ICIMOD

FOR MOUNTAINS AND PEOPLE

Field Report

Landslide Dam Outburst Flood in Chin Hill, Myanmar

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The International Centre for Integrated Mountain Development (ICIMOD) is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalayas (HKH) – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream and downstream issues. ICIMOD supports regional transboundary programmes through partnerships with regional partner institutions, facilitates the exchange of experiences, and serves as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop economically and environmentally-sound mountain ecosystems to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now and in the future.

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Salient Features of the Tonzang Landslide Dammed Lake and Landslide Dam Outburst Flood in Chin Hill, Myanmar

Landslide Dam

1. Location
   a. Latitude 23° 40′ N – 23°.45′N
   b. Longitude 93° 50′ E – 93° 55′ E
   c. 52 kilometers upstream from the Yazagyo Dam

2. Dam features
   a. Dam length: 1,500 m
   b. Channel length on dam: 1860 m
   c. Highest: 1402 masl
   d. Lowest elevation of dam: 1126 masl
   e. Height difference: 276 m

3. Dam material and condition
   a. Fractured shale
   b. Weathered sandstone
   c. Silt and clay in small amount

4. Landslide Dam Outburst Flood (LDOF)
   a. 3rd July 2016
   b. Phase wise Outburst
   c. Outflow discharge 1.2 m^3 per second

Lake (pre and post LDOF scenario)

	May 2016 before LDOF	**December 2016 after LDOF**
a. Water level:	1,364 masl	1330 masl
b. Length	1,707 m	1020 m
c. Width	563.5 m	212 m
d. Average Depth	50 m	15 m
e. Area	appr. 41 ha	21 ha
f. Water volume	15.5 million m^3	4 million m^3

Background

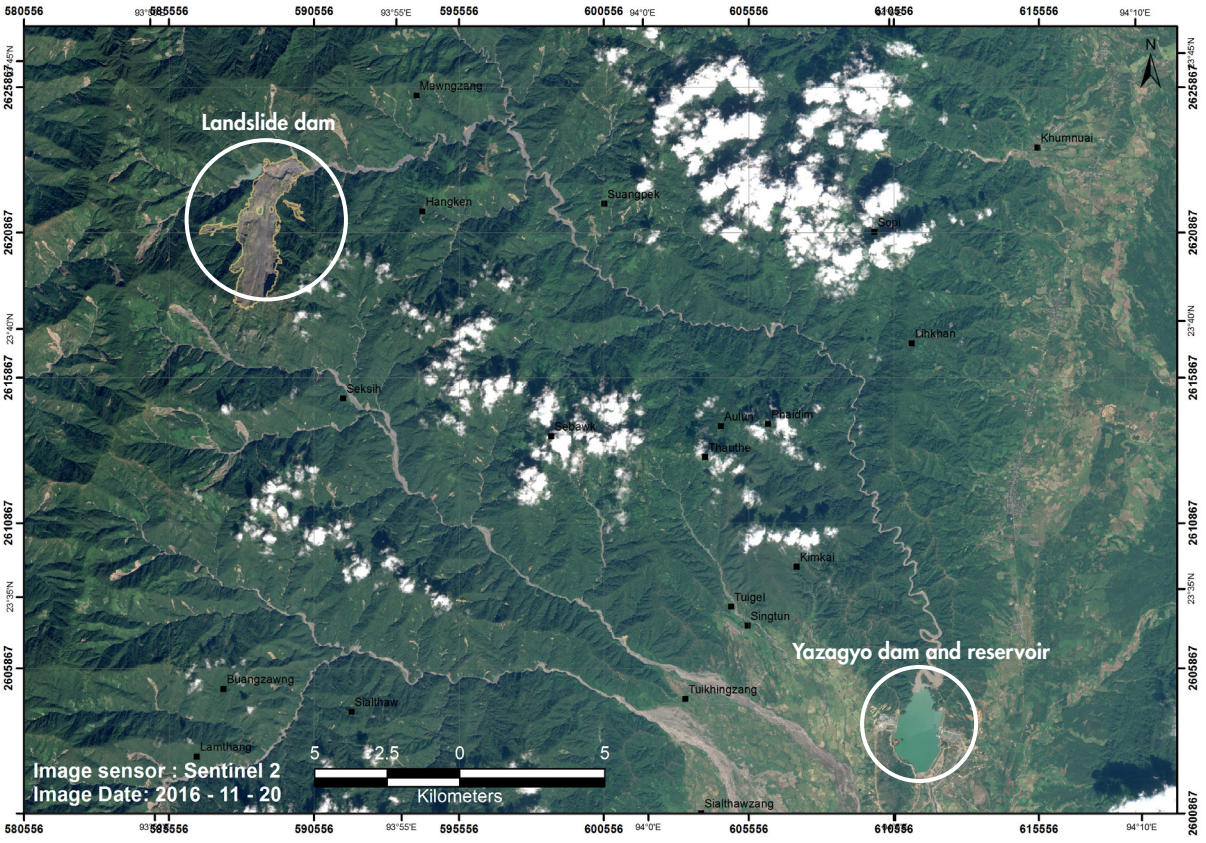
Heavy rainfall (480 mm) on 16 July 2015 triggered a huge landslide (DGSE and GDKU, 2016) that dammed the Tui Lam Lui River approximately 52 km upstream of Yazagyo Dam near Hangken Village, Falam District in the Upper Chin hill region in northwestern Myanmar (Figure 1).

The Chin Hill range is composed of fractured brown and gray shale with subordinate of brown sandstone. The steep slopes of the region combined with intense monsoon rains make the mountainous region one of the most hazard-prone areas in Myanmar. The dammed lake from the July 2015 landslide grew rapidly during the monsoon to 50 Ha by August 2015 and then reduced down to 41 Ha in the dry season. The lake contains 15.5 million cubic meters of water (DGSE, 2016). The landslide dam was formed by quick deposits of landslide materials, which lack sufficient consolidation. Hence, the stability of this landslide dam was a prime concern for local people.

The Ministry of Environmental Conservation and Forestry of Myanmar requested ICIMOD to assess the landslide dam and develop a comprehensive management plan to tackle the problem. The Director of the Forest Department of Chin State organized a short field trip to the landslide dam and lake area in May 2016 and the ICIMOD team led the investigation group. The team used remote sensing data and field data to be analyzed in a geographic information systems environment. Based on collected data, the ICIMOD team concluded there was a strong probability this landslide dam would breach (Bajracharya et al. 2016).

As predicted, the landslide dam did breach in July 2016. After the burst, the remaining lake area measured 19.6 Ha with 4 million cubic meters of water stored. To confirm the future stability of the lake, the Ministry requested ICIMOD to conduct additional investigations of the lake. This began in December 2016 and the details are presented in the remainder of this report.

Figure 1: Location of the Tonzang landslide dam in Chin Hill and Yazagyo dam and reservoir in Myanmar



Present Investigation

The December 2016 fieldwork on the Landslide Dam Outburst Flood (LDOF) near Hangken village focused on the following features for risk assessment:

- Landslide Dammed Outburst Flood (LDOF)
- Lake
- Landslide dam and channel profile

Landslide Dam Outburst Flood

The landslide dam outburst flood (LDOF) of July 2016 released about 11.6 million cubic meters of water and lowered the lake level by 35 m (Figures 2 and 3). At present the outflow from the lake is 1.2 m^3 per second. The terrace markings on the right bank of the lake outlet indicate that the LDOF might have occurred in more than seven phases (Figure 4). Discharge in the last phase of LDOF is estimated to be 7 to 8 m^3 per second based on flood markings.

The outwash of the LDOF deposited the debris 8 m thick near the dam and 4 m thick near Hangken village. The coarse sediment deposits can be seen down to 29 km along the river from the dam toe (as seen on the satellite image). Much fine sediment was transported up to the Yazagyo reservoir (Figure 5).

Figure 2: Lake and dam material (25 May 2016)

Figure 3: The lake water level has decreased by 35 m after LDOF. (photo: 16 December 2016)

Figure 4: The terrace markings on the river bank show the LDOF has occurred in more than seven phases. (16 Dec 2016)

Figure 5: Sediment deposited along **(a)** Tui Lam Lui river valley and **(b)** in the Yazagyo reservoir.

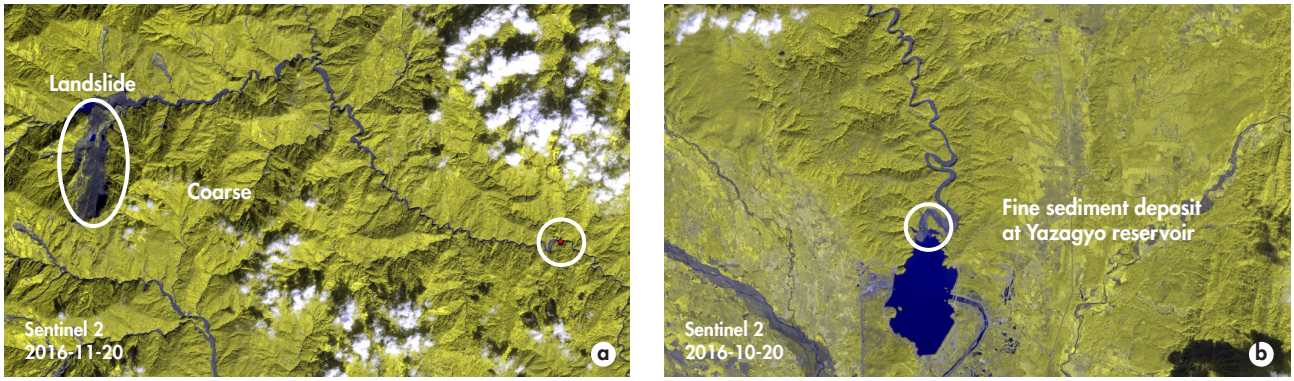


Figure 6: Sediment deposits on the river banks near Hangken village: **(a)** before LDOF and **(b)** after LDOF

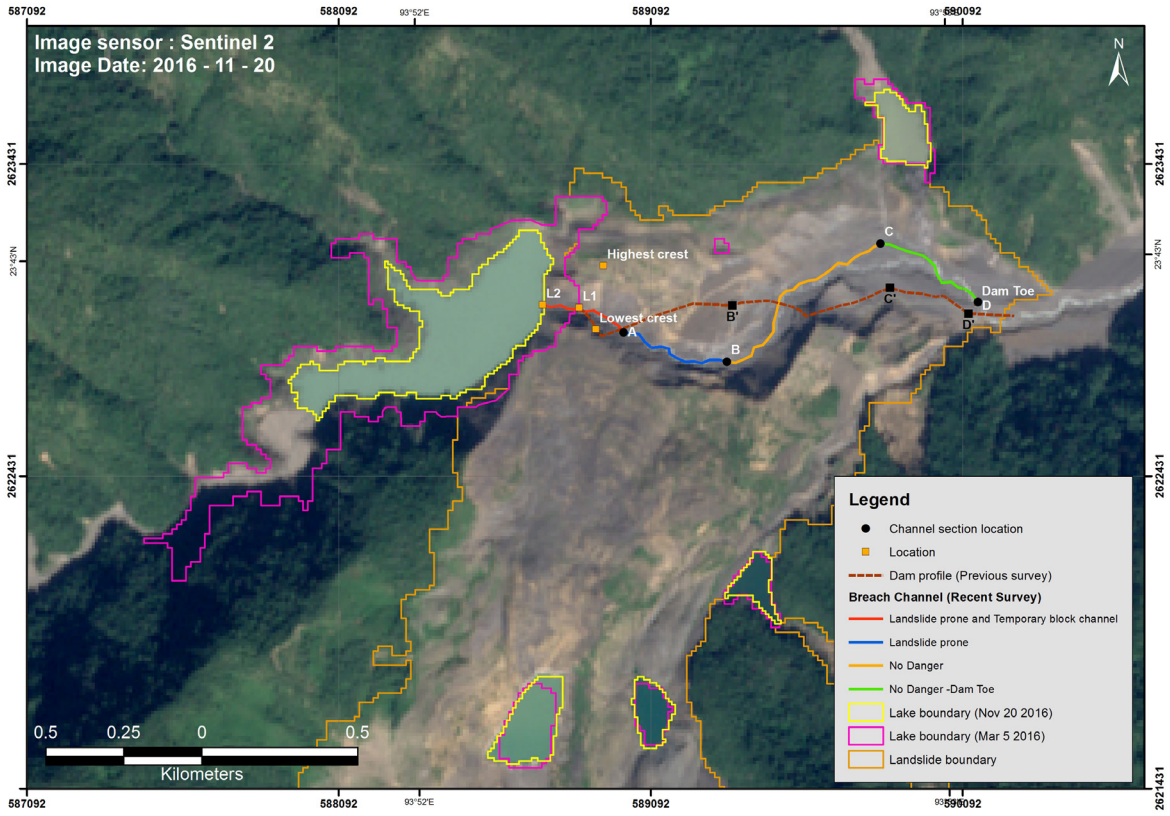
Figure 7: Sediment deposits near the Yazagyo reservoir

Lake

The July 2015 landslide dammed the Tui Lam Lui River and formed a large lake. The lake area grew to 34 ha by September 2015 and 40 ha a month later, as reported by *UNITAR-UNOSAT*. The lake area grew an additional 10 ha by March 2016. The fieldwork from May 2016 shows the lake area decreased by 3 m after attaining its maximum height during the last monsoon season. The water level during the May 2016 investigation stood at 1,364 masl.

Figure 8: The lake water level dropped by 3 m in the dry season (May 2016)

Figure 9: Chin hill landslide dammed lake area change scenario of pre and post LDOF



After the LDOF, the lake area had decreased from 50 Ha to 21 Ha. The red and yellow lines are the lake boundary before and after LDOF respectively (Figure 9). The lake water level had lowered by 35 m with the estimated water volume released was about 11.6 million cubic meter. The remaining lake area is 21 Ha in December 2016. The elevation of the lake had reduced from 1364 masl to 1330 masl. At present the average depth of the lake is 15 m with 4 million cubic meter of water estimated based on the previous exiting reports.

Dam and Channel Profile

The Tonzang landslide dam ranges in elevation from 1,126 to 1,402 masl. The dam length from the lake to the toe of the dam is approximately1,500 m and 1,860 m along the river channel. The dam and channel profile plan is shown in the figure 10. Its profile is divided into six zones based on the gradient and their characteristics as shown in the figure 11 and 12. The new lake level (L1) to Lowest Crest (A) is the breaching area. The present slope is about 7° towards the lake with a length of about 89 m. The lowest crest to point A also had a 7° slope for 132 m. The section A to B′ and B′ to C′ are 8° and 9°, respectively, with distances of 336 m and 535 m. The lowest section C′ to D′ has an 18° slope and 274 m in dam length. The overall dam length has a slope ranging from 7° to 18°. This degree of slope is not prone for erosion.

The current channel developed in the dam after the LDOF and has reached a length of 1,893 m long. This profile is also divided into four zones ranging from 4° to 8° with an average slope of 6° . The new lake level to point A of about 305 m length have 4° slope along the channel (Figure 13). Rest of the zones are having 6° to 8° slope for approximately 1,500 m. From L2 to point A has high potential for landslide and temporary blocking of this area is expected. The zone from point A to B also has the possibility of landslide but with less chance of blocking the river should a landslide occur. Further down from point B to C and C to D, these zone pose no risk, however, the gradients are slightly higher than the other zones. Overall the channel gradients are in stable condition.

Figure 10: Longitudinal profile along the dam as it was on 25 May 2016. The dark brown broken lines mark the dam. The other lines (red, blue, brown, and light green) mark the channel after LDOF (16 Dec 2016) and mark the changes in the lake area. These markings were established from Landsat 8 images taken on 5 March 2015. The yellow lines were marked from Sentinel-2 images taken on 20 November 2016.

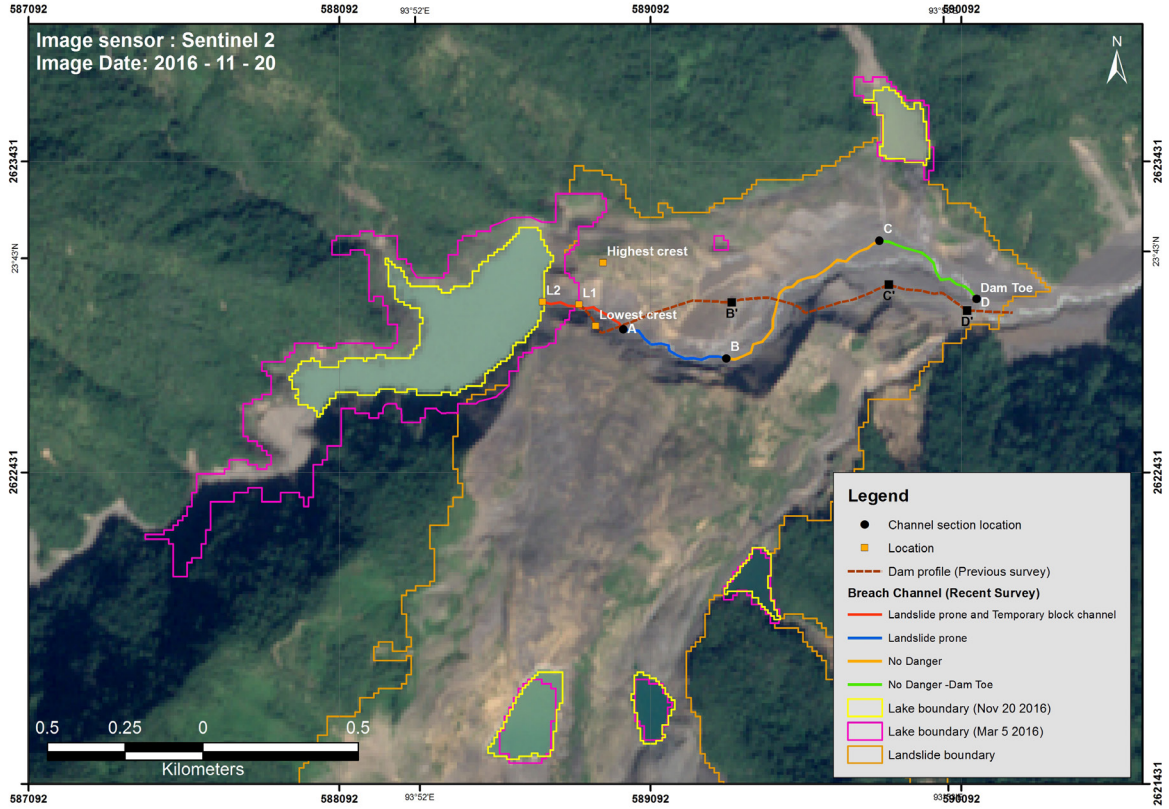
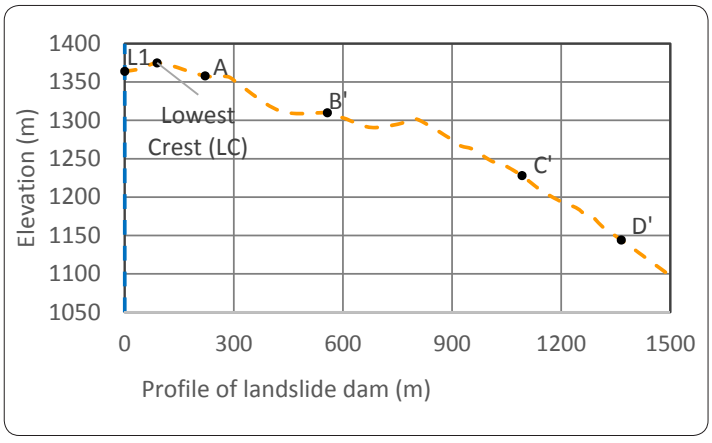
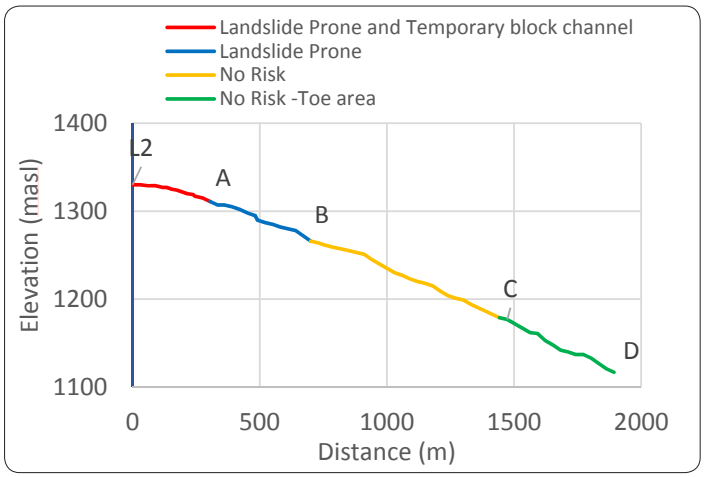


Figure 11: Longitudinal profile along the dam (25 May 2016)



Section	Highest (masl)	Lowest (masl)	Distance (m)	Slope (deg)
L1 to L.C	1375	1364	89	7
LC to A	1375	1358	132	7
A to B′	1358	1310	336	8
B′ to C′	1310	1228	535	9
C′ to D′	1228	1144	274	18
LC to D′	1375	1144	1365	10

Figure 12: Longitudinal profile along the river channel after LDOF (16 Dec 2016)



Section	Description	Distance (m)	Slope (deg)
L2 to A	Landslide Prone and Temporary block channel	305	4
A to B	Landslide Prone	366	6
B to C	No Risk	712	7
C to D	No Risk -Toe area	420	8
L2 to A	Total	1893	6

Figure 13: The lake outlet scenario: **(a)** The dammed lake outlet; **(b)** The gradient of the lake outlet channel near the snout; and **(c)** the gradient of the channel at 300 m downstream.

Conclusions

We draw the following conclusions based on our research:

- The LDOF occurred in phases, most likely seven or more phases.
- The lake area was reduced to 19.6 Ha from 50 Ha.
- The lake level dropped by 35 m and the remaining average depth of the lake is 15 m.
- LDOF discharged 11.6 million m^3 of lake water from a total 15 million m^3.
- Lake outflow is presently 1.2 m^3 per second
- Discharge based on flood markings on the lake outlet – 7 to 8 m^3 per second is estimated at the last stage of the LDOF
- Depth of the lake is 6 to 8 m deep at near to the lake outlet
- Debris along the river bed is compact shale and sandstone ranging up to boulder sizes at 3 m.
- The length of the channel is 1,860 m.
- Gradient of the lake outlet to the channel ranges from 4° – 8°
- There is a possibility of temporary damming at the upper stretches
- Debris may derive from the dammed material on the banks and in landslides
- The channel gradient from the lake outlet was 4° for more than 300 m. This indicates that the lake will be stable in normal condition.

Recommendations

- Gauge rain to measure the rainfall
- Continue measuring flood discharge
- Monitor flood levels
- Do not need to install early warning systems
- Construct a supporting wall at the lake outlet
- Construct check dams along and across the river to control debris
- This area could be developed for micro-hydropower and/or tourism

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