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Farmers' Perception on Climate Change: A Study in Tarai Region of Uttarakhand

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Climate change has emerged as a potent threat disrupting the development process and is hurting several sectors of Indian economy, especially the agriculture sector. Knowledge about these disruptive factors can enable the farmers to mitigate the negative impact of climate change on agriculture. Therefore, the understanding of location-specific farmers' perceptions and their adaptive behaviors can provide a better insight to design appropriate policy measures and guidelines to address these challenges effectively. The present study was aimed at determining farmers' perceptions about climate change on agriculture. The study sample comprised 180 farmers selected using simple random sampling. The findings indicate that all the farmers (100%) were aware of climate change. All of them reported "increase in temperature" and "erratic rainfall" and "shortening of winter season" as the major indicators of climate change as experienced by them. Besides, 85.55 percent famers reported that "peak time of winter" has changed in Uttarakhand, a hilly state. Such perceptions about climate change can be seen as a precursor mediating the adoption of recommended practices and adaptation measures. Thus, the results of the study will enlighten the policy makers and agriculture scientists in preparing a roadmap for policy formulation regarding adaptation measures (short run initiatives) as well as undertaking mitigation measures (long run initiatives) of climate change besides helping the agriculture extension agencies to design and plan locale-specific adaptation strategies and agriculture development programs.

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1. INTRODUCTION

Due to climate change, the frequency and intensity of extreme weather events are increasing every year globally. Consequently, climate change has emerged as an inseparable and inherent component of all global debates and dialogues on sustainable development. Climate change and agriculture both are global-level processes and are reciprocal to each other. 'Agriculture is given a sovereign/priority status in most developing nations due to its cardinal contribution to economic growth in these countries. Besides enabling the sustainable and affordable provision of food and providing livelihoods to the people, it is a dependable support system for ensuring stability to the economy in times of crisis' [1]. The agriculture sector being the principal driver of Indian economy affects the economic growth as much as it is affected by it. Though, the agriculture sector is relatively less organized, it is considered to be the most vulnerable and its impacts are felt as the biggest threats to sustainable agriculture development. Therefore, changes in weather parameters are the most pivotal indicators to identify the impacts of climate change and can play an important role in the effective decision-making process of sustainable agriculture. Global warming is recognized as one of the major changes in weather matrix such as temperature, absolute humidity, precipitation and global solar radiation etc.

The agriculture sector is deeply ingrained with human activities and climatic conditions, and their attitudes towards climate change, the rate of changes and the impact of such changes on the entire agroecosystem including soils, crops and livestock, etc. Farmers' adaptation to climate change mainly depends on what they perceive and how they react towards changes in climate and environment. Joshi et al [2] (2018) reiterated that farmers' perceptions about climate change strongly affect how they deal with climate-induced risks and uncertainties, and undertake specific adaptation measures to mitigate the adverse impact of climate on agriculture. Therefore, lack of sufficient perception and knowledge about climate changes and the impacts on agricultural production will have adverse effects on long-term sustainable agriculture in most developing countries [3].

Perception can be defined as the process of receiving information and stimuli from individual surroundings and then converting them into psychological responsiveness [4]. Farmers' perception about climate change is a complex process that encompasses of psychological constructs such as knowledge, beliefs, attitudes and concerns about if and how the climate is changing [5]. Perception on climate change is very complex idea for the farmers because it has limited boundaries, whereas individual's perception differs with the past and present situation [6]. Perception is influenced and shaped by the individuals' characteristics, their experience, the information that they receive, and the cultural and geographic context in which they live [7,8]

Farmers' perception and their knowledge on climate change both are mutually interdependent, a perception not only responsible to shape knowledge but knowledge also responsible to shape perception. Therefore, farmers' perception on climate change and its impacts on agriculture, may affect their correct decisions regarding climatic conditions such as how they can deal with climate-induced risks and uncertainties, and undertake specific coping strategies to reduce the adverse effect of climate change on agriculture and also recommended specific interventions needs to be undertaken to make their preparedness in dealing with its adverse impact [9].

Therefore, understanding of farmers' perception about climate change and trying to find out its determinants is not an easy task, because the local weather has variability from one day to the other day, from one season to the next, or between years; a person faces when trying to distinguish between normal short-run variations and climate change manifestations [10]. In fact, local short-term variations can be more salient than long-term trends and therefore may have a key impact on the formation of climate change perceptions [11].

Life experiences may influence perception, individuals who have been directly affected by extreme climatic events tend to report that the probability of such event happening again is relatively high [12,13]. Further, the perception that a person has about climate change can be influenced or modified by the information that they receive [14]. Therefore, perception is a subjective phenomenon, different people in the same locality might construct different perceptions of climate change even though they experience the same weather patterns [15].

Hence, adaptation to climate change not only requires that individuals perceive that something is changing or could change, but also that they attribute enough weight to this perception to be willing to take action and try to do something about it [16]. In this sense, perceiving that the climate is changing can be seen as a pre-condition for the adoption of agricultural adaptation measures [17, 18].Perception of farmers not only gears up towards on-time preparedness and effective adaptation measures (short term initiatives) but also specific mitigation strategies (long term initiatives) to successfully combat with the adverse effects of climate change. If the perception of farmers about the impact of climate change is different from the policymakers, then it is likely that the implementation of such policy will fail to achieve the desired outcomes.

2. MATERIALS AND METHODS

The methods and procedures developed for conducting the study are presented as follow:

2.1 Universe of the Study

The present study was conducted in Uttarakhand, which lies on the Southern slopes of the Central, Western Himalaya with total geographic area of 53,484 sq kms. It has total forest area of about 65% of the total geographical area which comprises 1.68% of the land area of the country. It extends roughly from 28° 43’ N to 31° 27’ N (Latitude) and 77° 34’ to 81° 02’ E (Longitude). Uttarakhand state is organised into two divisions – Kumaon and Garhwal- and 13 districts. viz., Almora, Bageshwar, Nainital, Udham Singh Nagar, Uttarkashi, Deharadun, Rudraprayag, Pithoragarh, Pauri, Tehri, Champawat, Haridwar and Chamoli.

2.2 Locale of the Study

Tarai region of Kumaun division in Uttarakhand was selected for the study. The Tarai belt included long and narrow strips of low lying plains of about 10-25 km width and North fringe of the Indo-Gangetic plains. In complete topographic contrast to the Mountain and Hill regions, the Tarai region is a lowland tropical and subtropical belt of flat, alluvial land stretching. Soil in the Tarai region is very fertile, clayey in composition and has got high water retaining capacity and humus content. Soil of Tarai is productive and suitable for extensive cultivation of high yielding variety crops like rice, wheat and sugarcane.

2.3 Sampling Procedure

2.3.1 Selection of district

Udham Singh Nagar was selected purposively for the study. The reasons behind its selection were that Udham Singh Nagar has been recognized as the food bowl of Uttarakhand sate, and the only district in Tarai region and it is characterized by high temperature, unpredictable and irregular rainfall.

2.3.2 Selection of blocks

Udham Singh Nagar has seven blocks (Jaspur, Kashipur, Bajpur, Gadarpur, Rudrapur, Sitarganj, and Khatima). Out of these seven, three blocks,namely Gadarpur, Bazpur, and Sitarganj, were selected randomly.

2.3.3 Selection of villages

Two villages were selected randomly from each of the selected block. Thus, a total of six villages were included in the study sample

2.3.4 Selection of respondents

Total 180 farmers was selected from six villages, in which thirty farmers were selected from each village by stratified random sampling based on land holding, and were categorized as small, marginal, and large farmers.

2.4 Data Collection Tools and Techniques

Data was collected using a pre-tested structured interview schedule. The farmers were interviewed by the researcher in field conditions during December 2020 to March 2021. Appropriate statistics such as frequency, percentage, etc. were used to analyse the data

3. RESULTS AND DISCUSSION

The tarai region of Uttarakhand, where the study was conducted, has three distinct and different seasons, viz. summer (March-June), rainfall (July-October) and winter (November-February).

Major crops grown by the farmers of the tarai region include Rice-Wheat, Sugarcane, Maize and Pulses. Hence, it was expected that farmers will be able to clearly identify the climate changes in these three seasons as it affects their farming decisions significantly.

Results of the study are therefore presented under three categories namely Farmers' perception on summer variability, rainfall variability, and winter variability.

3.1 Farmers' Perception on Summer Variability

Farmers' perceptions about climate change during summer season have been presented below in Fig. 2.

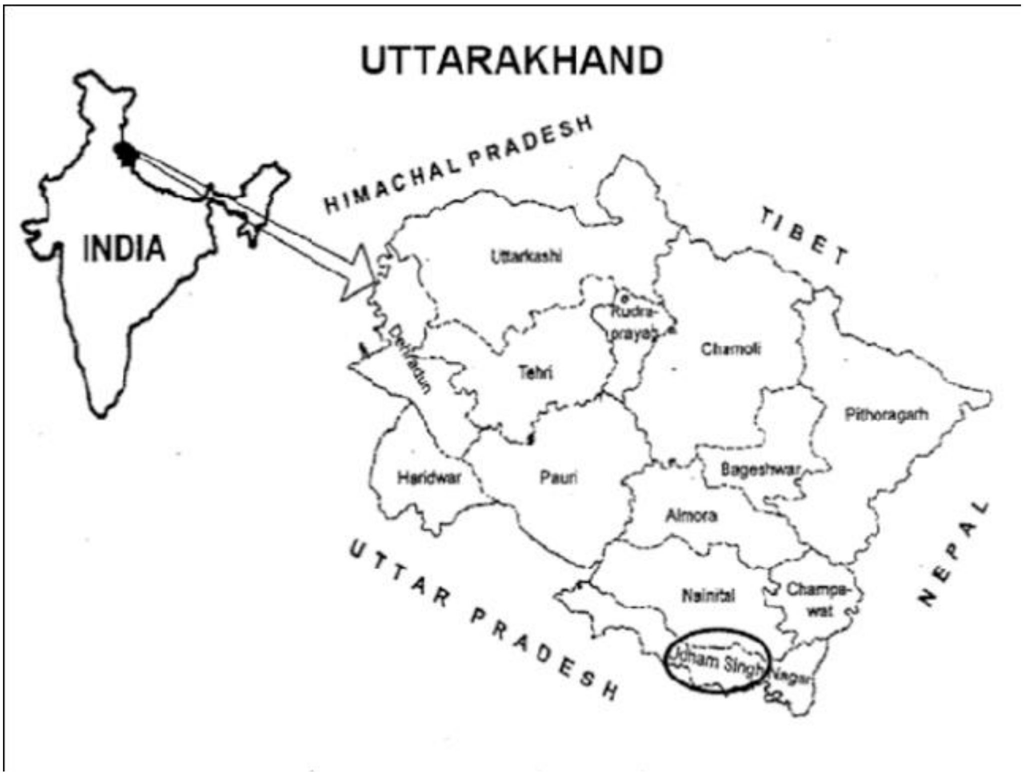

Fig. 1. Map showing study locale

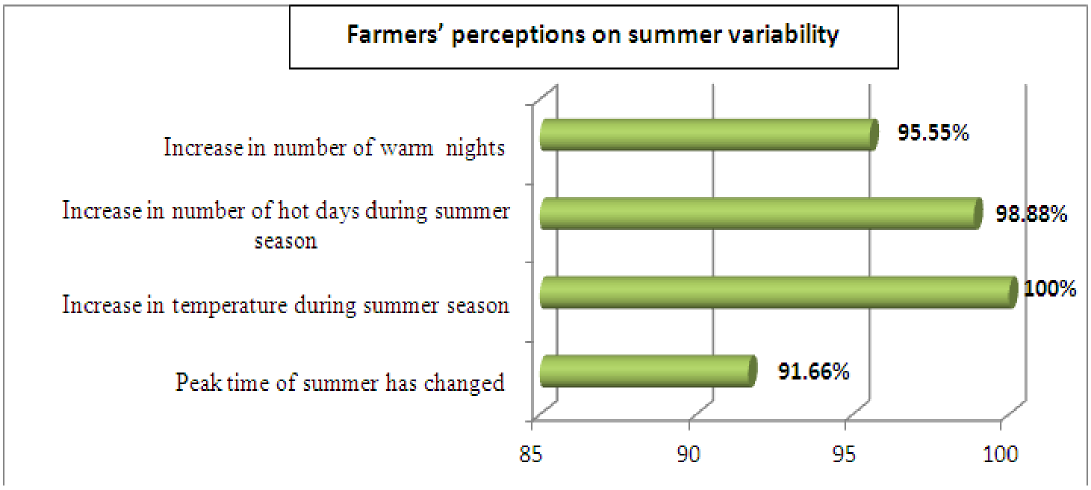

Fig. 2. Farmers 'perception on summer variability (n=180)

It was found that majority of the respondents perceived that summer seasons has changed significantly over the years. As regards the indicators of changing perceptions of farmers, all the respondents (100%) perceived that 'temperature during summer has been increasing', followed by 98.88 percent respondents who observed that 'the number of hot days during summer season' have increased; and 95.55 percent of the respondents reported that number of 'warm nights during summer season' has also increased, and while 91.66 percent of the respondents reported that 'peak time of summer' has also changed.

Thus, it may be concluded that all the farmers have reportedly perceived that there have been significant changes during summer seasons. The results of the present study are similar to the findings of Nizam [19] and Singh [20] who reported that farmers perceived that summers had become hotter, frequency of drought had increased. Besides, the finding also sho w similarity with the Shashidahra and Reddy [21] who also found that farmers perceived that temperature during summer had increased.

3.2 Farmers' Perception on Rainfall Variability

Indian agriculture is primarily rainfed wherein adequate rainfall during monsoon is very critical for farmers. Results obtained regarding farmers' perception on rainfall variability are presented below in Fig. 3.

Almost all the respondents perceived that rainy season has changed. All respondents (100%) perceived erratic rainfall, the occurrence of rainfall during rainy season has been changed. Besides, rainfall termination during rainy season has changed, and the occurrence of drought during rainy season has also increased, while 98.88 percent of the respondents perceived that peak time of rainy season has changed.

The similar results were found by Pandey et al. [22] that majority of the respondents observed delayed onset of monsoon, besides 'early withdrawal of monsoon, number of rainy days decreasing and occurrence of drought during rainy season has also increased. Dhanya and Ramachandran [23] reported that there was uniformity in farmers' opinion regarding the decreasing of rainfall and its unpredictable behavior, and drought occurrence has also increased during the rainy season. Besides, farmers also perceived delayed monsoon onset.

3.3 Farmers' Perception on Winter Variability

In Uttarakhand, winter climate is very critical for fruit crops besides other major cereal crops. The findings in respect of farmers' perceptions on climate change during winter season are presented below in Fig. 4.

It is evident from the results that a large majority of the farmers (85.55%) perceived that peak time of winter has changed, 60 percent of farmers reported that the intensity of fog has decreased during winter season, while 56.66 percent of the farmers reported that duration of winter stayed the same. Further, it was also observed that strong wind (42.22%) and bitterness of cold during winter has also increased (41.66%).

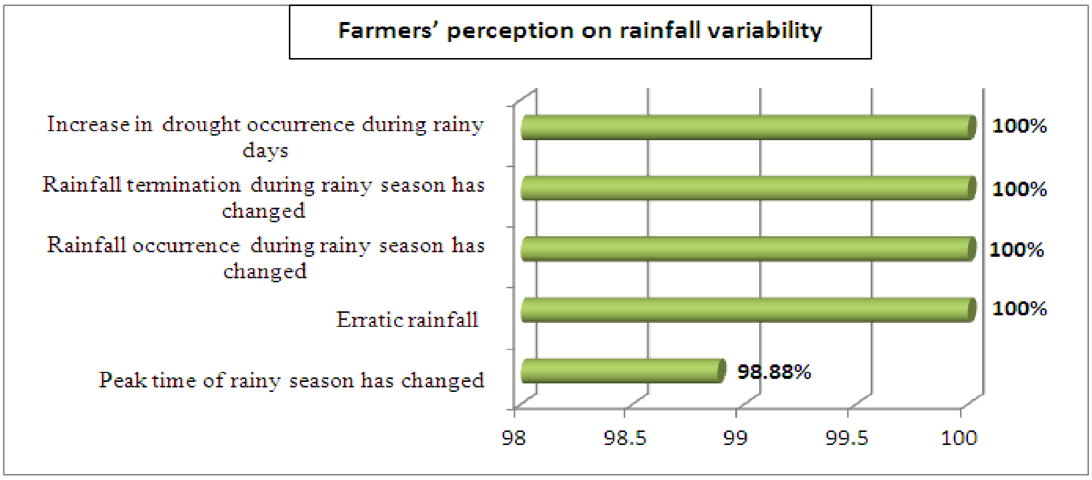

Fig. 3. Farmers 'perception on rainfall variability (n=180)

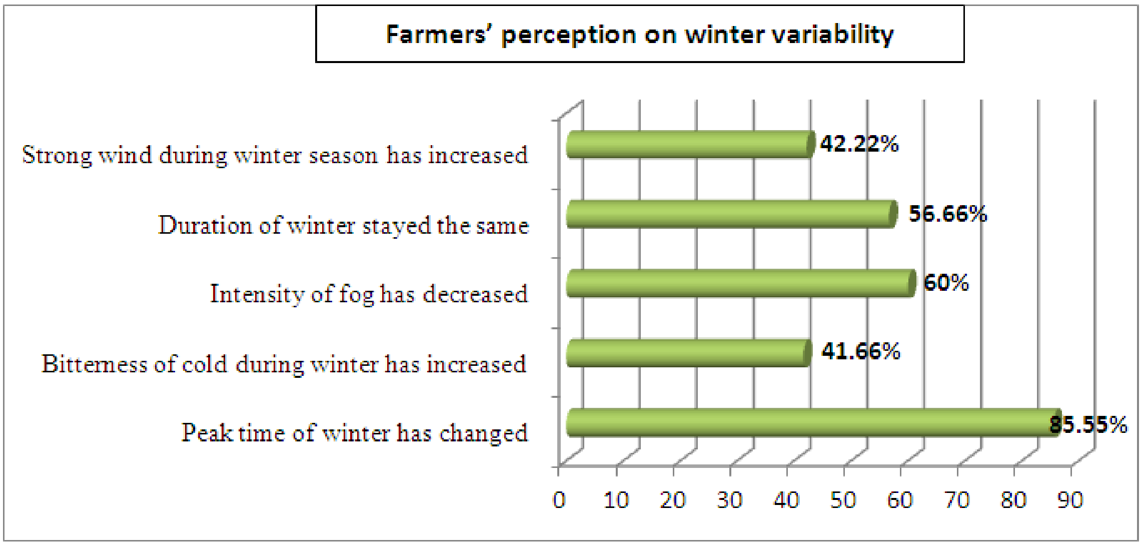

Fig. 4. Farmers 'perception on winter variability (n=180)

The study findings show similarity with the findings of Hein, Y.et al. [24] that peak time of winter and its duration has changed.

3.3.1 Variability of climatic parameters (temperature, rainfall, and precipitation) in Uttarakhand: A trend analysis

Climate variability in terms of temperature, rainfall, and precipitation is the most important factor for sustainable agriculture production. Global climate is changing rapidly, so it not clears to what extent farmers would be able to adapt to mitigate the adverse effects of climate change. In order to willingly adopt the recommended adaptation measures, farmers need to understand that the climate is changing or might have changed. So, the purpose to study the variability of climatic parameters (temperature, rainfall, and precipitation) becomes most important. Some data/ studies related to climate change over the years are discussed below.

3.3.2 Trend analysis of rainfall variability

In order to validate/ support the findings regarding farmers' perception about climate changes during the three seasons, time series data was collected from two major regional stations – Dehradun and Mukteshwar, in Uttarakhand; and the same are presented in Fig. 5, 6 & 7 below.

Rainfall data from 2000 to 2014 indicated that Dehradun region of Uttarakhand has consistently received higher rainfall in all the months over the years than Mukteshwar region (Fig.5). Further, it was also found that rainfall variability was high in both regions. In 2013, Dehradun received the highest rainfall which was about 3,265 mm whereas in 2009, rainfall was only 1,624.7 mm. Average rain during this period was 2,299.9 mm and it was observed that the extent of rainfall variability has increased continuously a yearly basis. Similarly, average annual rainfall has increased substantially. This situation was similar with the rainfall data of Mukteshwar region, although the average rain that occurred during the same period was 1311 mm, quite less than Dehradun region. The highest rain received in Mukteshwar was1,701.3mm (in 2010), followed1,626. 8 mm (2000) and 1,613.2 mm (2013). On the other hand, the lowest rain received in 2002 was 229 mm. In the corresponding years too, high variability in rainfall was observed. It has been observed that the plain region of the Uttarakhand Himalayas has received more rainfall than the mountainous mainland during the recorded period.

Monthly rainfall data of both the regional stations also reveal high variability (Fig. 6 &7). Generally, Dehradun received monsoon rain in four months of June, July, August and September, which indicated that in the months of July and August, Dehradun received the highest rain with high variability from year to year. In June 2013, Dehradun has received highest rain, which was unusual, causing havoc in both Kedarnath and Badrinath valleys and even in the entire Uttarakhand. Heavy rainfall also observed in

July, August and September in 2010 and in the month of August in 2007 and 2012. From 2001 to 2014, average annual rainfall was the highest in the month of February while during November and December, rainfall was scanty in Dehradun. The months of April, May and October also received scanty rainfall.

Although rainfall in Mukteshwar was found comparatively less than that in Dehradun. In Mukteshwar, monsoon rains start from May and ends in October. Hence, it received rains from the Western Disturbances in the four months of December, January, February, and March.It also received rains in the month of April; however, it was scanty and low. Rainfall data (Fig.6) shows that in Mukteshwar, the highest rain was received in the month of July in 2014, followed by September 2005, June 2013 and September 2010. High rainfall in June 2013 in Mukteshwar causing of flash floods and debris-flows disaster in Uttarakhand. The six months of summer (May to October) comprised of high rainfall variability. It was also noticed that average rainfall in the month of February was higher during the winter, with high variability. Except for November, Mukteshwar has received rain throughout the year.

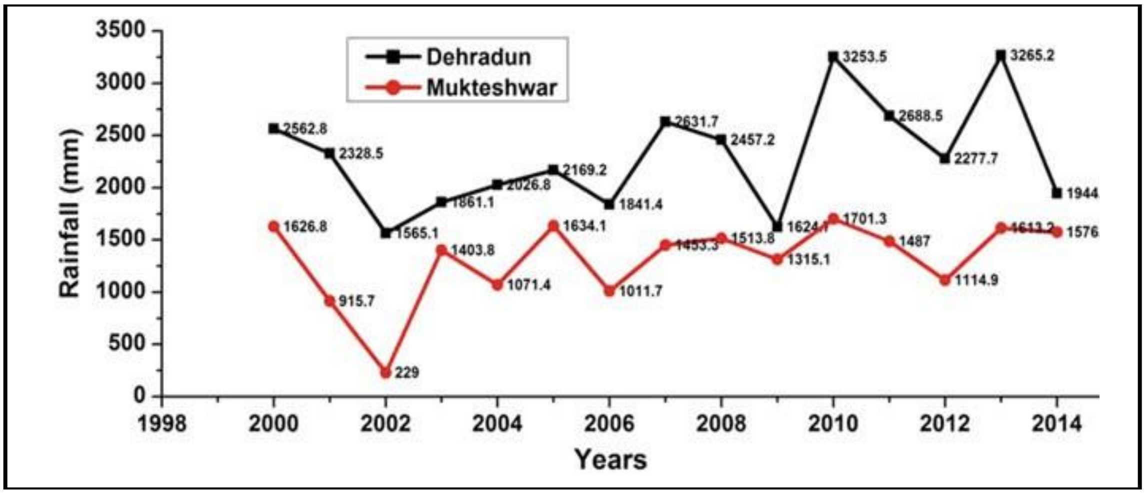

Fig. 5. Annual average rainfall

Source: India meteorological Dept. Govt. of India (statistical year book, India,2016)

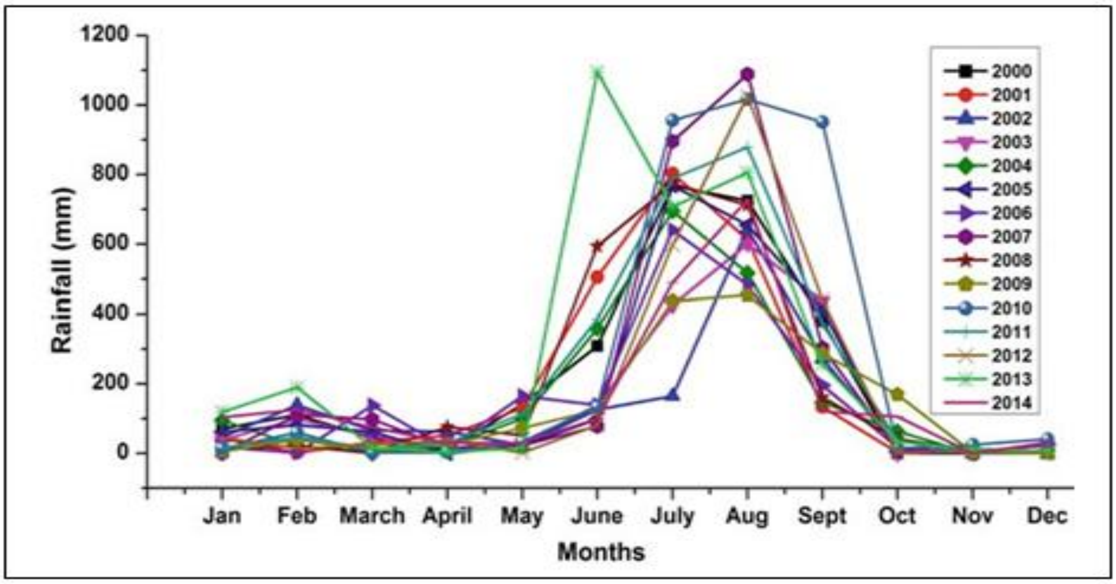

Fig. 6. Variation in monthly rainfall in Dehradun region

Source India Meteorological Department, Govt. of India (Statistical Year Book, India, 2016)

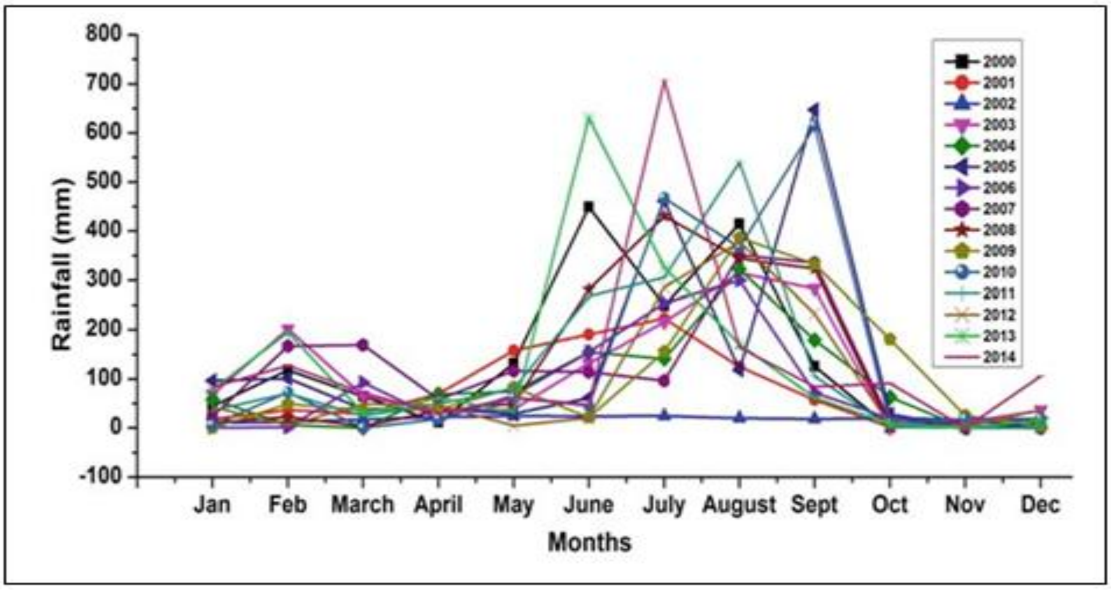

Fig. 7. Variation in monthly rainfall in Mukteshwar region
Source: India Meteorological Department, Govt. of India (Statistical Year Book, India, 2016)

3.3.3 Trend analysis of temperature variability

Fig. 8 indicates annual average of minimum and maximum temperature in Dehradun region. The average minimum temperature was recorded 16.18 °C. The highest minimum temperature was recorded 16.79 °C in 2006 whereas the lowest minimum temperature was recorded 15.51 °C in2012. Maximum temperature varied from 27.18 °C to 29.48 °C, with a maximum average temperature of 28.15°C. Temperature variation was found to be the highest in terms of annual average minimum temperature. In terms of annual average of maximum temperature, it was found almost constant from 2001 to 2008, with little variations. However, temperature variation was recorded highest from 2008 to2013.

Fig. 9 shows the Annual average minimum temperature in Mukteshwar region which varied from 8.34 °C in2011 to 12 °C in 2012 whereas annual average maximum temperaturevariedfrom18.12°Cin 2002 to 20.13°C in 2009. Further, the average temperature in annual average minimum temperature was recorded 9.46°C whereas it was 19.12°C in annual average maximum temperature. Annual average minimum temperature was recorded almost constant from 2000 to 2011, with little variations. However, high-temperature variation was recorded between 2012 and 2013. In the meantime, temperature variation was high throughout the reporting period in terms of annual average maximum temperature in Mukteshwar.

Banerjee et al. [24] in a study on “Temperature over the Himalayan foothill state of Uttarakhand: Present and future” observed that temperature over the Himalayan foothill region was highly variable with an increase in elevation. Further, it has been observed that higher elevation in the North-eastern part has higher warming rate than South-western part. Warming rate (temperature) was found to be maximum during June, July, August, and Septemberat4000–5000 m elevation belt. Munsiyari region of Uttarakhand state-observed the highest warming rate by 0.038°C/decade. It has been found that Maximum Temperature (T_{max}) trends were decreasing during1970–1979, but thereafter during 1980–1989,1990–1999 and 2000–2007, it increased.

Ahmed [25] conducted a study “Seasonal detection of trend and variability of climatic parameters in Tarai region of Uttarakhand” in which they analyzed the trend sand variability in the seasonality of climatic parameters in Tarai region along with the data over a period of 33 years (from 1981 to 2013). They observed seasonally an increasing trend in maximum, minimum temperature, rain fall, rainy days, relative humidity which was about 1412, decreasing trend in relative humidity that was 712 and wind speed observed an increase in maximum temperature which was about 0.1934^{o}C, minimum temperature an increase that was about 0.0217^{o}C.

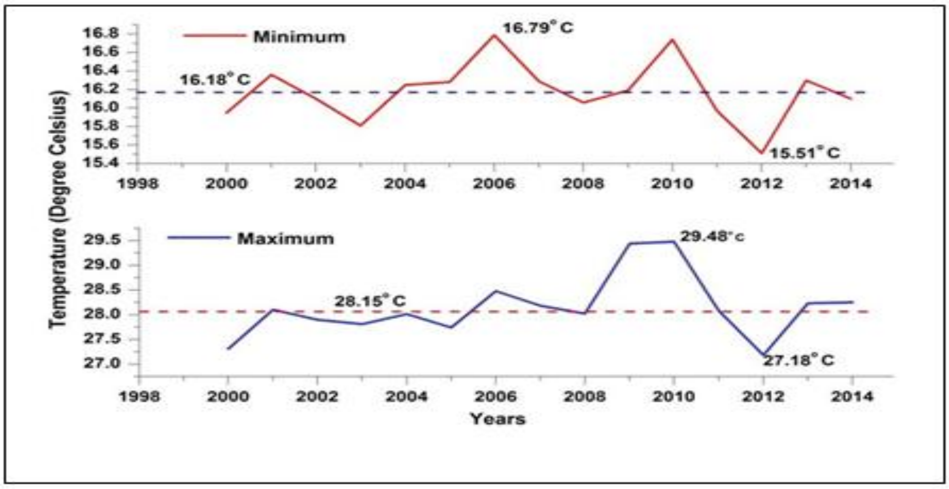

Fig. 8. Annual average of minimum and maximum temperature in Dehradun
Source Indian Meteorological Department, Govt. of India (Statistical Year Book,India2016)

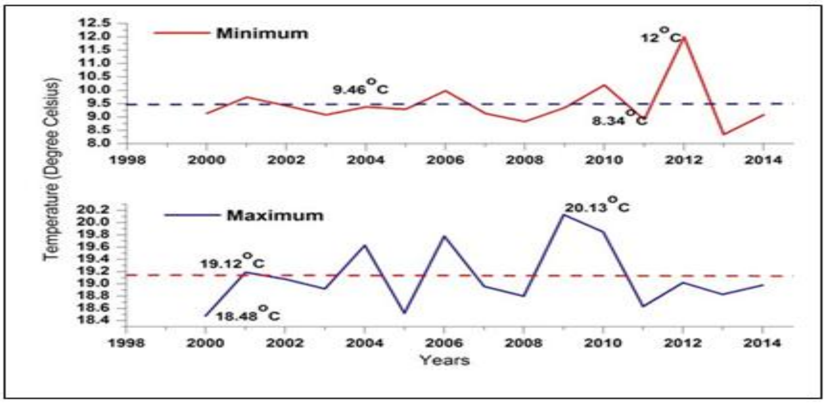

Fig. 9. Annual average of minimum and maximum temperature in Mukteshwar region
Source Indian Meteorological Department, Govt. of India (Statistical Year Book, India 2016)

Katariya [26] in a study on “Variability analysis of rainfall, temperature, and rainy days of Pantnagar, Udham Singh Nagar district (Uttarakhand)” observed the trend of rainfall, mean maximum temperature, mean minimum temperature and rainy days at Pantnagar for the period from 1961 to 2018 and 1981 to 2018. In the study, they found a significant decreasing trend in pre-monsoon and winter rainfall, whereas increasing trend in pre-monsoon rainfall. They also found increasing trends in mean maximum temperature, and mean minimum temperature.

Kiran [27] conducted a study on “long term trends and variations in rainfall under present climatic scenarios at Pantnagar” found an increasing trend of rainfall over the period of time during rainy season but the number of rainy days observed a declining trend for this season. During post-monsoon and summer seasons found a decreasing trend in rainfall with the rate of 0.11/year and 0.26 mm per year, respectively. They found a decreasing trend in rainy days during all the seasons in which August and November received average annual rainfall highest and minimum, respectively. Whereas, an average number of rainy days found highest in July and November received a minimum average number of rainy days.

Based on these studies, it can be concluded that the findings of farmers’ perception about climate change at local level and actual data (trend analyses) show similarities. which means farmers are aware of the fact that climate is changing. We need to take into consideration their perceptions about climate change in a collaborative manner among researchers/scientists from different disciplines and identify appropriate adaptation strategies. If such collaboration is successfully achieved, the results could generate recommendations for the design of location-specific adaptation policies that would be less costly, more efficient, and conducive to sustainable agriculture development.

4. CONCLUSION

Climate change has now become one of the biggest threats affecting agricultural productivity, production efficiency and farm profitability. Understanding public perceptions of climate change is critical in order to develop effective extension and communication strategies, develop relevant policies, and robust agriculture technologies. The unabated impact of climate change on agriculture productivity will seriously undermine national food security. The present study has shown how the climate in the Tarai region of Uttarakhand is experiencing an increasing trend in high temperature, erratic or irregular rainfall pattern, and changes in peak time of different seasons. Based on these findings, it would be essential for the policymakers as well as agriculture scientists to address climate change and determine the factors which negatively affect agricultural productivity, production efficiency as well as farm profitability.

Therefore, understanding farmers' perception towards climate change, factors contributing in farmers' perception towards climate change will go a long way in ensuring that farmers adopt appropriate adaptation strategies to ensure sustainable agriculture development. Besides, the need of the hour is to work on inter-sectoral approaches and consistent policies across agricultural, food security and climate change at all levels. Institutional and financial support is also needed for farmers and different stakeholders to undertake specific research work and develop suitable mechanisms and framework for promoting adaptation strategies (short term) and mitigation measures (long term) to take care of climate change related risks and uncertainties.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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