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Local Farmers' Perception of the Climate Change in the Selected Districts of Western Nepal

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Abstract
Local farmers have been handling climatic changes since a long time in their own styles. So they have unique and indigenous ideas about climate changes and ways to cope with its adverse outcomes. This study aims to examine the local farmers' perception of climate change in selected districts of western Nepal. Eight focus group discussions and 1046 household survey were conducted in western Nepal covering all three topographic regions. Local farmers' perceptionwas compared with actual time series data on temperature and rainfall between 1970 and 2018.The trend analyses of real time series data reveal a significant variation in temperature, but rainfall does not show a marked variation over the period. Local farmers' perception analyzed from household survey also confirms the findings of real time observed data. Therefore, local farmers' perception may be highly helpful for formulating the short term coping strategies, and thelocal adaptation plan of action (LAPA).

Key words*: Climate, Farmer; Perception, Temperature, Trend.*

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I. Introduction

Climate change impact is one of the serious threats to human progress and is considered to be the biggest problem for sustainable development in the 21st century. Forthe last 100 years, several visible pieces of evidence have been showing the changes in temperature and rainfall around the globe (Thakur et al., 2020; IPCC, 2018).Climate change is inevitable due to human activities such as; industrialization, urbanization, and the mode of agriculture practices (Shafiq et al., 2019; Ochieng et al. 2016). These activities are significantly related to the increment in temperature and it has a chain effect on the amount, frequency, and occurrences of rainfall locally and globally (Thakur et al., 2020). Due to the variations in these climatic parameters, there is a direct and indirect effect on the variousdimensions of availability and quality of natural resources(Ochieng et al., 2016; Jain et al., 2012). Among the affected areas, agriculture is one of the most affected areas because of its direct link with temperature and rainfall(IPCC, 2014). The climate change impact is not only associated withquality and quantity of the natural environment, but also tothe healthand well beingof all members of an ecosystem [(Oiamo, 2014; Podesta, et al., 2008).

Nepal is one of the most vulnerable countries with respect to climate change, due to greater warming in recent years than the global average(Malla, 2008; Tiwari, et al., 2014).Global trends revealed 0.6°C mean surface temperature rise from 1975 to 2005 but Nepal experienced a relatively higher temperature rise of 1.5°C (0.06°C per year) during a similar period from 1982 to 2006 [(Bawa et al., 2012). Similarly, the rainfall pattern is also becoming more erratic and irregular in western Nepal (Wang et al. 2013). The mean rainfall has been decreasing by 3.7 mm per month, per decade [(Malla, 2008). Furthermore, the general and the regional circulation model estimates the mean annual temperature to increase 1.4°C by 2030, 2.8°C by the 2060s, and 4.7°C by the 2090s while the annual rainfallcould be reduced within the range of 15% to 20%, across the country(MoE, 2010).Despite these long-range projections at the national level, there is still doubt about uncertainties at the local level. Besides, the projection models may also be insufficient to show a clear trend due to the lack of consistent climatic records and wider geographical variation in Hill and Mountain regions (Macchi et al., 2015; IPCC, 2007b). Therefore, farmers' perception may be the best alternative option for understanding climatic variability at the local level because local farmers have substantial knowledge of climate change and ways to cope with adverse consequencesforthe last hundred years [(Chaudhary et al., 2011).

For the last two decades, a substantial amount of scientific research based on quantitative analyses (especially focused on forecasting, modelling and simulation) has been conducted in Nepal. However, a significant amount of uncertainty still existsregarding climatic hazards in Nepal. A little space has been given to traditional and indigenous knowledgeof climate change research in recent years[(Riedlinger et al., 2001).Understanding climatic variations and theirimpacts may facilitate choosing an effective adaptive strategy for overcoming future hazards. Farmers familiarized with local climatic conditions could decide about the types of crops to be grown and other protective measures for mitigating adverse impacts in advance (Lebel et al., 2015; Raymond et al., 2013; Byg et al., 2009).Past experiences of adverse effects of climate change and hazardous events have a significant relationship with knowledge, perception, and awarenessofpeople. Therefore, understanding the local farmers' perceptionof the climate change impact may be importantin formulating a local adaptation plan of action and other relevant strategies [Sujakhu et al., 2016).So the main aim of this paper is to examine the local farmers' perception of climate change in some selected districts of western Nepal.

II. Materials and Methods

Five districts (Manang from Mountain, Lamjung, Kaski, and Tanahu from Hill and Nawalpur from Tarai regions) were chosen from western Nepal. These selected districts represent all topographic regions and climatic zones, ranging from79meters to 3519-metersheight. These districts are more vulnerable in terms of hazards and have a wide variation in temperature and rainfall. A national adaptation program of action (NAPA)to climate change has identified Lamjung as very high (0.787 - 1.000), Manang as high (0.61 - 0.786), and Kaski, Tanahu, and Nawalparasi as moderate (0.356 - 0.600) vulnerability ranking in the region (MoE, 2010).Also, the majority of rivers originate directly from Mountain and flow from north to the southern part of the region. Therefore, this area is highly sensitive and important in terms of climate change and its impact on agriculture and hydropower.

Both primary and secondary data were collected to understand climate change and the local farmers' perceptionof climate change. The data on rainfall and temperature were obtained from the Department of Hydrology and Meteorology (DHM) a government apex body for collecting, archiving, and distributing the reliable and valid climate-related data of Nepal. These data were used to analyze the trends of temperature and rainfall in the selected districts.

For primary data collection,a multistage sampling technique was used. At first, a topo map sheet was taken and two parallel lines (traverse) that pass through three topographical regions in north-south direction were drawn.At the second stage, ten village development committees (VDCs) lying on this traverse were chosen as the samplesfrom five districts. At the next stage, altogether 1046 households (57 out of 1448 HHs from Manang, 164 out of 42048 HHS from Lamjung, and 168out of 125459 HHs from Kaski, 224out of 78286HHs from Tanahu, and 433 from out of 128760 HHsfrom Nawalpur districts) were selected using systematic random sampling (CBS, 2014). Finally, household head or a household member of age 45 years and above, residing in that areaforthe last 15 years at the time of the surveywas chosen as a respondent. Only one respondent was selected from a household.

For qualitative data, eight focus group discussions (FGDs) at least one from each district, and field visits (observations) were also carried out to supplement the findings of the household survey. A rigorous literature review was done in developing the research instrument and also consulted with experts for maintaining its validity. Similarly, pre-testing was done and few modifications were made as per the findings of pre-testing.

To analyze the trends of temperature and rainfalldata, the Mann-Kendall Test(Mann, 1945; Kendall, 1975) and Sen's Slope (Sen, 1968)method have been used. These two methods are widely used to observe the trend of climate indicators.

III. Results and Discussion

Meteorological real-time series (1970-2018) data on temperature and rainfall have been analyzed to compare the local farmers' perception of climate change.To analyze the trends of temperature and rainfallMann-Kendall test and Sen's slope are used. Field survey data have been used to understandthe local farmers' perceptions.

Selected background characteristics of Farmers

Table 1 presents the demographic, social, and economic characteristics of the respondents. It includes sex, caste/ethnicity, marital status, religion, family type, family size regularly, age, educational status, farming experience, agriculture skill, and land ownership for agriculture production. Based on the information collected from 1046 respondents, this study has the following results.

Just over three-fifths of the respondents (61.7%) aremale, whereas female accounts about two-fifths of the total samples. The minimum age of the respondents is 45 years and the maximum age is 92 years with the average age as 56.05 years. More than nine-tenths (92.4%) of the respondents are married. The average family

size as 5.9which is greater than the national average (4.88). More than half (55.0%) of the respondents are Janajati (Gurung, Magar, Tamang) followed by Brahmin (23.0%), Chhetri (7.9%), Dalit (9.8%), Muslim (0.8%), and others (3.4%). Just over four-fifths (80.5%) follow the Hindu religion followed by Buddhists (15.6%), Christian (1.2%), Muslim (0.8), and others (1.9%) respectively. More than four-fifth (81.9%) of the respondents do not have any agriculture skills. The minimum farming experience of the respondents is 15 years and the maximum is 70 years with a mean 31.26 year. One third (33.5%) of the respondents have basic education followed by informal education (31.4%), illiterate (21.0%), secondary education (12.1%), and higher education (2.0%) respectively. More than nine-tenths (93.4%) of the respondents have agriculture as a major occupation followed by government services (2.3%), business (1.5%), private sectors (0.9%), and others (1.9%) respectively. Further, most of the respondents (86.3%) have their land for agriculture production. Just over four percent of the respondents have lease/profit sharing land for agriculture production, whereas almost ten percent of the respondents have both own and lease/profit sharing land for agriculture production.

Table 1*- Respondents classified according to selected background characteristics*

Characteristics	Number	Percent	Characteristics	Number	Percent
Age(Years)			Nuclear	423	40.4
45-59	691	66.1	**Religion**		
60 and above	355	33.9	Hindu	842	80.5
Family Size			Buddhist	163	15.6
Up to 5 549 52.5			Christian	13	1.2
6 and above	497	47.5	Muslim	8	0.8
Sex			Others	20	1.9
Male	645	61.7	**Agriculture skill**		
Female	401	38.3	Yes	189	18.1
Marital Status			No	857	81.9
Unmarried	26	2.5	**Educational status**		
Married	966	92.4	Illiterate	220	21.0
Divorced	54	5.2	Informal Education	328	31.4
Caste/Ethnicity			Basic Education	350	33.5
Brahmin	241	23.0	Secondary Education	127	12.1
Chhetri	83	7.9	Higher Education	21	2.0
Janajati	575	55.0	**Land ownership**		
Dalit	103	9.8	Own Land	903	86.3
Muslim	8	0.8	Lease/Profit Sharing	43	4.1
Others	36	3.4	Both	100	9.6
Family Type			Total (N)	1046	100.0
Joint	623	59.6			

Climatic analysis

To understand the trend of climatic variation in the selected districts in western Nepal, secondary data between 1970 and 2018 collected by DHM has been used. The trend of annual mean temperature, annual total rainfall, seasonal average temperature and seasonal total rainfall have been chosen for climatic analysis.

The Trend of annual mean temperatureand annual total rainfall

The observed annual mean temperature from 1970 to 2018 indicates that the annual mean temperature is rising at a rate of 0.026°C/year. It reveals that the temperature is rising faster in the latter year in this area. The maximum annual mean temperature is found 21.56°C in 1988 and 21.43°C in 2006. The annual total rainfall trend is decreasing at the rate of 0.454mm/year. The annual total rainfall is maximum 307.29mm in 1973 followed by 300.87mm in 1974. To examine the significant changes in the annual mean temperature and the annual total rainfall Mann–Kendall test and Sen's slope have been computed. This shows that there is statistically significant ($p<0.01$) increment in the trend of annual mean temperature while the annual total rainfall is "decreasing" but the change is not a statistically significant.

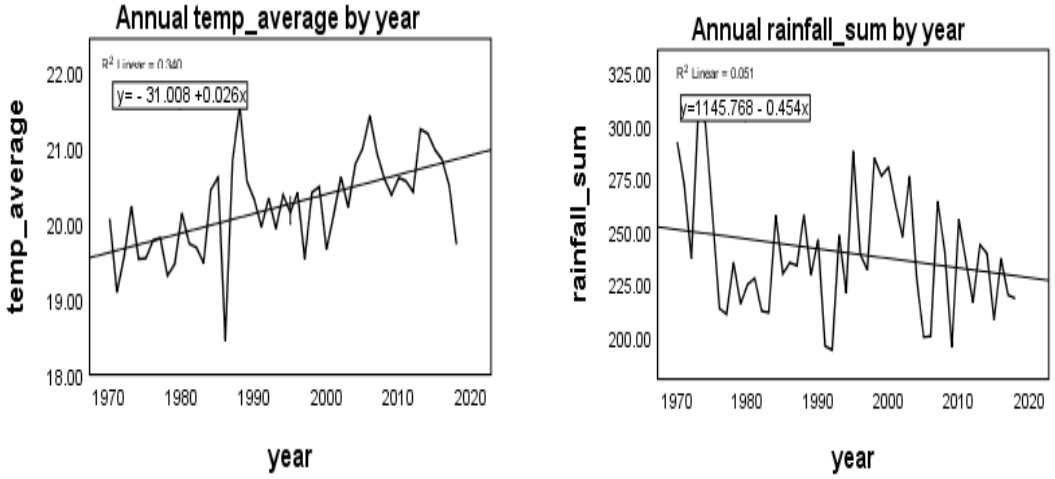


Figure 1*-Trend of annual mean temperature and total rainfall*

Table 2*-Mann-Kendall test and Sen's slope of annual total rainfall and annual mean temperature 1970-2018*

Variable	Tau-value	p-value	Sen's slope	p-value
Mean temperature	0.442	<0.001	0.0261	<0.001
Total rainfall	-0.112	>0.05	-0.4028	>0.05

Seasonal mean temperature

To observe whether certain seasons show consistently higher or lower temperature trends than others, the mean annual data series are subdivided into four seasons. Figure 3 shows seasonal variations in mean temperature. It indicates that temperature trends over the period (1970-2018) are not consistent by seasons. Mean temperature shows a warming trend with an average rate of 0.025°Cper year during pre-monsoon, 0.031°C per year during monsoon, 0.029°C per year during post-monsoon, and 0.024°Cper year duringthe winter season. To assess the significant variability in temperature by seasons, the Mann–Kendall test and Sen' Slope have been used. The results confirm that there is a statistically significant positive linear trend in mean temperature in all seasons ($p<0.001$).

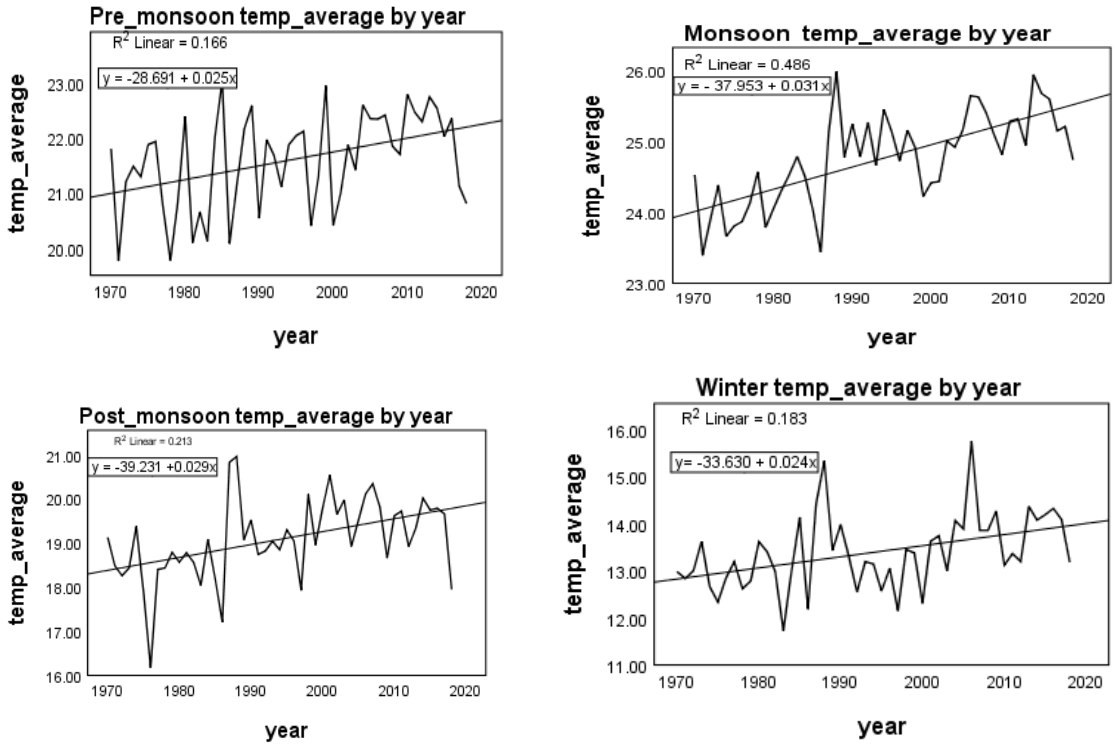


Figure 2*-Trend of seasonal mean temperature from 1970 to 2018*

Table 3- *Mann-Kendall test and Sen's slope of mean temperature from 1970 - 2018*

Temperature	Tau-value	p-value	Sen's slope	p-value
pre-monsoon	0.2820	<0.001	0.2494	<0.001
Monsoon	0.5070	<0.001	0.0320	<0.001
Post-monsoon	0.3540	<0.001	0.0299	<0.001
Winter	0.3380	<0.001	0.0244	<0.001

Seasonal total rainfall

As with seasonal mean temperature, the total annual rainfall data has been decomposed into seasonal total data. Figure 4 shows the seasonal trends of rainfall. It indicates that rainfall trends are increasing at the rate of 0.211mm/year during the pre-monsoon season anddecreasing in all other seasons at the rate of 0.848 mm/year in the monsoon, 0.603mm/year during post-monsoon, and 0.056mm/year duringthe winter season.The rate of decrease in the monsoon season is high as compared to post-monsoon and winter seasons. To assess the significant rainfall variability in different seasons, Mann–Kendall and Sen' Slope methods are used. The results confirm that there is no evidence of a markedvariation in rainfall in all seasons (p>0.05).

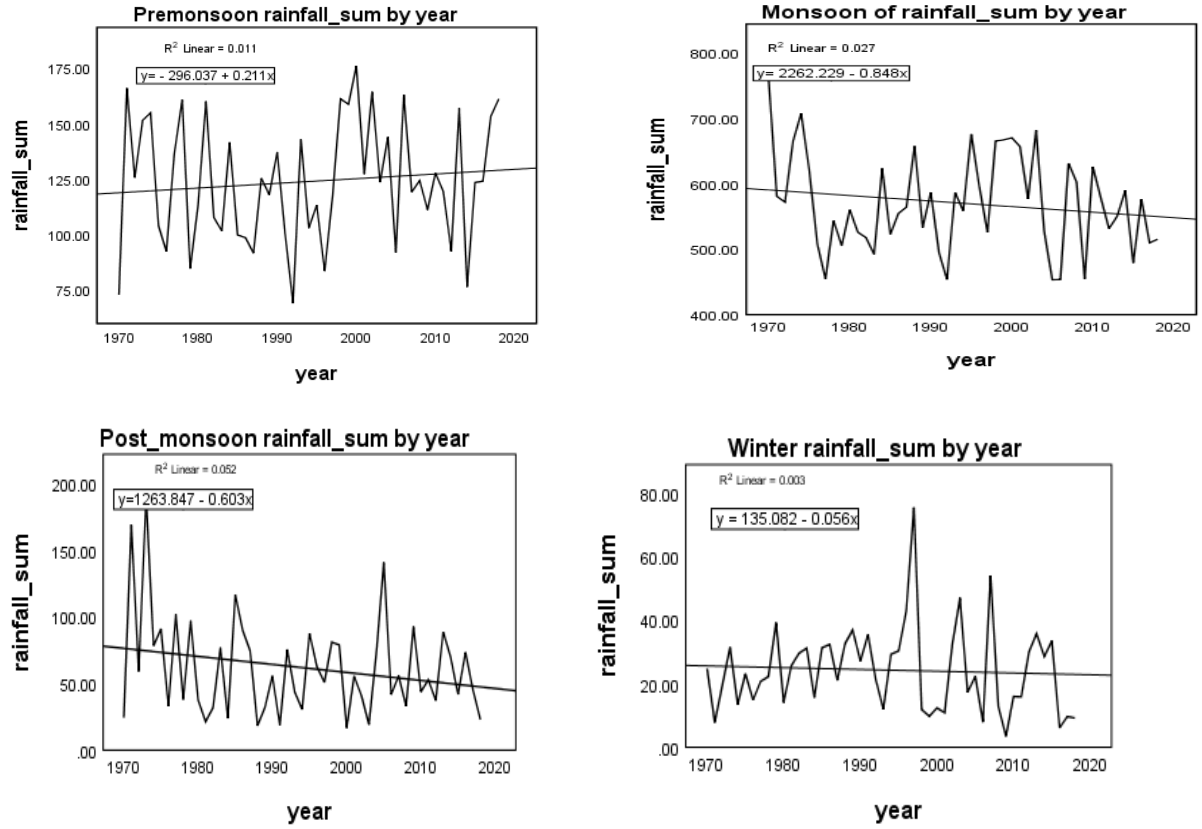


Figure 3-*Trends of seasonal rainfall from 1970 to 2018*

Table 4- *Mann-Kendall test and Sen's slope of seasonal rainfall from 1970 to 2018*

Rainfall	Tau-value	p-value	Sen's slope	p-value
pre-monsoon	0.0799	>0.05	0.2428	>0.05
Monsoon	-0.0714	>0.05	-0.6215	>0.05
Post-monsoon	-0.0969	>0.05	-0.0830	>0.05
Winter	-0.0527	>0.05	-0.0830	>0.05

Local Farmers' perception of climate change

Most of the farmers (just more than 90.0 percent) are aware of climate change. In terms of the degree of awareness, 77.5 percent is less aware, followed by 12.0 percent much and only 10.5 percent very much aware of climate change. Just more than 85.0 percent perceivesthat climate change has occurred in this place. In terms of the degree of perceived climate change,nearly two-thirds reported that less change, followed by 24.9 percent much and only 9.6 percent very much (table 5).

***Table 5**-Local Farmers' awareness and perception of climate change among*

Awareness about climate Change	**Number**	**Percent**
Yes	944	90.2
No	102	9.8
Degree of awareness (n=944)		
Little	732	77.5
Much	113	12.0
Very much	99	10.5
Perceived climate change		
Yes	895	85.6
No	151	14.4
Degree of perceived climate change (n=895)		
Little	586	65.5
Much	223	24.9
Very much	86	9.6

Local farmers' perception of rainfall

Local farmers were asked to put their views on rainfall variability in their usual place of residence for a last 15 years. In the response of the frequency of rainy days in monsoon and winter, more than two-thirds of farmers reported that annual average rainfall, the number of rainy days in monsoon and winter seasons had decreased.This result also confirms the analysis of actual rainfall data in the selected sites of the study area (figure4 and table 4).

Participants of focus group discussion (FGDs) also reported that there was a significant decrease in the frequency of rainy days in all seasons, particularly in the monsoon and winter seasons and frequency of rainfall was heavy, extreme and erratic during monsoon season. A senior citizen (age of 80 years) of Manang district of the Mountain regionexperienced that snowfall wasalso decreasing quicklyand rainfall was uneven, unseasonable and irregular for a last 30 years. It is evident that elderly people have clearly noticed a significant decrease in rainfall and temperature as compared to their childhood.

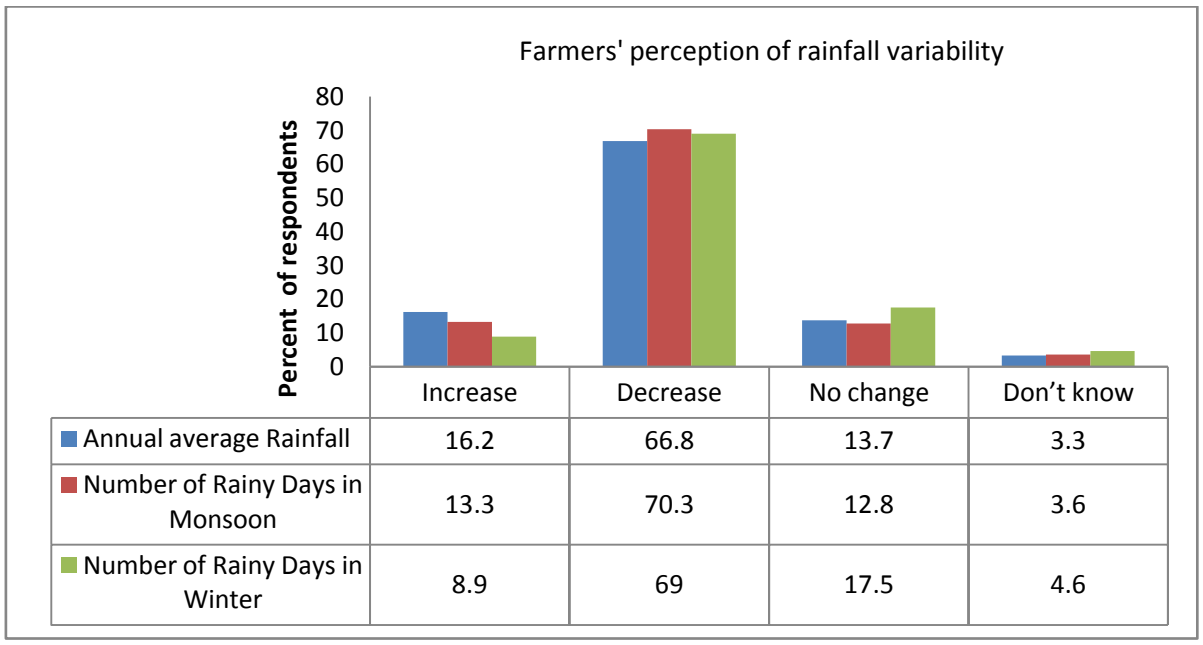


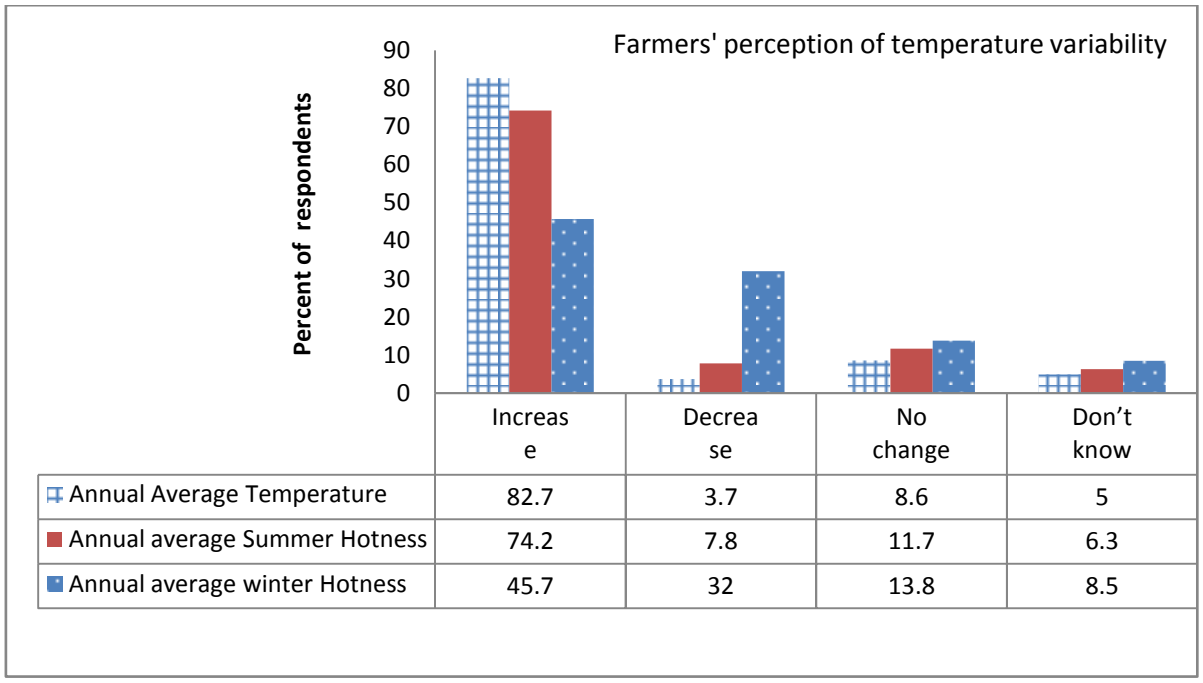
***Figure4**-Farmers' perception of rainfall variability*

Local farmers' perception of temperature

Farmers were also requested to express their views on variation in temperature for a last 15 years. The majority of them reported that annual average temperature, annual summer hotness and annual average winter hotness were increasing. Local farmers' perception of temperature is also consistent with the findings of the trends of actual temperature (figure5and table 3). This shows that the local farmers' perception matches with the climate change projection which may be important for preparing local adaptation strategies.

Most of the participants of FGDs in all sites (Mountain, Hill and Terai) agreed that the temperature was increasing in their areas. They further added that they had to face with many health related problems due to increment of temperature. An oldest participant of the Thumki villagein Kaski district observed early flowering

and early fruiting of some crops and fruits for a last 15 years. Also, most of the respondents in the Mountain regionexperienced increasing temperature that the number of warm days had increased than before.



	Increase	Decrease	No change	Don't know
Annual Average Temperature	82.7	3.7	8.6	5
Annual average Summer Hotness	74.2	7.8	11.7	6.3
Annual average winter Hotness	45.7	32	13.8	8.5

Figure5*-Farmers' perception of temperature variability*

IV. Discussion

Local farmers' perception of temperature and rainfall is consistent with the findings of actual temperature and rainfall data in study sites of western Nepal.A perception study on climate change conducted in western Terai, among the Tharu community also confirms the findings of this study. The study also reveals the similar agreement between Indigenous Tharu people's perception and the trends of temperature and rainfall (Devkota et al., 2011). Likewise, the results of a study conducted on community perception and response to climate variability and change in the Himalaya (hilly districts: Bajhang, Terarthum and Kavreplanchok) of Nepal also confirms that the community perception in line with the trends of observed change in climatic indicators (Machhi et al., 2015).A study on climate change in Nepal and its impact on Himalayan glaciers using rainfall data of 49 stations also revealed no marked variation in rainfall over the period of 23 years (1977-2000) which is consistent with our findings(Shrestha et al., 2011).Furthermore, a study done by Lamsal, Kumar and Atreya in eastern and far western part of the country also confirms the increasing trend of temperature while the amount of rainfall has been decreasing (Lamsal et al., 2017).

V. Conclusions

This paper analyzes the local farmers' perception of climate change using long term time series data (1970-2018) for trend analysis and field survey data for understanding perception of the local farmers in western Nepal. From the analyses, it has been concluded that the local farmers' perception of climate change supports the trends and patterns of temperature and rainfall of the real time series observed data. This shows that the local farmers' perception may be highly helpful for formulating short term coping strategies, and the local adaptation planofaction (LAPA).Representation of local farmers while formulating LAPA committee would be valuable. Local farmers have their indigenous knowledge of climate change and its impact, butlittle knowledge of adaptation strategies to cope with adverse situations. Therefore, it would be beneficial to provide information and skill related trainings on adaptation strategies. Further a large scale nationwide research may be essential to draw the firm conclusion.

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