

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. We have tried to response to all of them base on scientific and logical preasons and hope it will meet your expectation.

Best regards,

Authors

Referee 2:

First of all, the paper need a strong revision of the English by an English mother tongue. Second critical point, authors should avoid to repeat the same concepts too many times just by using slightly different sentences.

R: I have revised the text and removed repetition from different sections. The paper was reviewed by a mother tongue editor to make it as clear as possible.

Third, very important point. Authors talk about seismic microzonation of ground shaking amplification. This concept is not clear to me. Do they mean "seismic site response"? This is a crucial point that needs to be clarified. In addition, in the discussion section, authors suddenly introduce the concept of "susceptibility amplification" (line 469). Susceptibility is different from seismic site response! Authors need to clear state these concepts in the entire paper.

R: The aim of this study was to develop a new method based on thematic layers, AHP and Fuzzy logic theory for producing a qualitative output which can rank the susceptibility of the area to ground motion amplification phenomena.

I have revised the concept based on Aucelli et al. (2018) paper and applied the same terminology as they proposed " modelling of local seismic amplification susceptibility ". This concept have been used throughout of my paper.

Aucelli et al. (2018) proposed a method for producing susceptibility index to local seismic amplification in Isernia Province, Italy based on geological and geomorphological properties of studied areas. This research mostly followed an evidence based approach to estimate susceptibility level of local seismic amplification in the area, although they have not considered the use of multi-criteria decision-making methods (MCDM) in weighting and combining the influencing criteria which is the aim of conducting this research.

Fourth critical point, the method section is 12 pages long whereas the discussion and conclusion section is just 3 pages! This discrepancy is incredible! Methods section include too many repeats of the same concepts (e.g., authors said several time that they interviewed 10 experts!).

R: This is right, but I had to go through a series of different steps in this section to make it as clear as possible. Each step had its own result which I could bring them to the results and discussion section of the paper, but it will make a huge separation between data preparation and fuzzification of each criterion. I had to keep this two parts together to make a good image in readers mind.

R: I have tried to get rid of repetition through the paper.

In addition, discussion and conclusion section needs to be more detailed.

R: I have read several papers and tried to discuss the findings of this research via a critical approach.

In this study, we have focused on the site effect and local geology properties of a site that have a massive influence on local seismic amplification susceptibility in the study area. To deal with related uncertainties in preparing seismic microzonation, the most important criteria were selected, weighted and then fuzzified. Criteria with high uncertainty degree such as distance of active fault to the site, depth and magnitude of the probable earthquake were not considered because there was no possibility to exactly find out where and how an earthquake will be triggered. Therefore, only the criteria with known location (x and y) and known characteristics were taken into consideration.

Furthermore, to deal with uncertainties Fuzzy Logic is a suitable approach as we can define membership function of the effect of each criterion in the amplification of ground shaking by interviewing 10 experts and obtaining expert's knowledge. This can result in realistic output regarding the behavior of each criterion in ground shaking calculation.

The newly developed model uses AHP and Fuzzy Logic (Zadeh, 1965) to deal with complexities and uncertainties in data analyses in weighting the criteria and fuzzifying the sub-criteria of each criterion. Although, in studies for evaluating seismic microzonation in Bangalore (India) (Sitharam and Anbazhagan, 2008), Delhi (Mohanty et al., 2007), Haldia (India) (Mohanty et al., 2007), Erbaa (Turkey) (Akin et al., 2013) and Al-Madinah (Moustafa et al., 2016) only AHP method was applied to weight the criteria, and none of these studies considered weighting of sub criteria for each criterion even using other methods.

Few researchers have considered direct properties of influencing factors in assessing ground shaking amplification. Even, in evaluating seismic response developed models such as SiSeRHMap v1.0 (Grelle et al., 2016) and GIS Cubic Model (Grelle et al., 2014), the researchers have applied only lithodynamic, stratigraphic and topographic effects as influencing factors. Furthermore, Aucelli et al. (2018) suggested a method for producing susceptibility index to local seismic amplification in Isernia Province, Italy, and they have considered geological and geomorphological properties of studied areas. Although, they have not considered the use of multi-criteria decision-making methods (MCDM) in weighting and combining the influencing criteria which is the aim of current study. The current research

considers direct properties of each criteria and tries to manage uncertainties in criteria and sub-criteria of each criterion via weighting and fuzzification process using experts' knowledge and the use of direct properties of criteria. These processes can be extended in more details, which are subject to more investigation in the future.

Fifth point, most of the figures are very hard to read. Quality of figures should be increased. Several other comments are listed in the attached file.

R: Quality and size of all figures were increased as seen below.

Figures

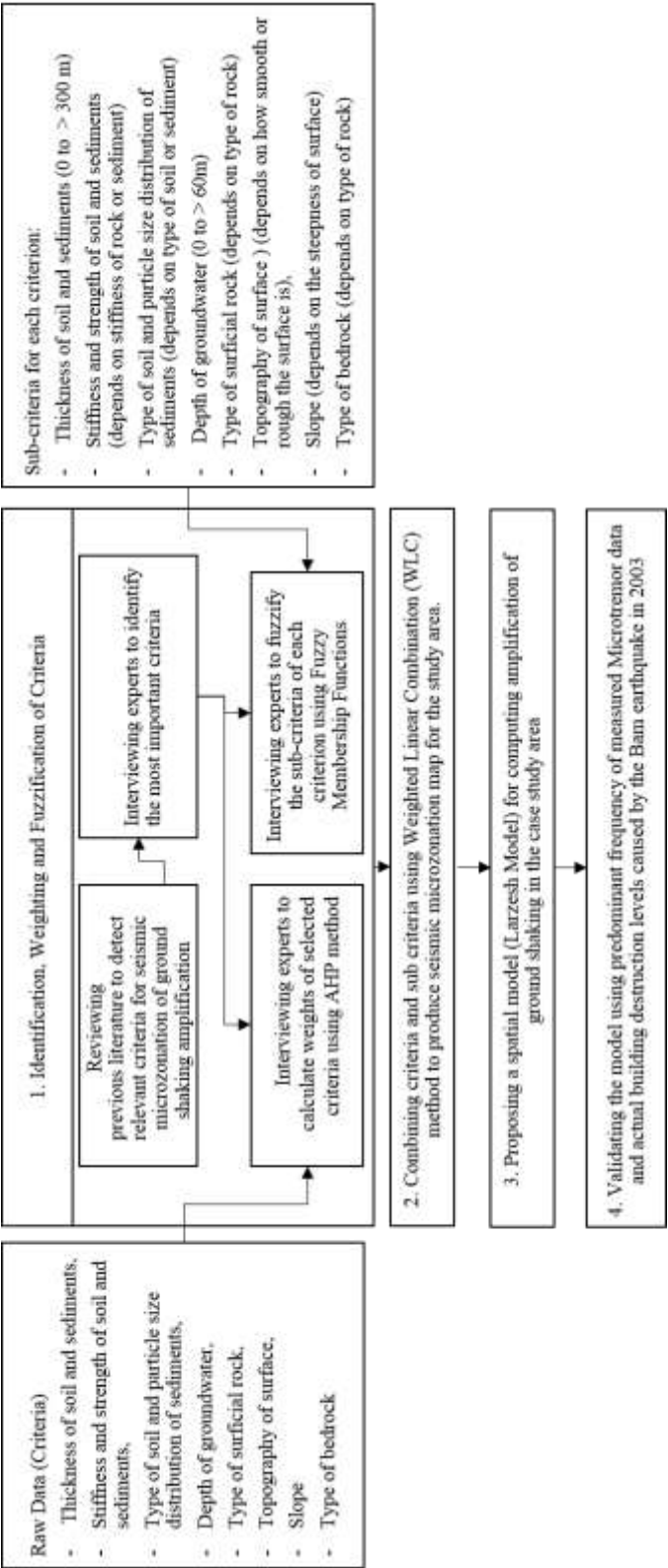


Figure 1. The methodological approach of the model

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Where: $a_{ij} = 1$, if $i = j$, and $a_{ij} = \frac{1}{a_{ji}}$, if $i = \overline{1, n}$ and $j = \overline{1, n}$.

Figure 2.AHP matrix (A)

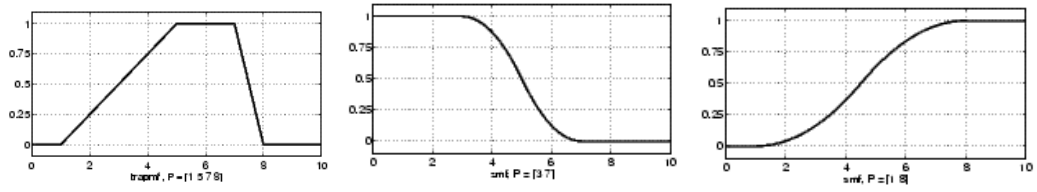


Figure 3. Fuzzy membership functions (After Mancini, 2012)

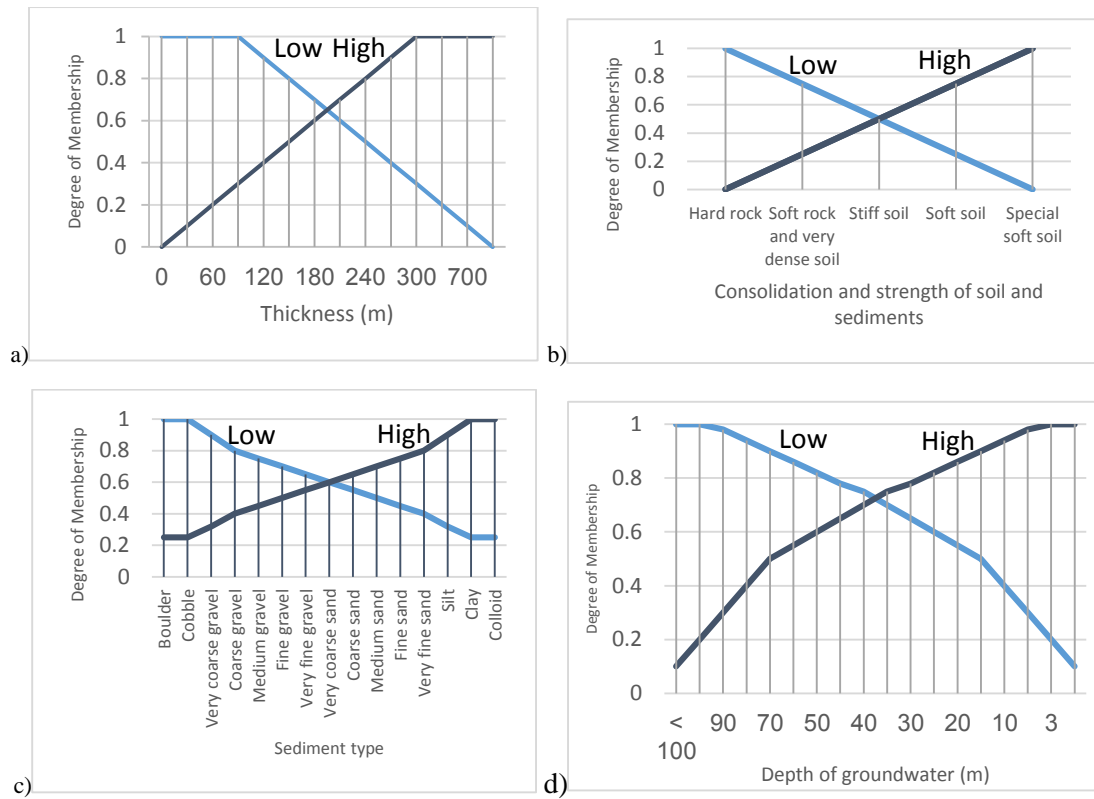


Figure 4. Membership functions (MFs) based on fuzzy logic system: Alluvial thickness (a), Stiffness and strength of soil and sediments (b), Type of soil and particle size distribution of sediments (c), Depth of groundwater (d).

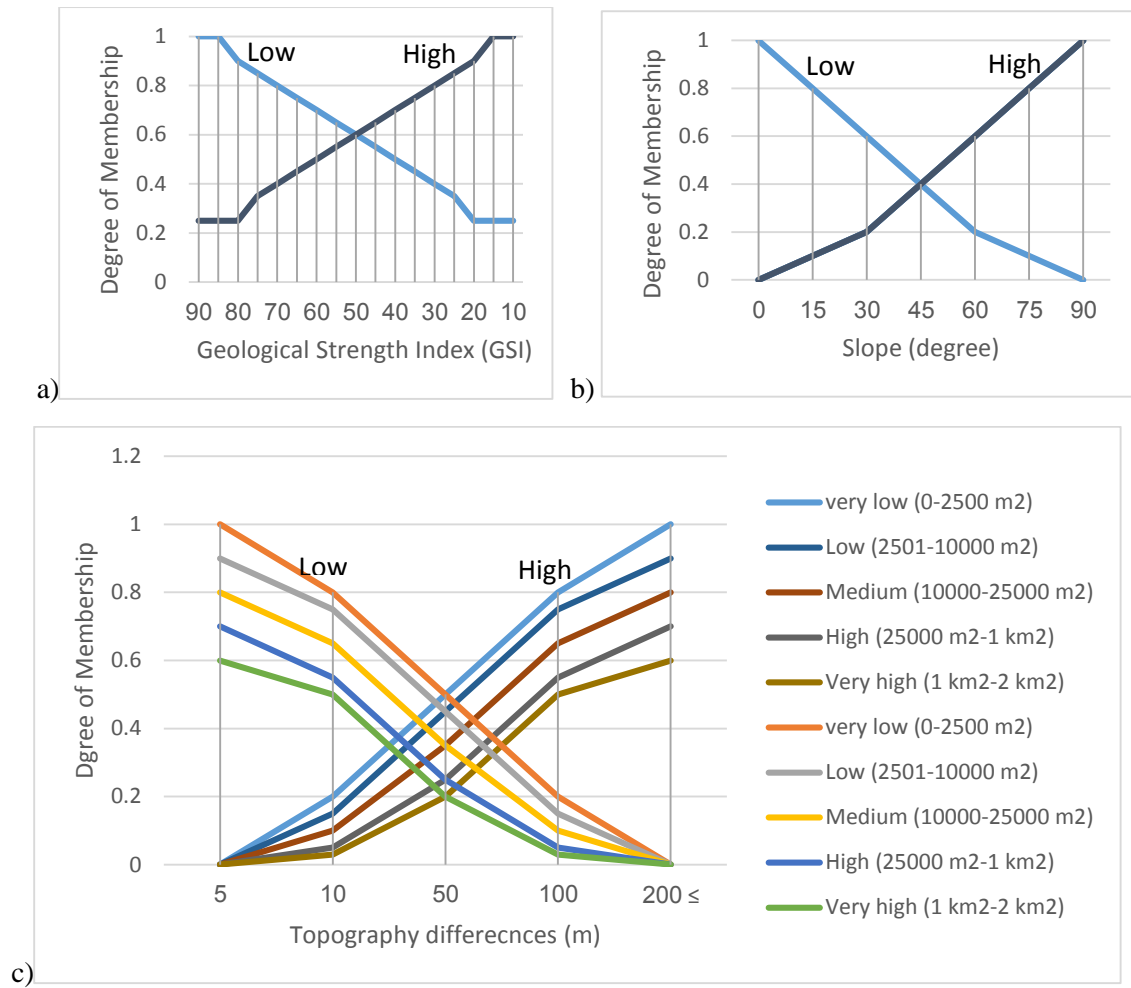


Figure 5. Membership functions (MFs) based on fuzzy logic system: Type of rock and bedrock (a), Slope (degree) (b), Topographic irregularities (c).

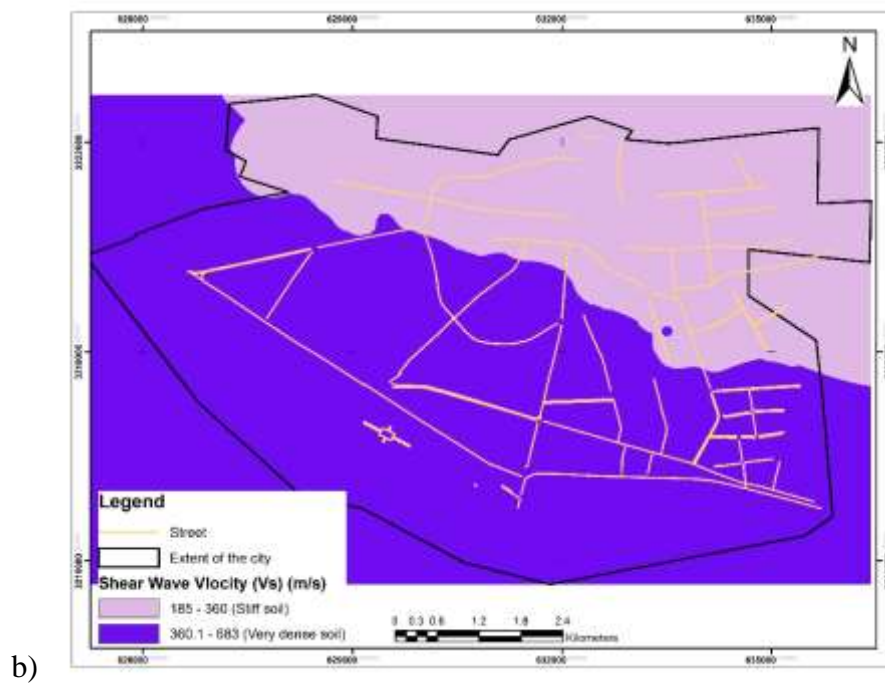
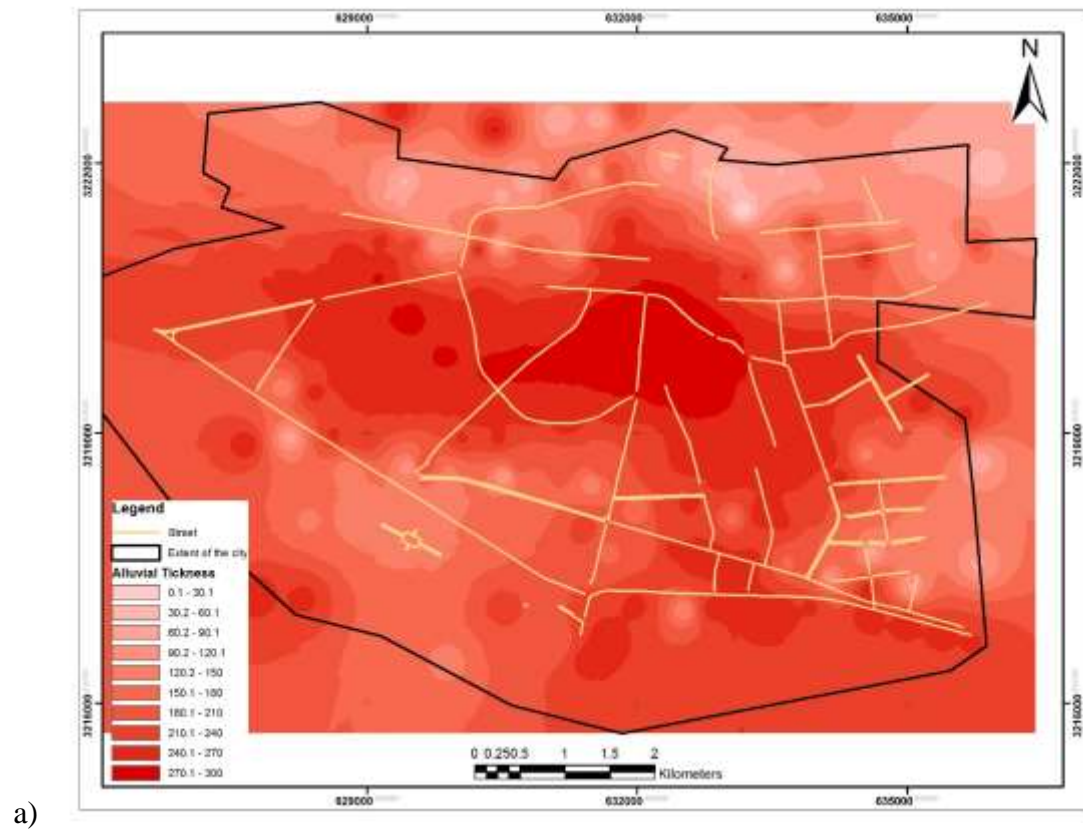


Figure 6. Thematic Layers of Bam city: Alluvial thickness (m) (a), Stiffness and strength of soil and sediments (b).

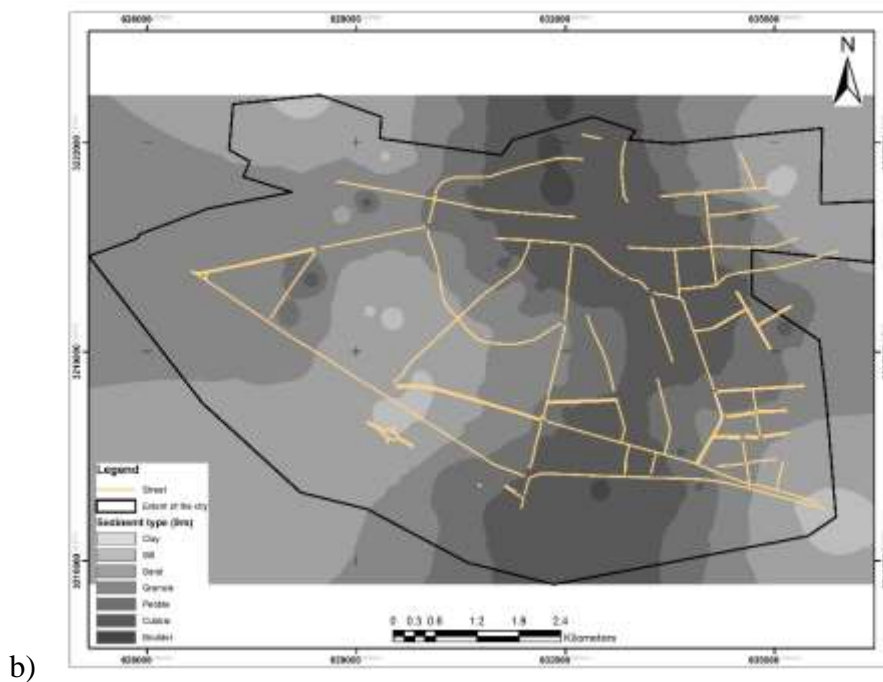
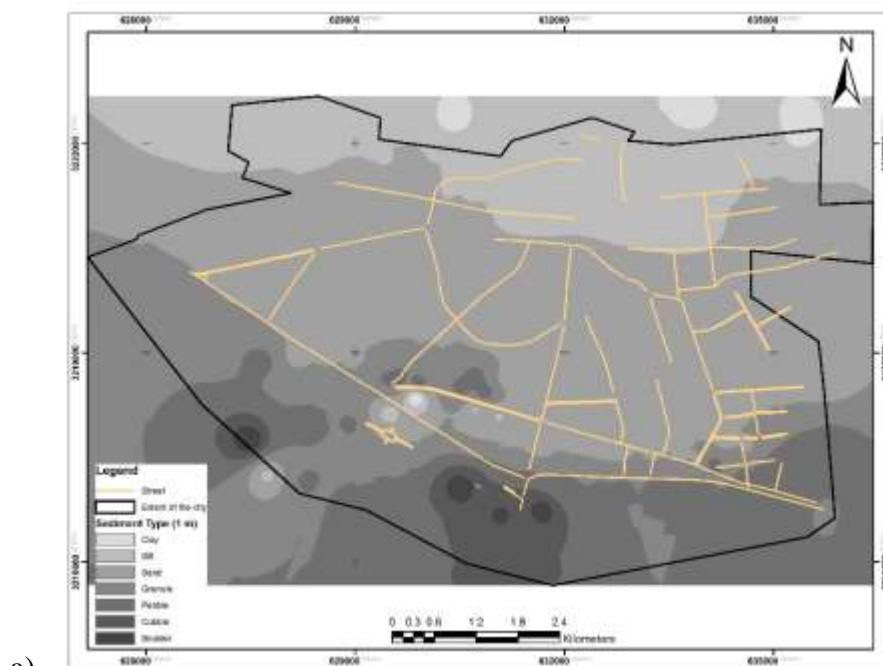


Figure 7. Thematic Layers of Bam city: Sediment type at depth of 1 meter (a) and at depth of 9 meters (b).

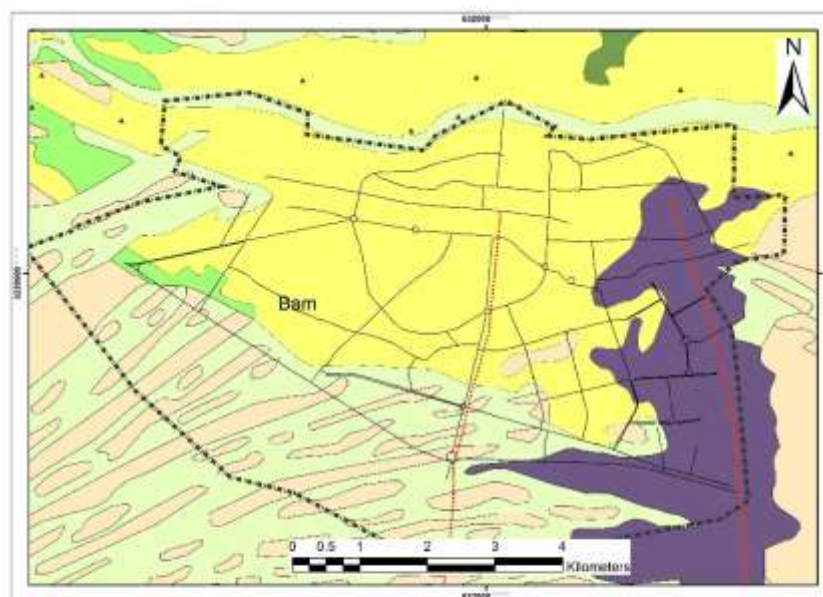
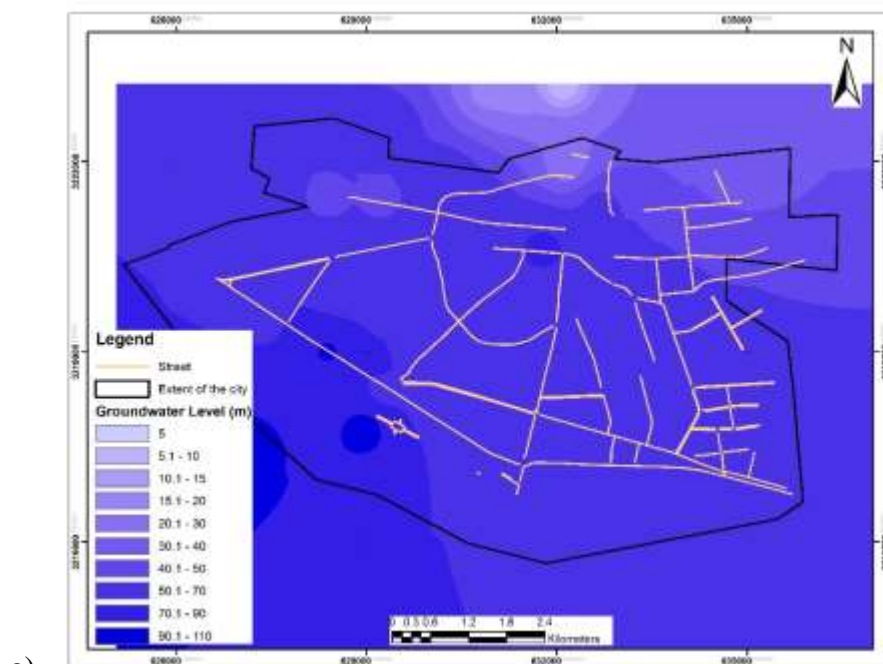


Figure 8. Thematic Layers of Bam city: Groundwater level (a), Geological map (type of rocks) (b).

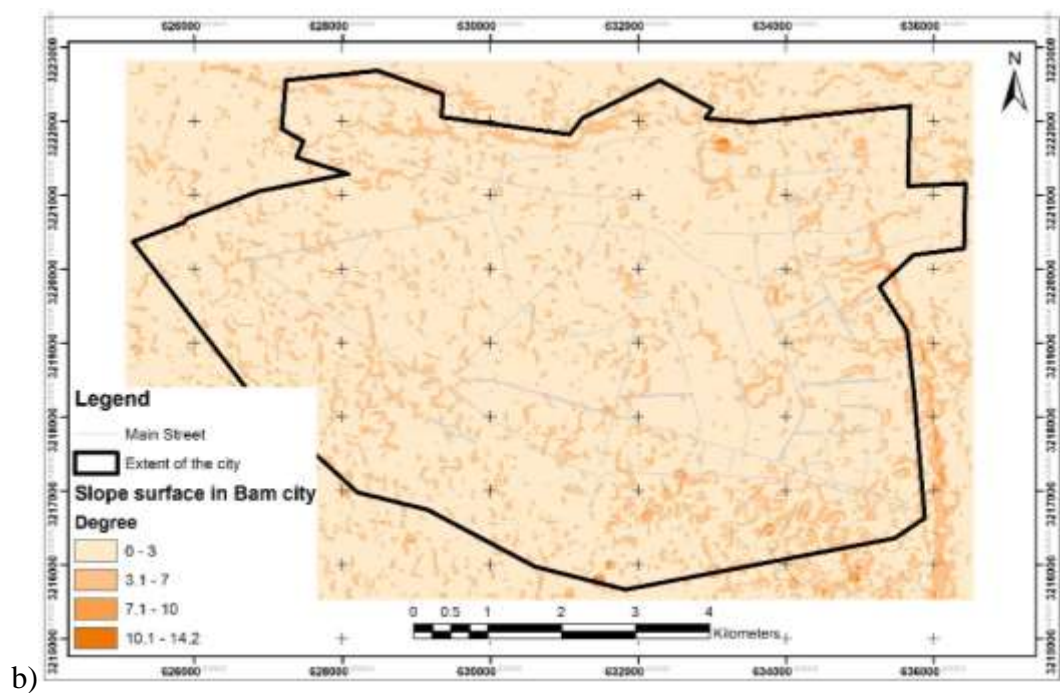
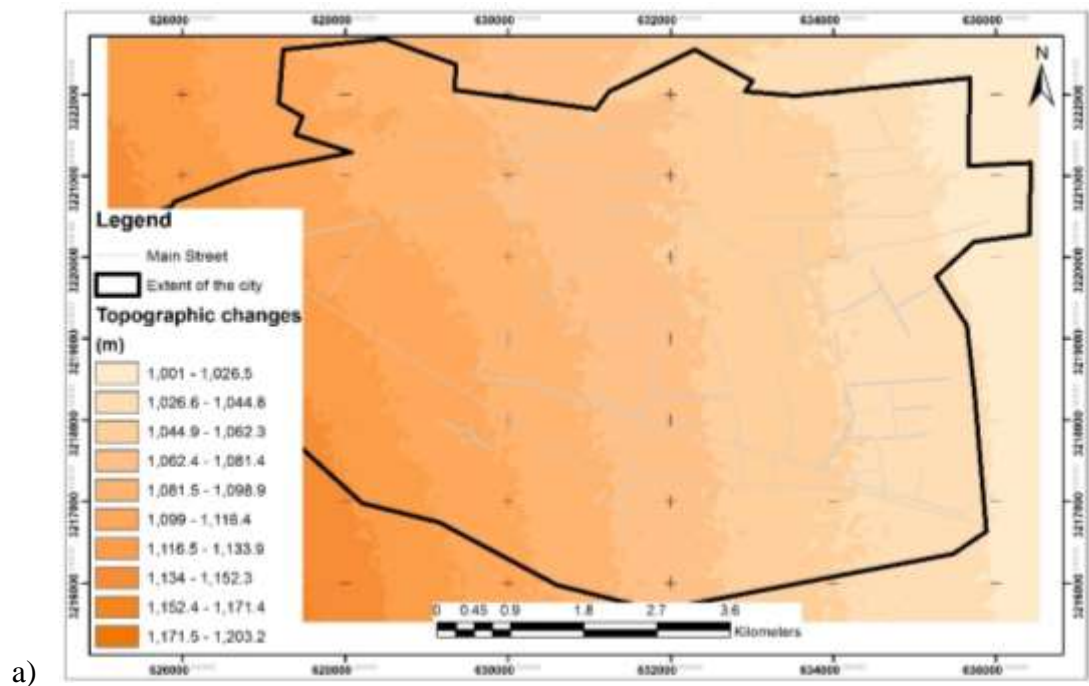
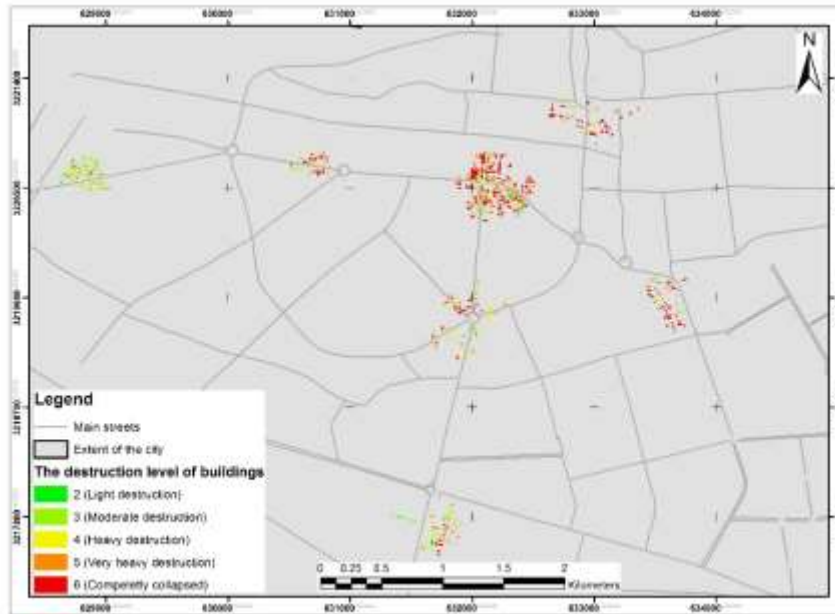
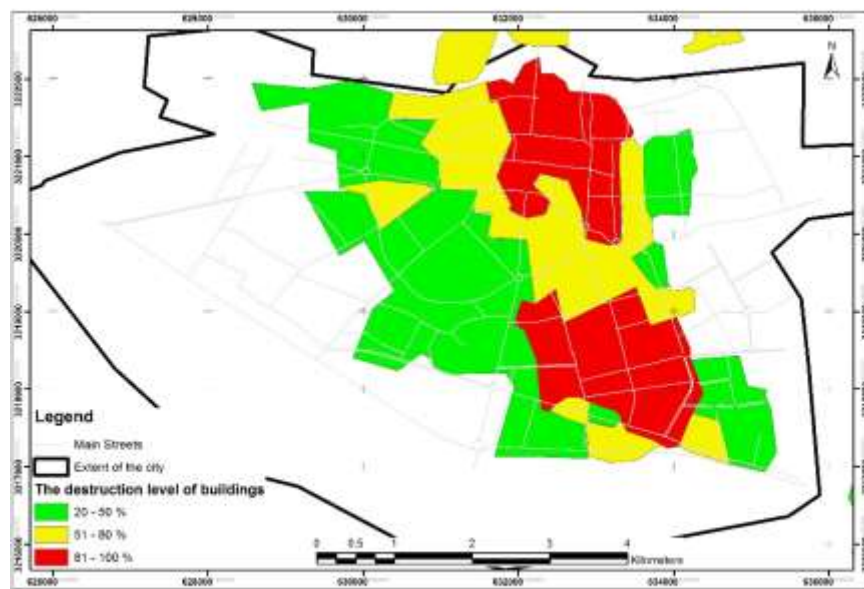


Figure 9. Thematic Layers of Bam city: Topographic irregularities (a) and slope (b).

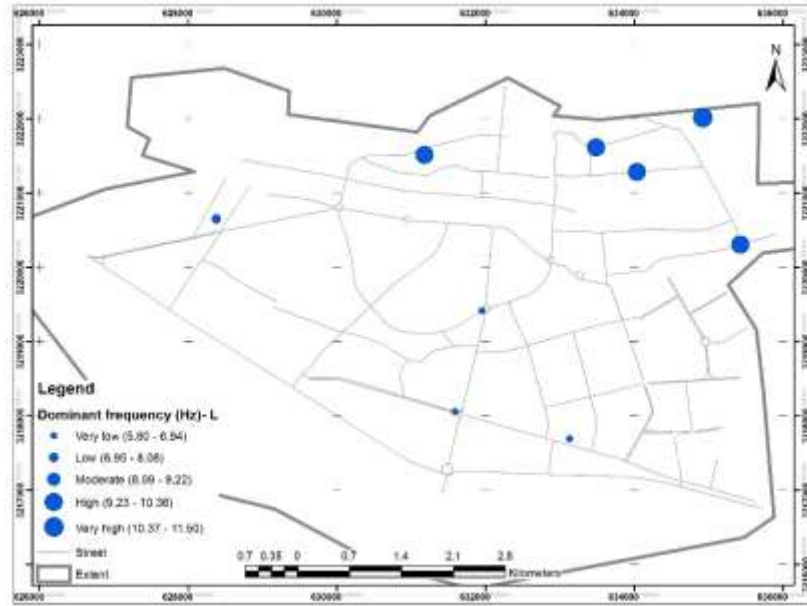


a)

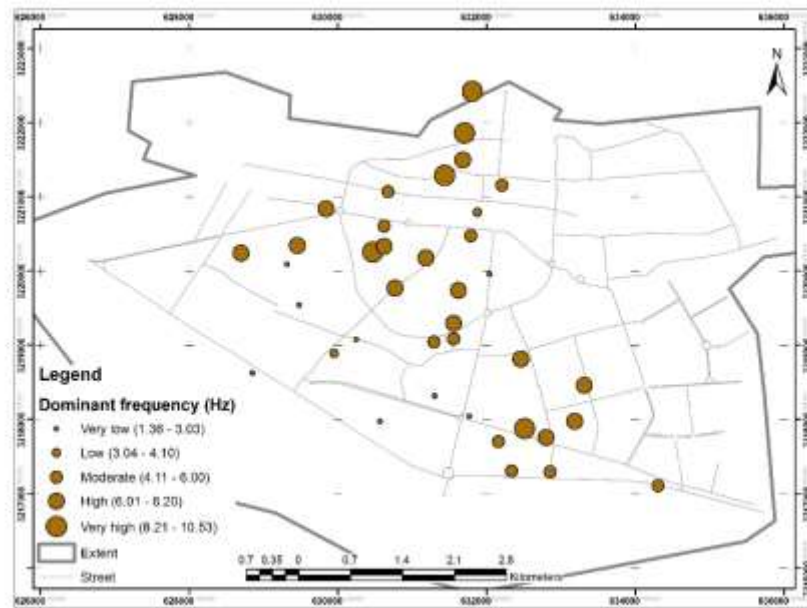


b)

Figure 10. Control data: Actual building destruction level (Hisada et al., 2005) (a), percentage of damage to buildings caused by the Bam earthquake in 2003 (National Cartographic Center (NCC), 2003) (b).

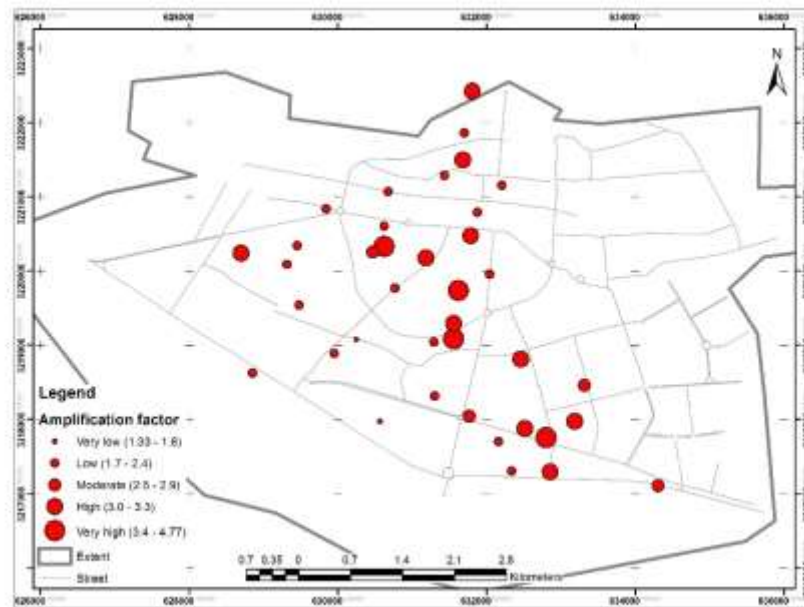


a)



b)

Figure 11. Control data: Dominant frequency by Lashkaripour (a) and by Motamed et al (Motamed et al., 2007) (b) using Microtremor field measurement.



e)
Figure 12. Control data: Amplification factor by Motamed et al. (2007) using Microtremor field measurement.

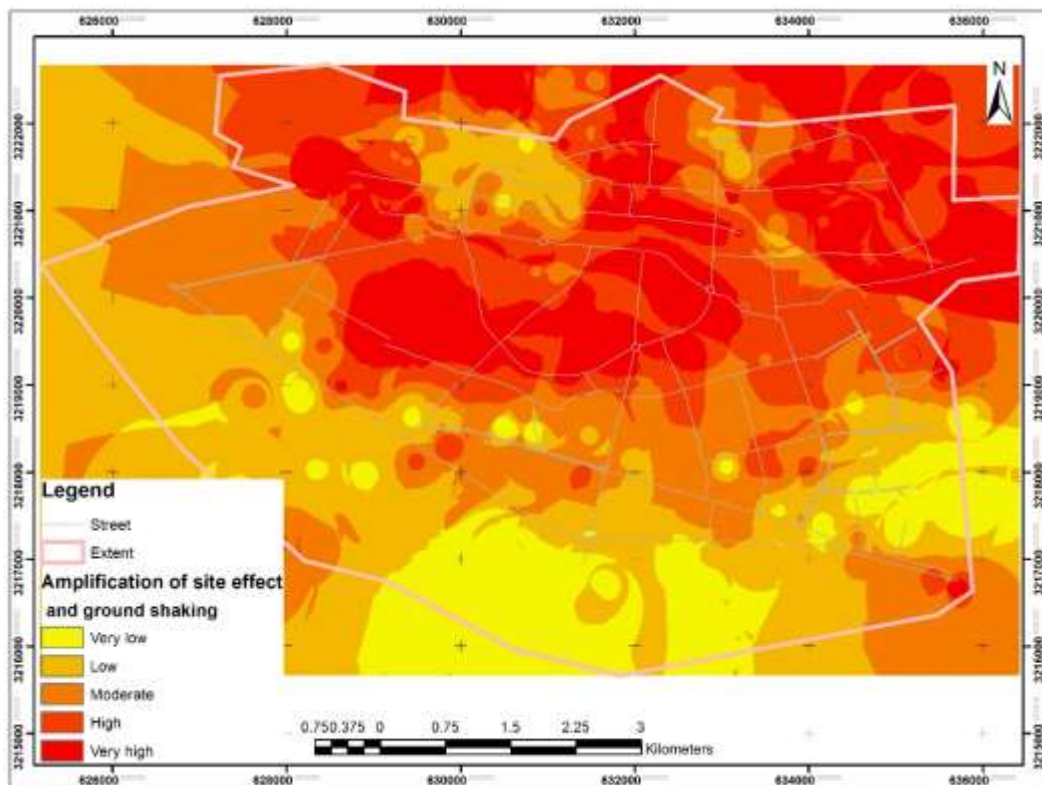


Figure 13. The susceptibility map of local seismic amplification map of Bam city