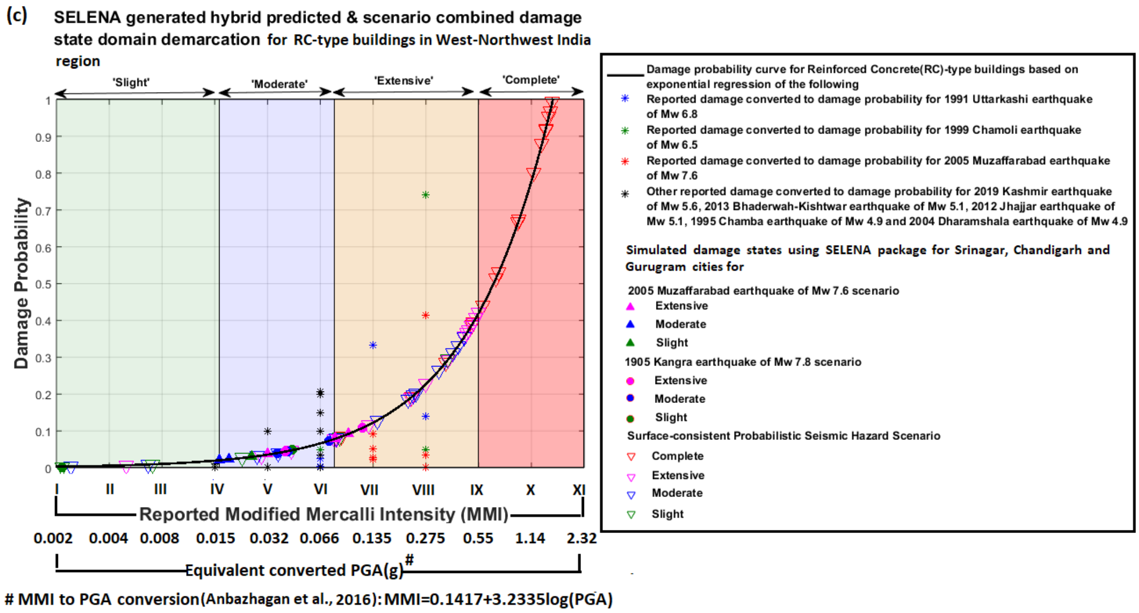


Figure 26. Damage probability curve for West-Northwest India region for (a) Adobe (A1), (b) Unreinforced Masonry (URM) and (c) Reinforced Concrete (RC)-type buildings based on exponential regression of reported damage converted to damage probability for different earthquake scenarios. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for three earthquake scenarios viz. 1905 Kangra earthquake of M_w 7.8, 1991 Uttarkashi earthquake of M_w 6.8 and 2005 Muzaffarabad earthquake of M_w 7.6 and Surface-consistent Probabilistic Seismic Hazard scenario.

Reviewer#1: Why would the authors mention many cities in the manuscript? Does that really make a sense?

Authors' Response: The observation has been noted and appropriate modifications will be done in the manuscript while revising it.

Reviewer#1: Although the work is interesting, how do the authors justify the novelty of the work?

Authors' Response: The Authors feel inspired by the words of appreciation and encouragement made by the Reviewer. The novelty of the work has been described in point-wise form below:

1. The Probabilistic Seismic Hazard formulation for both 10% and 2% probability of exceedance in 50 years amounting to 475 and 2475 years of return periods respectively for the Indian subcontinent have been implemented in a rigorous Logic Tree Framework consisting of the followings:

(a) Consideration of 172 polygonal as well as 3216 major tectectonic seismogenic sources defined through juxtaposition of active tectonic, seismicity and homogeneous declustered earthquake catalogue, the moment tensor solutions and faults and lineaments extracted through Remote sensing and GIS database.

(b) Consideration of multiple threshold magnitudes viz. M_w 3.5, 4.5 and 5.5 as ascertained from the complete and homogeneous declustered earthquake catalogue for 1900-2018 consisting of 64,153 main seismic events.

(c) Inclusion of depth wise variation of seismic activity rates for both the polygonal and tectonic seismogenic sources using smoothening seismicity (Frankel, 1995) for the depth ranges of 0-25km, 25-70km, 70-180km and 180-300km.

(d) Region-specific depth wise maximum earthquake prognosis from the sub-catalogues extracted from the main homogenous declustered catalogue of Nath et al. (2017).

(e) Selection of hordes of Ground Motion Prediction Equations (GMPEs) taken from all the local-specific researches totaling to about 197 of which there had been 68 Next Generation Spectral Attenuation models (NGAs) developed by Nath (2017) and Nath et al. (2021) as a part of the present research whose ranks and weights have been determined using Log Likelihood (LLH) calculations following Scherbaum et al. (2009).

(f) Usages of both the aleatory and epistemic uncertainties associated with magnitude, rupture distance and GMPEs/ NGAs for all the depth wise seismogenic sources in all the tectonic territories.

2. The Socio-economic Risk Map of India is generated by integrating vulnerability exposures viz. Population Density, Building Density, Landuse/landcover extracted from Census (2011) and Remote Sensing imagery viz. Sentinel 2, Landsat 8 and LISS-IV with IBC-compliant surface-consistent Probabilistic Seismic Hazard through an Analytic Hierarchy Process and expert judgement for the entire Indian territory.

3. An enriched database containing a huge volume of geophysical, geotechnical, geological, geomorphological and topography data has been used to towards seismic site classification and its characterization of entire ensemble from Kashmir Himalaya to Northeast India. Geology, Geomorphology, Slope and Landform are used for establishing a regional- specific empirical relation through a nonlinearly regressed 5th order polynomial equation to estimate the effective shear wave velocity (V_s^{30}) for characterizing the region into various Site classes based on NEHRP (BSSC, 2003), FEMA (2000) and Sun et al. (2018) nomenclature. Around 3000 data points have been used for the nonlinear regression analysis, out of which 80% (Training) data are considered for establishing the empirical relationship and remaining 20% (Testing) are used for the validation purposes. From the correlation

between geotechnical and regional dataset, it is observed that most of the data set are lying within the 70% confidence bound and nearly follow 1:1 correspondence line as is also reported by Nath et al (2021).

We have also used the lithology-specific and depth-dependent empirical relations between SPT-N and V_s for the alluvial plain region in which lithological units have been classified into sixteen categories by Nath et al (2021) according to their grain size, plasticity index and presence or absence of decomposed wood etc. as (i) Top Soil, (ii) Sand, (iii) Sandy Silt (iv) Silty Clay with Decomposed Wood, (v) Silty Clay with Mica, Sand and/or Kankar, (vi) Clay with Decomposed Wood, (vii) Silty Sand with Mica and/or Clay (vii) Silty Clay with rusty Silty Spots, (ix) Sand with Silt and Clay, (x) Silty Sand with Mica and Kankar, (xi) Bluish/Yellowish grey Silt, (xii) Silt, (xiii) Sand and (xiv) Fine Sand with Gravel (xv) Clayey Silt and (xvi) All Soils.

4. Seismic Site Characterization has been carried out for the entire ensemble from Kashmir Himalaya to Northeast India in terms of absolute site amplification factor, spectral site amplification factor, predominant frequency and generic site amplification spectra. Surface-consistent Probabilistic Seismic Hazard assessment is done through convolution of the bedrock level hazard with estimated site amplification factors as has been presented along with design response spectra at both bedrock and surface levels for many important cities indicating an appreciable enhancement in the existing design values.

5. SELENA-based urban structural impact assessment has been carried out for the first time for a few Capital-Spiritual-Commercial Cities such as Srinagar, Chandigarh, Gurugram, Kanpur, Asansol, Chittagong, Thimphu, Shillong, Imphal, Itanagar and Kathmandu for the surface-consistent probabilistic seismic hazard for 10% probability of exceedance in 50 years. Seismic damageability functions have been derived for the three seismogenic tectonic territories viz. West-Northwest Himalaya, North-central Himalaya and Northeast India along with the countries of Nepal and Bhutan for three most prevalent building types seen across the regions i.e. Adobe (A1), Unreinforced Masonry (URM) and Reinforced Concrete (RC)-type buildings. SELENA generated hybrid predicted and scenario combined damage states have been demarcated based on simulated damage states for different earthquake scenarios and surface-consistent Probabilistic Seismic Hazard.

Thus, this work presents a unique benchmark regional-local hybrid seismic hazard-disaster model for pre-disaster preparedness in the form of updated urban by-laws and post-disaster rehabilitation and future disaster management for the ensemble.

Reviewer#1: Please construct a methodological flowchart to summarize the work.

Authors' Response: We will include the following process flowchart in the revised manuscript as suggested by the Reviewer.

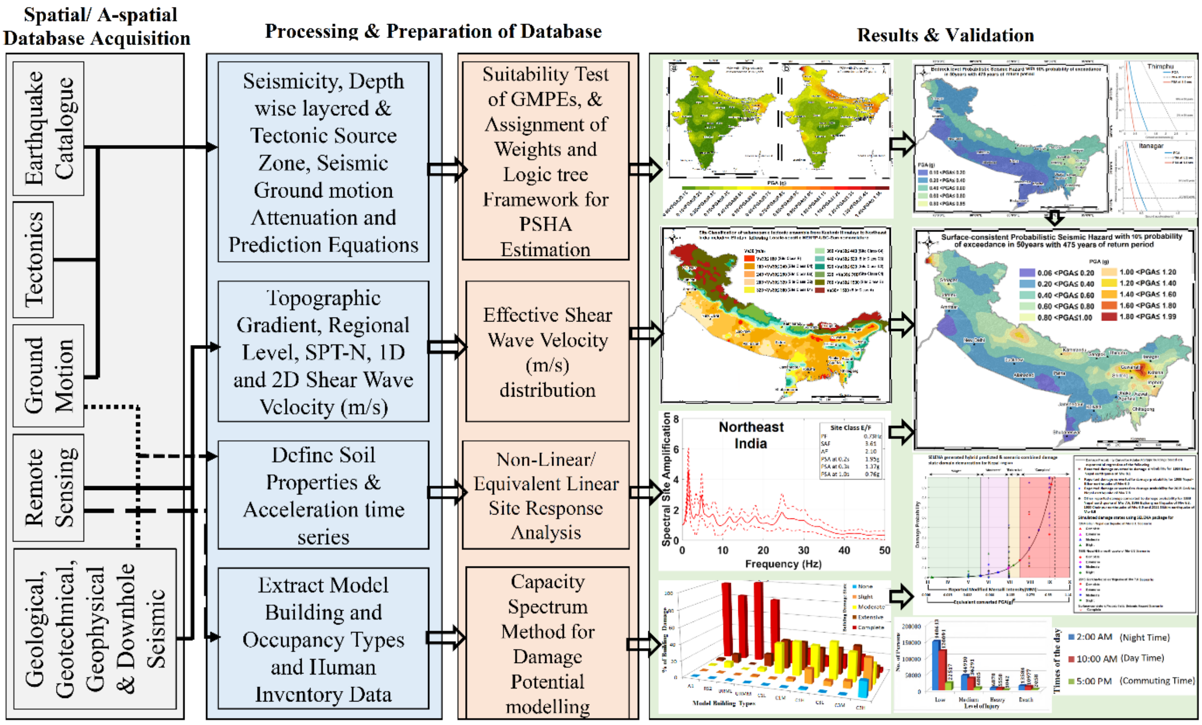


Figure 4. Methodological flow chart summarizing the present work.

Reviewer#1: Some of the illustrations do not have adequate quality, please consider replotting.

Authors' Response: This point is noted and appropriate remedial action will be taken while revising the manuscript.

Reviewer#1: Please flesh up your conclusions once your revise the manuscript.

Authors' Response: The observation has been noted and the conclusion section will be modified in the revised manuscript.

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