A Study on Seismicity Parameters with Gutenberg-Richter Law for Potential Nuclear Site in Kalimantan, Indonesia

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1. Introduction

Indonesia issued a law regulation No. 3, 2022 relating to the National Capital City. The nation's capital will be moved to the island of Kalimantan with the concept of net zero emission to support the Paris agreement on the issue of climate change. Nuclear technology is one of the potential sources of electrical energy since it belongs to the low-carbon emission technology category. Indonesia is located at the confluence of the Asian, Australian and Indian Ocean faults, earthquakes are common, and the government is concerned about the consequences of a nuclear accident, which could take place as a result of this seismic phenomena[1]. West-Kalimantan region was chosen as a potential site location for the nuclear power plant project. It satisfied the Spatial-weighted multi-criteria analysis. This location contains a water supply that may be utilized as a reactor cooling medium; nevertheless, there are still few residential areas; the land is quite large; it is not in a protected area or nature reserve; and it is not a peat area. [2].

The purpose of this study is to obtain a correlation between the magnitude and number of earthquakes in potential locations for the construction of nuclear power plants in Indonesia according to the Gutenberg-Richter Law (1956). Using seismic data recorded from 1900 to the end of 2019 to obtain seismicity parameters (a, b). The results of this study can then be used to calculate the Probability Seismic Hazard Analysis (PSHA) for the island.

2. Methods and Results

Analysis of seismicity, period 1900-2019 in the potential locations for the construction of nuclear power plants in Indonesia was carried out using the Guttenberg - Richter method (1956)[3]. In the earthquake catalogue, Gardner Knopoff (1974)[4] was applied to distinguish the main shock and the aftershocks, followed by Gutenberg-Richter Relationship.

$$\text{Log10 } N = a - b\,M$$

On this equation, N represents the cumulative frequency of earthquakes of greater or equal magnitude. While a-value is a measure of seismic activity within a particular time interval, and b-value refers to the magnitude of earthquakes in the interval. As a measure of the relative abundance of strong earthquakes to weak earthquakes, b value (the slope of the recurrence relationship) is considered to be correlated with the area's tectonic regime.

2.1 Event Map

Data used are earthquakes that occur at coordinates 7˚ to -5˚ longitude and 107˚ to 121˚ latitude, an area that encompasses Indonesia in the area around the island of Kalimantan and approximately 220 kilometers (2˚) from Indonesian territory outside the island of Kalimantan.

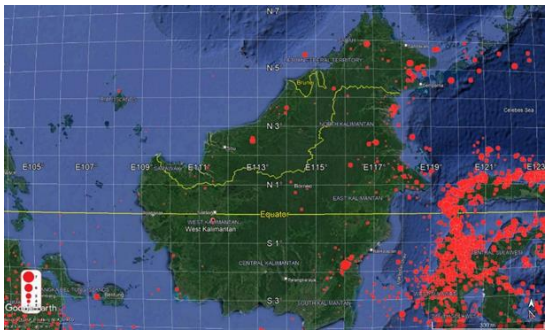

Figure 1 Earthquake Occurrence Kalimantan Island

For this study, magnitude recording was based on the GCMT and DJA data of moment magnitude type (MW). 159 earthquakes were recorded by GCMT (Global Centroid Moment Tensor Project) and 20 earthquakes were recorded by DJA (Geology, Climatology, and Geophysics Body of Indonesia) at depths of up to 50 km[5] in period 1900 to the end of 2019 [6].

2.2 Seismicity Parameter

Figure 2 shows a linear equation for obtaining a seismicity parameter (a, b) for Kalimantan Island.

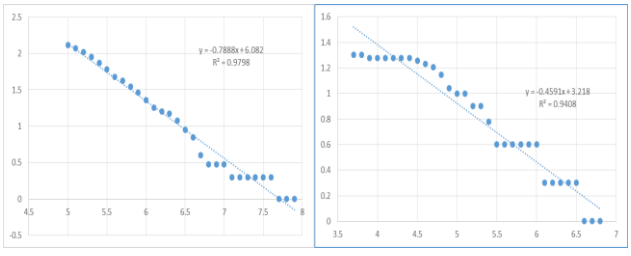

Figure 2 Gutenberg-Richter Plot (Left GCMT and Right DJA)

This study obtained a seismicity parameter for the potential location for future nuclear construction in Indonesia. Seismicity parameters, a-value, and b-value are the most important elements of PSHA input data. Table 2 shows the characteristics of each GCMT and DJA including a-value and b-value.

Author	Number of Earthquake	M_{max}	M_{nin}	a	b
GCMT	157	4.70	7.90	6.08	0.79
DJA	20	3.80	7.50	3.22	0.46

Figure 3 Seismicity Parameter

The number of earthquake frequencies is calculated based on their magnitude intervals and then arranged as in Table 1, The earthquake that occurred was in the magnitude range of 4.7 to 7.9 for GCMT and 3.8 to 7.5 for DJA.

Using data from GCMT obtained a-value 6.08 and b-value 0.79 values. While using data from DJA, a-value 3.22 and b-value 0.46.

Based on the results obtained, it can be seen that the Kalimantan Island has a relatively high a value and relatively low b value using the magnitude data recorded by GCMT.

As indicated by the high tectonic parameter (a value) in this region, the spatial variation of this value indicates relatively high seismic activity, while the low tectonic parameter (b value) and b variation indicates highly stressed conditions in this area and the potential for large earthquakes. Based on the value of b and value of a, it can be concluded that the Kalimantan region has a high stress level, indicating that this area is an area that has a high chance of a large earthquake occurring in the region.

PSHA in Kalimantan Island can be calculated. However, the earthquake catalog used in this study included earthquakes within 220 km of the island, and small portion of earthquakes occurred in western part of the island. Further studies are needed to obtain specific results. Therefore, if the analysis range of earthquakes is expanded or vice versa, the a-value and b-value can be changed. Among the things that set this study apart from previous studies are the research area chosen.

3. Conclusions

Analysis of the seismicity level earthquakes in the Kalimantan Island was carried out using the Guttenberg-Richter method. Based on the research that has been done. From the study, the b-value is 0.79 and the a-value 6.08 for GCMT, and the b-value 0.46 and a- value is around 3.20 for DJA. The smaller value of (a, b) in DJA is possible because there are fewer earthquake data (moment magnitude) recorded by DJA. While the calculation of the return period for the 4.7 – 7.9 (GCMT) and 3.8 – 7.5 (DJA) magnitude is adequate as a reference in estimating earthquake recurrence, but for magnitude greater than 7.9 is not expected to occur.

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