

The Significance of the Tibetan Plateau

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Abstract:

A glance at a map shows how the Tibetan Plateau dominates the geography of Asia. 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. Since time immemorial, the plateau holds the Hindu Kush Himalayan Ice Sheet, considered as the largest ice mass outside the poles. The current trend of glacial melting and permafrost degradation on the Tibetan Plateau would threaten the flow of mighty rivers that feed billions of people downstream.

Geographically, the Tibetan Plateau has a vast expanse of Permafrost (approximately 1.3 - 1.6 Million sq. km) and seasonally frozen grounds. The permafrost on the Tibetan Plateau is sensitive to climate change and is particularly vulnerable to warming temperature. For centuries, these permafrost soils have acted like a sponge, conserving and managing the flow of these mighty rivers. They have also been the store house for Millions of tons of carbon.

Lying few meters above the permafrost soil is the Tibet's rangeland that covers approximately 70 percent of the total area of the Tibet's area. These rangelands are the highest and coldest on Earth, made habitable through the co-existence of the Tibetan people and their yaks. Through their efforts the pastoral nomads and the herders have maintained the sustainable use of this area for many centuries. Over the past few decades, human intervention and natural causes have critically affected these rangelands and is now affecting the permafrost soil threatening not only the diverse species and nomadic way of life but also the underground aquifers that recharge these mighty rivers.

This paper will discuss the different arguments and research findings about the permafrost cover on the Tibetan Plateau, and also its significance towards the major rivers that flow down the Indian peninsula and South-East Asia.

Introduction:

Situated at the heart of Asia, with an average elevation of 4500 meters above the mean sea level,. The Plateau is ringed and criss-crossed by fourteen high mountain ranges from all the directions. For many generations these high peak mountains have served as a source of water and also acted as a barrier against any unwanted guests and in the preservation of its unique biodiversity. The Tibetan plateau even though very inhospitable to many species due to its high altitude and extreme climates holds one of the most diverse plant and animal species. There are many species (both plant and animals) that are only found on the Tibetan Plateau, for instance Wild Yak, Tibetan Antelope and medicinal plants such as *Rheum palmatum* (Chumtsa), *Frittilaria* (Abhika) and about 400 species of Rhododendron.

The infinite grasslands and meadows are breathtakingly awesome and serene. In the summer time it would be filled with different varieties of flowering plants and in the winter with a thick blanket of snow. These grasslands not only serve as feeds to the wild ungulates but recent scientific studies have revealed that these grasslands actually store more than 7400 million tons of carbon and grazing herds in turn play an important role in maintaining these grasslands in many ways (Figure1). These grasslands represent one of the last remaining agro-pastoral regions in the world covering the major part of the Tibet's total area.



Figure1. Summer pasture

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 pasture lands are the highest and coldest on Earth and are made habitable through the co-existence of the Tibetan people and their yaks. Through their efforts the nomads and the herders have maintained the sustainable use of this area for many centuries. The fresh water wetlands on Tibetan Plateau are distributed in an area covering approximately 1,33,000 sq. km. Besides acting as a potential sink for atmospheric carbon, they also recharge the underground aquifers which in turn feed the mighty rivers. The contractions in the wetlands due to climate change have led to reduced flows of the Driчу (Yangtze) and Machu (Yellow) Rivers. With the major Asian rivers originating from its plateau (See table 1), the total river basin area (as of 2003 data) is estimated above 5,477,700 sq. km. Beyond the populations residing in the watersheds of these rivers are the additional hundreds of millions or billions who depend on monsoon rains drawn inland by the Tibetan Plateau. For centuries, these permafrost soils have acted like a sponge, conserving and managing the flow of these rivers.

TABLE 1 THE MAJOR RIVERS OF TIBET AT A GLANCE

Tibetan	Other	Chinese	Source (ht. in metres)	Length (km)	Watershed regions	Outflow
Machu	Yellow River	Huang he	Amdo Bayanhar Mountain (5266)	5,464	Tibet, China, Inner Mongolia	Yellow Sea
Driчу	Yangtze	Chang Jiang	M t. Thangla (6328)	6,380	Tibet, China	East China Sea
Zachu	Mekong	Lancang Jiang	M t. Thangla (Ch. Tanggula)	4,500	Tibet, China, Vietnam, Laos, Cambodia, Thailand,	South China Sea
Gyalmo Ngulchu	Salween	Nu Jiang	M t. Thangla	2,800	Tibet, China, Burma, Thailand	Andaman Sea
Yarlung Tsangpo	Brahmaputra	Yarlung Zangbo	M t. Tesi range	2,900	Tibet, India, Bangladesh	Bay of Bengal
Macha Khabab	Karnali	Maqa Zangbo	M t. Tesi range	1,609	Tibet, Nepal, India	Bay of Bengal
Langchen Khabab	Sutlej	Langquen Zangbo	M t. Tesi (Kailash)	1,450	Tibet, India, Pakistan	Arabian Sea
Senge Khabab	Indus	Senge Zangbo	M t. Tesi (6638)	3,100	Tibet, India, Pakistan	Arabian Sea
Bhumchu	Arun		M t. Shishapangma (8012)	1,207	Tibet, Nepal, India	Bay of Bengal
Lhodrak Sharchu	Norbu Lakchu or Manas		M t. Zholchen (6106)	380	Tibet, Bhutan, India, Bangladesh	Bay of Bengal

Sources: Dorje 1996; DIIR 1995; DIIR 1992; Science Press, Beijing 1990.

Permafrost and frozen grounds:

Permafrost is defined as ground that remains at or below 0°C continuously for two or more years. It is widespread in high latitudes and in high-elevation regions. The permafrost cover on the Tibetan Plateau (1.3 to 1.6 million sq. km) is alpine permafrost best defined as warm permafrost and rich ground ice, usually not far from melting temperature. Tibetan permafrost comprises 74.5% of the Northern Hemisphere's mountain permafrost, and is a direct consequence of land uplift on the order of 3000 m over the last 2 million years (Figure2). Because the Plateau is geologically young and active, the geothermal gradient is steep (0.0514 °C/m), resulting in a thin, relatively warm permafrost layer containing many taliks.

This permafrost cover varies in its thickness from 1 to 130 m, depending on local characteristics and soil water content. Unlike the permafrost of other cold regions, the permafrost prevailing on the Tibetan Plateau is generally ice-poor as a consequence of the arid climate, high evaporation, and glacial history.



Figure2: Permafrost cover on the Tibetan Plateau

Over the past several thousand years, these frozen soils have enclosed vast amounts of carbons and methane. Many researchers fear that once the permafrost starts to degrade, the trapped gases will be released in the atmosphere leading to a positive

feedback. Such feedbacks would lead to abrupt changes in the climate that would likely be irreversible. Researchers in 2008 estimated that these alpine permafrost stores about 12,300 Million tons of Carbon. A separate study conducted at the source region of the Machu (Yellow River) indicated that significant amount of methane gases are trapped in the permafrost layer. If the current trend continues, it would result in continuous declining of permafrost table. As a result those thawed layers of soils in warm season cannot refreeze completely in the freezing season. Such process is leading to a complete change in the local habitat and hydrology of the soil. The presence or absence of this permafrost layer necessitates major variations in the soil's physical structure mainly its moisture and nutrient content. On the Tibetan Plateau, the permafrost region goes through a high solar radiation load unlike other permafrost regions such as Siberia, making it highly sensitive to climate warming and surface disturbances.

Degrading Permafrost on the Third Pole:

Over the past few decades, human intervention and climate warming have affected these permafrost regions and are now degrading and threatening not only the diverse species and nomadic way of life but also the underground aquifers that recharge wetlands and the mighty rivers.

Field observations conducted by various scientists at different location on the Tibetan Plateau reveal that the ongoing permafrost degradation on the Tibetan Plateau has to be taken seriously and without any delay in implementing new effective policies or revising old policies that are in play.

In late 1950's and the following few decades, the people liberation army - PLA, in order to maximize the agricultural production (winter crop) from the alpine grasslands have ploughed almost 20 million hectares of grassland in Tibet and Inner Mongolia. They were converted to croplands, by state owned farms, state-owned forestry operations, and other state owned enterprises. During that era, they were all labeled as "Newly Claimed Virgin croplands" but later failed to reap any harvest). These grasslands are now severely degraded.

In 1954, the construction of Siling Lhasa Highway (Ch: Qinghai–Tibet Highway) from Lanzhou and Xining to Lhasa led to the severe degradation of the permafrost soil, its vegetative mat along the highway and its adjoining areas. Based on a scientific field survey in the year 1990, thaw settlement along the highway accounted for 83% of the road damage. The initial highway re-construction using asphalt pavement that took place during 1973– 1984 led to further degradation of these frozen soils. According to some researchers, approximately 30% of this highway has to be repaired every year due to damage cause by frost action. Those areas covered by asphalt road surface showed significantly higher Mean Annual Ground Temperature (MAGT) compared to the adjoining regions. In other words, the road construction/ renovation have resulted in a faster degradation of the permafrost layer, compared to the natural state. The stretch of highway near the Kunlun Mountain revealed that the thickness of active seasonal

melt/refreeze layer under the asphalt road surface was 5.2 m compared to only 2.8m under the normal state; and the surface temperature was warmer compared to the normal state (MAGT ranging from -1.0 to -0.2°C under the asphalt road and -2.5 to -3.5°C for the normal state). It was also found that the heat accumulation under the asphalt road bases resulted in increased thaw depths too great to be seasonally refrozen and, consequently, resulting in the transformation of vertically connected permafrost into disconnected phase.

In another excavations in the Kunlun Pass (35°40' N, 94°02' E; 4715 m) the researchers found that the oil pipeline that was built in 1973 along the highway to pump Tibetan oil from Gormo to Lhasa, has induced a summer thaw depth of much higher magnitude compared to the nearby areas. They have also noticed that, due to the thaw settlement, the bridges and water conduits have also been damaged considerably.

At the highway near the Dhangla Ri-gyuth (Ch: Fenghuoshan Mountain), scientists found an arc shaped thaw slumping area measuring up to 73m wide and 103m long (in 2003) with the total volume of the failure about 10,000m³ caused by the repairing of the highway. Their survey results showed that the thaw slump has been active for more than 10 years compared to the general thaw slumping life year of 3-5 years and it will further remain active until the ice rich permafrost has disappeared altogether. The original sliding was caused by excavation of the slope toe in 1990 during the repairing of the Qinghai-Tibet Highway. After that, the excavation began to collapse in warm seasons and leave the ground ice exposed to the air.

Researchers have found that, the permafrost temperature at the source areas of Driчу (Yangtze River) and Machu (Yellow River) in the arid heart of the Tibetan Plateau has risen since 1980 resulting to the increase in the soil active layer. Under such conditions, the permafrost degradation is directly leading to the lowering of local water tables and lake water levels, and shrinking of wetlands and deterioration of marshy meadows. The diminishing marshy meadows allow for a greater depth of thaw thus further lowering of the water table. The same observations were also made by other researchers. Recently the researchers have noticed a shrinking of about 20% of the alpine meadows and the wetlands area in the vast Amdo area due to permafrost degradation.

These changes in permafrost regions has resulted (over the years) in loss of soil moisture and the subsequent release of trapped carbon to the atmosphere. Such degradation has/ will in future cause large scale environmental deterioration, including changes in surface hydrology, accelerated desertification, and destabilization of human infrastructure. Figures 3. depicts some of the impacts of thawing ice-rich permafrost inducing retrogressive thermal slumping on the highway, slope failures on the alpine pastures and drying up of the head regions of the rivers.

In short, climate warming will degrade the upper permafrost as a result converting the alpine wetlands to alpine meadowlands, alpine meadows becoming grasslands, and grasslands becoming deep-rooted shrub lands. Such changes if subjected under

climate warming over a long time can cause a further degradation of the permafrost and will finally lead to desertification. This is a succession of biomass productivity loss.



Retrogressive thermal slumping



Slope failures



Head region of Machu (Yellow River)

Figures3: Permafrost degradation and its impacts

The above findings reveal that the current permafrost degradation was mainly due to the surface disturbances while the global warming has played a secondary role in speeding up this degradation. It is also clear that infrastructure development undoubtedly exerted additional stresses on these sensitive permafrost environments.

How to restore the degrading permafrost?

Up until today, the modern science and technology has no solution to stop or reverse the degrading permafrost. Once the ground temperature starts to increase above zero degree, then there is no turning back, it further increases the depth of the active layer and thereby magnifies the thaw size in warmer months. But we can always delay and reduce its impacts by careful investigation and understanding the basic nature of the landscapes. Scientists have spent many harsh winters to actually read the basics of these grasslands that have preserved the frozen soil for the past several centuries. Modern science is now beginning to understand what was known to the pastoral

nomads for many generations. These nomads have evolved along with the extreme climates and are the best stewards of the grasslands. Although they might not know the technical and scientific details about the frozen soils and its relationship to the alpine grasslands but they were very sure that their ancestral cultures and their mobile lifestyle are successful in maintaining the grasslands healthy.

Does depopulating the grasslands actually help to restore the permafrost or the opposite is correct?

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, thereby not pushing the limits of the grassland so called 'carrying capacity'. The alpine 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 restrict the flexibility and mobility of the Tibetan nomads. They are compelled to settle in concrete housings. Their livestock and their culture are held responsible for the degrading the grasslands, which in turn will dry-up the precious water tower of China.

These days many researchers and rangeland specialists dispute the effectiveness of the grassland laws and related new policies which requires depopulating these alpine grasslands. According to the Chinese state media, under the "new countryside" program launched in 2006, the local Chinese government of Tibet Autonomous Region - 'TAR' had moved a total of about 300,000 families involving 1.43 million Tibetan nomads and farmers into new or fixed settlement homes. Another 185,500 families are expected to move into new homes by 2013.

Field observations conducted on these grasslands have revealed some positive connections between the grazing herds of the nomads and the grasslands. The researchers say that abandoning these grasslands will lead to the domination of the invasive species and do more harm for the grassland which in turn would affect the frozen soil.

Recent field studies also revealed that skillfully managed grazing pressure actually helps in regenerating the grasslands by improving the Carbon/ Nitrogen ratio and prolonging/ extending the growing season. These researchers say the degradation of these grasslands are due to many factors such as permafrost degradation, irrational human disturbance (mining, road construction, conversion of grassland to cropland, gold mining, overgrazing etc.) and climate warming. They say a managed grazing could actually reverse the grassland degradation. The researchers went further to prove that global warming and grazing cancel each other and there were no significant effect on

ANPP (Above Ground Net Primary Production) and those depopulated grasslands could in future have less ANPP. Their study 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 weeds under control
- Species richness in grazed areas remains stable, whereas in the absence of grazing, there is faster decrease in the species richness, especially the medicinal plants
- Grazing can increase the rangeland productivity and can reduce the negative effects of warming on both vegetation production and quality.

Some researchers even suggest that we cannot apply concepts such as "carrying capacity" and "stocking rates". They are not applicable because most of the Plateau's environments are extremely variable and unpredictable. Some even mentioned that the carrying capacities of some grassland were far exceeded partly due to inappropriate land-use and land management practices implemented in the 1950s. It was also mentioned that the major determinant for grassland productivity on the Tibetan Plateau is the rainfall rather than the past or the present livestock number.

Further human induced factors responsible for the degradation of the permafrost soil;

- Infrastructure development such as highways, new townships for settlers and railroad tracks
- Growing rapeseed on low-lying pastures - particularly by Chinese settlers and military units - around the pastoral plains of Amdo's Tso Ngongpo (Lake Kokonor)
- Uncontrolled gold mining and illegal harvesting of wild medicinal herbs on grasslands with the connivance of local authorities
- Chemical elimination of indigenous predators on the grasslands leading to the loss of natural checks on the population growth of pest species
- The construction of the 1120-km, 159-mm diameter Gormo (Ch: Golmud) to Lhasa Oil Products Pipeline (GLOPP) that took five years (1972 till 1977)
- Increased grazing pressure on the grassland due to sudden increase of livestock number (especially the number of sheep) during the commune system and during the implementation of fencing policy.

Conclusion & Recommendations

The Tibetan Plateau is the land bridge connecting South Asia with East Asia. If the neighboring countries maintain their habitual stance of viewing events in Tibet as some far place, they will fail to engage with the rapid changes outlined above, all of which directly impact on Tibetan Plateau 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 monsoon dynamic and water resources originating from the Tibetan Plateau. The impact on Tibet's landscape, especially the frozen grounds either due to human intervention or 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.

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.
