The Disaster Management of Large Scale Landslide: A Case Study of Debris Flow Early Responding Systems

Tien-Yin CHOU, **Chen-Yang LEE**, **Hsiao-Yuan YIN**, **Yi-Chia LIN**, **Mei-Ling YEH**
Taiwan

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SUMMARY

This paper studies the mechanisms of large-scale landslide management. It established early responding feedback mechanisms for the application in different scenarios. The paper started with the site descriptions of debris flow and large-scale landslides. It stated the fundamental differences between two types of disaster and followed by discussions of the uniqueness and necessity of large-scale landslide early responding mechanism establishment. With the current debris flow early responding systems as the evidence, this study clarified various important aspects in the early responding system. It includes the parameters of alerting area, monitoring equipment, data values, procedures of disaster prevention and evacuation. The clarifications can further shapes the workflows of large-scale landslide early responding system.

Meanwhile, this paper studies references for the large-scale landslide responding parameters of specified monitoring rain gauge and on-site monitoring devices. A series of simulations have been carried out to discover the disaster factors and its data collection methods. Knowledge obtained was then contributed to the real-time data analysis development. Subsequently, disaster discussion-making center can generate alerting parameters, calculation formulas and associated responding signals (red or amber) according to its associated environmental factors. At the end of the study, the mechanisms of issuing and disarming alert system, as well as the principles of issuing alert system have been discussed.

1. INTRODUCTION

The impact of global climate change has caused frequent occurrences of natural disasters in many countries and serious losses in personnel and the economy. It is suggested that if a disaster early-warning mechanism can be established, people may conduct disaster reduction and prevention work in advance before disasters appear, thus effectively reduce losses. However, at present, there is no unified warning publishing standard for different types of disasters in terms of the early-warning mechanism. When different disasters occur, it is easy to cause confusion among the public with different warning publishing standards, thus leading to a cost increase in disaster management.

Therefore, with the disaster early-warning mechanism for debris flows and large-scale landslides established by the Soil and Water Conservation Bureau (SWCB), this study will explore the applicability of yellow and red warning publishing rules to other disasters in the disaster early-warning mechanism, so as to further put forward the feasibility of standardization of yellow and red warning publishing rules.

2. MATERIALS AND METHODS

This paper studied the warning-issuing mechanisms at particular study sites. When the Central Weather Bureau issues typhoon warning or torrential rain warning, Debris Flow Disaster Prevention Center and Large-Scale Landslide Disaster Prevention Center would be initiated by SWCB. It provides monitoring data for the Debris Flow Disaster Prevention Information Platform. This study discussed the types of warning, their relevant descriptions and issuing mechanisms (Segoni, 2018). This paper also reviewed the warning-issuing procedures of debris flow and large scale landslide, applications of monitoring sensors and the basis to issue and disarm alerts (Zhang, 2020). The measurements under warning alerts, issuing principles, units and standards of warnings are the highlights of the mechanisms (Baum, Godt, 2010). This paper also explored the procedures of issuing warnings, monitoring data obtained and purposes of data distribution.

In order to enhance the accuracy of debris flow early responding system and reduce the impact by debris flow disaster, SWCB proposed the updates of reference values and operation instructions for debris flow early responding system. It based on the results from debris flow demonstration sites and adjusting the data constantly. The flow chart of debris flow reference value update mechanism as Figure 1 is shown as below.

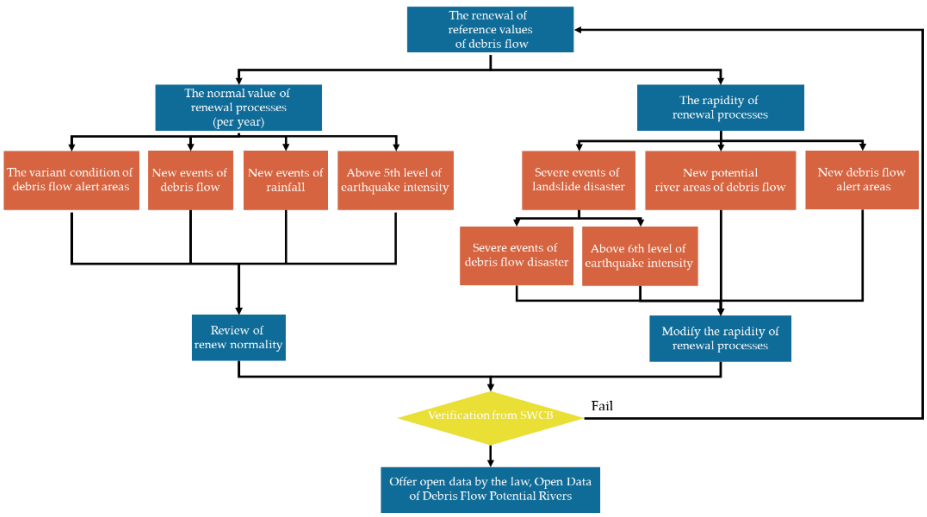

Figure 1. The flow chart of debris flow reference value update mechanism

3. THE FRAMEWORK FOR THE PUBLISHING PRINCIPLE OF WARNING

According to the types of disasters, the publishing principle of yellow and red warnings is to discuss the disaster occurrence factors and necessary conditions. Based on the occurrence factors and necessary conditions, corresponding on-site monitoring instruments should be set up accordingly to collect on-site monitoring data for recognizing the environmental characteristics in this area. Afterwards, an evaluation and analysis can be conducted based on the disaster occurrence factors and on-site environmental characteristics to serve as the warning reference value for possible disasters.

The warning reference value is served as the basis of the warning publishing principle. According to the types of disasters, the disaster occurrence speed and response time may be evaluated to establish various levels of warning classification, such as yellow warning symbolizing high warning and red warning symbolizing immediate danger. Based on the publishing principle of yellow and red warnings, corresponding contingency actions and disaster prevention measures may be taken.

For various levels of warning classification and contingency actions recommended, relevant instructions are yellow warning and red warning. When the warning reference value may be reached in the future based on the environmental information monitored in advance, indicating doubtful risk of dis-aster occurrence, a yellow warning will be published to advise local inhabitants to pay high attention and take corresponding disaster prevention measures according to various types of disasters. When the data monitored by on-site monitoring instruments have reached the warning reference value, indicating the risk of immediate disaster, a red warning will be published to force local inhabitants to take immediate disaster prevention measures according to various types of disasters.

4. THE APPLICATION OF THE PUBLISHING PRINCIPLE OF THE YELLOW AND RED WARNING

SWCB established the disaster early-warning mechanism for debris flows in 2004 and initially applied the publishing principle of the yellow and red warnings to the disaster early-warning mechanism. Moreover, it established the disaster early-warning mechanism for a large-scale landslide in 2021. In order to integrate various types of disasters, the publishing principle of the yellow and red warning is applied to facilitate the operation of disaster management. Below, the disaster early-warning mechanism for debris flows and large-scale landslides will be specified separately to illustrate the application method for the yellow and red warning principle.

4.1. Debris flows and disaster early-warning mechanism

It has been many years since SWCB established the disaster early-warning mechanism for debris flows. With abundant experiences in disaster prevention, this early-warning mechanism had already published warning messages many times before disasters occurred, successfully avoiding or reducing the losses caused by disasters. This study will explain below the application of the disaster early-warning mechanism for debris flows in terms of the characteristics of debris flows, as well as the publishing of yellow and red warnings.

As investigated by SWCB on the potential stream of debris flows every year. As of January 2023, 1, 731 potential streams of debris flow and their influence scope have been circled and drawn out at present. SWCB has taken rainfall as the reference basis of the warning reference value in these areas and set up the warning reference value and adjustment mechanism for debris flows. Next, SWCB has drawn up two levels of yellow warning and red warning to establish various levels of the disaster early-warning mechanism for debris flows. The warning levels are specified as follows, and the process is shown in Figure 2.

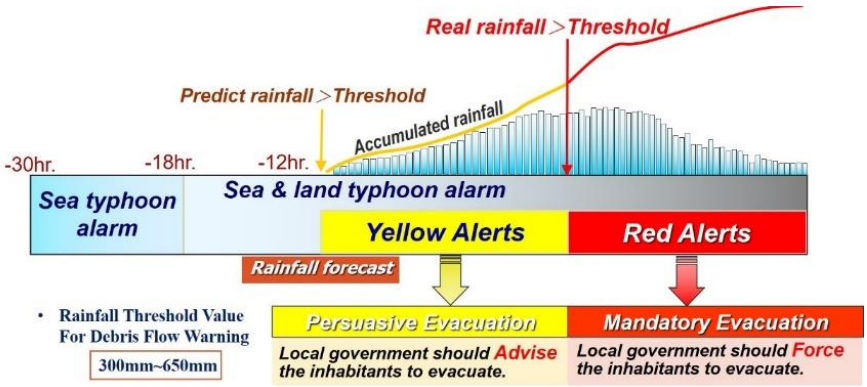

Figure 2. The flow chart of rainfall-based Debris Flow Warning Model

Yellow warning: When Central Weather Bureau publishes typhoon warnings or special reports of heavy rain, the effective rainfall accumulated in each region will be estimated. When this rainfall may reach the warning value of debris flows in this region, a yellow warning will be published to advise local inhabitants to evacuate and take refuge prophylactically.

Red warning: However, when the actual effective rainfall accumulated reaches the warning value of debris flows in this region, the warning level will be updated to be a red warning, so as to force local inhabitants to evacuate for resettlement.

4.2. Warning publishing process

The yellow and red warning publishing rules of the disaster early-warning mechanism for debris flows established by SWCB have been in operation for many years with rich practical operation experience. They have also been applied to the disaster early-warning mechanism for

large-scale landslide. Therefore, this study proposes to standardize the yellow and red warning publishing rules and set up warning publishing standards that can be applied to the early-warning mechanism for various disasters. This study suggests to study and draw out a standard process of the disaster early-warning mechanism with commonality as shown in Figure 3. The data collection information includes monitoring data and image data of on-site sensors, and relevant early-warning information is published through early-warning models of various disasters.

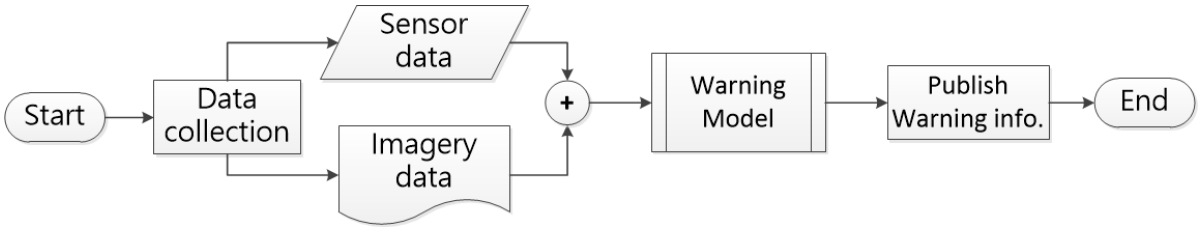

Figure 3. Standard Process of the Disaster Early-warning Mechanism

5. RESULTS AND DISCUSSION

This study aimed at the establishment of large-scale landslide early responding system. With the foundation of current debris flow early responding system, it is expected to build a relevant system for the large-scale landslide. When extreme weather approaches, it is designed to trigger the reference value, prepare and manage the situation before disasters happen. Due to the natural difference between large scale landslide and debris flow, the study seeks for the suitable on-site equipment to assist the rain gauges as the evidence for reference values. Through the setup of reference values, the work flow of large scale landslide early responding system can be completed. Currently, SWCB distinguished debris flow and large-scale landslide as two different forms of disaster. They broadcast different warning information for different disaster management purposes.

6. CONCLUSIONS

Key objective of the study is to develop the management mechanisms of large-scale landslide. The development based on current workflow of debris flow early responding systems, types of monitoring equipment required and their reference values. In present, there is no accurate formula to transform the data of on-site equipment to the reference values of alerting system. Monitoring data still require manual judgement to decide if it reaches the alerting standard. Therefore, the principal of issuing alert is still relied on participation level. It is wished to develop a reliable formula for on-site equipment data transformation, and the early responding system can be applied in different weather scenarios.

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BIOGRAPHICAL NOTES

Tien-Yin Chou, Distinguished Professor, GIS Research Center, FengChia University, Taiwan
Chen-Yang LEE, Director, Soil and Water Conservation Bureau, COA, Taiwan
Hsiao-Yuan YIN, Senior Engineer, Soil and Water Conservation Bureau, COA, Taiwan
Yi-Chia LIN, Assistant Engineer, Soil and Water Conservation Bureau, COA, Taiwan
Mei-Ling YEH, Assistant Professor, GIS Research Center, FengChia University, Taiwan

CONTACTS

Assistant Professor, Mei-Ling Yeh,
GIS Research Center, Feng Chia University
No. 100, WenHwa Rd.,
Taichung,
TAIWAN
Tel. +886-9-88175206
Email: milly@gis.tw
Web site: https://cocd.fcu.edu.tw/en/teachers-detail/?id=T89036&unit_id=CD00