Tibetan Plateau under the Mercy of Climate Change and Modernization

[We (at the Environment and Development Desk at DIIR, CTA) would like to alert all our readers about the impacts of Climate Change and Unplanned Urbanization on the Tibetan Plateau in series of short articles on this site]

The Significance of the Tibetan Plateau

Tibet referred to as 'The Third Pole' and 'The Water Tower of Asia' clearly reflects the significance of its snow capped mountains and its alpine grasslands. Since time memorial, the plateau holds the Hindu Kush Himalayan Ice Sheet, considered as the largest ice mass outside the two poles. Its plateau contains 46,000 glaciers covering an area of 105,000 km2. Tibetan Plateau (hereinafter referred to as TP) is guarded to the south by the mighty Himalayas, to the north by Kunlun, to its west by Hindu Kush and Pamir ranges. Glacial runoff from these regions feeds the largest rivers across Southeast Asia, including the Drichu (Yangtze), Machu (Yellow), Zachu (Mekong), Ganges and Singhe (Indus) rivers. 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.

Glaciers and Rivers

There is little doubt that melting glaciers of TP provide a key source of water in the summer months; as much as 70% of the summer flow in the Ganges and 50–60% of the flow in other major rivers. 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. The melting glaciers will recharge the mighty rivers for within a short period but later as the resource diminishes, the river runoff will decrease leading to drought. These snow peaks and glaciers enable Tibet to be the source of four major rivers that meets much of Asia's water demand. For instance, Drichu Tsangpo (Yangtze River), originating from the TP flows about 6,300 km eastwards to the East China Sea and plays a vital role in the socio-economic development of China. And Yarlung Tsangpo 'or' more famously known as the 'Brahmaputra River' drains an area of 651,335 km2, connecting Tibet (50.5%), India (33.6%), Bangladesh (8.1%) and Bhutan (7.8%). With an average discharge of 20,000 (m3/s), it originates from the glaciers of Mt. Kailash range. In short, close to 47% of the world population thrives on the watershed originating from the TP. The total river basin area (as of 2003 data) is estimated above 5,477,700 km2. For China alone, 30 % of its fresh water supply is met from the rivers flowing through Tibet.

Glacial retreat on Mt. Amnye Machen (Photo: Asia Society)

Zachu Tsangpo/ Mekong River (Photo: Losang, tibetanconnections)

Permafrost layers as carbon stores

Unlike the ones in that are widespread in the Arctic and boreal regions of Northern Hemisphere, the permafrost1 prevailing on the TP (1.3 to 1.6 million km2) are alpine permafrost due to its high altitudes. These types of permafrost are featured by warm permafrost and rich ground ice. They are among the most sensitive to climate change and are particularly vulnerable to warming temperature. 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.

Many researchers indicated in their studies that, a significant statistical correlation exist between the thickness of the permafrost active layer2 and the vegetative cover in the alpine landscapes of TP. And the thawing of permafrost or increase in the active layer corresponds to the decrease in the vegetative cover. The alpine permafrost on TP stores about 12.3 Pg C (equivalent to 12,300 Million tons of C) or 37% of the total Grassland soil organic carbon (hereinafter referred to as SOC). A separate study conducted at the source region of the Yellow River by a group of Chinese researchers indicated that a significant amount of methane3 (hereinafter referred to as CH4) is trapped in the permafrost layer of that region.

Under the influence of warming climate, the rise in temperature (above 0°C) favors the thickening of the active layers; it further triggers the microbial decomposition of organic matter within the frozen soil, eventually leading to a huge amount of carbon entering the atmosphere (climate feedback) and intensifying global warming.

The degradation of permafrost, besides disturbing the carbon balance over the plateau, will also lead to series of interconnected irreversible, yet gradual changes; it would result in the lowering of water table, loss of soil moisture content, extinction of native plant species, desertification and drying of swamps, it would also put the modern constructions at risk .

Alpine Grasslands and Meadows

Tibet's rangeland, 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% 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.

Yushu grasslands & Tsekyog grassland (Photo: Losang, tibetanconnections)

These rangelands and its cold alpine grassland soils are the major carbon sink and house a greater organic carbon pool. During the thaw season, the alpine meadows appears to absorb 'or' take up CO2 at the rate of (1840 – 3050) mg/m2.day. According to some researchers, the Alpine grasslands (alpine cold steppe and alpine cold meadows) being the most dominant ecosystem on the TP occupies over 60% of the total area and stores a large amount of organic carbon. Their studies showed that total SOC storage (sampled from the top 1 meter soil) in the alpine grasslands of TP was estimated about 7.4 Pg C or 7400 Million tons of C. They also indicated that the light fraction organic carbon (hereinafter referred to as LFOC) is enriched in the top soil and the changes in the vegetative cover (due to grassland degradation) could easily loose a significant amount of LFOC. They observed that when the alpine meadow was severely degraded, the LFOC decreased by 92%. This easily released LFOC accounts for 34–54% of the total organic carbon (hereinafter referred to as TOC).

Furthermore, the alpine cold swamp meadow soils of the TP have approximately the same TOC content (14.4 kg/ m2 for the 0–0.30 m soil layer) as wetland soils in Arctic regions, but its TOC content is far higher than that of a tropical savannah. With respect to the total carbon storage in the biomass of the TP, it was estimated to be 1.87 Pg (equivalents to 1870 Million tons of C accounting to over 56% of the total biomass of grasslands of China).

Lakes and wetlands as carbon sequesters

Lakes and Wetland throughout the world plays a pivotal role in recharging the aquifers in the arid and semi- arid regions of the world. 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. Even though, the role of wetland in the global carbon cycle is poorly understood, and more information is needed on different wetland types and their functioning as both sources and sinks of greenhouse gases (hereinafter referred to as GHGs). But as noticed in different parts of the world, the role of wetland as a carbon sink or source was closely related with the water table and the amount of precipitation.

Namtso (Photo: Phuntsok, AIT Alumni)

Yamdrog Tso (Photo: Lobsang, tibetanconnections.com)

The recent warming of climate has been linked to the contraction of wetlands in the TP. According to China daily news report, the recent contractions in the wetlands have led to reduced flows of the Drichu (Yangtze) and Machu (Yellow) rivers.

Fresh water wetlands on TP are distributed in the zones of 31° - 35° N and 89° - 95° E with an area covering approximately 1,33,000 km2. With their wealth of stored carbon, wetlands provide a potential sink for the atmospheric carbon, if not properly managed could become a source of GHGs. Statistics of the natural wetlands (excluding lake and floodplain) area by geographic regions in China revealed that Tibetan Highland holds over 51% of total natural wetlands. These wetlands are dominated by Salt Marsh, Peatland and Freshwater Marsh. Chinese researchers have indicated that alpine wetlands of Tso Jhang (Ch: Haibei) Northeast of the TP absorbed about 316 g CO2/m2 during the growing season and emitted 546 g CO2/ m2 in the non growing season. According to the Regional Environment Protection Bureau, the wetlands of Lhalu (with a total area of 6.2

km2), situated to the northwest of Lhasa, absorbed 78,800 tons of carbon and produce 57,300 tons of oxygen annually. These wetlands absorb and stores huge amount of carbon, the main component of global warming gas. This extreme high organic carbon concentration in the cold wetland is due to the low rate of organic matter decomposition owing to its low mean average ground temperature. According to some researchers, the annual CH4 emissions from freshwater wetlands on the TP were estimated between 0.75 to 1.05 Tg, equivalent to approx. 0.9 Million tons of CH4. This warming climate will not only alter the role of wetlands but also result in the melting of permafrost soils, subsequently emitting the trapped methane. Wetlands tend to trap carbon-rich sediments from watershed sources, but may also release dissolved carbon through water flow into adjacent ecosystems. Such horizontal transport pathways may affect both sequestration and emission rates of carbon.

Influence on Asian monsoon pattern

TP plays an important role in regulating the Asian monsoon. During summer, the TP intensifies the pressure gradient between the south Asian landmass and the Indian Ocean leading to the flow of air and moisture from the sea.

According to many scientist and researchers the ground freezing and thawing of the TP 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. Heat and moisture variations produced by these processes play an important role in the climate of East Asia. For instance, the onset of summer precipitation in Southern China and in the middle and lower basin of the Drichu Tsangpo (Yangtze River) are influenced by the spring thaw timing over the TP. In consistent to that, the significance of spring snow depth over the TP correlates with the amount of summer precipitation on the middle and lower basins of Drichu Tsangpo.

The plateau's seasonal heating during summer and spring plays a principal role in determining the large-scale circulation in summer. Heating over the TP 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. Hence the summer monsoon of East China is attributed to the heating up of the TP.

Impacts on the Tibetan Plateau

Tibetan Plateau is currently experiencing the impacts of Climate Change in its worst form, with the current warming of mean air temperature and to enhance this warming process, there is further input of GHGs from the climate feedback and ongoing anthropogenic activities. As a result (not only to our concern), the glaciers are retreating, grasslands are degrading, lakes and wetlands are shrinking, rivers are drying and desertification is taking its toll. The immediate recipients of the climate change impacts are those innocent herders and villagers who have been living in harmony with the nature for generations. As mentioned precisely by Julia Klein, ‘climate warming is an unusual environmental problem since the primary GHG 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’.

Critical components to Tibet's ecosystem are undergoing major transformations due to climate change. It has led to the receding of Tibet’s 46,000 glaciers, the shrinking of over thousands of lakes, the drying up of wetlands, the thawing of permafrost, and reduced flow regimes in many rivers. Furthermore, 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. Frequent landslides are causing land-use disruptions in the region. In addition, glacial lake outbursts and floods have increased in recent years.

According to the China National Climate Change Assessment Report published in early 2007, scientists from twelve different departments (including China's Ministry of Science and Technology), foresees a 5-10% reduction in agricultural output by 2030, more droughts, floods, typhoons and sandstorms, and a 40% increase in the population threatened by plague. It also reported the possibility of damage to the recently built Tibetan railway.

Degradation of Grasslands

In general, many factors are responsible, over a long period of time for the prevailing condition of the TP's alpine grasslands and meadows. Apart from the natural climate warming and its feedback, various anthropogenic factors on the TP are also responsible for speeding up this degradation. According to some Chinese researchers, the primary reasons that caused the centre of gravity of grassland to move along multiple directions are the various ways the people have utilized the grassland during the different time periods throughout the past 30 years (1950-1980). The degradation of grassland is highly related to the permafrost disturbances or the surface disturbances (Conversion of Grassland to Cropland and vice versa; Gormo to Lhasa Oil Products Pipeline 1972–1977; 110-kV Transmission Line installed in 2005–2006; Construction and renovation of Siling Lhasa Highway- SLH 1954, 1973-84; Construction of Siling Lhasa Railway (GLR/ QTR) 2001–2006; The design of a new express highway from Siling to Lhasa is already under way with the beginning of construction anticipated within a few years).

It is true that during the construction of the highways in early 50's, the permafrost knowledge was not known but somehow, unknowingly, the surface disturbances have resulted to the onset of permafrost destruction. The relationship between the permafrost and grassland degradation or desertification will be discussed in our next posting.

In brief, the overall plan during those periods of Collectivization4 and Household Responsibility5 was to maximize the agricultural production (more famously known as winter crop) from the grasslands, during that era, almost 20 million hectares of grassland were converted to croplands, by state-owned farms, state-owned forestry operations, and other state-owned enterprises. They were all labeled "newly claimed virgin croplands" in the 1950s and the trend continued over the last few decades, these grasslands are now severely degraded due to this conversion. For instance, in Amdo (Ch: Qinghai), about 670 km2 of grassland were converted to cropland and nomadic herders were forced to assume an agricultural lifestyle which was unfamiliar to them and unsuited to local conditions. In Amdo, this took desertification to a point beyond control. The first state farms in Tibet, founded by the People's Liberation Army (PLA) in 1952 to the west of urban Lhasa and just east of the borders of Toelung Dechen county, had historically been land used primarily for grazing sheep owned by the Tibetan Government. This land appropriation by PLA soon went beyond Lhasa to Shigatse, Chamdo, Tingkye, Kongpo and Ngari. The Cultural Revolution of 1966–1976 further intensified this commune system to the extent that private ownership of land and animals ceased altogether.

Today, we know that, for the past three decades or more (in the process of increasing the agricultural outputs) TPs alpine grasslands (with its permafrost soil) has been plowed and exposed to hazardous chemical fertilizers. Once these natural grasses above the permafrost soil are destroyed, it is very difficult to replenish under the same condition with the current warming climate.

As of today, to the general community and for some researchers, the innocent herders and the nomads were the scapegoat for anthropogenic activities related to grassland degradation. To offset this issue (despite all the other options) in the name of modernization or for easy governance, these nomads and herders were forced to move into permanent settlements by the Chinese government. This localization or the policy of

'Sedentarization' has not only taken the pride of the nomads but also made them dependent on the central government for future aid. In Amdo, about 100,000 nomad families have been settled/ voluntarily forced to move in permanent houses. The Chinese government has spent millions of dollars in the relocation process. According to one Chinese media release, Pu Qiong, Deputy director of the NDRC (National Development and Reform Commission) in Tibet announced that a total investment of 8 Billion Yuan (US$1.2 billion) would be earmarked to improve infrastructure, including domestic water mains, electricity, roads, mail and telecommunications for Tibetan farmers and herdsmen in 2009 and 2010. The loss of traditional pastoralist culture and the ancestral knowledge is altogether a different issue that needs to be addressed separately. Some of the newly moved nomads (in a recent coveted video file) clearly expresses the deprivation of their (only) aesthetic values and helplessness state at that time, when they were left with no other options but to move into these houses. This type of development or modernization if it comes at the cost of losing one's freedom or the mobility of the nomads, then certainly it has to do more than just merely protecting the grasslands. According to Professor Sen (Economist, 1990 Nobel laureate) in his classic work "Development as Freedom", he argued that development is "not the mere accumulation of goods but the enhanced freedom to choose, to lead the kind of life one values".

Then and Now (Pictures courtesy: Losang, tibetanconnections.com & ICT)

Technically, the degradation of TP grassland are due to many factors such as climate warming (permafrost degradation, non sequential rainfall patterns) overgrazing, irrational human disturbance (mining, road construction, conversion to cropland, gold collection, etc,.) etc,. Interestingly, apart from the other assumptions leading to the degradation of TP grasslands, Julia et al, in their field research work at (Haibei Research Station situated at 37°37´N, longitude and 101°12´ E) has shown clearly that grazing (simulated by clipping) is practically reversing the grassland degradation. According to their study, global warming and grazing cancels each other and they were no significant effect on Above Ground Net Production (ANPP), in fact those control samples (unclipped grasses) showed less ANPP. They have indicated that grazing prolongs/ extends the growing season and the improves the plant C:N ratio (carbon to nitrogen ratio). Their study also indicated the following points;

- Grazing can alter the age structure of leaves and regenerate older plants.
- It also helps to keep the expansion of invasive plants under control
- Species richness in the clipped plots remains stable whereas the species richness in the surrounding, unclipped plots decreased
- In the absence of grazing, there is faster decrease in the species richness compared to warming with grazing
- Grazing can increase the rangeland productivity and can reduce the negative effects of warming on both vegetation production and quality.

Desertification is now a major issue, especially in the northeast, the source region of the Machu and Drichu Rivers. From the field evidence and analysis of remote sensing images (as of year 2004), the area of grassland degradation and soil erosion at the source area of Drichu has reached 106,300 km2, accounting for 67 % of the total area. According to UNDP/ Kishan Khoday report (2007), Tibet's grasslands are being turned into desert at a rate of 2,330 km2 each year. Other researchers indicated that the degradation rate of grassland is 6,700 km2/ year and the rate of desertification is approximately 107,000 km2/ year.

A researcher (who wanted to remain anonymous) wrote to us about the extent of desertification near the Ghang Rinpoche/ Mt. Kailash and its adjoining areas. These pictures alone (taken in 2008, by the researcher), speaks for themselves, the degree of desertification.

Desertification near Mt. Kailash (Tibet, 2008)

Other human induced factors;

- Infrastructure development such as highways, new townships for settlers and railroad tracks
- Reclamation of communal land, the traditional pastures of semi-nomads, under a new policy to allow commercial development
- Growing rapeseed on low-lying pastures - particularly by Chinese settlers and military units - around the pastoral plains of Amdo's Tso Ngonpo (Lake Kokonor)
- Uncontrolled gold mining and illegal harvesting of wild medicinal herbs on grasslands with the connivance of local authorities
- Elimination of indigenous predators leading to the loss of natural checks on the population growth of pest species

Note to all the readers: *[In our next posting, under the Climate Change Impacts on the Tibetan Plateau, we will focus on the degradation of permafrost and glacial meltdown on the Tibetan Plateau. Should there be any suggestions and criticisms for the above article please write to us > edd.diir@gmail.com < we would be more than happy to review and incorporate your comments and criticism in our final report. We would also be thankful (in advance) if you could contribute some photo(s) that goes with our content/ subject.]*
- T. Norbu & Chokyi (EDD)

1. ***Permafrost:*** *The subsurface earth materials remaining below 0°C for two or more years*
2. ***Active layer:*** *The top layer of permafrost soil that thaws during the summer and freezes during winter. The temperature in the lower levels of the soil will remain more stable than that at the surface, where the influence of the ambient temperature is greatest. This means that, over many years, the influence of cooling in winter and heating in summer will decrease as depth increases*
3. ***CH4 (Methane):*** *Greenhouse gas, 21 times more Global Warming Potential (GWP) than Carbon dioxide*
4. ***Collectivism:*** *Forcing the peasants to organize themselves into millions of production units (known as collectives) and to pool their land and other significant means of production.*
5. ***Household Responsibility:*** *Or 'The Responsibility Contract': That an individual household, or a set of households with the land lease to the government, they assumes the task of production for and payment to the government. For the farmers: Virtually free from any interference from either the collective or the government, the Chinese peasants devoted their hearts and souls to the land under their control and made every effort to provide whatever consumers were demanding.*

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