the 25th Anniversary of the 1999 Chi-Chi Earthquake

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The Evolution and Innovative Applications of Post-Earthquake Sediment Disaster Mitigation Strategies in Taiwan Since the 1999 Chi-Chi Earthquake

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1. INTRODUCTION

If an earthquake is followed by heavy rainfall, it is highly likely to trigger larger-scale landslides and debris flows. These disasters not only endanger public infrastructure such as roads and bridges but also pose significant threats to the lives and property of people residing in these areas. For example, the 1999 Chi-Chi Earthquake caused massive landslides in the central mountainous regions of Taiwan, and the subsequent heavy rains brought by Typhoon Toraji in 2001 led to debris flows and sediment disasters, resulting in severe losses and damage, including the death and disappearance of 214 people across Taiwan (Figure 1). Although research on debris flow disasters in Taiwan began in earnest after Typhoon Ofelia severely impacted Hualien in 1990, the practical implementation of relevant laws and the establishment of dedicated agencies to promote disaster prevention and mitigation efforts only commenced following the 1999 Chi-Chi Earthquake. This event prompted the enactment and implementation of the Disaster Prevention and Protection Act in 2000.

Figure 1. Typhoon Toraji caused severe debris flow disaster in Shuili Township, Nantou County

2. POST-EARTHQUAKE EMERGENCY RESPONSE

After an earthquake, to quickly understand the situation of slope disasters and reduce the impact of secondary disasters, the Taiwanese government established relevant operational procedures following the 1999 Chi-Chi Earthquake. Table 1 outlines the post-earthquake operations and division of labor between the central and local governments.

Table 1. Post-Earthquake Operations and Division of Labor Between Central and Local Governments

Central Government	Local Government	Joint Projects
● Interpretation of New Landslide Areas ● Detection of Barrier Lakes Formation ● Preliminary Risk and Hazard Assessment ● Delineation of Impact Areas ● Current Investigation of potential debris flow torrent ● Adjustment of Rainfall Warning Thresholds and Issuance of Warnings	● Establishment of protected targets Inventory ● Formulation of Evacuation and Shelter Plans ● Disaster Prevention Advocacy and Risk Notification ● Conduct of Tabletop and Full-Scale Drills ● Development of Community Self-Resilience to Disasters ● Execution of Evacuation and Shelter Measures	● Establishment of Community Disaster Response Mechanisms ● Standby Heavy Machinery and Emergency Handling Contracts ● Implementation of Emergency Response Projects ● Inspection of Disaster Prevention Structures ● Vegetation Restoration on Landslide Areas ● Reconstruction of Soil and Water Conservation Projects

Simultaneously, by integrating the resources of industry, government, academia, and research, and building on research findings since 1990, Taiwan began establishing a debris flow warning issuance mechanism in 2002, spearheaded by the Agency of Rural Development and Soil & Water Conservation (ARDSWC). This mechanism has been continuously improved and refined over the years. Except for Typhoon Morakot in 2009, there have been no significant casualties caused by sediment disasters in Taiwan since 2005. Figure 2 illustrates the current debris flow disaster prevention framework in Taiwan, as well as the debris flow warning issuance and evacuation mechanisms.

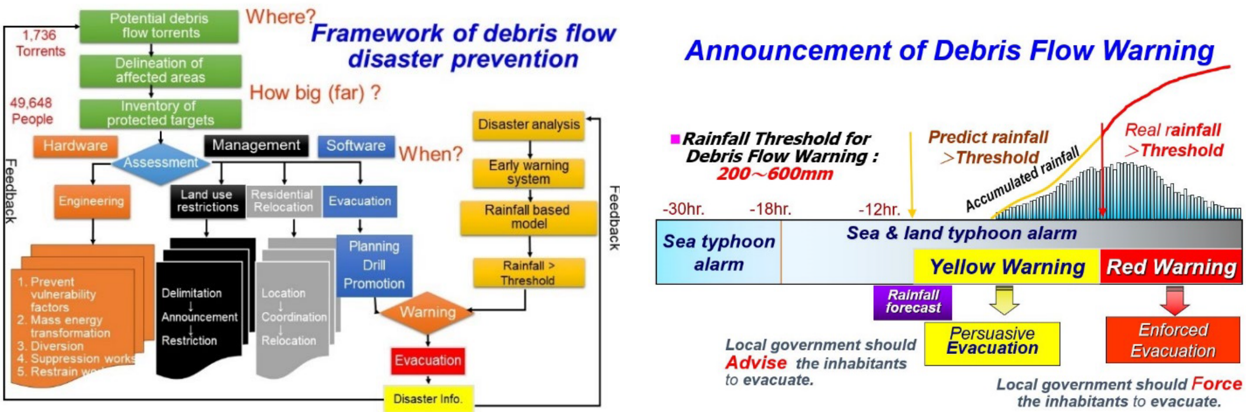

Figure 2. The current debris flow disaster prevention framework in Taiwan

3. INNOVATIVE APPLICATIONS

With the development of technology and advancements in techniques, Taiwan has not only established a web-based disaster response operation system since 2002 but has also recently integrated massive remote sensing information with Web-GIS technology to build the "Big Geospatial Information System" (BigGIS). Users can set various conditions to quickly search and locate extensive image maps, view them through 3D models or multiple windows, and utilize various customized tools and real-time online analysis functions. These include modules for automatic delineation of exposed land, hydrological and hydraulic analysis, and debris flow simulation, playing a role in data collection, integration, value-added application, and sharing. Figure 3 shows the results of landslide interpretation by the ARDSWC after the Hualien Earthquake on April 3, 2024, displayed on the BigGIS platform, with KML files available for download to facilitate value-added applications by other agencies. Additionally, the SDF simple debris flow model built into BigGIS can quickly assess the potential impact areas of subsequent sediment disasters using cloud computing.

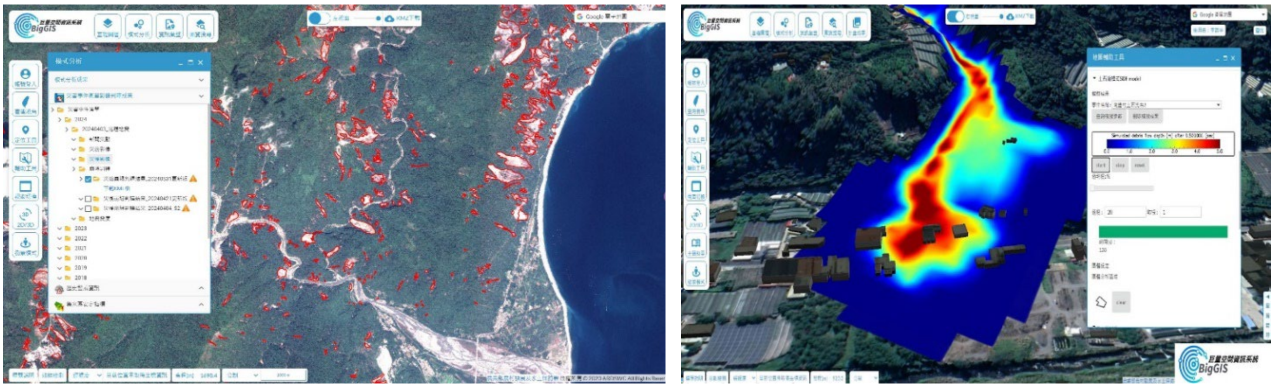

Figure 3. BigGIS can play a role in data collection, integration, value-added application, and sharing.

4. CONCLUSIONS

Earthquakes cause slope loosening, increasing the geological vulnerability of hillsides and further triggering large-scale landslides and debris flows under rainfall conditions. According to domestic and international experience, it takes at least 20 to 30 years for geological stability to return after a major earthquake. Therefore, establishing a comprehensive disaster prevention mechanism for slopes affected by large-scale earthquakes is a crucial issue. Since the 1999 Chi-Chi Earthquake, Taiwan has actively promoted disaster prevention and mitigation efforts over the past 25 years, achieving initial results. Moving forward, there will be continued efforts to strengthen public-private collaboration mechanisms, build community-based disaster prevention capabilities, and resilience to face the significant challenges posed by future climate change.