REFREE COMMENTS # 2

General comment: Midhat Fayaz et al. present a vulnerability assessment of the buildings in Srinagar city in the event of earthquake. The authors consider 69 municipal wards within Srinagar urban area. The analysis is based on a building inventory having details of the nature and structure of buildings. The authors perform a ground-based survey to validate the inventory which is commendable. The manuscript offers some insights into differential vulnerabilities of buildings within the urban area. Though there is not any visible flaw in the analysis and assessment some fundamental aspects of earthquake science is missing in the manuscript. Therefore, major revisions as following are required for this manuscript to be considered for publication.

Response: Many thanks for commending our work. Authors express their gratitude to the Reviewer for the careful assessment of our work and for valuable suggestions and comments, the incorporation of which have improved the quality of the revised manuscript. We agree with the comment that some of the earthquake related parameters are not included in this study. Below is the point-by-point response to the comments/suggestions.

Comment 1:-The authors list major earthquake events in Srinagar city/Kashmir. However, they do not explain how the relate the earthquake related parameters i.e., epicenter with the vulnerability assessments.

Response: Thank you for the comment. Agreed that the location of earthquake epicentre indicates the presence of geological structures (faults) in a particular area (Sana, 2018). The available records of historical and instrumental earthquake events (Table 1) in the study area indicate a high probability of earthquake events in the Srinagar city in the future. Dar et al., 2019 have shown that the River Jhelum, running through Srinagar city itself flows along or parallel at many places to a lineament or fault known as Jhelum fault in the Kashmir Valley. Besides high tectonic activity and the lithology (mostly unconsolidated sediments) of the area, makes the area vulnerable to earthquakes.

Therefore, it is believed that in light of the high vulnerability and occurrences of past earthquakes with epicentre in and around Srinagar makes the earthquake vulnerability assessment of study area an important exercise irrespective of the exact location of the epicentre. We assumed that the entire city is vulnerable because of the presence of the Jhelum fault in the midst of the city.

We have modified the study area map in the revised manuscript showing the nearest faults/lineament details (see fig. 1) and made a mention of the above facts in the revised manuscript at line number 124-138.

Sana, H.: Seismic microzonation of Srinagar city, Jammu and Kashmir, Soil Dynamics and Earthquake Engineering, 115, 578-588, https://doi.org/10.1016/j.soildyn.2018.09.028, 2018.

Dar, R. A., Mir, S. A., and Romshoo, S. A.: Influence of geomorphic and anthropogenic activities on channel morphology of River Jhelum in Kashmir Valley, NW Himalayas, Quaternary International, 507, 333-341, https://doi.org/10.1016/j.quaint.2018.12.014, 2019.

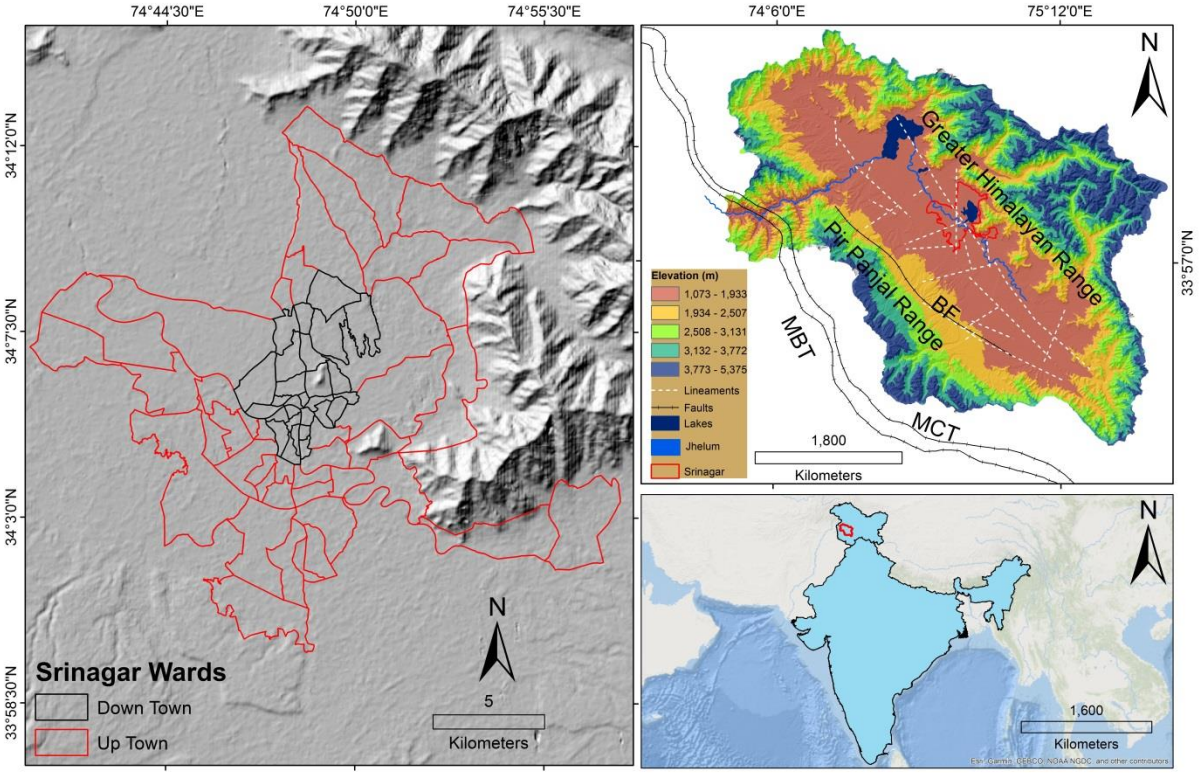

Fig.1: Location of the study area. Here MBT stands for Main Boundary Thrust, MCT stands for Main Central Thrust, BF stands for Balapur Fault.

Comment 2:- Nowhere it is mentioned how does the geology, lithology and faults are considered to zonate the likelihood of earthquake events within the city. It would have been helpful if the authors have at least considered an earthquake hazard zonation map in their analysis. Without these it is surprising that how the authors assess the earthquake vulnerability of buildings. The present manuscript gives an impression of vulnerability of buildings alone but not for earthquake events.

Response: Thanks for the comment. The present study was carried out to look into the vulnerability of built-up environment at a high spatial resolution at building footprint scale ward-wise in the Srinagar city. Geology, lithology, and lineaments faults were taken into account during data analysis. However, keeping in view the high occurrences of the past earthquakes with epicentre in and around Srinagar irrespective of the exact location of the epicentre and distribution of other geological/geomorphic and soil parameters, the entire city wards are equally vulnerable to earthquakes in the eventuality of an earthquake. The River Jhelum, running through the Srinagar city, itself flows along or parallel at many places to a lineament or fault known as Jhelum fault in the Kashmir Valley. Besides because of the high tectonic activity and the lithology (mostly unconsolidated sediments) of the area, it was found that there is very little difference in earthquake vulnerability between various wards because of the similar tectonic, lithologic and geomorphic set up of the city wards; therefore all of these parameters were kept constant. All of Srinagar's wards are situated on consolidated alluvium, or Karewas, which share similar characteristics in terms of how they react to earthquakes. Panjal volcanics are located in a few inconspicuous places, however these are hills that have no habitation, making lithology the least influential parameter in this study. Additionally, there is a very high earthquake risk in each of Srinagar's wards (Sana, 2018; Yousuf and Bukhari, 2020) (see Fig.2). Since the vulnerability at the ward level is the primary focus of the current study, all of the wards were treated as having an equal risk from seismic activity. Please see figure 2 and Figure 3 below for details about the distribution of earthquake related parameter and earthquake hazard map.

Accordingly, we have made a mention of same in the revised manuscript from line number 124-138 under Introduction Section.

Sana, H.: Seismic microzonation of Srinagar city, Jammu and Kashmir, Soil Dynamics and Earthquake Engineering, 115, 578-588, https://doi.org/10.1016/j.soildyn.2018.09.028, 2018.

Yousuf, M., Bukhari, S. K., Bhat, G. R., and Ali, A.: Understanding and managing earthquake hazard visa viz disaster mitigation strategies in Kashmir valley, NW Himalaya, Progress in Disaster Science, 5, 100064, https://doi.org/10.1016/j.pdisas.2020.100064, 2020.

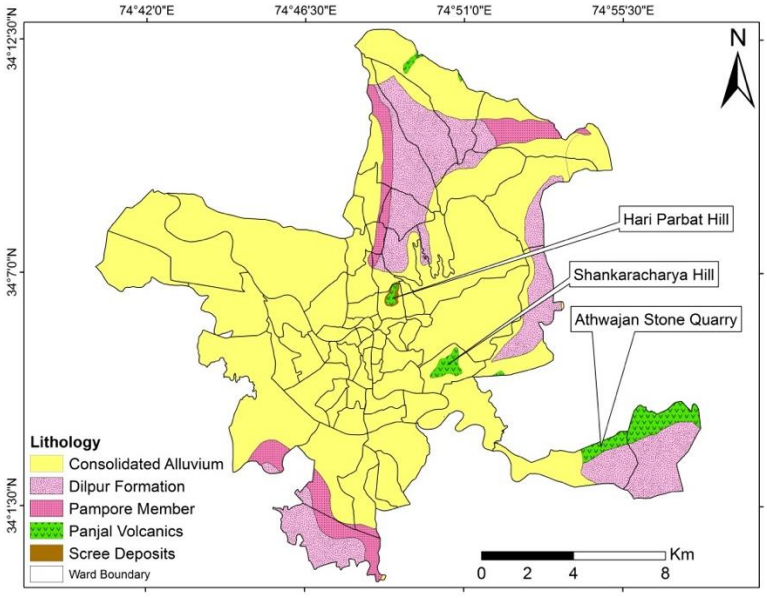

Fig.2: lithology map modified after Thakur and Rawat, 1992.

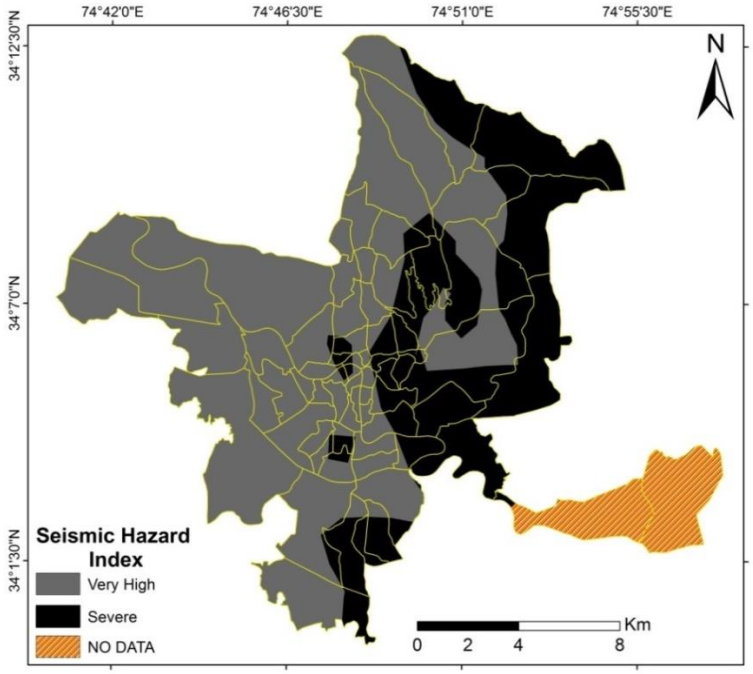

Fig.3: Seismic Hazard Index map modified after Sana, 2018.

Comment 3:- In addition, buildings are susceptible to failures due to ground failure during earthquakes i.e., liquefaction and other soil-structure related damages. Nowhere in this study these aspects have been mentioned or considered.

Response: Thanks for the comment. In a similar fashion like that of the lithology, soils and lineaments, the Liquefaction Potential Index (LPI) of the Srinagar shows very least variability from one ward to another. Please see the Figure 4 below for the Liquefaction Potential Index

of the Srinagar city (Sana et al., 2016). All the wards of the city fall within LPI of high to very high zone. Thus, like other geological factors, this factor was also kept constant for all the wards of Srinagar under study. It is pertinent to mention here that there are several studies conducted globally that have not included the geological/earthquake parameters in the analysis of earthquake vulnerability assessment of built up environment of cities because of the similar reasons e.g. Srikanth et al., 2010; Ishita and Khandaker 2010; Islam et al., 2013; Alizadeh et al., 2018; Adhikari et al., 2019; Menegon et al., 2019; Fan et al., 2021.

In light of the Reviewer's comments and above explanations, we have made a mention of the above response in the revised manuscript at line number 124-138.

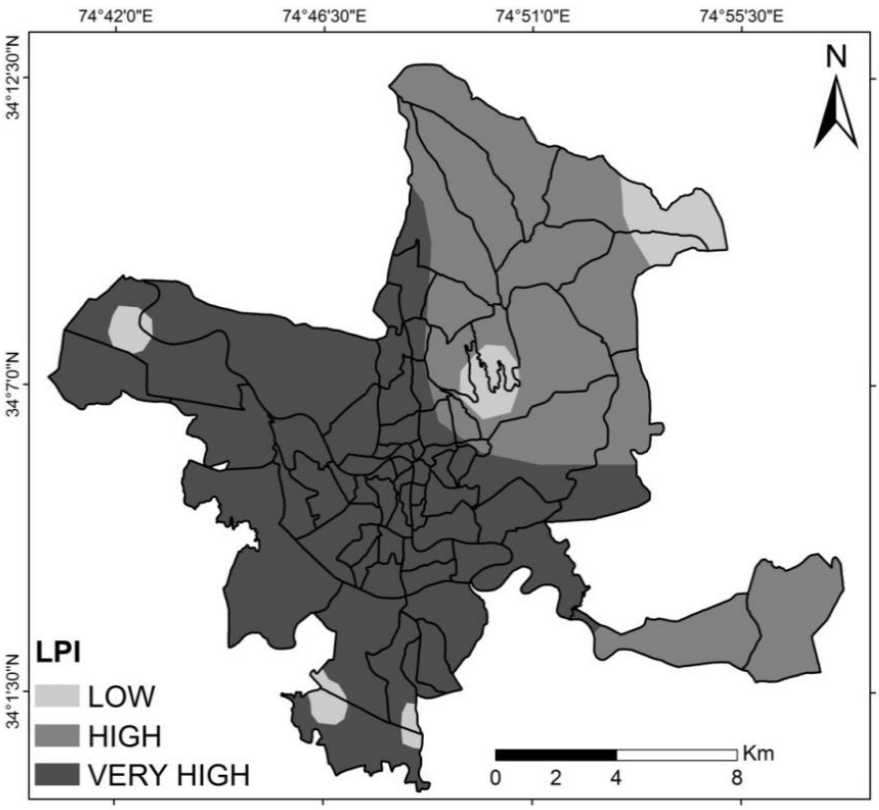

Fig.4: Liquefaction Potential Index map modified after Sana, 2016.

Sana, H., and Nath, S. K. (2016). Liquefaction potential analysis of the Kashmir valley alluvium, NW Himalaya. *Soil Dynamics and Earthquake Engineering*, *85*, 11-18.https://doi.org/10.1016/j.soildyn.2016.03.009

Srikanth, T., Kumar, R. P., Singh, A. P., Rastogi, B. K., and Kumar, S. (2010). Earthquake vulnerability assessment of existing buildings in Gandhidham and Adipur cities Kachchh, Gujarat (India). European Journal of Scientific Research, 41(3), 336-353.

Ishita, R. P., and Khandaker, S. (2010). Application of analytical hierarchical process and GIS in earthquake vulnerability assessment: case study of Ward 37 and 69 in Dhaka City. J Bangladesh Inst Plan ISSN, 2075, 9363.

Islam, M. S., Sultana, N., Bushra, N., Banna, L. N., Tusher, T. R., and Ansary, M. A. (2013). Effects of earthquake on urbanization in Dhaka City. Journal of Environmental Science and Natural Resources, 6(1), 107-112.

Alizadeh, M., Hashim, M., Alizadeh, E., Shahabi, H., Karami, M. R., Beiranvand Pour, A., ... and Zabihi, H. (2018). Multi-criteria decision making (MCDM) model for seismic vulnerability assessment (SVA) of urban residential buildings. ISPRS International Journal of Geo-Information, 7(11), 444.

Adhikari, A., Rao, K. R. M., Gautam, D., and Chaulagain, H. (2019). Seismic vulnerability and retrofitting scheme for low-to-medium rise reinforced concrete buildings in Nepal. Journal of Building Engineering, 21, 186-199.

Menegon, S. J., Tsang, H. H., Lumantarna, E., Lam, N. T. K., Wilson, J. L., and Gad, E. F. (2019). Framework for seismic vulnerability assessment of reinforced concrete buildings in Australia. Australian Journal of Structural Engineering, 20(2), 143-158.

Fan, X., Nie, G., Xia, C., and Zhou, J. (2021). Estimation of pixel-level seismic vulnerability of the building environment based on mid-resolution optical remote sensing images. International Journal of Applied Earth Observation and Geoinformation, 101, 102339.