Discussion paper on:

Climate Change- Himalayas, Mountains, People and Livelihoods

Climate Change Hotspots in South Asia: Glacier Loss and Way Forward

Netra Prasad Timsina and Kushal Pokharel
SIAS[1]

The paper is presented in Margalla Dialogue on "Peace and Development in South Asia, Middle East and Central Asia (SAMECA) **being** held on 13-14 November 2019 (***in the plenary session of Ecological Imbalance, Climate Change and Water Scarcity- Approaches for Regional Cooperation)*** organized by Islamabad Policy Research Institute (IPRI) in Islamabad, Pakistan.

[1] Acknowledgement- This paper is prepared by Netra Prasad Timsina and Kushal Pokharel, Chairperson and a Research Fellow respectively in South Asia Institute of Advanced Studies (SIAS), Kathmandu. Thanks also go to the scholars at SIAS who have participated in a number discussions pertaining to the process of preparing this paper and contributed for enriching the content.

Climate Change Hotspots in South Asia: Glacier Loss and Way Forward

Introduction

Out of eight South Asian countries, six largely depend on the water system of Himalayas and Mountains. The Himalayan region has the largest concentration of glaciers outside the polar caps generally called 'Third Pole'. The water system in Himalayas has been the basic lifeline of the billions people of the region as most of the river basin are glacierized and originated from the Himalayas and Mountains in South Asia. While Himalayas and Mountains in South Asia are highly vulnerable to climate change particularly by the rising temperature that have resulted into melting of glaciers, many of the inland (terrestrial areas) in the South Asian countries have been the hotspots of climate change adversely affecting the nature, people and economy of the region.

This paper is prepared primarily based on the secondary sources. The paper reviews the current trend of degradation of the Himalayas and Mountains as hotspots of climate change particularly due to the rise of temperature and pollution (emission of GHG and Black carbon) in the region. This also captures how water supplies are emerging as grave threats for hundreds of millions of downstream people across many parts of South Asia. The drivers of the climate change are also discussed with a focus on their role in glaciers retreat in Himalayas and extreme climate events in downstream terrestrial areas. In addition to the Himalayas as hotspot of climate change, this paper also reviews some of the studies on the hotspots in different places of South Asian countries. The paper also discusses about the impact of the climate change on the livelihoods of people in hotspots areas, where the temperature is already above the optimal value. The last section of the paper presents some key messages and policy implications to be considered by the South Asian governments to address the climate crisis in the region.

Glaciers melting in the Third Pole: Impact on water system and livelihoods

> *"In 1999, a report by the Working Group on Himalayan Glaciology (WGHG) of the International Commission for Snow and Ice (ICSI) stated: `glaciers in the Himalayas are receding faster than in any other part of the world and, if the present rate continues, the livelihood[sic] of them disappearing by the year 2035 is very high.'" (WWF Nepal, 2005, page 29).*

> *"The Himalayan Mountains are home to not only the highest peak in Mount Everest at 29,029 feet, but also to the third largest deposit of ice and snow in the world, after Antarctica and the Arctic. Now the first complete study of this remote region reveals that its glaciers lost billions of tons of ice—equivalent to more than a vertical foot and half of ice each year—from 2000 to 2016. That is double the amount of melting that took place from 1975 to 2000, revealing that*

the ice loss is accelerating with rising temperatures. It's also threatening water supplies for hundreds of millions of people downstream across much of Asia" (Leahy, 2019).

"*The immense upland of the third pole is one of the most ecologically diverse and vulnerable regions on Earth. People have only attempted to conquer these mountains in the last century, yet in that time humans have subdued the glaciers and changed the face of this wilderness with pollution and other activities. Researchers are now beginning to understand the scale of human effects on the region – some have experienced it directly: many of the 300 IPCC cryosphere report authors meeting in the Nepalese capital in July were forced to take shelter or divert to other airports because of a freak monsoon" (Vince 2019).*

The Hindu Kush Himalayan region stores more snow and ice than anywhere else in the world outside the north and south polar regions, giving its name: 'The Third Pole'. The Third Pole contains the world's highest mountains, including all 14 peaks above 8,000 metres, is the source of major rivers in South Asia and and forms an important global ecological buffer[2].

The three cases above are indicative of the alarming situation of glacier melting in the Third Pole, even though it will not disappear by 2035 as predicted by the WWF report 2005. The water system in the Himalayas has been the basic lifeline of the billion people of the world. With glacier coverage of 33,000 sq km, the region is considered as "Water Tower of Asia" as it provides around 86,000,000 cubic metres of water annually. These Himalayan glaciers feed seven of Asia's great rivers: the Ganga, Indus, Brahmaputra, Salween, Mekong, Yangtze and Huang Ho and ensure a year round water supply to about one billion people[3]. The Himalayas and the Mountains of South Asia particularly Nepal, India and Bhutan share one of the world's greatest freshwater resources- water from the snows of Himalayas and the monsoon which the mountain creates. Seventy percent of the world's freshwater is frozen in glaciers (WWF Nepal, 2005).

Most of the river basins originating from the Himalayas and Mountains in South Asia and Hindu Kush Himalayas are glacierized . The Indus River Basin is shared by four countries Afghanistan, China, India, and Pakistan, with the largest portions of the basin lying in Pakistan (52%) and India (33%). The main river originates at Lake Ngangla Rinco on the Tibetan Plateau in the People's Republic of China. Likewise, the Ganges river that originates with melting glacier water travels through two countries – India and Bangladesh with the tributaries of Nepal's main river system (Koshi, Gandaki and Karnali)[4]

[2] http://www.icimod.org/?q=3487

[3] http://lib.icimod.org/record/12785/files/1092.pdf

[4] A study has estimated that the contribution of annual glacier melting water to annual stream flow into the Ganges Basin from the glacierized catchments of the Nepal Himalaya represents approximately 4% of the total annual stream flow volume of the rivers of Nepal. www.the-cryosphere-discuss.net/4/469/2010/ （Alford, D. and Armstrong, R. (2010), The Cryosphere Discussion., 4, 469–494, 2010.

Source: The Guardian, 15 September, 2019

that provides a regular and reliable source of water flow in river basins. The melting water is especially vital in the post-monsoon season for regions with lower summer precipitation. According to a compilation of glacier mass and area change studies, glaciers in most regions are shrinking and losing mass. A number of studies have indicated that glacier mass loss will accelerate through the 21st century, and higher-emission scenarios will result in even greater mass loss. Wester et al., 2019 have indicated that the rise of regional equilibrium line altitudes (ELAs) will result in the complete disappearance of debris free lower elevation glaciers, and will increase volume losses from glaciers with high-elevation accumulation areas. Changes in climate variability have led to a rapid retreat of mountain glacier systems. Scientific studies have shown that 67 % of glaciers are retreating at alarming rate in the Himalayas as a result of various factors including climate change[5] . Some other studies have estimated that a quarter of the region's ice has been lost only over the last 40 years[6]. The melting means runoff is 1.6 times greater than if the glaciers were stable, resulting in seasonal flooding and the creation of many glacial lakes that create a risk of catastrophic outburst floods. In May 2012, one such flood killed over 60 people in villages near Pokhara, Nepal; it also destroyed houses and infrastructure (Leahy, 2019).

Columbia University researchers findings state that the third pole ice loss has accelerated over this century and the rate has now roughly doubled than that of 1975 to 2000, when temperature was on average 1 degree Celcius lower. Glaciers in the region are currently losing about half a vertical metre of ice per year because of anthropogenic global heating. The reason for the rapid ice loss according to the research is the warming rate of the Tibetan plateau which is three times as fast as the global average, by 0.3C per decade. In case of the Third Pole, this is because of its elevation, which means it absorbs energy from rising, warm, moisture-laden air (Vince, 2019)[7]. Even if average global temperatures stay below 1.5 degree C, the region will experience more than 2 degree C of warming; if emissions are not reduced, the rise will be 5 degree C (Wester et al., 2019). Winter snowfall is already decreasing and there are, on average, four fewer cold nights and seven more warm nights per year than 40 years ago (ibid).
While the estimates on the total number of glaciers in the Himalayas varies, inventories by various institutions suggest that there are over 5,000-6,500 glaciers in the Indian part of the Himalayas[8] and above 3000 glaciers in Nepal[9].

Projected change on snow melting- some evidences

There are relatively few projections of future snowpack behaviour in the extended HKH. At the basin scale, high emission climate scenarios (RCP8.5) from the most recent Coupled Model Intercomparison Project (CMIP5) show snowfall reductions of 30–50% in the Indus Basin, 50–60% in the Ganges basin, and 50–70% in the Brahmaputra Basin by 2071–2100 (Viste et al. 2015). A 50% reduction in average basin SWE has also been projected for the Upper Indus by

[5] http://lib.icimod.org/record/12785/files/1092.pdf

[6] https://www.nationalgeographic.com/environment/2019/06/himalayan-glaciers-melting-alarming-rate-spy-satellites-show/

[7] https://www.theguardian.com/environment/2019/sep/15/tibetan-plateau-glacier-melt-ipcc-report-third-pole

[8] ibid
[9] https://www.nepjol.info/index.php/HN/article/view/10034

the 2050s (Bocchiola et al. 2011) under a 'business-as-usual' emission scenario (SRES A2). Snow depth reductions of 25– 50% and 17–39% have also been projected for the Himalayas and Hindu Kush-Karakoram, respectively (Terzago et al. 2014), though an earlier modelling study of the Spiti River showed only a 1–7% decrease in SWE in response to a +2 °C temperature increase (Singh and Kumar 1997). Projected decreases in end of winter SWE (Diffenbaugh et al. 2013) across the Himalaya may not be relevant to local hydrology, particularly in monsoon-dominated regions, since winter snow only comprises a small fraction of all snow here.

By 2100, snowline elevations are projected to rise between 400 and 900 m (4.4 to 10.0 m/yr) in the Indus, Ganges, and Brahmaputra basins under RCP8.5 emission scenarios (Viste et al. 2015). Coarse resolution general circulation models (GCMs) project a similar rate of rise in the freezing line altitude (zero degree isotherm) for the region (Ghatak et al. 2014). Chevallier et al. (2014) project a snowline rise of 4–7 m/yr for the Pamir region. We note that these values are higher than the average 150 m increase in snowline that corresponds to a 1 °C increase in temperature in mountain regions (Beniston 2003).

In western China, snowfall totals may increase until mid-century (Li et al. 2008), while decreases are expected in eastern China and Inner Mongolia. Future decreases in snow cover and depth on the Qinghai-Tibetan Plateau (QTP) are dependent on emissions scenarios, with accelerated snow losses under high-emissions scenarios (Wei and Dong 2015).

Adapted from Wester et al., (eds), 2019

All the references included in this box are available in P. Wester, A. Mishra, A. Mukherji, A. B. Shrestha (eds) (2019), The Hindu Kush Himalaya Assessment—Mountains, Climate Change, Sustainability and People, Springer Nature Switzerland AG, Cham[10].

Rising temperature

South Asia region has varied geographical combination with regional circulation patterns to create a diverse temperature and climate. The glaciated northern part, which includes the Himalayas, Karakoram, and Hindu Kush mountains have annual average temperatures at or below freezing, whereas much of the South Asian countries averages 25°C to 30°C (77°F to 86°F)[11]. Both the hot and cold extremes are challenging for human well-being, and climate change heightens these challenges.

A recent World Bank's study found that average annual temperatures throughout many parts of South Asia have increased significantly in recent decades. Western Afghanistan and south- western Pakistan have experienced the largest increases, with annual average temperatures rising by 1.0°C to 3.0°C

[10] https://link.springer.com/content/pdf/10.1007%2F978-3-319-92288-1.pdf

[11] https://www.reuters.com/article/us-south-asia-climatechange-worldbank/half-of-south-asia-living-in-vulnerable-climate-hotspots-world-bank-idUSKBN1JO2AV

(1.8°F to 5.4°F) from 1950 to 2010. Southeastern India, western Sri Lanka, northern Pakistan, and eastern Nepal have all experienced increases of 1.0°C to 1.5°C (1.8°F to 2.7°F) over the same period. The precise magnitude of the estimated temperature changes varies across locations, but the direction of the changes is undebatable (Mani et al, 2018).

The same study has also indicated that rising average temperatures can affect living standards through diverse pathways, such as agricultural and labor productivity, health, migration, and other factors impacting economic growth and poverty reduction. Reduction in agricultural productivity will affect the living standard for the households who depend on agriculture. A warmer climate has a number of consequences in the life of the people as it will increase the propagation of vector-borne and other infectious diseases, resulting in lost productivity and income. On the other hand, a warmer climate can increase productivity in historically colder regions, such as mountainous areas by providing the opportunity of new crops, vegetables and fruit varieties. In the warmer areas, days of extreme heat are linked with low worker productivity. A changing climate can force people out of their traditional professional domains, resulting in individuals not earning as much money as they used to in normal situation (ibid).

Mani et al, 2018 took two scenarios to substantiate the evidences of climate change in South Asia- i) climate-sensitive scenario- in this scenario temperatures are projected to increase the most for the Hindu Kush and Karakoram mountains and ii) carbon-intensive scenario, the climate model projection is for annual average temperatures to increase 2.5°C to 3.0°C for Afghanistan, the portion of Pakistan neighboring Afghanistan, the Karakoram mountains, and the Himalayas, relative to 1981–2010 values. Part of the reason for this spatial pattern of large temperature increases is that these regions will lose substantial snow and ice cover under these climate scenarios. For example, Mosier 2015 and Wester et al., 2019 find that snowfall will decrease more in the Hindu Kush mountains than the Karakoram mountains. Snow and ice help to regulate air temperatures because they reflect solar radiation and regulate air temperatures through the melting process. Snow and ice also store water, which gets released during the hottest time of the year. Therefore, losing these important natural water reservoirs results in enhanced climate change and low water availability.

The Fourth Assessment Reports of the Inter Governmental Panel on Climate Change (IPCC) states that there is now a more concrete evidence to show that the Earth has warmed even more since 1750 because of anthropogenic activities. The IPCC also mentions that over the next century, average surface temperatures are expected to rise between 1-6.3 Celsius depending on various emission scenarios with impacts on health, agriculture, forests, water resources, coastal areas, species and natural areas. Impacts on high mountain systems including glacial retreat are amongst the most directly visible signals of global warming. One of the most important and visible indicators of climate change is the recession of glaciers in many parts of the World. Although the recession of glaciers has been suggested by some scientists as a natural phenomenon, in the later half of 20th century, an increase in the rate of retreat has been observed in most glaciers around the world including the Himalayas[12].

[12] (http://lib.icimod.org/record/12785/files/1092.pdf accessed on 16 November 2019)

Global rise in temperature has come to be seen as a major issue confronting the lives of millions of people around the world. Temperature data available since 1000 A.D. indicates that the 20th century was unusually warm and the decade of the 1990s was the hottest on record with six of the warmest years occurring in this last decade. Recent examples of erratic weather patterns have been experienced by the people on a regular basis across the world with the South Asia being more visible. The rapid growth in industrialized nations which have followed a fossil fuel based economic developmental path over the past few decades has resulted in an exponential increase in GHG concentrations emitted into the atmosphere. This has accelerated the melting of glaciers in Himalayas[13]. Glaciers are highly sensitive to even minor changes in the atmospheric temperature. It is well documented that temperatures in the Himalayas have risen in recent decades and that glaciers in the region are losing mass especially in the Southern slope of central Himalayas (Ren et al., 2006).

GHG as drivers of climate change-rising temperature and extreme events of precipitation

The primary driver of climate change is Green House Gas (GHG) emissions as the major contributor. The GHG emissions are triggered by the anthropogenic activities primarily the development activities. Projecting future climatic changes requires creating a scenario that projects the amount, timing, and type of future GHG emissions by human activities (Mani et al,. 2018). GHG being on of the major drivers of the climate, the 2015 Paris Agreement on climate change sets a target of limiting average global temperature increases to 2°C (3.6°F) relative to preindustrial conditions. The average prediction by these climate models is that annual average temperatures in South Asia will increase 1.6°C (2.9°F) by 2050 under the climate-sensitive scenario, and 2.2°C (3.9°F) under the carbon-intensive scenario. These increases are relative to 1981– 2010 conditions (Mani et al 2018*).* The study carries out by World Bank in 2108 shows that failure to reduce GHG emissions and take measures to build climate change resilience will lead to diminished economic performance in most South Asian countries.

Black carbon is one of the worst form of Co2 that accelerate the glacier melting. Black carbon has multiple climate effects, changing clouds and monsoon circulation as well as accelerating ice melt[14]. Vince 2019 writes "*air pollution from the Indo-Gangetic Plains – one of the world's most polluted regions – deposits this black dust on glaciers, darkening their surface and hastening melt. While soot landing on dark rock has little effect on its temperature, snow and glaciers are particularly vulnerable because they are so white and reflective. As glaciers melt, the surrounding rock crumbles in landslides, covering the ice with dark material that speeds melt in a runaway cycle. The Everest base camp, for instance, at 5,300 metres, is now rubble and debris as the Khumbu Glacier has retreated to the icefall"*[15].

---

[13] (http://lib.icimod.org/record/12785/files/1092.pdf accessed on 16 October 2019)

[14]

https://doi.org/10.1002/jgrd.50171, published in 2013

[15] https://www.theguardian.com/environment/2019/sep/15/tibetan-plateau-glacier-melt-ipcc-report-third-pole

Changes in temperature due to GHG emission cause extreme precipitation events which would result in an increase in damage and economic disruption, whereas decreasing precipitation would result in less overall water availability in South Asia, which would reduce agricultural yields and water security in the region.

More inland hotspots in South Asia

The Himalayas and Mountains are the hotspots of climate change in South Asia that is already dealt in section above. However, a number of studies have demonstrated that the many places of inland areas and downstream of Himalayas are getting hotter and experiencing the extreme events of climate. This has also contributed to the acceleration in melting of Himalayas. A study commissioned by the World Bank has found that most of the countries in South Asia are experiencing hotter temperature and getting negative impacts to the livelihoods of the people. The countries with the more prominent hotspots in South Asia are Bangladesh, India, Pakistan and Sri Lanka. The same study documents the cases of negative impacts of increasing temperature such as cities like Karachi, Pakistan, emerge as hot spots because higher temperatures are forecast to lower labor productivity and worsen public health. In others cases, like the central belt of India, hotter days and changes in rainfall patterns are expected to sharply increase stress on farmers.

The World Bank report says:
Under the carbon-intensive scenario, dozens of inland hotspots in the center of South Asia would shift from moderate in 2030 to severe by 2050. Coastal areas do not generally experience this additional deterioration in living standards. However, they could be negatively affected by other consequences of climate change, such as sea-level rise and a likely increase in storms and other extreme events.

Moreover, the study has flagged out that more than half of the region will be a hotspot by 2050 under the carbon-intensive scenario, with 45 percent of the present population of South Asia—800 million people— living in areas projected to become moderate or severe hotspots. Under the climate-sensitive scenario, the number of people affected would be 375 million, or 21 percent of the population. For India, it has been projected that living conditions in Chhattisgarh and Madhya Pradesh will deteriorate by more than 9%, followed by Rajasthan, Uttar Pradesh and Maharashtra. Of the top 10 most affected hotspot districts, 7 (Chandrapur, Bhandara, Gondiya, Wardha, Nagpur, Raj Nandgaon, Durg) are in Vidarbha and the remaining 3 in Chhattisgarh and Madhya Pradesh (Mani et al., 2018).

Hotspots impacting on livelihoods of people of South Asia

Climate change could sharply diminish living conditions for up to 800 million people in South Asia, a region that is already home to some of the world's poorest and hungriest people, if nothing is done to reduce global greenhouse gas emissions (The New York Times, June 28, 2018)[16].

---

[16] https://www.nytimes.com/interactive/2018/06/28/climate/india-pakistan-warming-hotspots.html

Many studies have found that the warming trend in the world will have greater impact in the Himalayas than other regions and places. Melting of snow and unseasonal rainfall can lead to flooding and destroy crops; too little snow and rain can also mean crop failure and have broad-reaching consequences on the economy and people's lives. This will also have an impact on wildlife, farming and grazing conditions, natural resources from timber to medicinal herbs, and the survival of a rich variety of unique cultures (www.icimod.org).

Various studies have proved that the present trend of climate change has adversely affected the livelihood of people. Mani et al., 2018 indicates that such changes (due to anthropogenic activities) in averages can be projected with greater impact than changes in extreme events. Although extreme events cause major disruptions to consumption, they generally are of relatively short duration, and consumption bounces back after relief and rehabilitation efforts have been undertaken. In contrast, the effects of long-term changes in climate, such as average temperatures and precipitation patterns, are recurring and will require adaptation to overcome. Same study (Mani et al., 2018) found temperatures in Bangladesh, India, Pakistan, and Sri Lanka are already above their optimal values. This means that at the national level, any further increase in average temperature will have a negative effect on consumption expenditures.
If the loss cause by the hot temperature is translated into gross domestic product (GDP) per capita, changes in average weather are predicted to reduce income in severe hotspots by 14.4 percent in Bangladesh, 9.8 percent in India, and 10.0 percent in Sri Lanka by 2050 under the carbon-intensive scenario compared to the climate of today (Mani et al 2019). Climate effects are smaller when the development are planned climate-sensitive.

Same authors (Mani et al., 2018) above argue that changes in average weather may have some benefits for Afghanistan, Nepal, and high-elevation areas of India because of their cold climates. According to them temperatures in Nepal are still less than the inflection point, meaning that increases in temperatures are predicted to have positive effects on consumption. However, not all effects of increasing temperatures will be positive in Afghanistan, Nepal, and high-elevation areas of India. For example, people in the mountain regions rely extensively on stream flow from snow and glaciers. Warming will affect the timing and availability of water resources, which could have profound effects. *Also there is no mechanism that the temperature level can be kept in balance once it is rise.* In addition, mountain regions may be less resilient to natural disasters.

Key messages and policy implications

1. The snow, ice and other forms of water source (Cryosphere) are the major source of fresh water supply in the South Asia and Hindu Kush Himalaya regions. The current phenomena and projected changes in the cryosphere presents a scenario that will affect the availability of water and streamflows over time across the region, with an impact both in upstream and downstream. If the present trend of rising temperature and melting of glaciers continued, it will worsen the ecology and economy resulting in the human crisis in these regions in near future.

2. Glaciers have thinned, retreated, and lost mass since the 1970s in the Himalayas. Studies have found that glacier volumes are projected to decline by up to 90% through the 21st century in response to decreased snowfall, increased snowline elevations, and longer melt seasons. The degradation of Himalayas snow and permafrost will destabilize some high mountain slopes and peaks, cause local changes in hydrology, and threaten transportation infrastructure.

3. Rivers which are heavily reliant on glacial runoff such as the Indus are particularly vulnerable (40% glacier-fed) showing reduced water levels because of diminished melting . So although mountain communities are suffering from glacial disappearance, those downstream are currently less affected because rainfall makes a larger contribution to rivers such as the Ganges as they descend into populated basins. Upstream-downstream conflict over extractions, dam-building and diversions has so far largely been averted through water-sharing treaties between nations, but as the climate becomes less predictable and scarcity increases, the risk of unrest within and between nations grows.

   Evidences have shown that productivity of the people in the hotspots areas is low (low earning, limited access to the basic livelihood services- food, health, income, employment, sanitation and hygiene etc). This in turn has increased the vulnerability of the people particularly poor, women and marginalized groups of the society. In fact, the hotspots of climate change exacerbate the existing inequality in South Asian societies.

4. Glacier lake outburst floods (GLOFs), mass movements (rockfalls, avalanches, debris flows), and glacier collapses present significant risks to mountain residents. The key messages here imply to implement the national and international commitments on reducing the impact of climate change through emission reduction. Lower emission pathways will reduce overall cryospheric change and reduce secondary impacts on water resources from mountain headwaters. The pathway also will reduce the impact on terrestrial areas and rising sea level.

5. In the past few decades, continuous impact on the Himalayas and Mountains in South Asia in the form of development interventions have caused large scale impacts on the ecology of the region. Climate change is expected to further accelerate the adverse impacts on these regions. There is a need to assess the ecological limit of the development so as to development interventions are designed on the ecological carrying capacity.

6. In the future, economic growth and structural changes will cause people to migrate to cities, leaving behind their agricultural and other climate-sensitive practices in rural areas. Although this could potentially make more of the population climate-resilient, urban migration also will create new climate impacts. Urban populations will face a number of health risks exacerbated by events such as heat waves and flooding.

7. Various stakeholders ranging from local communities, to academic institutions, civil society organizations and Government bodies and policy makers need to work in an integrated manner to make their regions climate friendly.

8. All the resilience strategies and actions should be inclusive, to avoid inequality in growth and opportunity. The projected emergence of many moderate and severe hotspots under the carbon-

intensive scenario shows the need for resilience policies to target impoverished populations and highly vulnerable regions.

9. Finally, the present trend of the climate change demands for changing the paradigm of current development. Evidences have proved that the crisis of climate is the by-product of the current development paradigm- the growth led economic development paradigm. It demands on the changes in lifestyle-production and consumption (economy), use of natural resources (ecology) and use of technology (more high tech we have, more climate change we observe). In fact, there is a dire need of reversal of current paradigm of development to halt the current rate of rising temperature and climate change. The starting point to halt the climate change is to seriously take actions to reduce GHG emissions and work toward meeting the targets established under the Paris Agreement and Development Agenda 2030 (SDGs).

Bibliography:

Alford, D. and Armstrong, R. (2010) The Cryosphere discussion 4, p 469–494.

Leahy, S. (2019) National Geographic, Article published in 19 June 2109. https://www.nationalgeographic.com/environment/2019/06/himalayan-glaciers-melting-alarming-rate-spy-satellites-show/

Mani, M., Bandyopadhyaya, S., Chonabayashi, S., Markandy, A. and Mosier, T. (2018) *South Asia's hotspots: The impact of temperature and precipitation changes on living standards*, The World Bank, Washington DC.

Mosier, T. M. (2015) *Characterizing Linkages Between the Climate, Cryosphere, and Impacts on Run-of-River Hydropower in Data-Sparse Mountain Environments.* PhD dissertation, Oregon State University, Corvallis.

P.C, S., Pradhananga, D., Ma, W. and Wang, P. (2014) 'An Overview of Glaciers Distribution in the Nepal Himalaya'. *Hydro Nepal: Journal of Water, Energy and Environment*, *13*, p 20-27. https://doi.org/10.3126/hn.v13i0.10034.

Ren, J., Jing, J., Pu, J. and Qin, X.(2006), Glaciers variations and climate change in the oentral Himalaya over the past few decades. Annals of Glaciology.

Vince, G. (2019) 'The world has a third pole and it is melting quickly', *The Guardian*, 15 Sept 2019.

Wester, P., Mishra, A., Mukherji, A., Shrestha, A. B.(eds) (2019) *The Hindu Kush Himalaya assessment—mountains, climate Change, sustainability and people*. Switzerland: AG, Cham.

WWF Nepal, (2005) An overview of glaciers, glacier retreat, and subsequent impacts in Nepal, India and China, Kathmandu, Nepal.