A Study on Criteria of Warning and Evacuation for Large-scale Sediment Disasters Considering the Relationships with Sediment Movement and Damage

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INTRODUCTION

In Japan, sediment disaster warning information for occurrence of a debris flow and slope failures due to rainfall is disseminated by the Prefectural Governments and the Japan Meteorological Agency. However, sediment disaster warning information doesn't cover the prediction of scale of sediment disasters. In this study, we analyzed the relationships among sediment movement, damage, and return period of rainfall causing sediment disaster to estimate suitable criteria of warning and evacuation for large-scale sediment disasters.

METHODS

Based on the Sediment Disaster Scale (SDS; Hayashi et al., 2015), we classified 22 previous large-scale sediment disasters in Japan (SDS ≥ 3, from 1961 to 2014) that were caused by rainfall. SDS evaluates the scale of sediment disaster by classifying sediment disasters into five grades by using the combination of an index pertaining to sediment movement, "Sediment Movement Magnitude" (SMM; Uchida *et al.*, 2005) and one pertaining to damage, "Damage Level" (DL; Kojima *et al.*, 2009). Then, using the 22 sediment disasters, we evaluated the return period of "Triggering Rainfall" (TR) that caused each sediment disaster by using AMeDAS return period calculation program (Public Works Research Institute, 2003). TR was determined by the rainfall index that had the longest return period of nine rainfall indices (maximum 1 h, 2 h, 3 h, 6 h, 12 h, 24 h, 48 h, 72 h and total rainfall).

RESULTS AND DISCUSSION

Fig.1 and **Table 1** shows the relationship between SDS category and the return period of TR (RPTR). For the upper value of RPTR (approx. from 960 to 51,000 yr), higher values of SDS category coincided with higher RPTR. However, for the lower value of RPTR (approx. from 30 to 50 yr), higher SDS category (e.g. 4 and 5) did not accompany higher RPTR.

Moreover, we analyzed the relationships between sediment movement and damage and RPTR, respectively, to clarify the cause of the relationship between SDS category and RPTR shown in **Fig. 1**. First, the rainfall indices of TR were divided into two groups, short-term (ST, 1 to 12 h) and long-term (LT, more than 24 h). Then, we analyzed the relationships SMM and DL with RPTR in ST and LT, respectively, by Spearman's rank correlation coefficient (SRCC) (**Figs. 2** to **5**). As shown in **Fig. 2** and **3**, the relationship between SMM and RPTR has no correlation in ST (SRCC =

0.11, P = 0.70), but the relationship has a significant and strong positive correlation in LT (SRCC = 0.71, P = 0.09). As shown in **Fig. 4** and **5**, the relationship between DL and RPTR has no correlation in ST (SRCC = 0.08, P = 0.77) or LT (SRCC = 0.29, P = 0.56). Because TR in LT tends to incur large-scale sediment movement (SMM ≥ 8.5), it may affect the relationship between SDS category and upper value of RPTR shown in **Fig.1**. In addition, because every scale of damage may occur irrespective of RPTR, it may also affect the relationship between SDS category and lower value of RPTR in **Fig.1**.

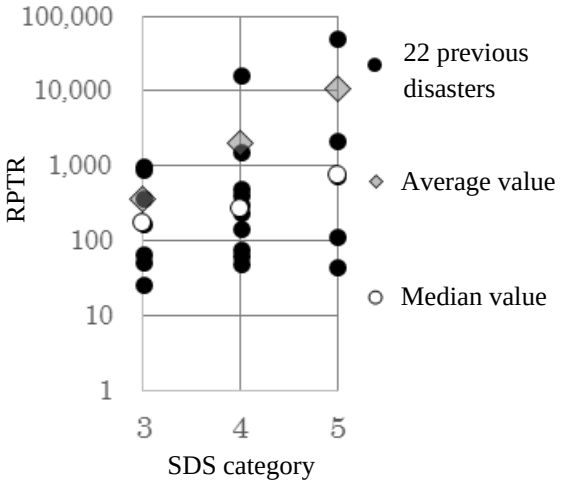

Fig.1 The relationship between SDS category and RPTR

Table 1 The average value and median value and standard deviation for SDS categories

	3	4	5
Average value (yr.)	360	2,000	11,000
Median value (yr.)	170	270	750
Standard deviation (yr.)	410	5,100	23,000

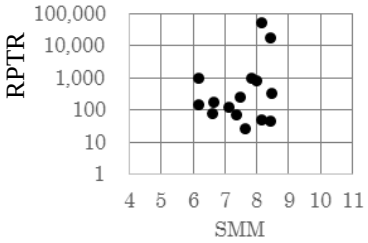

Fig.2 The relationship between SMM and RPTR in ST

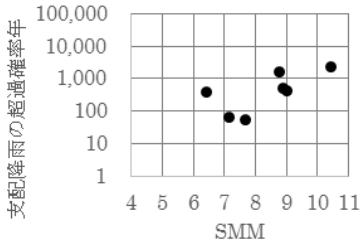

Fig. 3 The relationship between SMM and RPTR in LT

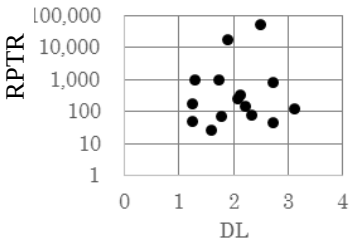

Fig. 4 The relationship between DL and RPTR in ST

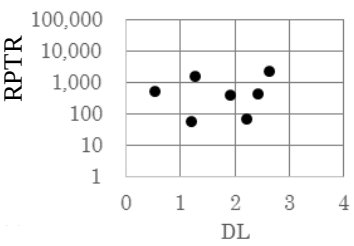

Fig. 5 The relationship between DL and RPTR in LT

CONCLUSIONS

In order to clarify the relationships among sediment movement, damage, and return period of rainfall causing large-scale sediment disasters (SDS ≥ 3), our study found that 1) large-scale sediment disasters may occur with 30 to 50 yr of return period rainfalls and 2) longer return period of rainfall in LT may cause large-scale sediment movement (SMM ≥ 8.5) and attention should be paid to it for the occurrence of large-scale sediment disasters.

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