

## Evolution and prospect of landslide hazard investigation before and after typhoon Morakot

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Compared with other natural hazards, landslide hazards possess higher frequency or probability of recurrence at the same areas. Therefore, landslide mitigation issue is generally valued by the relevant disaster management authorities. As the professional geological authority, the long-term and regional landslide investigations are mainly conducted by Central Geological Survey (referred to as CGS), Ministry of Economic Affairs, whereas local governments or other central authorities have also implemented investigation of landslides through contracts at specific sites after typhoon or earthquake events as well.

With the advances of science and technology, as well as the needs of social environment, the ways to investigate landslides have applied different technologies to produce certain benefits. From the perspective of CGS's mission, Typhoon Morakot in 2009 lashed Taiwan severely was the most crucial moment, and it was viewed as the turning point of technology development related to landslide hazard investigation. Especially high-resolution LiDAR DEM applied in potential landslide interpretation is the most effective outcome. It is suitable to illustrate the evolution and prospect of Taiwan's landslide hazard investigation via this key moment. Moreover, the Chi-Chi earthquake that occurred in 1999, causing no less than 100 kilometers of surface rupture and the collapsed rock mass in the mountainous areas. That moment was also the beginning of awareness that forced the government to pay close attention to geological hazards.

In the early 1990s, due to the demand for slope land

development, the environmental geological survey was conducted. Before the arrival of the millennium, the violent shaking of the central Taiwan fractured the rock mass in the mountainous area, reducing the stability of the slope thereby. Furthermore, the extreme weather has become routine phenomena since Chi-Chi earthquake in 1999, and the number of typhoons landing every year has also increased significantly. Taiwan also launched self-government Formosa Satellite II in 2005 coincidentally. The wide-range hazard survey can be conducted flexibly and environment changes can be seen from satellite images before and after the hazard event. The landslide inventories were used as the basic data for the susceptibility assessment of shallow landslide in nationwide or watershed scale. Because of the typhoon Morakot pouring beyond the imagination rainfall in 2009, the mountainous terrain and river terrain were seriously changed, and the society suffered heavy casualties owing to large-scale landslide disasters. The government invested more than 30 million US dollars, in order to re-map the topographic data of Taiwan Island. CGS had completed the 1 m resolution of Airborne LiDAR DEM/DSM in 6 years, and further application of the LiDAR DEM to interpret "potential large-scale landslides", usually induced by deep-seated gravitational slope deformation. By identifying the micro geomorphology characters in slope, such as scarp, ridge and terrace, those areas with similar geomorphic characters like Hsien-Du-Shan in Siaolin village would be able to detect in advance where a large-scale landslide will take place.

Besides the advances of investigation technologies and remote sensing resources, CGS has continuously invested in landslide observation research, monitoring data interpretation, landslide information cloud platform, and automated observation systems. Those detailed

results have been gradually applied to the landslide-landslip geologically sensitive areas, disaster management and land use; perhaps it can also be applied to evacuation warnings in the near future.