Landslide Disaster around Baguio City caused by Typhoon Pepeng in 2009

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Abstract

From September to October 2009, two typhoons hit the Philippines and caused massive floods and landslides. The heavy downpour brought about by the second one, Typhoon No. 17, caused massive landslides in Baguio City and in many parts of northern Luzon, leaving more than 200 casualties. We did a half-day survey of the extent of the landside damage and report the results. The damage from the landslide was due to the unprecedented amount of rainfall, and social factors, such as the unregulated overbuilding of houses on steep slopes, also contributed largely to the damage.

Key words: Landslide disaster, Typhoon Pepeng, Philippine, Baguio City

1. Introduction

Two typhoons hit the Philippines one after the other in the fall of 2009. The second of these typhoons, Typhoon No. 17, which landed in October, brought heavy downpour that caused massive earth slides, mudslides, and debris flows across wide areas of Benguet Province and Baguio City, located in the central part of northern Luzon, leaving more than 200 casualties and missing persons. We performed a field survey of the damage mainly in Baguio City and conducted interviews with city government officials and other agencies involved, albeit within a short period of time. Here, we report the extent of landslide damage on the basis of our field surveys and discuss the factors that may have contributed to the landslide disaster on the basis of the data that we obtained during interviews with the different agencies.

2. Overview of landslide damage caused by Typhoon Pepeng

Typhoon Pepeng made landfall in Luzon on Oct. 2 and brought massive rains while it traversed from east to west, but as it exited the northwest of Luzon, it changed its course due to the Fujiwara effect brought about by its interaction with Typhoon No. 18 (Shimokawa *et al*., 2011) and reentered Luzon from the northwest side, bringing more heavy rains. The complicated way in which it moved to make landfall twice caused intense rainfall that had two large rainfall peaks. Its first landfall on Oct. 3 brought a record rainfall of 531 mm in Baguio City (**Table 1**). Two days later, a record rainfall was also recorded for a period of three days from Oct. 6 to 8 at 260, 267, and 685 mm, for a total of 1,200 mm. This rainfall peak resulted in extensive damage as widespread landslides occurred in Benguet Province and Baguio City, and more than 200 people were reported dead or missing. Among the major damage it caused was a huge landslide in Little Kibungan, La Trinidad, Benguet Province, where 85 people died. Most of the landslide damage in Baguio City occurred during the second peak of the rainfall from Oct. 8 to 9. We conducted the survey of landslide damage on Nov. 27. After interviews with the city mayor's office, we visited at least five areas to inspect the extent of the damage. Since we were only able to conduct actual field inspection for a half day, we relied on field reports for the details of the extent of damage in the different areas.

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Table.1 Summary of landslides and heavy rain conditions.

Station/Date	Oct. 03	Oct. 04	Oct. 05	Oct. 06	Oct 07	Oct. 08
Laoag	90.6	402.6	197.3	47.5	60.0	33.0
Vigan/Sinait	168.9	417.3	126.2	75.4	68.6	111.8
Baguio	531.0	38.2	4.6	260.0	276.0	685.0
Dagupan	159.5	8.0	T	36.2	52.0	443.5

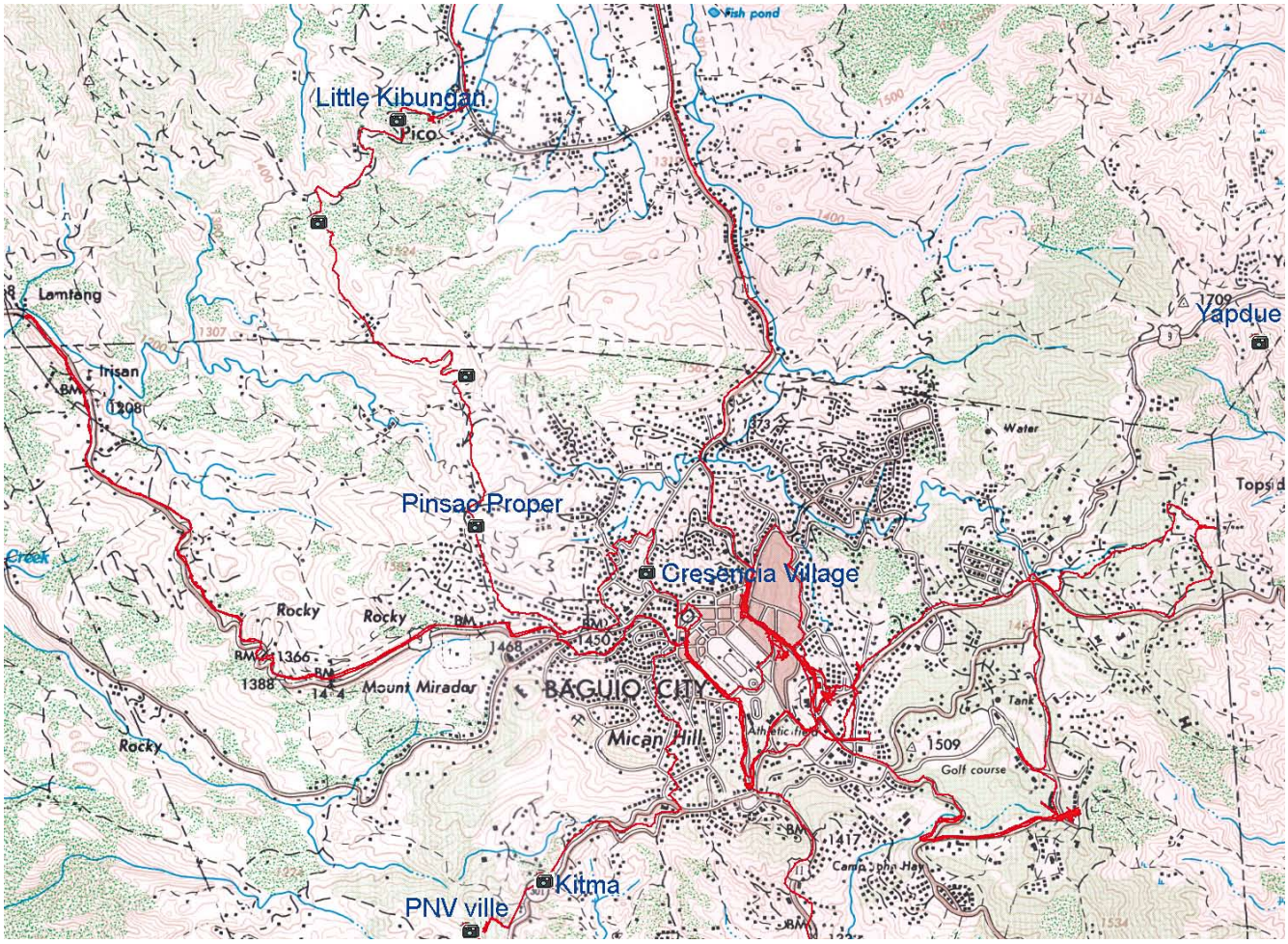

Fig. 1 Location of landslides investigated in Baguio City and surrounding areas.

3. Overview of landslide damage in Baguio City

Fig. 1 shows the survey points of landslide occurrences in Baguio city.

3.1 Landslide in Kitma, Baguio City

The first place we visited was the landslide on Marcos Highway, the main road that runs southwest from Baguio City along the mountain ridge. A 20-meter stretch of land below the road shoulder collapsed, bringing down with it houses built along the slope (Cover **Photo 1**). A family of eight people, including six children, was buried along with their house as the mountainside went down.

Almost nothing was left of the buildings on the central part of the landslide, where weathered soil was left exposed (**Photo 1**). Adjacent buildings had nothing but their foundations remaining. Based on interviews with some people at a nearby shop, the landslide occurred at around 1 am on Oct. 9. We believe that this was triggered by the record rainfall of 685 mm that fell the previous day in Baguio.

However, the landslide occurred in an area below a paved road surface where water infiltration was not expected to happen and where there is no water catchment surface. We found sewage pipes and tiles apparently made of concrete

Photo 1 Landslide in Kitma. The house in this photo collapsed down into the slope.

buried under the soil beneath the fault scarp below the road shoulder (**Photo 2**).

However, we did not have time to find out how the rainwater that falls on the road surface is drained. In the absence of other probable factors, we believe that it was possible that there was water leakage from the sewage pipes buried under the road. Even though we did not have information about the state of the buildings before the damage, it seemed that they were improperly built. Thus, we believe that the loosening of the soil due to the rains caused the unstable buildings to fall down with the land.

Photo 2 Sewage pipes found buried under the upper portion of the landslide in Kitma.

3.2 Landslide damage in PNB Ville

The next area we visited was the landslide at PNB Ville. Four people in a family that lived right where the landslide occurred were reported dead. The area is located near the Marcos Highway along a gently undulating mountain slope where houses were being built in a worm-like fashion and where there were still pine and other trees growing in the upper part of the slope. We visited the area only two months after the landslide, but most of the it was already covered with grass, so at first it did not appear as if there had been a landslide. **Photo 3** shows a picture of the area provided by the city government that was taken right after the landslide. It was a small-scale landslide that occurred on a 20-degree gentle slope, 10 m wide and 10 m deep. We inferred from **Photo 3** that the area was naturally sloped and composed of a thick layer of weathered soil, and although it has the features of a valley-type slope, the water catchment surface is not very large.

Although we did not obtain detailed information about how the area was developed, we believe that the major factors that caused the damage were the unregulated building of houses and the lack of consideration to building safety on mountain slopes, where there is a danger of landslides occurring after heavy rainfall.

Photo 3 PNB Ville site right after the landslide (Provided by the Baguio City Government).

3.3 Landslide in Cresencia Village

The landslide damage was similar to the first area we visited at Kitma, where a mudslide occurred below the road shoulder (Cover **Photo 2**). In this area, the houses were built in tiers along the slope so that all the houses located 30 to 40 m down from the portion that collapsed were damaged by the land and houses that fell down from above (**Photo 4**). Twenty-three people were killed in the landslide.

Photo 4 Damage of houses along the slope due to the landslide in Cresencia Village.

The area was an elevated residential one near the center of the city and located only around 500 m from the City Hall, with a nice view from the road. The area that collapsed was a steeply sloped area beneath the road shoulder that had a maximum width of 20 m, a slope length of 25 m, and a tilt of 30 degrees (**Photo 5**). Judging from the conditions of the surrounding area and from the topographical maps we obtained, we believe that the area was originally the uppermost part of the valley, a portion of which was probably filled during construction of the road. The side of the road where the slope collapsed did not have gutters or drainage systems, so it was possible that the rainwater flowed along the tilted road surface into the slope below it.

We believe that one major factor that contributed to the landslide that claimed many lives is the building of houses in a valley-like topographical area, which has a high risk for landslide damage, without proper land modification.

Photo 5 Condition of the slope where landslide occurred in Cresencia Village.

3.4 Other landslide disasters within Baguio City

We did not have sufficient time to actually enter and inspect the landslide areas other than the three mentioned above. Instead, we conducted the inspections mainly by taking pictures from afar. However, we would also like to give an overview of the extent of landslide damage for these areas within Baguio City by using the pictures that we took.

Photo 6 shows the landslide that occurred in Pinsao Proper, where earth movement occurred on a gentle slope that had a thick layer of advanced weathering-stage soil. This landslide area had the deepest slip plane among those we have mentioned so far, and the houses built over the landslip became greatly tilted. Since we were viewing the area from a distance, we could not accurately estimate the dimensions of the damage, so we estimated it to be approximately 100 m wide and 100 m long. The slope also did not have a significant water catchment surface area behind the landslide.

Photo 6 Landslide in Pinsao Proper.

Photo 7 Landslide in Yapdue area.

We believe that groundwater levels rose due to an infiltration of rainfall that reached a total of 1,000 mm over the sloped area. There were reports of two fatalities in this area, but we were not able to determine the actual location where this happened.

Photo 7 is a far-view picture of the landslide that occurred on a steep slope in the Yapdue area. From the picture, it would seem that the amount of collapsed land is minimal, but due to the collapse of the upper region of the slope, a wide area was laid bare. We were not able to determine the extent of damage for this area. There were other landslides having a similar type of damage in some other places within Baguio City. In this particular area, there were no houses beneath the collapsed portion, but there were several houses in the slope right next to it. Thus, if the landslide had occurred in a slightly offset point, it could have resulted in human casualties. Landslides of varying scales were also observed in many other areas.

3.5 Lessons from the landslide disasters in Baguio City

According to reports from the Baguio City government, there were around 100 areas within Baguio City where landslides had been determined, as well as 58 casualties and 5 missing persons. Baguio City was developed on mountain

ridges located 1,000 m above sea level to serve as the summer capital of the Philippines; hence, there are very few flat or gently sloped areas within the city. In our interviews with the city government officials, they pointed out the problems arising from the rapid population growth and the unregulated construction of residential areas. In particular, recent residences have been constructed on steeply sloped areas since the gently sloped areas have already been developed and filled up with houses. For example, it can be seen in Cover **Photo 4** that there are many clusters of houses that are built on unstable slopes.

Although landslide hazard maps are being drawn up for Baguio City, we feel that the choosing of a safe place for building houses is a social problem that does not have an immediate solution. We strongly believe that there is a need for a multifaceted approach to disaster prevention, including implementing non-structural ("soft") measures during heavy rainfall.

4. Rapid landslide damage in Little Kibungan, La Trinidad, Benguet Province

This landslide was one of the damages caused by Typhoon Pepeng, in which 85 people died, the largest number of casualties reported in one location. The landslide was located in an area called Little Kibungan, where a large portion of the slope collapsed onto an area along the road leading from Baguio City to the capital of Benguet Province in La Trinidad. Since the damage was large scale, we included an aerial photo (**Photo 8**) provided by Baguio City Hall to show the whole view of the affected area. The upper right part of the picture that shows scraped vegetation and exposed land is where the landslide started. The material from the landslide flowed from this point and cut through the road along the direction indicated by the arrows into the valley extending from the upper right to the lower left portion of the central part in the photo. It flowed right through the houses built along the valley, resulting in enormous damage that left 85 people dead (area encircled in **Photo 8**).

Photo 8 Landslide in Little Kibungan.

Photo 9 Origin of landslide in Little Kibungan.

The landslide occurred on a steep, 25-m-high slope that was directly above the road (**Photo 9**). It collapsed as if the land from the part near the ridge of the smooth-topped, hill-like peak was gouged. The landslide was around 30 m wide and 35 m in height. The fault plane that cuts the slope diagonally served as the boundary of the cliff on the right side of the landslide area, causing the land to collapse in a wedge-shaped pattern. The upper part of the landslide almost reached the ridgeline, and there was no significant water catchment area behind the landslide. As such, we believe that the infiltration of rainfall into the collapsed portion of the slope caused the landslide. It is possible that the rainwater that infiltrated the soil was blocked by the fault plane and accumulated on the area.

A massive amount of material flowed down at a rapid speed into the valley over a distance of 100 m, resulting in considerable damage. Houses lined both sides of the valley, and those that were along the path of the debris flow were either washed out or completely destroyed. Restoration work was already under way at the time of the inspection, so we could not see the actual damage, but the location of the houses in relation to the path of the debris flow can be seen in **Photo 10**.

Photo 10 Damage in houses built along the valley where landslide occurred in Little Kibungan.

It is difficult to predict precisely where landslides might occur in slopes that have complex and heterogeneous soil conditions, but needless to say, houses should not be built in areas near the valley flow path because of its inherently high topographical risk. We can learn from this disaster that proper risk assessment is an essential component in land use planning.

5. Landslide disasters along Kennon Road

On our way back to Manila after finishing the survey in Baguio City, we took Kennon Road, which is one of the few roads that connects Baguio City to the neighboring towns. Right after the typhoon, the roads leading to Baguio City were blocked at various places due to landslides and mudslides, so that, for a time, the city was isolated, and the transport of food and supplies was temporarily disrupted. Even after the roads were fixed, one-lane passing and time restrictions for traffic were still enforced in various portions.

Fig. 2 Distribution of landslides along Kennon Road.

On the way, we tried to stop and take pictures of several portions of the road where there had been landslides. Although there were not many places where we were able to actually stop and take a look, by using GPS, we also recorded the landslide locations and other areas where there were fallen rocks and debris scattered along the road. **Fig. 2** shows the results of our quick survey of landslide occurrences along Kennon Road.

Cover **Photo 7** shows an area damaged by the flow of rock and debris from the collapsed upper portion of the slope (**Fig. 2-A**). Debris that included giant boulders a few meters big had been moved away to the roadside, indicating that the road must have been impassable for a long period. At the time of the photo, the road was being repaired as an emergency measure, and alternating traffic caused congestion. To prevent future disasters, a bridge high enough to accommodate possible rock and debris flow from above must be built on the portion where the road traverses the river. Otherwise, roads must be constructed on both sides of the river so that even when one side is damaged, traffic can still pass along the road on the other side.

Cover **Photo 8** shows rocky slopes along Kennon Road that had collapsed (**Fig. 2-B**). In addition to rainfall infiltrating the fissures on the rocky slope, we believe that the river below had been eroding the base of the slope, making it unstable and eventually causing the rock flow.

Although it is difficult to predict rockslides in places like this, it is possible in this case that minor deformations had already occurred along the fissures that eventually became the slip plane for the rockslide. Since the area had been covered by vegetation, it would have been difficult to detect these early warning signs, so a regular inspection system must be employed to prevent disaster as part of proper road management practice.

6. Summary

Although limited in time, we were able to conduct a survey of the landslide damage caused by Typhoon Pepeng in Northern Luzon, Philippines. In Baguio City alone, although the landslides were of small scale, there were more than 100 areas where they occurred, resulting in a considerable number of casualties. Among the disaster areas that we surveyed were some where the slopes beneath the road shoulders collapsed and caused damage due to debris flowing onto the houses built along the slopes. The construction of houses along high risk steep slopes that accompanied the rapid growth of the city's population had exacerbated the damage brought about by the disaster. Nakasu (2011), also pointed out rapid population growth as an important factor in this disaster.

There were also other landslides that occurred around Baguio City, including a large-scale rapid landslide that occurred in La Trinidad, Benguet Province where 85 people

died in a very tragic disaster. The building of houses on dangerous areas along the valley is considered the main factor that exacerbated the damage. Considering that the Philippines is a typhoon-prone country, disaster prevention measures such as the optimization of land use must be strictly executed.

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