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EVALUATION OF STRONG GROUND MOTION FOR YOGYAKARTA DEPRESSION AREA, INDONESIA

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Abstract

The probabilistic seismic hazard maps are developed for Yogyakarta depression area. The earthquake catalog of ANSS (1970-2007) is taken into account with the complement of NEIC (USGS, 1973-2007) and the records of BMG (2000-2004). On the basis of seismicity of the area, tectonics and geological information, the seismic source zones are characterized for this area. The seismicity parameters of each seismic source are determined by applying the classical Gutenberg-Richter recurrence model, regarding the historical records. The attenuation relation for Yogyakarta depression area cannot be evaluated since the sufficient strong ground motion records are not available for this region. Therefore the attenuation relations which were developed for other territories as Europe and Japan are used for the present hazard calculation by validating, using the aftershocks records, modeling the peak ground acceleration maps for the recent event, 27 May, 2006, Yogyakarta earthquake inserting the damage area distribution pattern. The probabilistic seismic hazard maps are finally developed by using the McGuire (1976) EQRISK computer program by modifying for the present purpose. The seismic hazard maps expressed in term of peak ground acceleration are developed for the recurrence intervals of 10, 50, 100, 200 and 500 years.

1 Introduction

The earthquakes can cause the hazardous effects in three different ways: (1) those effects resulted directly from a certain level of ground shaking, (2) those effects on the land surface resulted from faulting or deformations, and (3) those effects triggered or activated by a certain level of ground shaking such as the generation of a tsunami or a landslide. The first one can be referred as the seismic hazard and the other phenomena can be assessed on the basis of this information. In the estimation of seismic hazards for a specific area or region, the two approaches as the deterministic and the probabilistic method can be traditionally used. The deterministic method attempts to determine a maximum credible intensity of ground-motion at a given site through estimation of a maximum credible earthquake likely to take place in the proximity of that site. However, after considering the insufficient data for seismicity, seismic sources and site conditions, we chose the probabilistic seismic hazard analysis for Yogyakarta area. Seismic hazard is defined as the probability that the ground-motion amplitude exceeds a certain threshold at a specific site. For the present work we used and calculated the peak ground acceleration (PGA in cms^{-2}) which is the most commonly used parameter in earthquake engineering. The methodology proposed by Cornell (1968) and McGuire (1976), and the program EQRISK of McGuire (1976) will be used for the present study and we will construct the probabilistic seismic hazard maps of the certain return interval for the Yogyakarta depression area.

2 Seismotectonics of Yogyakarta Depression Area

With 1,250 sq-miles (3,200 sq kilometers) Yogyakarta is one of the second smallest Indonesian provinces, however it is densely populated by more than 3

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million people. According to the historical and instrumental records, the Yogyakarta depression area was affected by some considerably high magnitude earthquakes in the last century, being the strongest event of the magnitude 8.1, 23 July 1943 earthquake which happened at the coordinate of 8.6S and 109.9 E with the depth of 90km. This earthquake caused about 213 people dead and over 3,900 people get injured and 12,603 houses collapsed, 166 houses heavily damaged and 15,275 houses damaged (Van Bemmelen, 1949). The largest damaged area was Bantul where 31 people were dead, 564 get injured and 2,682 houses were collapsed and 8,316 houses damaged. The second largest event was 7.2 M_s, 27 September, 1937 earthquake which strucked at the location of 8.88 S and 110.65 E. This event caused one death and 2,526 houses collapsed in Yogyakarta province (Newcomb and McCann, 2001 and Utsu, 2002). The most recent one was a magnitude 6.3 M_w earthquake struck on Saturday, May 27 at 5:54 am (22:54 GMT 26 May) local time with the duration of shaking of about 57 seconds. The epicenter was located at 7.962°S, 110.458°E (USGS) at around 20 km SSE of the Yogyakarta, 455km ESE of the Indonesian capital, Jakarta at the depth of 10 km. This earthquake caused 6,234 deaths, while 36,299 people have been injured, 135,000 houses damaged, and an estimated more than 600,000 left homeless (Indonesian Social Affairs Ministry). Bantul in Yogyakarta Province and Klaten in Central Java Province are the main two districts affected by the strong ground shaking. The most destructed area was the Bantul District located at the coastal region of Indian Ocean about 17 miles south of Yogyakarta city with the population of about 790,000 and its surrounding hinterland. It was reported to be the worst hit area with about 60% of houses destroyed, 4,121 people dead and more than 12,026 get injured while 18,127 injured and 1,041 peoples died in Klaten district (Elnashai *et al.*, 2006, MAE Center Report No.07-02).

As described before, Yogyakarta is a city and a province located in south-central Java with the dense population of more than 3 million people. Moreover the Yogyakarta depression area is mostly covered by the alluvium and the young volcanic deposits of Merapi volcano. This area is also located in the region between the volcanic arc of the Central Java, and the Java Trench, and is surrounded by several fault zones occupying as a segment of the Sumatra-Java trench extended over 5,600 km from the Andaman arc in the north-west to the Banda arc in the east. This subduction zone is one of the most active plate margins in the world and was formed by the convergence between the Indian-Australian and Eurasian plates. The Java Island is situated within the Sunda arc, on the Eurasian plate overriding the subducting Indian-Australian plate and located a few hundred kilometers from the Sunda trench. The convergence is nearly normal to the trench axis south of Java, while it is gradually oblique to the north and highly oblique in the north-west of Sumatra (Megawati *et al.*, 2004). The normal subduction below Java can be characterized by the development of typical fore-arc basins while the oblique subduction beneath Sumatra and further north results in partitioning of the convergent motion into thrust and strike-slip faulting. Along the arc, the age of lithosphere below Java is 96-134 Ma (Lasitha *et al.*, 2006).

3 Seismic Sources Characterization

Three types of seismic sources; fault specific sources, area sources and background seismic sources can generally be defined for any area of interest (Figure 1). For the present area, most of the faults are subsurface (blind) faults and the data for fault parameters cannot be available even though some geophysical surveys as gravity, magnetic and CSAMT surveys were conducted. The more detailed fault analysis as trenching is still needed to be performed for the present area.

In this current work, the geological and fault maps of Rahardjo *et al.* (1995) and McDonald *et al.* (1984) are utilized to develop the fault specific seismic sources (Figure 2). Moreover, the three area seismic sources are also assigned in the offshore region based on the seismicity of the region and focal mechanisms of the past earthquakes. For this purpose, the earthquake catalogs of ANSS (1970/01-2007/07) and the NEIC, USGS (1973/01-2007/07) are applied with the supplement of BMG (Yogyakarta) earthquake records (2000-2004) by evaluating the seismicity of the Yogyakarta depression area within the radius of about 300 km.

4 Estimation of Maximum Magnitude of Earthquake Potential

The maximum magnitudes of earthquakes which are expected to be caused by each fault specific seismic source are estimated by using the following empirical relation:

$$0.5\,M = \log\,L + 1.9$$

(Inoue *et al.*, 1993)

where M = earthquake magnitude, and L = the fault length. The maximum magnitude of earthquake potential from each fault specific sources is represented in Table 1. However, to determine the

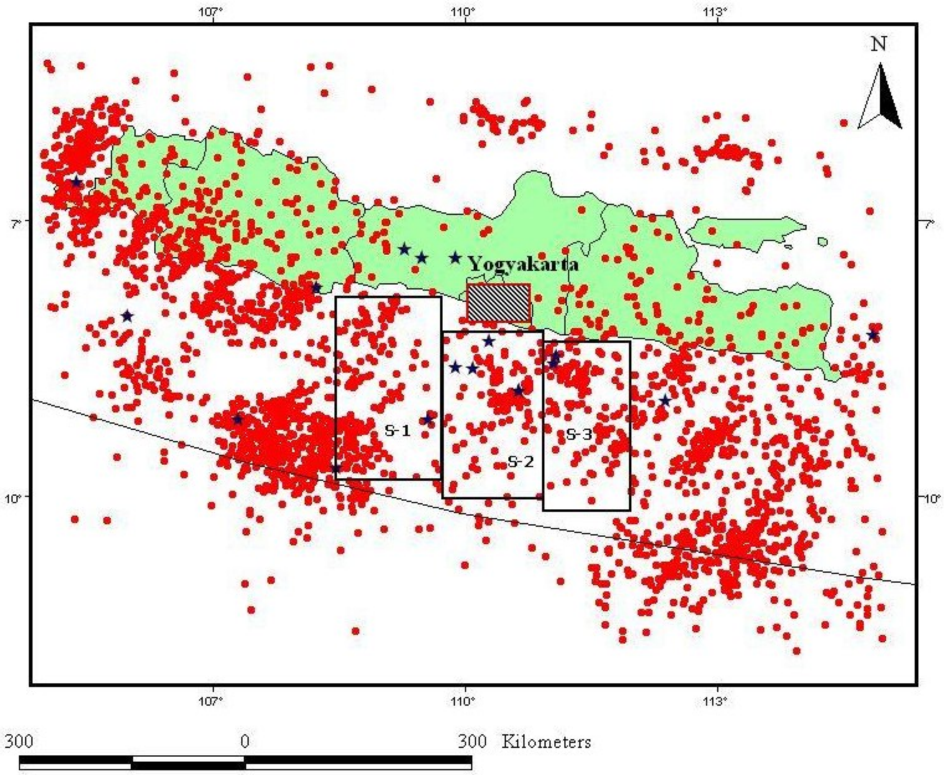

Figure 1: Map of areal seismic sources for Yogyakarta depression area depicting the historical earthquakes (dark blue colored stars) and the earthquakes of instrumental records in red colored circles.

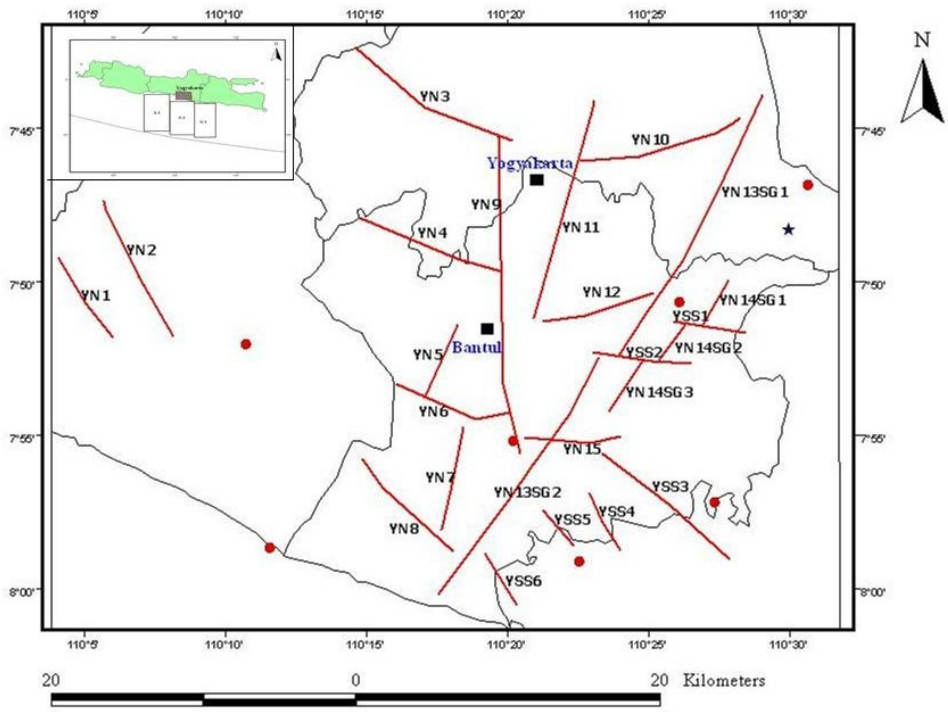

Figure 2: Map of fault specific seismic sources for Yogyakarta depression area depicting the historical earthquakes (dark blue colored stars) and the earthquakes of instrumental records in red colored circles.

Table 1: The assumed fault parameters and the estimated maximum magnitude model of the earthquake potentials of fault specific seismic sources.

Fault Specific Sources		Fault length	Max. Magnitude
Normal Faults	YN1	6.1	5.4
	YN2	10	5.8
	YN3	12.5	6
	YN4	10	5.8
	YN5	5	5.2
	YN6	7.2	5.5
	YN7	6.5	5.4
	YN8	8.5	5.7
	YN9	20.5	6.4
	YN10	10.5	5.8
	YN11	14.5	6.1
	YN12	7.5	5.6
	YN13SG1	19.7	6.4
	YN13SG2	19.3	6.4
	YN14SG1	2.7	4.7
	YN14SG2	2.9	4.7
	YN14SG3	4	5
	YN15	6.3	5.4
Strike-slip Faults	YSS1	4.5	5.1
	YSS2	6.5	5.5
	YSS3	10.5	5.8
	YSS4	3	4.8
	YSS5	2.9	4.7
	YSS6	3	4.8

mmax for the area seismic sources the following three relationships described below are handled .

$$m_{\max} = m_{\max}^{\text{obs}} + \frac{E_1(n_2) - E_1(n_1)}{\beta \exp(-n_2)} + m_{\min} \exp(-n)$$

(Kijko, 2004)

where, $m_{\max}$ = the maximum earthquake magnitude,
$m_{\max}^{\text{obs}}$ = the observed maximum earthquake magnitude
$m_{\min}$ = threshold of the completeness of the earthquake catalog,
n = the number of earthquakes greater than or equal mmin,
$\beta = b \ln(10)$,
$n_1 = n / \{1 - \exp[-\beta(m_{\max} - m_{\min})]\}$,
$n_2 = n_1 \exp[-\beta(m_{\max} - m_{\min})]$, and
$E_1(z) = \dfrac{z^2 + a_1 z + a_2}{z(z^2 + b_1 z + b_2} \exp(-z)$
in which a_1 = 2.334733, a_2 = 0.250621, b_1 = 3.330657, and b_2 = 1.681534

$$m_{\max} = m_{\max}^{\text{obs}} + \frac{1}{n} \frac{1 - \exp[-\beta(m_{\max} - m_{\min})]}{\beta \exp[-\beta(m_{\max} - m_{\min})]}$$

(Tate, 1959)

$$m_{\max} = -\frac{1}{\beta} \ln\{\exp(-\beta m_{\min}) - [\exp(-\beta m_{\min}) - \exp(-\beta m_{\min}^{\text{obs}})] \frac{n+1}{n}\}$$

(Gibowicz & Kijko, 1994)

It must be noted that Kijko's (2004) equation is not a direct estimator for $m_{\max}$ and $m_{\max}$ can be obtained by the iteration of this equation. However when $m_{\max} - m_{\min} \leq 2$ and n $\geq$ 100, the parameter $m_{\max}$ in n_1 and n_2 can be replaced by $m_{\max}^{\text{obs}}$ and $m_{\max}$ can be estimated without iteration (Kijko, 2004). *a*- and *b*-value for the Yogyakarta depression area are determined as 5.3528 and 1.045 by using the Gutenberg and Richter's classical relation and the earthquake catalog of ANSS (1970/01-2007/07) with the independent earthquakes greater than magnitude 4Mw. The maximum magnitude of earthquake potentials expected from the area sources are taken into account by the average of the results calculated using the above mentioned three equations (Table 2).

5 Attenuation Relations

The predictive relationships are mostly used to estimate the ground motion parameters usually expressed them as functions of magnitude, distance and in some cases, other variables used to characterize the earthquake source, wave propagation path and /or local site conditions. Those relationships for parameters such as peak ground acceleration or velocity that decrease with increasing distance are referred to as attenuation relationships (Kramer, 1996). Many attenuation relationships have been developed for different regions around the world and for different tectonic environments.

For present study, we applied four different attenuation formulae to carry out the comparative study of the results. The attenuation relations of Boore *et al.* (1997), Youngs *et al.* (1997), Fukushima & Tanaka (1990) and Takahashi *et al.* (2000) are applied for estimation of ground motion for Yogyakarta depression area. Fukushima & Tanaka (1990) developed the attenuation relation by using Japan and worldwide earthquakes happened during 1960-1990 with the magnitude range 5.1-7.9(M) and epicentral distance less than 300km (32 events, 555 records in Japan and 20 worldwide events, 278 records) and their attenuation relationship can be expressed as follow:

Table 2: The estimated maximum magnitude model of the earthquake potentials of three area seismic sources.

Area source	m_{max}(obs)	m_{min}	n	b	$^{1*}m_{max}$	$^{2*}m_{max}$	$^{3*}m_{max}$	Average m_{max}
S-1	8.1	4.04	36	0.809	8.163	8.116	8.325	8.2
S-2	8.1	4.16	37	0.809	8.089	8.116	8.319	8.2
S-3	8.1	4.04	50	0.809	8.07	8.112	8.262	8.1

$1^{*}m_{max}$- by using Kijko's (2004) equation, $2^{*}m_{max}$- by using Tate's (1959) equation and $3^{*}m_{max}$- by using the equation of Gibowicz and Kijko (1994)

$$\log_{10} A = 0.42M_w - \log_{10}(R + 0.025 \cdot 10^{0.42M_w}) - 0.0033R + 1.22$$

where A = peak ground acceleration in cms-2 and R = the shortest distance between site and fault rupture in km. We also utilized the attenuation relation of Takahashi *et al.* (2000) which can be described by the following equation:

$$\log_{10}(Y) = aM - bX - \log_{10}(X + c \cdot 10^{dM}) + (h - 20)\delta_h + S_k$$

in which Y = peak ground acceleration in cms-2, M = moment magnitude, X = source distance (km), h = focal depth (km), δ_h = 0 (h<20) or 1 ($h \geq 20$), S_k = site term, and a, b, c, d and e are the constants.

Boore *et al.* (1997) developed the empirical attenuation formula to estimate the peak ground acceleration for shallow crustal tectonic environments with defining the style of faulting as strike-slip, reverse-slip and the one which mechanism is not specified and the relation is given by the following expression;

$$\ln(Y) = b_1 + b_2(M-6) + b_3(M-6)^2 + b_5 \ln r + b_v \ln \frac{V_s}{V_a}$$

where, $r = \sqrt{r_{jb}^2 + h^2}$, Y is peak ground acceleration, M is the moment magnitude, r_{jb} is the closet horizontal distance to the surface projection of the rupture plane in km, V_s is the average shear – wave velocity to 30m (m/s) and b_1, b_2, b_3, b_5, and b_v are the constants.

While the attenuation formula of Boore *et al.* (1997) is used for the fault specific sources, the attenuation relationship of Youngs *et al.* (1997) is also applied to determine the ground motion of the earthquake potentials which are expected to be happened in the subduction zone tectonic environment. Youngs *et al.* (1997) evolved the attenuation relation by using the strong motion data of the earthquakes of interface and intraslab events and the relationship (the first for soil site and the last for rock site) is as follows:

$$\ln(y) = 0.2418 + 1.414M + C_1 + C_2(10 - M)^3 + C_3 \ln(r_{rup} + 1.7818e^{0.554M}) + 0.00607H + 0.3846Z_T$$

$$\ln(y) = -0.6687 + 1.438M + C_1 + C_2(10 - M)^3 + C_3 \ln(R + 1.097e^{0.617M}) + 0.00648H + 0.3643Z_T$$

in which y is the peak ground acceleration in g, M is the moment magnitude, r_{rup} is the closest distance to rupture zone (km), H is the depth (km) and Z_T is the source type (0 for interface event and 1 for intraslab events), and C_1, C_2 and C_3 are constants.

6 Characterization of the Attenuation Relation

The damage areas distribution resulted from the 27 May 2006 Yogyakarta earthquake and the ground motion recordings of the aftershocks from a temporary seismographs network are used to validate the attenuation relationship for Yogyakarta region by establishing the peak ground acceleration map for this event with the aid of the above mentioned attenuation relationships. The aftershocks ground motion recordings were made by Kyushu University and Gadjah Mada University nine days after the main shock. In this study, ground motion data recorded during 6–12, June and 30, July – 8, August will be utilized. The epicentral distribution of the aftershocks is represented in Figure 4.

The observed ground motion parameters of aftershock events are also determined from the recorded seismograms and then compared with the amplitude parameters determined by using the above mentioned attenuation relations. The plots of observed ground motion values versus each of the calculated amplitude parameters resulted by using the attenuation relationships are represented in Figure 5.

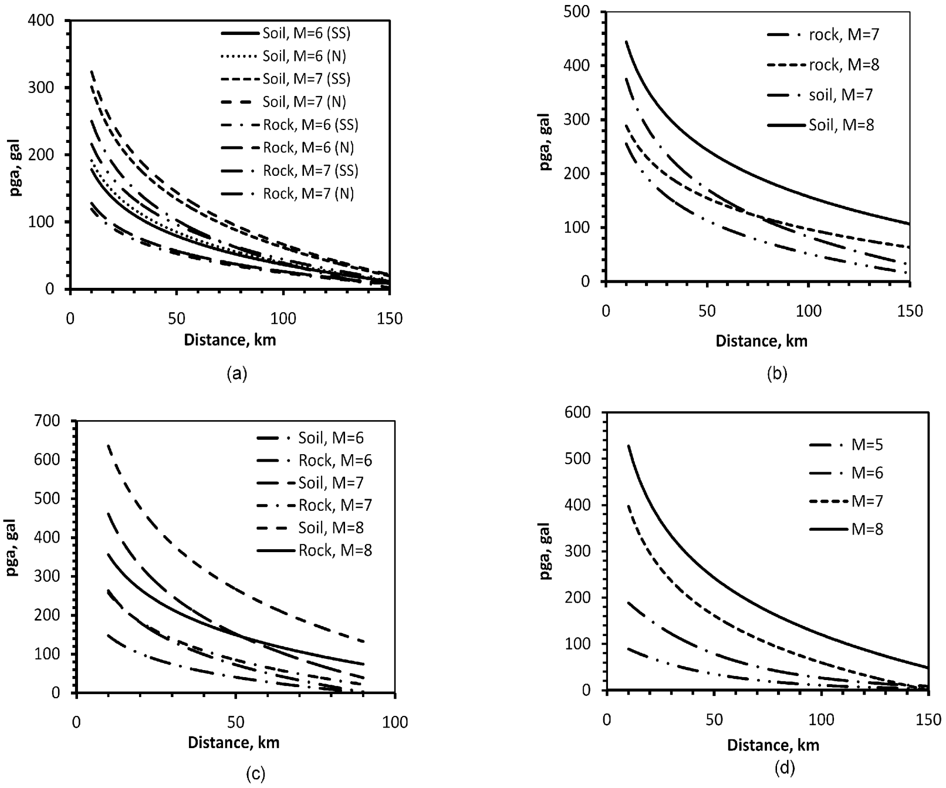

Figure 3: Variation of peak ground acceleration (PGA) with source distance for attenuation relation of (a) Boore *et al.*, 1997, (b) Youngs *et al.*, 1997, (c) Fukushima and Tanaka, 1990 and (d) Takahashi *et al.*, 2000.

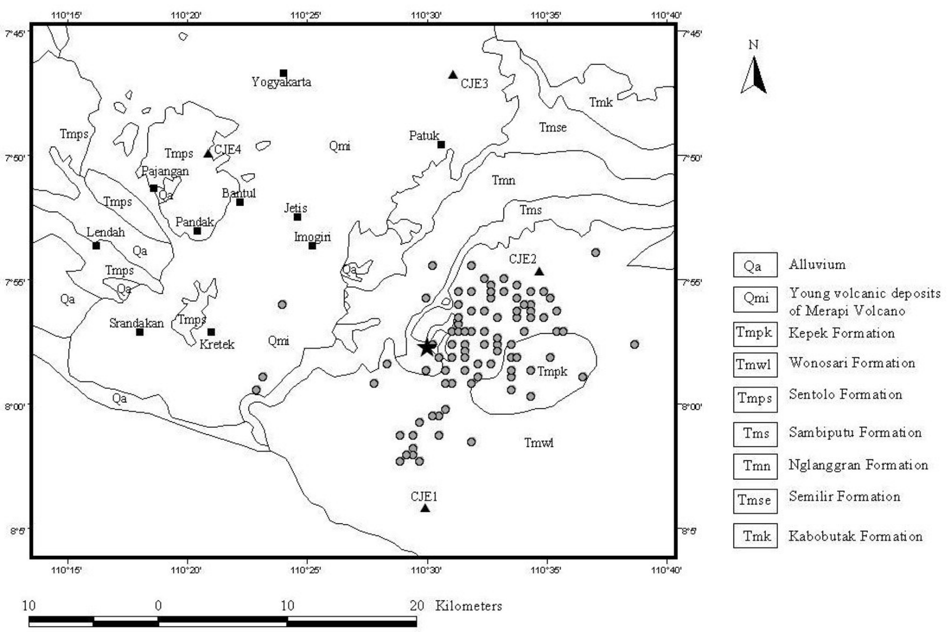

Figure 4: Map representing the epicentral distribution of the aftershocks (grey circles) and the 27 May 2006 Yogyakarta earthquake (Black star) in which the black rectangles are the recorded stations of aftershocks.

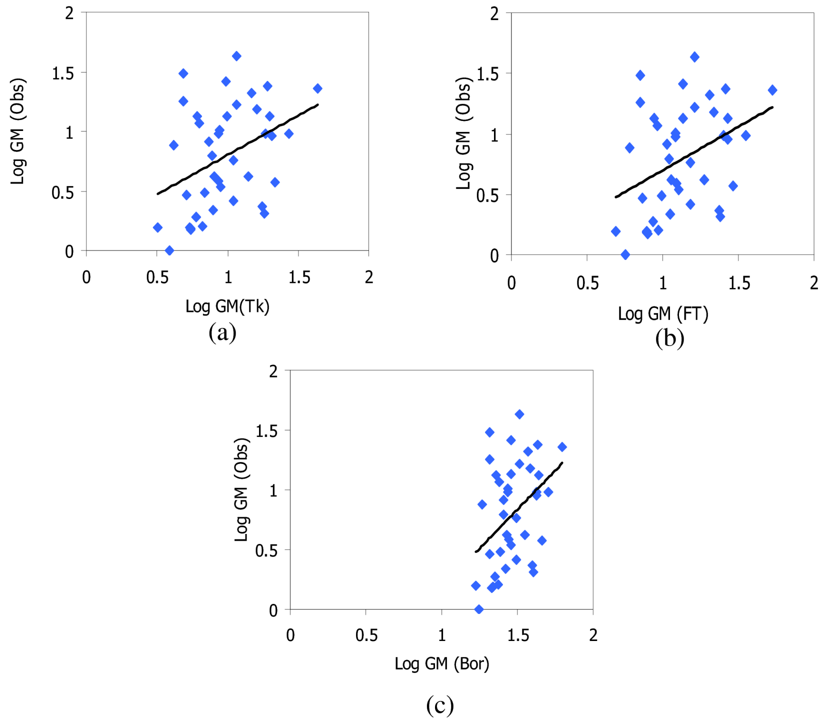

Figure 5: The plots of observed ground motion parameters; GM(Obs) against the resulted ground motion parameters using (a) Takahashi *et al.*, 2000 (GM (Tk)), (b) Fukushim and Tanaka, 1990 (GM (FT)) and (c) Boore *et al.*, 1997 (GM (Bor)).

Moreover the epicentral distribution pattern is also taken into account to model the fault dimension of 27, May 2006 earthquake. The PGA values of 27, May 2006 earthquake are estimated by using the above mentioned attenuation formulae to make the comparative study for each other. For this purpose the fault geometry is modeled as 232 and 86 for strike and dip receptively by referring the moment tensor solution of USGS and Harvard University, and the aftershocks foci distribution.

The fault length and width are estimated by applying the empirical relation of the fault length and earthquake magnitude of Inoue *et al.* (1993) and the relationship of fault length and width of $L = 2W$ (Bormann & Baumbach, 2000). Since the magnitude of that event is assumed as 6.3 M_w, the length of the earthquake source fault can be estimated as about 17.5 km and the width is about 8.75. Although the focal depths of the aftershocks are as shallow as 1.0km and the deepest one is 22.5 km, the upper boundary of the fault plane is assumed as started at around 3.5 km for this study. By applying these parameters of fault geometry, the PGA values of 27, May 2006 Yogyakarta earthquake were estimated. The peak ground acceleration values are determined for the Yogyakarta depression area by spacing $0.01° \times 0.01°$ grid interval in all cases Figure 6.

Figure 7a to c represents the PGA maps of 27, May 2006 Yogyakarta earthquake and the map of the most disastrous area. The most earthquake damage area is located along the eastern edge of Yogyakarta Basin, along the well-known Opak fault (Karnawati *et al.*, 2007 and Walter *et al.*, 2007). When the distribution pattern of the damage areas and the areas of high PGA values are compared, the PGA values of the high damage areas are as nearly high as in those areas which are in the closest distance from the source in the PGA maps of 27 May 2006 Yogyakarta earthquake developed by utilizing the attenuation relationships of Takahashi *et al.* (1990) and Boore *et al.* (1997). On the other hand, the areas of high PGA values seem to be not consistent with those of highly damage areas in the PGA map resulted by applying the attenuation relation of Fukushima & Tanaka (1990).

7 Probabilistic Peak Ground Acceleration Maps

McGuire (1976) developed the computer program, EQRISK for Probabilistic Seismic Hazard Analysis. The input parameters for this program are the co-

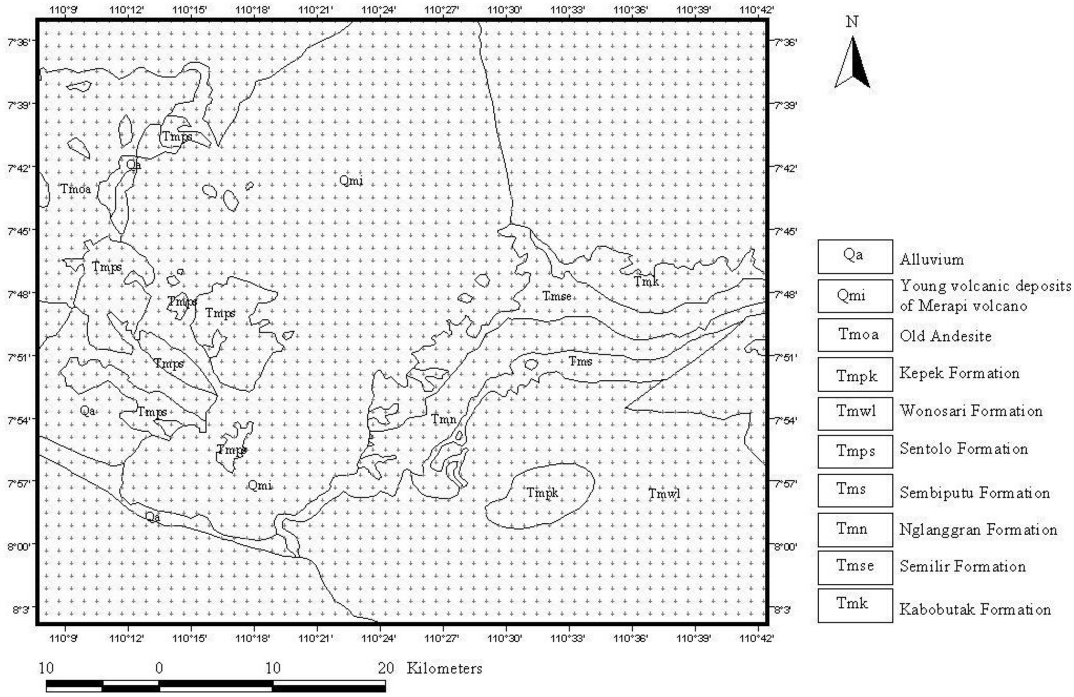

Figure 6: Geological map of Yogyakarta area showing the grid points in 0.01° × 0.01° interval where the peak ground acceleration values are estimated.

ordinates of the seismic sources, the seismic parameters for each seismic source as lower bound and upper bound earthquake magnitude, b-value, earthquake annual earthquake recurrence rate, and focal depth, the attenuation parameters and the coordinates of the site at which the seismic hazard want to be determined. Annual probability of earthquake occurrence and the seismic hazards are the output. We modified the EQRISK program for performing the probabilistic seismic hazard analysis for the Yogyakarta depression area.

Five probabilistic seismic hazard maps expressed in term of peak ground acceleration (pga, gal) are represented in Figure 8 to 12 for recurrence interval of 10, 50, 100, 200 and 500 years. The seismic hazard map for 10 years recurrence interval is represented in Figure -8 and the maximum pga value is about 500 gal. The hazard map for 50 years recurrence interval is also displayed in Figure 9 and the maximum peak ground acceleration reaches around 550 gal. Yogyakarta, Kasihan, Bantul, Pandak, Pudong and Imogiri areas are comprised of the high pga values.

Figure 10 depicts the hazard map for 100 years recurrence interval and the peak ground acceleration values are higher than those for 50 years return interval. The maximum pga value is about 650 gal. The pga values at the locations of Yogyakarta, Bantul, Kasihan, Imogiri, Pandak and Pundong is around 600 gal and constitute as the high seismic hazard area for this return interval. The features of the seismic hazard maps for the recurrence interval of 200 years and 500 years are represented in Figure 11 and 12. While the maximum pga values for the recurrence interval of 500 years reach up to 750 gal, that of 200 years belongs to 700 gal. The highest seismic hazard regions comprises of Kasihan, Bantul and Imogiri with the maximum pga values for 200 return interval and the pga values of Yogyakarta, Pandak, Pundong, and Berbah belongs to 650gal. However for the 500 years recurrence interval, in most part of the central Yogyakarta depression area seem to be comprised of the highest pga values. Yogyakarta, Kasihan, Bantul, Imogiri, Pandak, Pudong and Berbah areas comprise of the maximum pga values of 750 gal.

8 Conclusion

The probabilistic seismic hazard maps expressed in terms of peak ground acceleration for return intervals of 10, 50, 100, 200 and 500 years were built for Yogyakarta depression area. High seismic hazard areas are occupied in most part of the Yogyakarta depression area for 500 years recurrence interval with the maximum pga value of 750 gal as in Yogyakarta, Kasihan, Bantul, Imogiri, Pandak, Pundong and Berbah. However, the high seismic hazard

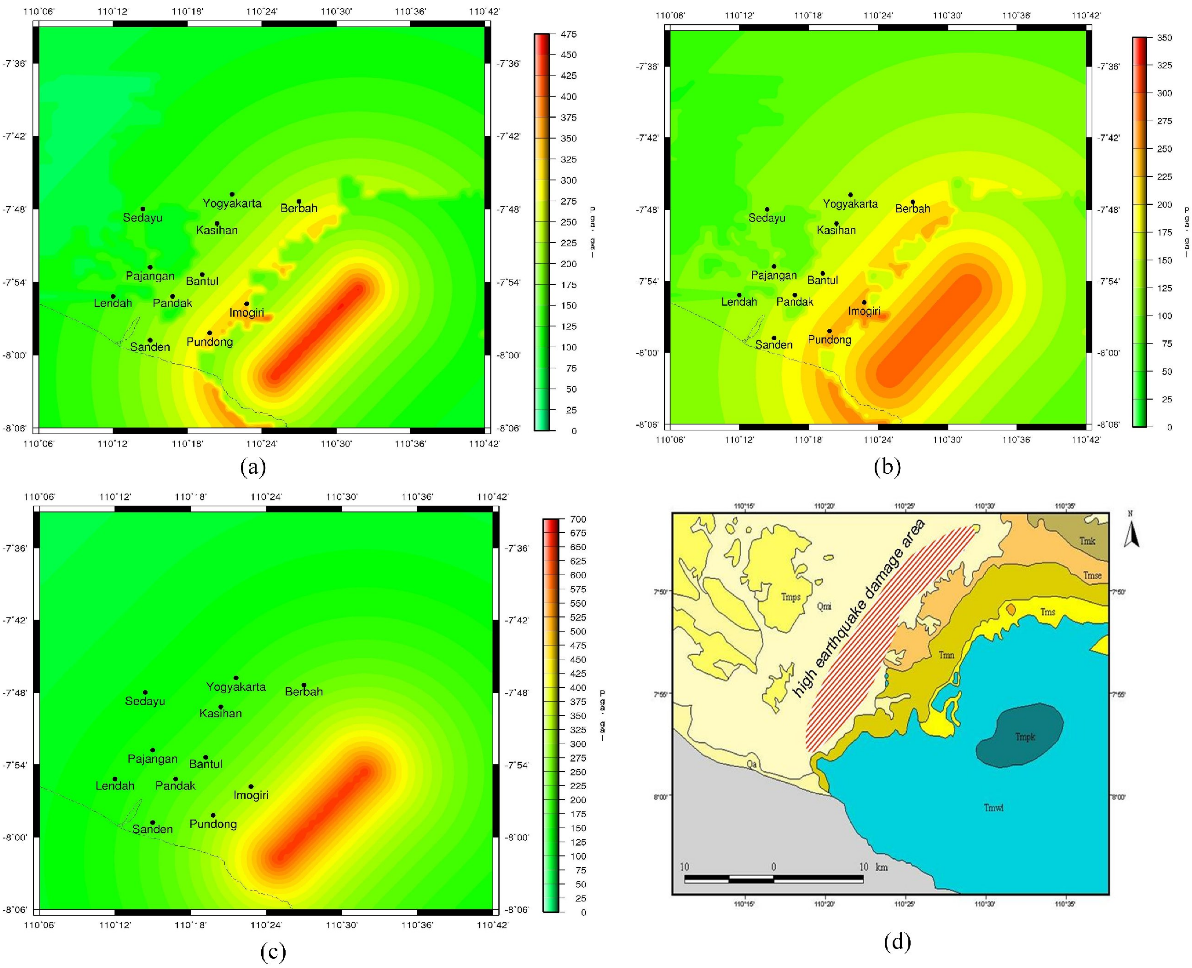

Figure 7: PGA map of the 27, May 2006 Yogyakarta earthquake by using the attenuation relationship of (a) Takahashi *et al.*, 2000, (b) Boore *et al.*, 1997, (c) Fukushima & Tanaka, 1990 and (d) Map showing the most earthquake damage area to correlate with the resulted PGA values.

Table 3: Parameters of seismic sources.

Sources	M_o	M_{max}	β	Annual Rate	Focal Depth
YN1	4.5	5.4	1.6095	0.054	10
YN2	4.5	5.8	1.6095	0.054	10
YN3	4.5	6	1.6095	0.054	10
YN4	4.5	5.8	1.6095	0.054	10
YN5	4.5	5.2	1.6095	0.054	10
YN6	4.5	5.5	1.6095	0.054	10
YN7	4.5	5.4	1.6095	0.054	10
YN8	4.5	5.7	1.6095	0.054	10
YN9	4.5	6.4	1.6095	0.054	10
YN10	4.5	5.8	1.6095	0.054	10
N11	4.5	6.1	1.6095	0.054	10
YN12	4.5	5.6	1.6095	0.054	10
YN13SG1	4.5	6.4	1.6095	0.054	10
YN13SG2	4.5	6.4	1.6095	0.054	10
YN14SG1	4.5	4.7	1.6095	0.054	10
YN14SG2	4.5	4.7	1.6095	0.054	10
YN14SG3	4.5	5	1.6095	0.054	10
YN15	4.5	5.4	1.6095	0.054	10
YSS1	4.5	5.1	1.6095	0.054	10
YSS2	4.5	5.5	1.6095	0.054	10
YSS3	4.5	5.8	1.6095	0.054	10
YSS4	4.5	4.8	1.6095	0.054	10
YSS5	4.5	4.7	1.6095	0.054	10
YSS6	4.5	4.8	1.6095	0.054	10
S1	5.5	8.2	1.8628	0.429	35
S2	5.5	8.2	1.8628	0.4785	35
S3	5.5	8.1	1.8628	0.6034	35

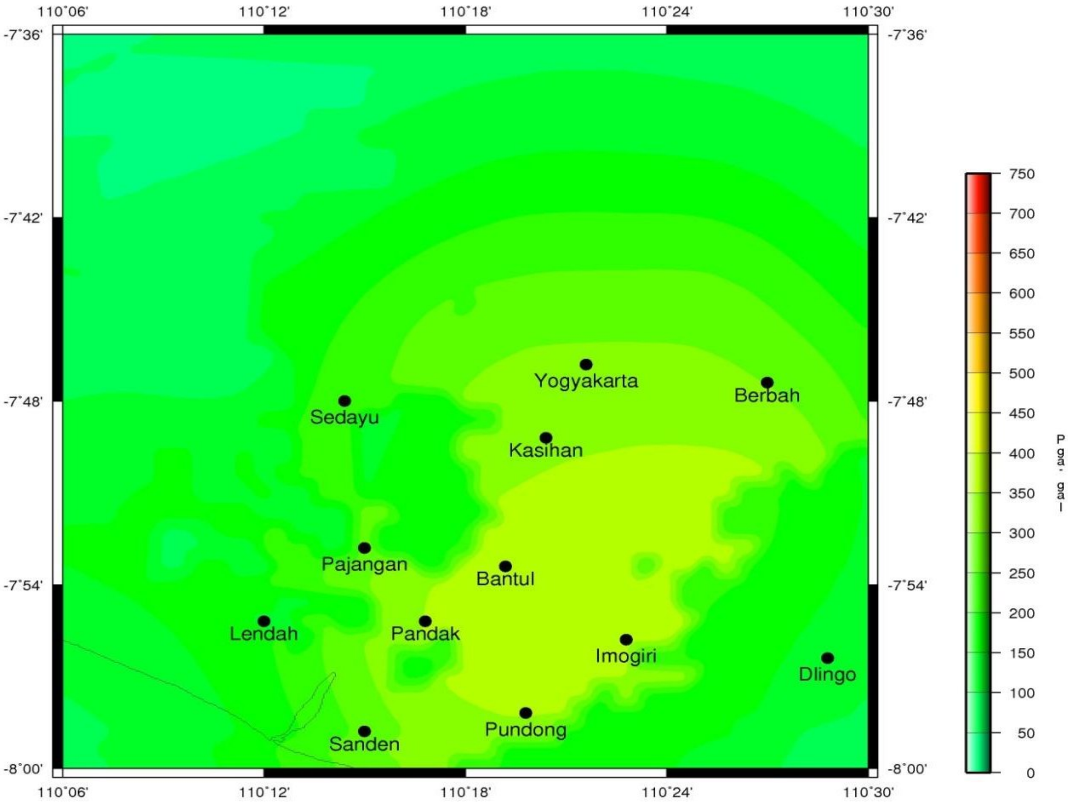

Figure 8: Seismic hazard maps expressed in pga (gal) for 10 years return interval.

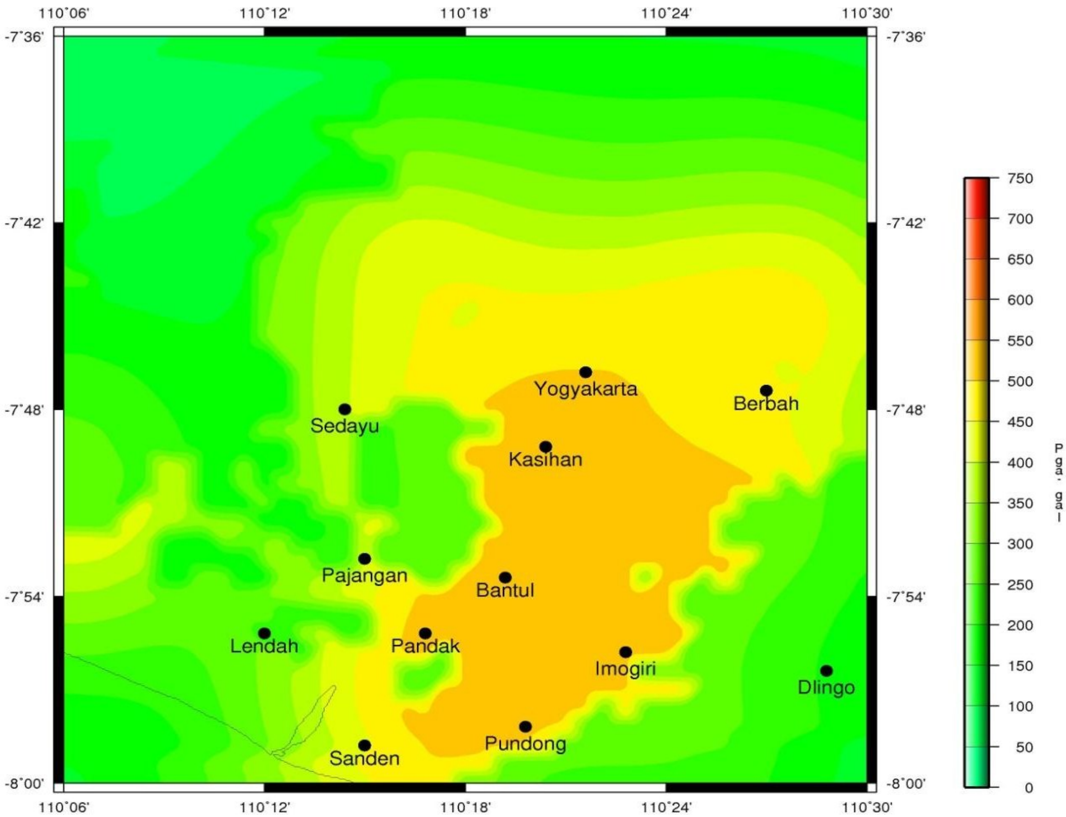

Figure 9: Seismic hazard maps expressed in pga (gal) for 50 years return interval.

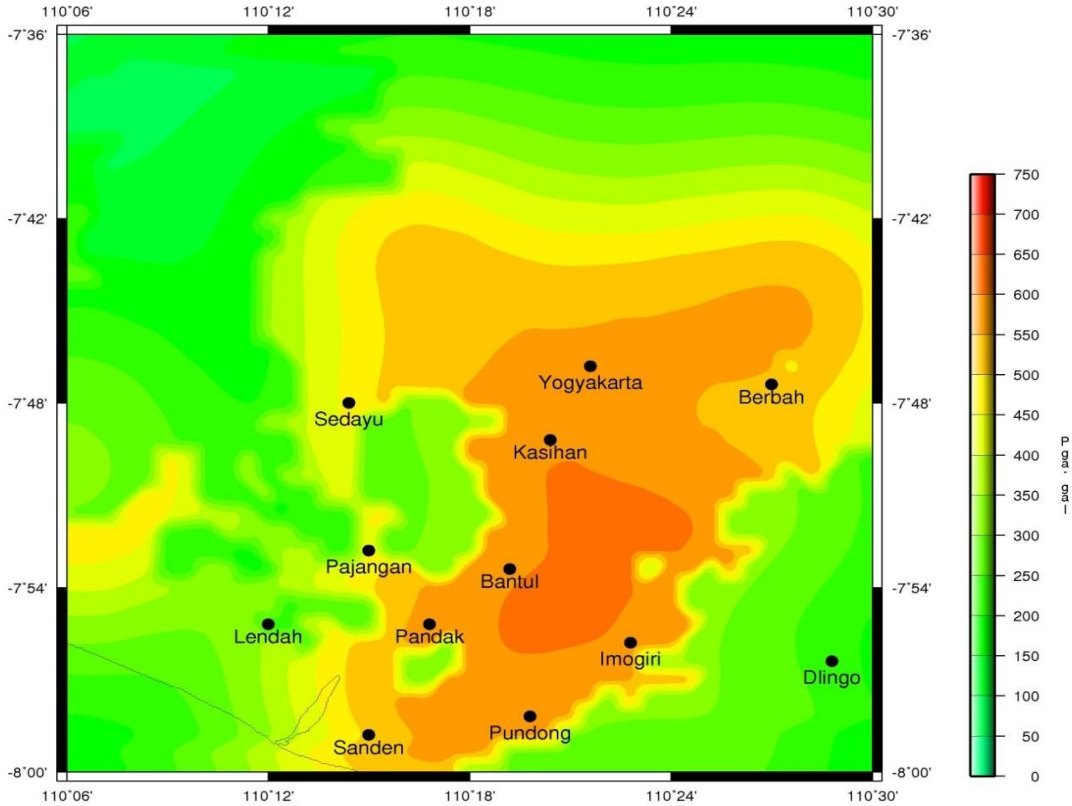

Figure 10: Seismic hazard maps expressed in pga (gal) for 100 years return interval.

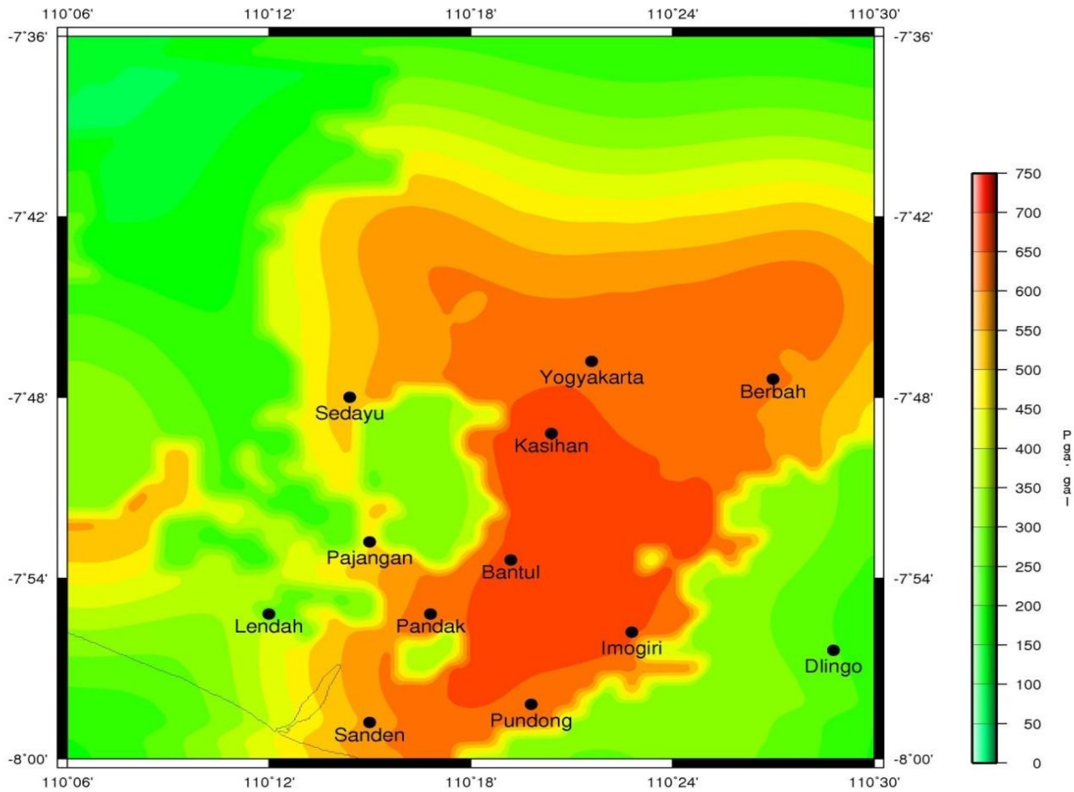

Figure 11: Seismic hazard maps expressed in pga (gal) for 200 years return interval.

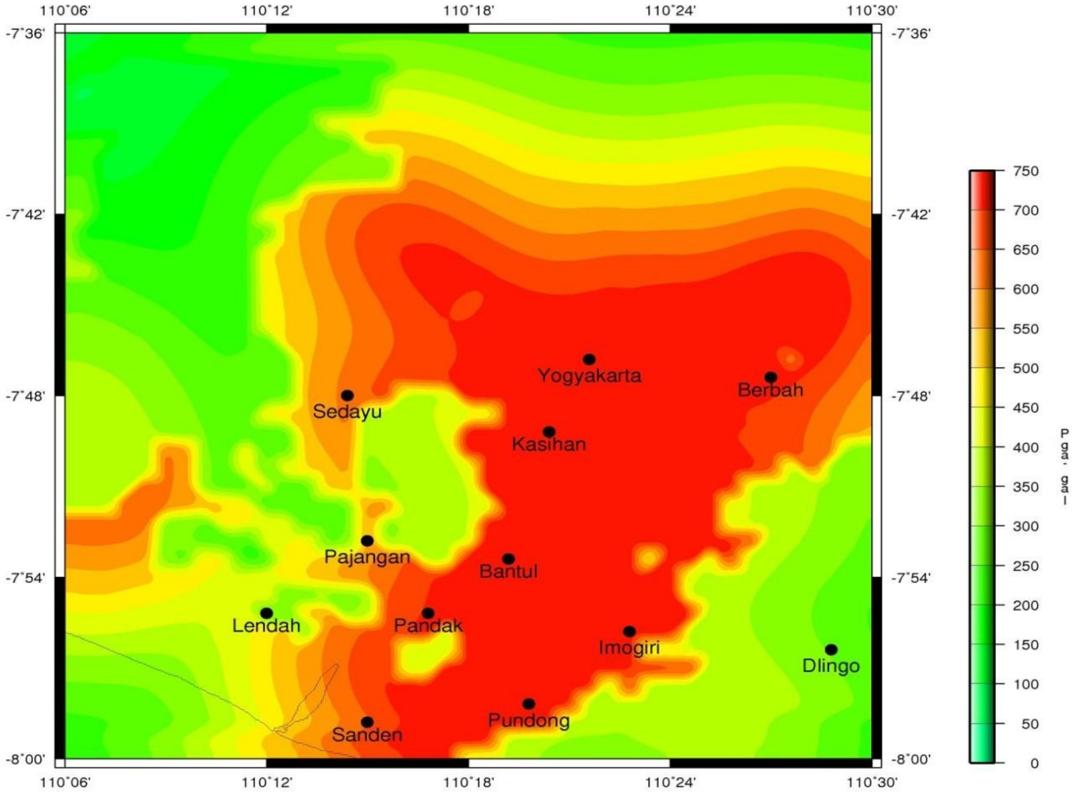

Figure 12: Seismic hazard maps expressed in pga (gal) for 500 years return interval.

characteristics are commonly distributed in the central portion of the area with the maximum pga value of 700 gal for 200 years recurrence interval especially in Kasihan, Bantul and Imogiri area. Most of the low seismic hazard areas comprise the area where are covered by the Tertiary rock units and the northernmost part of the Yogyakarta depression area. While the high seismic hazard areas, the central portion of this area is mostly covered by the young volcanic deposits of Merapi volcano. However, the resulted pga values seem to overestimate since the sufficient data are not available for this area. There would be some input parameters which are still needed to perform detail analysis. Neither sufficient information on the faults as the slip rate nor the detailed site condition as soft soil or medium soil or hard soil, etc. can be determined by the present works. When the seismic sources are characterized for the present area, the obtained data are not sufficient, especially for fault specific sources. The detailed analysis as trenching are still needed to conduct to get more information. Moreover, when the seismic source parameters as *a*- and *b*- values are determined, the resulted (input) parameters seem to be deficient since the instrumental seismic recorded period is too short for this area, especially for the determination of those values for fault specific seismic sources (inland earthquakes) the obtainable data are too sparse and not good enough to get the satisfactory value. Similar cases also face in the characterization of the areal seismic sources (subduction zone earthquakes). Therefore, the seismic hazards from the fault specific sources likely results more effects for the present area, compared with the seismic hazards resulted from the areal sources. By aquiring these required information further more, establishing seismic hazard map would be expected for the Yogyakarta depression area.

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