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Situation of ecosystem services and changing livelihood in Nepal Himalayas: A case study from upper mustang

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Abstract
Ecosystem services (ESS) are the bases of livelihood in mountains. Among several such services, water and agricultural land are the major ones in Upper Mustang and these ESS services are under threat due to climate change. Water is lifeline and essential for drinking and irrigation. The increasing temperature, and decreasing precipitation and its variability have negatively affected water yield and irrigation. It has directly affected agriculture. In this situation, based on detail field survey, installation and collection of river flow data, and analysis of long term rainfall and precipitation data, this paper discuss the situation of ESS and measures of adaptation that local people have adopted in Upper Mustang, Nepal.

Keywords: ecosystem services, climate change, livelihood, water, agriculture, tourism, upper mustang

Introduction

Ecosystem services refer to various services and benefits that people obtain from ecosystem. There are basically four types of services that we derive from the ecosystem. These are provisioning services, regulating services, cultural services and supporting services. Provisioning services include various products that we get from ecosystem such as food, fresh water, fuelwood, disease control, and genetic resources. Regulating service regulates the ecosystem processes and it includes climate regulation, water purification, pollination etc. Cultural services are the non-material services and there include cultural heritage, spiritual and religious places, recreation and tourism, traditional knowledge and social relations. The supporting services are very important as they support to produce various ecosystem services (ESS). These include soil formation, cycling of nutrients and all primary production which maintain the conditions for life on the Earth (MEA 2005).

Human livelihood is based on various ESS. The state of availability and access to various ESS determine the human wel-being and development. For instance, the material wel-being of human primarily depends upon the provisioning services (Fisher *et al*. 2014) [4]. ICIMOD (2009) [5] has claimed that due to various human and other stress, the condition of mountain ESS has deteriorated. A few major stressing factors include climate change, over extraction of various resources due to human pressure that has resulted water scarcity, decline in agriculture productivity, landslide, floods etc. It has affected the whole ecological system of the high mountains.

There is very close relationship between human livelihood and ESS. In the case of Mountain region of Nepal, people have been managing their livelihood based on the available ESS for a long time. According to Carpenter *et al* (2016) [2] there is persistent poverty and poor development of transportation and communication infrastructures in the mountains. It is thus people livelihood primarily depend on available ESS. Mustang district of Nepal lies in the trans-Himalayan region. It is located just behind the Annapurna Mountain Range. The mountain range blocks the southern Monsoon and thus gets little precipitation. Importantly, climate change has affected on amount and timing of precipitation in Mustang (Bhusal *et al* 2016) [1]. The winter snowfall is the major sources of drinking and irrigation water. Without water, agriculture production is impossible. The production of pasture also depends on water. Moreover, the study area is a part of the Annapurna Trekking Circuit where thousands of tourists visit annually. With the down of tourism development, changes have appeared in mountain livelihood of the Annapurna region (Subedi 2007, Chapagain 2008) [9, 3]. In this context, this paper aims to access the situation of major ESS i.e. water and agriculture in the context of climate change.

Martials and Methods

Mustang district is located in the north western part of Nepal. It is bordered with Tibet of China in the North. Dhakarjong and Phalyak are the two study villages. These villages are in the Kagbeni VDC and located across the Kaligandaki River at Yeklebhatti near Kagbani village (Figure 1). Geographically, the study villages are located at 3200 meters elevation and extended from 28^0 49' 23.7'' to 28^0 49' 32.1'' N latitude and from 83^0 44' 21.4'' to 83^0 44' 49.2'' E longitude. The study villages are in the rain shadow of Annapurna Mountain Range and the average annual rainfall is about 270mm. The maximum temperature is about 17^0 C and average minimum temperature is 5^0C. The winter is noticed with frequent snowfall and remains very cold.

Agriculture is still the major occupation. A limited crops such as potato, barley, buckwheat, peas are grown. People also have local breed cow, Himalayan goat and sheep. Only a few households have yak. Phalyak is a bigger village. It has 48 households and 249 population while Dhakarjong has 33 households and 191 population. Gurung is the major

inhabitants followed by blacksmith and migrants from Dolpa.
This study is based on the primary data collected from 2013 to 2016 using household questionnaire survey, key informant interviews, and filed observation. The household survey covered 33 households. The sample households were selected randomly. The information such as general demographic characteristics, land ownership, cultivated and abandoned land, crops grown and productivity, water availability situation for irrigation and drinking, livestock, and changes that has been experienced on rainfall and temperature situation were asked in the household survey. The six key informant interviews were done with present Mukhiyas (village head), previous mukhiyas and senior farmers in both villages. The discussion was concentrated on changing water availability situation and coping strategies of local people, emerging livelihood opportunities and challenges. The discussion also focused on traditional system of water governance at villages. The direct observation was focused on everyday practices of farming, water utilization, land abandonment, situation of water canal and water storage ponds and their maintenance. In addition to these, the irrigation canal were also mapped.
The fieldwork was supported by the Mountain EVO in which the author also involved. As a part of the program, a joint meeting and discussion were held at district headquarter Jomsom in November 2015 where local farmers, mukhiyas and government officials from district level office of agriculture, livestock, irrigation and district development committee were participated and discussed on the changing ESS and emerging challenges at villages. The rainfall and temperature data of Jomsom from 1985 to 2014 was collected from Department of Hydrology and meteorology in Kathmandu. The flow data of Lumbak River was not available as it was the ungagged river. The river is the main source of water of the two villages and located between these villages. As a part of the MEVO research project, the automatic river flow measuring instrument was installed at Lumbak River and it has got the monthly flow data of 2015.

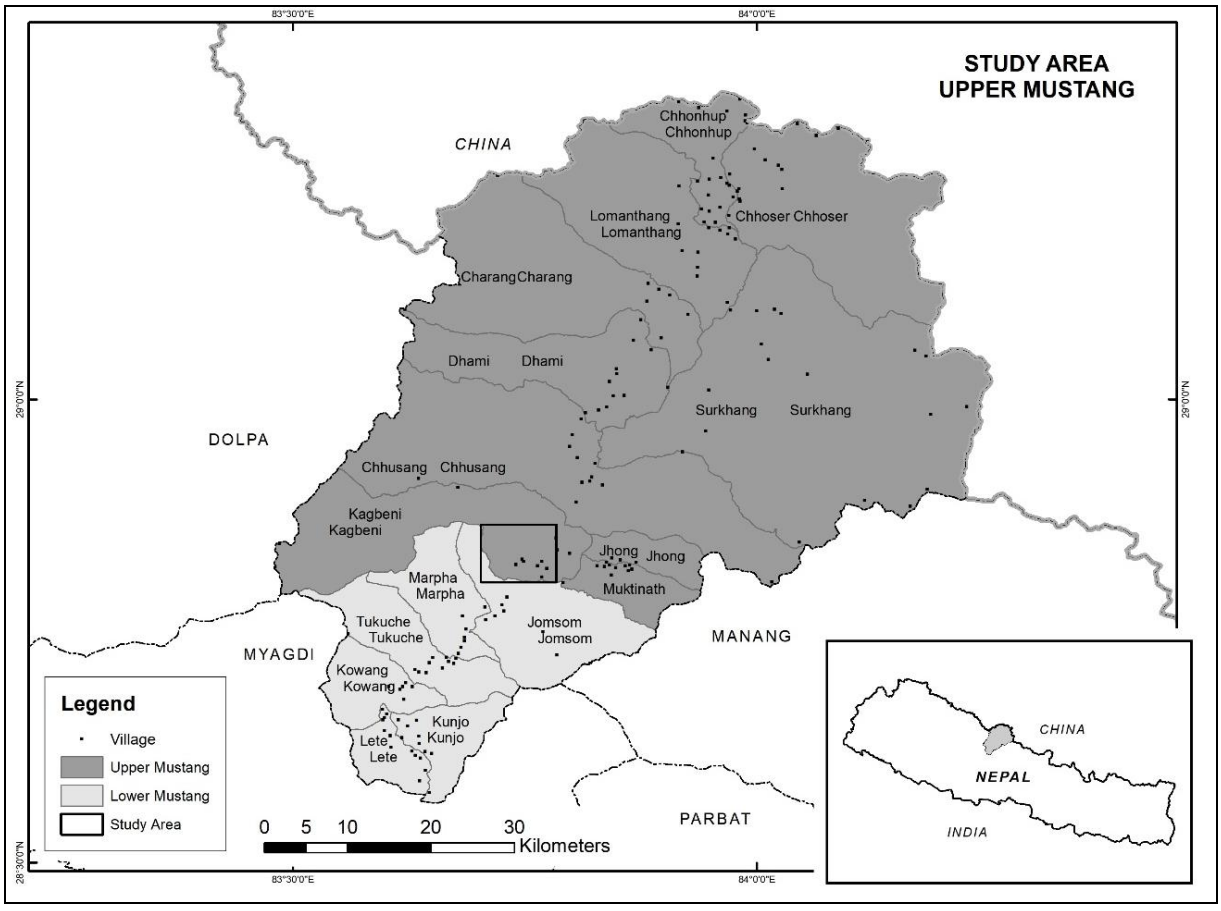

Fig 1: Study area

Major Ecosystem Services and Livelihood

Water sources and distribution

The availability of water at Lumbak River depends upon the situation of winter rainfall/snowfall. The maximum rainfall takes place due to the Monsson in July, August and September. The winter rainfall is due to westerly and the highest winter rainfall takes place in February followed by January. The annual average temperature at Jomsom, from 1981-2012, is about 12^0C. The maximum temperature reaches up to 18^0C and minimum average temperature is about 5^0C (Figure 2).

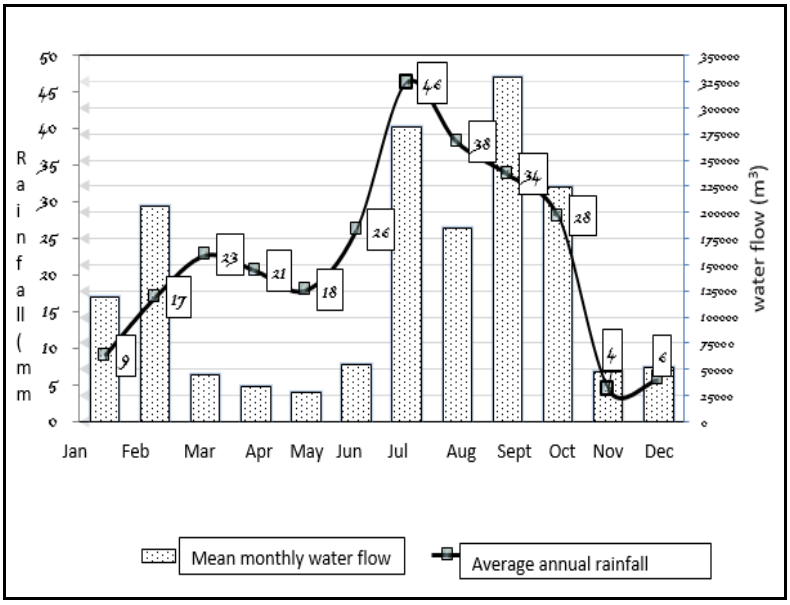

Fig 2: Average annual rainfall at Jomsom (1985-2014) and water flow at Lumbak River (2015)

The availability of water for irrigation and drinking is depend upon the amount of snowfall at the mountain above these two villages that. The accumulated snow melts during summer and provides water. In addition, the summer rainfall is another source of water for irrigation. If there is enough rainfall during summer, the water from Lumbak River is enough. If there is variability of rainfall in terms of amount and timing in rainfall, the demand of water for irrigation increases.

The Lumbak River catchment area above the irrigation canals to these settlements is about 10 square kilometers. There is a canal to each village. The irrigation canal from river to storage pond has stone wall with cement plaster. The canal to Dhakarjong is about 500 meters long while it is 700 meters long to Phalyak village. The water is stored at the top of the village. The storage pond of Dhakarjong is small (52*30 meters with 1.5 meter depth) while the pond of Phalyak is larger (60*40 meters with 1.5 m depth) (Figure 3).

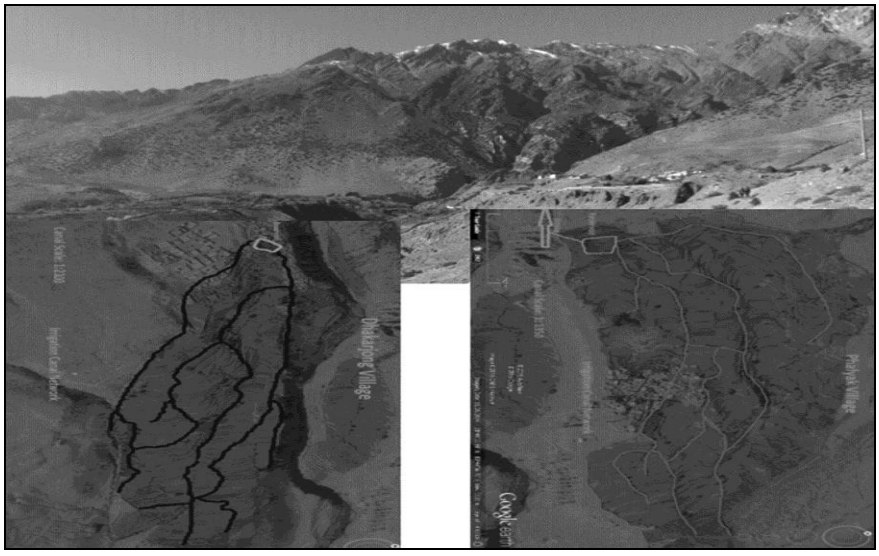

Fig 3: Water source (Lumbak River and snow at Mountain), irrigation canals and water storage ponds of Dhakarjong (left) and Phalyak (right)

The available water in Lumbak River is shared by the two villages. Phalyak share 60 percent and Dhakarjong 40 percent and use water for 3 days and 2 days basis by these village respectively for last 50 years. They store water during the whole night from 5 pm and irrigate field from 5 am in the morning. Individual household do not get water on the basis of land he own or cultivate. Traditionally, water was equally divided among the families in the villages. It was known as Dhongba system. Dhongba is a family. When family is splited the water right used to be shared accordingly. This system is in practiced until now. There are 37 Dhongbas in Phalyak and 22 Dhongbas in Dhakarjong village. One dhongba used to get 12 hours of water right. The households' water right at present is based on the number of sons of the Dhongba household and the divisions of land among them. Based on this system, one household gets minimum 3 hours to a maximum 12 hours of

water rights for irrigation. One gets his next turn after completing the turn of all Dhongbas and usually it takes about a month.

Agriculture land and major crops

All agricultural land is known as *khet*. The average agricultural land holding size of a household is about one hectare. About two third of the households have more than one hectare of agricultural land. About 26 percent households have half hectare to one hectare of land. Similarly, about 10 percent households have less than half hectare land.

Out of total agriculture land, the year round irrigated land is about 30 hectares in Phalyak and 20 hectares in Dhakarjong. In addition, there is about 30 hectares of land that is only irrigated in rainy season in Phalyak and such land is about 4 hectares in Dhakarjong. Importantly, both villages have abandoned a large agricultural land mainly because of lack of irrigation. Such land is about 24 hectares in Phalyak and 22 hectares in Dhakarjong village.

Farmers cultivate two crops in a year. The major crops include potato, barley, buckwheat and peas. In addition, many vegetables are also grown here. Apple farming has been increasing. Buckwheat is the major summer crop that is planted in June and harvested in October. Winter crops include barley which is planted in November and harvested in June. Potato is planted in April and harvested in October. Potato is the major crop and its productivity is about 600 kg per ropani (19.65 ropani = one hectare). Similarly, the productivity of barley, buckwheat is about 100 and 82 kg/hectare respectively. The productivity of crops is depend on the availability irrigation water. As the mountain soil is coarse so water infiltration is so high. It is thus water demand for irrigation is frequent. Potato needs three times irrigation, buckwheat needs four times irrigation and barley needs four to five time irrigation during the cropping period.

Demand and supply of irrigation water

The total availability of water in Lumbak River is calculated based on the river flow data. It has also calculated the total demand of water for irrigating the different crops. If there is average annual rainfall occurs as given in Figure 2, the irrigation water is theoretically sufficient in the study villages (Table 1). However, there is severe shortage of irrigation water.

Table 1: Demand and supply of water for different crops

Crops	Cropping period (Days)	Demand of water (mm)	Available water for irrigation (mm)	Demand of irrigation water for 1 ropani land (Cubic m)	Available water to irrigate 1 ropani land (cubic m)	Period of irrigation (months)
Barley	180	644	570	324	314	5
Potato	150	732	571	354	302	4
Buckwheat, pulses	180	968	1344	465	684	4

Source: MEVO, 2015.

There are a few reasons behind it. There are i) situation of irrigation canals and water storage pond, ii) nature of soil, iii) amount of rainfall and v) amount of winter snowfall.

The irrigation canals are of stone wall with cement plaster. The major canal is fine but the canals from storage ponds to the fields are rough and a lot of water infiltrates before reaching to the filed. The water storage pond of Phalyak is big and it is made of soil. It also leaks water from the pond. Secondly, the mountain soil is very corase and water infiltration is high. So the theoretical calculation of water supply in the situation existing irrigation infrastructure does not work. Importantly, both summer and winter rainfall have greater role. If there is normal summer rainfall, the available water will be manageable for irrigation. Otherwise, frequency of irrigation will increase and more water is required. Furthermore, there is greater role of winter snowfall. If there is normal snowfall, there will have water in the river otherwise severe water shortage is experienced. The rainfall and snowfall have been uncertain and pose risk to agriculture based livelihood.

Landscape beauty, culture and tourism

Mustang has very attractive mountain landscape, mountain peaks and ranges. In addition, it has reach culture, cultural heritage sites such as Muktinath and many Buddhist monasteries. Phalyak and Dhakarjong villages are in the lap of the high mountain and are very ancient settlements. The local people follow Buddhism and there are many chhortens, the sacred place of Buddhist, monasteries and very lively mountain culture. The physical diversity and cultural richness are the major sources of tourism. The study villages are part of the historical Lho Kingdom that existed before the unification of Nepal. It had direct trading route to Tibet known as Salt Route which is also a matter of historical importance.

The study area is also a part of the Annapurna Conservation Area where there is world famous Annapurna Trekking route. In has protected the unique high mountain landscape, mountain culture including many endangered plants and animal species such as snow leopard, musk deer, and red panda etc. The trekking route starts from sub-tropical region in the south and ascends up to 5416 meters at Thorong La pass and descends down towards the Muktinath and Jomsom in Mustang. One can closely observe world highest mountain peaks such as Annapurna, Dhaulagiri, Nilgiri, Tilicho, Gangapurna etc. Annually about 100,000 thousands trekkers visit here. The numbers of trekkers during 1980 were about 15000 that reached to35000 during 1990 and 75000 in 2000 and 95000 in 2010 (MoCTCA 2015) [7]. Tourism has recently become a major source of livelihood, income and employment in the region. However, tourism has not much flourished in the study villages as these villages are a bit off-site of the major trekking route. The tourism infrastructure has not much developed though there are high potentialities.

Emerging Livelihood opportunities and adaptation

The increasing stress on ecosystem services, particularly water

and agricultural land, has brought changes in livelihood strategies. Such changes are also supported by a few emerging opportunities such as tourism, development of road, and increasing market for local products. With increasing climatic uncertainty, local people have also became aware on climate change and various measures have taken to adopt in the changing context. Among the various strategies i) seasonal and permanent migration, ii) changes in crops, iii) adoption of new technology iv) changes in irrigation techniques, and v) reducing the herd size of livestock are important.

Migration has been an established strategies of mountain people. In the past they used to have seasonal migration to avoid severe winter cold and also used to migrate during agricultural off season. The aged and children usually migrate to their relatives in Kathmandu, Pokhara to avoid winter cold. The young men migrate to Dolpa or various places in India for livestock and other business while a few young women started to visit different places of Northeast India temporary jobs such as preparing woolen garments.

A major change has been appeared in agriculture. In the context of irrigation shortage, growing traditional crops has become challenging. At the same time, increasing tourism activities and out migration of youths have resulted agricultural labor shortage. The production and productivity of cereals has been decreasing. It has negatively affected the food security of the villages. Since last few years, local people have attracted towards apple plantation. Each household has planted apple. Apple plantation has covered about one third (31.62%) of the cultivated land. The farmers who have more than one hectares of cultivated land have planted apple in 38 percent of their total land. Similarly, those who have half to one hectare cultivated land have planted apple in 24 percent of their land and small farmers (those having less than half hectare land) have planted apple in seven percent of their land. Majority of the large land holders stay outside of the village and manage to look after land and house with the help of their relatives or helper at village. Apple farming demand less labor, less water and have good market. There is local market as well as it can be transported to Pokhara and elsewhere via road transportation. In addition to apple, people prefer to grow potato and beans which have higher demand and better market price.

People have also become aware about the modern irrigation technology such as spring-call. A few farmers have used it. They are thinking to use drop irrigation for apple. As there is lack of water for irrigation, people are also planning to pump the Kaligandaki River water up to the village. Local people have also reduce the herd size of their livestock. In the past, many households have yaks in the high mountain. At present only a few household have yak. All households have reduced the number of cattle and goats primarily because of decreasing pasture production and water.

Local people have also experience increasing temperature and decreasing rainfall and snowfall in winter. Snowfall has drastically reduced compared to the situation of 15 to 20 years ago. In the past, it used to have prolong snowfall with 3 to 4 feet accumulation and that was unmelted for two to three weeks. Because of slow melting, there used to have good soil moisture and very less water was required for irrigation. At present, snowfall timing has changed and there is less snow that melts with 2 to 3 days. Rainfall timing and amount has also changed. The rainfall become variable. Importantly, snowfall has been gradually decreasing and rainfall has been increasing which will have greater impact on existing housing system. The houses are mud roof which cannot sustain rain.

In the situation of less availability of snow, local people have divided the cultivated terrace into a number of small sub-divisions. The irrigation water put into a few terraces first and accordingly to the other sub/terraces before irrigating the next terrace so that the larger volume of water quickly spread over the sub-terrace and cannot much infiltrate. For saving the water, local people of Dhakarjong have made the wall of water storage pond concrete. The Phalyak people also thinking for the same. Furthermore, local people are becoming interested to switch towards less water demanding crops, cash crops. They are interested towards tourism and migration and diversifying household income.

Conclusion

Water, agricultural land, culture and majestic mountains and landscape beauty are the major ESS of upper Mustang. The region has experienced increasing temperature and decreasing precipitation within last two decades. The recent climate change has affected the ecosystem services particularly water, and pasture productivity. The decreasing amount of precipitation reduce the water flow in Lumbak River and thus irrigation water became scarce. Consequently, a large cultivated land has been abandoned in each village and farmer reduce the size of cow and goats.

Changes have gradually appeared in traditional livelihood strategy. People switch to other sources of livelihoods such as seasonal migration, short term to long term migration to larger cities, and switch towards apple farming instead of cereals. The large land holders have adopted migration and apple farming while the small land holders keep on continue to cultivate their own land and additional land of the migrated households. They also started earning income from emerging tourism by involving as porter, guide and by supplying their products such as potato, vegetables and animal products.

Theoretically, the available water at Lumbak River can irrigate the existing cultivated land. However, practically, the situation is different that there is severe water shortage. This shortage is primarily due increasing temperature, decreasing precipitation and the poor water infrastructure. The irrigation canals and water storage ponds need to be properly reconstructed. It is also essential to have additional water storage ponds so that they can harvest rainwater. Tourism can be the major source of income and employment and it needs to be properly developed so that the off-route settlements such as the study villages can also be benefited. It is also important to acknowledge the way that local people have conserve and governed the water and other ecosystem services.

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