

Climate Change in Tibet and Asia

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The Significance of the Tibetan Plateau

Tibet referred to as 'The Third Pole' and 'The Water Tower of Asia' reflects the significance of its snow capped mountains and its alpine grasslands. Since time immemorial, the plateau holds the Hindu Kush Himalayan Ice Sheet, considered as the largest ice mass outside the two poles. Its plateau contains more than 45,000 glaciers covering an area of 105,000 km². Encompassing an area of about 2.5 million square kilometers, or about one-third the area of the continental United States, the Tibetan Plateau is the largest and highest region on Earth. With an average elevation of 4,500 meters above sea level, the Tibetan Plateau stretches for almost 3,000 kilometers from west to east and 1,500 kilometers from south to north. The Plateau is ringed by high mountains – the Himalayas to the south, the Karakorum in the west and the Kunlun across the north (Figure 1). One can just learn by looking at its map to figure out how the Tibetan Plateau dominates the geography of Asia (D.J. Miller, 2009).



Fig1. Tibetan Plateau, (Image courtesy: NASA & D. J. Miller)

Glaciers and Rivers

Glacial runoff from these regions feeds the largest rivers in Asia, including Yarlung Tsangpo (Brahmaputra), Driчу (Yangtze), Machu (Yellow), Zachu (Mekong), Macha Khabab (Ganges) and Sengye Khabab (Indus River) and more. Referred to as 'The Water Tower of Asia', the Tibetan Plateau is the head region to major rivers that flow into India, Bangladesh, China, Nepal, Pakistan, Thailand, Burma and Vietnam (Figure 2). For China alone, 30 percent of its fresh water supply is met from the rivers flowing from Tibet. For many generations, this Plateau has met the basic necessities to sustain life and flourish human civilizations beyond its vast border. From the arid plains of Pakistan and India to the rice paddies of southern Vietnam, from the great Tonlesap lake of Cambodia to the North China plain, these rivers bring life and joy to millions of peoples (EDD, 2008).

There is little doubt that melting glaciers of the Tibetan Plateau provide a key source of water in the summer months; as much as 70 percent of the summer flow in the Ganges and 30–50 percent of the flow in other major rivers. The glacier-fed rivers originating from the Tibetan Plateau make up the largest river run-off from any single location in the world. Perhaps the most critical region in which the melting glaciers will negatively affect water supply (*in the next few decades*) will be China and parts of Asia, including India and Bangladesh.

Zachu or Mekong River, originating from Mount Thangla is the bloodline for the Mekong-region countries. This river flows from the central Tibet through Yunnan Province in China and then flowing through Laos, Thailand, Cambodia and finally ending its journey in Vietnam. This river directly supports approximately 70 million common peoples along its basin from fisherman to farmers.



Fig2. Water Tower of Asia

Permafrost layers as carbon store

The presence or absence of the permafrost layer entails major variations in the soil's physical structure, determining, to a large extent, the hydrological and nutritional status of the soil, which in turn, is pivotal in determining the vegetative coverage, plant community structure and productivity. Unlike the ones that are widespread in the Arctic and boreal regions of Northern Hemisphere, the permafrost prevailing on the Tibetan Plateau (1.3 to 1.6 million km²) are alpine permafrost. This type of permafrost are featured by warm permafrost and rich ground ice and are among the most sensitive to climate change and are particularly vulnerable to warming temperature. The alpine permafrost on Tibetan Plateau stores about 12,300 Million tonnes of Carbon. A study conducted at the source region of the Yellow River indicated that a significant amount of methane is trapped in the permafrost layer of that region (EDD, 2009).

Alpine Grasslands and Meadows as carbon sink

Tibet's rangeland (*Tib: Jhangthang*), from the Northern Plateau of upper Tibet to the extreme eastern edge of the plateau, with an average altitude of 4000 to 5000 meters, covers approximately 70 percent of the total area of the Tibet's area. The types of rangeland vary from alpine meadows and mountain scrub to mountain sparse wood and mountain desert, which helps sustain domestic herds and nurture a wide variety of wildlife species.

These rangelands and its cold alpine grassland soils are the major carbon sink and house a greater organic carbon pool. During the growing season, the alpine meadows appears to absorb 'or' take up CO₂ at the rate of (1840 – 3050) mg/m².day. Studies showed that total Soil Organic Carbon storage (*sampled from the top 1 meter soil*) in the alpine grasslands of TP was estimated about 7400 Million tonnes of Carbon.

For many generations, pastoralism on these rangelands has been the best and the only option to live successfully. Over the time, Tibetan pastoral nomads has skillfully introduced domestic herds and maintained an extraordinary biodiversity of grasses and sedges, enabling human life to flourish at the Third pole.

Wetlands and wetland areas as carbon sequesters

Statistics of the natural wetlands (*excluding lakes and floodplains*) area by geographic regions in China revealed that Tibetan Highland holds over 51 percent of total natural wetlands. These wetlands are dominated by Salt Marsh, Peat land and Freshwater Marsh. These wetlands tend to trap carbon-rich sediments from watershed sources.

The Wetlands in Tibet play a major role in regulating the flow of rivers and also are the major carbon stores. They act like sponge, absorbing water during the summer when the water is in excess and releasing it in the winter when the runoff is short.

Climate Change impacts in Tibet and Asia

Critical components to Tibet's ecosystem are undergoing major transformations due to climate change. For instance, it has led to the receding of Tibet's glaciers, shrinking and disappearance of

thousands of lakes, drying of wetlands, thawing of permafrost, and reduced flow regimes in many rivers.

Abnormal weather conditions due to climate change such as non-sequential rainfall, delayed in milking season, reduced growth of calf, etc., has made subsistence farming and herding more unpredictable, thus impacting the livelihoods of a majority of Tibetans. These days, on the plateau, the spring thawing is earlier and the permafrost is melting away before the growing plants can access the water. This affects not only the crops but also the native vegetation of Tibet, especially in wetlands and other low lying areas. The loss of wetland in turn threatens the migratory birds used to Tibetan stopovers (EDD-COP15).

Julia Klein (2005), mentioned in her studies that 'climate warming is an unusual environmental problem since the primary greenhouse gas emitters driving these changes can be far removed (*due to the large spatial disconnect between drivers and recipients*) from the most vulnerable recipients of the climate change effects'. This rise in temperature has also have its increased the rate of evapo-transpiration from the rivers and watershed areas intensifying the desertification process. According to Immerzel (2008), '**Eco-payment**' for the Tibetan farmers could become a viable solution in order to protect the downstream areas from possible water crisis.

At present, the plateau is undergoing a multi-facet environmental degradation; the melting of glaciers, non-sequential thawing of permafrost, drying up of wetlands and vast desertification of grasslands leading to the failure to assimilate atmospheric carbon. These carbon pool would soon disintegrate in due time, resulting in further emissions of greenhouse gases and the vicious cycle continues further. The immediate recipients of the climate change impacts are those herders and farmers who did nothing to cause climate change. Chinese National Climate Change Assessment Report (2007) revealed that China's average annual temperature could increase between 1.3 -2.1 degrees by 2020 and as much as 3.3 degrees by 2050. It is predicted that precipitation in three of the seven major rivers will drop by 30 percent in the second half of the century leading to a 37 percent decline in wheat, rice, and corn yields. Major cities in coastal areas will face serious challenges due to rising sea levels, and extreme weather patterns are likely to increase.

Glacial meltdown & permafrost degradation

According to Jane Qiu (2008), 82 percent of the Tibetan Glaciers have already retreated in the past half century. In the past 40 years, Tibet's glaciers have shrunk by 6,600 sq km (*as of year 2006*). It is estimated that they are currently melting at a rate of 7 percent per year. A separate study by a NASA scientist (2010) revealed that 20 percent of Tibetan glaciers have retreated in the past 40 years and if the current trend continues, more than 60 percent of the existing glaciers could be gone in the next 40 years.

The formation of glacial lakes as a result of the rapid melting of glaciers on the higher reaches of the mountain ranges continues to pose a serious threat to downstream countries, especially Nepal and Bhutan. International Centre for Integrated Mountain Development (ICIMOD) has identified some 8,790 glacial lakes in parts of the Hindu-Kush Himalayas out of which, the organization has confirmed 204 glacial lakes as 'likely to burst'. Greenpeace reported that Imja glacier in Nepal is retreating at nearly 10 meters per year. Other reports show that the average temperature in Nepal has increased by 1.5 Celsius since 1975. Scientists from Nepal's ICIMOD said the lake is growing by just under 50 meters per year and is in danger of bursting its banks – a

31 meter-high dam of rocks and stones – and flooding nearby villages and trekking routes. They predicted that more than 7,500 people would be affected by the floods, including tourists hiking along the popular Everest Base Camp route. A recent BBC news report mentioned that the ethnic community residing in Nepal's western province (Halji village) is threatened by a glacial lake on the mountain overlooking their village.

Studies have also shown that glacial melting and thawing of permafrost in the Tibetan Plateau will lead to a large scale release of greenhouse gases in the atmosphere and bringing further changes in the already warming climate. The permafrost layers and the seasonally frozen soils on the Tibetan Plateau are well preserved over a long time by low winter air temperatures. Its seasonal thawing and refreezing have also played a vital role in balancing the delicate alpine vegetations, until now. With the significant increase in the mean cold season average temperature, the permafrost layers and seasonally frozen grounds are slowly degrading leading to increased microbial decomposition of previously frozen organic carbon. Slope failures are often seen on the Tibetan Plateau due to permafrost degradation. Permafrost degradation has changed the regime of water retention and regulation by producing more runoff in areas of permafrost, leading to more evaporation. It has also prolonged the thawing period significantly leading to many interconnected ecological changes and technological worries. Locally, this degradation would result in the gradual desertification of grasslands, resulting to higher surface albedo and increased ground temperature.

Human interference is also largely responsible for the degradation of permafrost layer on the Tibetan Plateau. H. Jin *et al* (2008) in their study along the Siling Lhasa Highway (SLH) corridor have found that the heat accumulation under the asphalt road bases resulted in increased thaw depths too great to be frozen and, consequently, resulting in the transformation of vertically connected permafrost into disconnected phase. They indicated that the ground temperature at the shallow depths in transition and quasi-stable permafrost zone have been increasing noticeably, as a result leading to the shrinkage of permafrost boundaries. Some other researchers have pointed out that approximately 30 percent of the SLH has to be repaired every year due to damage cause by frost action.

Recent studies showed that permafrost thawing in many regions of TP is influencing both hydrological regimes and vegetation, as well as engineered structures. Such thawing of permafrost leads to the formation of thaw slumps, slope failure and in the process will inject lots of trapped carbons in the atmosphere. Examples of surface degradation associated with thaw of ice-rich permafrost on the Tibetan Plateau are shown in **(Figures 3 a & b)**.

The condition of permafrost degradation in some areas of the Tibetan Plateau was such that the active layers were oversaturated by water either from glacial runoff or rainfall during the thawing season.



Figure 3 a & 3b Permafrost degradation (Tibet)

a) Mass-movement feature, possibly an active-layer detachment slide, developed during summer of 1996 on the south side of the Kunlun Pass (Tibet); b) Retrogressive flow on the slope of Tanggula Mountain of the Tibet Plateau.

Influence on Asian monsoon pattern

The plateau's seasonal heating during summer and spring plays a principal role in determining the large-scale air circulation in summer. Heating over the Tibetan Plateau tends to generate a surface cyclonic circulation and upper-atmosphere anti-cyclonic circulation which results in the appearance of a large air motion in the eastern side of the plateau. As long ago as 1884, An English meteorologist working in India had the inspired idea that the snows of Tibet and the Indian monsoon are causally connected. Henry Francis Blanford, in the pages of Proceedings of the Royal Society, in London, proposed that the greater the snow cover in the land of snows, the later the Indian monsoon wets the parched earth on India. Conversely, he suggested, the less the winter snows in Tibet, the earlier the snowmelt, and the earlier the monsoon. During summer, the Tibetan Plateau intensifies the pressure gradient between the south Asian landmass and the Indian Ocean leading to the flow of air and moisture from the sea (EDD-COP15).

According to many scientist and researchers the ground freezing and thawing of the Tibetan Plateau have a significant influence on the atmospheric circulation. The rise in the soil moisture content (*due to active layer thawing*) increases the level of heat exchange between the atmosphere and ground surface. For instance, the onset of summer precipitation in Southern China and in the middle and lower basin of the Drichu (*Yangtze River*) are influenced by the spring thaw timing over the Tibetan Plateau. In consistent to that, the significance of spring snow depth over the Tibetan Plateau correlates with the amount of summer precipitation on the middle and lower basins of Drichu.

Shrinking lakes and wetlands

There used to be thousands of lakes in Tibet. Most of these lakes have no outlet, and depends entirely on local streams and underground sources to maintain their water level. These lake levels are mainly controlled by the warming climate and human activities. Already a large number of these lakes in Tibet have disappeared. As per Xinhua News Agency, wetlands on the Tibetan

plateau have shrunk more than 10 percent the last four decades, with wetlands at the Yangtze's origin contracting an alarming 29 percent.

The wetlands on the Tibetan Plateau are shrinking and drying resulting in the subsequent release of carbon dioxide, *methane*¹ and *nitrogen dioxide*². As such, this further adds up to the yearly greenhouse gas emission. Methane emission from the wetlands during the thaw season were estimated to be (0.7 – 1.05) Million tonnes per year and the annual N₂O emission from the wetlands of Tibetan Plateau are estimated at 0.022 – 0.025 Million tonnes. Adding up the total GHG emission of CO₂ (316.02 g CO₂/m²), CH₄ and N₂O from Tibetan Plateau wetlands in a year (*irrespective of their atmospheric stability and in terms of CO₂ GWP*), it sums up to 68 Million tonnes of CO₂.

Loss of carbon sinks from degraded grasslands, Endangering Pastoralism

Pastoralism on the Tibetan Plateau is an 'adaptation to a cold environment at elevations above the limit of cultivation'. For centuries, the Tibetan nomads and herders have successfully maintained a sustainable and mobile lifestyle, traveling from winter to summer pasture lands and autumn to spring pasture lands. The grasslands on the Tibetan Plateau represent one of the last remaining agro-pastoral regions in the world. The Plateau itself is covered in almost 70 percent of these precious grasslands. The pasture lands are made habitable through the co-existence of the Tibetan people and their yaks. Through their efforts they have maintained the sustainable use of this area for many centuries. China's introduction of different grassland policies over the years threatened the sustainability of this delicate environmental balance. The new policies restricts the flexibility and mobility of the nomads (*which is the main ingredient in the nomadic pastoral production*) and blames their livestock for overgrazing the grasslands (EDD-COP15).

These days, many researchers and rangeland specialist are arguing the applicability of these new policies, and how much these have actually benefited or affected. Recent scientific findings (Julia *et al*, 2007; Tony Lovell and Bruce Ward, 2009) give us more insight information about the regeneration of the grasslands and the vital role of grazers in replenishing the grasslands. In their studies, they revealed that grazing actually helps in regenerating the grasslands by improving the soil Carbon/ Nitrogen ratio and prolonging/ extending the growing season. Even some Chinese researchers have blamed the degradation of these grasslands on many factors such as permafrost degradation, irrational human disturbance (*mining, road construction, conversion of grassland to cropland, gold mining, overgrazing etc.,*) and climate warming.

Water availability and management

The International Centre for Integrated Mountain Development (ICIMOD) has revealed alarming details on the sustainability of the Himalayan ecology. According to their findings, the current trend of melting glaciers suggests that the Ganges, Indus, Brahmaputra and other rivers across the northern India plains could most likely become seasonal rivers in the near future. The tension on water availability is further raised by the rate at which the PRC is commissioning damming projects on those rivers that flows from Tibet. The Chinese dam building frenzy is creating huge

¹ CH₄ (Methane): 21 times more Global Warming Potential (GWP) than Carbon dioxide

² N₂O (Nitrogen dioxide): 310 times more GWP than Carbon dioxide

discussions on whether these dams could be an initial step in enhancing its ambitious water transfer projects. Some experts believe that the current railway network linking Beijing and Lhasa would further enhance the needful transportation of technical staff and inventories to initiate this water diversion project. After many years of denial, the Chinese side finally accepted in building a HPP (*Hydropower Plant; 510 megawatts*) on the upper reaches of Yarlung Tsangpo at dZam (Ch: Zangmu), at Lhoka prefecture in Tibet. No doubt, the PRC was quick in responding that the current HPP is a run-of-the-river project. But that too requires some storing of water to fill the reservoir. But that is not the end, six more dams are on the drawing board along the Yarlung Tsangpo and no clear information is flowing out of Tibet as to how and when they will initiate the other projects.

According to a report published by IDSA (2010), water demand in India will grow to almost 1.5 trillion m³ by 2030, principally driven by population growth and the domestic need for agriculture. And with no proportional increase in water availability and an ever increasing demand, a water crisis is imminent. Water-being international, indispensable, and emotional can serve as a cornerstone for confidence building and a potential entry point for peace.

China has built over 87,000 hydro dams, more than any other country in the world. Besides performing various functions, the issue of dam safety has always been treated as a sensitive subject. Now, incidents at a number of dams and reservoirs have cast doubt on the quality of these projects, but they are rarely reported to the general public (Lu and Shen, 2011),

Zhang Boting, vice secretary of the China Society for Hydropower Engineering, told reporters that the 12th Five Year Plan called for hydropower development to be prioritized. For various reasons, two thirds of the hydropower projects detailed in the 11th Five Year Plan had not been completed and would be revived in the 12th Five Year Plan (*China Tibet news, 2011*).

On March 5, premier Wen Jiabao presented his “government work report” during China’s annual parliamentary session in Beijing, revealing the key goals of the country’s 12th Five Year Plan (2011 - 2015). Apart from other grand visions to cut energy and carbon intensity, China also aims to boost the proportion of non-fossil fuels in primary energy consumption to 11.4 per cent. After the Japanese nuclear tragedy and the subsequent freezing of further approvals of nuclear projects in China (*at least for few years*), this statement is in fact a green signal for the dam construction companies to invest more on the Tibetan rivers and to meet its energy target (*please refer to Box1. for more information*).

Box 1. Hydropower development on the Tibetan Plateau

[Behind the scenes, preparations for hydropower development on the Yarlung Tsangpo (Brahmaputra) have been constant. In a recent media interview, Zhi Xiaoqian, head of the Chengdu Surveying Institute, said that plans had been drawn up for all of Tibet's major rivers, including the middle reaches of the Yarlung Tsangpo. But a lack of clear policy direction has meant approval for those plans has been slow and the projects have not commenced. "Now the time and conditions are ripe. China's energy supply is becoming ever more pressured, and there's an urgent need to develop the rich hydropower resources of Tibet," Zhi said. Currently less than 0.6% of Tibet's hydropower resources have been developed. In comparison with the rest of China, this is virgin territory....]

[Several key power stations will be built in the Driчу (Yangtse), Zachu (Mekong), Gyalmo Ngulchu (Salween) during the period covered by the 12th Five-year Plan, with an overall installed capacity of more than 5,000 megawatts as the eventual goal. Moreover, additional objectives include enhancement of the operational capacity to more than 5,000 megawatts and a planned installed capacity of more than 10,000 megawatts by the end of 13th Five-year Plan. The goal of this project is to create an energy production base for the West-to-East Electricity Transmission Program. Further efforts will be made to expand electricity transmission capacity to more than 2,000 megawatts by 2020, 5,000-10,000 megawatts by 2025, and 18,000 megawatts with an overall installed capacity of 10,000 megawatts by 2030...]

Source: Chinadialogue.net

Meng Si, the managing editor of Chinadialogue's Beijing office mentioned that, Chinese Environmental NGOs believes that hydropower projects could bring economic development, but not necessarily to the benefit of local people. They believe that today's insufficiently transparent policymaking mechanisms are maximizing the interests of hydropower industry, officials and a small number of experts, while driving ecological destruction, affecting local livelihoods and increasing the risk of geological disasters.

The damming activities along the upstream of Zachu/ Mekong have significantly affected the flow volume of the river. So far, the PRC has in total 21 HPP either built, under construction, under active consideration in Tibet alone (Tashi, 2011). The users downstream are turning their frustration on the Chinese government whose damming projects on the upstream Mekong River has greatly affected their lifestyles. Figures 4a and 4b reveal the current state of the Mekong River in Mukdahan Province and at Nakhon Panam in Thailand. The livelihoods of the local fishermen and many other communities from Cambodia are threatened by the reduced flow of the river but their concerned voices are blanketed by the aids their government receives from PRC.



Figures 4 a & 4b (Thailand)

a) Stranded fishing boats in Mekong River in Mukdahan province; b) reduced flow of Mekong river Nakhon Panam; Image courtesy; Ploysi, 2011

For China, Tibet's rivers are proving as rich resources for hydro electric and geo-political power as its mineral wealth. But frenzied dam construction projected until 2020 means that a prehistoric irrigation system that dates back 30 to 40 million years is coming to an end (*Huffington Post*, August 2011).

Growing industrialization, population growth, and increasing levels of consumption are placing heavy demands on water resources, which provide vital support for the subsistence livelihoods of millions of people. According to a report by the International Water Management Institute “the capacity of India and China to efficiently manage water resources, especially on a regional basis, is likely to be one of the key determinants of future global food security (K. Morton, 2008).

Conclusion & Recommendations

The Tibetan Plateau is the land bridge connecting South Asia with East Asia. If India maintains its habitual stance of viewing events in Tibet as if in some far place, it will fail to engage with the rapid changes outlined above, all of which directly impact on India and its long term sustainability.

As Jane Qiu quoted an excerpt in her article from Veerabhadran Ramanathan (*an atmospheric scientist*), “Our understanding of global climate change would be incomplete without taking into consideration what’s happening to the Tibetan plateau”.

The very survival of almost 2 billion people depends on the water resources originating from the Tibetan Plateau. The impact on Tibet’s landscape and its natural resources due to climate warming will threaten not only the future food security of many nations but also its developments. If Tibet’s grasslands are maintained and improved, through a combination of nomadic work and state/donor finance, they will form a part of the solution to a global problem. This is a far better alternative than excluding nomads, and will enable grasslands to recapture carbon while also sustaining human livelihoods.

India can and should take a proactive role in mitigating the environmental impacts of China's development policies in Tibet, so as to preserve the amenity and environmental services which Tibet provides to India.

While India has shown proper concern for the downstream impacts of dams on the river systems shared by both China and India, we need to recognize China now has plans for radical change which will impact well beyond security of water supply.

Much effort is needed on the ground in Tibet to restore wetlands, adapt farm and pastureland, and preserve forests before the impacts of climate change makes it more difficult to save ecosystems. Through state and people working together, desertification may also be reversed. The fate of future developments and social security of the lower riparian countries relies on how well the resources are managed in TIBET.

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