The Himalayas – water storage under threat

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The Hindu Kush-Himalayan region has the most extensive high altitude areas on Earth and the largest areas covered by glaciers and permafrost outside the polar regions – the 'Third Pole'. These mountains are now recognised to be a hotspot of climate change (Dyurgerov and Meier 2005), but they still receive significantly less attention than the Arctic or Antarctic.

The region's ranges and foothills encompass a wide spectrum of ecological zones with great socioeconomic potential. They contain significant biodiversity hotspots and a unique array of plants and animals of global importance. Furthermore, the wetlands, rangelands, and forests provide valuable ecosystem services such as plant-based production, soil retention, climate regulation, and carbon sequestration.

The ranges form a barrier to the easterly monsoon winds and are the origin of ten of the largest rivers in Asia. The huge water storage capacity of the mountains provides a lifeline for millions of people in the region and downstream; more than 1.3 billion people are estimated to depend directly or indirectly on Himalayan waters.

Climate change

The Himalayas are experiencing a general warming trend. The mean maximum temperature in Nepal increased by 0.06°C per year between 1977 and 2000. Similarly, the Tibetan Plateau has experienced warming in the range of 0.02°C to 0.03°C per year over the last fifty years (Yao et al. 2006) – much greater than the global average of 0.74°C total over the last 100 years (IPCC 2007). Based on regional climate models, it is predicted that the temperatures on the Indian sub-continent will rise between 3.5°C and 5.5°C by 2100, and on the Tibetan Plateau 2.0°C by 2050 and 5.0°C by 2100 (Rupa Kumar et al. 2006). Monsoon rainfall in India and Nepal has been found to be highly correlated with large-scale climatological phenomena such as El Niño. There are already signs of changes in the dates of the onset and retreat of the monsoon as well as the number and frequency of extreme precipitation events.

One of the main concerns in relation to climate change in the Himalayan region is the reduction of snow and ice, which reduces the region's water storage capacity. Changes in the intensity and distribution of rainfall may also lead to changes in the uptake of rainwater by soils and the recharge of aquifers. Climate change may affect people's wellbeing in numerous ways. For example, it is very likely to aggravate the existing food insecurity and problems of irrigated farming systems, especially in the Tarim and Indus river basins. The Indus Irrigation Scheme in Pakistan depends 50% or more on runoff originating from snowmelt and glacial melt from the eastern Hindu Kush, Karakoram, and western Himalayas (Winiger et al. 2005).

"The huge water storage capacity of the mountains provides a lifeline for millions"

The Himalayas as the water tower of Asia

The Hindu Kush-Himalayan mountains are the major source of stored water in the region. Water is retained in the form of ice and snow in the high mountains, as well as being stored in natural lakes, wetlands, and groundwater aquifers, and behind constructed dams.

The Himalayas have a total glaciated area of around 33,000 sq.km (Eriksson et al. 2009) which provides important short- and long-term water storage facilities. "There is about 12,000 cu.km of fresh water stored in the glaciers throughout the Himalayas – more fresh water than in Lake Superior" (Thompson 2007). Compared to glaciers in other mountain ranges, the Himalayan glaciers are retreating at higher rates, and these rates are accelerating. Projections of glacier retreat in the region (IPCC 2007) suggest that the projected increase

Himalayan mountain stream

in the mean annual temperature for High Asia of 1.0°C to 6.0°C by 2100 is likely to result in an extensive diminishing of glacial coverage. Continued deglaciation could have profound impacts on the hydrological regimes of the ten river basins originating in the Himalayas. It is suggested that river discharges are likely to increase for some time due to accelerated melting, but as the glaciers' water storage capacity is reduced, the flow is likely to decline. Indications of shifting in the hydrographs of some rivers in Nepal have already been observed. The hydrological implications of such deglaciation are expected to be most severe in the arid parts of the Himalayan region.

Areas in the high mountains and on the high plateaus not covered in perennial snow and ice are underlain by permafrost. The areas covered by permafrost are much larger than those covered by glaciers or perennial snow, especially in the Tibetan Plateau, China. The Tibetan Plateau has approximately 1,360,000 cu.km of perennial permafrost (Xin Li and Cheng Guodong 1999). But recent studies show that the extent of permafrost is shrinking, that the thickness of the active layer (the upper portion of soil that thaws each summer) is increasing, and that this has altered the hydrological cycle, vegetation composition, and carbon dioxide and methane fluxes which appear to be linked to permafrost degradation.

The Himalayas have many lakes with an enormous capacity for water storage. For example, the Tibetan Plateau alone has more than 1000 lakes, with a total area of approximately 45,000 sq.km. The major sources of lakewater are rainfall, and glacial, snow, and permafrost melting. In addition, many glacial lakes have formed associated with the retreat of valley glaciers. According to ICIMOD's inventory, there are 8790 glacial lakes in Bhutan, Nepal, and selected areas of China, India, and Pakistan. These lakes also offer a certain storage capacity, but a number of them are also potentially dangerous, that is they could burst out and cause catastrophic floods downstream (GLOFs) at any time. There have been at least 35 GLOF events in Bhutan, China, and Nepal in the past.

High altitude wetlands account for around 16% of the total area of the Hindu Kush-Himalayas Himalayas and play an important role in water storage and regulating water regimes (Trisal and Kumar 2008). They maintain water quality, regulate water flow (floods and droughts), and support biodiversity. They also play an important role in mitigating the impacts of climate change by acting as carbon sinks. The peatlands in the Tibetan Plateau are one of the most important stores of carbon in the mountain region, storing 1500-4000 tonnes per ha (Trisal and Kumar 2008). The Himalayan wetlands are under pressure from drainage for agriculture, tourism-related pollution, overgrazing, and climate changes. Some areas, such as the Ruoergai Marshes of the Tibetan Plateau, have been severely degraded over the past decades due to drainage, overgrazing, and climate change.

Groundwater aquifers are important for water storage in the Himalayan region, but there is little data available to allow assessment of the change and uses of groundwater on a regional scale.

Official statistics on dams higher than 15 metres from the World Register of Large Dams show that India has 4300 dams and China 1855, compared to 6600 in the USA and 2700 in Japan. There are also a large number of non-registered dams in China. Researchers have tried to explain the viability and cost of dam construction at a location in terms of its geographical features such as average land gradient and river gradient. They have also concluded that rivers flowing at a gradient of over 6% increase the suitability for dam construction. To this end, if mechanisms could be developed to ensure that environmental concerns are integrated in the process of planning and implementation of artificial water storage systems, it may be appropriate to promote environmentally-friendly dams and reservoirs that could provide water storage, as well as flood control and hydro-energy benefits.

China and India are traditionally two leading producers of rice in the world, most of the harvest coming from irrigated agriculture in the Ganges, Yangtze, and Yellow river basins. Moreover, China and India are today experiencing economic growth and are gaining in international importance. The development of these two giants demands increasing ecosystem services, especially freshwater resources.

The Himalayas – reconciling human demands and the environment in a globally warmed world

Climate change clearly has a global dimension. While the priority has to be adaptation, we are aware that the Himalayas are suffering the consequences of a global phenomenon. Unfortunately, global instruments in relation to the Kyoto protocol do not yet benefit the mountains. There is a continuum between mitigation and adaptation, where mountain systems should not be sidelined in world actions. The mountains, especially the Himalayas, require global solidarity. Adaptation calls for micro-level changes within national responsibilities, however, the Himalayan region needs regional consultation, as well as exchange of information and experiences. Certain tasks call for regional, transboundary actions as outlined below.

Promoting regional cooperation: Most of the large rivers originating in the Himalayas flow across several countries. The development of water resources in the Himalayan region requires transboundary cooperation. In the past, water resource management has been looked at from national and bilateral perspectives that hindered the optimum development of transboundary water resources in an integrated manner. Climate change has posed additional stress and challenges to water resources development and management, with an increased scarcity of water in the dry season, enhanced hazards in the monsoon, and increased temperature leading to melting of snow and ice. Cooperative efforts among the riparian countries are crucial for addressing this huge challenge.

Developing a regional programme for climate change monitoring: It is essential to develop a scientific framework for field observation in collaboration with government agencies and academia. Remote sensing allows for regular and repeated monitoring of snow cover, which can be carried out by countries such as China and India, with results shared with those lacking such technological infrastructure. Studies need to include both ground-based and satellite-based monitoring. Well-equipped stations and long-term monitoring, networking, and cooperation within and outside the region are essential.

Developing water storage systems and management strategies as options for climate change: It is necessary to assess the social requirements for water in the context of climate change, and then to develop natural systems and solutions for policymakers and stakeholders to take the required steps to meet those needs through wise use of high altitude wetlands, groundwater management, and construction of water storage systems, in the best manner possible. Water storage, based on local practices, should be encouraged in the region.

In the end, the Himalayas may be an example of how humans and the environment collide in a globally warmed world. Can the world's third pole be saved? What we do about this will probably determine what is going to happen to our world in the future.

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