Socio-Eco-Engineering-based Approach in Integrated Sediment Management in Mt. Merapi Area, Indonesia

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ABSTRACT

The sediment migration at Mt. Merapi area is very dynamics depending upon the dynamic of volcanic activity of Mt. Merapi and the rate of growth of infrastructure development at the area nearby. In almost all cases of environmental problems, the unbalance condition between the sediment supply and the sediment withdrawal from the watershed and stream system might contribute dominant role in environmental degradation. The complexity arise in the form of both triggers affecting the sediment migration process, i.e. the natural phenomena of the volcanic activity (such as the rainfall condition), as well as human interfere (sand mining activity). This paper presents result of the observation on the best practice program of integrated sediment disaster management which has been applied in Mt. Merapi area. The program has been actually initiated since 2001 which basically a combination of structural and non-structural approach, involving various parties. The sustainability of the program is found to be fluctuated as influenced by natural phenomena, i.e. 2006 Yogyakarta and Central Java earthquake, 2006 Mt. Merapi eruption, and 2010 Mt. Merapi eruption. In 2007 thru 2009, an institution and community development program at Mt. Merapi area was conducted and various raising resilience programs were. Furthermore, this paper also presents result of quantitative simulation on integrated sediment management adopting linear optimization technique and taking into account the socio-eco-engineering so that both the structural and non-structural approaches are considered.

Keywords: Sediment disaster management, socio-eco-engineering-based, optimization

INTRODUCTION

Mt. Merapi eruption which took place in 26 October thru 4 November 2010 contributed not only loss of human live but also the various loss of properties related to economic value. The material source that has been produced by the 2010 eruption was approximately 140 million m^3 occurred within less 10 days. For illustration, 1994 Mt. Merapi eruption produced approximately 3 million m^3 (Shimoda, 1995) and 2006 eruption produced 8 million m^3 (YEC, 2007). Conservative estimation of 2010 eruption shown that the hot pyroclastic flow of 30 million m3 flowed at Gendol River during less than 2 hours to reach at a distance of approximately 15 Km from the summit of Mt. Merapi. Among many disasters experienced by the country are earthquake, volcanic eruption (e.g.: pyroclastic flow and debris flow), landslide, flood, drought, river bank erosion, river/reservoir sedimentation, etc. Such disasters may be natural; however, some of them are human triggered ones. The capacity of the country to cope with such a large number of disaster occurrences (both frequency and intensity) may of course be limited, but the valuation for putting priority to mitigate the impact is often complex and requires continuous socialization on the understanding of the role and function of related infrastructures such as sabo works.

Typical Sediment Balance at a Single Sabo Structure

The analysis of sediment balance was carried out based on the Eq. (1), the sketch is shown in **Fig. 1**.

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$$V_E = V_S - (V_H + V_C + V_{se}) \quad (1)$$

where:

V_E : sediment overflowing the structure (m^3)
V_S : sediment entering upstream of structure (m^3)
V_H : sediment trapped at upstream of structure (m^3)
V_C : sediment controlled at upstream of structure (m^3)
V_{se} : dead storage of structure (m^3)

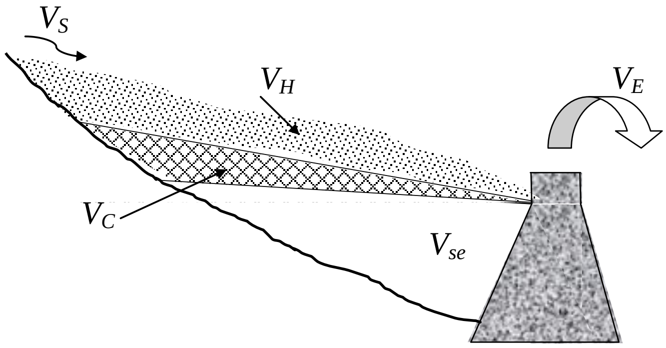

Fig. 1 Sketch of sediment balance at a single sabo structure (Bawias, 2012)

Depending upon the dynamic storage capacity of a structure which is a function of the dead storage volume (V_{se}), the sediment control volume (V_C), the sediment volume trapped or accumulated at the upstream of structure (V_H), the sediment supply from upstream (V_s), and the intensity of the sand mining activity, the sediment overflowing the structure (V_E) could be positive or zero. The very intensive sand mining activity is in such that the volume is much larger than the sediment supply. In such a case, the sediment overflow could be relatively small or even zero. The estimation of sediment balance due to the presence of sediment control structures (i.e. the sabo works) and the sand mining activity may be affected by the types of sediment control structures. The functional design of a single sabo structure to control debris flow is shown in **Fig. 2**.

a). GE-C2 of Gendo Riverl, 1998

b). GE-C2 of Gendol River, 2012

Fig. 2 Functional Design of Sabo Works at Gendol River