Critical rainfall for triggering debris flows in Mt. Bawakaraeng Caldera, South Sulawesi, Indonesia

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1. Introduction

Indonesia is located at the boundary of four tectonic plates. As a result, high elevations and very steep slopes characterize the topography of the country. As a consequence of such topography combined with frequent earthquakes in the region and constant torrential rains, Indonesia suffers from frequent floods, landslides, and debris flow events. Such events are frequently responsible for great economic damage, losses of human lives, and negative environmental impacts. Particularly in South Sulawesi Province, natural disasters like landslide and debris-flow were important issues for disaster mitigation.

At Mt. Bawakaraeng Caldera, South Sulawesi, a large-scale landslide producing debris flows occurred resulting in a volume of about 232 million m^3 of sediment in 2004. Properties were destroyed and 32 people lost their lives as a result of this accident (Tsuchiya *et al.,* 2004). The majority of landslides and debris flows have been triggered by intense rainfall. In this paper, we would like to show correlation between the total amount of rainfall and debris flow occurrence. The critical cumulative rainfall with the maximum recorded intensity is analyzed on diagram. This method might provide a basis for implementation of warning.

2. Rainfall events in the Mt. Bawakaraeng Caldera

The Mt. Bawakaraeng Caldera is frequently affected by severe meteoric events. From 1997 to 2008, a total of 22 episodes occurred, which triggered debris flows. Events are mainly concentrated in rainy season (Table 1). Fig. 1 shows relation between cumulative rainfall and debris flow events in February 2007 and February 2008. The Maximum intensity in February 2007 was 40 mm/hr causing large scale debris flow with a volume of about 7.8 million m^3 sediment (Hazama-Brantas, 2007). In February 2008, the maximum intensity was 34 mm/hr which caused debris flow with a volume of about 3 million m^3 sediment. Fig. 3 shows a large scale landslide including debris flow which occurred on March 26, 2004 and debris flow on February 16, 2007 in Mt. Bawakaraeng Caldera.

Table 1 Cases of debris flows in Mt. Bawakaraeng Caldera from 1997 to 2008

No	Date	Event	No	Date	Event
1	23-01-1997	Debris flow	12	09-06-2004	Debris flow
2	25-02-1999	Debris flow	13	08-07-2004	Debris flow
3	26-01-2000	Debris flow	14	26-01-2005	Debris flow
4	27-02-2001	Debris flow	15	12-03-2005	Debris flow
5	25-02-2001	Debris flow	16	17-04-2005	Debris flow
6	13-12-2002	Debris flow	17	07-07-2005	Debris flow
7	05-03-2003	Debris flow	18	26-11-2005	Debris flow
8	26-03-2004	Landside and debris flow	19	16-02-2007	Debris flow
9	16-04-2004	Debris flow	20	06-11-2008	Debris flow
10	03-05-2004	Debris flow	21	22-01-2008	Debris flow
11	07-06-2004	Debris flow	22	18-02-2008	Debris flow

3. Rainfall thresholds

By considering the critical pairs of rainfall amount-duration for reported debris flow events, the regression line that relates rainfall intensity in mm/day (I) and duration of rainfall in days (D) can be plotted (Fig.3). Therefore, the regression curve can be considered as a reliable rainfall intensity-duration threshold for the Mt. Bawakaraeng Caldera area, above which, debris flow events may occur. An empirical threshold above which, debris flow may occur can be described by the equation $I = 86.517D^{-0.408}$ where I is the rainfall intensity in mm/day and D is the duration of rainfall in days.

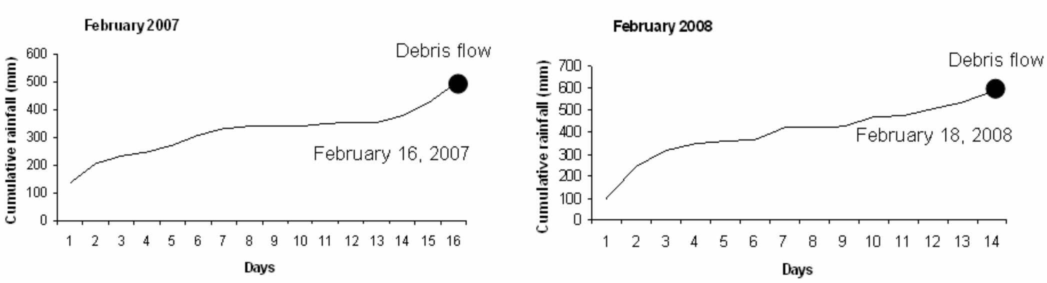

Fig. 1 Cumulative rainfall and time (days) for triggering debris flow in February 2007 and 2008

Fig.2 (a) Photograph representing the landslide producing debris flow at the Mt. Bawakaraeng Caldera, which occurred on March 26, 2004. Hundreds of million of m^3 volume of sediment deposited in the caldera, (b) Photograph revealing debris flows that occurred on 16 February 2007.

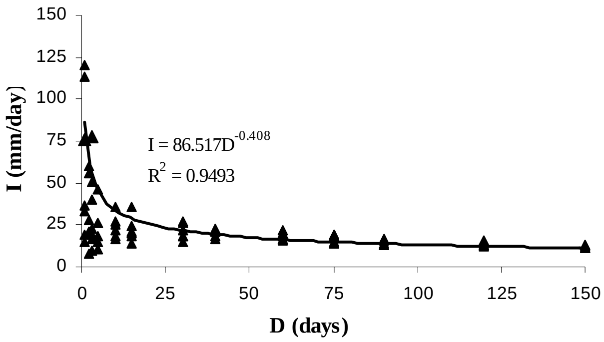

Fig.3 Regression line between critical rainfall intensity and corresponding event duration

4. Conclusion

The regression analysis shows that rainfall intensity increases exponentially as duration decreases, according to the equation $I = 86.517D^{-0.408}$. Therefore, the regression can be considered as a rainfall intensity-duration threshold for the Mt. Bawakaraeng Caldera area, above which, debris-flow events may occur.

References

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