IN-04

Evaluation of Rainfall-Based Warning Systems for Debris Flows and Slope Failures in Japan and Taiwan

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1. INTRODUCTION

Establishing warning systems and evacuating inhabitants are recognized as the most important approach for disaster risk reduction. While the rainfall-based warning model of landslide or debris flow disaster has been extensively investigated, the problems that the rainfall-based warning model implemented during typhoon or heavy rainfall faced are relatively unexplored. Taking Japan's and Taiwan's sediment disaster warning systems as examples, this study will explore both warning models and alert issuing systems, and try to find the insufficiencies by statistics and case study.

2. METHODS

2.1 Evaluation of Warning Model's Effectiveness

A complete sediment disaster warning system is comprised of the warning model and alert issuing system, and the effectiveness of warning model could be evaluated by four indexes: the warning hit rate, false alert rate, warning cover rate, and remaining time for evacuation.

The warning hit rate and the false alert rate can be expressed as eq. (1) and (2) (NILIM, 2005). To understand the proportion of sediment disasters not located within warning area, this study defines the warning cover rate as eq. (3)

Warning Hit Rate (WHR)=DEAA/DE (1)

False Alert Rate (FAR)=WTND/WT (2)

Warning Covering Rate (WCR)=DEA/DE (3)

where DE is the number of sediment disaster events; DEAA is the number of sediment disaster events that are located within the warning areas and occurred after warning issued; WT is the number of towns which had issued sediment disaster warning; WTND the number of towns which had issued sediment disaster warning but with no disaster occurring, and DEW is the number of sediment disaster events which occurred with the warning areas. Fig.1 shows an example for the definition of indexes of warning model's effectiveness.

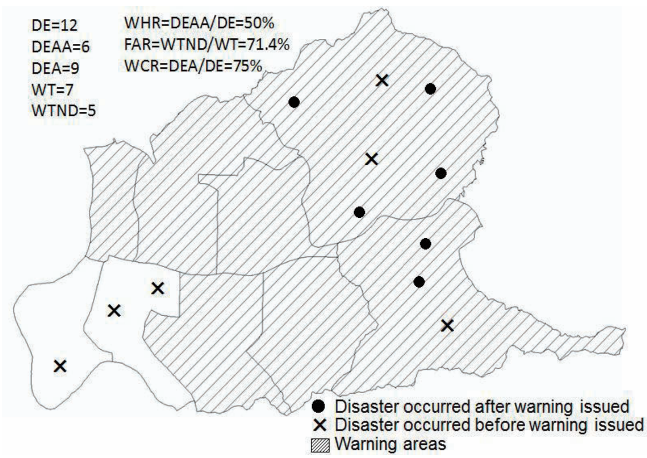

Fig. 1 Example for the indexes of warning model's effectiveness

To explore whether the remaining time for evacuation is sufficient, this study defines "remaining time for evacuation (RTE)" as the time from the alert issued to disaster occurring. That is, a valid alert has to be issued earlier than disaster occurring at least one SRTE (shortest remaining time for evacuation). Owing to the different conditions on traffic and population structure, different regions may have different SRTE.

2.2 Evaluation of Alert Issuing System

Because of the issuing alert systems involved in the government organization, it is difficult to find consistent quantitative assessment indexes. This study used the qualitative assessment that includes alert release unit, types and content of alert, issuing frequency, and so on.

3. DISCUSSIONS

3.1 Existing Warning System in Japan and Taiwan

As shown in Table 1, the WHR is about 50%, but the FAR is higher than 75%. To take the data in Japan in 2008 for an example, the FAR was 87.8%, that is, there were only 12.2% of towns which indeed suffered from sediment disaster in the warning areas. Such a high false alert rate is harmful to the trust of sediment disaster alert by local government and inhabitants.

Table 2 The Sediment Disaster Warning Effectiveness in Japan and Taiwan

	WT	WTND	FAR= WTND/WT	DE	DEA	DEAA	WHR= DEAA/DE	WCR= DEA/DE
JAPAN (2008)	**1129**	**991**	**87.8%**	**669**	**477**	**356**	**53.2%**	**71.3%**
Taiwan (2009)	**72**	**42**	**58.3%**	**117**	**91**	**85**	**72.6%**	**77.8%**
Taiwan (Ave. in 2007-2011)	**310**	**233**	**75.2%**	**262**	**164**	**119**	**45.4%**	**62.6%**

* Original data are from NILIM (2010) and SWCB (2007-2011)

3.2 Appropriate Timing of Issuing Warnings

Fig. 2 shows that over 50% disasters occurred in the difficult period of evacuation (DPE, 21:00~07:00) which bases on the environment of the mountain area and inhabitants' daily routine. It is necessary to issue alerts early (before the sunset) at the areas where rainfall where assessed to exceed CL (Critical Line) in DPE. Fig. 3 indicates that over 50% of the RTE in Taiwan are greater than 12 hrs, but over 50% of RTE in Japan are less than 2 hrs. It is worth to further study where RTE under 2 hrs is enough or not. Moreover, it seems unreasonable that the current formula for calculating warning hit rate in Japan does not consider the time required to disseminate alerts and evacuation. The estimation should be modified to include at least one SRTE as a valid warning.

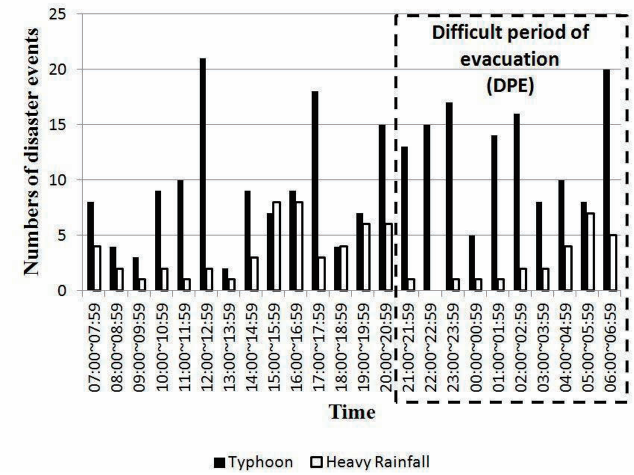

Fig. 2 The Statistics of Occurring Timings of Sediment Disaster Events in Taiwan

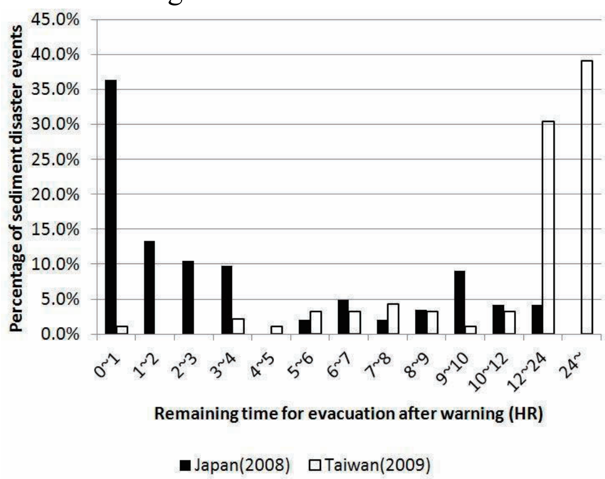

Fig. 3 The Remaining Evacuation Time after Warning Issued in Japan and Taiwan

4. CONCLUSION

Because the existing warning indexes just simply uses the rainfall data and doesn't consider the variation of geological and hydrological conditions, the existing warning model cannot provide more definite information about disaster locations, types, and possible magnitude. To improve the warning system, it is recommended to use the village extent as key areas. The major monitoring in the key areas should focus on the slopes which probably can damage the traffics and lifelines. New warning indexes are also recommended to consider both the geological and hydrological characteristics of the monitored slopes. Therefore, the existing warning system can be used as a warning system for large-scale response, and the new warning indexes can be used to develop a more detail, slope-scale warning system to enhance the warning accuracy and reduce the casualties.

Key Words: rainfall-base warning system, debris flow, slope failure, sediment disaster, evaluation

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