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Need for Permafrost Researches in Indian Himalaya

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Abstract: Permafrost is an integral, but hardly ever studied, component of cryosphere in the Indian Himalayan. Despite the fact that a considerable area of the Indian Himalaya is underlain by frozen ground (permafrost) which is highly sensitive to climate change, scientific data on its degradation and environmental effects are lacking. Meteorological air temperature data has shown an increase in the global average temperatures and more importantly the rise of temperature in the Himalaya has been reported to be double than the global averages. This has resulted in the permafrost thawing and increase in the instability of the rock slopes in steep areas. Therefore, it is indispensable to study and generate scientific data on permafrost, covering wider geographical and ecological domains of the Indian Himalaya and use multiple parameters that directly or indirectly influence the permafrost.

Keywords: Permafrost; Increasing temperature; Ladakh; Indian Himalaya.

Introduction

Permafrost is an integral part of the cryosphere research. It is the frozen ground that remains at 0°C or below for at least two successive years (van Everdigen, 1998; https://ipa.arcticportal.org.) and is the product of energy exchange over a long-time frame between the ground surface and atmosphere and is therefore a condition of ground climate (Burn et al., 2006). Although the permafrost has been portrayed as an essential climate variable of cryosphere by the world meteorological organization, yet, only a few studies—that also mostly related to rock glaciers—have been carried out in the Indian Himalayan region. Himalaya, being the highest and youngest mountain chain and sheltering the largest concentration of glaciers outside the poles (the water tower of Asia), is one of the most fragile ecosystems and biodiversity hotspot in the world. The glaciers alone account for ~33,000 sq. km and the proglacial areas with permafrost still more (van Everdigen, 1998).

This ecologically diverse harsh terrain and its geographical vividness has so far limited our understanding of the microclimates of this region and as a result remains largely uninvestigated. It is suggested that the Hindu Kush Himalaya has a wide belt of permafrost and the occurrence of these areas has been constrained and visualized by a global model (Gruber, 2012; Gruber et al., 2017). A few years back one collaborative Indo-Swiss research programme on permafrost was organized, but it just ended up with a single publication from the Kulu region of western Himalaya (Allen et al., 2016; Thayyen et al., 2016). This study stressed upon field campaigns targeting critical locations in permafrost terrain e.g. dammed lakes and ideally accessible areas, in view of long-term monitoring and repeat re-visits. However, attempts towards this direction are prominently lacking.

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), the "warming of the climate system is unequivocal, and since 1950, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen". This increasing trend of temperature has

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been reported from the central and western Himalaya post little ice age (LIA) (Shekhar et al., 2017) and it has accelerated after the industrial revolution. In general, the Himalayan region is also experiencing a warming trend that is more than the global averages. Instrumental records over a period of 17 years have revealed that the mean annual maximum temperature in the central mountain ranges have shown a two-fold increase than those in the outer Himalayan belt (Siwaliks and Terai) (Shrestha et al., 1999). The winter temperatures are further disturbing as there is a general agreement on increased winter warming.

The effects of an above global average warming during the past century is well depicted by the melting and fragmentation of the glaciers in Himalaya (Bali et al., 2013; Kulkarni and Karyakarte, 2014). Besides this, the warming and thawing of the permafrost has been taking place (Allen et al., 2016; Gautam et al., 2016, Wu et al., 2017), but this issue remains unaddressed in the Indian Himalayan scenario. The permafrost being an integral part of the proglacial areas, thawing of it may have pervasive impacts, the destabilization of steep slopes and road cuts, changes in subsurface hydrology and an increase in the sediment load during runoff and subsequently in the rivers (Allen et al., 2016; Schmid et al., 2015; Thayyen, 2015). Studies from the Tibetan Plateau and Khumbu region of Nepal have shown that the lower limit of the permafrost is increasing since 1970's (Yang et al., 2010), suggesting a progressive wasting of the permafrost areas in these climatologically sensitive regions.

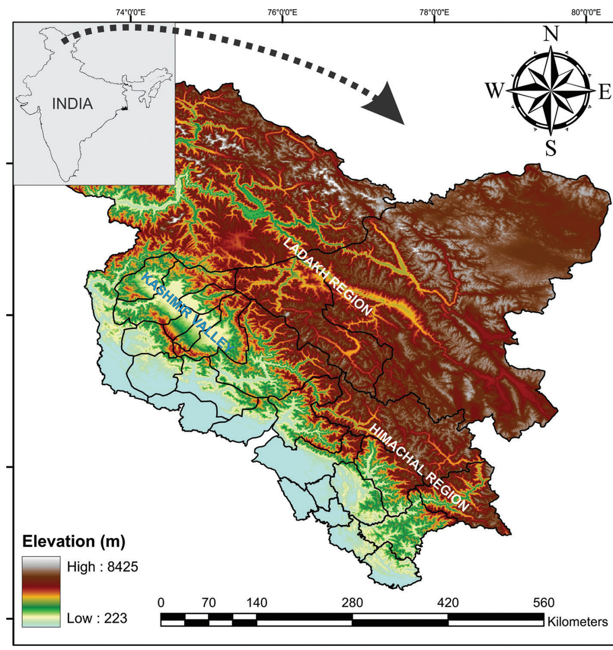

Figure 1: Shuttle Radar Topographic Mission (SRTM) Digital Elevation Map (DEM) of North western Himalaya (J&K and HP).

Results and Discussion

Although the permafrost wasting is similar to that of glacier wasting, its response is more delayed and persistent (Gruber et al., 2017). It is evident from the field observations that the rate of permafrost melting during the warm period has increased. The evidences of permafrost melting can be seen in the northwestern Himalaya as patches of vegetation (greenery) grow on wet ground during the summer. In the northwestern Himalaya (Ladakh), which represents a cold desert condition because of precipitation deficit, the melt water from snow patches and permafrost, act as a life line for vegetation, initiating and creating micro-habitats (Figure 1). These green patches of vegetation have drastically increased over the last two decades, as per the local residents of the region. Moreover, a phenomenal increase of instability of the rock slopes in steep areas and along the road cuts causing land sliding and road blockage has been observed. Prominent movement of frozen ground (permafrost) which is taking place during the warm summers also hints to excessive melting of the permafrost. While excavating a trench in the Changla region of Ladakh, we recorded that the permafrost table is present ~110 cm below the surface (Figure 2). These evidences suggest that large areas covered with permafrost underlie most of the Ladakh region and have a direct relation with the local climate and influences the ecosystem as well as the flora and fauna including the human population (Figure 3). Although the artificial glacier concept has been applied to meet the water shortage during the summer for crop growth in Ladakh, this accelerated thawing of the permafrost is going to exert adverse effects on the local patchy vegetation in the long run. These localized green belts are mostly used as pastures for grazing the herds by local communities and their degeneration will have a diverse effect on environment and the societal conditions. Hence, permafrost research is very important, as it is dealing with the water that has been under a frozen condition for several years to hundreds of years and can bring about immensely strong geomorphic, hydrologic and ecologic changes during thaw (Gruber et al., 2017).

Figure 2: Representative field photos: (a and c) Field photographs showing typical permafrost areas; (b and d) Synoptic view of permafrost slope; please note the green patches representing permafrost thawing.

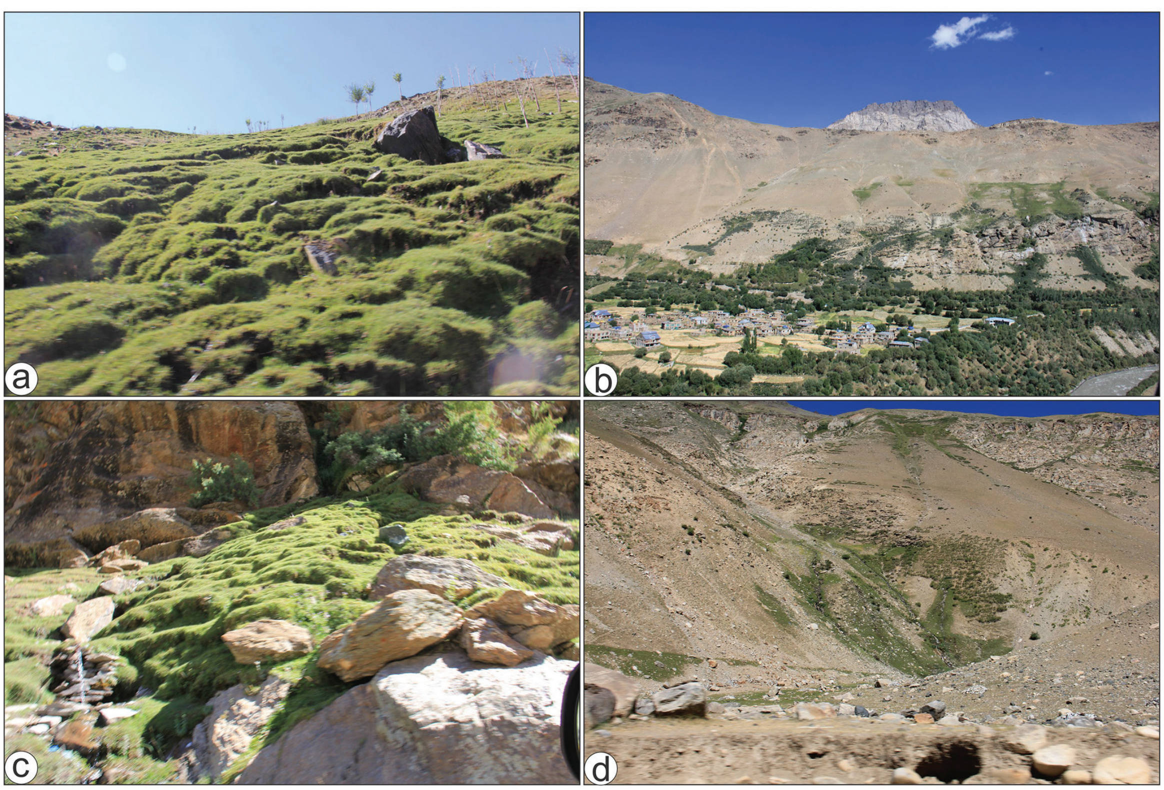

Figure 3: (a-d) Field photographs taken from Changla (Ladakh) showing permafrost table ~110 cm below the surface.

Conclusions and Future Perspectives

The facts and observations suggest that prominent areas of permafrost exist in the northwestern Himalaya and have a very crucial scientific and societal relevance. These have hardly been investigated in the Indian Himalayan region. Grubber et al. (2017) have mentioned that "*the importance of permafrost for many phenomena is as easy to overlook as it is to not see permafrost itself. Landslides exist without permafrost...*". It is time we should understand the complexity of this unseen danger earthed a metre below the surface of our mother earth which is silently thawing away. There is indeed a growing concern towards the impact of anthropogenically induced global warming on the Himalayan glaciers and the permafrost is also not left untouched. As it is proven that the permafrost plays a fundamental role in the alpine ecosystems (Burn et al., 2006); however, this is also true that the global trend of warming and related climate change if not accompanied by increased precipitation, permafrost degradation will cause a lowering of the water table, vegetation degradation and desertification (Wu et al., 2017, Yang et al., 2010). In view of the above discussed facts, it is indispensable to locate the permafrost areas with field evidences, generate data covering wider geographical and ecological domains of the Indian Himalaya and use multiple parameters that directly or indirectly influence the permafrost. Therefore, the science policy makers should consider permafrost researches as one important theme and a thrust area for assignment of future research funding.

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