

## Chapter 35

# Impact of Climate Change on the Retreat of Himalayan Glaciers and Its Impact on Major River Hydrology: Himalayan Glacier Hydrology

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### ABSTRACT

*Himalayan Glaciers are the largest freshwater resource on earth and the rivers originating from them are an important source of water. They significantly modify stream flow both in quantity and timing as annual basin run-off is enhanced or decreased in years of negative or positive glacier mass balance respectively. Although glacial advances and retreats are a part of its natural cyclic phenomenon, the rate of de-glaciations has accelerated in recent times due to climatic changes and global warming caused by anthropogenic activities. Some of the important glaciers of Himalayas are receding at an alarming rate, which could have dire consequences on river hydrology of the main rivers of this region namely, Indus, Ganga and Brahmaputra, initially causing floods and the paradoxically, scarcity of water later. This chapter is an attempt to summarize some of the studies on Himalayan glacier retreats and also to assess its impact on the availability of freshwater in the sub-continent.*

### INTRODUCTION

Glaciers represent ancient rivers of compressed snow and are the earth's largest freshwater reservoir, occupying an area that is roughly the size of South America. The earth, in its geological history, has witnessed a global climate change from being extreme cold to intense warm. This has manifested into the cyclic glacial and inter-glacial periods during the past. Geological evidences suggest that the earth has experienced glaciations during Pre-Cambrian, Perm carboniferous and in the last Pleistocene periods

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(Ramanathan et al., 2005). There have been at least 17 major glacial advances in the last 1.6 million years alone, the most recent one being the Last Glacial Maxima, which reached its peak some 20,000 to 18,000 years ago and came to an end about 10,000 years ago (Ramanathan et al., 2005). During the peak glaciations period of the earth, 47 million sq. km was covered by glaciers, three times more than the present ice cover of the earth (Kulkarni et al., 2007). Glaciations are followed by interglacial periods, during which the glacier retreats as a result of global warming. The interglacial period typically continues for about 10,000 years before the next glaciations begin. A number of ideas were proposed to explain the repeated cycle of glaciations on the earth. The most popular idea is related to the natural variation in the earth's orbit around the sun. The orbital cycles (100000, 41000 and 22000 years) can cause 10% variation of the incoming solar radiation in the various parts of the globe (Kulkarni et al., 2007).

Natural variations in the earth's orbit are well synchronized with the atmospheric variations in methane and carbon dioxide, leading to normal cycles of glaciations (Kulkarni et al., 2007). However, the natural cycle has been largely altered due to the greenhouse effect caused by anthropogenic changes made in the environment. During the past century or so, the economic development across the globe has been coupled with increase in atmospheric pollutants that trap the solar radiation and increase the mean temperature of the earth. This has led to an increase in global temperature by  $0.6 \pm 0.2^{\circ}\text{C}$  from the 1900 (IPCC report 2007). In addition to this, climate modeling suggests that greenhouse gases and aerosols have led to absorption of  $0.85 \pm 0.15 \text{ W/sq m}$  more energy by the earth than that emitted into space (Kulkarni et al., 2007). This implies an increase of about  $0.6^{\circ}\text{C}$  without any change in atmospheric composition.

Therefore, in the event of such enhanced global warming, it is important to study the effects and impacts on the glaciers across the world as they represent a vital source of water for a large percentage of people all over. They also affect the land pattern and river hydrology by their repeated melting and formation. Glaciers are dynamic systems, with periodic formation due to snowfall and melting taking place depending on the season. Snowfalls in the highest part of a glacier, which is known as the accumulation area, add to its mass and as the snow slowly turns to ice, the glacier grows in weight, forcing glacial movement (Ramachandran, 2001). Further down the glacier is the ablation area where most of the melting and evaporation of glacier.

## **IMPACTS ACROSS THE GLOBE**

Glaciers occupy a prominent portion of land mass of the earth across various continents and impact of climate change has been witnessed all throughout. A study carried out by World Wildlife Fund (WWF) on the impact of climate change on glaciers recorded conspicuous changes occurring in all glaciers and snow-covered regions of the world. Over the decades the Arctic glaciers have been observed to be shrinking, with the exception of Scandinavia and Iceland. The annual melting of ice has accelerated from 100 sq km in 1980-1989 to 540 sq km in 1998. Greenland, which represents 12% of the world's ice, has been significantly thinning and ice loss around the periphery. Recent studies show that the surface melting trickles down to the glacial bed, lubricating the ice sheet and making the whole mass of ice slide towards the sea.

In Northern America, glaciers in the Rocky Mountains and Western Coastal Ranges along with Alaska have shown significant glacial melting. Two-thirds of the glaciers of Glacier National Park have disappeared since its establishment in 1910. In Banff, Jasper and Yoho National Park in the Canadian Rockies, glacial cover has receded by 25% during the past century.

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