Recent catastrophic debris flows and risk assessment in China
(Extended Abstract)

Chuan TANG(1), Min CHANG(1), Xun HUANG(1), and Cees van WESTEN(2)

(1) State Key Laboratory of Geo-Hazard Prevention and Geo-Environment Protection, Chengdu University of Technology, China
E-mail:2401634274@qq.com
(2) Faculty of Geo-Information Science and Earth Observation, University of Twente, The Netherlands

Debris flows in mountainous areas are one of the most dangerous geomorphological events, primarily because of the substantial volumes of material that can be deposited on urbanized alluvial fans. As a consequence of climate change and increase in exposure in many parts of China, the risk associated with debris flows is growing. In recent years, many serious incidents related to debris flows have been reported in China. Several debris flows that occurred in China were truly catastrophic. Debris flows that occurred at Zhouqu City on 8th August 2010 demolished 5,500 houses and caused the death of 1,765 people along its flow path. In addition, a heavy rainstorm on 13th-14th August 2010 near the town of Yingxiu, located at the epicentre of the Wenchuan earthquake, triggered many hillslope and channelized debris flows. Among them was the Hongchun gully debris-flow, which transported huge amounts of sediment to the Minjiang River to form a debris dam, which in turn changed course of the river, resulting in the flooding of the newly reconstructed Yingxiu town. Finally, on 13th August 2010, in response to a high intensity rainfall, numerous debris flows occurred along the Qingping section of the Mianyuan river, southwestern China. As a result of these debris flow events, a very large volume of sediment and debris was transported onto the inhabited alluvial fans, directly causing the destruction of more than 100 houses along their flow paths in the Qingping area. A giant debris-flow, which developed in the Wenjia catchment, transported a total volume of about 3 million m^3 of sediment to the river. It generated a temporary debris-dam that entirely blocked the river. Subsequent floodwater, which had a high concentration of sediment, flowed into the newly constructed streets houses and streets in Qingping town. At least 750 houses were inundated or buried by the flows, and about 5000 residents had to be evacuated by helicopter.

In areas with high demographic density, protection works often cannot be built because of economic or environmental constraints, and is it not always possible to evacuate people because of societal reasons. Debris flow risk assessment (DFRA) is progressively becoming a requirement for the administrations in charge of debris flow risk management, because the risk assessment is one of the most effective soft measures in natural hazard prevention, and the base of hazard risk management, which can be contribute to the construction planning and prevention measure making. Debris flow risk assessment is still in its developing stage, and China does not have a standardized risk assessment procedure. Some case studies show that the successful implementation for regional debris flow risk assessment. However, there are even no studies for quantitative risk assessment for debris flows in China.

This paper focuses on the hazard and risk assessment methods developed recently for characterizing the danger caused by the giant debris flows in China, mainly defined as follows:

(1) Recent catastrophic debris flow hazards in China: an overview, aims to present the framework of debris flow problems in China, socio-economic impact, major events, regions with major debris flow problems.
(2) Debris flow inventory mapping, aims to present the state of the art in the development of debris flow inventories.
(3) Regional scale debris flow risk assessment, aims to present the input data requirements and the methods that are used on regional scales to derive debris flow risk maps.
(4) Methods for local scale and site-specific risk assessment, shows the application of physically based models for debris flow hazard and risk assessment.

The proposed methodology is composed of four main parts including data collection, hazard assessment (susceptibility assessment, analysis of triggers) consequence analysis and risk assessment. In this study, the methodology on debris flow risk

assessment for regional, local, and site-specific scales in practice are explained by the example of the case study of the region of Wenchuan, southwestern China. A special consideration was given to presents the dynamic run-out modelling focusing on continuum depth-average models and includes a quantitative risk assessment using run-out models in a specific study sites. Through the case study, we aimed at the follows:

• Assessment scale: regional, local, site-specific;
• Source of input data: empirical to remote sensing;
• Run-out modeling ;
• Application of vulnerability curves;
• Generation of risk map based on economic losses.

The paper proposes a methodology for debris flow risk assessment for regional-scale analysis. The developed debris flow risk assessment methodology is tested in Wenchuan area, in China. Geographic information systems and remote sensing techniques are used to create debris flow factor maps, to obtain hazard maps, elements at risk, and risk maps. Debris flow scenarios were built basing on different return periods of rainfall. Hazard maps are obtained by using a logistic regression model. The vulnerabilities are assessed by adopting some generalization approaches. Regional debris flow risk maps were produced on a continuous scale where numerical values indicate the distribution of risk including the probability of expected losses.

This paper also presents a quantitative risk assessment using run-out models in a specific study sites. The methodology used in the analysis consisted of several components, such as a detailed analysis of rainfall return periods (10, 50, 100 years return period), modelling of the runout of the debris flows, and application of debris flow height and impact pressure vulnerability curves and the generation of risk curves based on the economic losses. In the study, debris flow dynamic characteristics and mitigation plans were considered. Moreover, expected loss values of representative buildings and roads under different debris flow conditions were assessed accurately by combining numerical simulation, elements at risk database and corresponding vulnerability functions.

Keywords: debris flows, major events, run-out modeling, vulnerability curve, risk assessment