

## Adaptive Strategies to Scarcer Irrigation Waters caused by Changing Climates

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Received August 10, 2019; Accepted November 01, 2019; Published January 05, 2020

### ABSTRACT

This is a review article focused to author's research on "Coping with Climate Change: Water Availability and Adaptive Strategies in Irrigation practices in Mustang, Nepal" and related publications on the implication of climate change on water availability, where residents depend on farming for their livelihood and where water is becoming a crucial resource especially for irrigation, livestock and farming. Social, agricultural and hydro-met data available on and collected from the pilot areas were used in the analysis. Both quantitative and qualitative methods were treated as complementary rather than competitive. It was found that the effect of global warming on mountain hydrology has been impacting the existing yield pattern of water sources, the river flows, forests and vegetation grows and grazing lands and other resources on which mountain people are dependent on their livelihoods. If the trend on the average temperature rising continues as the prediction made by various researchers on climate change, it would have a serious impact on human and natural life in the mountainous people in the coming years.

**Keywords:** Climate change, Irrigation practices, Adaptive strategies, Livelihoods

### BACKGROUND

Many rural areas of Nepal are in rapid transformation phase in social and economic change, urbanization, out-migration [1-3] increased off-farm employment opportunities, increased absentee landowners and sharecroppers, and their higher education levels leading to diversifying social values [4]. Several recent works suggest that adjustment within irrigation systems is based on a process which includes the introduction of an innovation, field trials and adoption, modified adoption or rejection [5-8]. Attitudes and aspirations play a crucial role in participatory irrigation management and irrigation management transfer programs [9]. The incentive is an important ingredient in addition to the perception reforms for effective operation of the water user association driven participatory irrigation management program [10-12]. Indigenously managed farmers' irrigation systems in Mustang of Nepal are built and sustained on the foundations of power relations and social differentiation. Water rules and rights are exclusively power ridden in such systems [13]. The decreasing trend in livestock's pastureland and horticulture like apple production and natural herbs is an eminent concern [14,15]. Water shortages in the region inherent by the changing climates have been not only putting stresses in the local livelihoods [16,17] but also creating

water conflicts between communities [18,19]. The increase in surface temperature has been affecting the existing water availability situation [6,20,21] has been opening an opportunity of growing new crops. In such a complicated situation, local households have to cope with the water shortage through various ways and means in order to continue their farming system and improve their livelihoods [22,23]. On the other side, the rising trend of temperature in the mountain areas has been opening the opportunity of growing new crops. Apple farms traditionally being used at lowlands are found affected by rising temperatures [24] whereas new areas of higher altitude are becoming productive to apple [25]. There are numerous studies on climate change and effects in diverse areas but irrigation systems in high altitude areas in Nepal remained less

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**Citation:** Bhusal JK & Eng P. (2021) Adaptive Strategies to Scarcer Irrigation Waters caused by Changing Climates. J Agric Forest Meteorol Res, 4(1): 345-350.

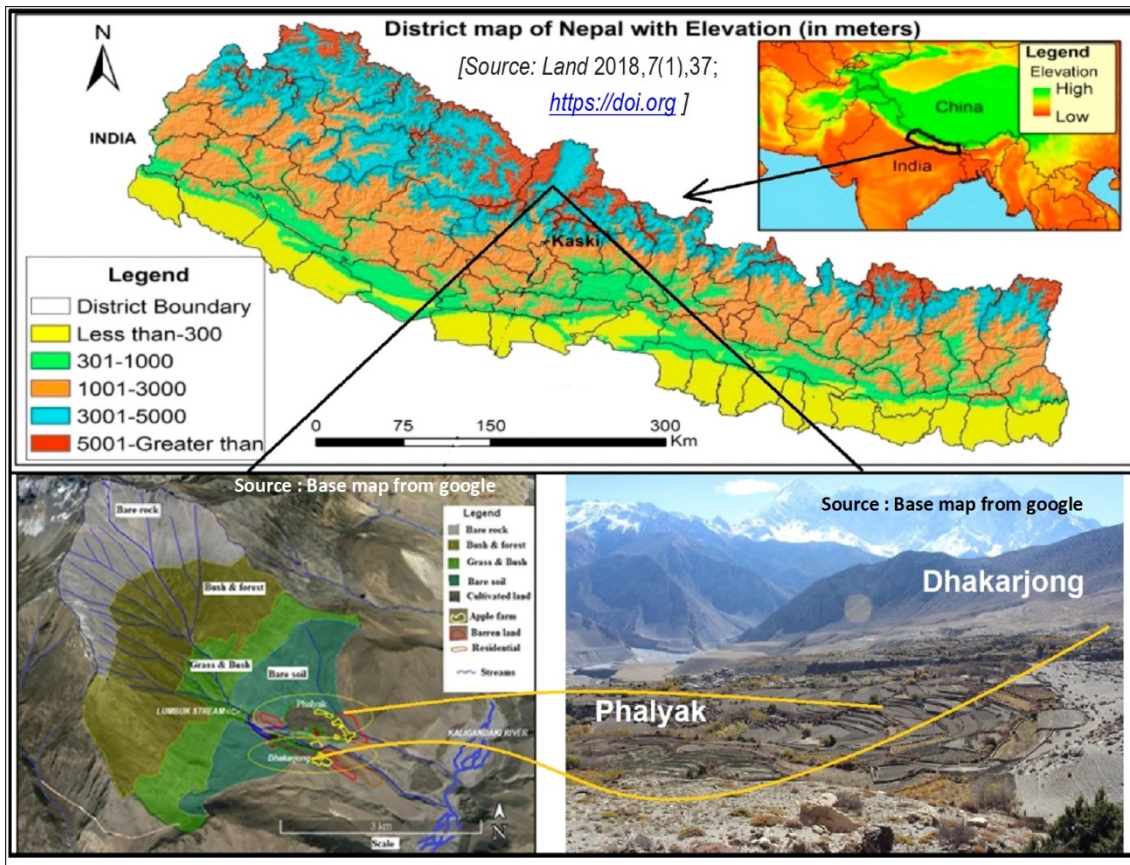
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assessed [26]. The effect of climate change on water availability and implication in local irrigation water has not been investigated in depth by taking cases of Trans-Himalayan areas [27]. Therefore, research works were focused to address issues on how local households in the mountain areas are coping with climate change and what are their adaptive strategies. Research questions included were (a) what are the trends of change in the seasonal temperature and precipitation in the study area (b) what implication has climate change placed in water availability situation and irrigation practices in the study area (c) how have the farm households perceived the impact of climate change on their

farming system and effectively managed water needs for their crops focused on irrigation practices?

**STUDY AREA**

The Trans-Himalayan area of Mustang of Nepal has been selected for the study (Figure 1). The research area lies above 3000 m altitude in the Himalayan region of Nepal and falls in the rain shadow area of Dhaulagiri (Peak- 8,167 m above mean sea level) and Annapurna (Peak- 8,091 m) massifs in the Himalayas. The area is categorized as the cold arid zone of Nepal Himalaya.



**Figure 1.** Location map of the study area (watershed, land use and settlements).

Historically, the area was said to be dependent mainly on agro-pastorism [28-30]. The agro-pastoral life was easier in the past because of the smaller population density and the abundance of virgin natural resources including freshwater [31]. People had had been accessing freely the highland pasturelands. With passes of time and environmental changes, highland pasture productivity and irrigation waters have been reducing in line with decreasing snowfall and changing rainfall patterns [32,23]. In the course of development, irrigation practices were followed with time [33]. The decreasing trend in the livestock’s pastureland, horticulture like apple farming has emerged as an eminent alternative in sustaining local livelihoods in addition to

agricultural farming in the region [9,24,30,34]. As the region consists of beautiful landscapes with cultural heritages and so tourism is also emerging as a part of the support of agricultural-based livelihoods [29,14,35].

**DATA AND METHODOLOGY**

Data for the analysis included long-term precipitation and stream flows [36-40] and *in situ* hydro-met data observations, peoples’ perception, key informant interviews and focused group discussions [19,27]. Fieldwork was carried out in 2010 and from 2012 to 2015. People’s perceptions and their understanding of climate change are

validated by statistical analysis of observed quantitative science data on stream flows, precipitation and temperature.

For the sale of bio fuels a final adjustment is done for the ash. The research methodology on coping with climate change and adaptive strategies in irrigation practices incorporate processes of natural and social sciences. The paradigm of the research adopted in the research is the mixed method, which is also categorized as pragmatic research [41,42] and a method that moves both forth and back between induction and deduction reasoning [43]. The research model was the process model followed by the mixed research process model (reduced size) by Johnson and Onwuegbuzie [44] with slight modification. In this research, both quantitative and qualitative methods are treated as complementary rather than competitive.

## RESEARCH FINDINGS

The research findings included climate change, i.e., changes in temperature and precipitation pattern, water availability situations and adaptation to climate change by locals. The rising trend of the mean annual temperature in Nepal will be in 0.045°C per year whereas the study carried out over the region showed that the rising trend on average maximum temperature (April to August) is 0.019°C per year and the rate of change on average minimum temperature (January to March) is 0.004°C per year. The maximum temperatures for May, July and August have increased at a rate of 0.03°C per year. The annual runoff on the Kaligandaki River at a monitoring location is found to have increased at a rate of 2.3 mm/year over the period 1975 to 2012. The reason for the increased surface runoff in the main Kaligandaki River is the rise of surface temperatures. But water sources fed by springs are found decreasing due to drying up springs. The drying of spring is caused by decreasing inputs by infiltration caused by fewer snow accumulations. The thinning frequency of snowfall, the temporal and the spatial variability in precipitation induced by climate change is the main reason that yields on most of the water sources went on decreasing and drying out. If a significant rise in temperature continues, runoff in the snow-fed streams increases for some years but water sources fed by spring would go drying out due to decreasing inputs as infiltration.

The major crops in the communities in Mustang Nepal are naked wheat, barley, buckwheat and potato. Pulses and maize are also grown. The total area of the pilot locations used for naked wheat and barley is 52% and 13%, respectively. Apple trees have been occupied 29% of the total cultivated land and are in increasing trend. While in summer, 39% of areas are cultivated for buckwheat, followed by 11% for potato. Out of the total labor, 27%

labor goes to plowing and land preparation, 33% labor force is required for harvesting whereas weeding requires 22%. The analysis revealed that available water is enough during the summer, but it seemed insufficient for the non-irrigated areas and for areas left barren that are potentially cultivable. About 25% of areas that can be cultivated are left barren because of water scarcity.

Farmers of the area are not aware of the fact of how much water they need for all crops and for all cultivable land they hold or land they are cultivating. Farmers do not have access also to the basic scientific information on crop water requirements and frequencies of irrigation that they need for each crop they sow. In flooding irrigation, communities could realize that the downward seepage rate equals or surpassing the horizontal sheet flow irrigation in low water due to which a long time is required to irrigate a plot or not possible to irrigate completely. People are feeling the changes but, are found to be unaware of the scientific reasoning of climate variability underpinned effects on water sources. Farmers lack knowledge of the porosity of soils and infiltration therein. Therefore strategically, large terraces are divided into several parts to irrigate from a small volume of water. Also, because of the adverse impact of climate change in water sources, people are now considering land and water as two separate ownership. People have been adopting the practice of selling land without selling water right inherited with it. Communities have been adopting with scarce waters by crop diversification as well as by land abandonment. Farmers strategically used apple farming instead of land leaving barren. Apple farming strategy is emerging as an option to cope with scarce water as well as to manage labor shortages. Locals' food behavior is found directly related to climate changes in the area. The decrease in crop production at the local level has been resulting in food habit changes which have been enhancing the increase of imported crops like rice and dry foods.

People are adopting irrigation practices at their own innovative knowledge but are not fully aware of the linkages of water sources with the hydrological cycles and climate change. There is a knowledge gap in understanding that the drying of spring is due to decreasing inputs by infiltration caused by fewer snow accumulations. The thinning frequency of snowfall, the temporal and the spatial variability in precipitation is the main reason that yields on most of the water sources went on decreasing and drying out. The study showed that the inherent cause of drying sources of water was found to be a root cause of water conflicts and disputes among communities where there are limited cultivable lands and food security demanded available land to be cultivated (**Figure 2**).

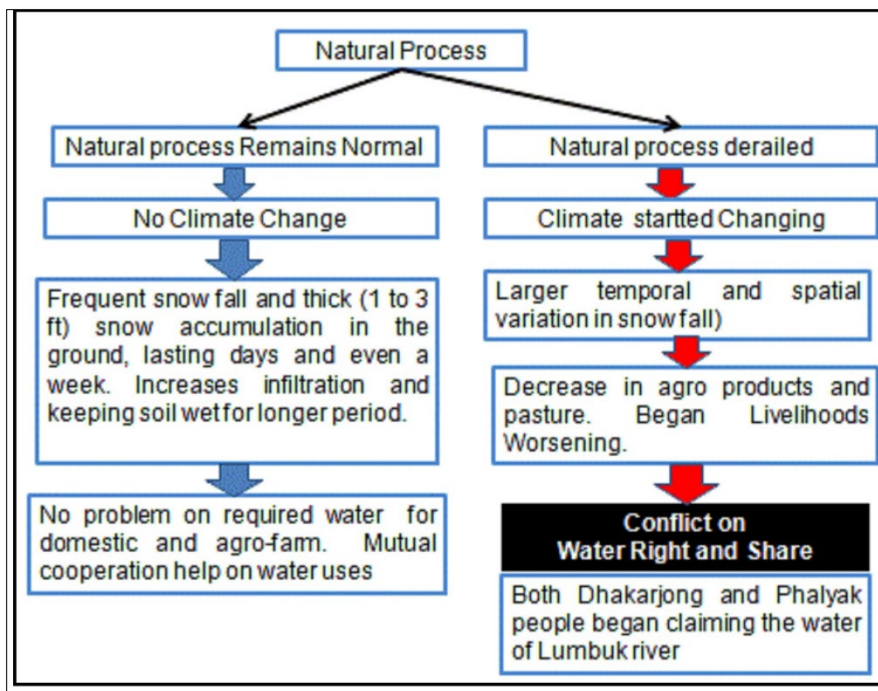


Figure 2. Underpinning process of climate change to water conflicts.

Source: ECOPERSIA (2014) Vol 2(2)

**CONCLUSION**

The research findings have shown that snow melts and its contribution to maintaining soil moistures and crop water requirements have been playing a major role in peoples’ livelihoods and food security.

It is thus, concluded that unless the regular precipitation as snowfall resumes in the winter with a longer period of snow accumulation in the area and drizzly type of rainfall in the monsoon, spring sources would not yield water constantly as in the past. The strategies adopted on only traditional knowledge would be ineffective in minimizing effects in the local livelihoods induced by climate change.

The study also supported that the effect of global warming on mountain hydrology has been impacting the existing yield pattern of water sources, the river flows, forest and vegetation grow and grazing land and other resources on which mountain people are dependent on their livelihood. If the present prediction on the average temperature rising trend continues, it would have a serious impact on human and natural life in the coming years.

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