

## Typhoon Disaster in Taiwan in August 2009

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### 1. Overview of disaster caused by Typhoon Morakot

#### 1) Overview of the typhoon and heavy rain

A tropical cyclone formed on August 3 in the Pacific Ocean northeast of the Philippines, which developed into a typhoon on August 5. The typhoon moved westward, gradually increased its force since the next day and, at around 5:00 pm on August 7, its storm zone hit various parts of Taiwan. The typhoon struck the area near Hualien City in the northern part of Taiwan at around 11:50 pm on August 7, went off the coast in the sea by around 2:00 pm on August 8, came ashore on the Chinese Continent at around 6:30 on August 9 and the main island of Taiwan got out of the storm zone. Subsequently, the typhoon weakened into a tropical cyclone at daybreak on August 11. In the course of these events, a series of torrential downpours that accompanied the typhoon started on August 5. It mostly died down on August 10 but turned out to be enormous downpours that broke the records of the maximum rainfall in various parts of Taiwan with the total rainfall during these days reaching as much as 3,000 mm in some areas.

The rainfall data obtained at most of the rainfall observatories in the central to southern parts of Taiwan exceeded the values of rainfall of a 200-year probability with all of the 24-hour, 48-hour, 72-hour and total rainfall, which shows how extraordinary the downpours were.

#### 2) Overview of the typhoon damage

The damage caused by this typhoon was mostly due to sediment-related disasters. Above all, extremely large quantities of rain fell in the mountainous areas from the central to southern parts of Taiwan and collapses, landslides and debris flows occurred and landslide dams formed and burst everywhere. In addition, flood flows caused bank erosion washouts here and there and large-scale sediment deposition in

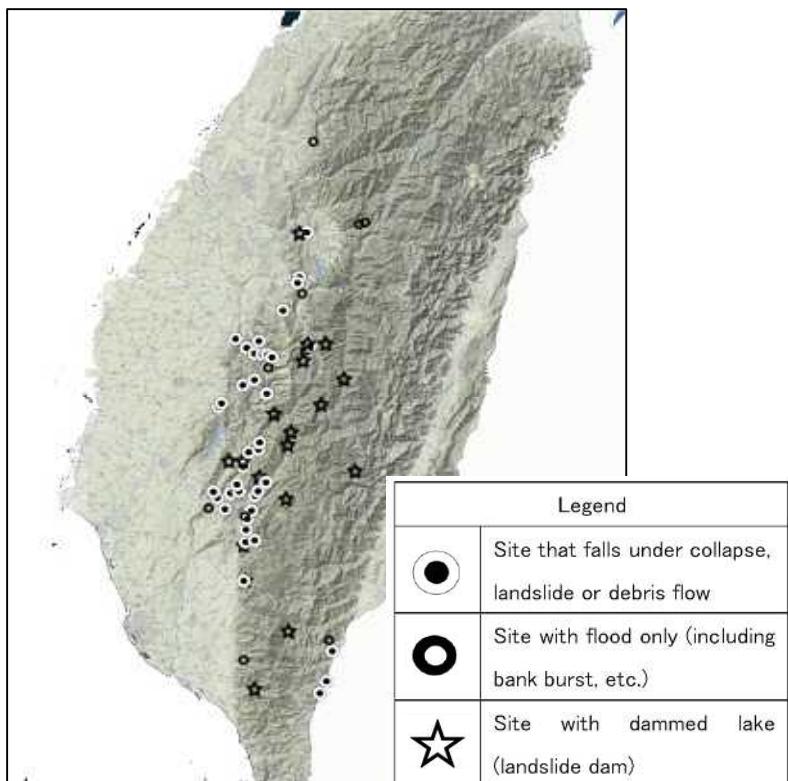


Figure-1: Major sites of sediment-related disasters caused by Typhoon Morakot

river mainstreams and local riverbed degradation occurred as well.

On major sediment-related disaster sites that suffered human and general damage, the Soil and Water Conservation Bureau published a preliminary report, which says that the number of sites was 52 in total, and the Forestry Bureau has reported that the number of dammed lakes (landslide dams) caused by the downpours was 18 in total. However, satellite images taken after the disaster suggest that, on top of them, even more collapses and debris flows occurred in forestland deeper in the mountains.

The impact of the disaster was extensive, which caused tremendous confusion of information due to the interruption of transportation and communication after the disaster, and the government was slow to gain information about the state of disaster especially in the mountains. This led to the delay in providing rescue and relief activities and the whole cabinet resigned to take the responsibility for it, which indicates the social impact of the disaster.

The total extent of human damage, including the number of people dead or missing, caused by Typhoon Morakot as of November 3 is 746, of which the number of deaths due to sediment-related disasters such as collapses, landslides and debris flows account for almost 80 percent.

One major characteristic of the disaster is that human damage in Kaohsiung County was particularly serious as represented by the destruction of Hsiaolin Village in Chiahsien Township of the County caused by just one case of collapse (debris flow) and burst of a landslide dam, which left 450 people dead or missing.

Table-1: Number of people dead/missing (as of November 3, 2009)

Classification	No. (of people or incidents)
Dead	671
Incomplete and unidentifiable body	47
Missing	28
Total	746

## 2. Conditions of sites

1) Basin of Chenyulan River, a branch of Jhuoshuei River (Sinyi Township of Nantou County, etc.)

Jhuoshuei River, which is the main stream, is a river under the administration of the central government and is located in the central part of Taiwan, runs westward from the riverhead in Taiwan's Central Mountain Range of 2,900 m above sea level to the river mouth on Taiwan Strait and has the second largest catchment area in Taiwan of 3,157 km<sup>2</sup>.

Chenyulan River is the left branch of this Jhuoshuei River and has a large dry riverbed covered with a large amount of sediment, steep valley topography on either bank and a catchment area of 448 km<sup>2</sup>.

The major sediment-related disaster site is the Hoshe River Basin, which is included in Shenmu Village, Sinyi Township in terms of administration. Hoshe River has three rivers flowing into it at the point of Shenmu Village: Aiyuzih River of  $8.6 \text{ km}^2$  in catchment area, Hosa River of  $28 \text{ km}^2$  (dammed lake formed in the upper reaches) and Tsushui River of  $4 \text{ km}^2$ .

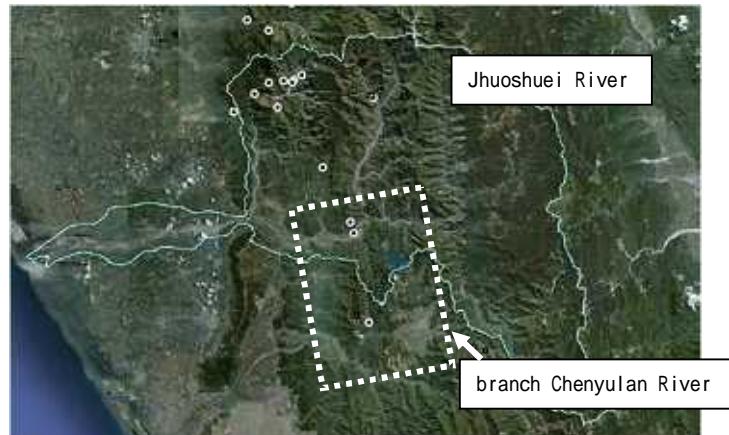


Figure-2: Jhuoshuei River and its branch Chenyulan



Figure-3: Satellite images before (left) and after (right) the disaster

The enormous downpour due to the typhoon caused collapses here and there on the mountainside in the upper reaches and the three branches generated massive debris flows down to the confluence into Hoshe River before the dawn of August 9 and large amounts of sediment deposited near the confluence where houses and Shenmu Elementary School were located, the thickness of which reached 20 m. Although no human damage was caused, the flows of the sediment destroyed Route 21 and the industrial road over approximately 600 m.

In addition, Longhua Elementary School (built after being struck by Chichi Earthquake in 1999) and about 20 houses suffered serious damage with their foundations washed away due to bank erosion.

Furthermore, in the lower reaches of Chenyulan River near the confluence into the main stream of Jhuoshuei River, bank scouring and erosion washed away the foundations of Route 21 and houses along the road, which indicates the furiousness of the flood flow.

The restoration of damaged roads was quick including well-thought-out restoration work such as bridge abutments making use of container boxes and pier foundations.



Photo-1: Tremendous bank erosion



Photo-2: Temporary bridge abutments making use of container boxes

## 2) Tsengwen River Basin (Nanhua Township, Tainan County) and Chishan River (branch of Kaoping River) Basin (Chiahhsien Township, Kaohsiung County)

Tsengwen River and Kaoping River in the southern part of Taiwan are rivers under the administration of the central government that originate in Taiwan's Central Mountain Range of 2,900 m above sea level and respectively have basins elongated north-south. The catchment areas are 1,117 km<sup>2</sup> for Tsengwen River and 3,257 km<sup>2</sup>, which is the largest in Taiwan, for Kaoping River.

Regarding the conditions of sites in these areas, this report focuses on Hsiaolin Village, which suffered the most serious human damage.

Hsiaolin Village had a community with 184 households on a small terrace surface on the left bank in the upper reaches of Chishan River, a branch of Kaoping River. Residents who managed to survive the disaster say that a large collapse of the slope behind the village occurred in early morning at 6:00 of August 9, which buried most of the village, and the landslide dam that formed due to the collapse burst between 6:00 and 8:00, causing a flood that swept away and completely destroyed the village and claimed more than 450 lives in a moment.



Figure-4: Tsengwen River and Kaoping River



Figure-5: Satellite images before (left) and after the disaster in Hsiaolin Village

According to the data provided by the Taiwanese group, it has been estimated that the area of the large collapse on the left bank of Chishan River that directly struck the village was approximately 350 ha (of which the range of collapse was 190 ha with the maximum width at 1.2 km and maximum flow distance at 3 km, the maximum depth of collapse was 80 m and range of sedimentation was 160 ha), the relative elevation difference was approximately 900 m and the total amount of collapsed sediment was around 10 million m<sup>3</sup>. A large landslide collapse occurred also on the right bank across Chishan River, the sediment from which was combined with the sediment washed down due to the large mountainside collapse on the left bank dammed up Chishan River and formed a landslide dam that seems to have burst soon. Of the 184 households in the community, only two survived.

Based on the data obtained by the Central Weather Bureau Chihsien Observatory, the daily rainfall on the previous day August 8 until the occurrence of the large collapse was 1,071 mm (in excess of the rainfall of a 200-year probability of 904 mm) and the cumulative rainfall from August 7 to the occurrence of the collapse on August 9 was approximately 1,500 mm, which is an extraordinary downpour. This caused such a large-scale sediment-related disaster.

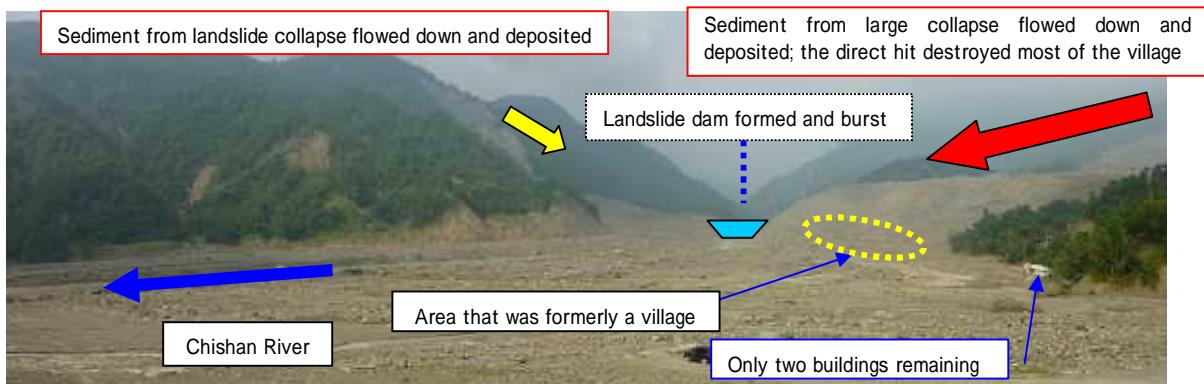


Photo-3: Conditions of site in Hsiaolin Village (overlooking the upper reaches of Chishan River; head of the collapse totally unobservable from the riverbed)

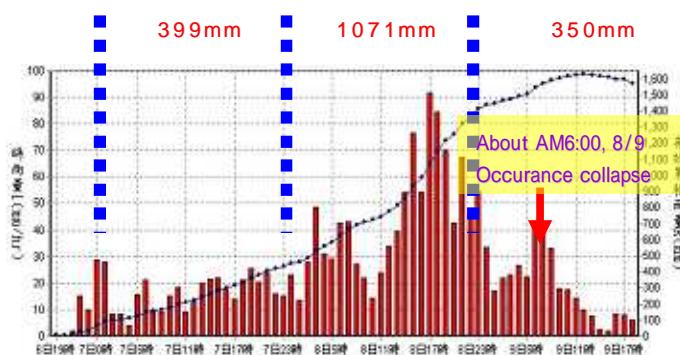


Figure-6: Rainfall graph (Chiahsien Observatory)



Photo-4: Gigantic stone apparently caused by a collapse

Prior to the on-site investigation, the entire research group prayed for the souls of the victims and offered incense. Then, members of the group made a field investigation in a 1-km-long section along the riverbed (in the lateral direction from the end of the collapse) but the enormous scale of the phenomenon completely prevented the head of the collapse from being seen from the riverbed and left it unclear. An accurate assessment of its conditions cannot be expected with a brief investigation as the present one and the result of close investigation by the Taiwanese group in the future is anticipated.

### 3) Laolong River (branch of Kaoping River) Basin (Liouguei Township, Kaohsiung County)

Laolong River is the biggest branch of Kaoping River and runs southward parallel to the east side of Chishan River mentioned in 2).



Figure-7: Sinkai Village and Sinfia Village with their communities engulfed by a debris flow (left: before the disaster)

An explanation was given that, on top of the two sites with an entire community completely destroyed by a debris flow, the state of dilapidation in the basin was striking and, within the scope of the present field investigation conducted, this Laolong River Basin suffered more incidents of collapses and debris flows than the entire Chishan River Basin (except for Hsiaolin Village) and a huge amount of sediment flowed into and down the river channel of the main stream.

In Paolai Village in the uppermost reaches of the Laolong River Basin accessible by car and investigable, the group visited a fire station with flood marks caused by the breach of the landslide dam

remaining on the wall and obtained a valuable testimony from a young female fire chief that a large flood apparently caused by the burst of a dammed lake upstream hit the site on August 11 after the rainfall stopped.



Photo-5: River conditions near Paolai Village in the middle- to upper reaches of the Laolong River Basin