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Study Of Earthquake Hazard Risk In The Special Region Of Yogyakarta Using The Probabilistic Seismic Hazard Analysis (PSHA) Approach Method

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Abstract: The Special Region of Yogyakarta (DIY) is an area with high seismic potential because its area is close to the southern subduction zone of Java Island and has active faults. Seismic hazard analysis is essential for disaster mitigation and building management. This study aims to create a map of the distribution of earthquake prone areas and determine the distribution area with a seismic risk level based on the Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) values using the Probabilistic Seismic Hazard Analysis (PSHA) method which can estimate the seismic risk at a location by considering the probability of earthquake intensity in a certain period of time in the future. Earthquake catalog data obtained from USGS, IRIS, and ISC from 1970-2023 were used in this study. The results obtained are a distribution map of PGA and SA values with a probability of being exceeded of 5% in 10 years, obtained PGA values ranging from 0.52 g - 0.77 g, SA values (T = 0.2 s) between 1.07 g - 1.51 g, and SA values (T = 1 s) between 0.33 g - 0.4 g, and a probability of being exceeded of 7% in 75 years with PGA values ranging from 0.97 g - 1.39 g, SA values (T = 0.2 s) between 1.96 g - 2.54 g, and SA values (T = 1 s) between 0.58 g - 0.74 g. Bantul Regency and the southern part of Gunung Kidul Regency are areas in the DIY region with the highest PGA values, namely, 0.7 g - 1.39 g and the highest SA for the probability of exceeding 5% in 10 years (T = 0.2 s) of 1.51 g and (T = 1 s) of 0.4 g, and the probability of exceeding 7% in 75 years (T = 0.2 s) of 2.54 g and (T = 1 s) of 0.74 g.

Keywords : Seismic hazard, Probabilistic Seismic Hazard Analysis (PSHA), Peak Ground Acceleration (PGA), Spectral Acceleration (SA).

I. INTRODUCTION (*HEADING 1*)

The Special Region of Yogyakarta is recorded as a region with activity earthquake Enough tall with the earthquake that ever happened There were 2,202 earthquakes in the Special Region of Yogyakarta along 2023. Condition This because of the location of the DIY region is more near with the subduction zone in the South of Java Island and existence activity from Fault local . Earthquake history earth big that had time happened in DIY, among others happen 1867 , 1937, 1943, 1981, and 2006 (Riswandi , et al ., 2022).

Probabilistic Seismic Hazard Analysis (PSHA) method is a Deterministic Seismic Hazard Analysis (DSHA) method that refers to the criteria for earthquakes with the largest ground movements, but takes into account uncertainty factors such as earthquake frequency, location, and size (Azmiyati, 2021). The distribution of potential impacts from one earthquake to calculate the impact on construction and infrastructure in the affected area generally uses the PSHA method. The PSHA method can combine risks or hazards from one area to various sources. In the PSHA analysis, the maximum resistance at each source, the last earthquake, and the frequency of the earthquake must be identified by taking into account the greatest chance of passing through a certain seismicity.

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The parameters applied to the study of the scale of land damage caused by earthquakes that occur on the surface are Peak Ground Acceleration (PGA). PGA is used to analyze the risk of earthquake hazards and is used as a criterion for assessing the earthquake hazard of an area.

Within a period of time three year , namely 2017 to 2020 , USGS take notes Already happen not enough more than 40 earthquakes with magnitude ≥ 5 SR with a radius of 500 km from center Yogyakarta city . Based on the description, this study was conducted by applying the PSHA method to determine the risk of earthquake hazards in DIY for disaster mitigation efforts due to earthquakes, it is necessary to update the calculation of Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) values and create a map of the distribution of earthquake-prone areas on a micro scale (regional) because the earthquake map released by the government together with PUSGEN is still on a macro scale (national). This study uses a probability of exceeding 5% in 10 years and 7% in 75 years based on SNI 1726 concerning earthquake-resistant building design standards based on earthquake catalog data from USGS, ISC , and IRIS in 1970-2023 with the criteria of an M> 4 Mw earthquake, a depth of <300 km, and a distance of no more than 500 km from the research area..

II. Basic Method

A. Territotorial Order of the Province DIY

DIY is geographically located at 7.5 °-8.2 °south latitude and 110 °-110.9 °east longitude . Physiologically, DIY has two parts, namely the plains and the mountains. The DIY plains are located south of Mount Merapi to the South Coast of Yogyakarta which is composed of young Merapi volcanic deposits from agglomerate breccia material, alluvial, lava flows, and tuff. Meanwhile, the DIY mountains are the Southern Yogyakarta Mountains which are formed from Oligocene-Miocene volcanic rocks and Miocene-Pliocene limestone which is located in the south of the DIY province (Teguh et al., 2011).

Figure 1 shows structure DIY geology in the form of fault , namely the Opak Fault which forms escarpment elongated to southwest -east direction the sea which then turn to direction east and join with system Batur Agung thrust fault which has No active . Opak Fault is fault with mechanism fault shift with speed rate shift of 4-6 mm/ year.

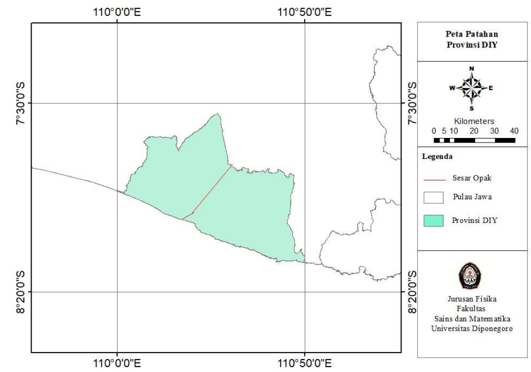

Figure 1 Local faults in DIY

B. PSHA

The PSHA method is widely used as an earthquake hazard assessment using a probabilistic approach that takes into account and combines various uncertainty factors including magnitude, location, and time of the earthquake. These factors make the method PSHA is used to determine the worst probability that will occur in the affected area based on the total probability theory. The total probability theory considers magnitude and distance as continuous independent variables (Cornell, 1968). The PSHA method can estimate the earthquake hazard in an area that has the worst impact, which is why the PSHA method is considered more appropriate to use when compared to the DSHA method. with One source earthquake Already deterministic and not taking into account uncertainty factors related in the process of analysis.

C. PGA

PGA or the largest ground acceleration is the value of the largest ground vibration acceleration that has occurred in an area caused by an earthquake. The condition of the rock or soil geology is a parameter that identifies the size of the PGA value, the more solid the rock formation, the smaller the PGA value in the area and vice versa (Kramer, 1996).

magnitude value is large , then energy produced by a source the earthquake that caused the more the magnitude disaster caused will the more big . One of the reason source damage earthquake stated in acceleration parameters land . PGA value because vibration earthquake at a area can identify level risk earthquake in the area said . The more big the resulting PGA value , then will the more big risk the earthquake that occurred . While SA value is specified acceleration based on response structure in the period specific and related with PGA in the period short as well as varies in a way significant in the period long.

D. Earthquake Parameters

The seismic activity of an area can be seen in the seismic parameters applied in earthquake risk assessment. The parameters used are b-value, a-value, Magnitude of completeness (Mc), mechanism, fault dimensions, slip rate, maximum magnitude, and others (Sunardi, 2013).

Parameters $a, b$are mathematical models that state the activity of an earthquake that occurs in the bedrock of an area. Seismic parameters are obtained from the Guttenberg-Ricter recurrence relationship . The value $a$states the seismic activity in the observation period, the level of seismicity in the area, and the area of observation, the value $b$states the gradient or slope of the linear equation of the relationship between magnitude and frequency and Mc is the minimum magnitude of the earthquake in an area with a certain time period. Parameters a, b, and Mc are stated as seismicity parameters that state the tectonic characteristics of earthquakes in an area (Guttenberg and Richter, 1944).

III. RESEARCH METHODS

A. Research Place

Study this conducted at the Faculty of Science and Mathematics, Diponegoro University with the area that was made object study that is DIY Province using secondary data catalog earthquake earth .

B. Research Tool

The research tools used are a laptop, Matlab software , ZMAP, Crisis 2007 , and Acrgis 10.8.

C. Research Data

The data used in this study uses secondary data from USGS, IRIS, and ISC sources from 1970 to 2023 with provision magnitude more from 4 with depth not enough from 300 km with distance No more from 500 km from area study.

D. Procedure Study

Study This done through a number of stages , namely earthquake data collection, magnitude scale conversion, separation of main earthquakes (declustering), identification of earthquake source zones, determination of seismic parameters, seismic hazard processing , and analysis of results.

E. Earthquake Data Collection

Data were obtained from USGS, IRIS, and ISC from 1970 to 2023 with provision magnitude more from 4 with depth not enough from 300 km with distance No more from 500 km from the research location.

F. Earthquake Unit Conversion

Data obtained from catalog USGS, ISC, and IRIS own scale different earthquakes , so that all scale of earthquake data obtained must equated using the Scordilis formula to scale magnitude moment (Mw).

G. Main Earthquake Separation

Earthquake data that has been equated the scale in Mw, then done declustering between earthquake main (mainshock) and earthquake aftershock refers to the algorithm Gardner and Knopoff with Matlab ZMAP software.

H. Identification of Earthquake Source Zones

Source Zone earthquake categorized into 3, namely zones source earthquake subduction , source zone earthquake background , and source zone earthquake fracture . Divided based on depth earthquake , start from depth 0-50 km which is in the megathrust zone , 50-100 km is categorized as a source earthquake Benioff , and 100-300 km are in the source zone earthquake deep background . Modeling source earthquake This using the repetition model Guttenberg-Richter recurrence.

I. Determination of Seismic Parameters

Parameters a, b, and Mc are obtained from chart connection between magnitude and frequency . Determination parameters a and b use method McBestCombo Solution on Matlab-Zmap software.

J. Seismic Hazard Processing And Result Analysis

Processing seismic hazard use RCRISIS 2007 software .

Earthquake data processing as well as data analysis will obtain possible PGA and SA value parameters used as a parameter for determining risk danger earthquake .

Distribution results PGA and SA values were analyzed based on tall low the resulting PGA value from each district . Analysis danger earthquake can done with classify PGA value based on level danger earthquake by (BNPB, 2012), in the following table 2

TABLE I CLASSIFICATION EARTHQUAKE HAZARD BASED ON BNPB PGA VALUE NO. 2 OF 2012

Risk Level		
Low	**Currently**	**Tall**
PGA < 0.2501 gal	0.2501<PGA>0.70 gal	PGA>0.70 gal

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IV. RESULT AND DISCUSSION

A. Results Probability of Exceeding 5% in 10 years

The distribution of PGA values was carried out at a period of 0 seconds with a probability of being exceeded of 5% in the 10-year life of the building, resulting in PGA values between 0.52 g – 0.77 g as mapped in Figure 2.

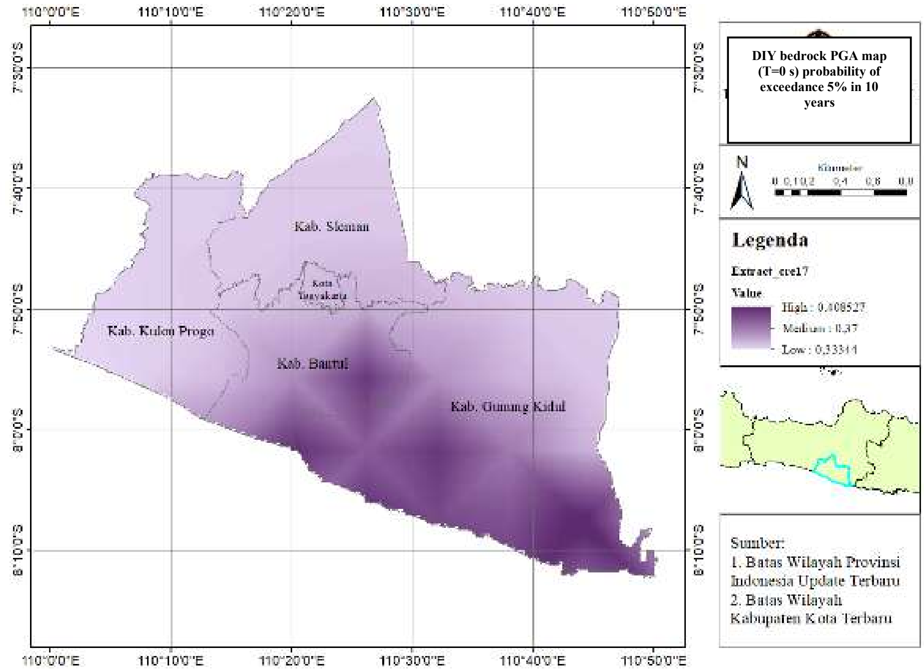

Figure 2 DIY bedrock PGA map (T=0 s) probability of exceedance 5% in 10 years

B. Result T=0,2 s Probability of Exceendance 5% in 10 years

The results of the distribution of short-period SA values (T=0.2 seconds) for a probability of being exceeded by 5% in the 10-year life of the building, namely 1.07 g – 1.5 g, as shown in Figure 3.

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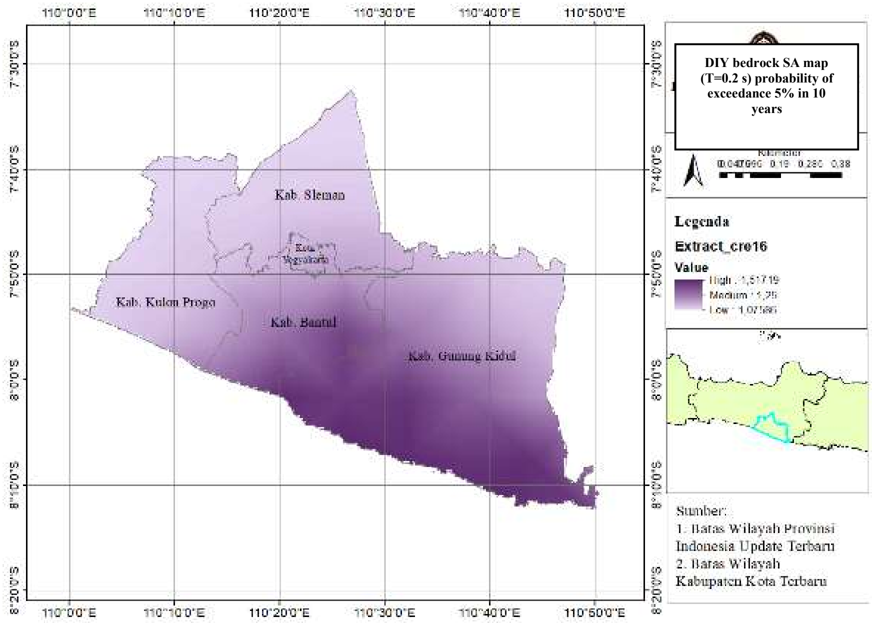

Figure 3 DIY bedrock SA map (T=0.2 s) probability of exceedance 5% in 10 years

C. SA Result T=1 s Probability of Exceendance 5% in 10 years

The results of the SA analysis for a long period of 1 second for a probability of exceeding 5% in 10 years obtained SA values in the range of 0.33 g – 0.4 g as shown in Figure 4.

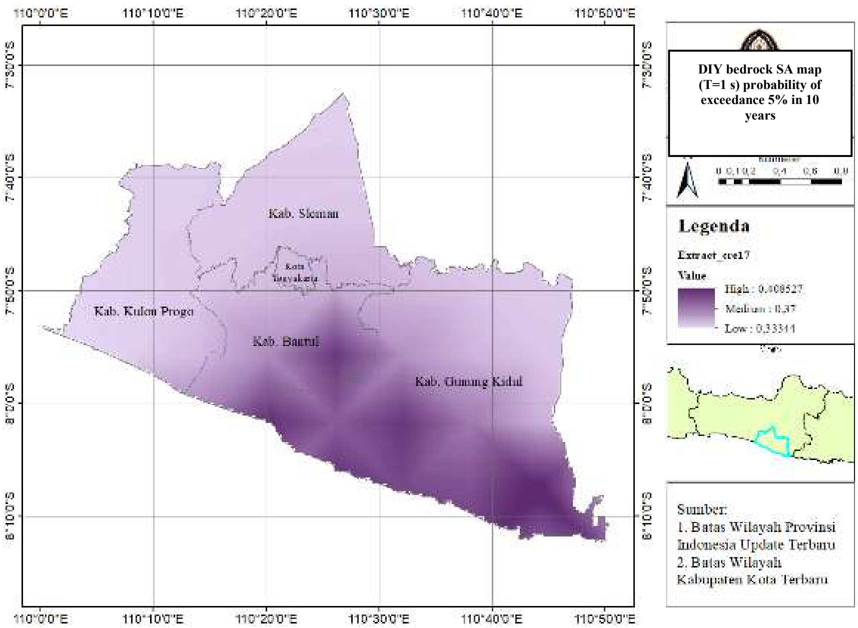

Figure 4 DIY bedrock SA map (T=1 s) probability of exceedance 5% in 10 years

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D. Results Probability of Exceeding 7% in 75 years

The distribution of PGA values was carried out at a period of 0 seconds with a probability of being exceeded of 7% in the 75-year life of the building, resulting in PGA values between 0.97 g – 1.39 g as mapped in Figure 5.

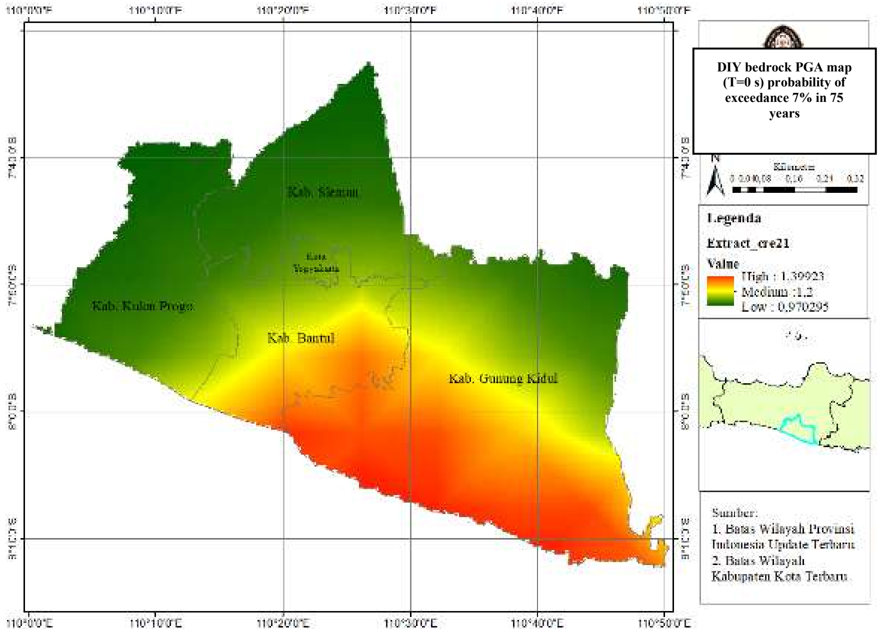
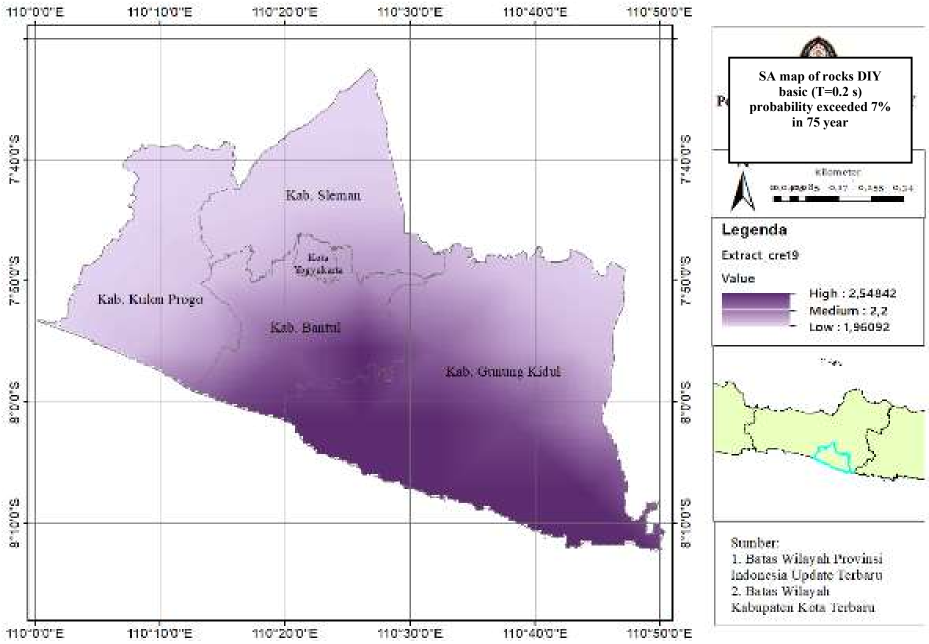


Figure 5 DIY bedrock PGA map (T=0 s) probability of exceedance 75% in 75 years

E. Result T=0,2 s Probability of Exceendance 7% in 75 years

The results of the distribution of short-period SA values (T=0.2 seconds) for a probability of being exceeded by 5% in the 10-year life of the building, namely 1.96 g – 2.54 g, as shown in Figure 6.



F. SA Result T=1 s Probability of Exceendance 7% in 75 years

The results of the SA analysis for a long period of 1 second for a probability of being exceeded of 7% in 75 years obtained SA values in the range of 0.58 g – 0.74 g as shown in Figure 7.

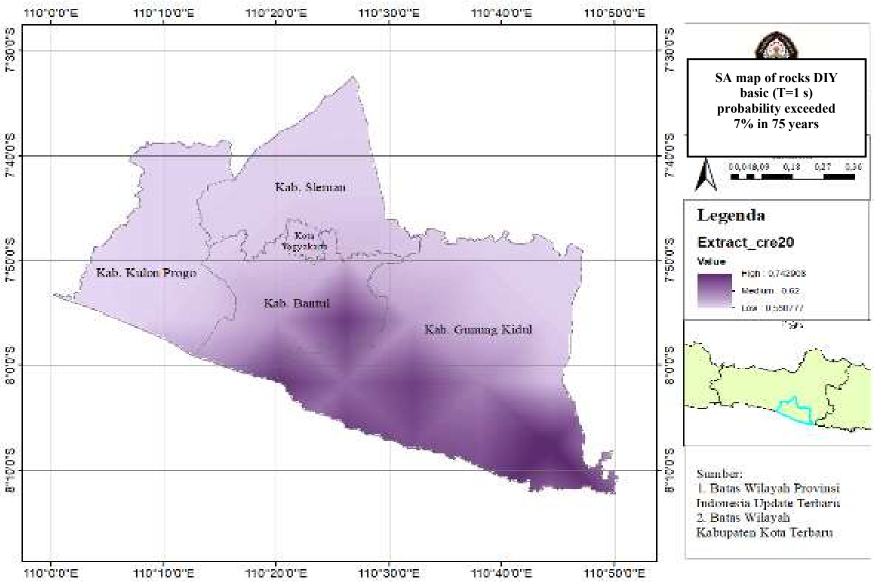


Figure 7 SA map of rocks DIY basic (T=1 s) probability exceeded 7% in 75 years

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