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Adaptation: The only way to tackle the issues of Climate Change in Indian Himalayas

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ABSTRACT

Himalayan regions are among the most affected climate change regions in the world. Understanding farmers' awareness and adaptation practices to climate change are necessary to enforce adequate agricultural policies and food security implementation. A total of 200 farmers were interviewed. Maximum respondents (67%) were fully aware of the phenomenon of irregular and erratic rainfall, increase in temperature (68%), reduction in snowfall (61.5%), and changes in water level of waterbodies (57.5%). To adapt to climate change, many respondents (92.5%) adopt drought-tolerant varieties, 91.5 per cent diversify from farming to non-farming activities, and 88 per cent of the farmers store fodder for animals in lean seasons of the year. The awareness level of farmers is significantly related to age, education, size of landholding, Information seeking behaviour, and farmers' socioeconomic status. Adaptation strategies to climate change have significant and positive correlation with landholding size, information-seeking behaviour, and farmers' socioeconomic status. The results may help the government facilitate location-specific research, policy formulation, and implementation in hilly regions for the sustainable future of farmers.

1. INTRODUCTION

Climate change has been an essential part of the sustainable development conversation. Governments in all countries are concerned about changing climate as it poses a significant challenge to long-term growth. Climate changes harm the environment, and human health in addition to economic growth. Changing climate conditions are a challenge to human life and economic growth [1]. In the climate change environment, biodiversity and socioeconomic conditions of mountains are severely affected [2]. Climate change has made the Himalayan areas more vulnerable. Over the last 100 years, the Himalayas have warmed faster at 0.74^0C [3], [4] than the global average and ecosystems at higher elevations are more vulnerable [5], [6] to climate change. In the past 100 years, there has been an increase in average global

temperature by 0.740 degrees Celsius and also projected 1.8 - 4^0 C increase in warming. They are further expected to increase around 1.8-4^0 C by 2100 [7]. Such climate-mediated risks affect food security, nutrition, rural socioeconomic stability and driving poverty, migration, and unemployment [8], [9].

In its fifth assessment report, Intergovernmental Panel on Climate Change (IPCC) reported that climate change reduces agricultural productivity in tropical regions and poses a threat to human security by affecting water supplies, agriculture, coastal areas, and livelihoods directly or indirectly, especially in Asian nations [10]. Agriculture is primarily the backbone of the Indian economy, contributes about 19.9% to India's Gross Domestic Product (GDP), and employs about 41.49 % of the population [11]. Though agriculture contributes significantantly to the Indian economy, this sector faces numerous climate-mediated threats like precipitation, temperature, humidity, soil quality etc. Climate is a significant constituent that affects agricultural production in India, affecting food production and the economy on a wide scale [12]. Yields of rice will fall by 32-40%, and yields of wheat will fall by 41-52% under the scenario of a temperature increase of 2.5-4.9 degrees Celsius, causing GDP to decrease by 1.8-3.4 per cent in India [13]. Due to severe droughts, floods, cyclones, hailstorms, high winds, and temperatures, farmers are more vulnerable to changing climate [14]. Losses of annual agricultural income because of the changing climate in India [15] is predicted to be around a 20%–25% increase for unirrigated as well as for irrigated lands in India. Small-scale farmers are disproportionately affected by changing climatic conditions due to their dependence on monsoon. They are dealing with it through adaptation [16]. Adaptation is modifying any system in response to actual and anticipated climatic impact [4].

Climate change is the most significant risk to India's Himalayan region, and Uttarakhand is a crucial part of the Himalayan regime, making it particularly sensitive to climatic risks. Climate change severely impacted the livelihood pattern of the Uttarakhand farmers, like temperature rise in a mountainous region, natural resource depletion, the occurrence of extreme weather events, irregular rains, shifting of cultivation zones, etc [17].

Given the above, this research aimed to measure the farmer's climate change awareness level and adaptation strategies in Uttarakhand. The study's specific objectives were to measure farmers' climate change awareness level and analyze the farmers' adaptation strategies to tackle the same.

2. MATERIALS AND METHODS

The study was conducted in the four districts; Tehri Garhwal, Uttarkashi of Garhwal and Bageshwar & Nainital of Kumaun region. From each district, one block was randomly selected Chamba, Chinyarisaur, Garur, Bhimtal. Thus a total of eight villages, two from each of four blocks was selected. A total of 200 respondents (25 from each village) from eight villages was selected randomly on the basis of household list of the local government. A pre-tested structured interview schedule. Focused group discussions (FGDs) of participants and observation methods were used for data collection. Farm household formed the unit of study; all the households were personally interviewed based on their availability and willingness.

According to the locale, the 'bad consequence' scale of [18] with some modification was used to measure the farmers' climate change awareness level. Responses were collected on a three-point scale ranging from fully aware, somewhat aware, and not aware. Adaptation strategies of farmers were found out with a scale of [19] with needed modifications. Microsoft Excel and SPSS 20.0 was used for data analyzis. The study used descriptive statistics, frequency, mean, percentage to assess the farmers' awareness of adaptation practices. Statistically significant association between the independent variables with the farmers' climate change awareness level and adaptation strategies was studied using a Pearson correlation coefficient. The

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null hypothesis that there is no association between the farmer's awareness level and adaptation strategies used by them with the demographic variables under study was tested against the alternative hypothesis that some association exists.

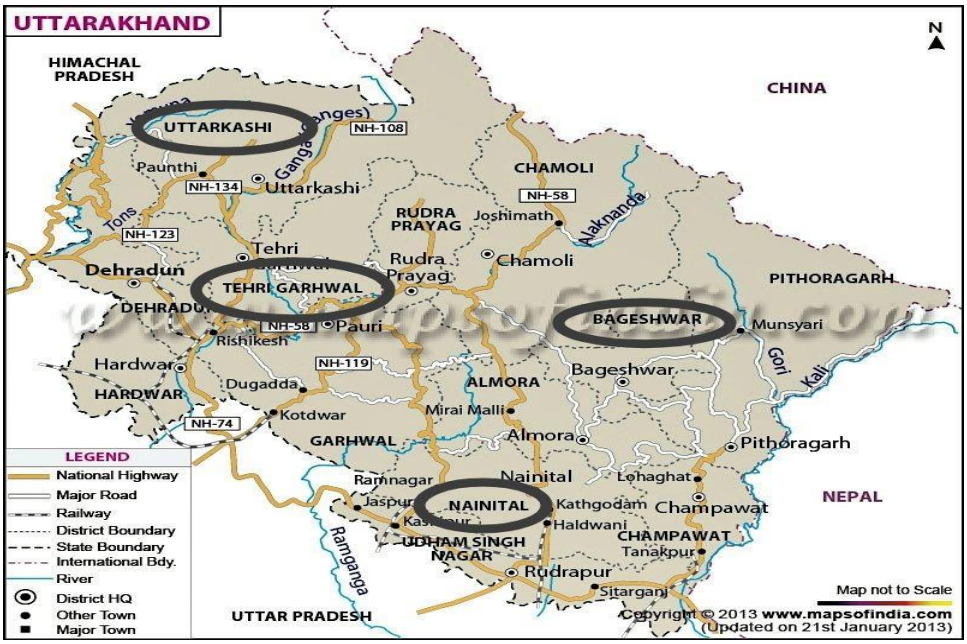

Fig. 1. Locale of the Study

3. RESULTS AND DISCUSSION

3.1 Socio-demographic status of farmers

More than half (54.5%) of the farmers were middle-aged and women (50.5%). Most of the farmers (96%) had less than 34 *Naali* landholdings, 43 per cent had low farming experience, and only 31.5 per cent of farmers were educated upto high school. Most farmers (88%) had low socioeconomic status and low information-seeking behaviour (47.5 %). The findings are in line with [20], who found that majority of the farmers were middles aged, womens and had less than 34 landholding.

3.2 Farmers' awareness level regarding climate change

It refers to the level to which farmers had climate change information on its potential consequences. It was observed from the findings that 67 per cent of the farmers were fully aware of the phenomenon of irregular and erratic rainfall, increase in temperature (68%), reduction in snowfall (61.5%), and changes in water level of water bodies (57.5%). Further, 37.5 per cent of respondents were fully aware of the change in length of seasons, change in intensity and frequency of storms, cyclone (18%), the occurrence of extreme events (13.5) and increased melting down of glaciers (2.5%). Only four farmers were fully aware of the phenomenon of a heavy flood. Around 66.5% farmers were somewhat aware of storms & cyclone intensity and frequency changes. More than half of the farmers had awareness related to the occurrence of extreme events and heavy fog (62.5%), change in season length like short winter and long summer (59.5%), and the phenomenon of a heavy flood (55%). Comparatively, less per cent of farmers were aware of changes in water level of water bodies (40%), reduction in snowfall (36.5), the phenomenon of irregular and erratic rainfall (30%), and increase in temperature (30%). Only 26.5% and 13% were aware of the increased melting down of glaciers and increased sea level water, respectively. The conclusion is that most respondents (71%) were not aware of the increased melting down of glaciers. At least, they were aware of

changing climate conditions in their region and the factors that contribute to it. The findings are similar to [21], [22] findings, who reported that most farmers (97.27%) were aware of 'irregular and extreme rainfall' and 90.90 per cent were aware of 'increase in temperature because of climate change. [23] reported that more than half (51%) farmers were aware of rising temperatures, and 53% were aware of declining rainfall over the last 20 years in Ethiopia.

Table 1. Awareness of farmers on climate change indicators (n=200)

Sl. No.	Indicators of climate change	Awareness		
		Fully Aware	Somewhat Aware	Not Aware
1.	Increased Glacier melting	5(2.5)	53(26.5)	142(71)
2.	Increase in temperature	136(68)	60(30)	4(2)
3.	Reduction in snowfall	123(61.5)	73(36.5)	4(2)
4.	Changes in water level of water bodies	115(57.5)	80(40)	5(2.5)
5.	Irregular and erratic rainfall	134(67)	60(30)	6(3)
6.	Change in season length- short winter and long summer	75(37.5)	119(59.5)	6(3)
7.	Change in frequency of storms, cyclone	36(18)	133(66.5)	31(15.5)
8.	Occurrence of extreme events like a cold wave, heatwave, and heavy fog	27(13.5)	125(62.5)	48(24)
9.	Increase in sea level water	0	26(13)	174(87)
10.	Phenomenon of heavy flood	4(2)	110(55)	86(43)

Note: Figures in parentheses indicate percentages

3.3 Farmers Climate Change Adaptation strategies

Adaptation is referred to various coping mechanisms implemented by farmers in the field situation to mitigate the negative impact of climate change. Findings showed that most farmers (92.5%) adopt drought/frost-tolerant variety, 91.5 per cent diversify from farming to non-farming activities and 88 per cent store fodder for animals in lean seasons of the year. Still, 87 per cent change their land size under cultivation, 86 percent change the use of chemicals and fertilizers, 80 percent bring diversification in livestock assets in their farm. Almost three-fourths of them (79.5%) bring diversification of crops and varieties in their farm and replace chemical farming with organic farming (73%). Significantly less no. of farmers (10.50%) formed farmers groups to discuss climate change and adopt climate-friendly technology in the last five years (25.50%). More than a quarter of the farmers' understudy had built water harvesting schemes (26%) and implemented soil and water conservation schemes (28%). [24] reported that 65 per cent of farmers adopted drought-tolerant varieties in adverse climate situations, and only 28 per cent were implementing water harvesting schemes.

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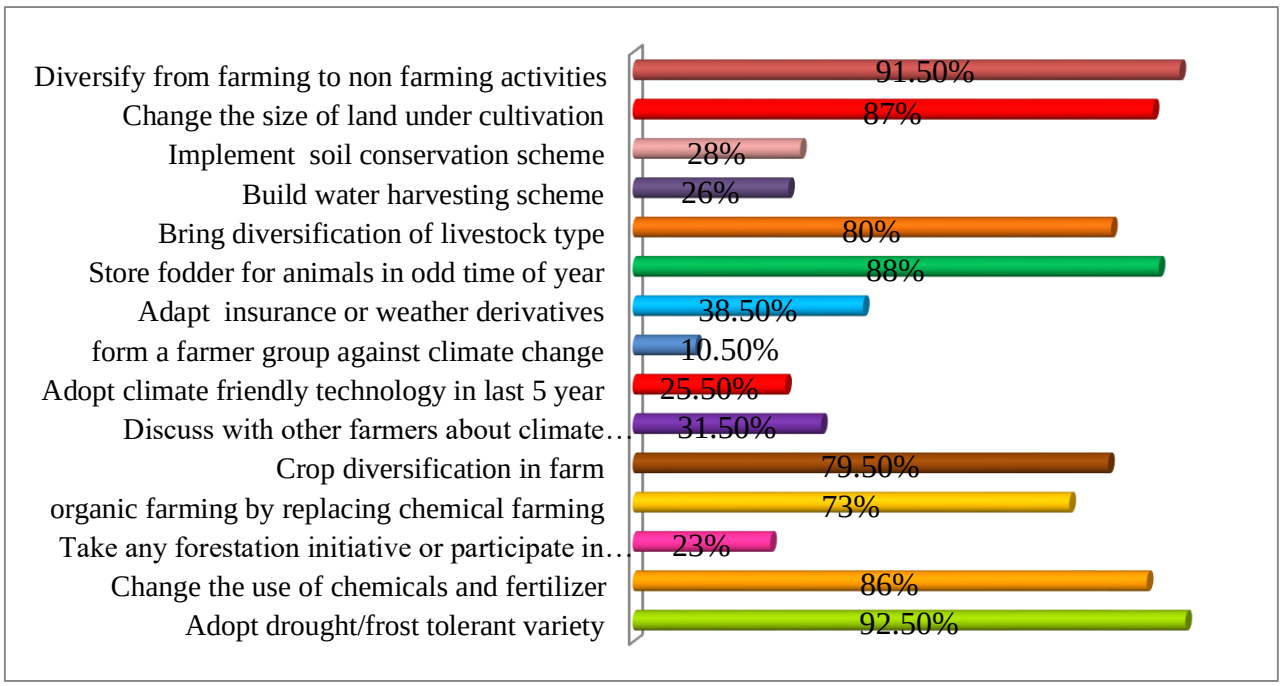

Fig. 2. Distribution of respondents based on climate change adaptation strategies

[25] support the findings that found that water harvesting structures are a famous climate change adaptation mechanism among the farmers. [14] stated that farmers' central climate change adaptations include soil and water management activities and the cultivation of drought-tolerant crops.

3.4 Association of farmers' awareness level and adaptation strategies to climate change with socio-demographic variables

Table 2 reveals that age, size of landholding, information-seeking behaviour, and socioeconomic status had a significant positive association to the awareness of farmers at a 1 per cent significance level, and education had a significant positive relationship at 5 per cent significance level. It means farmers who were old age, had large landholdings and had high information seeking and socioeconomic status are more aware of the changing climate change events.

Further, it reveals that the farmers' landholding, information-seeking behaviour, and socioeconomic status had a significant positive association with the climate change adaptation measures. It means farmers with large landholdings and high socioeconomic status are adapting more climate change adaption measures. Reasons that these farmers have more resources, information, and income to implement various climate change adaptation strategies Education also increases the farmers' awareness about new technological innovations and hence induces them to adopt.

Table 2. Association between farmer's climate change awareness level and adaptation strategies with socio-demographic variables

SI. No	Socio-Demographic Variables	Awareness Level (r)	Adaptation on climate change (r)
1	Age	0.187**	0.058
2	Farming experience	0.136	0.034
3	Education	0.139*	0.114

4	Size of landholding	0.259**	0.316**
5	Information seeking behaviour	0.292**	0.265**
6	Socio-economic status	0.281**	0.329**

** significance at 0.01 significance level, *significance at 0.05 significance level

4. CONCLUSION

Results show that farmers are familiar and aware of the climatic changes, especially the events like temperature increase, irregular and erratic rainfall, reduction in snowfall, and changes in water bodies in the Himalayan region of Uttarakhand. The awareness level of farmers is significantly related to age, education, size of landholding, Information seeking behaviour, and farmers' socioeconomic status. Most of the farmers adapt through the adoption of drought/frost-tolerant variety, diversify from farming to non-farming activities, store fodder for animals in lean seasons of the year, and change land size under cultivation. Not only this, but they also change chemicals and fertilizers, bring diversification in livestock and crops and varieties in their farm. Observations depict that many farmers are not adopting the available adaptation and mitigation practices despite their awareness on climate change. However, to adapt to socioeconomic changes, they are adapting their agricultural practices. As a result, we can infer that farmers are familiar with the changing climatic conditions and are aware of adaptation strategies. This nformation on farmers' awareness has been used as an essential parameter to design the location-specific adaptation and mitigation strategies for the farmers of a hilly region that already have many situational constraints due to the area's topography. These adaptation and mitigation methods should form a part of the farmers' practices to cope up with the adverse climatic situation. Developing accessible climate science data would necessitate an iterative process that establishes clear links between scientists and decision-makers. We recognize that the lack of region-specific climate change information will severely limit the usefulness of current data for policymaking. There is a greater need to resolve potential climate change uncertainty to determine effective adaptation options [26].

At the macro level, plans are formed based on cumulative data, with little consideration for people's local needs and requirements. Developing locally tailored solutions and enhancing farmers' need-based adaptive capability is essential to include ground realities and involve village/local communities [08].

This brief survey and awareness assessment is a first step for the small farmers' group, extension workers, regional decision-makers, and policymakers to measure climate change concerns and farmers' needs in the Himalayan region of Uttarakhand. To make the farmers more responsible about the changing climate scenario, they must be more aware and knowledgeable about the climate change process. It is a clarion call for the extension personnel and social workers to organize awareness events for local people by using various mass media tools and conduct demonstrations on various adaptation practices to provide them with a clear understanding.

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