Geohazards in the aftermath of the 25 April 2015 (12 Baisakh 2072) earthquake

A rapid analysis prepared for the Government of Nepal
1. Executive Summary

After a large earthquake on 25 April the mountainous regions of Nepal have experienced various geohazards that might pose short and long-term risks to people, properties, and infrastructure.

This report is a preliminary attempt to assess landslide and glacial lake outburst flood risks in the aftermath of the earthquake.

Major points of this report are:

- Among numerous landslides that have occurred or reactivated after the earthquake, six have been identified as important. Among them the risk level of two are high, two medium, and two low.
- One high risk landslide is located in Tibet Autonomous Region, China.
- Continued monitoring of these lakes and detailed risk assessment is recommended.
- Detailed hazard assessment should precede resettlement.
- No additional risk has been posed by the earthquake to the potential dangerous glacial lakes.
- Detailed risk assessment, particularly on the moraine stability should be conducted.

2. Background

In the aftermath of the 7.8 magnitude earthquake that struck Nepal on 25 April 2015, numerous landslides have occurred in the steep mountains and hills throughout the earthquake impacted zone. The attention of a large number of scientists within Nepal and beyond has been drawn to the potential secondary geohazard risks that might arise in the future. These geohazards include landslide-dammed rivers, future mass movements (landslides/debris flows), glacial lake moraine failures, and avalanches.

This rapid assessment is primarily based on analysis of satellite images received from government and private agencies including NASA, DigitalGlobe, Indian Remote Sensing Satellite, Sentinel Asia, and Gaofen (China), as well as some field assessment and community interactions.

The report is prepared based on analyses done by the following groups

- A group of more than 40 ICIMOD staff and volunteers working at the ICIMOD headquarters on a 24/7 basis (www.icimod.org/nepalearthquake2015)
- The NASA-USGS-interagency Earthquake Response Team coordinated by Greg Leonard and Jeffrey Kargel from University of Arizona, USA and Joseph Shea, ICIMOD (www.nasa.gov/subject/3130/hazards/)
- An expert team of Chinese Academy of Sciences (CAS) lead by Prof Cui Peng from Institute of Mountain Hazard and Environment and consisting of scientists from IMHE, CAS, Institute of Tibetan Plateau (ITP), and Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI).
• The Department of Hydrology and Meteorology (DHM), Government of Nepal (www.dhm.gov.np/)
• Ministry of Home Affairs (MOHA) (http://moha.gov.np/home)

The report focuses on mainly two aspects of geohazards:

• Landslides and potential risk of landslide dam outburst floods
• Potential risk of glacier lake outburst floods (GLOF)
3. Landslides

Figure 1 shows the location of major landslides that have occurred after the earthquake. While the actual number of landslides is many-fold larger, the figure shows only the major ones. Among the landslides numbered below seem to be critical and are dealt with in detail here.

![Google Earth view of hazards discussed in this summary report. (Source: J. Shea, NASA-USGS Interagency Earthquake Response Team)](image)

<table>
<thead>
<tr>
<th>S No</th>
<th>River Name</th>
<th>Location</th>
<th>District</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trishuli River, near Chongsecun (China/Nepal)</td>
<td>28.359N, 85.365E</td>
<td>Gyirong (China); Rasuwa (Nepal)</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Marshyangdi River, near Lower Pisang</td>
<td>28.628N, 84.133E</td>
<td>Gandaki/Manang/Pisang</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Bharatang village Ward no 1, Pisang VDC</td>
<td>28.571N, 84.187E</td>
<td>Manang District</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>Tom Khola (Budhi Gandaki tributary)</td>
<td>28.559N, 84.793E</td>
<td>Manaslu/Gorkha/Prok</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
<td>Budhi Gandaki, Lho Bazaar</td>
<td>28.573N, 84.710E</td>
<td>Manaslu</td>
<td>Medium</td>
</tr>
<tr>
<td>6</td>
<td>Langtang River</td>
<td>28.215N, 85.497E</td>
<td>Rasuwa</td>
<td>Low</td>
</tr>
</tbody>
</table>
3.1 Landslide Blockage of Trishuli River, near Chongsecun (China/Nepal)

**Location:** 28.359N, 85.365E, ~2,600 m. Upper Trishuli River, (also shown as Gyriong Zangbo)

**Administrative Districts:** Gyriong (China); Rasuwa (Nepal)

**Description:** A large landslide (800m x 200m) has crossed a road and dammed the Trishuli River (also known as Gyriong Zangbo) north of the China/Nepal border (Figure 2). A lake approximately 100 m wide and 500 m long had formed as of 30 April 2015. This landslide is located about 7 km north from the Nepal-China border. The latest satellite imagery from 3 May 2015 (Figure 3) shows that the lake has not changed size.

**Risk:** High, potential dam breach and downstream flooding

**Recommendation:** Need continued monitoring, aerial survey, and detailed risk assessment in collaboration with China

**Last Imagery:** 3 May 2015
Figure 2: Pre and post-event imagery of Trishuli River blockage near Chongsecun. (Source: E. Miles, University of Cambridge, and J. Steiner, ETH-Zurich)
Figure 3: High-resolution DigitalGlobe image of the Chongsecun River blockage, 3 May 2015.
(Source: A. Bevington and L. Wu, DigitalGlobe)
3.2 Landslide blockage of Marshyangdi River, near Lower Pisang (Nepal)

Location: 28.628N, 84.133E, 3,300 m. Upstream of Lower Pisang

Administrative Areas: Gandaki/Manang/Pisang

Description: Two landslides have blocked the Marshyangdi River, upstream of Lower Pisang. The older upstream landslide had been draining at a well-formed outlet. A second, newer landslide that occurred between 27 April and 2 May has blocked the river downstream of the first landslide and formed a lake 500 m long and ~50 m wide that is draining slowly through a small channel.

Risk: High. Villages of Lower Pisang are at risk of being flooded if the dam is breached.

Recommendation: Need continued monitoring, aerial survey, and detailed risk assessment

Last Imagery: 2 May 2015

Figure 4: Pre- and post-quake imagery of Marshyangdi River landslide blockage, near Pisang. (Source: D. Shugar and N. Nahirnick, DigitalGlobe)
3.3 Landslide near Bhartang village Ward no 1, Pisang VDC, Manang District

**Location:** 28.571N, 84.187E.

**Administrative District:** Manang

**Description:** This landslide/avalanche occurred near a settlement of about ten houses. On 27 April the river appeared to be completely blocked, while the image of 29 April shows the water flowing through the landslide.

**Risk:** Low

**Recommendation:** Needs monitoring

*Figure 5: Image of Bhartang landslide on 27 April and 29 April (Source: S. Bajracharya, DigitalGlobe)*
2.4 Landslide blockage of Tom Khola (Budhi Gandaki tributary), near Prok (Nepal)

**Location:** 28.559N, 84.793E, 2,500 m. Upstream of Ghapsya

**Administrative Area:** Manaslu/Gorkha/Prok

**Description:** A potentially large volume of water stored in a lake formed behind a small landslide on the Tom Khola, a tributary of the Budhi Gandaki. The new lake is upstream of the villages of Ghapsya and Ghap, and has continued to grow in size to 3 May 2015.

**Risk:** Medium. The river is now flowing through the landslide dam but maybe not in full capacity. The lake is growing.

**Recommendation:** Need continued monitoring, aerial survey, and detailed risk assessment. Need monitoring of the downstream river gauge.

**Last Imagery:** 3 May 2015

![Image of Landslide blockage Tom Khola, a tributary to the Budhi Gandaki River near Prok](Source: K. Voss, NASA)
Figure 7: Digital Globe imagery of Tom Khola landslide from 3 May 2015. (Source: NASA-JPL, DigitalGlobe)
2.5 Landslide blockage of Budhi Gandaki, Lho Bazaar (Nepal)

**Location:** 28.559N, 84.793E, 2,500 m. Upstream of Ghapsya

**Administrative Area:** Manang/Manaslu/Lho

**Description:** A debris flow/landslide from the Lanjam Glacier terminal moraines narrowly missed Lho and Lhi villages in the Manaslu region, and has blocked the Budhi Gandaki River. It is not clear if water is building up behind the dam, or if water is flowing underneath the debris.

**Risk:** Medium

**Recommendation:** Need continued monitoring, aerial survey, and detailed risk assessment.
Figure 8. Budhi Gandaki landslide near Lho Bazaar. (Source: D. Wolfe and A. Bevington, DigitalGlobe)
3.6 Langtang Valley Landslide and River Blockage

**Location:** 28.215N, 85.497E

**Administrative Area:** Rasuwa/Langtang

**Summary:** A massive landslide/avalanche and pressure wave immediately after the earthquake destroyed Langtang Village, and deposited materials across the Langtang River. There has been no evidence of lake formation upstream of the landslide.

**Risk:** Low. There might be residual risk of avalanche and debris flow in the valley, especially with the onset of the monsoon.

**Recommendation:** Need risk analysis and location for resettlement.

*Figure 9: Pre- and post-earthquake image of Langtang Valley. (Source: W. Immerzeel and P. Kraijjenbrink, NASA)*
4. Glacial Lake Outburst Flood (GLOF)

Glacier lake outburst floods occur when lakes dammed by glacier moraines fail catastrophically. A major concern was that the Nepal Earthquake had destabilized the moraines and could lead to a GLOF. However, Figure 10 shows that shake intensities at large glacial lakes were low. Very strong shaking was experienced in the midlands of central Nepal, and strong to lower levels of shaking were experienced in the fore and Higher Himalaya. Only one potentially dangerous lake, Tsho Rolpa, is located within this region and the level of shaking in the lake area was low. Other potentially dangerous glacial lakes, i.e., Imja, Thulagi, Barun, etc. are beyond the major shake areas. Pre- and post-event images of Thulagi and Imja were analysed and no immediate risk was identified. The Department of Hydrology and Meteorology (DHM), Government of Nepal, has also done a detailed analysis and consulted with the local community of Imja Lake. They have declared that an immediate risk due to the impact of the earthquake does not exist. Continued monitoring of moraine stability is recommended.

Risk: No additional risk due to the earthquake identified.

Recommendation: Detailed investigation using high resolution satellite images, aerial survey, and field investigation.

Figure 10: Shake intensity map
Figure 1: Condition of Thulagi and Imja glacial lakes before and after the earthquake