Gangotri Glacier

On every inch of this ever-shifting pathway, ice caps climb upwards in loose and fragmented towers, while ice pillars hold up plinths. We are minute mobile creatures in a realm of dissipating frozen Himalayan water edifice. As we move deeper into a sacred section where Lord Shiva is worshiped, we also witness the source of one of the greatest flowing courses of fresh water on the planet, the great Mother River, the Ganga…

Location and geology

Located in the extreme terrain of Uttarkashi district, Uttarakhand, Gangotri Glacier is 28 km long and almost 4 km wide. Originating from the cirque below the highest peak of the Gangotri group, Chaukhamba Peak the glacier flows northwest in between the meadows of Tapovan and the course of water takes a turn resembling the shape of a cow's mouth thus the terminus is named Gaumukh (Gau, cow + mukh, face). The Gangotri Glacier borders Tibet and is the primary source of water for the holy river Ganga and Bhagirathi- one of the biggest tributaries of Ganga.

Gangotri being the largest Himalayan Glacier is enveloped by Shivling, Bhagirathi III, Meru, and Thalay Sagar Peaks. The majestic nature and lush meadows around make for an exciting prospect for trekkers and adventurers. Gangotri Glacier is a group of 18 tributary glaciers among which 8 Chaturangi Glacier (72.91 km^2), 7 Rakt Varn Glacier (45.34 km^2), and 3 Kirti Glacier (31.28 km^2). Sumeru, Swachand, Miandi, and Ghanohim are the other tributary glaciers that form the Gangotri. Meru, Maitri, Bhrigupanth, and Manda Glaciers supply the river, Bhagirathi.

It is a valley-type glacier, extending in height from 4120 to 7000 meters above sea level with a temperature range between 6

degrees centigrade on the hottest days to -31 degree centigrade on the coolest nights. Composed of bedrocks of granites, garnet mica schist, kyanite schist, quartz biotite schist, augen gneiss, and banded augen gneiss, the glacier is witness to a variety of depositional features such as talus cones, snow-bridges, snow-avalanche fans, and dead ice mounds, and erosional features like pyramidal and conical peaks, waterfalls, serrated ridge crests, glacial troughs, smooth rock walls, crags and tails, gullies, rock basins, and glacial lakes. All along the length of the Gangotri glacier, several longitudinal and transverse crevasses are fabricated parallel to which ice blocks have broken down. The ablation zone of the Gangotri glacier is blanketed by a thick pile of supraglacial moraines and is characterized by several ice partitions, melting into pools of supraglacial lakes. Because of disintigration and the fast degenerating nature of the glacier, the core of the glacier is filled with increasing numbers and sizes of supraglacial lakes. On this side of the higher Himalayas, glacial melt water dominates the water resources. The ice cover, in total, is approximately 200 km^2 and has about 20 km^3 of ice in volume.

History and Religious Significance

The glacier is adorned by the Gangotri temple built in the 18th century by General Amar Singh Thapa. It is one of the four Char Dhams located at a height of 3048 meters and a distance of 98 km from Uttarkashi. It is the highest and the most auspicious temple of Goddess Ganga. A natural submerged rock in the form of partial Shivaling along the Gangotri Temple brings great magnificence where it is believed to be the same place where Lord Shiva entangled the huge waves of river Ganga in his matted locks.

Legend says that King Bhagiratha descended into deep meditation for a long time to plead with Goddess Ganga to bring her entourage down to Earth so that she could wash away the sins of his ancestors. His predecessor was King Sagar who had 60,000 sons born to Queen Sumati. King Sagar killed demons and planned on an Ashwamedh Yagya (to declare his supremacy). It was decided that the sacrificial horse will be taken around the Earth by Asamanja, born to his other queen Kesani. Lord Indra decided to hamper his plan and stole the horse that he tied to the doorstep of hermit Kapil Muni. Kapil Muni was meditating when the sons of King Sagar came looking for the horse and found it outside his hermitage. They presumed he was the thief and refuted him. It was then Kapil muni opened his eyes and the 60,000 sons were instantly killed. King Bhagiratha, the grandson of King Sagar, decided to perform penance and bring down Ganga to wash away the sins of the 60,000 sons so that they could ascend to heaven. The goddess was pleased and agreed. However, Lord Shiva knew that her mighty force could destroy Earth so he welcomed her in his matted locks and broke the force. Ganga is also known as Bhagirathi as King Bhagirath called for her.

Another tale is: Ganga was a beautiful woman born from the water vessel belonging to Lord Brahma. The water was collected in the vessel after Brahma washed Lord Vishnu’s feet after his victory over the demon king Bali. Therefore, Ganga is also named Vishnupadi (Vishnu, lord Vishnu + padi, feet). Vishnu, in his avatar of Vaaman, had asked Bali for three footsteps of land after the demon king overthrew Lord Indra from heaven. Bali agreed and so Vaaman grew in size. On one step he placed his foot on the Earth, on the second he placed his other foot on the Sky and on the third step he strived on Heaven. However, he stubbed his toe at the vault in Heaven and released Vishnupadi who streamed her way across the sky onto the earth.

Biodiversity

The glacier is situated inside the Gangotri National Park (GNP) which is the biggest (2,390 km2) Protected Area in the state of Uttarakhand. It is located in the upper catchment of the Bhagirathi river in Uttarkashi District. The northeastern boundary of GNP snakes along the international boundary between India and China. It forms a perpetual landscape for conservation and wildlife protection along with the Govind National Park in the west and Kedarnath Wildlife Sanctuary towards the south. The elevation ranges from 1,810 to 7,083 meters above sea level. It falls under biogeographical zone 2B of the western Himalaya however, Nilang Valley and the surrounding region can be imperviously categorized within Trans-Himalaya (Zone 1). The area is outlined by high ridges, crags, deep gorges, precipitous cliffs, glaciers, and narrow valleys.

A large variation in elevation and aspect results in diverse vegetation, grouped into five major forest types: Himalayan moist temperate forest, Himalayan dry temperate forest, sub-alpine forest, moist alpine scrub, and dry alpine scrub. So far, 15 species of mammal and 150 bird species have been documented from the part which includes Snow leopard (Panthera uncia), Musk deer (Moschus chrysogaster), Black bear (Ursus thibetanus), Brown bear (Ursus arctos), ,Koklass (Pucrasia macrolopha), Blue sheep or Bharal (Pseudois nayaur), Himalayan tahr (Hemitragus jemlahicus), Himalayan monal (Lophophorus impejanus), and Himalayan Snowcock (Tetraogallus himalayensis). Along with pilgrims, it also attracts a large number of adventure seekers and wildlife enthusiasts.

Also, the park is home to various endemic species of butterflies: Goniorhynchus signatalis, Lista haraldusalis,Spilosoma obliqua, Trichopterigia rufinotata, Psyra similaria, Nordstromia lilacina, Diarsia albipennis, Cyana horsfieldi, and Spilosoma strigulata.

Environmental Issues

Melting of Glacier

Unfortunately, the area is under tremendous pressure from the threat of loss of biodiversity due to various anthropogenic activities like increasing human population, conversion of forested land to agricultural patch, livestock grazing of pastoral people, and shifting cultivation.

Many scientists consider receding glaciers as a symptom of global climate change. While certain types of glaciers such as tidewater glaciers and surge glaciers are expanding, there are several areas where scientists report glaciers are withering away and that climate change is the culprit.

A glacier recedes when it melts faster than fresh snow can accumulate. Studies are being conducted to determine how old each tree was and how far from the terminus (end of a glacier) it was now as they could calculate the minimum distance the glacier had receded. The findings were published as a part of a paper in ‘Quaternary International’ by Elsevier.

So far, only 11 Himalayan glaciers have been taken under analysis for mass balance and around 100 are being monitored for fluctuations, as the study said.

Gangotri has been retreating since 1780, although studies show its rate of recedes has quickened after 1971. Over the last three decades, Gangotri glacier has thawed more than 850 meters, with a recession of 76 meters from 1996 to 1999 alone. To exemplify 97% of the Gangotri glacier retreat occurred in just the last eight decades.

Industrial and carbon emissions

Black carbon emission due to indiscriminate burning of paddy and sugarcane stubble has not only put the National Capital Region (NCR) under grave stress of pollution but because of its light-absorbing nature can also catalyze the melting of the Gangotri glaciers in the high altitude eco-sensitive Indian Himalayas in India. Forest fires also contribute to increasing black carbon concentration. According to a report by the Forest Survey of India, forest fire activity generally occurs in Uttarakhand from February to June, with a peak in fire incidences in May and June.

In addition to man-made causes for forest fires in the state, other reasons include friction of falling rocks, lightning, and monkeys accidentally throwing stones that create sparks leading to forest fires.

Researchers from Wadia Institute of Himalayan Geology, (WIHG) an autonomous institution under the Indian Department of Science and Technology in their study conducted at Chirbasa station (3600 m) near Gangotri Glacier in 2016 found that black carbon concentration varied from 0.01 micrograms per cubic meter in winter to 4.62 micrograms per cubic meter during summer, that is spike by 400 times during summer.

It was for the first time, measurements of ambient black carbon mass concentration were made at such a high-altitude region in the Indian Himalayas.

The study concluded that the seasonal cycle of black carbon was significantly influenced by the emissions resulting from agriculture burning (in the western part of the country), forest fires (along the Himalayan region) in summer, and to some extent, the contribution from long-range transport of pollutants in winter, the prevailing meteorological condition as the reason behind this seasonal increase.

The positive aspect is that while CO2 stays in the atmosphere for as long as a century, black carbon lingers only for a much shorter time. So if most of the Himalayan glacial melt observed in recent decades is not due to increases in carbon dioxide but more particulate pollution. It can be much more easily handled, at least abstractly.

Effects on Vegetation

Glaciers are directly subjugated by climatic conditions. So, they are more susceptible to the effects of climate change. That is evident in the vegetation that can grow around them.

“Many of the high-elevation species in the western Himalayas are identified to be expanding to higher elevations in response to warming,” the study in Quaternary International said. Among these, the Himalayan birch is the one found uppermost with signs of unhurried expansion to upper elevations, that is, as the average temperature in glacial region surges, the species has to keep roving higher to colder altitudes to survive.

The oldest tree recorded for the study was a Himalayan birch at Bhojbasa, going back to at least 1571.

The tree was 1.4 km away from the glacier’s snout at the time. Now, it is 3.26 km away meaning the glacier has moved 1.86 km. “Its net retreat was only 63m during 1571-1934,” the study quoted. Since then, it has receded another 1.8km. “The glacier snout retreat has accelerated since 1957 (1.57km), which is consistent with the observed regional warming.”

Increased risk of floods

The immediate and short-term effect of glacial melting is flooding in many north Indian states. The Kedarnath tragedy of 2013 and the Chamoli flash floods of 2021 which destroyed

Raini village, two hydropower plants and took 170 lives, both of which horrified the state of Uttarakhand can be attributed to constant glacial melt in the Himalayan region. Such massive flooding can cause havoc to the lives of people living in the region and also damage the infrastructure and environment.

Water Scarcity

In the long run, the thawing of glaciers would pose severe challenges to the water security of the region and by extension, almost half the country. The Gangotri glacier is the primary source of the river Ganga. In the summer season, the glacier fills the Bhagirathi river, which is Ganga's source stream. About 700 million people depend in part on seasonal runoff from Himalayan glaciers for irrigation, hydropower, and drinking water. Consequently, any deficiency in water resources would reduce agricultural yields. Moreover, since global warming induces glaciers to melt in spring itself thereby aggravating the risk of crop failure in the summers when there is already high water demand.

Solution

Research-based approach

To create solutions, one must dwell deeper into the issue, and keeping that in mind, scientists at the United States Geological Survey (USGS), in concert with the National Snow and Ice Data Center (NSIDC) and NASA, are developing a global inventory of all the world's glaciers to help researchers track each glacier's record. The inventory combines current information on size and movement with historical data, photos, and maps of each glacier. The purpose is to better enable scientists to connect changes in each glacier with any shifts in local climate, such as temperature or precipitation

changes.

But it is not practical to visit and measure every major glacier on Earth. There are almost 158,000 glaciers in Earth’s polar regions and high mountain environments. Therefore, researchers are, to a greater degree, using satellite remote sensors to routinely survey the world’s glaciers in a fraction of the time and cost it would otherwise take.

Important indicator groups like moths that produce morphological variations in the spree to adapt to changing climate can be utilized to plot the overall picture of biodiversity.

Sustainable use of resources

The Uttarakhand government has submitted plans to the court to monitor Gangotri Glacier. It has been decided to oversee the judicious use of electricity, water resources, and fossil fuels in an effort to curb black carbon emissions.

Effectively, alternative energy sources can be introduced and popularised to slow down global warming. Solar panels trap the heat from the sun which can later be converted to electrical energy. Wind turbines use the kinetic energy from the wind to generate power. Geothermal energy utilizes the heat from inside the earth. Biofuels such as ethanol can be produced by fermenting and mixing vegetables, grain waste, and fruit; ethanol has the remarkable potential of replacing diesel. Electric cars are battery-operated that do not rely on the highly polluting internal combustion engine; hydrogen fuel cells are being developed for these batteries. Tidal and wave power utilize the humongous power of the ocean by harnessing the energy with generators placed on the ocean bed. These are a few yet phenomenal ways to deal with global warming.

Individual Contribution

As an individual, you can give a hand by saving power and reducing the use of fossil fuels. These seemingly little things make a large impact if they are done on a large scale, and they'll go a long way toward reducing your carbon footprint and saving the glaciers.

Conclusion

The Gangotri glacier has been present ever since civilization started taking baby steps and people found out that Ganges originates from there. The glacier has supported billions of people in the form of water for thousands of years. Whether its religious significance or scientific significance, the Gangotri glacier will always have extreme importance on the people, ecology, geology, religion and biodiversity of India.

With global warming, too much tourism, pressure on water resources, the Gangotri glacier faces more challenges than ever in this century. The situation can definitely improve and we can make sure that this heavenly glacier survives this century and we hand it over to our coming many generations in the same way it has been passed to our ancestors for thousands of years.