Human Dimensions to Climate Change: Insights from the Case Study in the Nhāson Valley of Nepal Himalaya

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Abstract

The climate change in the Nepal-Himalayan region is not just about increased temperature and subsequent glacier melting. It speaks to broad questions on the relationship between society and the environment, science and knowledge, global and local. The present study analysis supports the understanding and responses of agro-pastoral communities on climate change in Nhāson valley of the southeast Manang District. The stories from local participants were documented and analyzed for their agro-pastoral experience. The communities inhabit in the place engaging in daily activities and accommodate practices to cope with anthropogenic climate change. The paper is based on nine months ethnographic study (from 2012-2018) undertaken in six settlements that practice agro-pastoralism for livelihood. In addition, quantitative data was also used to supplement local narratives about the changes in environmental phenomena visually in the local real world. The findings depict that the mountain agro-pastoral communities are more aware with the environmental changes associated with climatic variables. The communities' observation is grounded on the lived experience. Moreover, climate surpasses many disciplinary boundaries. Both, qualitative information based on local narratives and quantitative data, offer complementary to address complexities of global climate change.

Keywords: *climate change, scientific, local knowledge, Himalaya, agro-pastoral communities*

Introduction

My writing in reference to the widely cited book 'Wisdom sits in places' (1996) by Keith H. Basso tells us the bound with place are important for the production of knowledge. Such knowledge is an important aspect to understand climate change and its impacts on human life at local level (Ingold & Kurtilla 2001; Cruickshank 2005; Crate 2008; Poudel 2020).

Researches across the Himalayan regions indicates warming at a rate three times higher (0.060C/year) than the average warming of the earth (0.02 0C/year) (Shrestha & Aryal 2011; Shrestha et al., 2012). However, the warming rate is not the same in different altitude zones in Nepal; it is higher in the hills (1500-2500 meter (m) above the sea level (a.s.l.) (0.072 oC/ year) compared to Terai (< 200 m a.s.l.) (0.024 °C/year) and Trans-Himalayas (Jomsom: 2744 m a.s.l.) (0.029 °C/year) (Nayava et al., 2017). As compared to other parts of Nepal, warming rate (annual maximum temperature) was observed to be highest in Manang (0.118 0C/year) (Government of Nepal, 2017). The impacts of increased temperature on the Himalayan natural ecosystems and human communities are noticed and experienced. For instance, studies depict the biological responses to climate change have manifested the modification of plant communities, shifting of elevation from lower to upper landscape, disappearance of alpine plant taxa (Shrestha, et al., 2012; Brandt, et al., 2013; Minish, et al., 2016). Similarly, precipitation patterns (intensification and distribution) are being shifted, glaciers are melting rapidly, glacial lakes are expending, new lakes are forming, and events of outburst of glacial lakes have been increased in the Himalayan region due to climate change (Vetaas, 2007; Agrawala, 2008; Shrestha & Aryal, 2011; ICIMOD, 2011; Shrestha, et al., 2012). However, it not only impacts on plant ecosystems, glaciers and permafrost; it also affects all aspects of human life including health, homes, livelihoods, culture and our physical environment (Fiske, et. al., 2014). It also dislocates human-nature relationship (Ingold & Kurtila, 2001; Vedwan & Rhoades, 2001; Strauss & Orlove, et al., 2003; Cruickshank, 2005; Crate, 2008; Crate & Nuttall, et al., 2009; Adger, et al., 2009; Crate, 2011; Poudel, 2012 & 2020; Barnes & Dove, et al., 2015; Crate & Nutall, et al., 2016) which is place specific and cultural specific. However, human dimensions are rarely covered by scientific studies. Thus, agro-pastoral communities of Nhāson, a small valley of Nepal Himalaya, may have been noticing climate change differently which is an important question.

Himalaya is known as the water tower of Asia or third-pole. The existing literature shows that climate change has posed threat to the people and their livelihood and culture in the region (Vadwan & Rhoades, 2001; Byg & Salick, 2009; Pandit, 2017; Poudel, 2020). When I began to talk with the people in the Nhāson valley, I learned that climate change for local villagers is more than increased temperature and melting of glaciers or expanding of glacial lakes as explained by natural scientists and development practitioners. For the agro-pastoralists of the valley, it also means shift in crop landscape and disturbance in seasonal cropping calendar, opportunities to grow new crops and challenges to grow the existing one, loss of meadows for livestock, difficulty in cross-breeding yak with local cows, and threats to their customary laws and indigenous knowledge and practices. I feel that such issues and problems are rarely accounted in the ongoing climate change discourse of the Himalaya, in spite of the fact that this region has remained hot spot of discussions for scholars, development practitioners and even government and non-government organizations (Ministry of Environment, 2010; ICIMOD, 2011; Shrestha et al., 2012; Brandt et al., 2013; Minish et al., 2016; Nayava et al., 2017).

My ethnographic study tells that local agro-pastoralists are neither blind to notice environmental changes nor passive in coping with risks imposed by anthropogenic climate change. Indeed, there is no option beside adaptation with climate change (Adge et al., 2009). They are seeking new strategies like planting new crops, practicing intercropping and planting drought resistance variety of crops to resist with prolonged drought, exchange of seeds, upward shifting of the yak habitats, creating water storage ponds to feed livestock, connecting meadows with piped water systems, searching for new meadows, updating customary laws, and searching new places for cross-breeding yak and cow to cope with the risks created by climate change. Such strategies are effective and rational until encountered limitations. Hence, ongoing global warming and associated climatic and other anthropogenic environmental changes ask newer people how the people in the Himalayas can thrive by giving continuity to agro-pastoralism embedded with their culture and livelihood. Hence, the paper focuses on human dimensions of climate change in the Nepal Himalaya.

Research methods

The study was carried out for nine months of field research at six settlements namely, Thanchok, Tache, Nache, Unash, Ghyalanchok and Tilche, in the Nhāson valley, located in the central Himalaya of Nepal, between 2012 and 2014. Extended period of residence and research at a community, [what Geertz (1997) termed 'being there'] helped me to grasp the contextual understandings of climate change from grounded perspectives. I documented oral narratives on the changes in climatic variability (snowfall, rainfall and temperature) and physical landscapes that the people have been noticing in their locality and stored them as a live memory inside their heads. During the fieldwork, I largely paid higher attention to elders than young one because they had lived many years and accumulated wider and absolute knowledge by seeing things, including climate events, changes, and impacts in their everyday life (Roncoli et al., 2009). I hang out with the villagers, especially farmers and herders, while visiting their farmlands, and meadows that helped me to contextualize the issue.

In addition, I had taken some photographs of apple and maize farming when I visited Upper Manang. The photos were used in the discussion with the people of Nhāson. This method gave us a better opportunity to contextualize the higher limit of vegetation landscape that was in the past and how it has been changed since the last three decades and more in the Nhāson valley.

Besides ethnographic methods, I also used meteorological data (temperature) to verify the local narratives. Moreover, I also used topographic maps of the scale of 1:25000 to analyze climate change, particularly vegetation and livestock landscapes.

The setting

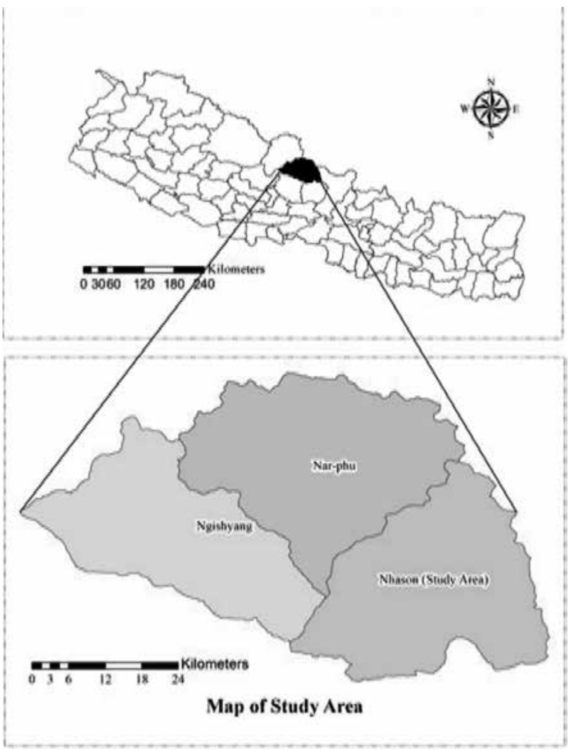

Figure 1: *Study Area (Nhāson valley, Manang) is shown in an enlarged form from the recent map of Nepal.*

Geographically speaking, the Manang District is located in the central part of Nepal (Figure 1). The district is divided into three micro-ecological zones: Gyasumdo (Nhāson), Nar-Phu and Nisyhang (Gurung, 1976; Spengen, 1987). Nhāson is located in the southeast of the district. It covers a wide vertical zone from 1,645 to 8,125 m a.s.l. (HMG/N, 2000). In 2011, maximum temperature and minimum temperature of the valley (Chame) were 22.30C and -5.80C respectively (DHM, 2011). Annual maximum temperature increment in winter season is 0.1180C (Government of Nepal, 2017).

Gurung was the politically, socially, culturally and economically dominant group of the valley. The valley's name 'Nhāson' is also derived from Gurung words. The term consists of Gurung's two words 'nhā' and 'son', meaning 'villages' and 'three' correspondingly. Nhāson, therefore, traditionally denotes the three villages, namely Tache, Nache and Tilche. In 2018, there were 16 settlements formed after the arrival of new groups over the last one and half century ago[1], whereas a few settlements were after the expansion of tourism on the corridor of the Annapurna mountain range in the late 1970s and Manasulu in the 21st century. The settlements are located in the Marsyangdi gorge and its tributary the Dudh-Khola in the 'V' shape. The settlements are scattered in different attitudinal ranges i.e., 1,645 to 3,700 m a.s.l. Tal is located in the lowest altitude and Bimthang in the highest.

Agro-pastoral life in the Nhāson valley

Agriculture, animal husbandry and trade/tourism based business are the key three pillars of livelihood (re)shaped by the local environment as well as a wider political-economic processes and state interventions in different time periods. Every household raises livestock of one kind or another, including yak, *cho/choamma* (yak-cow crossbreeds), cow, ox, sheep, goat and horses. These livestock have both cultural and economic values to them. The animal products consumed locally include meat, milk and milk products, dung, wool and draft power. Yak, sheep and goat are for meat. Sheep wool is used as the basic raw material for blankets and clothes. Sometimes, they offer gifts of woolen items to their kin who reside outside the valley. Draft power (ox) is necessary for plowing the field. Crossbreeds are for making cash. They offer the blood to their deities by sacrificing animals (sheep and goat) for the prosperity, good health of household or community members and good productivity. However, animal husbandry is under a threat in the Nhāson valley due to climate change, state policy, international policy (blockade of Nepal and Tibet border), market economy and development intervention (Poudel, 2016). Although, yak herding is rapidly flourishing in the valley when they started eating yak meat.

The main crops grown in the valley are maize (improved and local), naked barley, buckwheat, wheat and potato. They have never grown enough crops for their consumption because of the limited agricultural land, low productivity and short growing season. They would be involved in salt-grain-salt trade with Tibetan people and lowland dwellers until the early 1960s when Tibet was a free state. After Tibet became a part of China, salt-grain-salt trade plummeted rapidly to a halt. Thereafter, they largely relied on lowland dwellers for foods such as imported rice from Lamjung. Once connected by motorway in 2012, they started to export potatoes, main grown crops of the valley.

In the valley, there are three agricultural seasons, namely spring, summer and winter. It is, however, impossible to grow crops in all seasons in a given year due to the short agricultural season. Therefore, they have been practicing rotational cropping practices thrice in two years based on seasons and agricultural lands. For instance, they grow winter crops and summer crops on 'X' field this year and spring crops on 'Y' field, and in alternative years they grow spring crops on 'X' field and winter crops and summer crops on 'Y' field. The rotational growing of crops in different agricultural lands in different seasons is also important to them for the management of their livestock in the winter due to lack of ground grasses to grazing livestock in high pastureland, except fallow-lands.

1 The ancestors of Gurung had come and settled down at Nhāson about 150 years ago from Lamjung, an adjacent district of Manang located in southern part, the ancestor of Kami came in the 1st part of 20th century and Lama in the early 20th century from Mustang

Landscape variation and agro-pastoral systems

In the Nhāson valley, the agricultural landscape is largely located between approximately 1,700 to 3,500 m a.s.l. As other parts of the Himalaya, the crops grown are determined by altitudinal and climatic factors in the valley (see Allen, 1986; Goldstein & Messerchmidt, 1880; Messerchmidt, 1976; Stevens, 1996). The farmers of the valley grow improved maize, buckwheat, wheat, naked barley, latte (quinoa like grain), potatoes, kolo (Himalayan beans), soybean, cauliflower, cabbage, pumpkins, cucumbers, and green-leafy vegetables in 1,700 to 2,500 m a.s.l. However, they grow potato, local variety of maize, buckwheat, naked barley, wheat, cabbage, cauliflower, pumpkins, kolo, green leafs vegetables at the altitude between 2,500 to 3,000 m a.s.l. From 3,000 to 3,500 m a.s.l., they only grow buckwheat, naked barley, potatoes, green-leafy vegetables, cabbages, and cauliflower. The agro-pastoral systems of the study area are summarized in Table 1.

Table 1: Altitudinal distribution and diversification of the agro-pastoral systems of Nhāson

Altitude in meters	Agro-pastoralism systems
4,501 & above	Snow
4,001 -4,500	Pastoralism only
3,501-4,000	Summer only crops production: potato, buckwheat and naked barley, apple*
3,001-3,501	Potato, buckwheat, naked barley, local maize*, apple*, pumpkins*, cauliflower, green leaf-vegetable, and cabbage
2,501- 3,000	Potato, local variety of maize, improved variety of maize*, buckwheat, naked barley, wheat, cabbage, cauliflower, pumpkins, kolo, green leafs vegetables, cucumber*
1,700-2,500	Potato, maize (local and improved varieties), beans, soybean; buckwheat, naked barley, winter wheat*, apple, cabbage, cauliflower, pumpkins, kolo, green leafs, cucumber, tomato*, chilli* tree tomato*

*Source: The author's field study, 2012-2018 (*recently growing crops and vegetables).*

In the valley, the selection of crops is not only shaped by altitude, but geographical slopes also have important role to determine it. For example, farmers cannot grow wheat in the sun-shadow zone in summer whereas they do in the sunlight zone within the same altitude.

Climate change and its effects on agriculture

Figure 2 shows Annual maximum and minimum temperature trends of the Chame valley. The maximum temperature of the valley has increased (0.0334°C/year), and minimum temperature has decreased (- 0.080°C/year) considerably over the three decades, indicating that temperature extremes are prevailing in the valley.

Like other parts of the Himalaya, vegetation landscape of domestic crops is being changed in the valley along with increment of temperature. Upward shifts of agriculture can be 150-200 meters per degree of warming in the mountain region (Meyer-Abich, 1993). Agro-pastoral communities of the valley have not gone unnoticed to it. They have been experiencing and observing it. At Thanchok (2,682 m a.s.l.), for instance, they could not grow cucumber and improved variety of maize due to cold and less number of hot days until the end of 2007, but today they do it. In reference to the change in the maize landscape over the last few years, Yagya Ghale, (a 58 years old farmer) said:

The weather at Thanchok (2,682 m a.s.l) is not like the past. In the past, summer used to quite cold and short. We (villagers) could only grow local maize, but not *dale* and *bikase* (improved varieties) maize and cucumber at village as the down-settlers (who live upto 2,400 m a.s. l) did. We tried to grow *dale* and *bikase* varieties of maize and cucumber several times but never succeed. Since the last decade and more, we have been experiencing hot days in the summer, and the days are also more. We succeed to grown cucumber in 2007 for the first time and improved variety of maize in 2010 (Y. Ghale, personal communication, November 20, 2012).

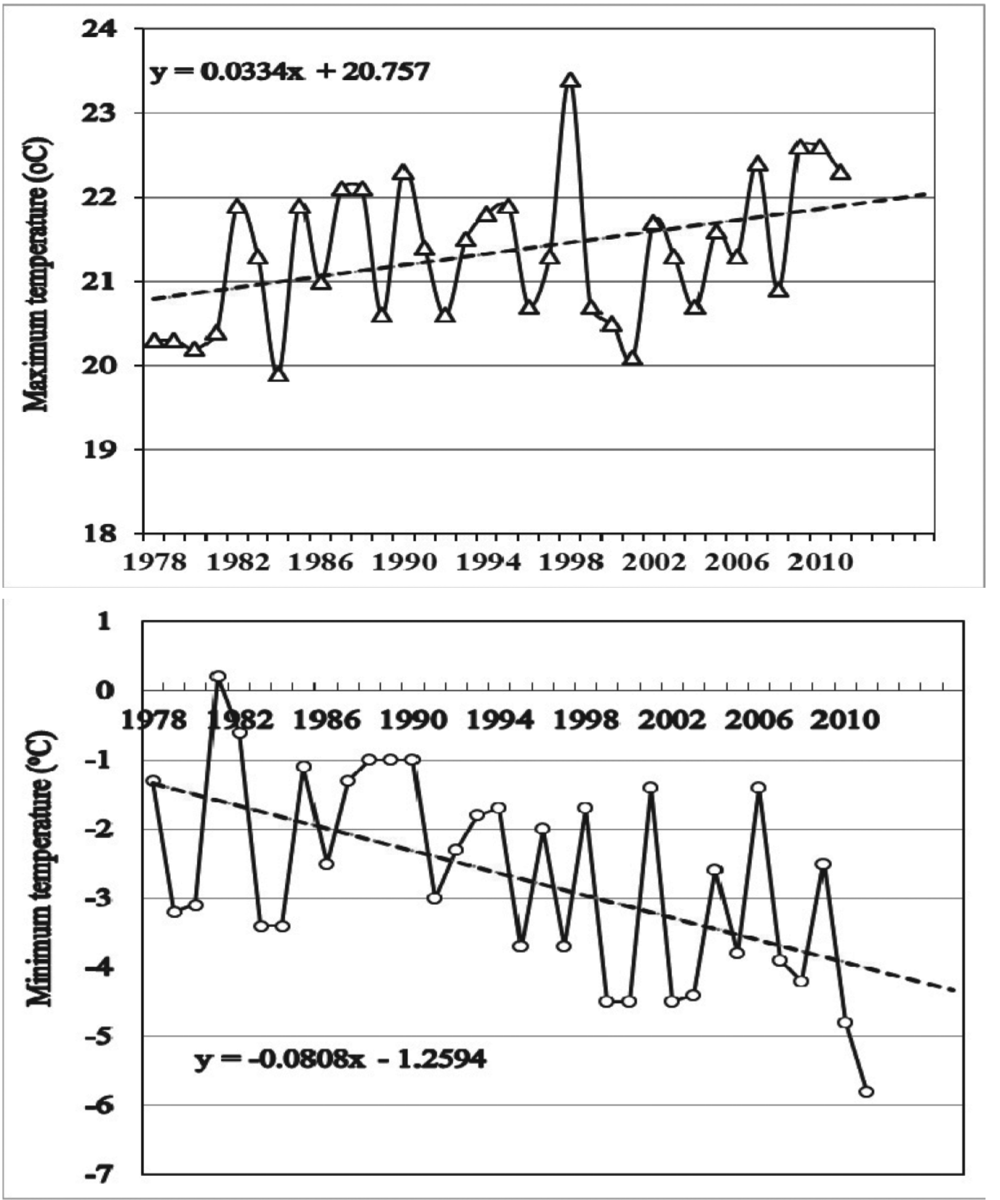

Figure 2 : *Annual maximum (upper) and minimum temperature trends at Chame from 1978 to 2011. The broken lines show the temperature trends.*

Similarly, chilli, tomato and tree tomato could not grow in 1,700-2,500 m a.s.l. until 2007, but now it becomes possible to grow along with increased temperature. In 2012, when I visited to Upper Manang area, I saw maize filed at Dhikurpokhari (3,240 m a.s.l.) (Figure 3, a) and apple fruits grown at household at Pisang (3,250 m a.s.l.) (Figure 3, b). Growing of maize and good apple yield are recent phenomena for the area. When I showed the pictures to my informants on the screen of my laptop, they could not believe me. The eldest informant, Ratan Ghale (81years old man) stopped me and exclaimed:

> What's a good maize farm and apple fruits! When I was young, maize used to grow at Thanchok (2,682 meters) only, and it began to grow at Chame (2,710 meters) very late. Apple fruits also look better than here. They may not be from there, may they?" Apples were only grown in the Nhāson valley. As I recalled my earlier days, it would grow upon Bhratang (2,850 meters) only, and it would be small, hard, and sour. But it looks larger and brighter like what we would grow at our village in the past (R. Ghale, personal communication, November 15, 2012).

(a) Maize farming at Dhikurpokhari (3,240 m a.s.l.) *(b) Apple fruits at Pisang (3,250 m a.s.l.)*

Figure 3: *Maize (a) and apple (b) farming in the upper Manang area*

Ratan Ghale's remark is telling that the place or altitudinal zone which was good for apple is no better now and vice versa (see Figure 4). Indeed, Thanchok was the upper limit of maize cultivation in the Marsyangdi valley until the early 1970s (Gurung, 1980) and began to grow at Talekhu (2,750 m a.s.l.) in the early 1980s (Koirala, 2038 BS). Over the last three and a half decades the landscape of maize has shifted 520 meters upwards i.e., from Thanchok (2,682m a.s.l.) to Dhikurpokhari (3,240 m a.s.l.) along with the increment of temperature.

The interventions government, non-government organizations, the Annapurna Conservation Area Project (ACAP) and private sectors in new technology and methods in agriculture sector definitely create a new environment for growing new crops and fruits in the Nhāson valley as well as Upper Manang but people considered climate change are more responsible for it. Yam Bahadur Gurung, a staff of ACAP, shared his experiences like this:

> ACAP trialed vegetable farming in greenhouse tunnel in 1992, but could not success until 1998. New technology is necessary for change, but everything cannot achieve by it. The suitable climate is also essential for it. The decline of snowfall in winter and increased temperature in summer in Manang create new environment to grow green vegetables, primarily tomatoes in plastic tunnel (Y. B. Gurung, personal communication, November 18, 2012).

Climate change is not only producing opportunities to grow new varieties of crops, but also uprooting the traditional crops landscape. For example, the agro-pastoral communities in the valley could no longer grow good quality and quantity of apples over the last one and half decades due to decline of snow which is also reported in other regions of the Himalaya (Vedwan & Rhoades, 2001). Likewise, they have been noticing the decline of buckwheat yield, losing both yield and taste of (*kolo*) Himalayan bean, potato and maize due to climate change.

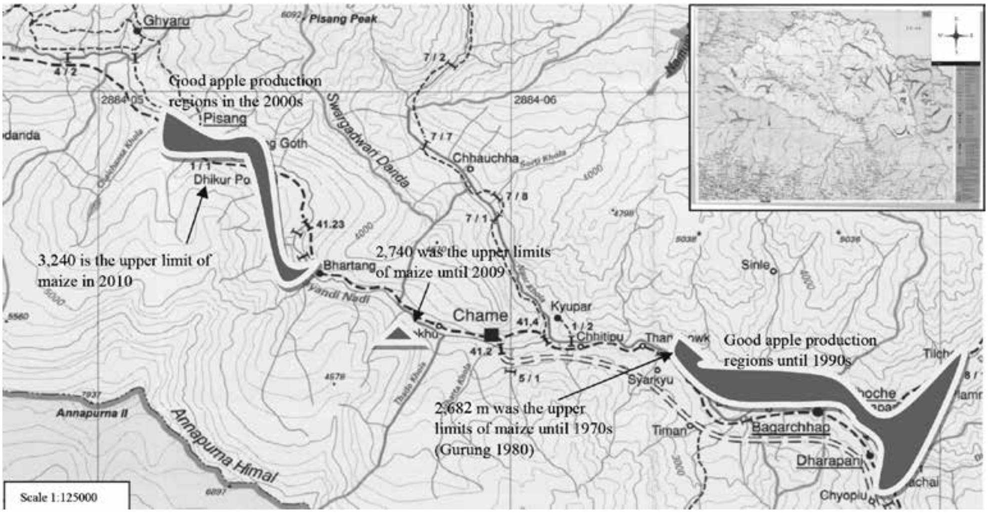

Figure 4: *Vegetation landscapes changed in Nhāson over the last 30 years. Source: Poudel, 2016*

Landscape variation and pastoral systems

The Nhāson valley covers a wider geographical landscape i.e., from about 1,700 m a.s.l. to 8,000 m a.s.l. This wider vertical landscape favors to raise different types of livestock like yak, *cho/choaama*, cow, goat, sheep and horse. Due to lack of limited agricultural land, they cannot grow enough crop residues as fodder to feed their livestock. Hence, they practice a seasonal movement of livestock. In summer, they move their livestock in high altitude meadows and in winter to villages and their surroundings and the low altitude pasturelands located in lower adjacent districts. The movement of livestock varies according to types of livestock. It is largely shaped by physiological characteristics of animals. For example, yak can only live until 120C (Haynes et al., 2014). Therefore, yak herds remain in high elevation meadows (3,500 m a.s.l.) whereas herds of cow and cho-aama moves in high elevation meadows in summer (from mid-April to mid-May, and from mid-August to mid-October), and middle elevation meadows (around 3,000-3,200 m a.s.l.) and village and its surroundings (from 2,000 to 2,500 m a.s.l.) in winter (mid-October to mid-April). Likewise, sheep and goats move in high elevation meadows in the summer, and the middle elevation meadows and the village and its surroundings in pre-winter (mid-October to mid-December) and low altitude (from 500 to 1500 m a.s.l.) in winter. Since 2016, the traditional practice of grazing livestock in lower altitude (about 500 – 1,700 m a.s.l.) has almost stopped when lowland dwellers started to grow cash crops on their private agricultural lands and community forests. It has brought great challenges for herding, especially sheep and goat. Due to restrictions on grazing on community forests and private land in lowlands, some households sold their livestock and some of them reduced herds' size.

The rotational movement of livestock adapted by the agro-pastoralist communities in the Nhāson valley can preserve ground grasses and crop residues of fallow farmlands. They use it during the pre-winter and winter seasons. Without moving their herds in meadows in different seasons for grazing, they cannot manage their herds in the limitation created by climate.

Climate change and its effects on pastoralism

In the Nhāson valley, the challenges of climate change seem to be on traditional habitat, cross-breeding, access to water resources for feeding on high meadows and access to ground grasses for grazing. In the valley, the local people were observing the changes in the meadows landscape. For instance, in May 2013, I was talking with some herders at the Nache village about climate change and livestock management practices. One of the informants Mangal Bahadur Gurung (68 years old), narrated the climate change that he has been noticing on their meadows like this:

> There were a few species of rhododendron and other thorny trees at Kromche pastureland, and most of the lands were covered with grasses. Snow used to cover the land for a longer period in winter. However, the weather and vegetation landscape have been changing a lot since the 1970s. There is very little snowfall in the winter, and now it does not remain on the ground for a long time as it used to. The decrease in snowfall made it possible to grow new vegetation in Kromche grazing land. The rapidly growing and increasing of trees, especially thorny species, have made the grazing space smaller. Moreover, in the past, it was not difficult to count cattle because we could see them by standing in a high place. But now, we rely on the sound of a bell that hangs on the neck of our cattle to know where they are (M. B. Gurung, personal communication, November 18, 2012).

The similar experience was shared by Lal Bahadur Gurung (54 years old), a local forest guard and former herder, from the same valley like this:

> I spend my early life (age between 14-24 years) as a shepherd and even today I occasionally make supervision of my sheep and cattle herds. In the summer, our herds would be at Prochha, Timle and Yoba meadows, and even stay there. There was no single tree. Now, 50% of these meadows are covered by shrubs and pine trees. We are missing our meadows (L. B. Gurung, personal communication, November 16, 2012).

The life experiences of herders are telling that the thorny and shrub flora of the lower elevations is slowly making incursions into grazing meadows, and a number of species historically known as quality grasses to their livestock from these habitats could no longer be located. Studies on responses of climate change in the Himalayan region also reported the changes in plant phenology, elevation range shift in plants, upward moves of tree lines, changes in plant communities structures, incursion of low elevation shrub vegetation into the alpine meadows, disappearance of alpine plant taxa (Shrestha et al., 2012; Minish et al., 2016; Pandit, 2017). By 2050 and 2070, it is predicted that about 16 percent and 18 percent of endemic angiosperm species would be likely to lose their habitat (Brandt et al., 2013; Manish et al., 2016). Such vegetation community modification will lead to decline of yak population in the Himalaya and extinction of a unique human culture that have evolved in these highlands over thousands of years (Pandit, 2017; Poudel, 2020).

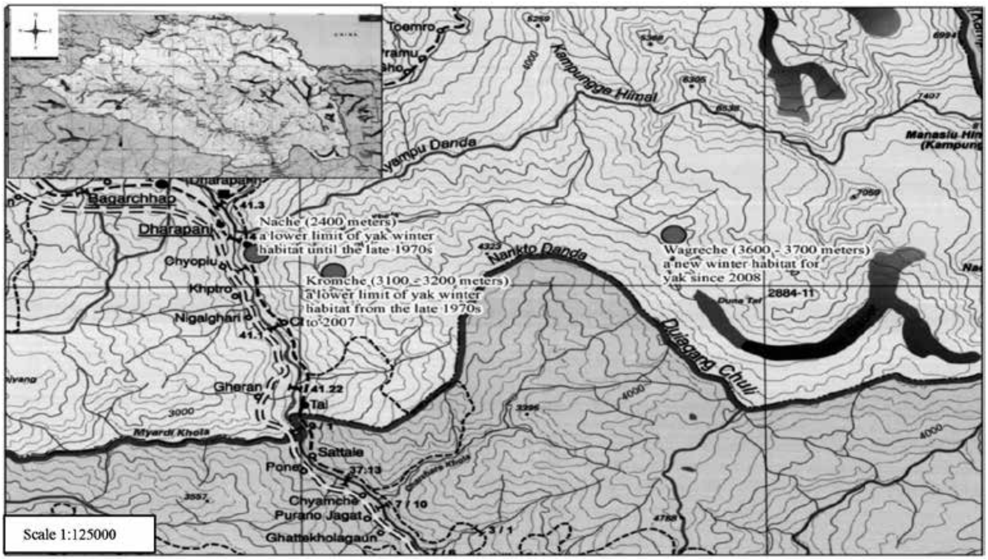

Figure 5: *Yak landscapes changed in Nhāson over the last 30 years. Source: Poudel (2020).*

The major challenge of climate change (mostly increase in temperature) is in the habitat for livestock, especially yak. Over the last four decades (1978-2020), the annual maximum temperature has increased by about 1.40C (0.0334 0C/ year). Studies reported a closed connection between temperature and physiological character of yak. Physiologically, yak can only live up to 120C. At 130C, yak's respiration rate starts to rise; at 160C, its heart rate and body temperature start to rise, and at 200C, it stops moving, grazing, drinking, or ruminating (Haynes et al., 2014). Hence, the agro-pastoral communities of the Nhāson valley have shifted the habitat of their livestock. For instance, the communities used to keep their yak herds at an altitude of 2,400 m a.s.l. until the 1970s; after that, the same altitude was not found to be suitable for keeping the yaks. After that, they began keeping their yaks at an altitude of 3,100-3,200 m a.s.l. The place was good until 2007; thereafter, this altitude has become no longer climatologically good for keeping the yaks. Then, they have started keeping them at an altitude of 3,600-3,700 m a.s.l. (see Figure 5). With every instance of increased temperature, the communities have shifted the location of their yak herds towards higher altitude in order to cope with the risk.

Global warming is not only dislocating the habitat of yak. It has more impacts on yak and associated culture or tacit knowledge. The Nhāson valley is geographically and climatologically suitable for hybrid production (Poudel, 2016). For household economy, the herders of the valley have been producing hybrids by cross-breeding yak-bulls and cows. It is, however, a complex task. It requires both biological and human dimensions as suggested by Bishop. She writes:

> Hybrid should be impossible, however, some species are sufficiently close either due to recent domestication or because of insufficient time or selection pressure for differentiation, that their chromosomes will match up and produce a viable offspring, especially with human assistance in the mating process itself. (Bishop 1998:31)

In my discussion with herders, I found that three components seem essential for hybrid production. They are: sound knowledge about the local ecological system (such as temperature, geographical location, availability of grasses and water for livestock in pasturelands); animal behavior (mating season of cow and yak); and human resources in the households (Poudel, 2020). This shows a close connection between human and ecological systems for crossbreeding. However, ongoing climate change has threatened the rhythm of the natural system and is breaking the relation between the social and the ecological system. For instance, Kromche (3,100-3,200 m a.s.l), which is a pastureland of the Nache village, was not only a geographical space but also an empirically tested place for cross-breeding between yak-bull and cow. In the beginning of May, the villagers would move their cow-herds upwards to Kromche and reach there by mid-May. They would keep yak-bull and cows together for crossbreeding by separating nak (female yak) and bulls from each herd. It requires more human resources to herd nak and bulls separately. If they did not separate yak from nak and bull from cows, it would be impossible to cross-breed between yak and cows. They would keep yak-bull and cows together from mid-May to mid-July for mating by separating them from their opposite sex. Thereafter, herders would move the yak-bull to a higher altitude because the yak-bull cannot live in high temperature due to its physiological characteristics. In my interviews with the herders of the Nache village, they reported that the place is no longer good for cross-breeding because of increased temperature, which is illustrated by the following case.

> In our village, there was a yak-bull raised for cross breeding. One particular winter, a yak bull was left at Kromche (I could not recall the date). In that winter, there was heavy snowfall which continued for several days and it remained on the ground for a long time as frozen ice. The yak-bull could not get anything to eat due to thick layers of snow and it died of hunger, eventually. Today, the event, which was a reality in the past, has become like a fairy tale. The same place where we lost yak-bull due to heavy snowfall in the past is also the place where we lost our six yak-bulls due to low altitude sickness between the years 2000 and 2009 when we kept them for mating with cows for cross-breeding. Today, the villagers hardly move their yak herds down from Wagreche (3,700 m a.s.l) throughout the year (M. Gurung, personal communication, November 24, 2012).

The story, narrated by Meghalal, describes what has been happening to yak in the mountain region over the last few decades due to climate change. Temperature has increased dramatically, and winter snowfall has decreased severely. Scientific data also shows that the maximum temperature increased by about 1.4 0C over the last four decades at the Chame valley. The changes in temperature and snowfall patterns in the Himalayan region are threatening natural ecosystem and livelihood (Pandit, 2017). In the Nhāson valley, the changes in temperature and precipitation have gradually been disturbing the social and ecological systems, that is, declining of moisture in soil, increasing incursions of busy plants on meadows, shortage of grasses and water to feed livestock that badly affected the traditional habitat of yak, seasonal moving cycle of livestock, shrinking of meadows, breeding cycle of livestock, fat in the body of livestock. Indeed it is largely threatening the livelihood. Moreover, it is disturbing indigenous knowledge and practices that were built up through multi-generations of interaction with the local ecological system which is gradually breaking down due to climate change.

Conclusion

The data presented in the text tells us that environmental change associated with variations in weather and climate has not gone unseen by the agro-pastoral communities who are observing and experiencing change first-hand. As the first eyewitness, agro-pastoral communities' science or knowledge is pragmatic, tacit and grounded rather than theoretical, myopic and satellite. To be a pragmatic, tacit and grounded knowledge, the place and continuous attachment with it are important for the production of knowledge that sits in places' (Basso, 1996). Hence, place and the relation with it; place and the memory with it; places and the oral history attached with it come as a central for discussion on climate change to agro-pastoral communities. However, global warming is gradually dislocating people relation with environment (Crate & Nuttall, 2009) including indigenous knowledge that cannot be transmitted as a set of customary prescription or formulae; it accumulates from a lifetime of experiences traversing and inhabiting well known places and is embodied in tacit knowledge (Ingold & Krutilla, 2000; Cruickshank, 2014). This knowledge is really important to understand climate change and its impacts on human dimensions at local level. Moreover, it can be a vital evidence to complement and enrich scientific understandings. It is, therefore, critical to recognize the value of traditional knowledge or eye witness of local communities on what is happening absolutely in communities and their surroundings. As pragmatic knowledge, indigenous/local knowledge on climate change seems as a system of knowledge that could inform science rather than an object for science as Cruickshank (1998) said.

Community people have a distinct way of telling climate change as scientists do. They see it through the window of crop performance (Vedwan, 2001). Recalling the past crop or grass landscape and comparing it with the present is a method of measuring the changes. People compared the size, color and taste of present fruits, quality of grasses, behavior of animals with the past that they noticed and observed.

The Himalayan communities are less responsible for global warming. Nonetheless, they are highly affected by global warming. The ways of life of the communities are disturbed, uprooted and dislocated from its past realities (Poudel, 2020). Climate change is not only affecting to Himalayan glacier and permafrost as well as the natural ecosystem, but it is also adversely affecting socio-cultural systems. However, there is a wider gap in epistemology and ontology between scientific and local knowledge, natural science and ethno-science to understand climate change (Poudel, 2012). Neither western science nor traditional knowledge is sufficient in isolation to address all the complexities of global climate change (Riedlinger & Berkes, 2001). It is essential to cross-fertilization between western scientific analysis and local understandings (Rhoades et al., 2008). Only with a strong interdisciplinary and transdisciplinary approach that involves the participation of the local people directly affected can we hope to achieve the solutions to address the current issue of climate change.

Acknowledgement

I acknowledge the people of Nhāson for generously sharing their lives and experiences, my guru Professor Ram Bahadur Chhetri for his incessant support and encouragement, Professor Sunil Adhikary, Tribhuvan University & Dr. Naresh N. Rimal, a freelance socio-ecological resilience specialist and the subject head teaching research methodology at Armed Police Force Command and Staff College of the Government of Nepal in making suggestions to the manuscript, and Binod Adhikari for drawing maps. I also acknowledge to anonymous reviewers for their insights comments.

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