Research priority of the potential earthquake on the java island using decision making analysis

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Abstract. Referring to the Indonesian earthquake source and hazard map published by the National Earthquake Center (Pusgen) in 2017, it was stated that there were 34 active faults on the island of Java and could potentially be a source of earthquakes with earthquake strength more than the 6.5 M scale. Each potential source of earthquake needs to be carried out detailed research on each fault that is declared active so as to reduce uncertainty in the seismic hazard analysis. Due to limited funding and human resources researching, it is necessary to make research priorities based on the level of urgency. By utilizing decision making analysis techniques, priority of research is carried out by considering several aspects, such as the magnitude of the earthquake that may occured possible economic impact factors, population density and the level of importance of a region on a national and international scale. From the modeling results, it is shown that faults that have the potential to become earthquake sources that are located near large cities are a top priority for detailed research such as the Lembang, Semarang and Surabaya Faults.

1 Introduction

The island of Java which is located on the north of the subduction between the two plates namely the Indo-Australian Plate and the Eurasian Plate has several tectonic faults as a form of stress accommodation produced by subduction in the south [1]. According to [2], a tectonic fault is a local deformation zone that accommodates plate movement through aseismic creeping at certain depths and earthquake or creeping in the shallower layers. The structures on Java Island had two main trends where the basement structures tends to have the northeast-southwest trend (the Meratus trend) and the surface structures tend to have the east-west trend (figure 1).

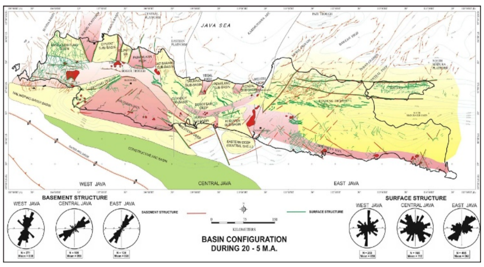

Fig. 1. Main structures in Java Island

1.1 Active land faults on Java Island based on GPS data

Several previous Global Positioning System (GPS) studies in Java were conducted by focusing on local deformation studies in the main fault areas such as Cimandiri Fault, Lembang Fault and Baribis Fault [3,4,5]. [6] conducted a study of the GPS method in the Kendeng Fault, which is an active fault that extends from the eastern part of East Java to the western part of Central Java which is active every year with a 5 mm / year velocity. Muria Fault in Central Java is an active fault that extends from the southwest to the northeast with the upward fault mechanism. [7] performed a calculation of the Muria fault rate using elastic dislocation assumptions. [8] conducted GPS observations of the active movement of Opak faults which resulted in the Yogya Earthquake on May 27, 2006 with magnitude 6.4 having a sliding fault mechanism at a rate of 4-6 mm /year. Some of the identified faults and their speed in Java Island as a result of GPS method can be seen in figure 2.

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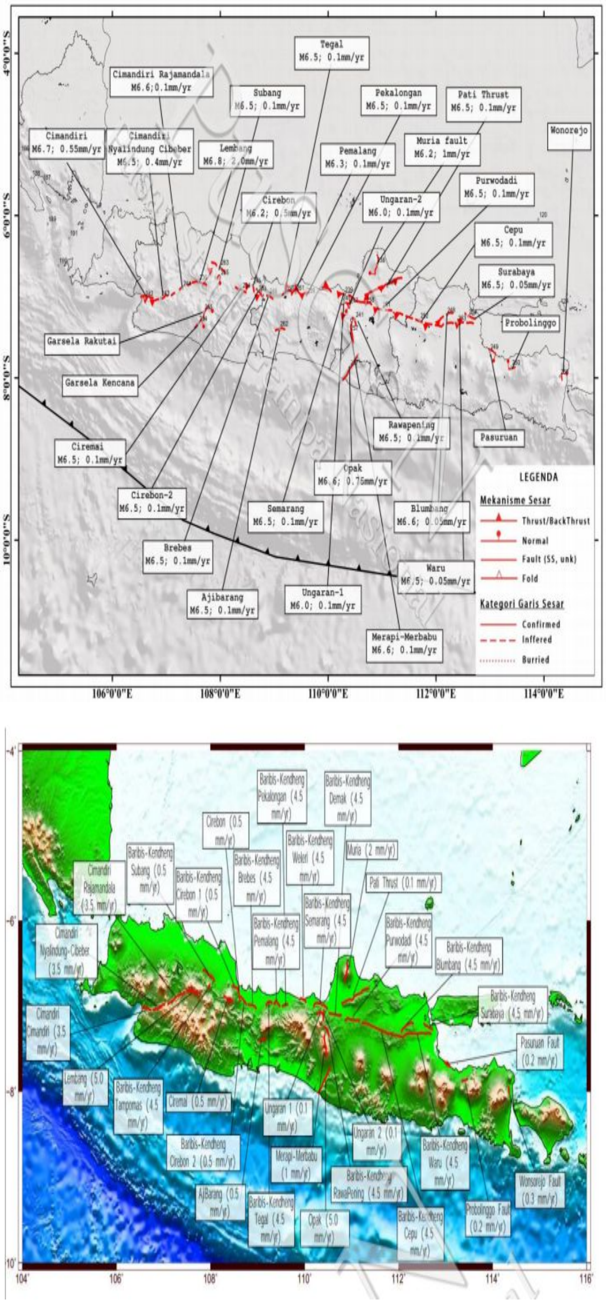

Fig. 2. Active fault segment shear rates on Java Island

1.2 Decision Making Analysis

Decision making is a study to identify and choose alternatives that have the highest probability of success and are most suitable for purpose. Decision-Making Tools and techniques suggested the analyzing and prioritizing issues in your needs assessment process and, ultimately, for deciding to take action [9]. There are tools to support the decision-making process below:

1. Nominal Group Technique
2. Multicriteria Analysis
3. Tabletop Analysis
4. Pair-Wise Comparison
5. 2x2 Matrix Decision Aids
6. Fishbone Diagrams
7. Root Cause Analysis
8. Fault Tree Analysis

Decision making methods that used in this paper is muticriteria analysis which is a valuable tools that offer a systematic and quantitative comparison across multi-attribute utility. Variables in the analysis can each be given a weighting that reflects the priorities of the project [10]. The process of multicriteria analysis could be started from identify the most important criteria to making decision and the performance criteria required of alternative solutions. Typically, consider no more than five to eight attributes for any decision.

2 Methodology

A general decision making process can be divided into the following steps [11,12]:

1. Identify the problem
2. Decide requirements
3. Establish goals
4. Recognize alternatives
5. Specify Criteria
6. Choose a decision making tools
7. Assess alternatives againts criteria
8. Validate solutions againts problem statement

Depending on the context of your decision and as a useful technique, apply weighting to the diverse criteria. The weights differentiate criteria according to their relative importance to the decision. It is important to use the same scale for each attribute. Create a table or spreadsheet with the performance attributes listed in the columns along the top and the potential solutions listed in the rows. For each alternative intervention or activity, include an estimate for each performance criterion. Review the result of analysis. As a useful approach, consider a combination of alternative activities rather than viewing each option as mutually exclusive.

The number of active faults on the Java Island contained in the 2017 earthquake source and danger map of Indonesia are 34 active faults which are divided into several fault segments. Table 1 performed multicriteria analysis for fault priority decision.

Table 1. Muticriteria analysis of faults priority

Skor	Magnitude	Region
3	M>= 4-5	Big cities/Capital of the province, very densely populated, Modern and complete infrastructure, middle-high economic level, middle-high education level
2	M>=2-3	district, low-middle education level, relatively dense population, low-medium economic level, low-medium education level, Relatively good infrastructure
1	M>=0-1	sub-district, low-medium education level, fewer population, low-medium economic level

3 Result

Table 2 described the active faults on the Java Island and its magnitude.

Table 2. Land Fault Segment on Java Island and its Magnitude

No.	Active Faults			
	Main Fault	Segment	Type	Magnitude
1	Alternative 1 Cimandiri Fault	Cimandiri	R	3.5
2	Alternative 2 Cimandiri Fault	Nyalindung-Cibeber	R	3.5
3	Alternative 3 Cimandiri Fault	Rajamandala	SS	3.5
4	Alternative 4 Lembang Fault	Lembang	SS	5
5	Alternative 5 Baribis-Kendeng Fault	Subang	R	0.5
6	Alternative 6 Baribis-Kendeng Fault	Cirebon-1	R	0.5
7	Alternative 7 Baribis-Kendeng Fault	Cirebon-2	R	0.5
8	Alternative 8 Baribis-Kendeng Fault	Karang Malang	R	0.5
9	Alternative 9 Baribis-Kendeng Fault	Brebes	R	4.5
10	Alternative 10 Baribis-Kendeng Fault	Tegal	R	4.5
11	Alternative 11 Baribis-Kendeng Fault	Pemalang	R	4.5
12	Alternative 12 Baribis-Kendeng Fault	Pekalongan	R	4.5
13	Alternative 13 Baribis-Kendeng Fault	Weleri	R	4.5
14	Alternative 14 Baribis-Kendeng Fault	Semarang	R	4.5
15	Alternative 15 Baribis-Kendeng Fault	Rawa Pening	R	4.5
16	Alternative 16 Baribis-Kendeng Fault	Demak	R	4.5
17	Alternative 17 Baribis-Kendeng Fault	Purwodadi	R	4.5
18	Alternative 18 Baribis-Kendeng Fault	Cepu	R	4.5
19	Alternative 19 Baribis-Kendeng Fault	Waru	R	4.5
20	Alternative 20 Baribis-Kendeng Fault	Surabaya	R	4.5
21	Alternative 21 Baribis-Kendeng Fault	Blumbang	R	4.5
22	Alternative 22 Baribis-Kendeng Fault	Tampo Mas	N	4.5
23	Alternative 22 Baribis-Kendeng Fault	Kendeng	R	5
24	Alternative 24 Opak Fault	Opak	SS	5
25	Alternative 25 Muria Fault	Muria	N	2
26	Alternative 26 Ciremai Fault	Ciremai	SS	0.5
27	Alternative 27 Ajibarang Fault	Ajibarang	SS	0.5
28	Alternative 28 Ungaran Fault	Ungaran-1	N	0.1
29	Alternative 29 Ungaran Fault	Ungaran-2	N	0.1
30	Alternative 30 Merapi-Merbabu	Merapi-Merbabu	SS	1.0
31	Alternative 31 Pati Fault	Pati	SS	0.1
32	Alternative 32 Pasuruan Fault	Pasuruan	N	0.2
33	Alternative 33 Probolinggo Fault	Probolinggo	N	0.2
34	Alternative 34 Wonorejo Fault	Wonorejo	N	0.3

Table 3 below showed the result of multicriteria analysis with 6 criterions and its average rating.

Table 3. Criterion of Faults Priority Analysis

Criterion 1 Rating Magnitude	Criterion 2 Rating Region	Crit aerion 3 Rating Population Density
3	2	2
3	1	1
3	1	1
3	3	3
1	2	2
1	2	2
1	2	2
1	1	1
3	2	2
3	2	2
3	2	2
3	2	2
3	1	1
3	3	3
3	1	1
3	2	2
3	2	2
3	2	2
3	1	1

3	3	3
3	1	1
3	1	1
3	1	1
3	3	3
1	1	1
1	1	1
1	1	1
1	1	1
1	1	1
1	1	1
1	2	2
1	2	2
1	2	2
1	1	1

Criterion 4 Rating Education Level	Criterion 5 Rating Infrastructure	Criterion 6 Rating Economic Level	Average Rating
2	2	2	2.17
1	1	1	1.33
1	1	1	1.33
3	3	3	3
2	2	2	1.83
2	2	2	1.83
2	2	2	1.83
1	1	1	1
2	2	2	2.17
2	2	2	2.17
2	2	2	2.17
2	2	2	2.17
1	1	1	1.33
3	3	3	3
1	1	1	1.33
2	2	2	2.17
2	2	2	2.17
2	2	2	2.17
1	1	1	1.33
3	3	3	3
1	1	1	1.33
1	1	1	1.33
1	1	1	3
3	3	3	3
1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1
1	1	1	1
2	2	2	1.83
2	2	2	1.83
2	2	2	1.83
1	1	1	1

4 Discussion

Based on the assessment table with multicriteria analysis as part of the decision making process for determining fault priorities on Java Island, it was found that the biggest weight in the priority analysis of active faults which had the 3 (three) values as the highest average ratings where fault locations were in large cities with high population densities, good in education level, high economic level with complete and modern infrastructure. The first level priority are Lembang Fault, Semarang Fault, Surabaya Fault, Kendeng Fault, Opak Fault, The second priority is the fault with an average rating value of 2.17 where the character of the fault has a relative magnitude of> 4, but the fault location is at the district level where the population density is relatively not as dense as the provincial capital, the infrastructure is relatively a few and less modern, low to medium education level. The third priority is the fault with an average rating of 1.83 where the fault character has a small magnitude <1 but the fault location is in a district with moderate population density and little infrastructure. The fourth priority is a fault with a value of 1.33 average rating where the fault character has a magnitude> 4 but the fault location is in an area with low population density, less infrastructure, middle to lower economic level and low to medium education level. The fifth priority is a fault with an average rating of 1 where the fault character has a low magnitude <1. However the fault location is in sub-district areas with low population density, little infrastructure, middle to lower economic level and lower secondary education level.

5 Conclusion

Java Island is passed by active land faults based on revised maps of source and earthquake hazards in Indonesia 2017 so it is necessary to do earthquake research priority mapping using the decision maker method-multi criteria analysis including criteria for magnitude, fracture location administratively, population density, infrastructure, level of education and economy. The results of the decision maker-multicriteria analysis method showed that the highest priority in fault analysis is a fault with an average rating of 3 with a high magnitude >4 through a large city or provincial capital with high population density, complete and modern infrastructure, and education and middle to upper economy level. For examples are Lembang fault, Opak fault, Semarang fault, Surabaya fault. The next priority is faults with an average rating of 2 with fault characteristics having a high magnitude >4 but different in fault locations located in cities or districts with fewer populations than the provincial capital. In addition, the priority of fault analysis is worth an average rating of around 1 with the character of high to small magnitude however the fault location is in sub-districts with a small population density, less important infrastructure, middle to lower economic and education levels.

References

1. W. Hamilton. Tectonics of the Indonesian Region, 3–10 (1973)
2. A. Satyana and M.E.M. Purwaningsih. *Proccedings of Joint Convention Jakarta*. (2003)
3. B. Setyadji, I. Murata, J. Kahar. Ann.Disas.Prev. Res. Ins. Kyoto Univ 40, **B-1** 27-33 (1997)

4. H. Z. Abidin, H. Andreas, M. Gamal, A.D. Wirakusumah, D. Darmawan, T. Deguchi, Y. Maruyama. J. App Geod. **2**(3) 167-177 (2008)
5. I. Meilano, H. Z. Abidin, H. Andreas, I. Gumilar, D. Sarsito, R. Hanifa. J.of Diss.Researc **7**(1) 12-18 (2012).
6. A. Koulali, S. McClusky, S. Susilo, Y. Leonard, P. Cummins, P. Tregoning, I. Meilano, J. Efendi. And A.B. Wijanarto, Earth and Planetary Sc. Lett. **458** 69–79 (2017)
7. Y. Okada. Bull.Seis. Soc.Am. **75** 1135-1154 (1985)
8. H. Z. Abidin, H. Andreas, I. Kato, T. Ito, I. Meilano, F. Kimata, D. H. Natawidjaya J. Earthq.Tsunami **3**(2) 77-88 (2009)
9. Decision Making Tools and Techniques. *A Guide to Assessing Needs Sect 3B*
10. V. Belton, T. Stewart. *Multiple Criteria Decision Analysis-An integrated Approach*. (Kluwer Academic Press, 2002)
11. D. Baker, D. Bridges, R. Hunter, G. Johnson, J. Krupa, J. Murphy, and K. Sorenson. *Guidebook to Decision Making Methods*. (Department of Energy, USA, 2002)
12. J. Fulop. Introduction to Decision Making Methods.