Indian Journal of Extension Education
Vol. 56, No. 4 (October-December), 2020, (1-8)

ISSN 0537-1996 (Print)
ISSN 2454-552X (Online)

Farmers' Vulnerability to Climate Change: A Study in North Himalayan Region of Uttarakhand, India

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ABSTRACT

Erratic, unpredictable and unexpected changes in climate are threatening agriculture productivity as well as livelihood security of rural communities. Climate variability and Climate change can disrupt food supply chain, reduce access to food, and affect food quality. Consequently, vulnerability of farmers, and *ipso facto* the agriculture production systems, are increasingly stressed which is reflected on various human development indicators of the region. The present study was undertaken to assess farmer's vulnerability for enhancing location-specific adaptation and mitigation strategies. The study was conducted in Garhwal and Kumaon Division of Uttarakhand, a North Himalayan state of India. Study sample comprised of 200 farmers selected through simple random sampling. A vulnerability index was developed applying principal component analysis of the selected variables. The study findings indicated that majority of the respondents (64%) were found moderately vulnerable to climate change. Further, 71.4 per cent displayed medium level of awareness about climate change, and more than 50 per cent had highly favourable attitude towards climate change. Additionally, more than 90 per cent knew about adaptation practices such as adoption of drought/frost tolerant practices, Change in planting time, diversification from farming to non-farming activities and diversification of crops and varieties. The study has implications for policy makers as well as scientists designing adaptation strategies to minimise the adverse impact of climate change on agriculture in the vulnerable zones of the North Himalayan state in India.

Keywords: Adaptation strategies, Climate change, Climate smart agriculture, Farmers' vulnerability, Himalayan region, Rural livelihoods

INTRODUCTION

Global development debates and dialogues have repeatedly focused on the issues of climate change and its adverse impact on human lives and their livelihood profiles. Researchers as well as policy analysts have emphasised that climate change is very likely to affect agriculture productivity, production efficiency and farm profitability. Climate variability and Climate change can disrupt food supply chain, reduce access to food, and affect food quality. India's agriculture being dependent mostly on rainfall, its potential effect on the economy and livelihood security of rural people will be very severe and crippling. Jamshidi *et al.* (2019) observed that in order to assess the vulnerability of farmers to climate change, we need to investigate the awareness, attitude and perceptions of farmers towards climate, climatic hazards events and the factors contributing to vulnerability. Ansari *et al.* (2018) reiterated that farmers' perceptions about climate change strongly affects how

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they understand and deal with climate induced risks and uncertainties, and undertake specific measures to mitigate the adverse impact of climate change on agriculture.

IPCC (2001) defined Vulnerability as the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Further, it is also referred as "the propensity or predisposition to be adversely affected". In considering the perspective of scenarios of climatic anomalies, vulnerability may be regarded as a possibility of "future damage". In the context of present study, vulnerability therefore represented the ability – either of a system (farming system) or an individual (farmer) or a community (farming community) - to not being able to modify the impact of climatic extremes/ disasters and lacking the means to cushion the risks/ damages inflicted upon by the adverse climate scenarios (Raghuvanshi *et al.*, 2017). Climate vulnerability, at the national level, manifests itself more in poorer countries due to lack of resources and capacity to respond. At the community level, class, caste, gender, ethnicity, age, level of education and access to resources all determine the vulnerability (Blaike, 1994; IPCC, 2001). So it is of great significance to assess the climate change vulnerability of farmers from socio economic perspective. The present study was conducted with the aim to assess the climate change vulnerability of farmers in Himalayan region of Uttarakhand. It would be helpful for preparing the policies for capacity building of farmers for effective adaptation and mitigation. It improves the decision making process of planners in formulating policies or programs that may increase the agriculture resilience during the occurrence of hazardous events. As per the IPCC's definition and framework, vulnerability is understood as a function of three components-Exposure, Sensitivity and Adaptive capacity. The challenge of adapting to the impacts of climate change is growing and researchers are identifying the importance of climate change information and knowledge systems in climate sensitive sectors. Vulnerability to climate change, according to Quintao (2017), is a complex and dynamic phenomena involving social and physical/environmental aspects. Fussel (2007) observed that vulnerability assessment therefore requires a trans-disciplinary approach based on identification of appropriate indicators representing different properties of the studied system.

METHODOLOGY

The study was conducted in Garhwal and Kumaon divisions of Himalayan region in Uttarakhand state as this area is among the most vulnerable in the Indian Himalayan Region. Four districts–Tehri Garhwal and Uttarkashi districts from Garhwal division, and Nainital and Bageshwar districts from Kumaon region - were selected purposively as the locale for this study because according CRIDA's Report (2013) on vulnerability of Indian agriculture to climate change, these districts were the most vulnerable districts in Uttarakhand state. Following simple random sampling, the study sample comprised of 200 farmers, selected from the eight villages selected from four blocks (2 villages from each selected block) of four selected districts of Uttarakhand. The analysis of collected data was done by using SPSS software (version 20). The study used the descriptive-analytical research design to assess the vulnerability of farmers to climate change and also investigates the factors which contribute more to vulnerability.

IFPRI (2009) observed that there are many methods to measure the climate vulnerability. The indicator approach is one method which is based on developing a range of indicators and selecting some of them through expert judgment, principal component analysis, or correlation etc. Drawing from the approaches adopted by studies undertaken by TERI (2003) and UNDP (2002), a composite vulnerability index was worked out and respondents were grouped under the categories of highly vulnerable, moderately vulnerable and less vulnerable. Total seven indicators viz. Awareness, Attitude, knowledge of adaptation practices, Fatalism, Social Cohesiveness, Risk Perception and Level of dependence on natural and social resources indicators were selected, and for each indicator sub-indices were calculated.

The computation of each indicator value followed the process of standardisation adopted from the

computation of the life expectancy index of the HDI by Hahn *et al.* (2009). Normalisation was done by subtracting the minimum value from the observed value and dividing by range (maximum value minus minimum value).

$$\text{Normalized value (NV)} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}}$$

After normalization, factor analysis for each data set (indicators) was done choosing Principal Component Analysis (PCA) for extraction and Varimax method for rotation of factors after giving due weight to each indicators of vulnerability through PCA. The normalized indicators (NV) then multiplied with the assigned weights to construct the indices separately for each component of vulnerability. Vulnerability of each farmer was calculated by using the following formula:-

$$VIj = \frac{\sum_{i=1}^{n} WiNVij}{\sum_{i=1}^{n} Wi}$$

Where,

VIj = vulnerability index of j respondents

NVij = normalized value of i^{th} indicator for j^{th} respondents

SWi = summated value of weightage of all i indicators

n = no. of indicators (here, it ranges from 1 to 7)

For the indicator with negative connotation, index value was reversed (1- index value). The overall index was formed from weighted average of the sub-indices. The aggregated figure ranged from 0 to 1, where 0 signified highest level of vulnerability.

Awareness level of the farmers about climate change was measured with their responses on a three-point continuum of "fully aware, somewhat aware and not aware at all". Also the modified 'bad consequence' scale of O'Conor *et al.* (1999) was used to assess the level of awareness about the climate change. Attitude towards climate change was measured by modified scale of DEFRA (2007). Knowledge of adaptation practices was measured by using the modified scale of Austin *et al.* (1998). The scale consists of eight items presented on a dichotomous (Yes/No) continuum. Fatalism of the farmers were measured by using the modified scale of Leiserowitz (2006) on a five-point continuum strongly agree to strongly disagree with a scoring pattern of 5 to 1, respectively. Social cohesiveness among the individuals was studied with information related to inhabitancy pattern, kinship ties pattern and Interdependence pattern. The response was collected as Yes/No and recorded. Peoples adaptation pattern depends on how they perceive the risk associated to climate change, to calculate the risk perception of farmers a different scale was developed and farmers were categorized in low, medium and high category. Level of dependence on natural and social resources was calculated with the help of developed statements on three-point continuum of fully dependent, somewhat dependent and not dependent.

RESULTS AND DISCUSSION

According to the IPCC assessment report climate change vulnerability to agriculture is the manifestation of the agricultural sensitivity and adaptive capacity to climate changes (Wang, 2003). For the present study vulnerability was operationalised as the degree to which a farmer is susceptible to, and unable to cope with adverse effects of climate change. It was measured at household level. It involves a combination of factors that determine the degree to which someone's livelihood is put at risk by identifiable events in nature or in society.

It was operationalised as the degree to which a farmer is susceptible to, and unable to cope with, the adverse effects of climate change. It was measured at household level. It involves a combination of factors that determine the degree to which someone's livelihood is put at risk by identifiable events in nature or in society. It is evident from the results given in Table 1 that a majority of the respondents (64%) were in moderately vulnerable group followed by about 19 per cent in less vulnerable group, while only 17 per cent were in highly vulnerable group. Field observation and informal interactions with the respondents also indicated that the farmers in the study area largely had small landholding, low education status, low SES, low information seeking behaviour and medium mass media exposure; and these may be the contributing factor to their vulnerability level to climate change.

Table 1: Distribution of respondents according to their level of vulnerability (n=200)

Category	Freq-uency	Perce-ntage
Highly vulnerable (Less than 0.42)	34	17
Moderately vulnerable (0.42 to 0.65)	128	64
Less vulnerable (More than 0.65)	38	19

These findings are in line with the Dabbadi and Singh (2012) who found that majority of the respondents (50%) were in moderately vulnerable group followed by 21 per cent in highly vulnerable group and 29 per cent in less vulnerable group. However, the findings are contrary to Sarkar *et al.* (2010) who reported that most of the respondents (47%) were in highly vulnerable group followed by about 37 per cent in vulnerable group, while about 17 per cent were in moderately vulnerable group. Further, the selected components of vulnerability were also studied separately. The results obtained are given hereunder.

Farmers awareness about adverse impact of climate change on agriculture greatly affects their response to undertake specific measures. The results obtained in respect of level of awareness of farmers about climate change are given in Table 2. The data reveals that majority of the respondents (71.5%) had medium level of awareness about climate change followed by 14.5 per cent who had high level of awareness about climate change and 14 per cent with low level of awareness about climate change. These findings are however similar to another study by Raghuvanshi (2016) in the same area who reported that half of the respondents (50%) had medium level of awareness of climate change followed by 27.28 per cent of respondents who had low awareness level. It was also found that 22.72 per cent of respondents have high level of awareness towards climate change. The difference (increase) in awareness levels could be attributed to ICAR's NICRA project (National Innovations on Climate Resilient Agriculture) activities being undertaken by various stakeholders in the study area.

Table 2: Distribution of respondents on the basis of their awareness about climate change (n=200)

Category	Frequency	Percentage
Low	28	14
Medium	143	71.5
High	29	14.5

Attitude is an indicator of a person's thinking, perceptions and outlook towards an object, individual or an event. Positive attitude reflects a person's readiness to accept new ideas or behaviour. The results obtained in respect of farmers' attitude towards climate change are presented in Table 3.

Table 3: Distribution of respondents according to their attitude towards climate change

Category	Frequency	Percentage
Unfavourable	29	14.5
Moderately favourable	71	35.5
Highly favourable	100	50.00

It is evident from the above table that fifty percent of the respondents had highly favourable attitude towards climate change followed by 35.5 per cent who had moderately favourable attitude and 14.5 percent respondents displaying unfavourable attitude towards climate change. Thus, it can be concluded that half of the respondents in study sample had highly favourable attitude towards climate change. This may be due to the fact that the impact of changing climate is easily noticeable in agriculture sector, as it is one of the most vulnerable sectors. Farmers are able to notice the causes and factors that contribute to impacts of climate change in agriculture like occurrence of insect-pest, shifting in the flowering pattern of different crops. Secondly, more mass media exposure, medium level of social participation and medium attitude towards research station could also be the reason for this. Li *et al.* (2017) reported that farmers' risk perception was heightened by an increased awareness of directly observable climate change phenomena; and the awareness of extreme weather events was a significant driver of adaptation behaviour.

It is how farmer understands about the various adaptation measures/strategies available to cope up with the adverse impacts of climate change. A number of

statements regarding various adaptation measures were given to the respondents and they were asked to rank them as per their understanding of their potential in mitigating climate change risks and uncertainties. The results obtained are given in Table 4. The results reveals that a large majority (92%) of the respondents adopt drought/frost tolerant variety, followed by diversify from farming to non-farming activities (91%), store fodder for animals in lean seasons of year (88%), change their size of land under cultivation (87%), change the use of chemicals and fertilizers (86%), bring diversification in livestock assets on their farm (80%) and bring diversification of crops and varieties in their farm (79.5%). When probed further about the knowledge about the adaptation alternatives, they gave different responses as listed in the above table. Brar, Sharma and Gill (2020) while studying Adaptation Strategies being followed by Paddy Growers towards Climate Change in Punjab State reported that majority (91.2%) farmers had adopted short duration crop varieties and 82.4 per cent farmers were availing weather forecast services. Perception of risks associated with climate change drives the farmer's search for new knowledge and practices. This was measured in the study and the results obtained are given in Table 5. Table reveals that about half of the respondents (52.5%) had medium risk perception about climate change followed by 32.5 per cent of respondents who had high risk perception and only 15 percent of the respondents had low risk perception about climate change. Risk Perception of the farmers depends on individual personality, society etc. so the success of any climate smart policy depends on the kind of perception (positive or negative) a person had towards climate change. So before taking any initiative it is important to determine the farmer's perception about climate change. Here, it was found that around half of the respondents displayed medium risk perception about climate change. This may be due to the fact that many climate change activities are easily observable and identifiable in hilly region as compare to plain region.

It is the extent/level to which farmer is depending on the natural and social capital. It was observed that most of the respondents were fully dependent on cultivable land, forest and water sources and somewhat

Table 4: Distribution of respondents according to their knowledge about adaptation practices

Statements	Yes		No	
	N	%	N	%
Adopt drought/frost tolerant variety	185	92.5	15	7.5
Change the use of chemicals and fertilizer	172	86	28	14
Takes any forestation initiative or participate in any such programme	46	23	154	77
Replace chemical farming with organic farming	146	73	54	27
Diversification of crops and varieties in farm	159	79.5	41	20.5
Discussion with other farmers about climate change and help to increase awareness of others	63	31.5	137	68.5
Adopted any climate friendly technology in last 5 year	51	25.5	149	74.5
Formation of a farmer group against climate change	21	10.5	179	89.5
Adaption of any insurance or weather derivatives to deal with the impacts of climate change	77	38.5	123	61.5
Store fodder for animals in odd time of year	176	88	24	12
Diversification of livestock type in farm	160	80	40	20
Build any water harvesting scheme	52	26	148	74
Implement any soil conservation scheme	56	28	144	72
Change the size of land under cultivation	174	87	26	13
Diversification from farming to non-farming activities	183	91.5	17	8.5

Table 5: Distribution of respondents on the basis of farmers risk perception about climate change (n=200)

Category	Frequency	Percentage
Low (Less than 49)	30	15
Medium (49 to 66)	105	52.5
High (More than 66)	65	32.5

dependent on community, neighbourhood and community land, village institutions, water sources, forest, farmers' association. Data regarding level of dependence on natural and social capital has been presented in Table 6.

It is evident from the table that the most of the respondents (92.5%) were fully dependent on cultivable land followed by 66.5 per cent of respondent who were fully dependent on forest and 62 per cent of respondents fully dependent on water sources. Further, it was found that 45, 41, 25, 16 and 13.5 per cent of respondents had full dependence on community land, neighbourhood, farmers association, village institution and community, respectively. Additionally, it was observed that 57.5 per cent of respondents were somewhat dependent on community followed by neighbourhood (50.5% somewhat dependent) and community land (44%), village institutions (42%), water sources (36%), forest (33%), farmers association (26.5%) and only 5.5 per cent respondents who were somewhat dependent on cultivable land. It was also found that 48.5 per cent of respondent were not dependent on farmers association followed by village institutions (42%), community (29%), community land (11%), neighbourhood (8.5%) and 2 per cent respondents were not dependent on cultivable land and same as water sources. Only 0.5 per cent of respondents were found to be not dependent on forest. Generally there was greater dependency on the cultivable land, forest and water sources among the farmers in study area. Less dependency on community shows their self-establishment. These findings are in line with the Dabbadi and Singh (2012) who found that majority of the respondents (47.5%) were fully dependent and 32.5 percent were dependent to a larger extent upon land for livelihood. About 24 per cent of the respondents were fully dependent and about 46 per cent were dependent to a greater extent on river or canal for irrigation. It is evident from table that majority of farmers (63%) showed medium level of dependence on different natural and social resources like village institutions, community, water sources, cultivable land etc. for different purposes followed by 30 per cent who showed less dependence on natural and social resources. Only 7 per cent of farmers had high dependence on different natural and social capital.

CONCLUSION

The vulnerability of farmers in Himalayan region of Uttarkashi and shows that majority of the farmers in the study area are moderately vulnerable to climate change. The farmers of hilly region had medium level of awareness on climatic events. Therefore, we need to undertake multimedia campaigns to raise awareness

Table 6: Level of dependence on natural and social capital (n=200)

Resources	Degree of Dependence					
	Fully Dependent		Somewhat Dependent		Not Dependent	
	N	%	N	%	N	%
Cultivable land	185	92.5	11	5.5	4	2
Community land	90	45	88	44	22	11
Forest	133	66.5	66	33	1	0.5
Water sources/rivers	124	62	72	36	4	2
Neighborhood	82	41	101	50.5	17	8.5
Community	27	13.5	115	57.5	58	29
Village institutions	32	16	84	42	84	42
Farmers Association	50	25	53	26.5	97	48.5

Multiple responses were allowed

levels in the farming community, modify their attitude, educate them about climate associate risks and uncertainties and offer them the alternative location-specific adaptation strategies to cope-up with the adverse impact of climate change. Appropriate policy measures along with location specific adaptation strategies need to be developed as climate vulnerability varies across the region depending upon the exposure and sensitivity to climatic events. Climate change adaptation involves holistic changes in agricultural and ecological management practices comprising a combination of distinct responses, the indigenous knowledge systems, alternative practices and accessible technologies. Therefore, adaptation policies should be framed taking into account the farmers' perspectives and the degree of their vulnerability to climate changes.

Paper received on : October 17, 2020
Accepted on : November 07, 2020

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