Extended Abstract DOI: https://doi.org/10.64862/ajeg.2025.2sp.135.294 Open Access

On the Catchment Sedimentation and Landslides in Ta-Chia River Induced by 1999 Chi-Chi Earthquake

Keh-Jian Shou[1 *]

[1] Department of Civil Engineering, National Chung-Hsing University, Taiwan

(*Corresponding E-mail: kjshou@dragon.nchu.edu.tw)

Received: October 2, 2025, Accepted: November 7, 2025

Abstract: Western Taiwan is highly susceptible to landslides and sediment-related hazards due to its steep topography, weak geological formations, active tectonics, and intense typhoon-induced rainfall. This study investigates the relationship between landslides and catchment sedimentation following the 1999 Chi-Chi earthquake (Mw = 7.6) in the Ta-Chia River and Wu-His catchments. Field investigations, satellite imagery, and Digital Terrain Models (DTMs) were used to analyze landslide distribution, sediment production, and river morphology changes during typhoon events Toraji and Mindulle. The results indicate that earthquake-induced landslides significantly increased sediment generation and transport processes. A conceptual sediment equilibrium model demonstrated that landslides strongly influence channel morphology and downstream sedimentation. The findings provide important information for flood hazard assessment, watershed management, reservoir sediment control, and disaster mitigation planning.

Keywords: ***Earthquake-induced landslides, Catchment sedimentation, Sediment dynamics, River channel morphology, Ta-Chia River catchment, Typhoon rainfall, Watershed geomorphology.***

Introduction

The geologically young and tectonically active terrain of western Taiwan is highly susceptible to landslides and sediment-related hazards. The region is characterized by steep mountainous slopes, weak and highly fractured rock formations, and intense seasonal rainfall associated with typhoons. These environmental and geological conditions make western Taiwan one of the most landslide-prone regions in East Asia (Dadson et al., 2004). Frequent earthquakes and short-duration high-intensity precipitation events further accelerate slope instability, sediment production, and channel morphology changes within the river catchments. Therefore, understanding the interaction between earthquakes, landslides, and sediment transport processes is essential for disaster risk reduction, watershed management, and infrastructure planning.

Impact of the 1999 Chi-Chi Earthquake

The western foothill region of Taiwan experienced severe geomorphic disturbances following the 1999 Chi-Chi earthquake (Mw = 7.6). The earthquake triggered a tremendous number of landslides across the watersheds of western Taiwan, causing widespread slope failures and large-scale sediment generation (Lin et al., 2004). In addition to producing immediate landslides, the seismic event significantly weakened the geomaterials by increasing rock mass fracturing and discontinuities. The earthquake also altered river morphology, channel geometry, and sediment transport processes in the affected catchments. Consequently, the post-earthquake landscape became highly vulnerable to subsequent typhoon-induced landslides and debris transport.

Study area and methodology

This study focused on the Ta-Chia River and Wu-His catchments in western Taiwan. These catchments were selected because of their contrasting geomorphic characteristics, different levels of seismic disturbance, and the availability of pre- and post-earthquake datasets. The study investigated the relationship between landslides and catchment sedimentation following the Chi-Chi earthquake, particularly during the typhoon events Toraji and Mindulle.

The research consisted of two major components: catchment sedimentation analysis and correlation analysis between landslides and sediment dynamics. Field investigations, high-resolution satellite imagery, and Digital Terrain Models (DTMs) were used to identify landslide distribution, estimate sediment volumes, and analyze changes in river morphology. Comparison of geomorphic conditions before and after major typhoon events enabled the evaluation of temporal variations in sediment transport processes within disturbed mountain environments.

Landslide and sediment dynamics

The landslide inventory and catchment sedimentation analyses revealed significant changes in sediment generation and transport after the Chi-Chi earthquake. A conceptual equilibrium model of sediment dynamics within sub-watersheds was developed to evaluate the relationship between sedimentation and controlling geomorphic factors. The results indicate that landslides play a critical role in sediment production and downstream sediment transport processes. Their

influence became particularly strong immediately after the earthquake due to the highly fractured and unstable condition of the slopes, although the impact gradually decreased over time as the landscape adjusted toward a new equilibrium condition.

The study further demonstrated that sediment transport is intrinsically linked to landslide activity because river morphology and channel stability are strongly controlled by repeated slope failures. Typhoon-induced rainfall mobilized large quantities of earthquake-generated loose materials, resulting in channel aggradation, bank erosion, and increased sediment delivery to downstream areas.

Conclusion and practical implications

The findings of this study provide valuable insights into the long-term geomorphic response of earthquake-affected mountainous catchments. The integration of landslide inventory analysis, satellite interpretation, field investigation, and DTM-based sediment assessment proved effective in understanding sediment dynamics in western Taiwan.

These results can support government agencies and planners in flood hazard assessment, reservoir sediment management, watershed planning, and slope stabilization design. Furthermore, the study highlights the importance of considering the combined impacts of earthquakes and typhoon-induced rainfall in disaster mitigation strategies for tectonically active mountainous regions.

References

Dadson, S.J., Hovius, N., Chen, H., Dade, W.B., Hsieh, M.L., Willett, S.D., Hu, J.C., Horng, M.J., Chen, M.C., Stark, C.P., Lague, D., and Lin, J.C., (2004). Earthquake-triggered increase in sediment delivery from an active mountain belt. Geology 32(8), 733–736. https://doi.org/10.1130/G20639.1

Lin, C.W., Shieh, C.L., Yuan, B.D., Shieh, Y.C., Liu, S.H., and Lee, S.Y., (2004). Impact of Chi-Chi earthquake on the occurrence of landslides and debris flows: example from the Chenyulan River watershed, Nantou, Taiwan. Engineering Geology 71(1–2), 49–61. https://doi.org/10.1016/S0013-7952(03)00125-X