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INFLUENCE OF CLIMATE CHANGE ON TRADITIONAL AGRICULTURE OF COLD DESERT REGION-LADAKH

*Phuntsog Tundup[1], M.A. Wani[1], Sonam Dawa[2], Shabber Hussain[3], A.P. Rai[4]
[1]Division of Soil Science
[2] Division of FMAP, [3] Division of Fruit Science, SKUAST-K, Shalimar-190025
[4] Division of Soil Science, SKUAST-J
*Corresponding author email: ameerbibi@uaf.edu.pk

ABSTRACT
Leh district is situated between 31-36° N latitude and 76-80° E longitude with an altitude ranging from 2500 to 6000 m above mean sea level. Leh is the largest district in the country with an area of 45,100 Km^2. Agriculture is the main occupation of the rural people of the district. It was observed that from 2003 onward monthly mean of daily minimum temperature during May increased from 4 °C to 8 °C up to 2007. Similarly, monthly mean of daily maximum temperature was observed higher (>20 °C) before 2003 but decreased during 2003 to 2009 (range 15 to 20 °C). Snowfall was a common phenomenon during month of May before 2003, but was not observed during 2003 to 2009. Therefore, it is hypothesized that increase in both minimum and maximum temperature during May had enabled the farmers to grow new crops. Moreover, during the month of April, snowfall events were significantly reduced in 2003-2009 and in month of May snowfall events was not recorded at all. Warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields. Ladakh witnessed a heavy and untimely rainfall, followed by the hellacious flash floods resulted from cloudburst in recent past. Also, the agriculture will be adversely affected due to continuously retreating glaciers of the region. On the other side, the positive effect was that the farmers in Ladakh have benefited from the recent global warming as they are able to grow number of new vegetable crops, which were earlier not grown. Therefore, it is quite apparent that climate change influenced the traditional agriculture and crop acreage.

KEY WORDS: Leh, precipitation, Climate change, Traditional agriculture, Cloudburst.

INTRODUCTION

Leh is the largest district in the country with an area of 45,100 Km^2. Agriculture is the prominent occupation of the rural folk of the district. Naked barley, locally known as 'grim' is the major food grain crop of the district. Wheat, pulse, oil seeds and other millets are also grown in scattered areas. Whole of the cultivated area is irrigated and the source of irrigation water is mainly streams originated from glaciers. Both diurnal and seasonal variation of temperature is very high with a range of temperature from 35°C during summer and -35°C during winter season. Annual average rainfall of Leh is 100 mm, which mainly occurs during May-September and snowfall during winter (November to March) is a common weather phenomena. According to crop calendar of Leh district, barley is sown during mid of May and wheat crop is sown during last week of April to 2nd week of May. Due to the limitations like water scarcity and harsh climate, only one crop is grown in leh and adjoining areas while two crops i.e. Main crop (Barley/Wheat) and short duration crops like buckwheat , vegetables (mainly turnip) is grown in lower leh (Khaltsi block) and kargil district with the exception of drass.

The cold desert region of India is characterized by harsh climatic condition i.e. dry and cold weather, heavy snowfall, low temperature, which sometimes on an average goes down to as low as -30ºC in late nights. Some time in summer months, on an average temperature reaches to as high as +30ºC in after noon (Sharma *et al*., 2011). Analysis of meteorological data for last 35 years indicated that there was rising trend of minimum temperature at Leh nearly 1ºC for the winter months and 0.5ºC for summer months (Singh and Dwivedi, 2011). They have also indicated that the present horticultural zone in lower valleys could shift in some cases over hundreds of kilometers in higher cool and mountainous areas. In contrast, the already warm areas climate change can cause reduced productivity. Apricot cultivation is not affected much by climate change although there may be a shift in flowering time and maturity period. Snowfall during bloom adversely affects apricot production and productivity. Sea buckthorn plant is able to tolerate moisture as well as temperature stress (-30ºC) (Singh, 2008). In potato maximum harvest index of 0.8 is obtained at the night temperature of 15oC and it becomes zero at 28oC. Increase in night temperature would increase its area in high altitudes above 12000 feet, improve productivity and total yield (Singh, 1995). For sustainable crop production in the region, there is need to develop technologies especially, in the context of climate change. Research efforts were made by SKUAST-K and State agriculture departments to improve the crop production in the region but limited efforts were done to formulate alternate cropping pattern under weather change condition. According to IPCC (1995), the years have become warmer over the last few decades. As per UK Meteorological Office, global average temperature has been rising by 0.15˚ C every decade. It has been observed from these

studies that the geographical areas are more likely to be adversely impacted by climate changes because these areas are already ecologically fragile, where inhabitant communities rely exclusively on scarce natural resources.

A consensus has emerged that the mountain regions are more vulnerable to the adverse impacts from climate change due to its fragile environment. Ladakh, often referred as 'cold-desert' due to its high altitude and cold arid climate is one such region where changes have been observed in the trends of some extreme weather and climatic events. Recent research and data on climate also indicated rapid changes in climate of Ladakh. Patterns of rainfalls and snowfalls have been changing, glaciers and permanent snow fields are receding affecting water runoff in the rivers/streams, and rise in temperature and humidity causing favourable conditions for intrusion of insects and pests. A survey conducted by an NGO, GERES-India indicates that between 1973 and 2008, there was a rising trend in mean temperatures by 1˚C in winter and 0.5˚ C during summer". These trends raise several concerns for the region, particularly for the agricultural sector.

MATERIALS & METHODS

The ladakh region (Figure 1), one of the most elevated (2900m to 5900m asl) and coldest region (-30^{0}C to -70^{0}C) of the earth. It covers more than 70,000 square Km geographical area of Jammu and Kashmir, India and lies between 31^0 44' 57'' to 32^0 59' 57" N latitude and 76^0 46' 29'' to 80^0 41' 34'' E longitude. Its eastern and western borders form the line of actual control (LAC) between India and China and line of control (LOC) between India and Pakistan, respectively (Fig. 1). Weather data of Leh district were collected for 2000-2013 from Defence Institute of High Altitude Research (DIHAR), Leh and State statistical department, Leh- Ladakh, J&K. These weather data are mainly of temperature (°C) (minimum and maximum), relative humidity RH (%), and precipitation (mm). Analysis of weather data and acreage data were carried out in MS excel 2007. The survey was conducted via questionnaires and interviews with elderly people regarding the past and present status of crop and vegetables growing, in Leh district of Jammu and Kashmir.

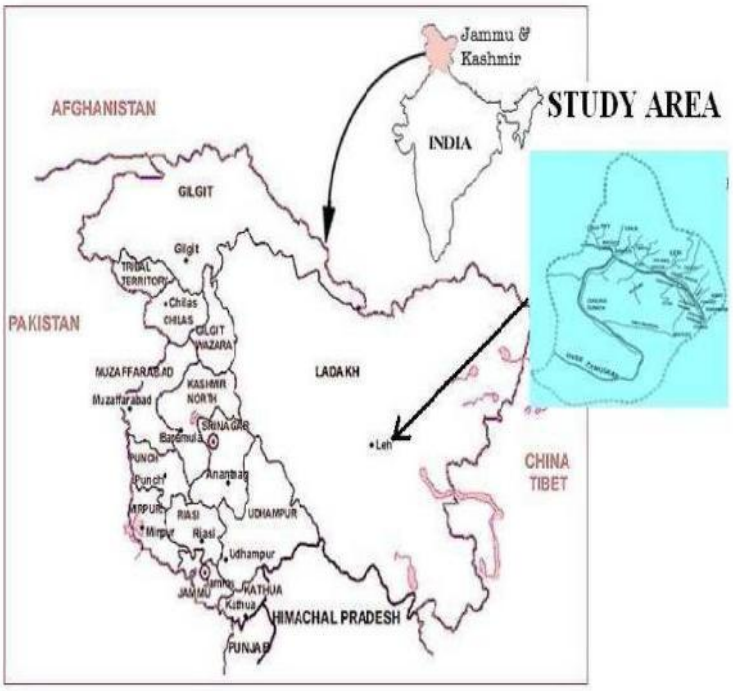

FIGURE 1: Map of study area

RESULTS & DISCUSSION

Precipitation

Annual rainfall of Leh district is less than 100 mm and mostly occurs in form of snow. From the point of view of crop establishment, April and May month is very important because according to crop calendar of Leh district, barley is sown during mid of May and wheat crop is sown during last week of April to 2nd week of May. In the month of April in 2004 and 2005 occurrence of snowfall was recorded however, after 2005 rainfall occurrence was observed upto 2009 and in the year of 2010 both were recorded (Table 1). In the month of May, Snowfall was recorded in 2010; however from 2003 to 2009 there was no snowfall in this month (Table 1). Monthly mean of precipitation variability of Leh during 2000-2013 (Fig.2). In general, rainfall occurred during crop growing period (April-Sept) is too meager (Ahmad and Kanth, 2014).

TABLE 1: Monthly mean of precipitation (mm) (R-rainfall and S-snowfall) during 2004-2010

Month	2004	2005	2006	2007	2008	2009	2010
Jan	55 (S)	58(S)	29(S)	NIL	21(S)	66(S)	15(S)
Feb	5(S)	135(S)	115(S)	41(S)	25(S)	20(S)	70(S)
Mar	48(S)	165(S)	NIL	NIL	NIL	5(S)	11(S)
Apr	12(S)	87(S)	24(R)	NIL	6.6(R)	NIL	42(R)
May	0.5 (R)	0.4(R)	NIL	NIL	8.7(R)	NIL	19.6(R)
Jun	9.5(R)	2.7(R)	NIL	5.2(R)	0.9(R)	4.4(R)	35.5(R)
Jul	NIL	28(R)	NIL	11.4(R)	10.3(R)	3.0(R)	2.5(R)
Aug	7(R)	NIL	78(R)	NIL	23.9(R)	5.5(R)	74.4(R)
Sep	6.5(R)	NIL	50(R)	NIL	23.5(R)	10(R)	12.5(R)
Oct	25(R)	NIL	NIL	NIL	NIL	40(S)	9(S)
Nov	NIL	NIL	3(S)	NIL	NIL	190(S)	NIL
Dec	NIL	NIL	615(S)	NIL	30 (S)	30(S)	97(S)

Source: Defense Institute of High Altitude Research, C/o 56 APO

Relative humidity

Initial analysis of the data revealed that mean relative humidity (%) is highest at Leh in the month of February (55.6 %) and December (55.3%). It was also observed that the relative humidity prevailed low during crop growing period as compared to other periods. During the last decade, decreasing trend of relative humidity was observed (Fig. 3b).

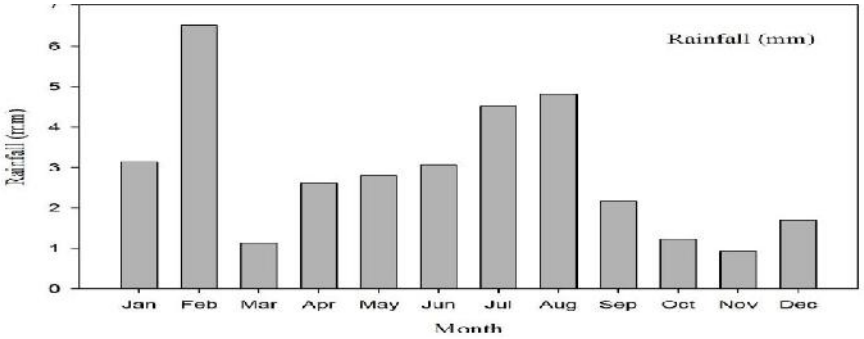

FIGURE 2: Monthly mean of rainfall during 2000-2013

Temperature

It is most important weather parameter in cold arid region for sustaining, agriculture and livestock from livelihood point of view. July was observed as the hottest month with mean maximum temperature reaching up to 28.9°C. January was observed as the freezing month with mean minimum temperature reaching up to -15.39°C. Monthly mean of maximum temperature varied from -0.8 °C to 26.9°C during the year, while ranged from 14.07 °C to 26.9°C during the crop growing period. In case of minimum mean temperature, it was also varied from -14.5 °C to 13.6 °C and in crop growing season it ranged from -0.3 °C to 13.6 °C. During the winter season range of mean minimum temperature was - 1.5 to -12.9 °C. Minimum temperature was observed above freezing point only 5 months (May to September) during 2000-2013, it indicates crop growing period is only of 5 months for the whole year. Trend of the 14 years annual mean temperature data (maximum and minimum) indicated that global warming has a significant effect in the regional climate of Leh (Fig.3a).

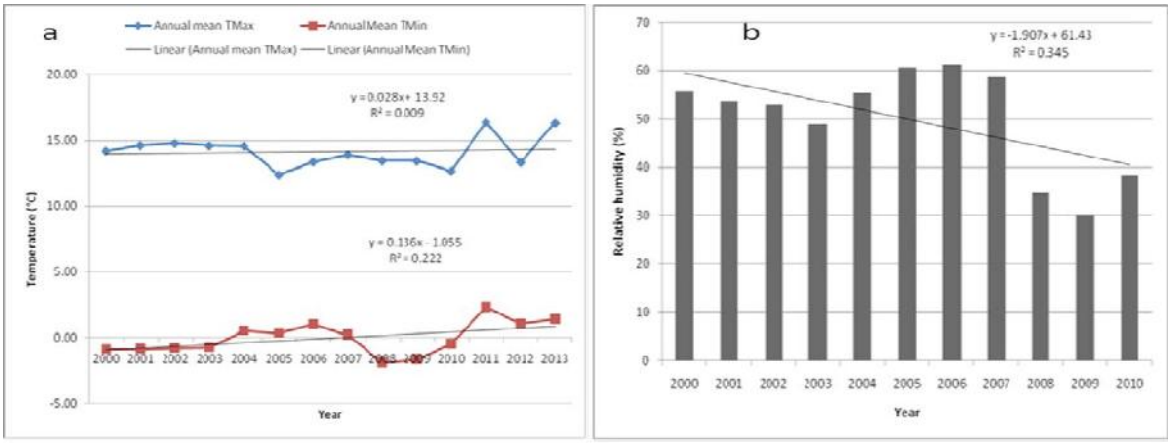

FIGURE 3a) Mean annual temperature (maximum and minimum) trend during 2000-2013
b) Annual mean of relative humidity trend during 2000-2010

Impact on Agriculture

Agriculture is one of most sensitive sectors to impacts of climate change due its high dependence on climate and weather. Over centuries, farmers in Ladakh have evolved self sustained farming systems not withstanding scarce resources, amidst a climatically challenging environment. In fact, it has been the mainstay of economy and provides food and livelihood security for the people of Ladakh. However, recent climate changes are damaging this fabric of Ladakhi's sustainability. The impact of climate change over the last few years has immense potential adversely affecting agriculture in this region in different ways. About 90 per cent of farmers in Ladakh depend on irrigation by snow and glacial water, the productivity of agriculture depends on the supply of glacial-melt water. Agriculture will be adversely affected due to continuously retreating glaciers of the region. Any change in the supply of glacial-melt water poses a serious threat to agriculture, and therefore to the economy and food security. It is believed that a rise in temperature could alter crop yields, which mean in either positive or negative. The effects on agriculture and its consequences on the society are likely to differ locally depending on the type of climate change that has taken place in that area and the options available to farmers. It could bring down the yield of wheat. However, higher temperature may improve the wheat in the higher altitude area. Warmer temperatures may make many crops grow more quickly, but warmer temperatures could also reduce yields. Crops tend to grow faster in warmer conditions. However, for some crops (such as grains), faster growth reduces the amount of time that seeds have to grow and mature (Karl et al. 2009). Over the years, farmers have introduced plants into their farmlands. Er. Angchuk, who is currently executive engineer at the irrigation department of the Ladakh Autonomous Hill Development Council (LAHDC), pointed out that the floods in 2010 ravaged many irrigation canals and reservoirs. If we look at the brighter side of the impact of climate change, it is worth mentioning that farmers in Ladakh have benefited from the recent global warming as they are able to grow number of new vegetable crops. "Earlier vegetables and fruits had to be brought from areas lower in altitude but now they are available in the higher altitudes," said Tsewang Dolma, a farmer and SHG member at Skurbuchan, Leh. But this could spell trouble for the region in the longterm. Climate change is also associated with increasing extreme climatic events such as drought, cloudburst and floods. As Ladakh witnessed a heavy and untimely rainfall, followed by the hellacious flash floods resulted from cloudburst in August 2010, inundated agricultural fields with rock and sand (mudslides), rendering them unsuitable for further cultivation. Further, many agricultural lands and roadways were washed away due to continuously occurring floods over the last few years, leading to decline in net agricultural lands. In addition, livestock is also vulnerable to the impact of climate change in the region. In Changthang region, nomadic people known as the Changpas, acutely feel climate change. These people are dependent on the rearing of livestock, the pashmina goats for their wool. In recent years, the migration routes of the Changpas have changed due to decrease in pasture land. Further, uncertain snowfall has led to loss of many livestock in the region. In future, climate change in Ladakh is likely to affect agriculture and increase the risk of water for irrigation. The villagers could face severe water scarcity which is attributed to heavy runoff from faster snow melt. Furthermore, an increase in the incidence of pest attacks and weeds could also create havoc in the region. In 2013-14, a team of scientists headed by Dr.Waliullah from SKUAST-Kashmir reported insect (Brown tail moth- *Euproctis chrysorrhoea*) outbreak in Kargil district and Dha-Beema villages of Leh district, observed seriously defoliation of apricot, apple and plantations. Recently in 2016, aphids infestation on apricot trees leading to curling of leaves were noticed in Skurbuchan, Achinathang, Lehdoo and some other villages of Khaltsi block.

CONCLUSION

It can be concluded from the above discussion that climate change may have serious consequences in the region. If not addressed on time it could be a catastrophe. Therefore, more research should be carried out, mainly focussing on agro-climatic components, including simplified approaches to simulating adaptation responses, i.e. changes in agro-technology that enables farmers to minimise risks and/ or maximise profits under changed climates.

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