Field Survey of the M 6.1 South of Banten Sea Earthquake of January 28, 2018

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Abstract

We did field survey of felt earthquake M 6.1 in south-west of Lebak-Banten at Tuesday, January 23, 2018 06:34:53 UTC. It was located in the sea on 7.23° S and 105.91° E with 61 km depth. It triggered damage and injuries in some locations including Bogor and Sukabumi regencies. We conducted aftershock and natural micro-tremor data acquisition and analysis on a few sites survey in Bogor and Sukabumi regencies since January 24-27, 2018.

We used Omori, Mogi 1, Mogi 2, and Utsu decay methods on forecasting the end time of aftershocks. It was predicted to end within 5-6 days after the mainshock. We used HVSR method for comparative study with geological map. The series of these earthquake is categorized as Mogi 1 type

Keywords: Felt Earthquake, Aftershock, Site Class.

Introduction

A felt earthquake of magnitude Mw 6.1 occurred off the south-west coast of Lebak regency, Banten Province, Western part of Java Island, Indonesia at 13h 34m 53s local time or 06h 34m 53s GMT on January 23, 2018. The epicenter was at 7.23° S; 105.90° E (BMKG) about 43 km from capital of Lebak regency, demonstrated in figure 1.

The shock was felt on almost whole of western part of Java island including Banten, Jakarta and West Java province. The hypocenter was about 61 km depth and did not generate tsunami. The seismic intensity distribution can be seen on BMKG Shake-map as in figure 2. It was potentially felt in Jakarta, South Tangerang and Bogor IV-V MMI, Bandung, Purwakarta, Lampung, Kebumen and Bantul II-III MMI. This is relevant to reports that this earthquake was felt almost whole of Banten, Jakarta and Banten Province.

The focal mechanism type of this earthquake is oblique thrust (BMKG). The focal mechanism parameter and picture of this earthquake shows in table 1 and figure 3. According to West Java Province Disaster Management Office report, the statistics of the impact is shown in table 2.

According to BMKG earthquakes catalogue collected from many sources, 38 damage earthquake events occurred in Western part of Java since 1834 until 18 July 2017, 13 of them were not recorded by Seismograph (1834-1923). While number of 25 earthquakes after 1963 have been recorded by Seismograph demonstrated in figure 4[4].

BMKG formed a survey team for this damaging earthquake. This survey aimed to socialize updated earthquake information for evacuee in impact area; to forecast the end time of aftershocks based on aftershocks decay data acquisition and analysis[23]; to classify the site based on natural micro-tremor data acquisition and analysis[3,21] and to study the damage or macro-seismic[2,20].

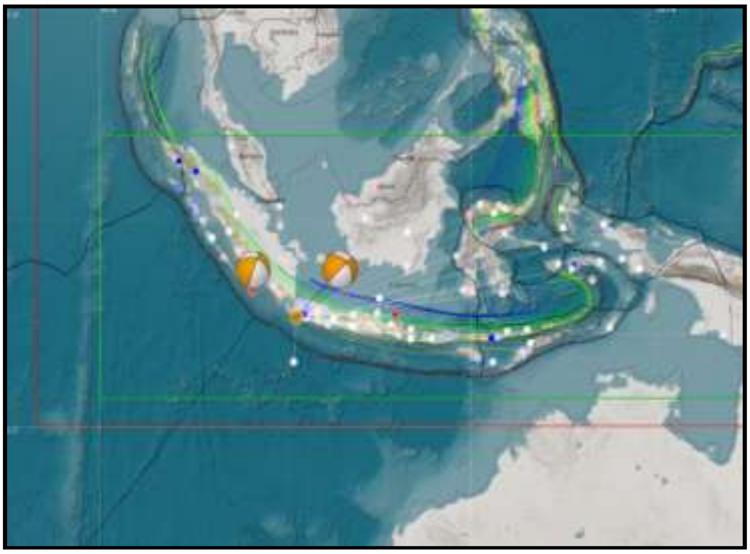

Figure 1: Epicenter location of Mw 6.1 South of Banten Sea Earthquake of January 28, 2018
Source: The Agency for Meteorology, Climatology and Geophysics (2018)

Figure 2: Shake-map of Mw 6.1 South of Banten Sea Earthquake of January 28, 2018
Source: The Agency for Meteorology, Climatology and Geophysics (2018)

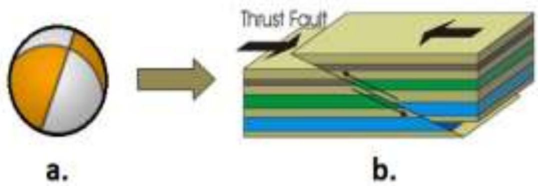

Figure 3: (a) Focal Mechanism Picture of Mw 6.1 South of Banten Sea Earthquake of January 28, 2018, (b) Fault Plane Illustration.[4]

Table 1
Focal Mechanism Parameter of Mw 6.1 South of Banten Sea Earthquake of January

Nodal Plane	Strike$^{(0)}$	Dip$^{(0)}$	Rake$^{(0)}$
NP 1	305	55	164
NP 2	44	77	35

Source: The Agency for Meteorology, Climatology and Geophysics (2018)

Table 2
Final Data of Human and House Damage by Regencies in West Java

Regency / City	Human Injury		House Collapsed		
	Heavy	Slight	Totally	Partially	Slightly
Cianjur	6	2	-	3	11
Bogor Reg.	-	-	51	187	453
Sukabumi	-	-	136	308	1.009
Bogor City	-	-	-	-	3

Source: West Java Province Disaster Management Office (2018)

Research Methods

We choose Bogor and Sukabumi regencies due to equal distribution of missions with the other teams that also did similar survey in the other impact regencies. Besides that, the survey was conducted based on National Disaster Management Office information in terms of loss and damage on those regencies.

On January 24-25, 2018, we did focus field survey in Bogor regency located in the southern part of Jakarta. First, we did coordination to Regency Disaster Management Office of Bogor for getting the information of impacted location. They suggested us to visit Nanggung sub-regency as the most impactful place, therefore we visited Nanggung sub-regency office. Furthermore, we did field survey of aftershocks and micro-seismic on 2 sites at Nirmala, part of Nanggung sub-regency.

On January 26-27, 2018, we did focus field survey in Sukabumi regency. First, we also did coordination to Regency Disaster Management Office of Sukabumi for getting the information of impacted location. We visited Cikakak and Pabuaran sub-regency office. Furthermore, we did field survey of aftershocks and micro-seismic in 2 sites on each sub-regency, so that we got 4 sites survey on Sukabumi regency (Table 3).

For data acquisition and analysis equipments, we used to Seismometer Short Period LE-3D Lite, Data *Logger* Taurus Nanometrics, GPS Garmin 76CSx, Compass Brunton and for data interpretation, we used Notebook.

Results and Discussion

Socialize the updated earthquake information for evacuee: This earthquake caused hundreds of house hold to evacuate due to number of reasons. Survey team socialized the updated earthquake information in our aim to socialize the knowledge of current status of local seismicity in terms of ignoring the unofficial information called hoax. Due to that reason, survey team was encouraged by military and local government for giving information in the evacuee shelter in terms of current aftershocks information and clarify unofficial information.

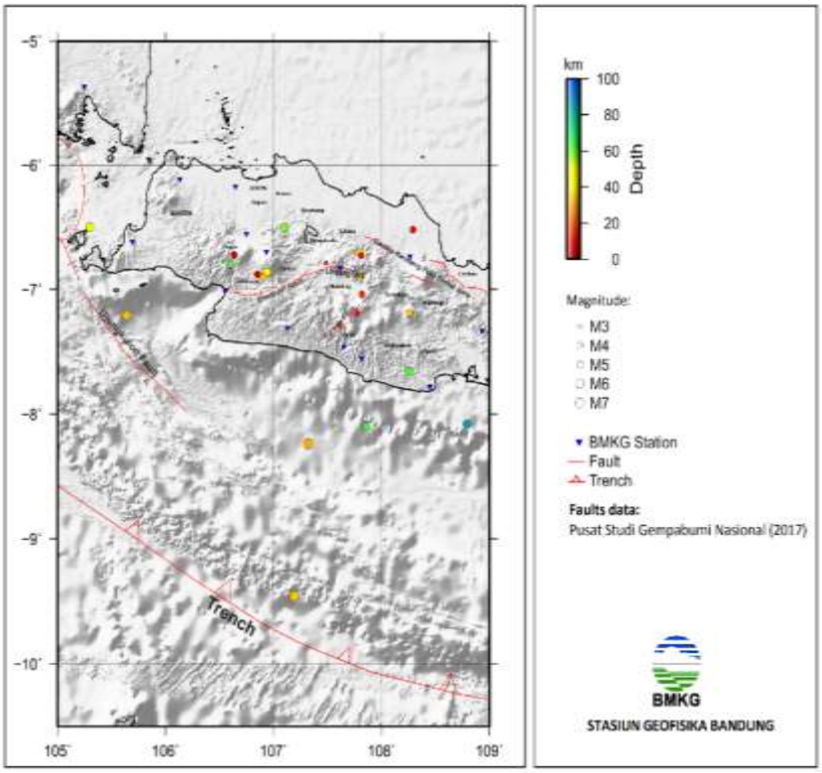

Figure 4. Epicenter Map of Damage Earthquake Events in West Part of Java since 1963 - July 2017[4]

Table 3
Site Survey in 3 Different Sub-Regencies

Regency	Bogor	Sukabumi	
Sub-Regency	**Nanggung**	**Cikakak**	**Pabuaran**
Site 1	Tea factory – **Nirmala**	Residence – **Sinarsari**	Residence – **Bantarsari**
Site 2	School – **Nirmala**	Residence– **Margalaksana**	Yard – **Bantarsari**

Aftershock data acquisition and analysis: We used aftershocks decay data to forecast the end time of aftershocks, using the graphic of time - aftershocks distribution (Figure 8-11). This graphic used four methods that are Omori, Mogi 1, Mogi 2, and Utsu decay model. This graphic was using earthquake decay data from 23 to 28 January 2018. The number of recorded aftershock was 58 events (Table 4), with the range of magnitude 2.5-5.2. The most recorded number was on the first day that is 44 events.

Graphics on figure 8, figure 9, figure 10, and figure 11 show that the trend of aftershocks is decreasing day by day with strong correlation value 0.7-0.85[1,22]. According to this result, we estimated that aftershocks end time will be finished within 5-6 days after the mainshock. It can be concluding to classify earthquake as the Mogi 1 type, the earthquake without started by foreschock[15,16]. This result hopefully can be used by decision maker on emergency response condition for public announcement in impact area.

Micro-tremor data acquisition and analysis: We used micro-tremor data to classify the site on the measurement point refering to NEHRP Site Classes[5] on table 5. Micro-tremor data acquisition was recorded using Short Period LE-3D Lite connected into Data Logger Taurus Nanometrics and notebook.

We used GPS Garmin 76CSx and Compass Brunton to determine the direction, also supporting well and proper acquisition. The result of comparative study of recorded micro-tremor data at 6 points is shown in table 6.

Figure 5: Updated Earthquake Information Announcement by Survey Team

Table 4
Number of aftershocks on each days[4]

Aftershock Frequency			
Date	**Frequency**	**Date**	**Frequency**
01/23/2018	44	01/26/2018	5
01/24/2018	5	01/27/2018	1
01/25/2018	2	01/28/2018	1

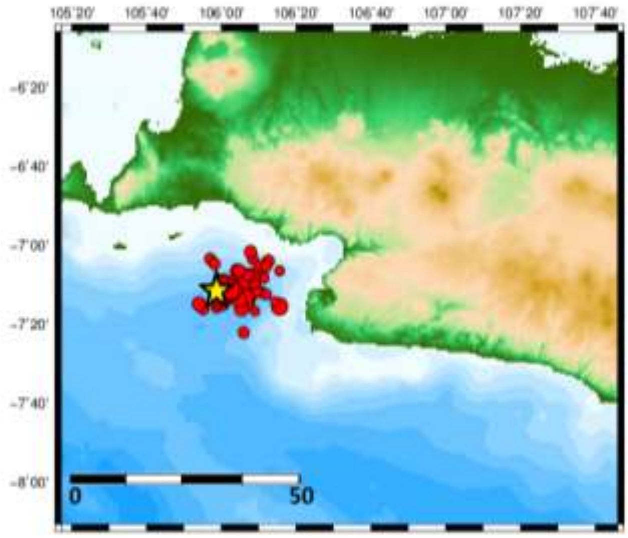

Fig. 6: Map of Aftershocks Distribution Since January 23, 2018 Until January 28, 2018[4]

The first five measurement locations are the damage buildings area while the last location is the yard 200 m from damage area. However, site class observation is almost on homogeneous[23]. Dominant period is quite consistent on 0.10 to 0.37 second range. Site class is bed rock on all results, relevant to the geographic location on hills[6], standing on base rock according to geological map[7]. Geological map of Bogor and Sukabumi regencies is shown in figure 7.

Damage Observation: Survey team was visiting damage location according to suggestion of Regency Government Disaster Management Office. They proposed to observe the damage in the Nanggung sub-regency in Bogor, and Cikakak and Pabuaran sub-regencies in Sukabumi. There is an interesting report by Sukabumi Regency Disaster Management Office regarding the most number of collapsed house in the east area (Pabuaran sub-regency) which is far from epicenter of main earthquake, more than west area (Cikakak), which is closer to the epicenter. On the seismological perspective, this case can be explained using wave radiation pattern, which demonstrated using source mechanism beach ball (Figure 3)[8].

Observation results on structural building show that few collapsed due to material failure and inappropriate design[9]. It could be reduced if people obey the building permission rules, based on earthquake mitigation[10]. We documented some pictures in the damage area demonstrated in the figure 12 and figure 13.

Loss and damage were strongly induced by environmental condition[11,12]. Many people are living in the hills, a small part of them living in the steep hills. On the other hand, the current season was rainy. We found some ground cracking in few sites survey which holds rain water[13,14]. It can induce landslide due to land move to be instable theoretically[17,18]. Most of people in Nirmala are living on the tea plantation and factory area, Mount Halimun national park. Some evacuees are worried for going back home due to instability of land, collapsed house caused by earthquake, living in the landslide prone area and current peak rainy season.

Unfortunately, we also found rain along day of survey schedule. It was a little bit disturbing to access to the site survey area. Using the limited equipment and unequivocal condition, we tried to let people know the updated earthquake information day by day and shelter to shelter. We also adviced people to cover the ground cracks soon for reducing the hazard risk possibility[19].

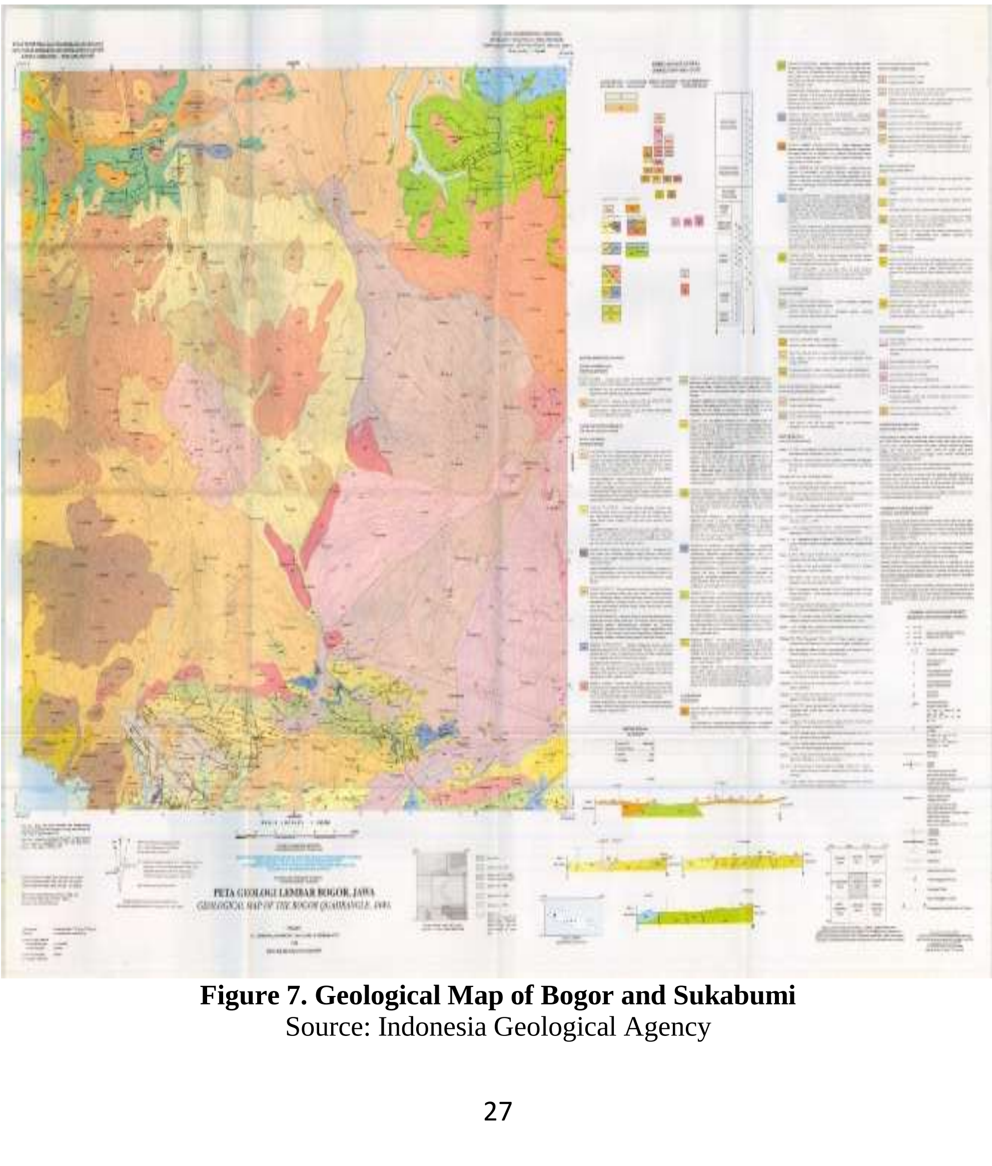

Figure 7. Geological Map of Bogor and Sukabumi
Source: Indonesia Geological Agency

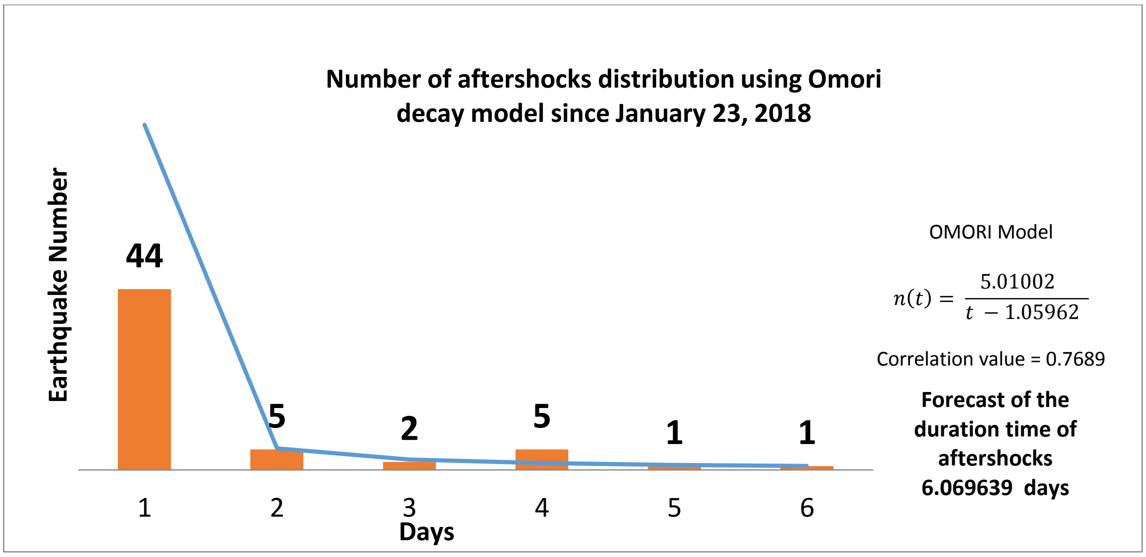

Figure 8: Graphic of Aftershocks Distribution using Omori Decay Model

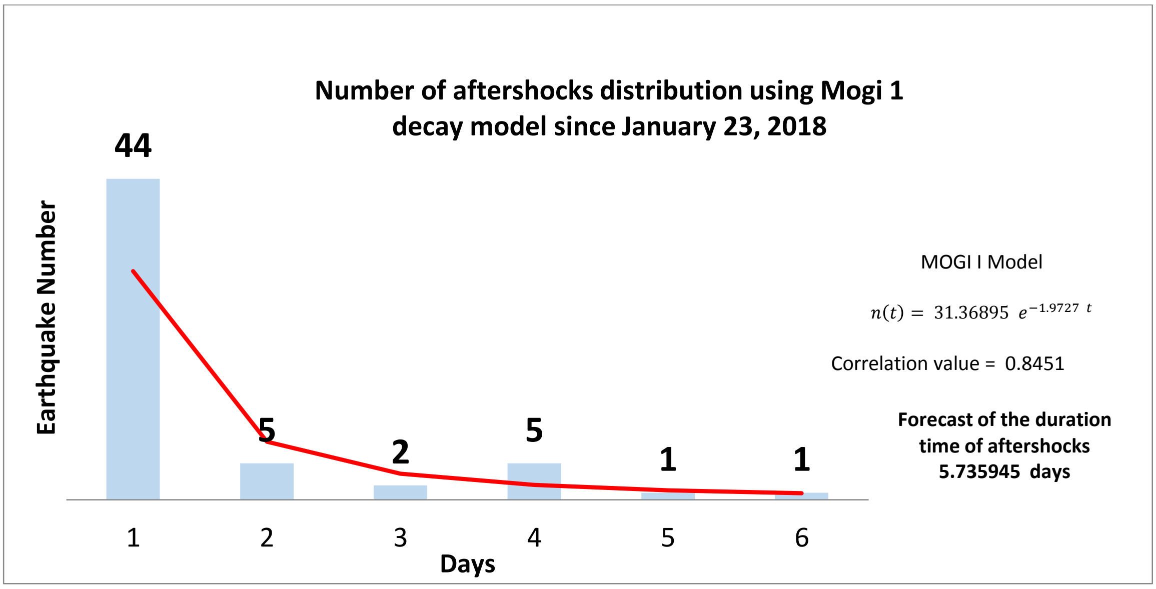

Figure 9: Graphic of Aftershocks Distribution using Mogi 1 Decay Model

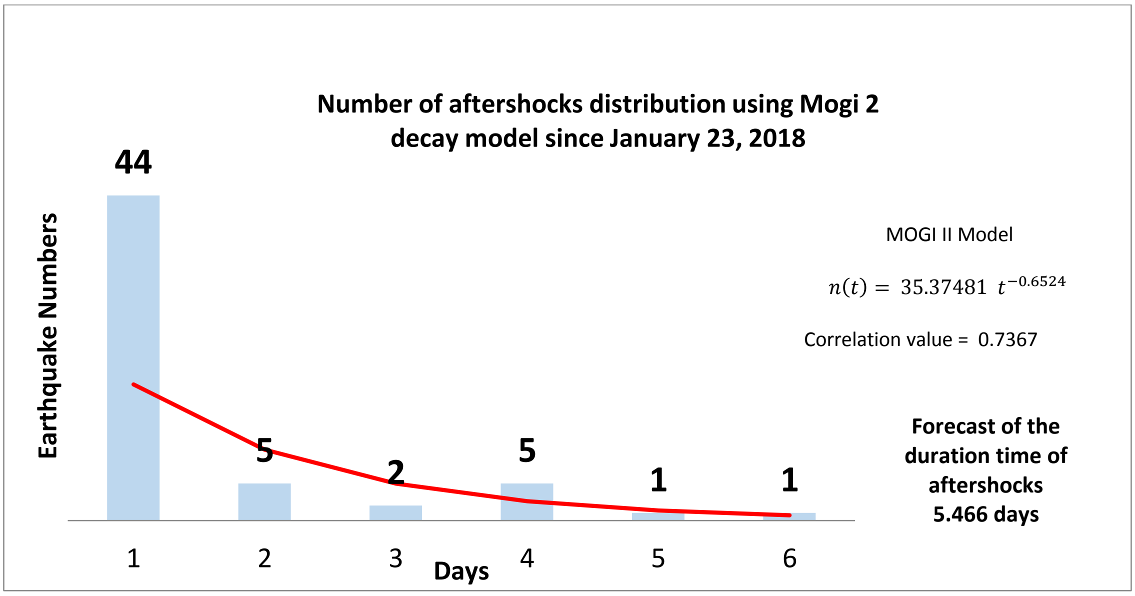

Figure 10: Graphic of Aftershocks Distribution using Mogi 2 Decay Model

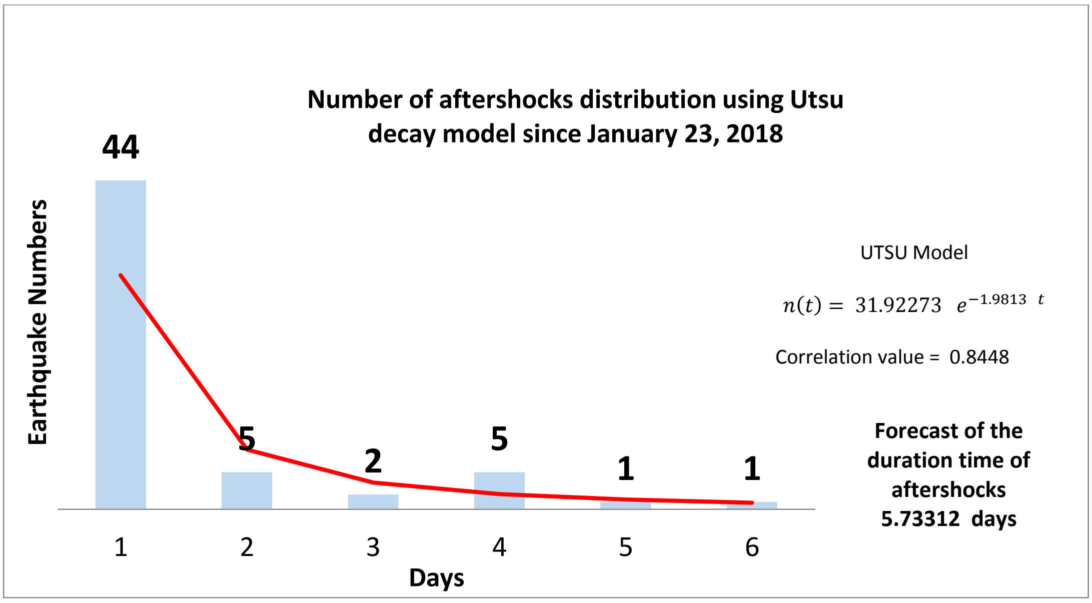

Figure 11: Graphic of Aftershocks Distribution using Utsu Decay Model

Table 5
Site Classification using NEHRP Class[5]

Site classes	Site natural period (s)	Average shear-wave velocity	NEHRP class
SC I: (Rock/stiff soil)	$T_G < 0.2s$	$V_{30} > 600$ m/s	A+B
SC II: (Hard soil)	$0.2s \le T_G < 0.4s$	300 m/s $< V_{30} \le 600$ m/s	C
SC III: (Medium soil)	$0.4s \le T_G < 0.6s$	200 m/s $< V_{30} \le 300$ m/s	D
SC IV: (Soft soil)	$T_G \ge 0.6s$	$V_{30} \le 200$ m/s	E

Table 6
Comparative Study of Micro-Tremor Data and Site Classes on Each Points

S.N.	Site Survey Measurement	f0 (natural frequency)	Tdom (dominant period)	Site Class	Information
1	Tea plantation area – Nirmala	8.7699 Hz	0.1141 s	I	*Stiff Soil*
2	School area – Nirmala	2.6915 Hz	0.3717 s	II	*Hard soil*
3	Resident area – Sinarsari	9.4718 Hz	0.1055 s	I	*Stiff Soil*
4	Resident area – Margalaksana.	8.0679 Hz	0.1239 s	I	*Stiff Soil*
5	Resident area – Bantarsari	3.8100 Hz	0.2624 s	II	*Hard soil*
6	Yard area – Bantarsari.	4.8319 Hz	0.2070 s	II	*Hard soil*

Conclusion

Mw 6.1 South of Banten Sea Earthquake of January 28, 2018 was strongly damaging and generated losses on few sites survey in Bogor and Sukabumi. This event struck houses, public facility, and human injuries. We did socialize updated earthquake information in terms of let local people know the current status of local seismicity.

We did forecast study on earthquakes end time using aftershocks time decay model. We are estimating aftershocks end time will be finished within 5-6 days after the mainshock. It can be concluding that this earthquake is classified as the Mogi 1 type, the earthquake without started by foreschock. The site survey of micro-tremor in Bogor and Sukabumi was conducted in damage area. The result was relevant to the geographic location on hills area. Observation result on structural building showed that few of buildings collapsed due to material failure and inappropriate design.

Acknowledgement

We appreciate to local Government of Bogor and Sukabumi for providing open access widely for site survey. We are very much thankful to colleagues in Geological Agency of Indonesia who helped us on questions related to landslide.

Building Security damage at Nirmala.

Ground cracking in tea factory - Nirmala.

School (SDN 03) damage in Malasari

Ground cracking in the hills of Malani. Length about 2.8 m

House damage totally at Citalahab

Masque damage totally at Citalahab

Figure 12: Damage building documentation in Nanggung - Bogor Regency

House damage slightly in Sinarsari

Masque damage partially in Margalaksana

House damage totally in Bantarsari

School damage totally in Bantarsari

Figure 13: Damage building documentation in Sukabumi Regency

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