Development Prototype of Indonesia Seismic Microzonation Information System (Inasmis)

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Abstract. Indonesia has a high level of seismic vulnerability because located in the junction area of four large plates, namely the Eurasian plate, Indo-Australian plate, Pacific plate, and Philippine Plate, and also the number of active faults that stretch throughout its regions. One of the efforts to mitigate earthquake disasters is to conduct seismic hazard microzonation efforts. The Research and Development Center of BMKG has carried out ongoing research in the field of seismic microzonation to obtain information on the level of seismic hazard in some regions based on microtremor parameter values, including in the Sukabumi (2009), Bantul (2010), Padang (2011), Cilacap (2012), Kulonprogo (2014), Tasikmalaya (2017), Garut (2018) and Pangandaran (2019). This study tries to prototype the seismic microzonation information system in a web-based spatial information system called InaSMIS (Indonesia Seismic Microzonation Information System). InaSIMS contains information about the analysis of microtremor survey results, including the value of the dominant period (T0), Ground Shear Strain (GSS), and USGS Vs30, which states the level of seismic hazard in an area. InaSMIS is still being developed in the research stage and is not yet an operational service for BMKG. In the future, InaSMIS expected to be a source of public information to determine seismic hazards in Indonesian regions.

Keywords: InaSMIS, microzonation, seismic hazards

1. Introduction

Indonesia has a high seismic vulnerability level because located in the junction area of four large plates, namely the Eurasian plate, Indo-Australian plate, Pacific plate, and Philippine Plate. The sources of earthquakes on land also come from active fault lines that stretch almost all parts of Indonesia. The occurrences of the earthquake and tsunami that have occurred have certainly caused casualties, damage to buildings, and significant economic losses. BNPB recorded losses due to natural disasters, including earthquakes in 2019, reaching 80 trillion [1].
Until now, earthquakes have not been able to accurately predict the location, time, and how much strength \[2\]. Therefore, earthquake hazard mitigation efforts are very important to do to build preparedness so that casualties and the risk of socio-economic loss can be minimized. One of the many earthquake mitigation efforts that have been carried out is seismic microzonation. Seismic microzonation is defined as the process of subdividing an area into zones with respect to geological characteristics of the sites, so that seismic hazards at different locations within a city can correctly be identified \[3\].

The Research and Development Center of BMKG has carried out ongoing research in the field of seismic microzonation to obtain information on the level of seismic hazard in some regions, including in the Sukabumi (2009), Bantul (2010), Padang (2011), Cilacap (2012), Kulonprogo (2014), Tasikmalaya (2017), Garut (2018), and Pangandaran (2019) \[4\]. Several methods have been applied in seismic microzonation research, such as the Horizontal-to-Vertical Spectral Ratio (HVSR) method on microtremor data to determine the local site effect \[5, 6, 7, 8, 9\], the Multichannel Analysis of Surface Waves (MASW) method to determine the value of Vs30 so that the soil type of an area can be determined \[10, 11, 12, 13\] and Probabilistic Seismic Hazard Analysis (PSHA) method for knowing the Peak Ground Acceleration (PGA) of a region \[14, 15, 16, 17\].

Unfortunately, the results of seismic microzonation measurements have not been collected in an integrated and easily accessible database (web-based). The data from microzonation research are still scattered and have not yet become a single unit of data. This research tries to collect all the data from the microzonation measurements that have been carried out by the Research and Development Center of BMKG from 2009-2018 and present the results in a web-based prototype spatial database. We expect in the future, the scientific community and the general can get information about the vulnerability of earthquakes in a particular region.

2. Data and method

This research tries to make a web-based spatial database prototype called InaSMIS (Indonesia Seismic Microzonation Information System) to display the results of microzonation research that has been carried out by the BMKG Research and Development Center. InaSMIS designed using the concept of an interactive web-based Geographical Information System (GIS) where users can display earthquake hazard level data in an area without any prior GIS knowledge. The maps displayed include the predominant period, ground shear strain (GSS) Map, USGS Vs30 Model, and Earthquake Catalog. Figure 1 shows the InaSMIS application design concept.

![Figure 1. InaSMIS application design concept](image-url)
The predominant period is the time required for microtremor waves to propagate in the surface sediment layer. Predominant period value can evaluate the subsurface layer's site class to characterize soil properties in a particular area. We use site classification proposed by [18]. Ground Shear Strain (GSS) is a soil layer material's ability to stretch or shift during an earthquake. The relationship between strain and dynamic properties of soil uses the classification introduced by Nakamura [19]. Areas with a high GSS value means having an increased risk of ground motion due to earthquakes, leading to landslides, land subsidence, and liquefaction. The Vs30 USGS Model, based on high-resolution topographic data, is the time-averaged shear-wave velocity (VS) in the upper 30 meters and adopted by the earthquake engineering community to account for seismic site conditions [20]. For catalog data, it obtained from the BMKG earthquake repository [21].

3. Results and Discussion

The InaSMIS prototype has been developed and can access at http://puslitbang.bmkg.go.id/inasmis. This application consists of several menus, including Spatial Data, Earthquake Catalog, Slab Model, and About. Figure 2 shows the interface of InaSMIS. The map view of the results of seismic microzonation for several regions displayed in the Spatial data menu, which consists of the USGS Vs30 Model Map for all of Indonesia and the Dominant Period and Ground Shear Strain (GSS) Maps for each study area. For the basemap, we can use three options to display, namely: Esri Topographic Map, Light Gray Canvas, and Open Street Map (OSM).

The Vs30 map of the USGS model for all Indonesia regions shown in Figure 3, where the Vs30 values obtained are correlated with SNI 1726-2012 to get rock classes. Information on seismic microzonation research results for several areas that have been carried out shown in Figure 4. Examples of maps of the predominant period and ground shear strain for the Garut City area shown in Figure 5 and Figure 6.

An earthquake catalog map from BMKG is also displayed, with a magnitude range of 1-9. We can show all magnitudes' earthquake events or select them based on the magnitude range: 1 - 4.5, 4.5 - 5.5, and 5.5 - 9.5. The earthquake catalog data from BMKG shown in Figure 7. The Slab Model menu is still under development, while the About menu contains an explanation of the InaSMIS application.

![InaSMIS Interface](image)

**Figure 2.** InaSMIS interface, consisting of 4 main menus: Spatial data, Catalog, Slab Model, and About
Figure 3. The USGS Vs30 model for all regions of Indonesia, correlated with SNI 1726-2012 for site classification.

Figure 4. Selected display of seismic microzonation research results in several areas that have been carried out.
Figure 5. Map of the value of the predominant period for the Garut City area

Figure 6. Map of Ground Shear Strain (GSS) for the Garut City area
Figure 7. Display of BMKG’s earthquakes catalog

InaSMIS application is still being developed in the prototype stage because there are still a lot of seismic microzonation data that has not been included, including Vs30 measurement results using the Multichannel Analysis Surface Waves (MASW) method, Vs30 from spatial autocorrelation technique (SPAC), Probability Seismic Hazard Assessment (PSHA), Seismic Analysis Risk, and the collection of seismic microzonation measurement results that have been carried out by the other division of BMKG.

4. Conclusion

InaSMIS has been developed to provide information on the level of potential seismic hazards in several regions in Indonesia, measured by the BMKG Research and Development Center. InaSMIS is still being developed in the research stage and is not yet an operational service for BMKG. In the future, InaSMIS is expected to be a source of public information to determine seismic hazard level in Indonesian regions.

5. Acknowledgments

This study was funded by the Research and Development Centre of BMKG. The support is gratefully acknowledged.

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