Chapter 8
The Inventory of Glacial Lakes

8.1 Brief Description of Glacial Lake Inventory

The inventory of glacial lakes is based on topographic maps, aerial photographs, and satellite images. The topographic maps published by the Survey Department of Nepal on a scale of 1:50,000 still do not cover all the glaciated regions of Nepal. The 1:63,360 scale topographic maps published by the Survey of India in the period from the 1950s to the 1970s are used for the inventory of glacial lakes. As some of the topographic maps are unavailable due to restrictions, the data of that area are assembled from satellite images and aerial photographs. The aerial photographs, on a scale of 1:50,000, used for the inventory of lake areas, were acquired in 1992 for eastern Nepal and 1996 for western Nepal. Images of the Land Observation Satellite (LANDSAT) Thematic Mapper (TM), Indian Remote Sensing (IRS), and Stéréo Système Probatoire d'Observation de la Terre (SPOT) of different years are used.

8.2 Glacial Lakes—Their Numbering, Type and Characteristics

A glacial lake is defined as a water mass existing in a sufficient amount and extending with a free surface in, under, beside and/or in front of a glacier and originated by glacier activities and/or retreating processes of a glacier.

The numbering of the lakes started from the mouth of the major stream and proceeded clockwise round the basin.

For the inventory of glacial lakes, it is obvious to note that the lakes associated with perennial snow and ice originate from glaciers. But the isolated lakes found in the mountains and valleys far from the glaciers may not have a glacial origin. Due to the faster rate of ice and snow melting, possibly caused by global warming noticed during the last half of the twentieth century, accumulation of water in these lakes has been increasing rapidly. The isolated lakes above 3,500 masl are considered to be the remnants of the glacial lakes left due to the retreat of the glaciers.

The lakes are classified into erosion lakes, valley trough lakes, cirque lakes, blocked lakes, lateral and end moraine-dammed lakes, and supraglacial lakes.

Erosion lakes

Glacial erosion lakes are the water bodies formed in a depression after the glacier has retreated. They may be cirque type and trough valley type lakes and are stable lakes.

Supraglacial lakes

The supraglacial lakes are small and change their position in the glacier. The Lanzhou Institute of Glaciology and Geocryology (LIGG)/the Water and Energy Commission Secretariat (WECS)/the Nepal Electricity Authority (NEA) study did not consider such lakes in their classifications. However, the history of past glacial lake outburst flood (GLOF) events of moraine-dammed lakes indicates that they are initially derived from supraglacial lakes. As the target of the project is to identify and monitor the potentially dangerous glacial lakes with the help of time series' satellite images, aerial photographs, and topographic maps, it will be helpful to know the activity of supraglacial lakes. If supraglacial lakes are situated at the toe of a valley glacier, larger in size, or grouping rapidly to expand their size, then they are potentially dangerous and may burst out in the near future.

The supraglacial lakes develop within the ice mass away from the moraine with dimensions of from 50 to 100m. These lakes may develop in any position of the glacier but the extension of the lake is less than half the diameter of the valley glacier. Shifting, merging, and draining of the lakes characterise the supraglacial lakes. The merging of lakes results in expansion of the lake area and storage of a huge volume of water with a high potential energy. The tendency of a glacial lake towards merging and expanding indicates the danger level of the GLOF.

Most of the potentially dangerous lakes, including Tsho Rolpa, Imja, Lower Barun, Thulagi, etc, are advanced forms of supraglacial lake.

Moraine-dammed lakes

A typical example of a moraine-dammed lake is one formed on the tongue of the Imja Glacier in the Khumbu region, eastern Nepal. In the retreating process of a glacier, glacier ice tends to melt in the lowest part of the glacier surrounded by lateral and end moraines. As a result, many supraglacial ponds are formed on the glacier tongue. These ponds sometimes enlarge to become a large lake by interconnecting with each other and have a tendency to deepen further. A moraine-dammed lake is thus born. The lake is filled with melt water and rainwater from the drainage area behind the lake and starts flowing from the outlet of the lake even in the winter season when the flow is minimum.

There are two kinds of moraine: an ice-cored moraine and an ice-free moraine. Before the ice body of the glacier completely melts away, glacier ice exists in the moraine and beneath the lake bottom. The ice bodies cored in the moraine and beneath the lake are sometimes called **dead ice** or **fossil ice**. As glacier ice continues to melt, the lake becomes deeper and wider. Finally when ice contained in the moraines and beneath the lake completely melts away, the container of lake water consists of only the bedrock and the moraines.

Ice-dammed lakes

An ice-dammed lake is produced on the side(s) of a glacier, when an advancing glacier happens to intercept a tributary/tributaries pouring into a main glacier valley. The typical ice core-dammed lakes are shown in Figure 8.1. Three lakes are seen on the right bank of the debris covered glacier tongue of the Ngozumpa Glacier in the Dudh Koshi Basin, which is one of the largest glaciers in the Nepal Himalayas and flows from top to bottom in the figure. The lakes were still frozen and covered by snow when the image was captured. Since the glaciers in the Nepal Himalayas produce relatively rich debris, thick lateral moraines are deposited on both sides of the glacier tongue. As such an ice core-dammed lake is usually small in size and does not come into contact with glacier ice. This type of lake is less susceptible to GLOF than a moraine-dammed lake.

A glacial lake is formed and maintained only up to a certain stage of glacier fluctuation. If one follows the lifespan of an individual glacier, it is found that the moraine-dammed glacial lakes build up and disappear with a lapse of time. The moraine-dammed lakes disappear once they are fully destroyed or when debris

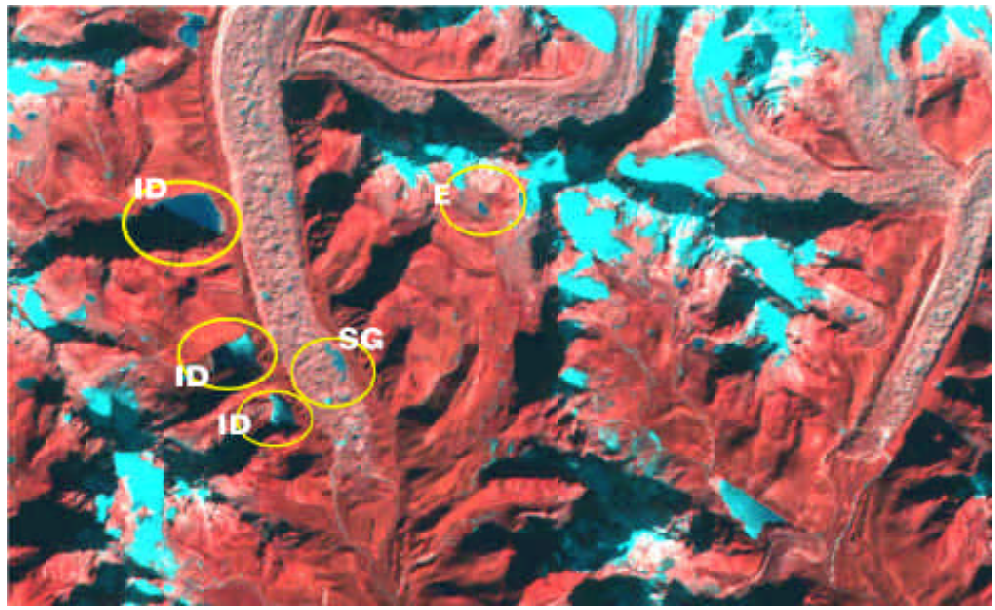

Figure 8.1: The lakes labelled ID, SG, and E represent ice core-dammed, supraglacial, and erosion lakes respectively around the Ngozumpa Glacier, one of the largest glaciers in the Nepal Himalayas (LANDSAT TM satellite image of 17 December 1991)

fills the lakes completely or the mother glacier advances again to lower altitudes beyond the moraine-dam position. Such glacial lakes are essentially ephemeral and are not stable from the point of view of the life of glaciers.

Only moraine-dammed lakes pose a threat in the Nepal Himalayas. The description hereafter is, thus, mainly concentrated on moraine-dammed lakes and associated outburst floods.

8.3 Glacial Lakes of Nepal

As in the inventory of glaciers, major river systems like Koshi, Gandaki, Karnali, and Mahakali are further divided into sub-basins. Altogether 2,323 lakes have been identified above 3,500 masl. They cover an area of 75.70 sq.km (Figure 8.2).

The Koshi River basin

There are 1,062 lakes in the Koshi River Basin covering an area of around 25 sq.km, of which the largest number is of erosion lakes and supraglacial lakes. Generally, the erosion lakes are isolated and far away from the glaciers, and the supraglacial lakes are situated in groups, within the ice mass.

The number as well as the mean area per lake of the Dudh Koshi Sub-basin are higher than those in the other sub-basins of the Koshi Basin. The lakes of the Sun Koshi Sub-basin have a minimum mean area per lake. The Likhu and Indrawati Sub-basins are smaller in area and consist of only 14 and 18 lakes respectively (Table 8.1).

The Tamor River is the easternmost branch of the Koshi River. It consists of the highest number of lakes (356) after the Dudh Koshi Sub-basin (Figure 7.3). Besides the erosion, valley, and cirque lakes, it consists of 21 moraine-dammed lakes, 6 blocked lakes, and 72 supraglacial lakes (Table 8.2). The erosion lakes, cirque lakes, and valley lakes are not potentially dangerous as they are isolated and not associated with the hanging glaciers. In general, erosion and valley lakes are higher in number. The most potentially dangerous lakes

Table 8.1: Distribution of lakes in the sub-basins of the Koshi River Basin

Sub-basin Name	Number of Lakes	Area (km²)	Mean area per lake (km²)
Tamor	356	7.320	0.020
Arun	109	2.530	0.023
Dudh	473	13.075	0.027
Tama	57	1.258	0.022
Sun Koshi	35	0.412	0.011
Likhu	14	0.217	0.025
Indrawati	18	0.278	0.015
Total	1062	25.090	

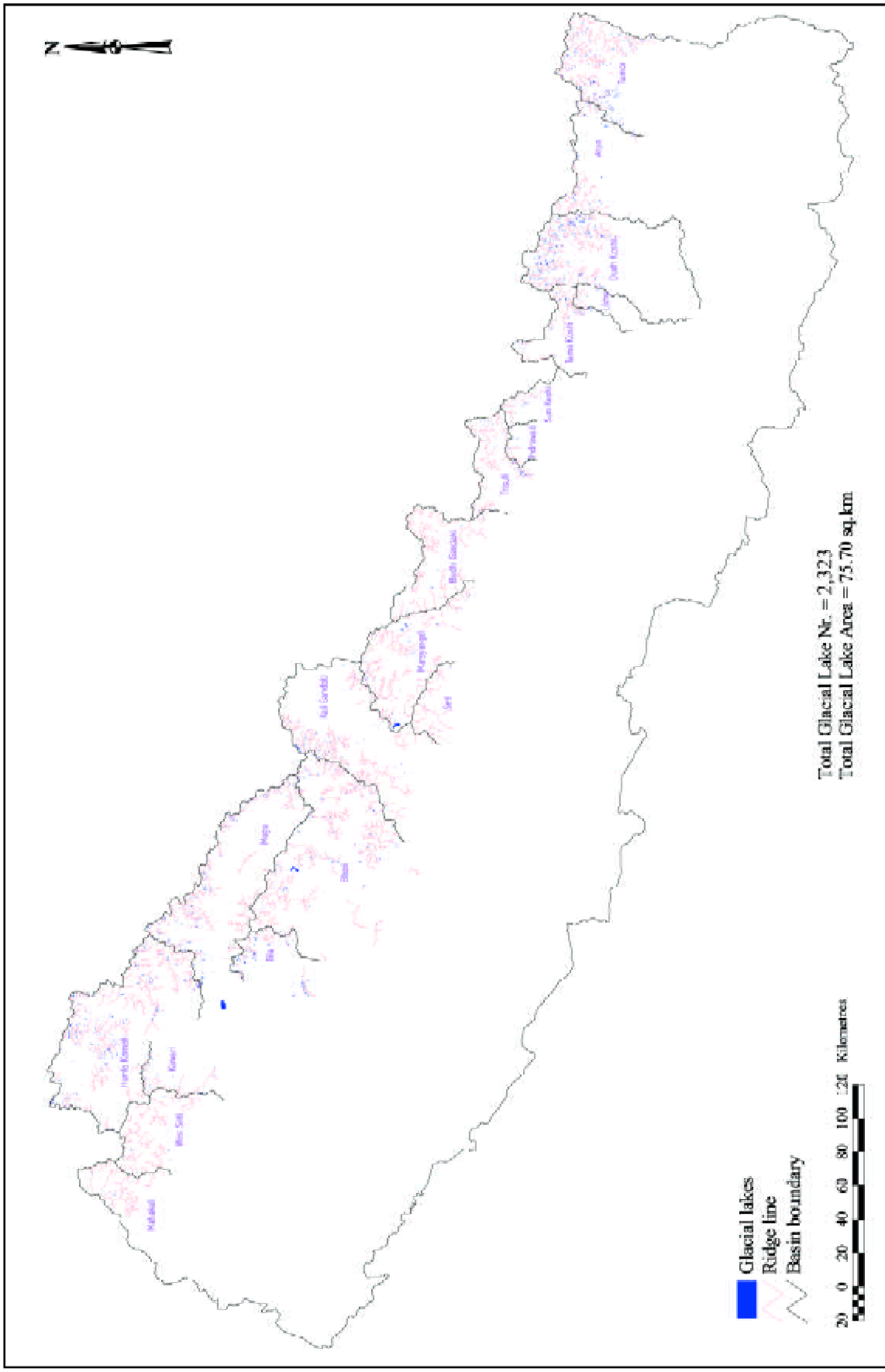

Figure 8.2: Glacial lakes of Nepal

are identified in the categories of moraine-dammed lakes and blocked lakes. They are described in Chapter 11.

The Arun Sub-basin is the largest sub-basin of the Koshi River Basin. Since the major part of the Arun River catchment lies in Tibet (China), a large number of lakes is also situated in China. The number of lakes in Nepal is 109 (Figure 7.4), of which the majority are erosion and cirque lakes. There are seven valley lakes (Table 8.3). The valley lakes situated at the toes of the glaciers are potentially dangerous. Beside the six supraglacial lakes, there is also one moraine-dammed lake with an area of around 100,000 sq.m. Among the sub-basins of the Koshi River Basin, the Dudh Koshi River Sub-basin has the highest number of lakes. There are 473 glacial lakes (Figure 7.5). It has the highest number of supraglacial lakes in the sub-basins of the Koshi River Basin (Table 8.4). There are large numbers of moraine-dammed lakes and blocked lakes too, and this signals potential danger. More than 25% of the lake area is occupied by moraine-dammed and blocked lakes. The well-known lakes in the sub-basin are Lumding Tsho, Dig Tsho, Chokarma Cho, Imja Tsho, Tam Pokhari, Dudh Pokhari, Hungu, and Chamjang Lakes. Some of them have already burst in the past.

The Likhu River Sub-basin is smaller in aerial extension and has a less lakes than other sub-basins (Figure 7.6). Most of the lakes are the erosion type. Some are also cirque and supraglacial types (Table 8.5). None of these lakes is categorised as potentially dangerous.

There are only 57 lakes in the Tama Koshi Sub-basin, of which 20 are supraglacial lakes (Table 8.6 and Figure 7.7). The well-known Tsho Rolpa Glacial Lake of this sub-basin created great panic some years ago and has undergone mitigation measures recently. In the beginning the Tsho Rolpa Glacial Lake developed in the form of a supraglacial lake, this has now transformed into an end moraine-dammed lake of extreme vulnerability.

Table 8.2: Types of lakes in the Tamor River Sub-basin

Type		Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion		110	31.61	1239403.71	16.93	98767.42
Valley		127	36.49	3472215.36	47.42	252344.62
Cirque		20	5.75	826671.91	11.29	140286.65
Moraine dammed	End	16	4.60	633442.78	8.65	181146.84
	Lateral	5	1.44	84861.79	1.16	28668.04
Blocked		6	1.72	104259.38	1.42	58676.11
Supraglacial		72	20.69	961400.70	13.13	57731.49

Table 8.3: Types of lakes in Arun River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Cirque	15	13.76	510323.37	20.19	148940.53
Erosion	80	73.39	1596781.06	63.19	84476.61
Supraglacial	6	5.50	67157.84	2.66	34637.33
Valley	7	6.42	235533.86	9.32	119113.94
Moraine dammed	1	0.92	117189.64	4.64	117189.64

Table 8.4: Types of lakes in the Dudh Koshi River Sub-basin

Type		Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion		141	29.81	3607401.97	27.59	406643.81
Cirque		9	1.90	335125.01	2.56	120568.60
Blocked		10	2.11	1764386.87	13.50	529069.35
Valley		13	2.75	1706397.20	13.05	650699.06
Supraglacial		267	56.45	3369527.74	25.77	207314.33
Moraine-dammed	End	19	4.02	1392918.84	10.65	209834.47
	Lateral	14	2.96	898282.51	6.87	274296.89

Table 8.5: Types of lakes in the Likhu River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	10	71.43	154020.08	70.98	35 149.26
Cirque	2	14.29	61597.42	28.39	55 973.54
Supraglacial	2	14.29	1379.44	0.64	689.72

Table 8.6: Types of lakes in the Tama Koshi River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	29	50.88	469010.52	37.28	69078.25
Supraglacial	20	35.09	369637.62	29.38	231693.33
Blocked	3	5.26	155797.44	12.38	91653.36
Moraine dammed	2	3.51	26209.41	2.08	13529.15
Valley	2	3.51	123725.40	9.84	74224.63
Cirque	1	1.75	113618.33	9.03	113618.33

Table 8.7: Types of lakes in the Sun Koshi River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	20	57.14	254793.22	61.87	67479.81
Supraglacial	9	25.71	62047.23	15.07	21381.08
Moraine-dammed	1	2.86	18919.21	4.59	18919.21
Valley	4	11.43	53718.13	13.04	23246.04
Cirque	1	2.86	22343.82	5.43	22343.82

The Sun Koshi River Sub-basin comprises 35 glacial lakes, out of which 20 are erosion type, 9 supraglacial, 1 moraine-dammed, 4 trough valley, and 1 cirque (Table 8.7). The distribution of the lakes is shown in Figure 7.8. The areas of lakes located within Nepalese territory are very small and, therefore, none of these lakes is dangerous from the perspective of the GLOF event. However, the GLOF that occurred at the headwaters of this sub-basin located in Tibet has affected infrastructures in Nepalese Territory (see Chapter 9).

Table 8.8: Types of lakes in the Indrawati River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	17	94.44	266296.58	95.57	118854.35
Supraglacial	1	5.56	12336.82	4.43	12336.82

The Indrawati River Sub-basin is small in aerial extension and has less lakes than other sub-basins (Figure 7.9). Most of the lakes are erosion types. There is only one supraglacial lake in the sub-basin (Table 8.8). None of these lakes is categorised as potentially dangerous.

The Gandaki River basin

The area covered by the glaciers in this basin is the largest, but the area covered by the lakes is the smallest among the three major basins, namely, the Koshi, Gandaki, and Karnali basins. There are 338 lakes in total listed in this basin with an area of 12.28 sq.km (Figure 7.10). The average lake area ranges from 0.01 to 0.08 sq.km (Table 8.9). Among the sub-basins, the Trishuli River sub-basin has the highest number of lakes (117), whereas the largest area (6.28 sq.km) is covered by the Marsyangdi River Sub-basin.

Table 8.9: Distribution of lakes in the sub-basins of the Gandaki Basin

Sub-basin Name	Number of Lakes	Area (m^2)	Mean area per lake (km^2)
Trisuli	117	2.03	0.02
Budi Gandaki	37	0.64	0.01
Marsyangdi	78	6.28	0.08
Seti	10	0.26	0.03
Kali Gandaki	96	3.29	0.03
Total	338	12.50	0.17

The Trishuli River Sub-basin elongates in the east–west direction in general. The major part (50%) of the river is in China and goes by the name of Chi_lung Ho, and it enters Nepal by the name of Bhotekoshi, one of the major tributaries of the Trishuli River. It consists of 117 lakes and accounts for the highest number of lakes amongst the sub-basins of the Gandaki Basin (Figure 7.11). The number of supraglacial lakes is highest, then erosion lakes, and then valley lakes (Table 8.10). There is one each of the blocked, cirque, and lateral moraine-dammed lakes. No potentially dangerous lake in this sub-basin within the territory of Nepal is recorded.

Table 8.10: Types of lakes in the Trisuli River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	29	25	831945.59	41.0	167467.28
Erosion	34	29	860809.58	42.4	214713.77
Blocked	1	1	52452.09	2.6	52452.09
Supraglacial	51	44	273297.61	13.5	19430.01
Cirque	1	1	7907.41	0.4	7907.41
Lateral moraine-dammed	1	1	4075.06	0.2	4075.06

The Budhi Gandaki River Sub-basin generally trends from north to south. The river originates in Chinese territory. About 25% of the catchment area lies in China. It comprises only 37 lakes in Nepal (Figure 7.12), of which most are supraglacial and erosion lakes (Table 8.11). There are three valley lakes and one moraine-dammed lake. As the area occupied by the supraglacial lakes is

Table 8.11 Types of lakes in the Budi Gandaki River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	6	16.22	259549.82	40.47	11268.31
Supraglacial	27	72.97	242422.06	37.80	51740.41
Moraine Dammed	1	2.70	81544.98	12.72	81520.93
Valley	3	8.11	57800.67	9.01	46511.86

small, they do not pose any danger. But the moraine-dammed lake (Gbu_gl 9) is identified as potentially dangerous.

In the Marsyangdi River Sub-basin, there are almost equal numbers of supraglacial lakes, erosion lakes, and valley lakes, seven blocked lakes, and two of both cirque lakes and moraine-dammed lakes (Table 8.12). The distribution of glacial lakes is shown in Figure 7.13. The area occupied by the supraglacial and blocked lakes is not sufficiently large to pose danger. Out of the two moraine-dammed lakes, the Gmar_gl 70 (Thulagi) is identified as a potentially dangerous lake.

Table 8.12: Types of lakes in the Marsyangdi River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	22	28.21	4298517.64	68.37	3945017.46
Cirque	2	2.56	72127.42	1.15	66752.43
Valley	21	26.92	744357.63	11.84	175545.74
Supraglacial	24	30.77	393065.41	6.25	54129.02
Moraine dammed	2	2.56	227176.83	3.61	223385.35
Blocked	7	8.97	551861.73	8.78	269240.01

The catchment area of the Seti River Sub-basin is small and it consists of only ten lakes (Figure 7.14). Out of these, seven lakes are erosion lakes, two are valley lakes, and one is a blocked lake (Table 8.13). The maximum area occupied by the lake is less than 0.11 sq.km, so this sub-basin is relatively safe.

Table 8.13: Types of lakes in the Seti River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	7	70.00	209 675.40	78.26	104 519.29
Blocked	1	10.00	13 332.66	4.98	13 332.66
Valley	2	20.00	44 926.30	16.77	28 165.46

Some parts of the Kali Gandaki River catchment area lie in Chinese territory. This sub-basin consists of a substantial number of glaciers as well as lakes. The average area per lake is greater than in the Trishuli River Sub-basin. Besides the valley lakes and erosion lakes, there is a significant number of moraine-dammed lakes and supraglacial lakes (Table 8.14 and Figure 7.15). The average area of the moraine-dammed lakes is about 0.78 sq.km, which is very large in comparison with the average area of lakes in other sub-basins. The lakes Gka_gl 38, Gka_gl 41, Gka_gl 42, and Gka_gl 67 are found to be potentially dangerous. All the identified potentially dangerous lakes belong to the category of moraine-dammed lakes.

Table 8.14: Types of lakes in the Kali Gandaki River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Supraglacial	15	15.63	159068.98	4.82	36016.13
Erosion	25	26.04	476364.32	14.44	62110.84
Moraine dammed	20	20.83	1569623.88	47.58	1013344.49
Cirque	4	4.17	137024.40	4.15	80975.14
Lateral M. dammed	1	1.04	6115.95	0.19	6115.95
Valley	30	31.25	941285.01	28.53	213460.15
Blocked	1	1.04	9676.79	0.29	9676.79

The Karnali River basin

The Karnali River Basin comprises six major sub-basins: the Bheri, Mugu Karnali, Humla Karnali, Kawari, Tila, and West Seti sub-basins. The headwater area of the Humla Karnali River lies in Chinese territory, all the other sub-basins are located completely within Nepalese territory. The Humla Karnali and Mugu Karnali rivers comprise a great number of lakes. The mean area of the lakes in the basin ranges from 0.03 to 0.07 sq.km (Table 8.15). Altogether the basin consists of 907 glacial lakes (Figure 7.16).

Table 8.15: Distribution of glacial lakes in the sub-basins of the Karnali River Basin

Sub-basin	Number of lakes	Total area (km^2)	Mean area per lake (km^2)
West Seti	15	0.40	0.03
Tila	71	4.97	0.07
Mugu	280	8.56	0.03
Kawari	44	1.57	0.04
Humla	345	13.01	0.04
Bheri	152	9.16	0.06
Total	907	37.67	0.04

Compared with other sub-basins, the Bheri River Sub-basin consists of a large

Table 8.16: Types of lakes in the Bheri River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	52	34	6990069.79	76.3	4528440.96
Supraglacial	9	6	94548.50	1.0	24879.75
Erosion	72	47	1766679.72	19.3	162017.17
Cirque	1	1	61927.77	0.7	61927.77
Blocked	1	1	12467.04	0.1	12467.04
Moraine-dammed	12	8	161772.72	1.8	29714.46
Lateral moraine-dammed	5	3	76404.75	0.8	26264.98

Table 8.17: Types of lakes in the Mugu River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	115	40.71	4 253595.34	49.71	165 593.90
Erosion	124	44.29	3 064 581.15	35.82	350 348.34
Blocked	3	1.07	44 464.82	0.52	26 696.57
Lateral moraine-dammed	3	1.07	35 558.60	0.42	15 867.67
Moraine-dammed	4	1.43	829 649.10	9.70	681 094.15
Supraglacial	30	10.71	270 656.40	3.16	27 668.97
Cirque	1	0.36	58 188.81	0.68	58 188.81

Table 8.18: Types of lakes in the Tila River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	34	47.89	785220.57	15.80	101072.72
Cirque	16	22.54	1767515.46	35.57	444312.07
Valley	20	28.17	2354834.31	47.38	604064.51
Supraglacial	1	1.41	62189.80	1.25	62071.29

Table 8.19: Types of lakes in the Kawari River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	24	55	804 247.79	51	116 558.66
Erosion	14	32	424 950.91	27	103 303.37
Cirque	1	2	114 363.86	7	114 363.86
Supraglacial	3	7	131 758.28	8	112 440.43
Blocked	1	2	42 273.82	3	42 273.82
Moraine-dammed	1	2	61 549.92	4	61 549.92

number of glaciers scattered in the form of remnants. The number of lakes is only 152, which is the third highest in the sub-basins (Figure 7.17) of the Karnali Basin. Among the total number of lakes, there are 12 moraine-dammed lakes, nine supraglacial lakes, and five lateral dammed lakes (Table 8.16). Valley lakes occupy about 76% of total lake area in the sub-basin.

The Mugu Karnali River Sub-basin comprises the second highest number of lakes in the Karnali Basin. The distribution of glacial lakes in accordance with the glaciers is shown in Figure 7.18. The highest number of lakes is of the erosion type, followed by valley lakes (Table 8.17). There are seven moraine-dammed lakes. Most of the lake areas are less than 40,000 sq.m, except Kmu_gl 129, which has an area of 70,000 sq.m. The Kmu_gl 129 is a moraine-dammed lake that is potentially dangerous and may trigger a GLOF event in coming years.

As the number of glaciers is less than in other sub-basins and they are scattered in the form of remnants in the Tila River Sub-basin, the lakes that have developed in the sub-basin are also scattered and their areas small. The lakes are mostly of erosion, valley, and cirque types. There is only one supraglacial lake (Table 8.18). The distribution of glacial lakes in accordance with the glaciers is shown in Figure 7.19. No potentially dangerous lakes are identified in this sub-basin.

There are 44 lakes in total in the Kawari River Sub-basin. Among them, the valley lakes and erosion lakes are highest in number (Table 8.19). There are three supraglacial lakes and one cirque lake, blocked lake, and moraine-dammed lake. The distribution of glacial lakes in accordance with the glaciers is shown in Figure 7.20. No potentially dangerous lakes are identified in this sub-basin.

The Humla River Sub-basin consists of the highest number of glacial lakes (345). Their distribution is shown in Figure 7.21. Most of the lakes are valley lakes due to the dissected topography. The cirque lakes and erosion lakes are of more or less equal proportions (Table 8.20). The sub-basin consists of a high number of moraine-dammed lakes compared to other sub-basins of Nepal. There are 35 moraine-dammed lakes and seven blocked lakes.

Only 15 lakes are found in the West Seti River Sub-basin (Table 8.21). As there are few glaciers, there are only a few lakes. The average size of the erosion lakes is 0.04 sq.km, while it is 0.02 sq.km for other lakes. There is one blocked lake of around 0.07 sq.km in size. The distribution of glacial lakes in accordance with the glaciers is shown in Figure 7.22. None of the lakes is potentially dangerous in this sub-basin.

Table 8.20: Types of lakes in the Humla River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	204	59	8577157.50	65.90	681700.23
Cirque	40	12	812645.73	6.24	94911.87
Supraglacial	15	4	198499.80	1.53	35683.79
Erosion	44	13	616489.85	4.74	137592.48
Moraine dammed	32	9	2155825.39	16.56	689886.51
Lateral M. dammed	3	1	22669.70	0.17	12629.26
Blocked	7	2	631707.95	4.85	319369.88

The Mahakali River basin

The Mahakali River has two major sub-basins on the Nepalese side. Both of these drainage basins join the Mahakali River at the Nepal–India border. The Mahakali River Basin, in its Nepalese portions of the catchment, has only 16 lakes with a total area of 0.38 sq.km (Figure 7.23). The mean area per lake in the Mahakali River Basin is 0.02 sq.km.

Table 8.21: Types of lakes in the West Seti River Sub-basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Erosion	6	40.00	247514.48	60.51	66 019.25
Valley	3	20.00	32057.42	7.84	16 937.63
Supraglacial	5	33.33	54563.99	13.34	21 496.65
Blocked	1	6.67	74877.61	18.31	74 877.61

Since most of the lakes have developed within the glaciers, there are quite a number of supraglacial lakes. There are nine supraglacial lakes, four blocked lakes, and three valley lakes (Table 8.22). The average area of the lakes ranges from 0.01 to 0.03 sq.km. No potentially dangerous lakes are identified in the Nepalese portion of this basin.

Table 8.22: Types of lakes in the Mahakali River Basin

Type	Number	Number (%)	Area (m^2)	Area (%)	Area of largest lake (m^2)
Valley	3	18.75	109329.95	28.08	77128.26
Blocked	4	25.00	120236.98	30.88	55602.75
Supraglacial	9	56.25	159767.74	41.04	52803.86