

## **5. Distribution of Glacier Lakes in the Nepal Himalaya**

How many glacier lakes exist in Nepal and where are they located? These are the most basic information concerned with the potential GLOF hazard. The maps already published are one source to obtain such information but those are relatively too old to identify the present status of the glacier lakes. Unfortunately the speed of development of the lakes is remarkably high rate as discussed in Section 6. 3. Though satellite imageries could be useful for above purpose, they only permit identifying the location of a glacier lake whose area is more than some critical size ; the state of danger is never evaluated because of the limitation in the resolution. The flight observation is mostly an effective and an useful measure because it could enable inspection and identification of the detailed features of a glacier lake such as its potential dangerousness and also topographical conditions around the lake.

Flight observations were first conducted in the pre-monsoon season in 1991 (Yamada, 1991) and one set of oblique photographs of glacier lakes was obtained. The flights were made in the Langtang Khola basin on April 22nd, 1991, and in the Barun Khola basin, a tributary of the Arun river, and the Dudh Koshi basins including the Honku and the Hinku river basins on April 25th, 1991 and in the Chilime Khola basin (Ganesh Himal), tributary of the Trisuli river, southern part of Manaslu range and a part of the Marsyangdi river basin on May 5th, 1991. The flights were also made over the Tama Kosi basin on October 9th, 1991 ; the Shorong and Rolwaling Himal on 12th May., 1993. The Khumbu region and the Langtang Khola basin could be relatively well observed among the basins flown over.

The distribution of the glacier lakes observed by the flight in the Khumbu regions, which includes the drainage basins of Barun Khola, Hunku, Hinku and Dudh Kosi, is shown on the map based on the Glacier Inventory Map of Khumbu Himal (Higuchi et al., 1978) in Fig. 4 (Yamada, 1993). The other lakes compiled with the aid of maps and satellite imageries are shown in Fig. 5 (Yamada, 1996). The number beside the lake in Figs. 4 and 5 corresponds to the Photo's number shown in this Chapter.

The remarkable lakes at each basin will be described below with reference to their aerial oblique photos, if available to show.

### **5. 1 Tamur River Basin**

Three glacier lakes are identified by the satellite imageries in the upstream area of Tamur River as shown in Fig. 5. Since there are no detailed information, a flight observation is required.

### **5. 2 Arun River Basin in Nepal**

Two glacier lakes were found on the Barun glacier and on the Lower Barun glacier in Barun Khola, one of the tributaries of the Arun river, the approach route to the famous Mt. Makalu (8475 m a.s.l.). The glacier lake on the Barun glacier looks too small to cause a serious disaster downstream. The glacier lake formed on the Lower Barun glacier (Photo 4 ; No.4 in Fig. 4) is dammed by an ice-cored moraine. The lake makes contact with the cliff-shaped glacier terminus,

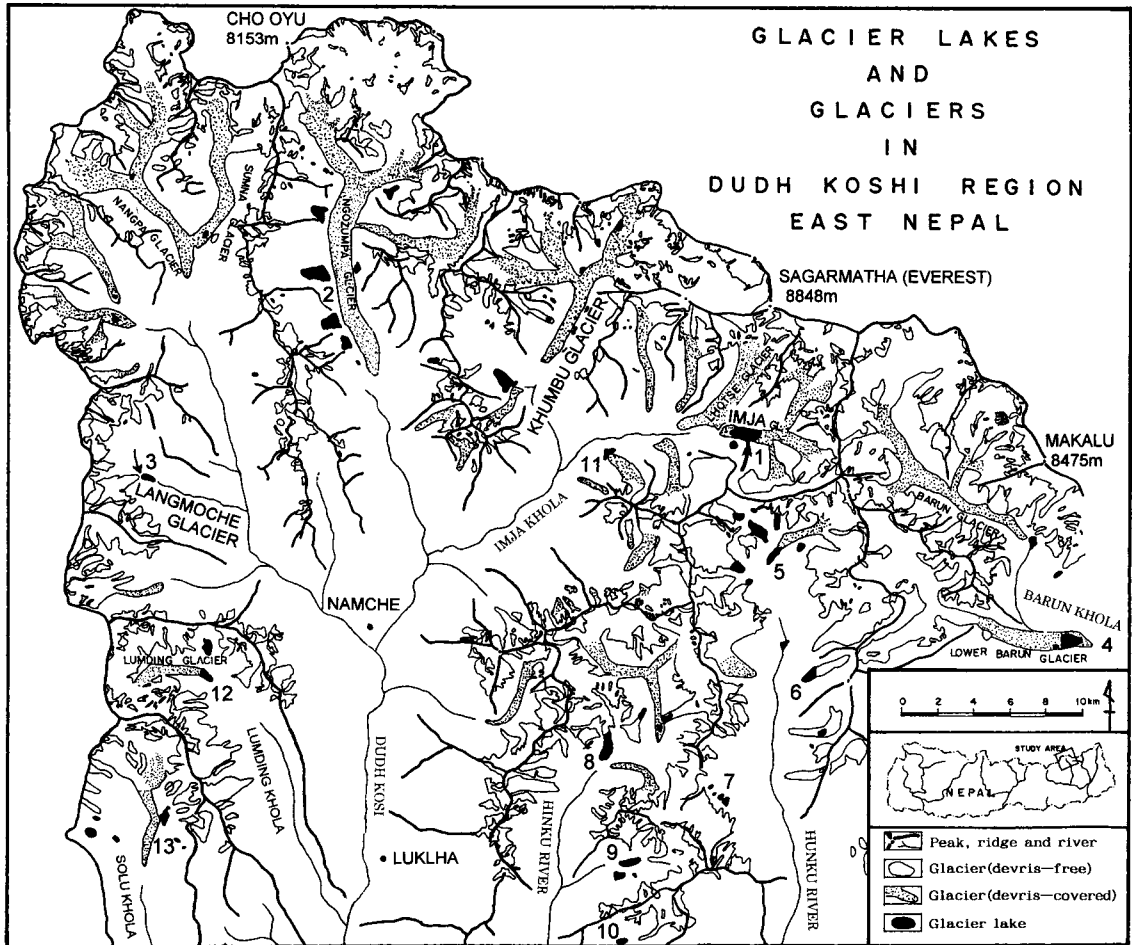
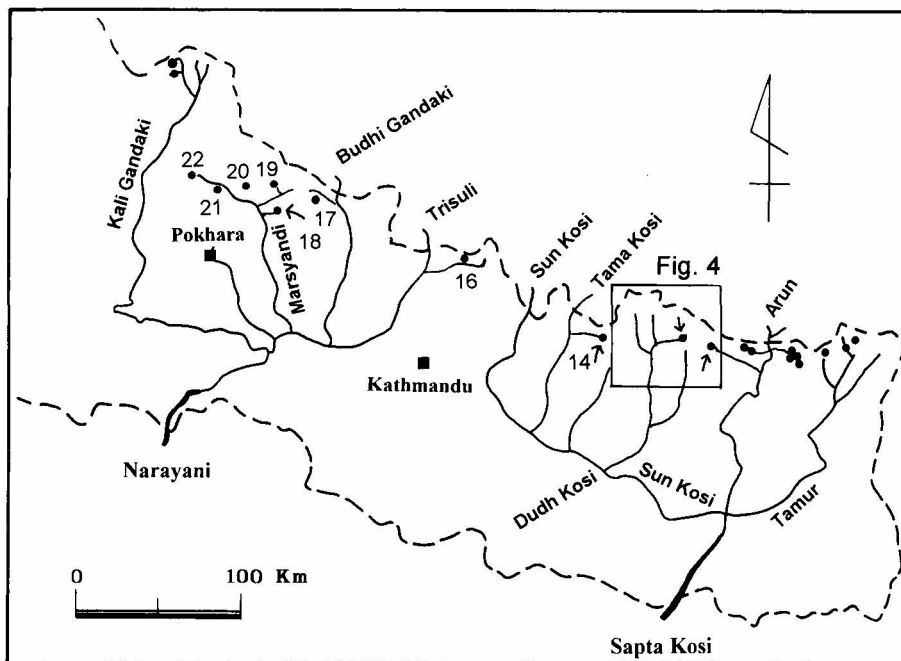


Fig. 4 : Detailed distribution of glacier lakes and glaciers in the Dudh Kosi region, East Nepal. Arrow pointing Imja glacier lake and Dig Tsho. Number beside a lake corresponding to the Photo's number in Chapter 5.

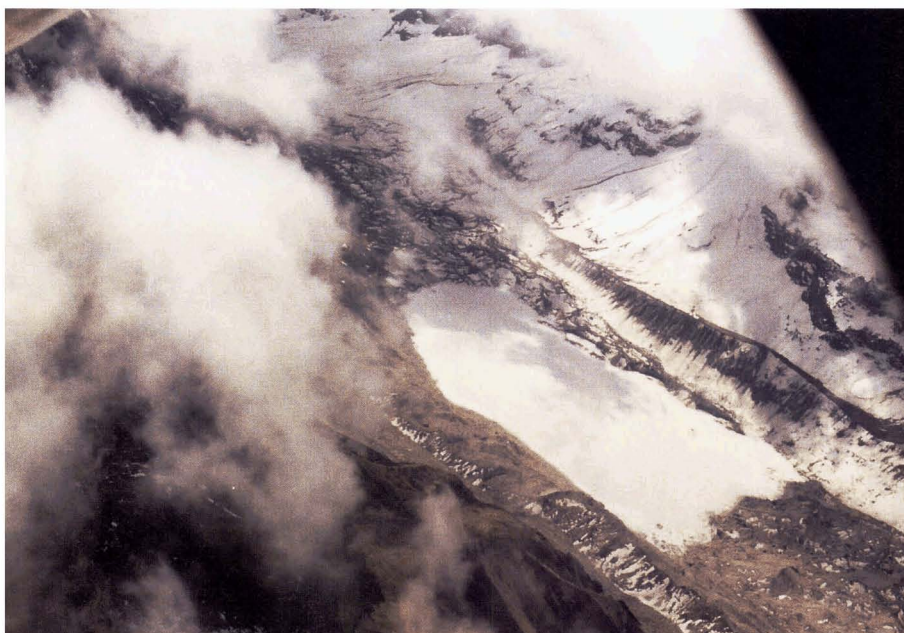
which is stagnant and covered with thick debris. Since the lake seems to be potentially dangerous, the investigation was made in 1993 (Kadota and Mool, 1993). The outline of the lake will be stated in Chapter 6.

Besides the Barun Khola, glacier lakes of other areas were investigated by Nepal Electricity Authority (NEA) within the territory of Nepal above Arun 3 and the Upper Arun Project sites for a hydro-power development (NEA Report, 1987). Two lakes near Kepu Pokhari were visited on foot to identify the GLOF potential, which is located in the headwater of Chhokang Khola, the first tributary on the right bank side of Arun river after it enters Nepal from Tibet. A flight observation was also made of Tingde Danga Pokhari consisting of four lakes located in the upper reach of the Medok Chheje Khola, the first tributary on the left bank side of Arun river after it enters Nepal from Tibet. Those lakes were concluded to be safe.





**Fig. 5 :** Distribution of glacier lakes found so far except the Dudh Kosi region shown in Fig. 4. The potentially dangerous glacier lake being pointed by an arrow. Number beside the lake corresponding to the Photo's number in Chapter 5.



**Photo 4 :** Glacier lake formed on the Lower Barun glacier in the Barun Khola basin (No. 4 in Fig. 4).

### 5. 3 Dudh Kosi Basin

#### 5. 3. 1 Hunku Khola Basin

Sixteen glacier lakes were observed by the flight. Some of them were already separated from the mother glacier and looks safety. The remarkable ones are only introduced here. The glacier lake on the terminus of Hunku glacier located at the headwater of the Hunku river is shown in Photo 5 (No. 5 in Fig. 4). The lake still contacts with the mother glacier. Photo 6 (No. 6 in Fig. 4) shows Chamlang Tsho (left in the photo) and an unnamed glacier lake (right in the same photo) formed at the glacier tongues. Both the lakes are now separated from the mother glaciers. Four small glacier lakes were formed in front of the Naulekh glacier located on the right bank side of the Hunku river, which are shown in Photo 7 (No. 7 in Fig. 4) ; all the lakes are separated from the mother glacier.

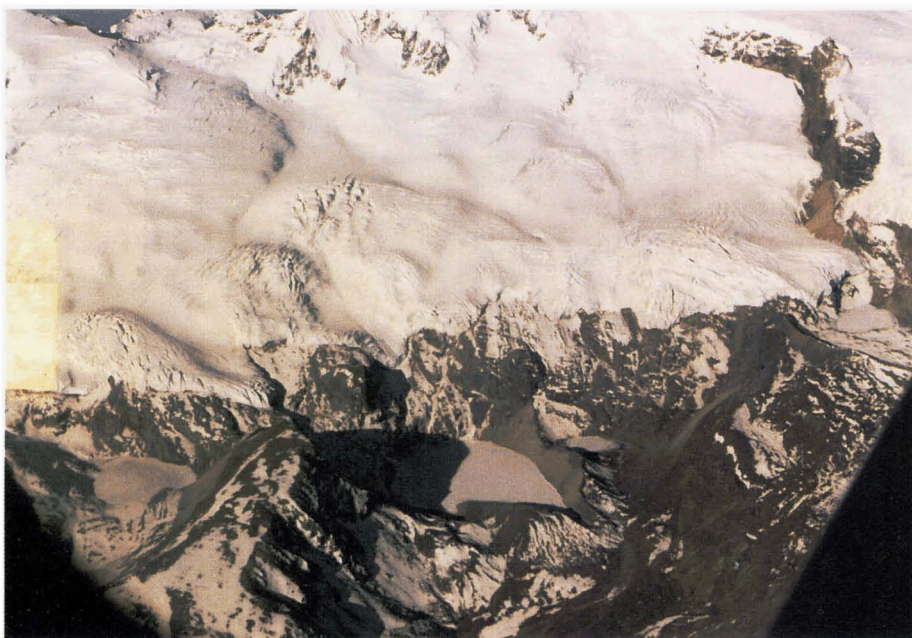


**Photo 5 :** Glacier lake formed on the Hunk glacier in the Hunk river basin (No. 5 in Fig. 4).





**Photo 6** : Glacier lake, Chamlang Tsho, and an unnamed glacier lake in the Hunku river basin (No. 6 in Fig. 4).



**Photo 7** : Glacier lake formed in front of the Naulekh glacier in the Hunku river basin (No. 7 in Fig. 4).

### **5. 3. 2 Hinku Khola Basin**

A total of three large and four small glacier lakes were identified as shown in Fig. 4. Photo 8 shows a glacier lake, Sabai Tsho, formed on the tongue of the Sabai glacier (No. 8 in Fig 4) ; the very steep mother glacier approaches the lake. The glacier lake, Dudh Kund on the Sanu glacier is shown in Photo 9 (No. 9 in Fig. 4). Photo 10 shows the glacier lake at the end of the Mojang glacier also on the left bank side of the Hinku river (No. 10 in Fig. 4). Both the lakes are separated from the glaciers.



**Photo 8 :** Glacier lake, Sabai Tsho, formed below the Sabai glacier in the Hinku river basin (No. 8 in Fig. 4).





**Photo 9** : Glacier lake, Dudh Kund, formed below the Sanu glacier in the Hinku river basin (No. 9 in Fig. 4).



**Photo 10** : Glacier lake formed below the Mojang glacier in the Hinku river basin (No. 10 in Fig. 4).

### 5. 3. 3 Dudh Kosi Basin above Namche Bazar

This basin is known as the heart of the Nepal Himalaya, where the famous great Himalayan peaks over 8,000 m including Mt. Everest (officially named Sagarmatha in Nepal and Qomolangma in Tibet) are located. The basins were fully flown over and 21 glacier lakes were observed.

Imja glacier lake (No. 1 in Fig. 4) and Ngozumpa glacier lakes (No. 2 in Fig. 4) already introduced as a typical moraine-dammed lake and a ice-dammed lake, respectively in Section 3. 2 are located in this region. The glacier tongue of the Imja glacier is stagnant and covered with thick debris. The lake contacts with the cliff-shaped glacier end. The Imja lake will be discussed in detail in Chapter 6. Dig Tsho previously reported as a glacier lake burst in the past is also located in this region (No. 3 in Fig. 4). It is sure that the ponds on the Ngozumpa glacier tongue have been quickly growing year after year ; they seem to have a possibility to become a glacier lake in the near future. A crescent-shaped glacier lake in front of the Duwo glacier is shown in Photo 11 (No. 11 in Fig. 4). The lake is already separated from the mother glacier.



**Photo 11** : Crescent-shaped glacier lake formed in front of the Duwo glacier in the Imja Khola basin (No. 11 in Fig. 4).



#### 5. 3. 4 Lumding Khola Basin

Only one glacier lake, Tsho Og, is found on the Lumding glacier tongue as shown in Photo 12 (No. 12 in Fig. 4). One more lake seen to the north of the Lumding glacier, Lumding Tsho Teng, may be a safety cirque lake.



**Photo 12 :** Glacier lake, Tsho Og, formed on the Lumding glacier in the Lumding river basin (No. 12 in Fig. 4).

#### 5. 3. 5 Solu Khola Basin

In the headwater area of the Dudh Kund Khola, a tributary of the Solu Khola, many lakes can be seen. An ice-dammed lake is only observed as a glacier lake on the left side of the Dudh Kund glacier (Photo 13 ; No. 13 in Fig. 4). The lake is dammed by the thick lateral moraines and the glacier. They are evaluated as safe.



**Photo 13** : Ice-dammed glacier lake beside the Dudh Kund glacier in the Dudh Kund Khola basin, a tributary of the Solu Khola (No. 13 in Fig. 4).

#### 5. 4 Tama Kosi Basin

Only one glacier lake, Tsho Rolpa, can be found within the territory of Nepal in the basin. The lake is located at the uppermost reach of the Rolwaling Khola and formed on the terminus of the Trakarding glacier below the Trambau glacier as shown in Photo 14 (No. 14 in Fig. 5) and the cover photograph. The lake can be easily found in Schneider's Map of "Rolwaling Himal" on a scale of 1 : 50,000 edited in 1981. The lake has been investigated in detail (Mool et. al., 1993 ; Kadota, 1994 ; Yamada, 1995 ; Yamada, 1996) ; The detailed description will be given in Chapter 6.

During the flight many ponds were observed on the tongue of the Drotpa Nagtsang glacier as shown in Photo 15 taken in 12th May, 1993, which was located in the Tibetan side, just behind Mt. Kang Nachuga (5736 m a.s.l. in Schneider Map) north of Naa Gaon (see Fig. 10). The ponds may be the embryos of a future glacier lake.





**Photo 14 :** Moraine-dammed glacier lake, Tsho Rolpa, formed on the terminus of the Trakarding glacier, Rolwaling Khola, a tributary of Tama Kosi (No. 14 in Fig. 5).



**Photo 15 :** Ponds seeming to be typical embryos of the future glacier lake on the Drogpa Nagtsang glacier located in Tibetan side behind the Gaurisankar Himal.

### 5. 5 Langtang Khola and Chilime Khola Basin

The full area in the Langtang Khola (Langtang Himal) basin and a partial area of the Chilime Khola basin (Ganesh Himal) were observed. No remarkable glacier lakes were found. The most noticeable lake is shown in Photo 16 (No. 16 in Fig. 5), which was a very small glacier lake under the hanging glacier of Khyimjung glacier located at the right bank side of the Langtang Khola. The end moraine-dam might have burst once and the deep breach can be noticed.



**Photo 16** : Glacier lake formed below the Khyimjung glacier in the Langtang Khola basin, a tributary of the Trisuli river (No. 16 in Fig. 5).

### 5. 6 Burhi Gandaki Basin

The basin was not yet observed by the flight but Mr. Yoneyama, who belongs to the Academic Alpine Club of Hokkaido University, Japan, took a terrestrial photograph of the glacier lake formed on Manasulu glacier tongue as shown in Photo 17 (No. 17 in Fig. 5) taken in around 1982 (personal communication). The lake is dammed by the moraines. Uplake end contacts with the cliff-shaped mother glacier end. There is no other information of a glacier lake in this basin, yet.





**Photo 17 :** Glacier lake formed on the Manaslu glacier in the Burhi Gandaki basin (No. 17 in Fig. 5). The photograph being taken by S. Yoneyama in 1982.

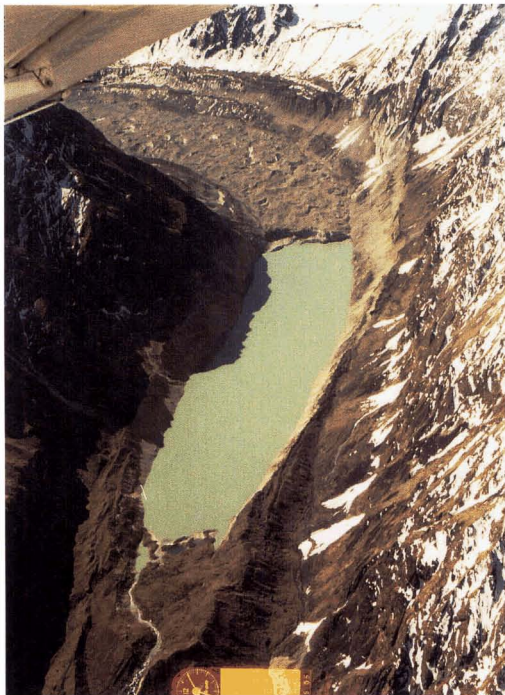
### 5. 7 Marsyangdi Basin

The basin was also partially covered by flight observation over only in the southern areas of Mt. Manaslu (8156 m a.s.l.) to the uppermost reach of the Marsyangdi river via the Himlung Himal over the Dudh Khola and the Phu Khola. The glacier lake on the terminus of the Thulagi glacier is shown in Photo 18 (No. 18 in Fig. 5), located at the south-west of Mt. Manaslu, uppermost reach of the Dhana Khola ; the lake still contacts with the cliff-shaped glacier end, which is stagnant and covered with thick debris ; the lake will be also discussed in Chapter 6. Two ice-dammed lakes formed beside the Himlung South glacier and the Kicakekhola glacier are found as shown in Photo 19 (No. 19 in Fig. 5) at the upper reach of Dudh Khola, north-west of Mt. Manaslu. A glacier lake formed under a nameless glacier on the south-west slope of Mt. Kang Guru (7,010 m a.s.l.) is shown in Photo 20 (No. 20 in Fig. 5). A small moraine-dammed lake is found near the Manan Village at right bank of the Marsyangdi river on the terminus of the Gangapurna glacier as shown in Photo 21 (No. 21 in Fig. 5) ; the lake is already separated from the mother glacier. The famous lake, Tilitsho (Photo 22 ; No. 22 in Fig. 5), located on the headwater of Marsyangdi is also a glacier lake dammed by moraine ; the lake contacts with a sheet-shaped glacier end below Mt. Tilitsho Himal (7134 m a.s.l.).

### 5. 8 Kali Gandaki Basin

Several glacier lakes are seen in the headwater of the Kaligandaki river in the satellite imageries. One of them burst in 1995 as mentioned in Section 4. 4. The detailed information of the lakes still remains unknown.

Glacier lakes develop in the eastern part than in the western part in the Nepal Himalaya because the glaciers are much developed in the former regions.



**Photo 18** : Glacier lake formed on Thulagi glacier in the Dhana Khola basin, a tributary of Marsyangdi river (No. 18 in Fig. 5).



**Photo 19** : Two ice-dammed glacier lakes formed beside the Himlun South glacier and the Kicakekhola glacier in the Dudh Khola basin, a tributary of Marsyangdi river (No. 19 in Fig. 5).



**Photo 20** : Glacier lake formed on an unnamed glacier flowing down along the south - west slope of Mt. Kang Guru at left hand side of the Marsyangdi river (No. 20 in Fig. 5).





**Photo 21** : Small moraine-dammed lake on the terminus of the Gangapurna glacier at the right bank of the Marsyangdi river near the Manang Village (No. 21 in Fig. 5).



**Photo 22** : Glacier lake, Tilitsho, in the headwater of Marsyangdi river (No. 22 in Fig. 5).