

This is the fourth article of a 15-part series on the GLOF research and mitigation project between May 2009 and March 2012. The articles will highlight latest findings on glacier, glacial lakes condition and natural hazards in the Bhutan Himalayas. Experts from the department of geology and mines (DGM), Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST) are involved with the project.

# Glacier districts in Bhutan

Most of the Bhutanese rivers flow down to the south from the glacierized headwaters. These glacierized areas consist of rocky peaks, streams, lakes, snow and ice, which are breathtakingly beautiful scenery and sometimes hazardous. However, it is difficult to see such landscapes from the foot of the mountain except a few of local residents, yak herders and trekkers, because the area is extremely remote. Therefore our serials will attempt to introduce

small fractions of such natures, especially the condition of glacial lakes in the six major watersheds in coming four weeks. The target basins are; the upper Paro Chu (Soe Chu, red line in the right upper figure), Punatsang Chu (green line), Mangde Chu (light blue line), Chamkhar Chu (dark blue line), Kuri Chu (light purple line) and Dangme Chu (dark purple line). As for today's topic, I will illustrate the upper streams of parents river, that is Pho Chu and Mo Chu, which join together at the front of Punakha Dzong.

(Dr. Jiro Komori, JICA expert in DGM)



**Pho Chu:** The river system of the upper Pho Chu consists of

Tarina Chu in the west and Pho Chu mainstream in the east.

**Mo Chu:** Comparing to Pho Chu, the glaciers in Mo Chu which situated in from 5000 to less than 7000 meter, so there are comparatively small lakes. The relative danger of the GLOF hazard there is therefore lower than the Pho Chu. As for the past case of the GLOF, while there are topographical evidence on the outlet and outwash as the past outburst event (yellow "X" in the right lower figure and lower photograph), damage has not been recorded in the villages downstream. This is a clear distinction from Pho Chu, which has several GLOF records with severe damages in the past. According to the result of our satellite analyses, there is not an

immediate danger of GLOF in Mo Chu, but more field survey is recommended.

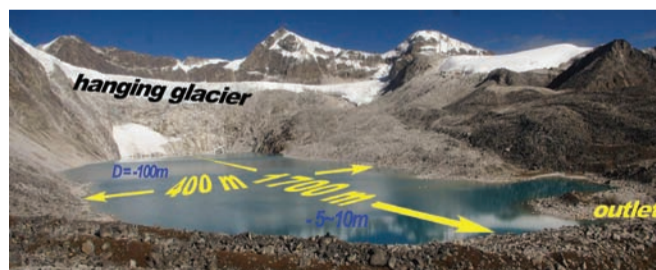
The watersheds of Pho Chu and Mo Chu have covered the most of Gasa district, the biggest Dzongkhag in Bhutan. The area has a rich and diverse national environment and people's life is not easy in high mountain villages. Historically they had traveled with the Tibetan side. Including an acclimatization date, 10 days are required to visit Lunana from Gasa. As for the nature, life, history, and tough journey, this is definitely one of the most unique and precious districts in the world. I'd like to keep an eye on these glacierized areas from now on.

The altitudes around peaks and ridge of the Himalayan range (Chinese border) are 6000 to over 7000 meter above sea level. The white patches in the right lower figure indicate the distribution of the glaciers in the northern Bhutan (drawn by Mr. Hiroto Nagai, Nagoya University). Most of the glaciers are located along the border and the dividing ridge between Tarina Chu and Mo Chu (north of a red star in the lower figure). The size of each glacier in the northeast of Pho Chu is relatively-large. In the satellite images, some of them may look

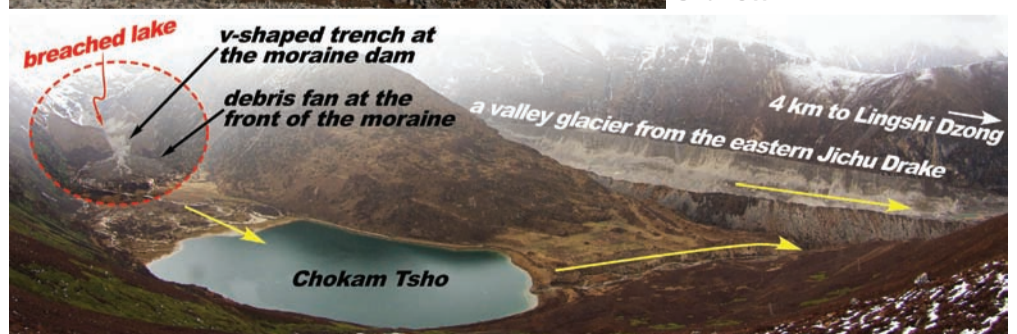
like neckties. These large neckties although not really white, are over 10 km long and over 1 km in width. The upper Thanza village, or the east of these neckties, three typical and large glacier lakes; Luggye, Thorthormi, and Raphstreng Tsho, are adjacently occurred. These are sometimes called "Lunana complex". The well-known GLOF mitigation project by UNDP GEF/DGM is ongoing at the Thorthormi Tsho from 2009. The west of Thorthormi, the terminal moraine of Raphstreng Tsho also was artificially trenched along the outlet in the late 1990s by Bhutan/India collaboration for the disaster

mitigation. Nevertheless the potential hazards remain until now. Unlike the both lakes, Luggye Tsho seems to be not potentially hazardous, because the height difference between the lake level after 1994 GLOF and the downstream river bed is small.

We furthermore conducted the lake depth surveys on the two lakes near Gangju La pass (red star in the lower figure and an upper photograph), which have been considered as two of the 25 potential dangerous lakes. According to our survey result, both lakes have showed stable condition and unlikely to cause dam breaching.



The surveyed glacier lake in the north of Gangju La. The condition seems to be safe, because the water depth near the outlet is shallow.



The past case of outburst near Lingshi Dzong. The event was at least before the mid-1960s.