Response to reviewers' comments:

Dear referee,

I wish you a Merry Christmas and a Happy New Year.

Thank you very much for your valuable comments. I have tried to response to all of them base on scientific and logical reasons and hope it will meet your expectation.

Best regards,

Authors

Referee 1:

1) The output is a qualitative ranking of the susceptibility of the area to ground motion amplification phenomena. The Authors should stress that is a kind of level-1 or grade-1 microzonation study according to international standards and guidelines. More detailed studies are needed in high-risk areas and should be based on numerical modelling of site effects (i.e, physically based procedures which cannot be replaced by influencing criteria methods).
   *R: Yes, the research is conducted based on first level seismic microzonation procedure.

"The main purpose of this paper is to develop a model for evaluation of local seismic amplification using AHP, Fuzzy Logic and Weighted Linear Combination (WLC) methods in GIS. At this stage, model inputs are direct characteristics of local geology, hydrology, sedimentology, and topographical factors that should be taken into consideration. Firstly, all selected criteria were weighted using AHP method by interviewing 10 experts, next all criteria were converted into fuzzy sets, then fuzzy membership functions (MFs) were produced, finally WLC and fuzzy inference rules were applied to develop a model for producing a first level susceptibility map of local seismic amplification based on level-1 seismic microzonation procedure for a study area. "

2) My biggest doubts concern the criteria selected for the procedure. "consolidation and strength": consolidation should be replaced by stiffness (in terms of shear wave velocity or shear modulus) while the strength (i.e. soil resistance) is not pertinent; the resistance should influence the slope stability or the resistance to liquefaction not the amplification phenomena. The "particle size distribution" does not affect the amplification phenomena: the stiffness of soil is the controlling factor not the particle size: a coarse-size if loose soil can be softer than a consistent over consolidated fine grained clay ! The "depth of groundwater" is not pertinent for amplification effects, it only controls the possible occurrence of soil liquefaction in loose sandy soils.

*R: This study tries to propose a method in dealing with uncertainties. As you mentioned, there not a clear procedure of considering all influencing criteria to produce susceptibility level of local seismic amplification. Here what we are trying to say is how we can consider all criteria in a logical procedure. We know it is not a perfect way, but still give ideas to people in this field of study to work on each influencing criteria by its own and improve the model.

The criteria were selected based on an extensive literature review. In order to be able to come up with the idea of influencing criteria on susceptibility level of local seismic amplification, we have to consider the effect of geology, geomorphology, topography and bedrock on this phenomena. We have to make separation among all influencing criteria to be able to solve our problem based on fuzzy theory. According to this theory we can handle uncertainties. As, you said regarding liquefaction and groundwater level. We are not 100 percent sure that the groundwater level will not have any effect on amplification coefficient of an area. Then, we have to come up with the idea that it may have an influence, event it is minor effect. Therefore, fuzziness can solve this problem as seen in the paper.

Yes, I understand consolidation/stiffness is the controlling factor, but still there is an effect of particle size on the local seismic amplification, which is considered through fuzziness of each criterion. Threofre, we have main controlling factors/criteria (main criteria with high weights) and minor criteria (with low weights) based on AHP method. Furthermore, sub-criteria for each criterion that are weighted based on Fuzzy Logic method, as seen in Figure. 1 spatial soft soil has fuzzy membership of 1, while hard rock has fuzzy membership (FM) of 0. It means spatial soil (unconsolidated soil and sediment) has more effect on amplification factor and areas with this type of soil will be highly amplified.
Figure 2 shows the effect of grain size on amplification factor by itself (alone). Fine grain (clay) sediment has FM of 1, while coarse grain sediment (boldder) has FM of 0.3.

Let's see collateral effects on amplification factor:

- Unconsolidated fine grain sediment (unconsolidated clay) = 1 * 1 = 1
- Unconsolidated boldder = 1 * 0.3 = 0.3

  As seen above if we are dealing with unconsolidated clay the amplification factor will be 1, while in unconsolidated bolder the amplification factor will be 0.3.

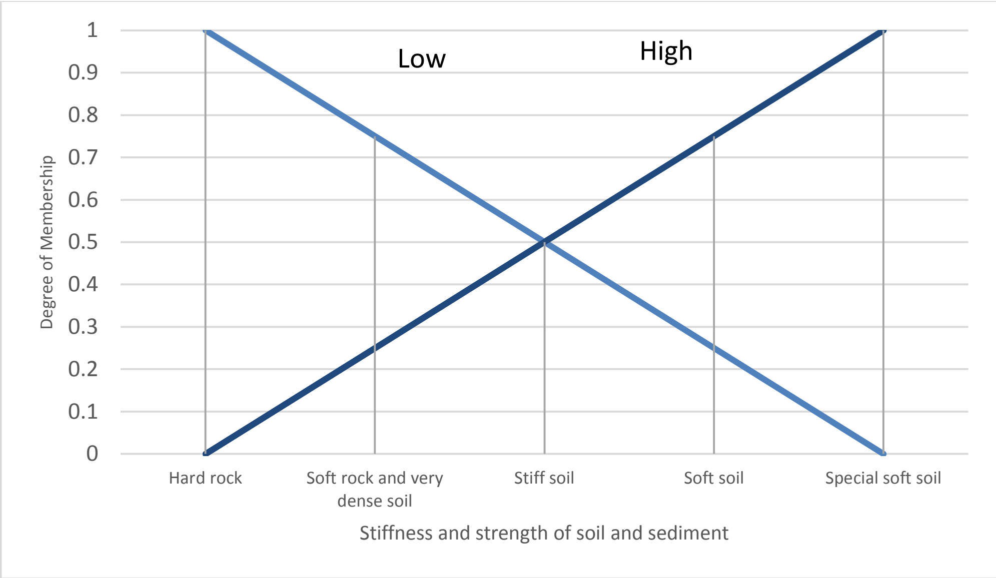


Figure 1. Fuzzification of stiffness and strength of soil and sediment

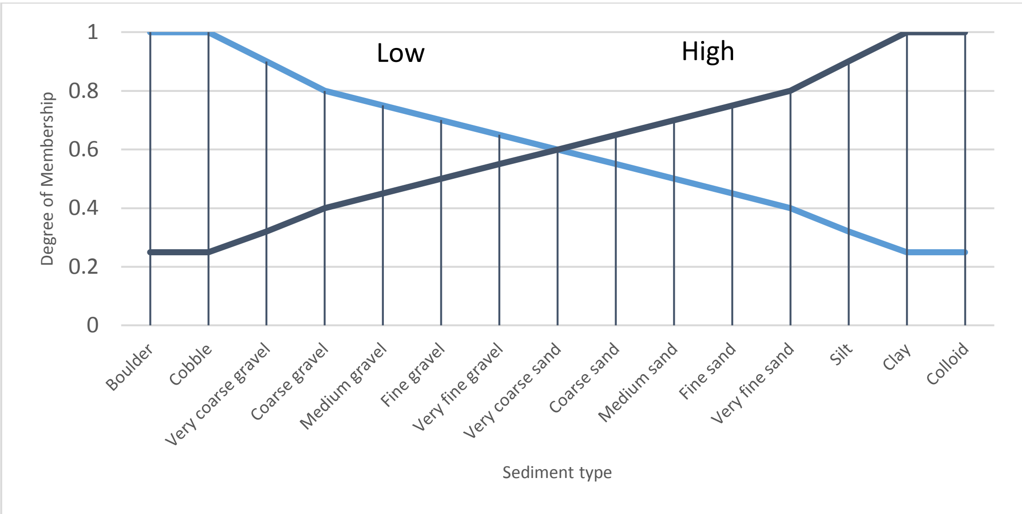


Figure 2. Fuzzification of grain size criterion

In terms of groundwater level, as seen in Figure 3, it is the main factor in effecting liquefaction susceptibility, but it can still effect on local seismic amplification factor.

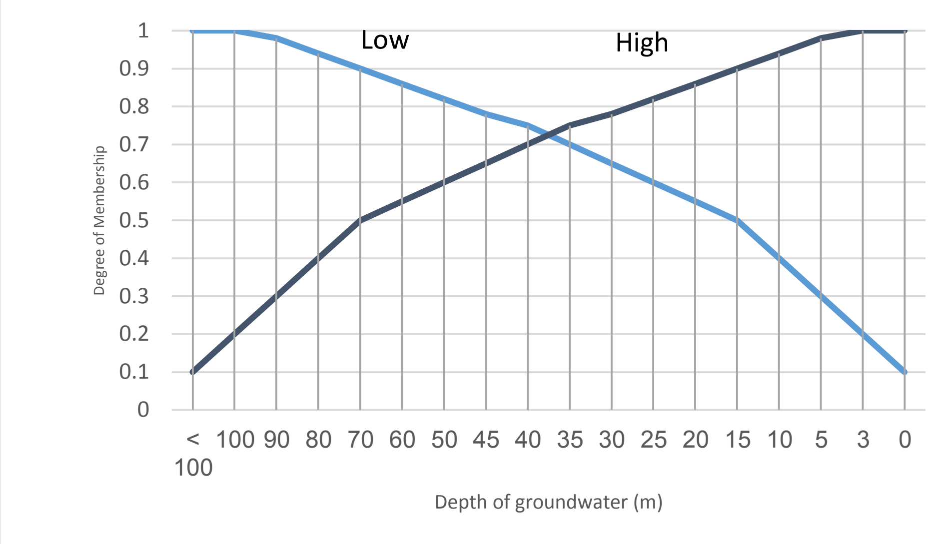


Figure 3. Fuzzification of depth of groundwater

3) In table 1 is not clear the difference between morphology of bedrock and topography of bedrock (even if, as I understand, they are considered as minor criteria). I strongly suggest to remove these factors or better define them.

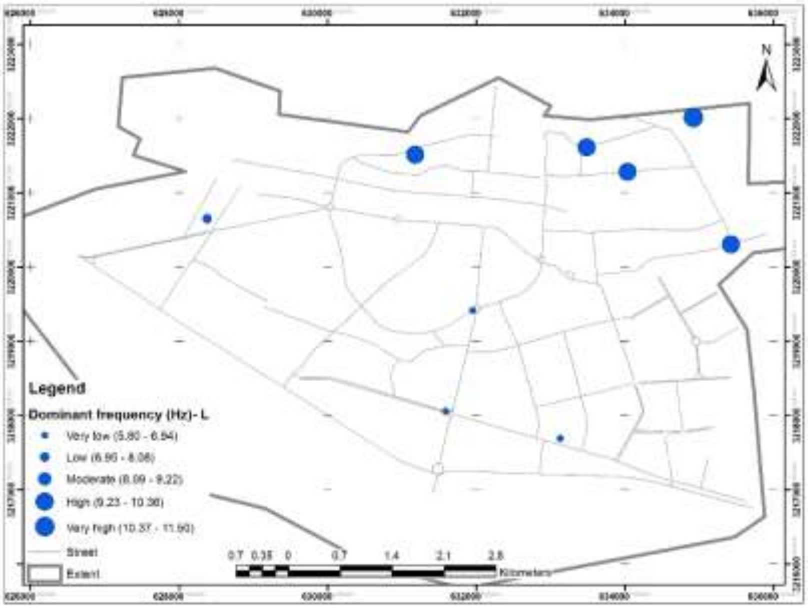
*R: Morphology of bedrock defines the shape of bedrock. It can be like bowl, cylindrical, semi-spherical, conical, or even invers conical and semi-spherical as a result of revers faults.

Topography of bedrock is very similar to the topographic irregularities, it all says about roughness or smoothness areas and elevation changes.

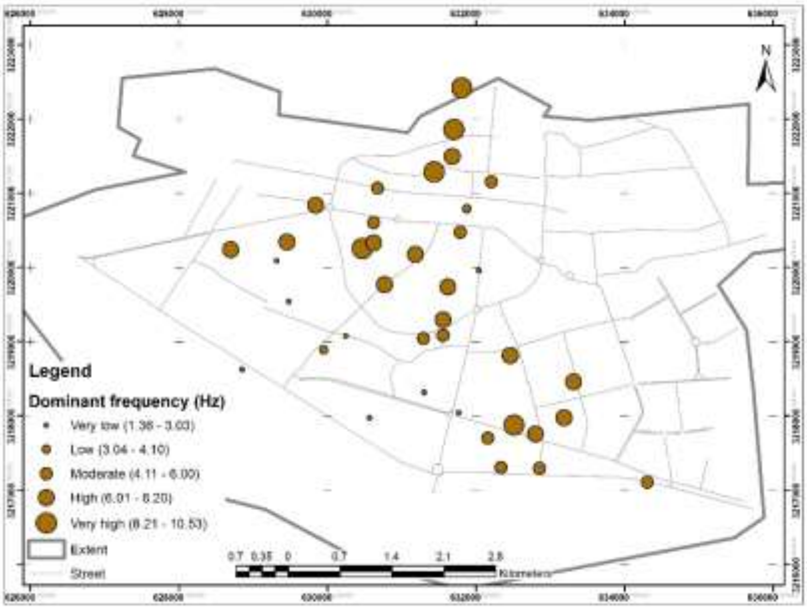
4) Specific comments 1) It is not clear how the output of model is compared with experimental resonance frequencies. In terms of amplitude of HVSR peak with levels of shaking map ? Please describe better this validation phase.

*R: Predominant frequency ranges from 1.36 to 10.53 Hz, and amplification factor ranges between 1.33 and 4.77. These findings indicate that soil type in Bam city is mainly stiff, and amplification factor is relatively large. There is a high frequency zone from the north and northwest to the southeast of Bam where amplification factor trends to large values. However, in west and southwest of the city, fundamental frequency is low and amplification factor exhibits smaller values compared to other parts of the city.

Predominant frequency (Figure 4a and b) has been divided to 5 classes including: very low, low, moderate, high and very high. These 5 classes overlay the output of the model which has 5 classes that renege from very low to very high susceptibility levels. By comparing these two maps an error matrix will be created and overall accuracy of the output of the model will be calculated.



a)



b)

Figure 4. Control data: Dominant frequency by Lashkaripour (a) and by Motamed et al (Motamed et al., 2007) (b) using Microtremor field measurement.

5) Pag. 3: at the state of art, I don't believe that SSHA methods can be used for microzonation: source and path parameters are still quite significant to define. PSHA assessments at regional scale (at outcropping rock) and site response modelling at local (urban scale) are the most adopted procedure almost worldwide.
   *R: I have revised this section based on your comments as shown below:
   Probabilistic Seismic Hazard Analysis (PSHA) (Cornell, 1968) has been used to assess ground-motion hazards from earthquakes (Atkinson et al., 2015;Petersen et al., 2016). This method depend on "the length of the causative faults and depth of the earthquake", which are generally unknown thus causing uncertainty in assessing ground-motion of

earthquakes (Wang et al., 2017). In deterministic seismic hazard analysis (DSHA) (Campbell, 2003;Atkinson and Boore, 2006) the lack of relevant ground-motion attenuation relationship for specific geographic areas can cause uncertainty in applying DSHA for assessing ground motions of an earthquake (Wang et al., 2017). Scenario-based seismic hazard analysis (SSHA) (Panza et al., 2012) applies ground-motion simulations of a scenario earthquake using specified source, path and site parameters, however the parameters needs to be defined significantly. By conducting many simulations, earthquake variability of different sources, ground-motion propagation characteristics, and local site effects can be considered. Therefore, uncertainties using SSHA are quantified explicitly (Wang et al., 2017), although this method is still under development. Therefore, PSHA assessments at regional scale and site response modelling at local scale are the most adopted procedure almost worldwide.

6) Typing 3) Pag. 11: “microtremor” instead of “microtremore
*R: I have revised the word.