Chapter 2

Global Climate Change and Retreat of Himalayan Glaciers in China, India, Bhutan and Nepal

The global climate system is a consequence of and a link between the atmosphere, the oceans, the ice sheets (cryosphere), living organisms (biosphere), and the soils, sediments and rocks (geosphere). Climate is normally defined as a long-term average of the weather in a certain location. Weather is the atmospheric condition at the surface of the earth and changes continuously over a timescale from minutes to weeks. However, the climate in a certain location varies between more or less extreme states and events (called the climate variability), such as severe droughts, heavy rainfall, or unusually hot or cold weather. The more extreme the events, the less frequently they occur. Recently, the occurrence of extreme weather or climatic events has been used to indicate overall climate change. Moreover, looking at the frequency of these extremes themselves is an appropriate way to predict climate change (Thomas et al 2005). Global climate change is a natural phenomenon; it is well known that the earth's average surface temperature has been increasing since the end of the Little Ice Age. The average temperature of the earth's surface did not vary much between 1940 and 1970 AD, but a continuous rise in temperature has been recorded since 1970 (Figure 2.1). Over the past few decades, human activity has significantly altered the atmospheric composition, leading to climate change of an unprecedented character (WHO/WMO/UNEP 2003). This climate change may also be reflected in the glacial environment; some measurements indicate that Himalayan glaciers have been retreating at an increased rate since 1970 (Bajracharya et al. 2006).

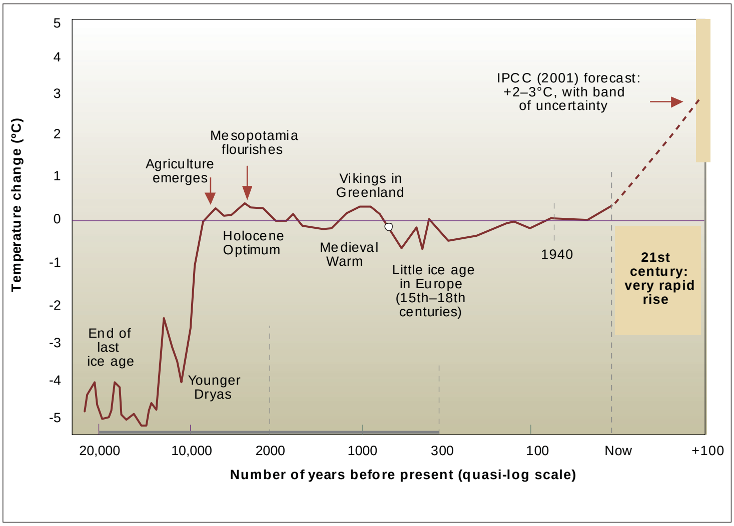


Figure 2.1: Variations in earth's average surface temperature over the past 20,000 years. From Intergovernmental Panel on Climate Change, reprinted with permission

Natural climate change

Variations in the earth's atmospheric temperature are generally governed by the amount of incoming solar radiation (terrestrial), volcanic activity (geothermal), and combustion of fossil fuel (human activity). If the earth's surface receives less solar radiation during the summer months, snow deposited during the previous winter does not all melt. When snow accumulates year after year, glaciers advance. The more albedo (shiny white surface) of snow and ice, the more solar radiation reflects back into space, causing a negative feedback to the solar thermal input cycle. Temperatures would drop even further, and eventually another ice age would occur. When the earth's surface receives more solar energy, the planet warms up due to a positive feedback mechanism; snow melts and glaciers retreat. The rise and fall in the amounts of solar energy impinging on the earth (particularly in the far north during summer) is a major driving mechanism behind climate change (Milankovitch 1920).

Human interference

The Intergovernmental Panel on Climate Change (IPCC) reported that the global atmospheric concentration of CO_2 has increased from a pre-industrial value of about 280ppm to 379 ppm in 2005. The atmospheric concentration of CO_2 in 2005 exceeded by far the natural range (180 to 300 ppm) over the last 650,000 years as determined from ice cores. The annual CO_2 concentration rate was greater during the last 10 years (1995–2005 average: 1.9 ppm per year) than it has been since the beginning of continuous atmospheric measurements (1960–2005 average: 1.4 ppm per year) although growth rates vary from year to year (IPCC 2007). Projections indicate that within the next 50 to 100 years atmospheric CO_2 concentrations will double from their pre-industrial values (Figure 2.2). The greenhouse gases trap outgoing radiation and redirect it back to the surface, causing warming. Increased concentration of greenhouse gases in the atmosphere is likely the most significant factor affecting current global climate change. Several other greenhouse gases such as methane, nitrous oxide, chlorofluorocarbons (CFCs), and tropospheric ozone are increasing in concentration because of human activities. These gases tend to reinforce the changes caused by increasing CO_2 levels. However, the observed decreases in the lower stratospheric ozone since the 1970s, caused principally by human-introduced CFCs and halogens, contribute to some cooling (IPCC 2001a).

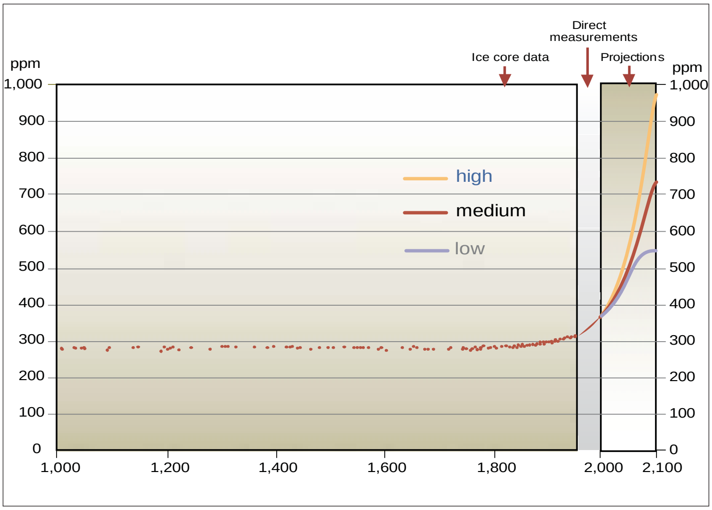


Figure 2.2: Atmospheric concentration of CO_2 from year 1000 to year 2000 (The data are from polar ice cores and from direct atmospheric measurements over the past few decades. Projections of CO_2 concentrations for the period 2000–2100 are based on the IPCC's six illustrative SRES scenarios and IS92a. From Intergovernmental Panel on Climate Change, reprinted with permission

Temperature change

Since the advent of industrialisation, human activities have contributed to a steady increase in the concentration of greenhouse gases in the atmosphere. The average surface temperature of the planet has risen between 0.3 and 0.6°C over the past hundred years. The IPCC in its third assessment report revealed that the rate and duration of warming in the 20th century was larger than at any other time during the last thousand years. The 1990s were likely the warmest decade of the millennium in the Northern Hemisphere, and 1998 was probably the warmest year (IPCC 2001a). According to the World Meteorological Organisation (WMO), the mean global temperature in 2005 deviated by +0.47°C from the average calculated for the period 1961–1990 (Faust 2005). However, Baker and Ekwurzel (2006) reported that measurements from 1998 and 2005 were so similar (i.e., within the error range of the different analysis methods or a few hundredths of a degree Celsius) that independent groups (e.g., NOAA, NASA and the United Kingdom Meteorological Office) calculating these rankings based on reports from the same data-collecting stations around the world disagree on which year should be ranked first. Annual global rankings are based on combined land-air surface temperature and sea surface temperatures and have been reported since 1880. Therefore, the year 2005 was pushed into a virtual tie with 1998 as the hottest year on record. For people living in the northern hemisphere – most of the world's population – 2005 was the hottest year. Similarly, 2002 and 2003 were respectively the 3rd and 4th warmest years since the monitoring and documentation of climate statistics began in 1880 (Baker et al. 2006). It is highly unusual and worrying for so many record years to occur within such a short time span.

Climate projections

According to the IPCC (2001) and its assessment based on climate models, the global temperature will continue to rise during the 21st century (Figure 2.3). The increase in the global mean temperatures over the next one hundred years could range from 1.4 to 5.8°C (depending on the climate model used and on the intervening greenhouse gas emission scenarios). Studies show that the annual warming in the Himalayan region between 1977 and 1994 was 0.06°C (Shrestha et al. 1999). As per the Third Assessment Report for the IPCC, the spatial average annual mean warming over the Asian region is projected to be as much as 3°C by the 2050s and about 5°C by the 2080s as a result of continued green house gas emissions – as calculated based on the simulation of general circulation models. However, the warming would be limited to 2.5 and 4°C if the combined effects of greenhouse gases and

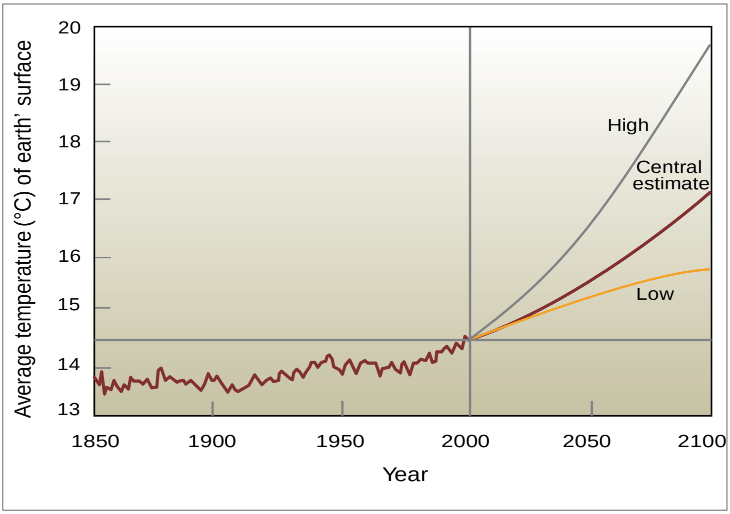


Figure 2.3: Global temperature record since instrumental recording began in 1850 and projection to 2100, according to the IPCC From Intergovernmental Panel on Climate Change, reprinted with permission

sulphate aerosols are taken into consideration. In addition, the report also warns of different warming scenarios for winter and summer in the northern hemisphere and differences in the diurnal temperature range.

On the Indian subcontinent, temperatures are predicted to rise between 3.5 and 5.5ºC by 2100. An even higher increase is predicted for the Tibetan Plateau (Lal 2002). Climate change is not just about averages, it is also about extremes. The change in climate is likely to affect both minimum and maximum-recorded temperatures as well as triggering more extreme rainfall events and storms. For the Indian sub-continent, predictions anticipate decreasing rainfall in winter and increasing precipitation during the summer monsoon. For 2050, a 10–20 per cent decrease in winter precipitation and a 30 per cent increase in summer precipitation have been projected (Lal 2002). In essence, one could expect an increase in droughts during the dry winter season and an increase in floods during the summer monsoon.

In high altitude areas of the HKH, an increased annual average temperature will cause increased thawing of permafrost and ice, including glaciers. In the short term, this may lead to an increase in annual discharge in the rivers, which carry a large proportion of the water coming from snow and ice covered areas. However, the annual discharge may eventually decrease; in particular, the dry season discharge may decline, further limiting downstream communities' access to water supply (Lal 2002).

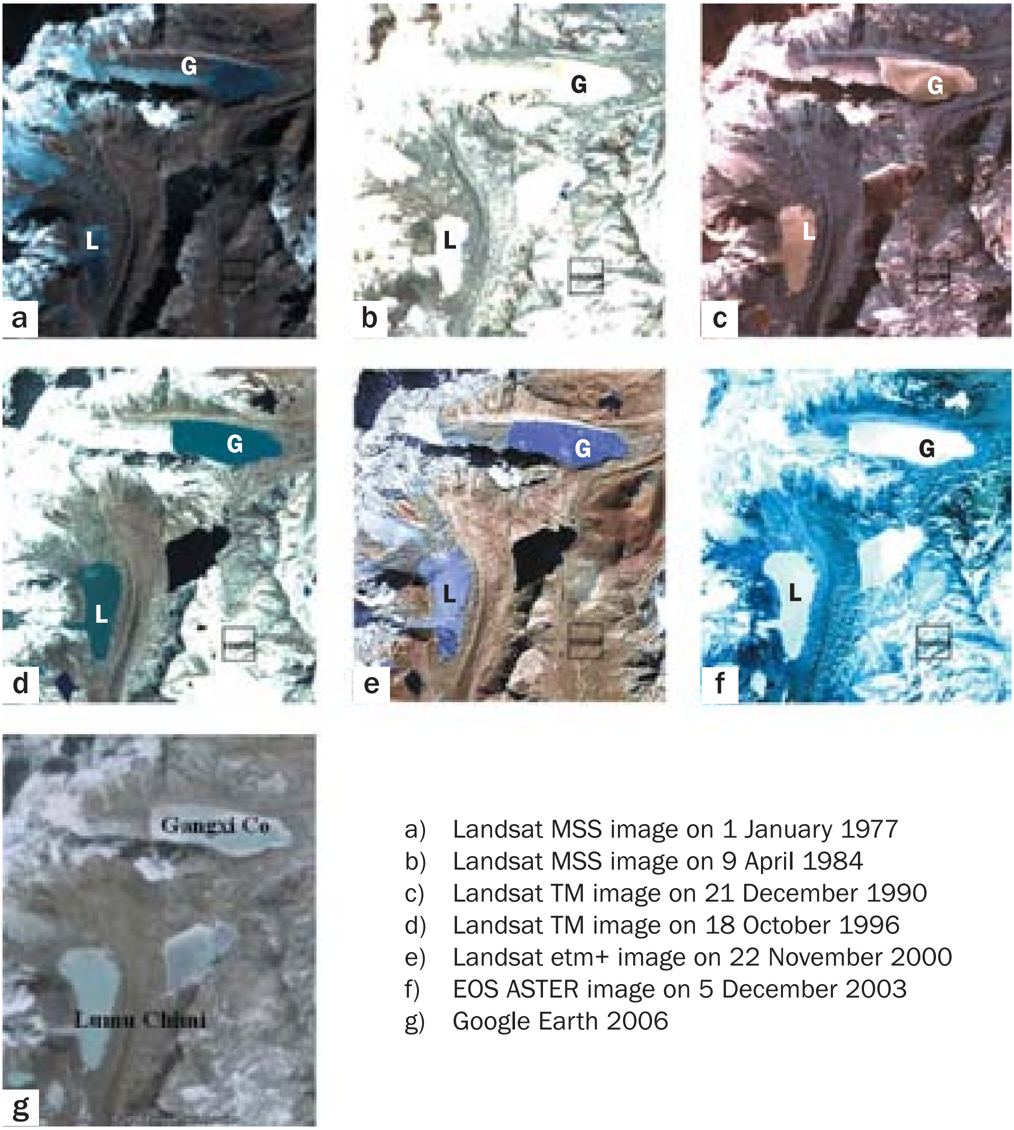
Retreat of Himalayan glaciers

Several future scenarios have been predicted for the climate of the HKH; and speculating too much about which particular scenario is more apt may be imprudent (Faust 2005). Nevertheless, it is highly likely that temperatures will increase. These changes in climate will inevitably affect glaciers and glacial lakes. The change in glacier ice or snowmelt impacts water storage and the water yield to downstream areas. Sustained glacier retreat will cause two effects on river hydrology. First, large increases in river peak flows will increase the quantity of glacio-fluvial sediments transported due to excessive melting. This can then cause large-scale damage to downstream river valley schemes such as agriculture and water supply. In addition, increasing threats arise from the formation and eventual outburst of high altitude glacial lakes. These climatic changes will have a significant impact on the lives and property of downstream communities.

Numerous studies carried out during 1999 to 2001 lend credence to the link between climate change and glacier melting. Overall, the evidence supporting the phenomenon has been conclusive enough to make glacial melting and retreat an important indicator for climate change. The Himalayan glaciers have retreated by approximately a kilometre since the Little Ice Age (Mool et al. 2001a). Studies using satellite data have tried to correlate the change in the size of existing glaciers (compared and contrasted with their previous size from historical records) with fluctuations in temperature. Results show that recession rates have increased with rising temperatures. Evidence also shows that temperature changes are more pronounced at higher altitudes. Analysis of air temperature trends across 49 stations in Nepal between 1977 and 1994, for example, reveals a clearly rising trend, and the change is much more pronounced in the higher altitude regions of the country (Shrestha et al. 1999). This has a twofold impact on the mass balance of glaciers. First, higher temperatures contribute to accelerated melting. Second, higher temperatures can cause precipitation to occur in liquid instead of solid form, even at very high altitudes. The absence of a blanketing layer of snow on the ice lowers its albedo, making glaciers further prone to radiative melting (Mool et al. 2001a).

Glaciers in China

A long-term study entitled 'The Chinese Glacier Inventory' by the Chinese Academy of Sciences has reported a 5.5 per cent shrinkage in the volume of China's 46,928 glaciers over the last 24 years, equivalent to the loss of more than 3000 sq.km of ice. Yao (2004) predicts that if the climate continues to change at the present rate, two-thirds of China's glaciers will disappear by 2050, and almost all will be gone by 2100.



a) Landsat MSS image on 1 January 1977
b) Landsat MSS image on 9 April 1984
c) Landsat TM image on 21 December 1990
d) Landsat TM image on 18 October 1996
e) Landsat etm+ image on 22 November 2000
f) EOS ASTER image on 5 December 2003
g) Google Earth 2006

Figure 2.4: Different satellite images taken between 1977 and 2006 showing the growth of Gangxi Co (G) and Lumu Chimi (L) lakes in Poiqu basin, Tibet Autonomous Region, P.R.China. See Figure 2.5 for details.

Detailed work in the Poiqu basin by Mool et al. (2005) at ICIMOD mapped 153 glaciers with a total area of 244 sq.km in 1988 and 232 sq.km in 2000, indicating an area loss of 12 sq.km (5 per cent of the total area) in 12 years. This study also noted that the valley glaciers with IDs 5O191B0029 and 5O191C0009 on the eastern slope of the Xixiabangma mountain are retreating at a rate of 45m and 68m per year respectively, and there has been about 100m shift upslope in elevation of the termini of these glaciers since 1977 (Figures 2.4 and 2.5).

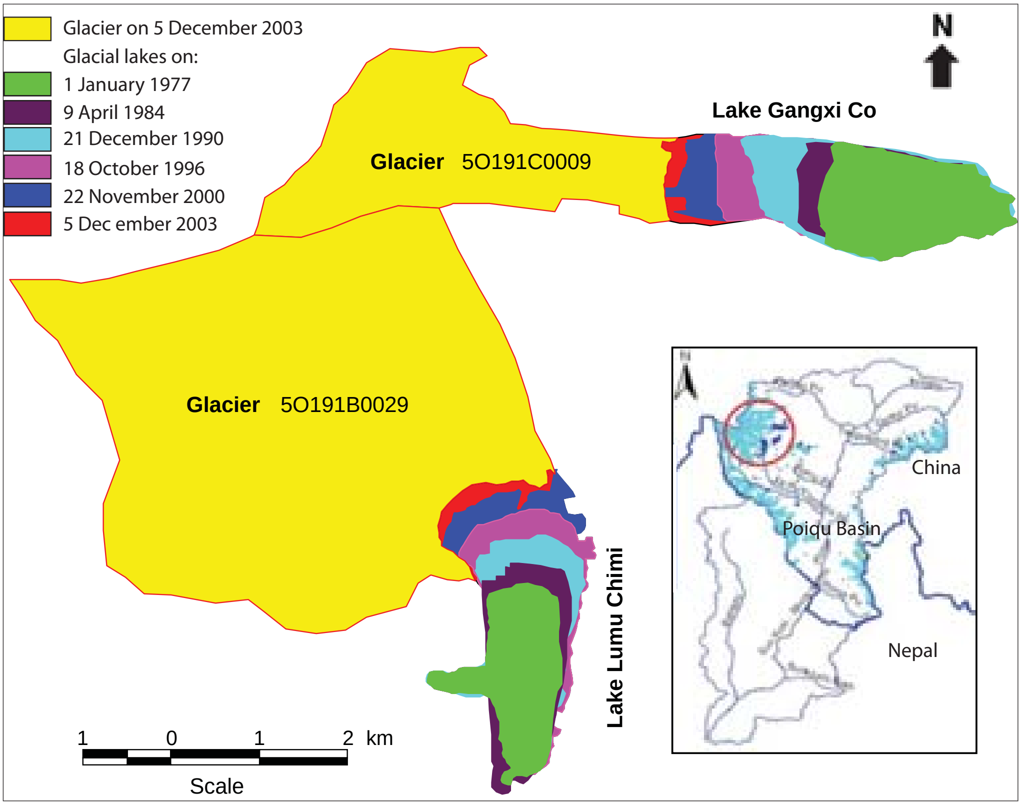


Figure 2.5: Glacier retreat and growth of Gangxi Co and Lumu Chimi lakes in Poiqu basin (from Mool et al. 2004)

Glaciers in India

Many studies have been carried out on the fluctuation of glaciers in the Indian Himalaya and significant changes (mostly retreats) have been recorded in the last three decades. The retreat of selected glaciers is summarised in Table 2.1; most of these glaciers have been retreating discontinuously since the post-glacial period (Table 2.1). For example, the Siachen and Pindari Glaciers retreated at a rate of 31.5m and 23.5m per year respectively (Vohra 1981). The Gangotri Glacier retreated by 15m per year from 1935 to 1976 and 23m per year from 1985 to 2001 (Vohra 1981; Thakur et al. 1991; Hasnain et al. 2004). On average, the Gangotri Glacier is retreating at a rate of 18m per year (Thakur et al. 1991). Jeff Kargel of the USGS showed that the position of the Gangotri Glacier snout retreated about 2 km in the period from 1780 AD to 2001 (Figure 2.6) and is continuing to retreat. Shukla and Siddiqui (1999) monitored the Milam Glacier in the Kumaon Himalaya and estimated that the ice retreated at an average rate of 9.1m per year between 1901 and 1997. Dobhal et al. (1999)

Table 2.1: **Retreat of some important glaciers in the Indian Himalaya** (modified from WWF 2005)

Glacier	Location	Period	Avg. retreat rate (m/year)	Reference
Siachen	Siachen		31.5	Vohra (1981)
Milam	Uttarakhand	1849–1957	12.5	
Pindari		1845–1966	23.5	
Gangotri		1935–1976	15	
Gangotri		1985–2001	23	Hasnain et al. (2004)
Bada Shigri	Himachal Pradesh	1890–1906	20	Mayekwski and Jeschke (1979)
Kolhani	Jammu and Kashmir	1857–1909	15	
Kolhani		1912–1961	16	
Machoi		1906–1957	8.1	Tiwari (1972) cited in WWF (2005)
Chota Shigri	Himachal Pradesh	1970–1989	7.5	Surendra et al. (1994)

Figure 2.6: Retreat of the Gangotri glacier snout during the last 220 years (from 1780 AD to 2001)

monitored the shifting of the snout of the Dokriani Bamak Glacier in the Garhwal Himalaya and found that it had retreated 586m between 1962 and 1997. The average retreat was 16.5m per year. Matny (2000) found that the Dokriani Bamak Glacier retreated by 20m in 1998, compared to an average retreat of 16.5m over the previous thirty-five years.

Table 2.2 shows the average retreat rates of other important glaciers in the Indian Himalaya. The Geological Survey of India (Vohra 1981) studied the Gara, Gor Garang, Shaune Garang and Nagpo Tokpo Glaciers of the Satluj River Basin and observed an average retreat of 4.2–6.8m per year. The Bada Shigri, Chhota Shigri, Miyar, Hamtah, Nagpo Tokpo, Triloknath and Sonapani Glaciers in the Chenab River Basin retreated at a rate of 6.8 to 29.8m per year. The highest and lowest retreat rates were reported for the Bada Shigri Glacier and Chhota Shigri Glacier respectively.

Between 1963 and 1997, Kulkarni and others found that the Janapa Glacier had retreated by 696m, the Jorya Garang by 425m, the Naradu Garang by 550m, the Bilare Bange by 90m, the Karu Garang by 800m, and the Baspa Bamak by 380m (Kulkarni et al. 2004). In their studies they observed an overall reduction of 19 per cent in glaciated area and a 23 per cent decrease in glacier volume over the last 39 years.

Based on the field survey carried out in 1999, the snout of the Shaune Garang Glacier was marked at an altitude of 4460m, whereas the Survey of India 1962 topographic map marked the snout at an altitude of 4360m (Philip and Sah 2004). This indicates a vertical shift of 100m as well as a retreat of 1500m within a span of 37 years. These authors also suggest that global warming has affected the snow-glacier melt and runoff patterns in the Himalayas. One of the best examples of glacier retreat is shown in Figure 2.6.

Table 2.2: **Average retreat rates of some major glaciers in the Indian Himalaya**

Glacier name	Retreat rate (m/year)	Reference
Gangotri	18	Thakur et al. (1991)
Milam	9.1	Shukla and Siddiqui (1999)
Dokriani Bamak	16.7 20 in 1998	Dhobal (1999) Matny (2000)
Gara,Gor Garang, Shaune Garang, Nagpo Tokpo	4.2–6.8	Geological Survey of India (Vohra 1981)
Bada Shigri, Chhota Shigri, Miyar, Hamtah, Nagpo Tokpo, Triloknath, Sonapani	6.8 for Chota Shigri 29.8 for Bada Shigri	Srivastava (2003)
Janapa	20.5	Kulkarni (2004)
Jorya Garang	12.5	
Naradu Garang	16.2	
Bilare bange	2.6	
Karu Garang	23.5	
Baspa Bamak	11.2	
Shaune Garang	40.5	Philip and Sah (2004)

Glaciers in Bhutan

Glaciers in the Bhutan Himalaya are less well studied than those in other countries. Nonetheless, there is some indication of glacier retreat in the Bhutan Himalaya. Ageta et al. (2000) examined the rate of retreat of some selected large debris-covered glaciers associated with large lakes by comparing archived photographs, satellite images, and maps of previous years. Using lake expansion rates up-valley to calculate retreat rates for the related glaciers, the authors reported retreat rates in the range of 30–35m per year. The Tarina Glacier retreat rate was 35m per year from 1967 to 1988 (Ageta et al. 2000). However, the rates were found to be variable with time, a phenomenon attributed to irregular calving at the tongue of the mother glacier, which is in contact with the lake water (Ageta et al. 2001). Debris free or 'clean' glaciers (C-type) are considered more sensitive to climate change than debris covered (D-type) ones. Karma et al. (2003) examined terminus variation for 103 debris-free glaciers in the Bhutan Himalaya over a period of 30 years (from 1963 to 1993). Retreat rates (on the horizontal projection) as high as 26.6 m/year were reported for these glaciers.

A ground survey of the C-type, Jichu Dramo glacier was conducted in the Bhutan Himalaya as part of fieldwork in 1998; the glacier was resurveyed in 1999 to assess the changes. Naito et al. (2000) recorded a 12m retreat (from 1998-1999) and estimate that the surface was lowered by 2–3m.

The retreat rates for C-type glaciers in the Bhutan Himalaya were compared with retreat rates for some glaciers in eastern Nepal. Karma et al. (2003) report that the retreat rates were higher for glaciers in the Bhutan Himalaya than for glaciers in eastern Nepal; attributing the sensitivity of these glaciers to the intensity of the monsoon. Table 2.3 shows the results.

Karma et al. (2003) studied 66 glaciers by comparing 1963 topographic maps with 1993 satellite images and found that the glaciers had retreated by 8 per cent. The glacier area from the 1963 data was 146.87 sq.km and from the 1993 data only 134.94 sq.km – a considerable decrease in 30 years. Smaller glaciers retreat at a higher rate than larger ones; some of the smaller glaciers (<0.2 sq.km area) seen in 1963 had completely disappeared by 1993.

Table 2.3: **Average variation rates of glacier termini in east Nepal and Bhutan in recent decades (adapted from Karma et al. 2003)**

Region	Period (years)	Variation rate (m/year)		No. of glaciers
		Vertical	Horizontal	
For all types (retreating, stationary, and advancing glaciers)				
Nepal	33 (1959–1992)	0.59	3.14	100
Bhutan	30 (1963–1993)	1.90	6.27	103
For retreating and stationary glaciers only				
Nepal	33 (1959–1992)	1.13	4.36	88
Bhutan	30 (1963–1993)	1.90	6.27	103
For retreating glaciers only				
Nepal	33 (1959–1992)	1.72	6.61	58
Bhutan	30 (1963–1993)	2.23	7.36	86

Glacier retreat in the Pho Chu sub-basin of Bhutan

The study of glaciers and glacial lakes in the Lunana basin from 1968 to 1998 showed retreating glaciers and growing glacial lakes (Figures 2.7, 2.8 and 2.9) (Mool et al. 2001). The Luggye Glacier retreated by 160m per year from 1988 to 1993, resulting in a high growth rate of Lake Luggye Tso. The Raphsthreng Glacier retreated on average 35m per year from 1984 to 1998, but from 1988 to 1993 the retreat rate was 60m per year. It is noteworthy that, for all the years studied, the decadal growth of glacial lakes has been rapid for all lakes, except for the lake associated with the Drukchung Glacier. Glacial lakes are discussed in detail in the following chapter.

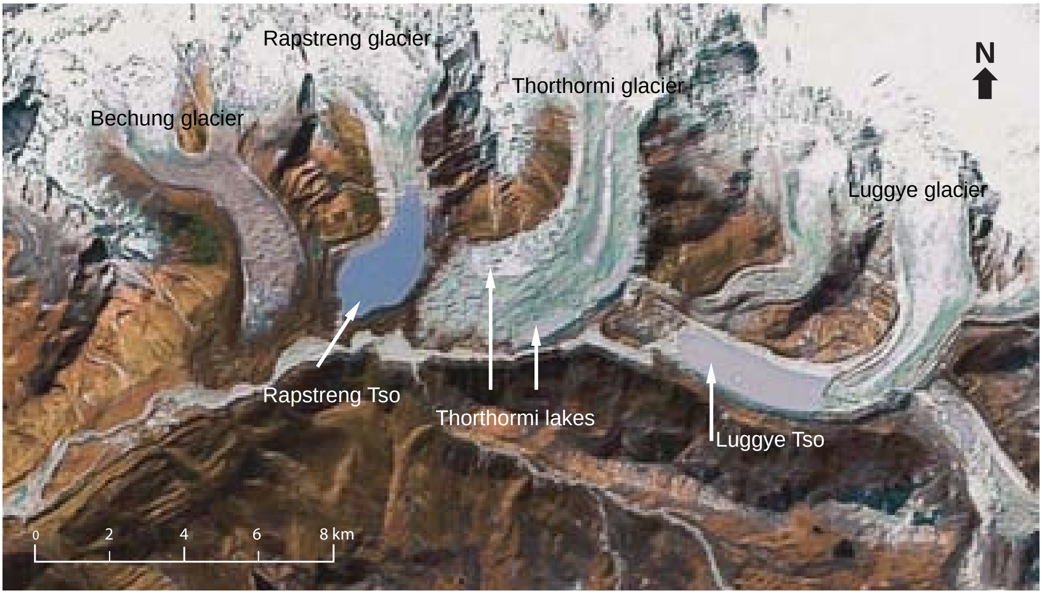


Figure 2.7: Glaciers and glacial lakes in the Lunana basin, base image Google Earth

Glaciers in Nepal

ICIMOD undertook the first ever attempt to carry out a systematic study of glaciers and glacial lakes throughout Nepal in 2001 and that study provided the first baseline information. Previously, no systematic study of glacial activity had been made in Nepal and most studies were sporadic investigations of individual small mountain basin glaciers and some valley glaciers. For example, different scholars had studied the glaciers of the Kanchenjunga, Khumbu, Langtang, and Dhaulagiri regions since the 1970s in an attempt to understand glacial activity. A major finding of the ICIMOD work is that glaciers in Nepal retreated dramatically between 1994 and 1998. Asahi et al. (2001) of the Glaciological Expedition in Nepal (GEN 2006) and Kadota et al. (1997) measured glacier retreat in the Khumbu and Shorang regions and positioned benchmarks in the vicinity of the termini of 19 small debris-free glaciers. They found that glaciers in the Shorang region retreated an average of 8m per year; and glaciers in the Khumbu region retreated an average of 5 to 10m per year. They also remarked that the glacier retreat rate accelerated after 1990 (Figure 2.10a and Table 2.4).
During the 30-year period from 1970 to 2000, the loss of glacier area in the Tamor River sub-basin of Nepal (Bajracharya et al. 2006b) was about 5.9 per cent or 0.2 per cent per year. Fujita et al. (2001) reported a higher glacier retreat rate between the 1970s and the 1990s

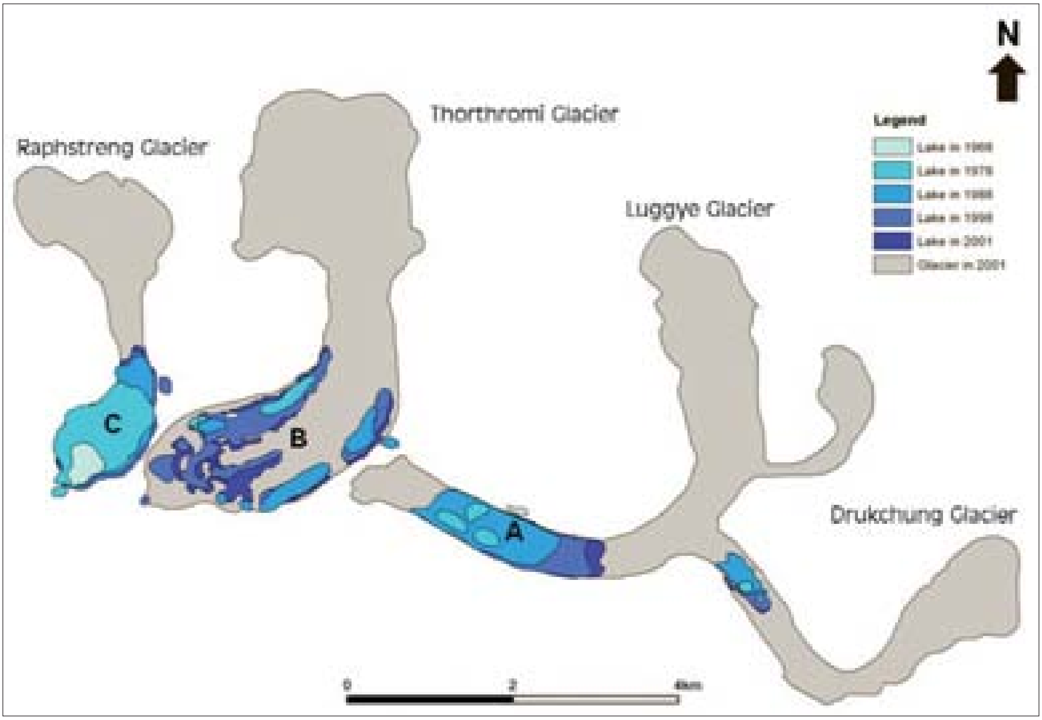


Figure 2.8: Glacier retreat and growth of glacial lakes in the Lunana basin

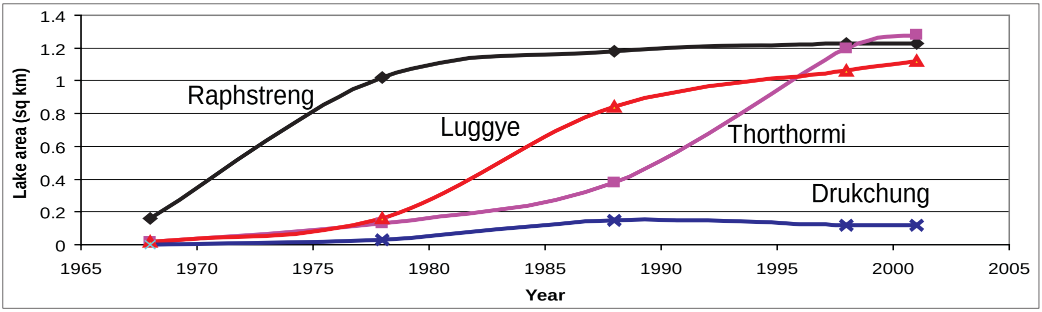


Figure 2.9: Development trend of glacial lakes in the Lunana basin

Table 2.4: **Retreat rates of some glaciers in the Nepal Himalaya**

Glacier name	Retreat rate	Reference
AX010	30 m per year (1978–1989)	Fujita (2001)
Khumbu	10 m surface lowering from 1978 to 1995	Kadota et al. (2000)
Seven unnamed clean type glaciers in Khumbu region	30–60 m per year (1970s to 1989)	Yamada et al. (1992)
Imja glaciers	41m per year (1962 to 2001) and **74** m per year (2001 to 2006)	Bajracharya (2006a)
Trakarding glacier	66 m per year (1957 to 2000)	WECS (1993), Bajracharya (2005)

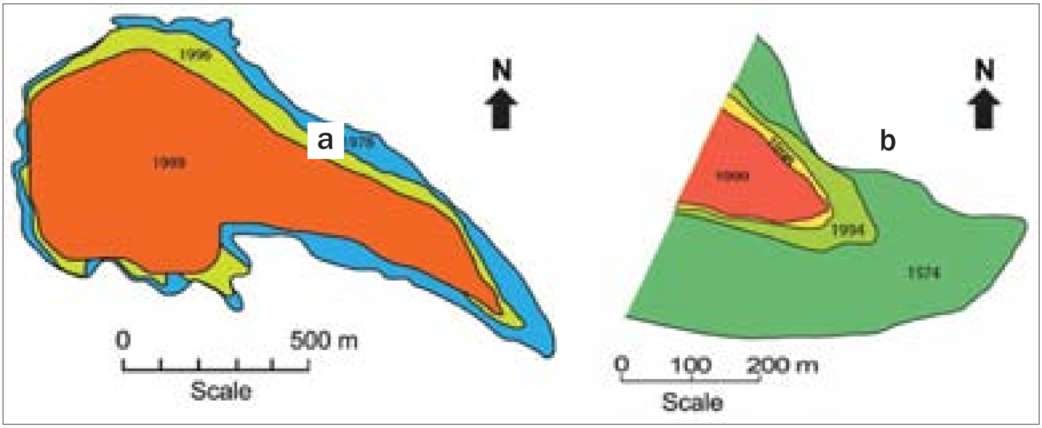


Figure 2.10: Maps depicting the changes in glacier area on different dates: a) AX010 glacier, Shorang Himal; b) Rika Samba glacier, Dhaulagiri region (Adapted from Fujita et al. 2001)

in the Shorang Himal area of eastern Nepal as well as in the Rika Samba glacier of the Dhaulagiri region of western Nepal (Fujita et al. 2001; Figure 2.10).

Glacier retreat in the Dudh Koshi sub-basin

The Dudh Koshi sub-basin is one of the largest glaciated basins in Nepal. To understand the activity of glaciers in this region between 1960 and 2001, some of the valley glaciers' tongues were delineated in satellite images and compared (1976 Landsat MSS and 1992 Landsat TM and Landsat etm+ (Nature Vue) of 2001). The Dudh Koshi sub-basin is home to about 36 valley glaciers; of these, due to certain limitations of the remote sensing (such as shadows, poor resolution, etc.), only 24 have been studied by satellite imaging in 1976, 1992, and 2000/2001 to identify their retreat rate. All of the valley glaciers in the Dudh Koshi sub-basin that could be studied had retreated by at least 10 to 59m per year. The glaciers show a remarkable change from the 1960s to 2001. In general, glaciers are shrinking and valley glaciers are retreating. The consequence of this is that an increasing number of moraine-dammed lakes are forming. The minimum retreat of glaciers was not less than 400m and the maximum was 2340m in 40 years (Table 2.5). The average minimum glacier retreat rate was 10m per year; this was observed on the Langdak, W. Lhotse, Lhotse, and Setta glaciers. **The fastest retreating glacier was the Imja glacier, with an average rate of 59m per year and a surprising 74m per year for the past half decade**. Other fast-retreating glaciers are W. Chamjang and Ombigaichain.

A good indicator of glacier retreat is the growth of supraglacial lakes; these are discussed at length in the following chapter. The noted continuous retreat of glaciers highlights the importance of monitoring. It will be important to continue monitoring the Himalayan glaciers and glacial lakes for the sound management of water resources. However, the study of this phenomenon will also continue to remain a challenge; the limits imposed by the higher altitude, the rarefied atmosphere, the remoteness of many of the locations and the short mapping season cannot be underestimated.

Table 2.5: **Retreat rates of some valley glaciers in the Dudh Koshi sub-basin, Nepal**

S.N.	Glacier ID	Glacier Name	Mean length (m) in year		Total retreat (m) within period			Average retreat rate (m/year) between 1960–2001
			1960s	2000 or 2001	1960–2001	1976–2001	1992–2001	
1.	Kdugr 21	Lumding	6,015	4,700	1,315	1,015	184	33
2.	Kdugr 40	Langmuche	3,160	2,388	772	323	323	19
3.	Kdugr 47	Langdak	4,430	4,028	402	209	209	10
4.	Kdugr 48	Chhule	7,600	6,818	782	534	534	20
5.	Kdugr 52	Melung	8,870	7,430	1,440	375	0	36
6.	Kdugr 54	Bhote Koshi	17,100	16,455	645	400	330	16
7.	Kdugr 67	Lumsamba	9,500	8,955	545	466	242	14
8.	Kdugr 100	Ngojumba	22,500	21,625	875	350	300	22
9.	Kdugr 120	Cholo	2,520	1,586	934	753	170	23
10.	Kdugr 133	Khumbu	12,040	11,198	842	483	145	21
11.	Kdugr 152	Nuptse	6,330	5,898	432	309	124	11
12.	Kdugr 153	W.Lhotse	4,110	3,722	388	186	116	10
13.	Kdugr 156	Lhotse	8,870	8,453	417	280	173	10
14.	Kdugr 160	Imja	10,770	8,430	2,340	812	558	59
15.	Kdugr 166	Ombigaichain	4,110	2,123	1,987	1,205	994	50
16.	Kdugr 167	?	5,060	4,311	749	640	600	19
17.	Kdugr 169	Amadabalam	2,530	2,056	474	390	301	12
18.	Kdugr 170	Setta	2,215	1,811	404	276	255	10
19.	Kdugr 186	Kyashar	6,330	5,797	533	?Shadow	245	13
20.	Kdugr 202	Sabai (Sha)	4,110	3,511	599	0	0	15
21.	Kdugr 205	Inkhu	10,770	9,786	984	824	561	25
22.	Kdugr 221	?	3,160	2,683	477	?Shadow	367	12
23.	Kdugr 233	?	1,900	1,259	641	330	228	16
24.	Kdugr 264	W.Chamjang	3,800	1,558	2,242	1,015	550	56