Point by point response to the observations & comments of Anonymous Reviewer # 3 on the manuscript titled "Seismic Vulnerability & Risk Assessment of Kolkata City, India" (ms# nhess-2013-467)

We greatly appreciate the review of the manuscript by the anonymous referee#3. We hereby put forth the clarifications as follows.

Overall Observations of Reviewer # 3: "The authors are trying to bring out the Seismic Risk of Kolkata City based on Geological, Geotechnical and Structural analysis. The overall approach of the manuscript is good. However it needs some minor revisions."

Thanks very much! We very much appreciate your comments. The minor corrections indicated and suggested will be incorporated in the final uploaded manuscript for typesetting and printing once the same is desired by the Editorial Board and the handling Editor of the manuscript.

General Comments & Response to each:

Comment 1: All figures since bar scale used the text scale 1:25,000 can be removed;

Response: This indeed is a very good suggestion and the same will be complied with in the final uploaded manuscript for typesetting and printing to be uploaded after the editorial decision is made and all the suggestions wrapped up together. The expectedly modified Figures 4-6, 8,10-12, and 14-16 will be as follows.

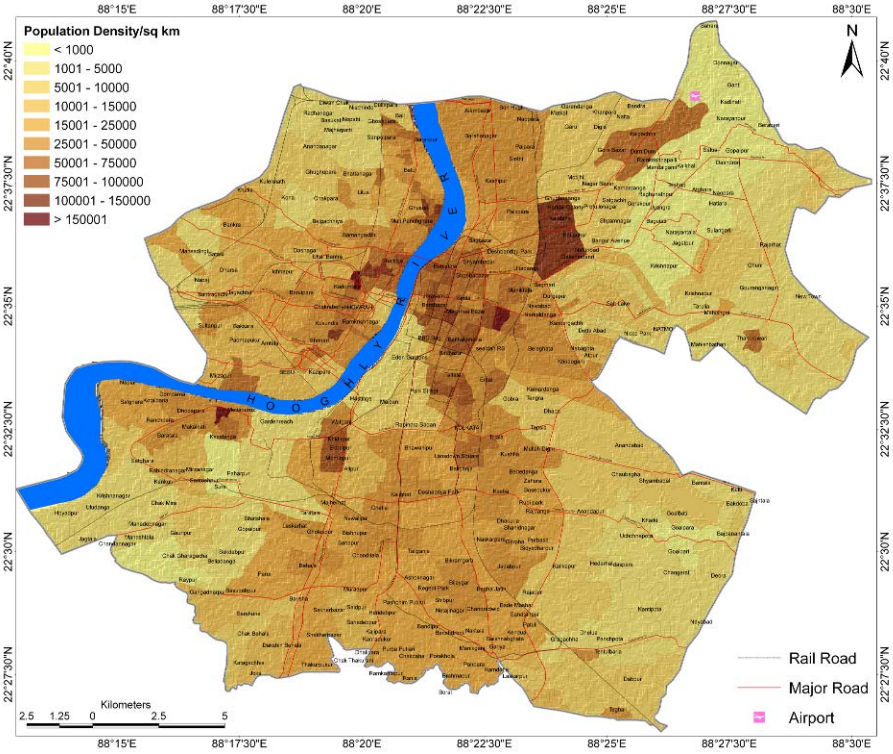

Fig. 4. Population Density distribution of Kolkata after 2011 Census data.

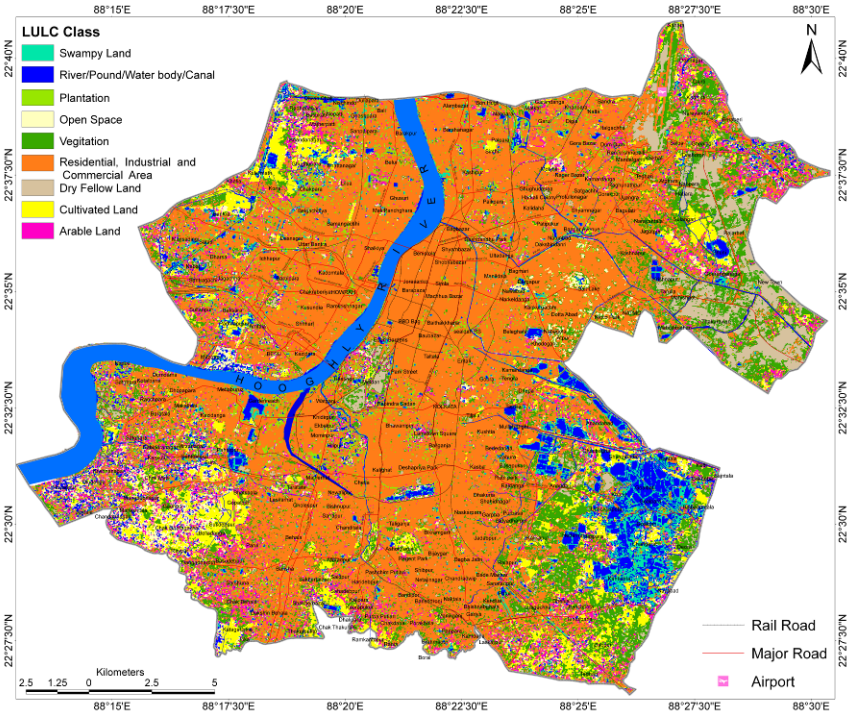

Fig. 5. Landuse/landcover map of Kolkata generated using LISS IV and PAN imagery.

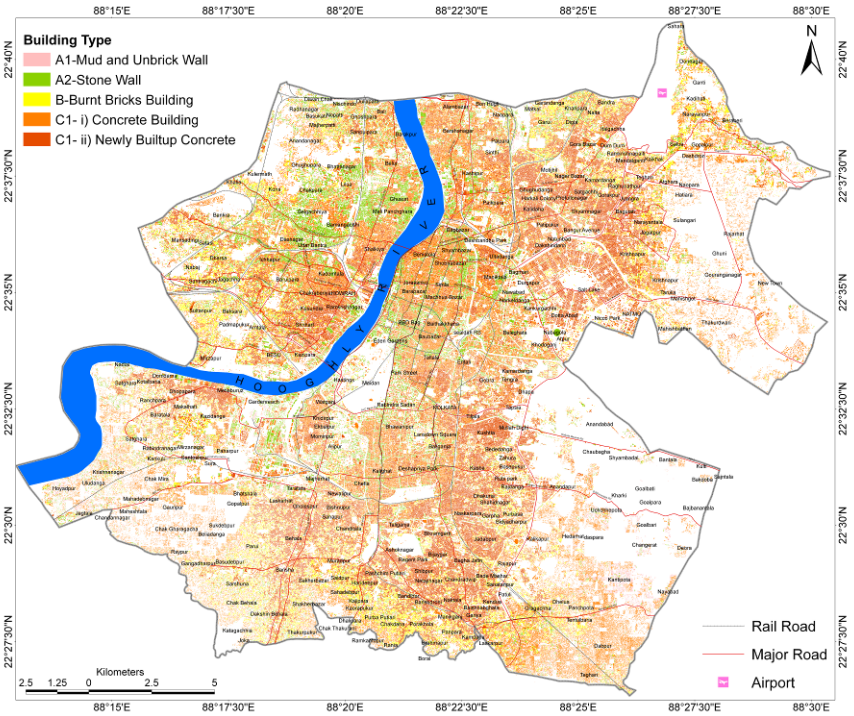

Fig. 6. Building Typology distribution map of Kolkata derived using LISS IV, PAN and LANDSAT TM imagery.

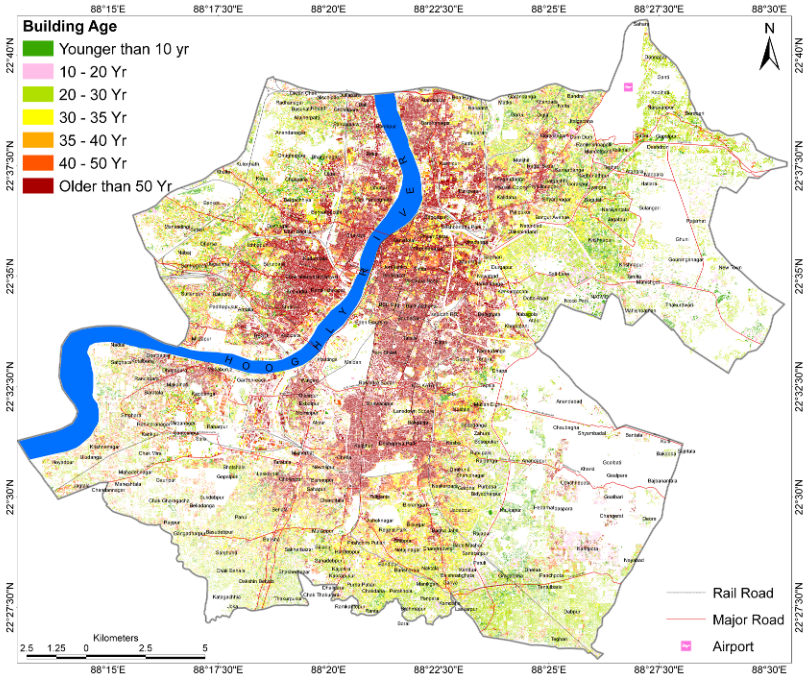

Fig. 8. Building Age classification map of Kolkata using multi-temporal LANDSAT MSS, TM and ETM data for the period of 1975-2010.

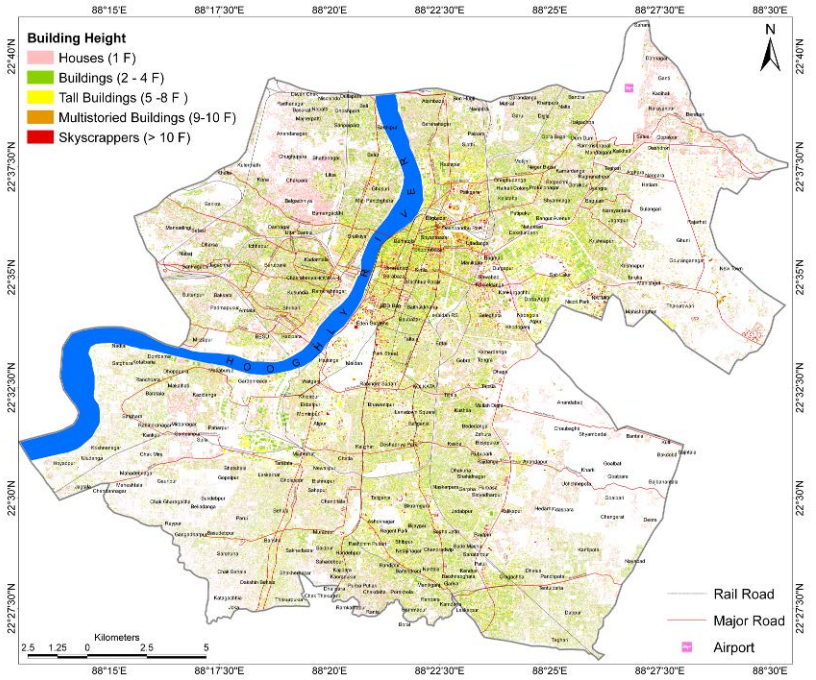

Fig.10. Building Height distribution map of Kolkata using Google Earth.

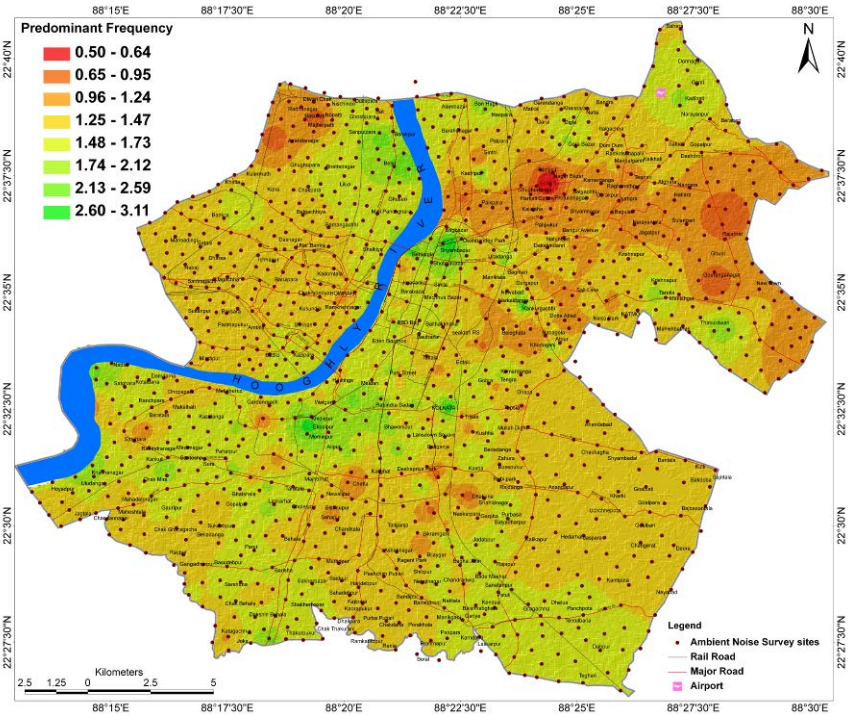

Fig. 11. Spatial distribution of Predominant Frequency in Kolkata as obtained from Ambient Noise Survey at 1200 locations and processing those by Nakamura Ratio.

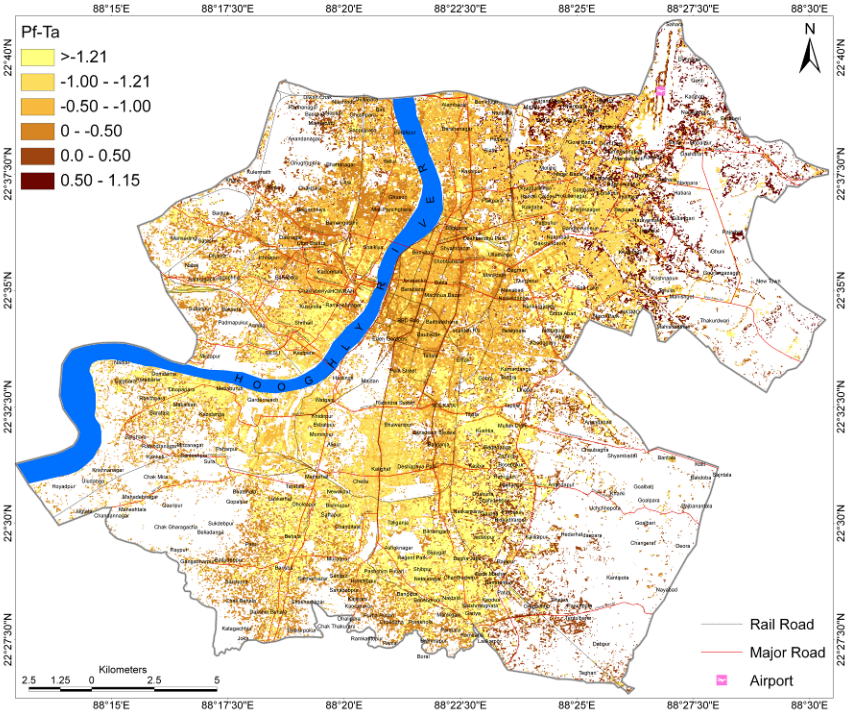

Fig. 12. The difference between the natural period of vibration of structure and the predominant period of the respective site indicating damage possibilities of existing structures/logistics.

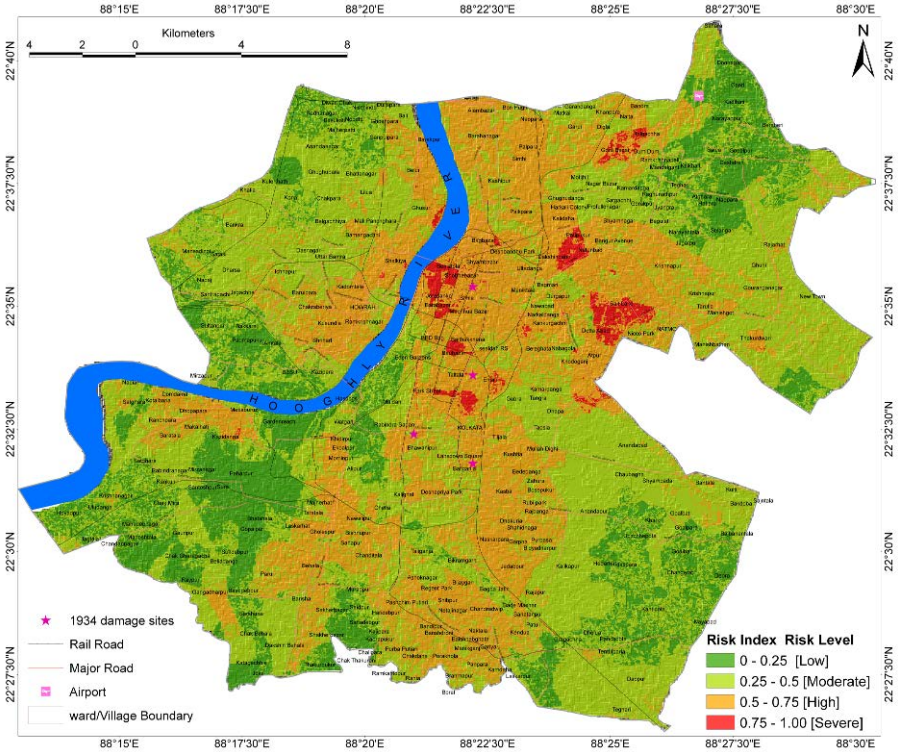

Fig. 14. Probabilistic Seismic Socio-Economic Risk Map of Kolkata. Four broad divisions have been identified with Risk Index (SERI) defined as: $0.75 < SERI \leq 1.0$ indicating severe risk condition in Salt Lake area and a patch at central Kolkata, $0.50 < SERI \leq 0.75$ indicating High risk in central and north Kolkata, $0.25 < SERI \leq 0.50$ indicating moderate risk in the most part of southeast, northeast and west Kolkata, while $SERI < 0.25$ presents a completely risk free regime. The damage distribution due to the 1934 Bihar Nepal Earthquake of Mw 8.1 (GSI, 1939) are identified in the High risk zone (marked by *).

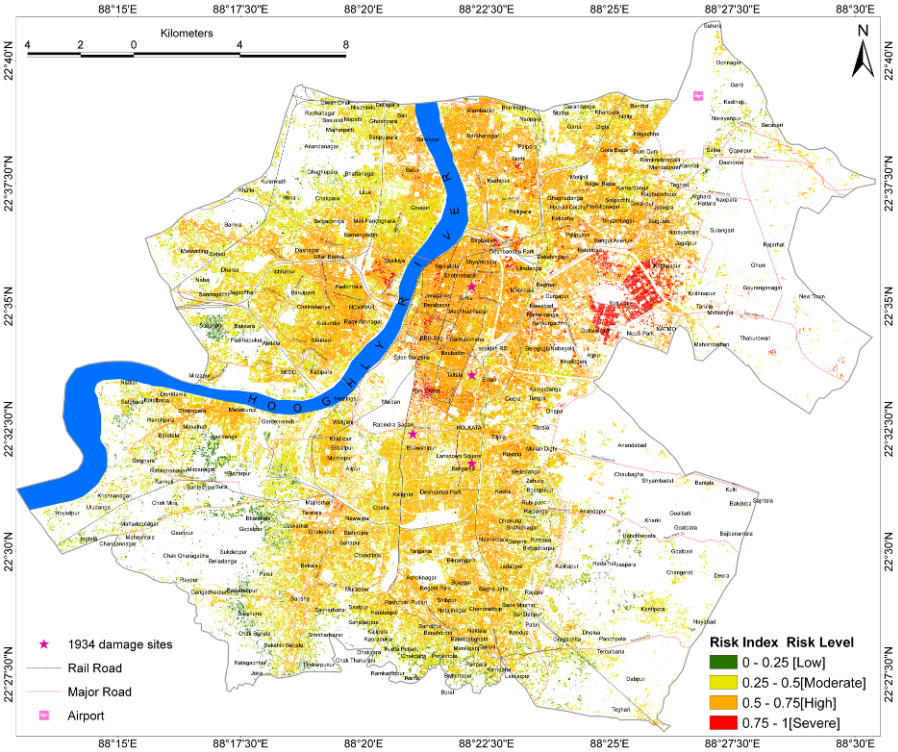

Fig. 15. Probabilistic Seismic Structural Risk Map of Kolkata. Four broad divisions have been identified with Risk Index (SRI) defined as: $0.75 < RI \leq 1.0$ indicating severe risk condition in Salt Lake area, $0.50 < SRI \leq 0.75$ indicating High risk mostly in central Kolkata, $0.25 < SRI \leq 0.50$ depicting moderate risk in the most part of West Kolkata, while $SRI < 0.25$ presents a completely risk free regime. The damage distribution due to the 1934 Bihar Nepal Earthquake of Mw 8.1 (GSI, 1939) are identified in the High Risk zone (marked by *). The detailed structural attributions are presented in Table 8.

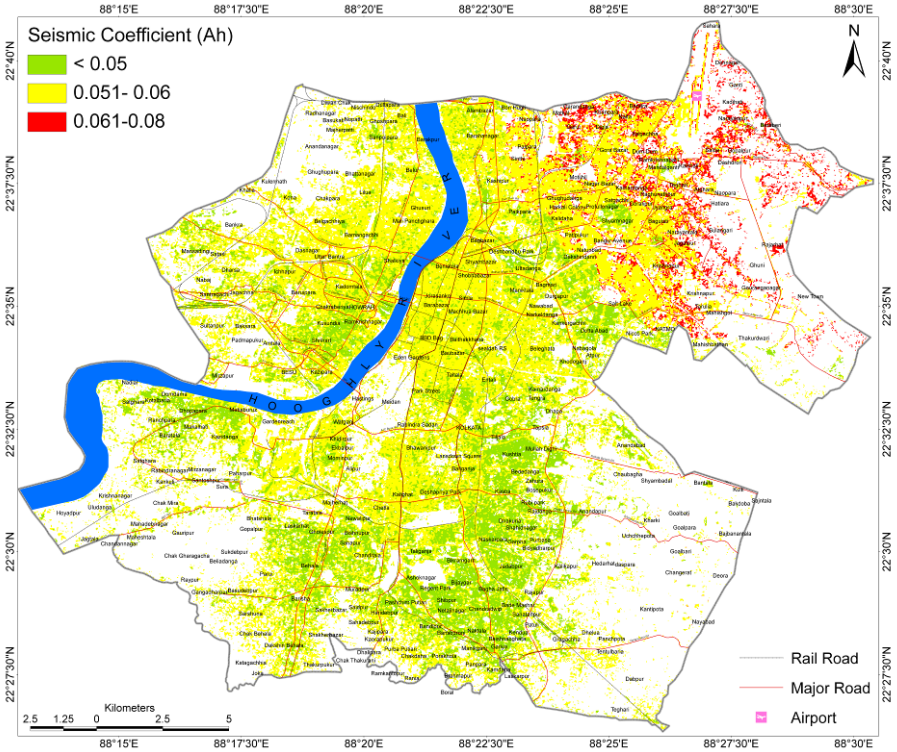

Fig. 16. Spatial distribution of horizontal Seismic Coefficient (A_h) to be used for Kolkata for structures with 1.0 sec predominant period.

Comment 2: Page No.2 Introduction - English correction needed.

Response: The introduction may be modified as follows,

"The necessity of evaluating seismic risk in terms of damage potential of structures and socio-economic set-up of built-up regions due to deadly earthquakes has become an important issue in the Indian context especially after the occurrence of Killary (1993) earthquake of Mw 6.2, Jabalpur earthquake (1997) of Mw 5.8, Chamoli earthquake (1999) of Mw 6.8, Bhuj earthquake (2001) of Mw 7.7, Kashmir earthquake (2005) of Mw 7.6 and Sikkim earthquake (2011) of Mw 6.9 causing widespread destruction & loss of life and property. The number of earthquake impacted fatalities is associated with the vulnerability of local buildings, population density and the intensity of ground shaking. Vulnerability Exposure refers to all man-made facilities namely, the residential, commercial, and industrial buildings, schools,

hospitals, roads, bridges, pipelines, power plants, communication systems, and so on. For the safety and sustainability of urban regions, it is, therefore, necessary to implement long-range urban planning and risk assessment tools that rely heavily on an accurate and multidisciplinary urban modeling. The Kolkata metropolitan city is one of the most densely populated regions in the world and being a major business and industrial hub of east and northeast India supports vital industrial and transportation infrastructures. The metropolitan city is placed on the border of Seismic Zones III and IV as per the seismic zoning map of India (BIS, 2002) with a sedimentary thickness of the order of 7.5 km above the crystalline basement and is highly vulnerable to earthquake disasters."

Page No. 3 Since its a international journal, its better to have a location of study area in the India map so that the readers can understand the seismic hazard of the study area.

Response: It is absolutely right. The expectedly modified Figure 1 will incorporate the seismic zonation map of India not only to depict the location of Kolkata but also to project the hazard level of the city in the existing perspective.

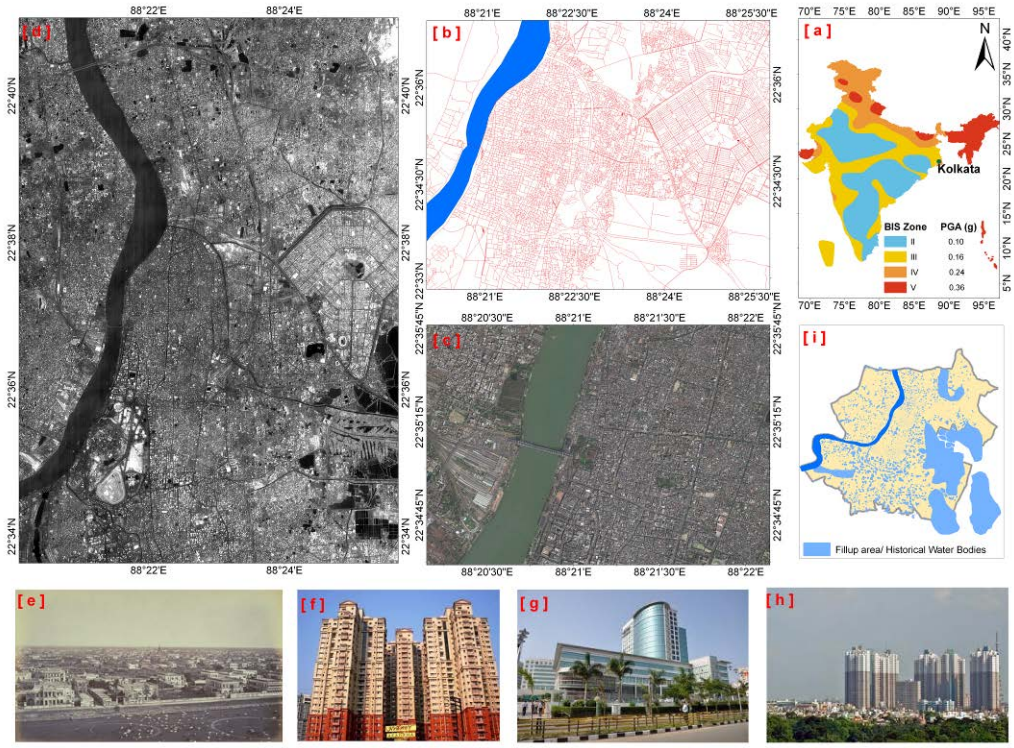

Fig. 1. Urban Kolkata, the study region of the present investigation: (a) Seismic Zonation of India (BIS, 2002) , (b) Road network of central part of the City, (c) GEO-eye (http://www.esri.com/data/basemaps) image of central Kolkata, (d) Cartosat-1 DEM represents the dense urban settlement of central Kolkata and Salt lake region, (e-h) Representative old structure, Skyscraper, Steel structure, Multi storied structures of the city and (i) Fillup area/ historical water bodies map of the region based on Landsat MSS (1972) and Historical maps (Rumsey, 1800 & 1958; http://www.davidrumsey.com).

Comment 3: Page no. 3. Line 18. The population details give as 11 and 14 million is has not match with the data given in 3.1 Demography please check which is correct?

Response: The population details given in page 3, line 18 and section 3.1 are appropriate. The detailed population growth has been illustrated in Table 1. However, in page 3, line 18; we indicated an overall population increase from 1.5 million to 14 million in the city from the year 1901 to 2011.

Comment 4: Page No.3. Line 8. The Kolkata city is among the ..... or One among the ? Check

Response: The expectedly modified sentence will read like "The Kolkata metropolitan city is one of the most densely populated regions in the world and being a major business and industrial hub of east and northeast India supports vital industrial and transportation infrastructures."

Comment 5: Page No.3. Line 22 and 23. 80% of the city has buildings are high rised buidling? Is there any proof or literarture in this regard? It has mentioned that congested business districts? how districts will form in cities?

Response: Detailed Vulnerability analysis and ground truthing in Kolkata for the last 3 years of field investigations have revealed that "More than 80% of the city has built up areas with high rise residential buildings". Also the reference cited (Nandy, 2007) reported the same for the city of Kolkata in the year 2007 itself.

Comment 6: It would be better to give area of the city so that its easy to calculate back the density of population.

Response: In the present study we used ward-wise population density for 300 wards for the vulnerability assessment of the city. It is the population density distribution map of the City that has been presented in Figure 4.

Comment 7: Page No.6 Line 11/ It has mentioned Congalton et.al in the text however in the reference only one author name is given which is correct?

Response: That it is Congalton (1991) is noted.

Comment 8: Page No.8. Line 9. It has given ten major LULC unites in the text however in the figure 5, in the legend there were only 9 classes. Please check? Also the match the legend and text.

Response: Fig 5 depicts major LULC class of Kolkata i.e. residential, commercial and industrial area; river/pond/water body/canal, plantation, open space, vegetation/grassland, swampy land, dry fallow land, cultivated land, canal and arable land. We merged 'Canal' with the 'river/pond/water body' in the LULC unit. Thus, there had been nine LULC units instead of apparently ten as per legend.

Comment 9: Page no.10. Line 25-28 on what basis the building categories are classified, Is there any reference on no of storey and building category?

Response: The detailed classification have been performed as per Kramer (1996) and NIBS (2002).

Comment 10: Page 19. Conclusion. The objective of the manuscript is not rightly justified in the conclusion part. The authors are advised rewrite the conclusion part correlating with the objective part.

Response: Seismic vulnerability and risk has emerged as an important issue in high risk urban centers across the globe and is considered an integral part of earthquake induced disaster mitigation and management. The seismic risk framework adopted here is a multidimensional protocol based on integrated seismic hazard and vulnerability exposures viz. population density, landuse/landcover, building typology, building height and building age judiciously integrated on Geographical Information System to identify those structural and socio-economic conditions which are responsible for turning earthquake disaster into a catastrophe.

Thus the knowledge of risk in the city based on existing urban built-up environment will immensely contribute towards its disaster mitigation and management.

Comment 11: Page 19. Line 8.It has mentioned artificial non engineered filled up regions. Where is the evidence of lakefill/marshy land filled up area? match with the landuse land cover area.

Response: The artificial non-engineered filled regions/historical water bodies will be captured from Landsat MSS (1972) and the available Historical maps (Rumsey, 1800 & 1958; http://www.davidrumsey.com) and the same will be incorporated in the proposed revised version of the diagram. Incidentally as depicted in landuse/landcover (Fig. 5) a large part of the city have been developed on artificial deposits.

Comment 12: Page 23. Table 1. 2011 population is 14.11 million but in the figure 4. its has mentioned in the legend >150000. how?

Response: Figure 4 represent the ward-wise population density map of Kolkata which is defined as:

Population Density= Total Population of the ward/ Total area of the ward in Km.

Thus the legend (>150000) in Fig 5 represent the density of population (per sq km) of respective wards.

Comment 13: Page 41. Figure 8. In legend the building year range can be added.

Response: Figure 8 will be modified and a new legend will be incorporated as, younger than 10 yr, 10–20 yr, 20–30 yr, 30–35 yr, 35–40 yr, 40–50 yr and older than 50 yr.

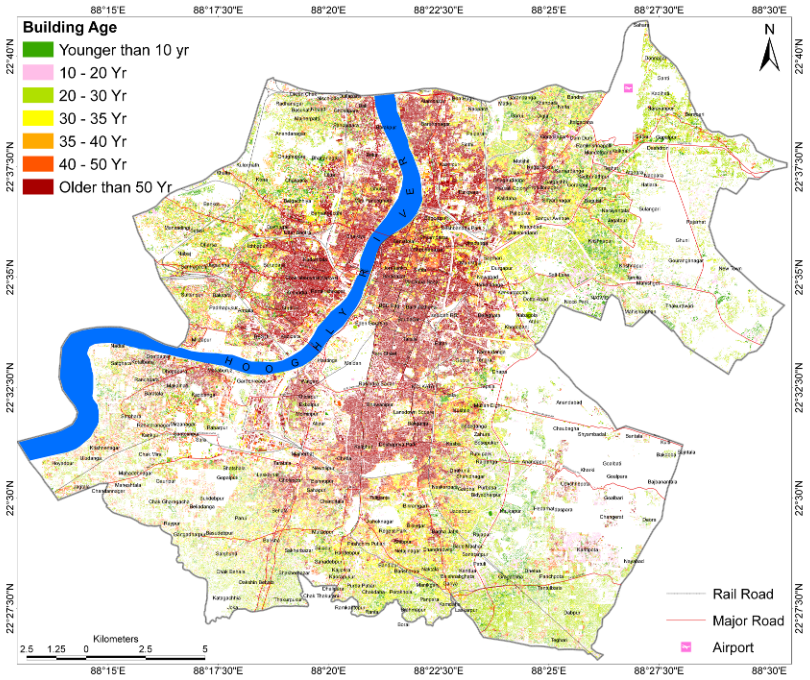

Fig. 8. Building Age classification map of Kolkata using multi-temporal LANDSAT MSS, TM and ETM data for the period of 1975-2010.

Comment 14: Page. 48. Figure 15. The Risk interval calculation what is the engineering base behind the interval. Explain?

Response: The concept of social vulnerability helps in identifying those characteristics and experiences of individuals and communities that enable them to respond and hence to recover from earthquake disaster. Seismic Risk Microzonation is based on a dimensionless quantitative zonation in micro-scale that helps in indexing the seismic risk in terms of socio-economic & structural both as 'Low', 'Moderate', 'High' and 'Severe' individually to demarcate the most vulnerable zones in the view of socio-economic and structural risk aspects of the city.

References:

BIS: IS 1893–2002 (Part 1): Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1 – General Provisions and Buildings, Bureau of Indian Standards, New Delhi, 2002.

Congalton, G. R.: Review of Assessing the Accuracy of Classifications of Remotely Sensed Data, Remote Sens. Environ., 37,35-46, 1991.

Kramer, S. L.: Geotechnical Earthquake Engineering, Prentice Hall, Upper Saddle River, NJ, 653 pp, 1996.

Nandy, D. R.: Need for seismic microzonation of Kolkata megacity, Proceedings of workshop on microzonation, Indian Institute of science, Bangalore, India, 2007.

NIBS: HAZUS99- earthquake loss estimation methodology, technical manual In, FEMA (Editor), Technical Manual. Federal Emergency Managemen Agency (FEMA), National Institute of Building Sciences (NIBS), Washington. DC., 2002, pp. 325.