Chapter 5

Glacial Lake Outbrust

An Overview

Glaciers have perennially been the source of fresh water for more than 1.3 billion of people[1] in the Indian subcontinent. About 15,000 glaciers and 9,000 glacial lakes in Bhutan, Nepal, India, Pakistan and China have been reported in a baseline study conducted by ICIMOD (full form), UNEP, and the Asia Pacific Network for Global Change Research (APN).[2] A recent inventory carried out by ICIMOD and UNEP/EAP-AP shows that there are 3,252 glaciers covering a surface area of 53,23 sq km and 2,315 glacial lakes, out of which 26 potential dangerous glacial lakes are in Nepal (ICIMOD and UNEP/EAP-AP 2000). Field studies of the six glacial lakes (Tsho Rolpa, Imja, Thulagi, Lower Barun, Dig Tsho, and Tam Pokhari) in Nepal have been carried out by different organisations. Similarly, the inventory carried out shows that in Bhutan there are 677 glaciers covering 1,316 sq km and 2,674 lakes, of which 22 are potentially dangerous.

The climatic change/variability in recent decades has made considerable impacts on the glacier life-cycle in the Himalayan region. As a result, many big glaciers melted rapidly, forming a large number of glacial lakes. Due to an increase in the rate at which ice and snow melted, the accumulation of water in these lakes started increasing rapidly. Sudden discharge of large volumes of water with debris from these lakes potentially causes glacial lake outburst floods (GLOFs) in valleys downstream. These result in serious death tolls and destruction of valuable natural resources, such as forests, farms, and costly mountain infrastructures. The Hindu Kush-Himalayan region has suffered several GLOF events originating from numerous glacial lakes, some of which have trans-boundary impacts.

A GLOF occurs when a lake contained by a glacier or a terminal moraine dam fails. This can happen due to erosion, water pressure, an avalanche of rock or heavy snow, an earthquake or cryoseism, or if a large enough portion of a glacier breaks off and massively displaces the waters in a glacial lake at its base.[3] The collapse of Glacier Lake generates huge debris mixed flash flood downstream. There are many cases of GLOF across the world. In 1996, the volcano under the Grimstvon lakes in Iceland generated a flood in (45,000 m^3/s) Skaftafell National Park. In Alaska, Lake George near the Knik River had large annual outbreaks from 1918 to 1966.[3]

In the United States of America, a GLOF occurred from Grasshopper Glacier in the Wind River Mountains, Wyoming on 6 September 2003.[3] In 1994, a GLOF occurred at Farrow Creek in British Columbia,[4] Canada. In October 1994, a GLOF 90 km upstream from Punakha Dzong caused massive flooding on the Pho Chhu River in Bhutan.[3] Nepal and Tibet have a history of many GLOFs in the past. There have been 13 reported cases of GLOFs in Nepal since 1964 with substantial losses of human lives, livestock, land and infrastructures. Many GLOFs at Tibet struck Nepal in the past. Some GLOF events are presented in Table 5.1.

Table 5.1: GLOF events recorded [3,4,5]

Date	Name of Lake	River Basin
450 years ago	Machhapuchhare, Nepal	Seti Khola
21 September 1964	Gelaipco, Tibet	Arun
1964	Zhangzangbo, Tibet	Sun Koshi
1964	Longda, Tibet	Trishuli
1968	Ayaco, Tibet	Arun
1969	Ayaco, Tibet	Arun
1970	Ayaco, Tibet	Arun
3 September 1977	Nare, Tibet	Dudh Koshi
23 June 1980	Nagmapokhri, Nepal	Tamur
11 July 1981	Zhangzagbo, Tibet	Sun Koshi
27 August 1982	Jinco, Tibet	Arun
4 August 1985	Dig Tsho, Nepal	Dudh Koshi
12 July 1991	Chubung, Nepal	Tamo Koshi
3 September 1998	Sabai Tsho, Nepal	Dudh Koshi
A glacial lake outburst flood August 1935	Taraco, Tibet	Sun Koshi
1996	Iceland	
From 1918 to 1966	Alaska	Knik River
6 September 2003	USA	Wind River
1994	British Columbia, Canada.	Farrow Creek
October 1994	Bhutan	Pho Chhu River

Increasing GLOF Vulnerability in South Asia

Almost all glaciers in the Himalayas have been retreating since the Little Ice Age (1400-1650 AD)[6], increasingly leading to formation of the numerous glacier lakes in the Himalayas. Rapid glacier melt, driven by climate change/variability, has been causing water-level rise in these lakes and some of them have turned highly vulnerable to the instantaneous release of the stored lake water which may create devastating floods. In India, glaciers are melting in a greater pace. The melting rate of Siachen, Pindari and Bara Shigri glaciers is above 20 metres per year.[2] In Nepal, a high rate of glacier melting (more than 50 metres/year) is taking place at Imja, W Chamganj and Ombigaichan Glaciers.[2] In Bhutan, retreat of Luggye Glacier is 160 metres per year from 1988 to 1993 causing growth in Luggye Tso Lake. The Raphsthreng Tso Glacier retreated on an average 60 m per year from 1988 to 1993 metres per year.[2] Out of 2,323 glacier lakes, 20 lakes have turned potentially dangerous for outburst[5] and Imja has been identified as one of the most vulnerable glacier lakes in Nepal

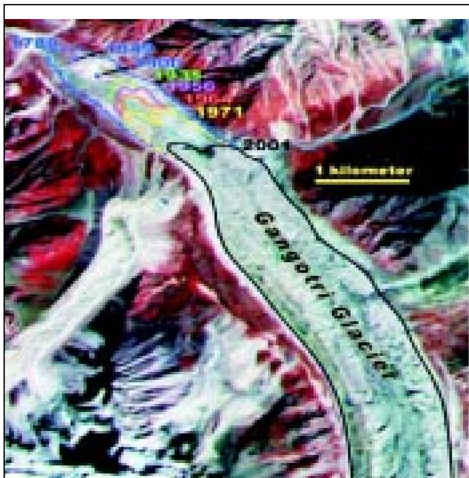

Figure 5.1: Retreat of Gangotri Glacier snout during the last 220 years from 1780-2001, India (cited ICIMOD/UNEP,2007)[2]

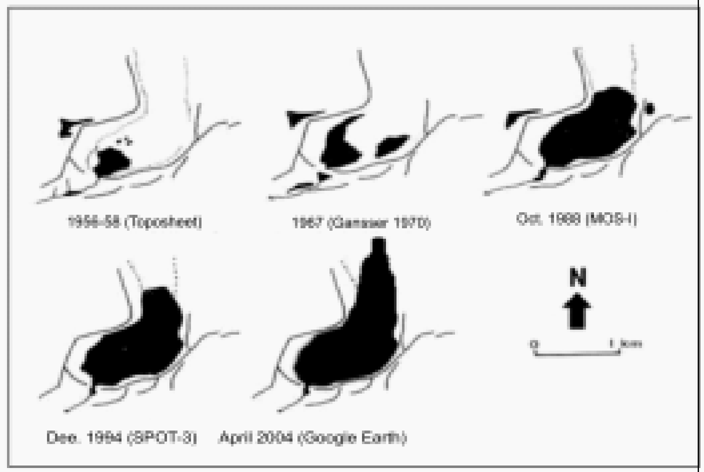

Figure 5.2: Expansion of Raphsthreng Tso Glacier, Bhutan[2]

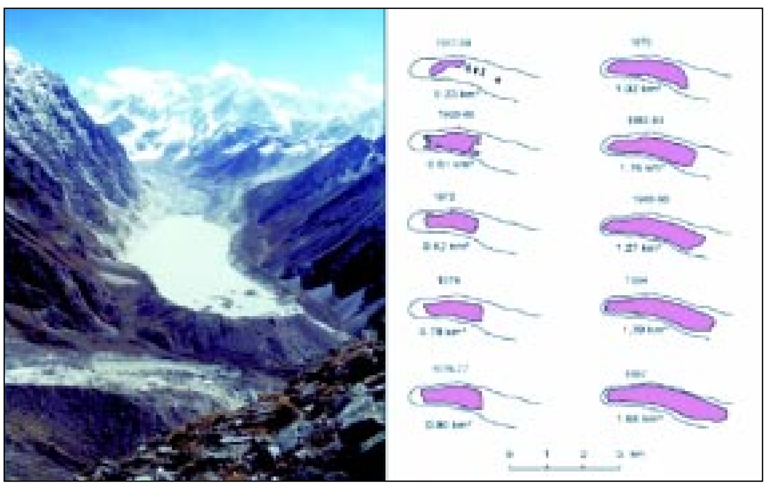

Figure 5.3: Growth of Tso Rolpa Glacier Lake 1957-1997 Nepal (cited Chaulagain 2006)[11]

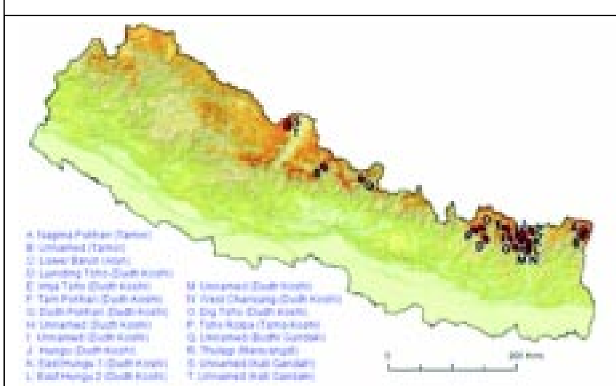

Figure 5.4: Potentially dangerous 20 Glacier Lakes, Nepal[5]

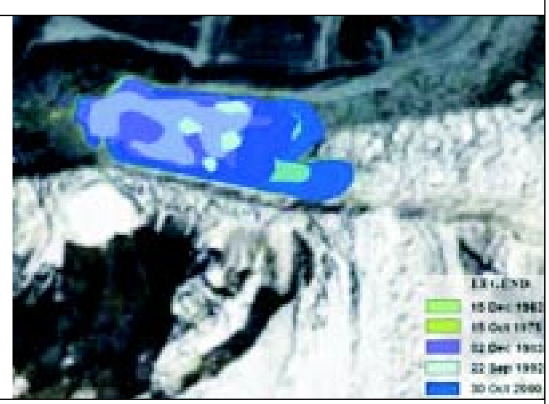

Figure 5.5: Development pf Glacier Lake 1962-2006 (ICIMOD/UNEP, 2007)[2]

Vulnerability Management through Cooperation: A Recent Example

The Pereechu lake in the Tibet region (across the Indian border – 35 km away from India's border in inaccessible terrain of China, formed during end-July 2004 due to blockade by landslide) was regularly monitored till end-June 2005, when the blockade was seen to have been breached. The information was provided to MHA and CWC, all through the life of the lake, in a timely manner so that adequate precaution to prevent loss to lives and property downstream in Himachal Pradesh could be taken by the concerned authorities.

Within 12 hours of receiving the alert, the newly formed lake on Pareechu river was identified and information on its geographical location, lake dimensions and water spread were computed and furnished to Ministry of Home Affairs. At the request of the Cabinet Secretary, the lake was monitored on a daily basis during Aug/Sept 04 and information was provided on a day-to-day basis. Based on the dynamic information with regard to the life-cycle of the lake, Governments of India and China worked in cooperation for all kinds of mid-course interventions. Monitoring of Pareechu Lake was continued from its frozen state. During the last week of June 2005, heavy discharges were reported in Sutlej River in Himachal Pradesh. IRS-P6 data of 27 June 2005 was analysed and observed that the blockade was breached and free flow of water from the lake was noticed. The cooperation between China and India worked in reducing the risk of flooding downstream.

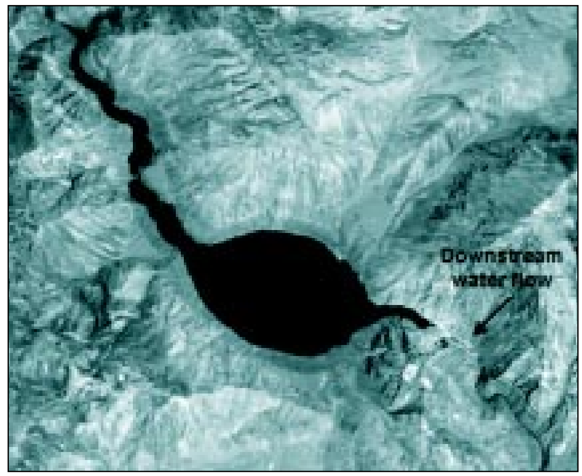

Figure 5.6: Pareechu Lake satellite image 17.8.2007[12]

Establishing Early Warning and Enhancing Preparedness for GLOF in 2007

While there was no incidence of GLOF in South Asia in 2007, preparedness to GLOF received priority among all the vulnerable countries – Bhutan, Nepal and India. The National Action Plan for Adaptation (NAPA) to Climate Change prepared by Bhutan and National Communication on Climate Change Mitigation and Adaptation brought out by Govt. of India have placed considerable focus on GLOF vulnerability reduction efforts.

There was a notable development with regard to GLOF risk reduction in Nepal. The ICIMOD/UNEP field study report identified Imja Glacier Lake of Nepal as one of the most vulnerable glacier Lakes in South Asia. In October 2007, a team led by Japanese Professor Fukui and other researchers from the National Agricultural Research Centre installed a unique monitoring device called a Field Server on the shore of Lake Imja Glacier Lake in Nepal.[1] The Field Server is an automatic device, powered by solar cells and capable of collecting a meteorological data, as well as images of time lapse. The Field Server is connected to the Internet under the collaboration with the Asia Pacific Advanced Network (APAN) and Nepal Research and Education Network (NREN).[1] The Internet Field Observation Robot at Imja Glacier Lake is located at an altitude of 5,000 m near Imja Lake.[8] The WiFi (wireless LAN) was extended from the Namche village to the lake, which is more than 27 km away. The captured images and several types of meteorological data are enabled for real-time data transfer to a server located in Japan at http://fsds.dc.affrc.go.jp/data4/Himalayan/[8]

In September 2007, a field study carried out by Department of Hydrology and Meteorology, Tribhuvan University with support from WWF and UNESCO estimated flood level at vulnerable communities living downstream of Imja Lake in case of lake burst. The study suggested VDC Phakdin as the most vulnerable community. The study estimated Imja GLOF impact in Dudh Koshi and Imja River (upstream of Dudh Koshi) and the anticipated GLOF discharge estimated more than 1300 m3/s at Phakdin.

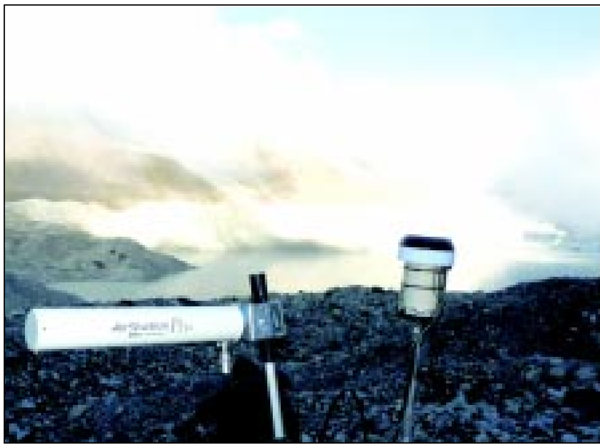

Figure 5.7: Field Server at Imja Glacier Lake[8]

Figure 5.8: Field Server with solar panel at Imja Glacier Lake[8]

Figure 5.9: Image from Field Server at Imja Glacier Lake 15 Nov 2007 1009GMT[8]

Figure 5.10: Image from Field Server at Namche Bazar 10 Dec 2007 0048GMT[8]

A good practice: Imja Disaster Risk reduction Project, Nepal

The major steps towards disaster risk reduction have been taken by the Department of Hydrology and Meteorology, Nepal Government with support from an international donor in 1998. In January 1998, MeteorComm and its partner British Columbia Hydro International Ltd. (BCHIL) of British

Columbia, signed a contract with Department of Hydrology and Meteorology, Nepal Government of Nepal (DHM), to design, supply, install and commission an audible warning system downstream of the Tsho Rolpa glacial lake. The main aim was to save as many as 6,000 lives, numerous villages, farmlands, bridges, trails, roads, as well as the construction site for a 60 MW hydroelectric project for 60 miles or more downstream.[9] The flood risk reduction system was installed at Tso Rolpa Glacier Lake in Nepal. In June 2000, approximately 3 m water level of lake reduced by constructing an open channel across the moraine dam-crest and thereby the flood risk was reduced by 20%.[6] The early warning system was also installed at villages downstream. The sensing system detects the failure of dam and transmits the warning.

The Department of Hydrology and Meteorology, Government of Nepal is monitoring and operating the system every year. The project is one of the finest examples of disaster risk reduction.

Figure 5.11: Early Warning Tso Rolpa, Nepal[10]

Figure 5.12: Sluice Gate, Tso Rolpa, Nepal[10]

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