The Impact and Adaption of Typhoon Hazard in Taiwan: A Case Study of Typhoon Morakot 2009

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Abstract

Taiwan is located not only within an active tectonic area, but also at monsoon area with abundant annual rainfall. These circumstances result in a great variety of landscape forms and habitats. Landslides and debris flows in the mountain areas caused by heavy rainfall happen commonly. Typhoon Morakot in 2009 was a typical example. Over a four day period between 8-11 August 2009, the Alishan weather station recorded a rainfall accumulation of 2,965 mm. The intense rainfall caused several landslides, generated landslide dams and floods which were responsible for more than 677 deaths in Kaoshiuing and Pintong counties. This was the severest damage caused by heavy rainfall in the last five decades. Economic losses totaled over one billion US dollars across the whole island.

The present research area focuses on Launon River of southern Taiwan. This paper review (and analyze) the power and influence of Typhoon Morakot over the island. Morphological study demonstrates that there are several types of erosion from this event. Aerial photo and satellite images interpretation and comparison study also explain various types of hazard occurred in this typhoon event. The Morakot typhoon also demonstrates that high rise river terraces in Taiwan may be flooded by heavy rainfalls or landslide dam, not only caused by tectonic uplifting.

A series of adaption policy are proposed as management measures. It is suggested that the culture of aboriginal tribes should be taken into account in a decent way. Early warning system of typhoon and flooding should be adopted and developed in the event of coming typhoons for both low-lying areas and high mountain areas.

Key words: landslide, typhoon hazard, adaption, Taiwan

Introduction

Taiwan's most detrimental natural hazard is severe tropical storms and typhoons. It demonstrates the power of the natural processes (Chen and Petley, 2005; Lin et al., 2006). The episodic high-magnitude rainfall event is capable of yielding over 1,749 mm within 24 hours (31 July 1996 in Alishan) which is quite close to the world record of 1,870 mm. Because of the tectonic movements and frequent extreme climatic processes, the land of Taiwan is fragile and vulnerable. The high denudation rate and serious soil

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erosion also make it necessary to be wary of the natural processes, especially the influence of earthquakes, mass wasting, soil erosion, tropical cyclones and other climatic hazards.

It is commonly to use remote sensing imagery in identifying landslide area and hazard area (Soeters and Westen, 1996; Metternicht et al., 2005; Western et al., 2008). According to the aerial photo interpretation and photogrammetric surveying, the typhoon had high deposition volume at the Launon River. The highest deposition area of sediments on channel was more than 50 m. It means that the landform had changed and all the villages along the river channel are at high risk of flooding. Although these deposits could be flushed away by next typhoon, many villages must take flooding as potential hazards.

The Typhoon Morakot

Typhoon Morakot caused the severest damage to Taiwan over the past 50 years. The disasters, including floods, landslides and landslide dams simultaneous, yielded composite hazards. The devastated extinguishing of Siaolin Village is an unfortunate example of composite hazards.

The rainfall of Typhoon Morakot is found to be high intensity and long duration. Figure 1 shows that the rainfall intensity at Alishan Station which is located very close to the Shaolin Village was as high as 120 mm/hr. There is a duration of rainfall intensity higher than 50 mm/hr within 24 hours. With such a huge rainfall and long duration, the hill slope can be vulnerable to be eroded. There is no reason that southern Taiwan
could escape such a high erosion process. The Shaolin landslide occurred when there were circa 2,000 mm rainfall. Together with such huge rainfall, many landslides occurred around the research area. Figure 2 demonstrated a positively high relationship between accumulated rainfall and the distribution of landslides. The rainfall mainly distributed at the high mountain area of southern part of Central Range.

The Shaolin landslide is a kind of wedge landslide. The total volume of sliding mass is circa 26 million m³ and 90% of sliding mass are still on hill slope. Only 10% of sliding mass was flushed away. Because Shaolin Village was buried under sliding mass, which caused more than 466 casualties, a series of reconstruction projects were launched (Figs 3, 4, 5, 6, 7 and 8).

The Shaolin landslide mass buried on channel also formed a landslide dam (Fig. 9). The landslide dam last only less than half hour and became failure, not to keep the dam functioned. Such failure caused the Shaolin Village suffered a second devastating damage.

**Accumulated Precipitation(mm)**

8/07 00:00 ~ 8/11 23:00

*Fig. 2. The landslide sites overlay with rainfall data.*
Fig. 3. The landslide caused by Typhoon Morakot. There are more than 50 sites of such similar landslides. It is quite a dilemma between keeping the landslide site the way it is and making the trail available to the settlements nearby. It is a matter of management decision. How can we manage the trail in a safe way?

Fig. 4. Shaolin Village before Typhoon Morakot at a bird's eye view. The Shaolin Village is at the bottom of the photo.

The adaption policy

The deposition of sediments can be as high as 50 m on river channel of the Laonon river. It also demonstrated that the landslides provide huge supply of materials. However the sediments were not moved totally to the lower catchment area during Typhon Morakot periods. Such sediments make future typhoons or rainfalls potential hazards to near-by settlements (Fig. 10). The rise of channel becomes a type of pressure to the villages along the Laonon river (Fig. 7).
Fig. 5. Shaolin Village after Typhoon Morakot. The whole Shaolin Village was flushed away. The landslide was 850 m in relief.

Fig. 6. The Shaolin Village and the boundary of landslide before Typhoon Morakot.

Because of such disaster, the reconstruction or rehabilitate work is sensitive to the aboriginal tribe because they moved to the Shaolin Village only less than 100 years ago. As the demolishment of the Shiaolin Village becomes a terrifying lesson for reconstruction, what kind of policy measures or adaption method could prevent such unfortunate events in the future? It is very dangerous to reconstruct the village at the same site because of pressure from flooding because that the original high terrace became part of flood plain. Some aboriginal people do not like to move to another place
because of their farm, garden and job. It is legitimate for the aboriginal people to be resistant to relocation as the place was considered the root of their culture. So it is a critical issue how we respect the aboriginal culture (Fig. 3).

Taiwan's hill slope environment is linked strongly to its geological structures as well as its processes. Although substantial achievements were made in raising awareness of the nature of geomorphic processes and their dynamics, and awareness of how the understanding of geomorphology can aid effective management and decisions on engineering strategies, the hill slope environment as partly contributed by river dynamics is not well understood. The interconnectedness in geomorphic systems and the long-term variability of processes and landforms is understood better (Hooke, 1999). Radical changes in both policies and decision-making frameworks that ought to be taken in the approach to river drainage management could benefit from the ideology and
Fig. 9. Landslide dam at the Taimali River.

Fig. 10. Road engineering work after Typhoon Morakot. Such a new road can only last for a few months. The next heavy rainfall could destroy the new highway again easily.

practice of ‘work with nature’, as Hooke (1999) identified of British government. Therefore, management will achieve better results if it is implemented to facilitate and encourage integrated planning.

Facing increasing risks of climate change, the planning and implementation of adaptation measures are to be taken to protect the economic, social, and environmental security of the state and of the local communities. For effective actions to be implemented, information is required for fundamental reasons, as Tribbia and Moser (2008) pointed out in their study of California coastal managers. However such requirement poses issues of selections and options. What compounds the issue of information is the strong need for boundary organizations to serve various intermediary functions between sciences and practice (Tribbia and Moser, 2008). The enhancing of intra- and inter-governmental and cross agency collaboration could be a key to the
success of hill slope environmental protection and management.

Discussions and conclusions

Critically urgent and action-demanded hill slope environmental issues face today's world everywhere, partly due to physical environmental changes and partly due to the existing human structural elements and forces.

As a subtropical island with more than 70% of hilly and mountainous terrains, Taiwan faces the urgency of extreme weather events that could bring hazardous consequences to hill slope. Such issues are not unique to Taiwan.

The challenges associated with the Taiwan's sensitive hill slope landscapes are aggravated by the increasing magnitude of changes in both magnitude and frequency of hill slope processes. Such brief statement seems to be short of logical support. However it could be sufficiently supported by understanding the impact of typhoon and hill slope process of Taiwan, and the policies that support such circle and accumulation. This is one critical reason to associate the environmental changes and challenges with the socio-economic development and aptitude for capital accumulation in Taiwan, where neo-liberal government dealings with various environmental changes are practiced without much reflective thinking on environmental consequences, and where lack of geographically suitable policies are formulated and implemented.

While the need to reduce the vulnerability of hill slope infrastructure and land uses is great in Taiwan, major studies on hill slope environment are mainly natural studies in nature. The socio-economic and political implication and policy implication are relatively scarce, as the integration of natural and human sciences does not come easy, and the policy implication of a true integration of the two could be detrimental to the state as a whole.

References