Indian Journal of Extension Education
Vol. 57, No. 2, 2021 (15-27)
DOI: 10.5958/2454-552X.2021.00073.6

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

Understanding the Socio-economic Vulnerability of Farmers towards Climate Change in the Himalayan Ecosystem of India

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ABSTRACT

The impact of climate change has already been witnessed in different part of India and farming sector has faced the impact of this change more than other sectors. The farming communities of the Himalayan ecosystem seemed to be more vulnerable due to its difficult terrain and geography coupled with its high sensitivity to climate change. Therefore, the present study was conceptualized to assess the vulnerability level of farmers toward climate change in the Himalayan ecosystem of India. The state Himachal Pradesh was selected purposively keeping the impact of climate change in mind. Two districts namely Shimla and Kullu were selected purposively and a sample of one hundred farmers was randomly selected from these two vulnerable districts. Total twenty nine socio-economic and psychological variables were identified to determine the vulnerability level of farmers. Data were collected through personal interview and focused group discussion with structured schedule. Data were analyzed using statistical techniques like principal component analysis, regression analysis, mean, standard deviation *etc.* The results of the study revealed that vulnerability level was quite high in Himachal Pradesh (Index score 0.82). Majority of the respondents belonged to moderately vulnerable group (44%) followed by 38 per cent respondents in highly vulnerable group. The findings revealed that socio-economic variables like land holding, education, income, awareness level about climate change, communication pattern and psychological variables like achievement motivation, adaptive behavior, stress and pessimism were important predictors of vulnerability. It was inferred from the finding that the different socio-economic factors and personality characteristics of farmers must be considered for better implementation of any adaptation strategy.

Key words: Adaptation, climate, socio-economic vulnerability.

INTRODUCTION

Global climate change has been recognized as the most pressing critical issue affecting the survival of human kind. It has been considered as the most complex and challenging environmental issue, a potential threat to agriculture and food security across the globe (Rao *et al.* 2016). The rise in temperature, sea levels, and speedy melting down of glacier has increased the events of frequent climatic disaster like flood, drought, famine and new disease throughout the world. It is now accepted fact that agricultural sector is more vulnerable to climate change than industrial or service sector due to its high sensitivity to different climatic parameters, thus, making the farming community more vulnerable. Therefore, any climate-change-related threats to agriculture means menaces to the life and livelihood quality of farmers, and need for sound adaptation and mitigation strategies for agriculture has been increasingly felt over time (Coumou and Rahmstorf 2012; Howden *et al.* 2007; McCarl 2010). Though climate change is global in nature, it is developing countries like India that faces more serious

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consequences due to its high dependence on agriculture (Rao *et al.* 2016). Till toady, the agricultural production in India depends on the timing and strength of South-West and North-East monsoon. Therefore any deviation from normal climatic trend will have significant impact on the farmer's life and livelihood. Different past studies indicated that climate change effects have already been observed in India. For example, Bhattacharya *et al.* (2007) reported an increase of 0.4-0.6°C temperature in last 100 years. Cruz *et al.* (2007) similarly mentioned about increasing trend of annual mean temperature and higher warming during post monsoon and winter season. Beside these, the frequency of hot days and heat waves in India has increased in last century (IPCC 2007). The impact of all these changes has strongly been felt in all spheres of life and livelihood especially in agriculture sector. The findings of Sinha and Swaminathan (1991) supported the above proposition when they reported that an increase in winter temperature by 0.5°C would reduce the wheat yield by 0.45 *ton/hectare*. Further, Guiteras (2009) mentioned that the crop yields will decline by 4.5-9 per cent in the short-run (2010-2039) and by 25 per cent in the long-run (2070-2099) in the absence of any adaptive measure. In this regard, Burgess *et al.* (2014) observed that with rising temperature the farm productivity will decline by 12.6 per cent and real wages by 9.8 per cent, and will raise the annual mortality of rural populations by 7.3 per cent in India. The economic survey mentioned that India incurs an estimated loss of $9-10 billion/year (₹62000 crore) on account of extreme climatic events (https://www.livemint.com).

However, all these changes in climatic parameter are not equally felt by the country due to its vast geographic variability and unequal social system. The different regions have experienced differential change in terms of temperature rise, amount of rainfall received, flood witnessed, and number of cyclone witnessed. Accordingly, vulnerability to climate change varies significantly among different region and social group. Among the different sensitive ecosystem or region, Indian Himalayan ecosystem is considered as one of the most fragile habitat and most vulnerable ecosystem towards climate change beside coastal ecosystem (Chaturvedi *et al.* 2011; Upgupta *et al.* 2015; Barua *et al.* 2018; IPCC 2014; Karma *et al.* 2010; Cruz *et al.* 2007). The hard geographic feature of this region makes the local biodiversity, water bodies, agriculture, and human well-being more difficult than other region. In addition, the region experiences diverse climatic conditions, extreme weather events, frequent flash floods, along with high current climate variability due to varying altitude. The region already witnessed higher increase in temperature than the global average, low rainfall, fast melting down of glacier, more number of warm days (Shrestha *et al.* 1999; Brohan *et al.* 2006; Diodato *et al.* 2011; Dimri and Dash 2011; Bhutiyani *et al.* 2010; Sontakke *et al.* 2009). The Himalayan belt is also known for heavy land degradation, landslides, deforestation, proliferation of invasive species, loss of biodiversity, invasion of commercial crops, low productive agriculture, and high rate of migration *etc.*

These climatic and non-climatic stresses make the Himalayan ecosystem and communities highly vulnerable. But the extent of vulnerability of the Himalayan farming communities to climate change and related disaster is largely not understood. Therefore, it is vital to conduct vulnerability assessment for the Indian Himalayan region and its communities. Vulnerability assessment can help in the identification of the drivers of vulnerability, and assist in designing adaptation interventions specific to the area. Hence, a thorough and systematic examination of farmers' vulnerability to climate change in the Himalayan ecosystem is necessary and urgent. Unfortunately, to the best of our knowledge, information on the extent of vulnerability and adaptation is highly scanty in the literature (Alhassan *et al.* 2019). Though of-late several studies were undertaken to measure the vulnerability towards climate change but majority of them focused only on bio-physical vulnerability ignoring the social dimension. In this regard, Sharma *et al.* (2009) and Barua *et al.* (2018) raised the concern on limited knowledge and data on impact of climate change on people. Recently, Dumenu and Tiamgne (2020) also emphasized on the need of capturing the social dimensions of climate change vulnerability, and simultaneously expressed his concern on lack of study on vulnerability of household, social group or communities taking socio-economic and demographic factors into consideration. The major reason for lack of studies on socio-economic vulnerability stems from the fact that it lacks in sound methodology in climate change context, lack of appropriate indicators and difficulties in quantifying them. So assessing the vulnerability level of farming community to climate change including their socio-psychological and economic indicators becomes the rising concern of researchers.

The present study was undertaken to understand the socio-economic vulnerability of farmers towards climate change in the Himalayan ecosystem of India. The study is intended to develop an index for measurement of social vulnerability. The need of studying social vulnerability emerges from the fact that all sections of society though exposed equally to climatic event, but their adaptive capacity differed based on their socio-economic characteristics. The social vulnerability index will help us to understand the each region's relative susceptibility to damages and will be useful in future modeling and in taking future policy decisions regarding the equitable distribution of resources for adaptation. The social vulnerability index to climate change will help in identifying areas where adaptation is urgent and time–sensitive, and where policy intervention is most critical.

METHODOLOGY

Conceptualizing vulnerability

Vulnerability assessment provides a framework or guidance for identifying the social, economic, and environmental factors of a disaster (Zarafshani *et al.* 2016) and is considered as the most important exercise before devising any adaptation policy to mitigate the adverse impact of climate change (Corobov *et al.* 2013). Being highly complex and multifaceted concept, measuring vulnerability has become the most tedious task to any research bodies (Adger *et al.* 2005). The term 'vulnerability' has been used to sketch different interpretations in different disciplines and does not lend itself to a precise and concise concept. Thus, the concept 'vulnerability' has become multidimensional in nature with little consensus about its actual meaning (Thornton *et al.* 2006; Reed *et al.* 2013; Fellmann 2012; Gallopín 2006).

In general, the term 'vulnerability' refers to the capacity to be wounded *i.e* the degree to which a system is likely to experience harm due to exposure to a hazard (Turner II *et al.* 2003). Liverman (1990) mentioned that the term vulnerability has become synonymous to concepts such as resilience, risk, marginality, adaptability and exposure. Turner *et al.* (2003) defined vulnerability as the degree of injury likely to be caused to a system as a result of its exposure to a hazard. Cutter *et al.* (2008) and Nelson *et al.* (2010) conceptualized vulnerability as the predisposition of any group of people, location or system to disorders determined by exposure and sensitivity to distresses, including their adaptive capacity. The third and fourth assessment reports of the IPCC (2014) came up with the most accepted definition of vulnerability as the level to which a system is susceptible to, or incapable of coping with the adverse effects of climate change, climate variability and extremes. Thus, vulnerability of any system is frequently considered as a function of three elements: exposure to a hazard, sensitivity to that hazard, and the capacity of the system to cope with and adapt or recover from the effects of those conditions (Reed *et al.* 2013; Smit and Wandel 2006).

The concept 'vulnerability can be analyzed and studied at different scales or level like regional or country level, sub-national level, community level, household or even at individual level. Due to its multiple level and numerous conceptualization, different scholars came up with diverse approach and theories for vulnerability assessment in different context (Füssel and Klein 2006; Reed *et al.* 2013; Pearson *et al.* 2011) like end point vs. start point approach, econometric vs. indicator approach. Among all these methodological approach, the indicator method of vulnerability assessment has gained popularity because of its easiness and greater statistical accuracy. Hence, the present study used the indicator method to assess the social vulnerability of farming communities towards climate change.

Selection of state

Climate change is a global phenomenon and its impacts are being observed all over the world. However, its impacts are most seriously felt in certain sensitive ecosystems like Himalayan ecosystem (IPCC 2007). Keeping these in mind, the state Himachal Pradesh representing the Himalayan ecosystem was purposively selected as the farmers in Himachal Pradesh already experienced climate change led impacts like melting down of glacier, rise in temperature, erratic rainfall and late snowfall. Incidences of floods, droughts, loss of biodiversity, health hazards and poverty as a consequence of climate change are the biggest concern in Himachal Pradesh. The production and productivity of major crop apple has already showed a declining trend and major apple growing areas shifted to higher altitude. The cumulative effects of these impacts have created an uncertain future in the region (Agarwal *et al.* accessed on 29.11.2020). Therefore, the impact of climate change on agriculture is likely to enhance the socio-economic vulnerability of the state.

Selection of districts and respondents

Two districts- Shimla and Kullu were selected purposively from Himachal Pradesh keeping the impact of climate change on apple growers in mind. The findings of past studies reveal that both districts had high exposure to climate change and witness impact in different sphere of life system. Upgupta (2015) reported that most vulnerable districts due to climate change in Himachal Pradesh were Kullu, Shimla, Chamba, Mandi and Kangra. Jamwal (2019) mentioned that Kullu district was identified as a climate hotspot and the most flood affected district in the state. Similarly, Rao *et al.* (2013) highlighted that another district *i.e* kullu of Himachal Pradesh too witnessed high projected rise in min temperature and low rainfall events. On the other hand, state strategy & action plan on climate change in Himachal Pradesh-2012(https://desthp.nic.in/publications/HPSCCAP_A1b.pdf, accessed on

29.11.2020) reported a decline of 13.3 per cent rainfall event in last 25 years in Shimla. Kumar (2012) reported that with rise in temperature in Himachal Pradesh, the apple cultivation has declined upto 2400 m above mean sea level (amsl) in Kullu and Kinnaur district. The apple belt has shifted upward from 1250 m amsl where sufficient chilling hour is still available. Keeping all these impact in mind, the above mentioned two districts *i.e* Kullu and Shimla were selected for the present study. Thereafter, two blocks namely Theog and Nagar block representing apple belt from Shimla and Kullu were purposively selected to assess the vulnerability level of apple growers. Again two villages- Sandhu and Koti from Theog block and another two villages–Katrain and Kamsari from Nagar block were selected purposively keeping the availability of apple farmers and feasibility of data collection in mind. Finally, twenty five farmers from each village in Himachal Pradesh were selected randomly. Thus, total one hundred farmers were interviewed in the present study. Beside farmers, experts from Central Potato Research Institute, Shimla; IARI regional station Katrain; CAZRI, Jodhpur; and Krishi Vigyan Kendra subject matter specialists were also interviewed to enrich our primary observations.

Measurement of dependent variable - Vulnerability

The dependent variable vulnerability was operationalized as the inability of individuals/households to cope up with or adapt to climate change induced stresses placed on their livelihood and well-being. Considering the various psychological dimensions of individual (attitudinal, knowledge and value orientation), social (interconnectedness and cohesiveness), demographic (age, education and land holding), economic (physical resources, income and other livestock resources); an attempt was made to develop an index to measure the vulnerability level of sample respondents. Drawing from the approaches of Intergovernmental Panel on Climate Change (IPCC), The Energy and research Institute (TERI)-2003, Cutter *et al.* (2003), O'Brien *et al.* (2004) and United Nations Development Programme (UNDP)-2002, a composite vulnerability index was worked out and respondents were grouped under the categories of highly vulnerable, moderately vulnerable and less vulnerable. For each component of vulnerability, sub-indices were worked out using the following formula.

Sub Vulnerability Index (SVI) = (Actual value – Minimum value) / (Maximum value - Minimum value)

The high index values mean high vulnerability but the indicators such as income, area, knowledge *etc.* hypothesized to decrease the vulnerability with increasing values. So, the index values were reversed for those factors by subtracting them from 1 *i.e.* [1-index value].

Then, weights were attached to the indicators by using principal component analysis (PCA) with the help of statistical software SAS. The assigned weights were then multiplied with each variable to calculate each principle component score by taking their linear summation. The PCA score of first few principal components which explain more than 80 per cent of total variation for final vulnerability index was taken into consideration for final vulnerability index. The summation of average index score of those selected principal components was performed for final vulnerability index. Following formulae were formulated to calculate the final vulnerability index which are as follows-

Principal Component Score (P)= (∑WiPi*SVIij)

Where, SVIij = index value for i^{th} variable and j^{th} individual (Here, 'i' ranges from 0 to 29 and 'j' ranges from 0 to 100)

Wi= Weightage for i^{th} principal component (here, 'i' ranges from 0 to 29)

Pi= Number of principal components (here, it ranges from 0 to 29)

Final vulnerability index= (∑PCSi/n)/N

Where, PCSi= Different principal component score

n=Number of principal components

N=Number of respondents

The respondents were then classified into three categories- high, moderate and less vulnerability group. The classification was done based on cumulative cube root frequency (CCRF) method. The formulae to calculate CCRF is as follows-

$L_i=Y_i-1+[\{(L_i*Sk/L)-S_i-1\}/ \sqrt{f_i}]*[Y_i-Y_i-1]$

Where, $L_i=i^{th}$ strata

Sk=summation of cumulative cube root frequency

S_i-1=cumulative square root of the frequency of the preceding class

Y_i= Upper limit of the class interval

Y_i-Y_i-1=width of the class

f_i= frequency of the class

Finally, linear regression analysis was employed to find the major predictors of vulnerability level of respondents.

Measurement of independent variables:

Twenty nine socio-economic and psychological predictors of vulnerability were chosen after consultation with the experts. The socio-psychological variables like achievement orientation, pessimism, openness, stress, production orientation, and sustainability behvaiour were measured by modified scale of Austin *et al.* (1998). Attitude of the respondents was measured by the scale of Department of environment, food and rural affair (DEFRA)-2007, whereas respondents' fatalism and egalitarianism were measured by modified scale Leiserowitz (2006). A knowledge test was developed to measure the knowledge of respondents. Three scales were developed to capture famers' perception, risk perception and value orientation towards climate change. Primary data were collected on socio-economic variables like age, education, sex, caste, income, asset, communication behaviour, social cohesiveness and social participation using standards tools and techniques.

Data collection

The primary data was collected from the respondents by personal interview. Survey, in-depth discussion and participant observation methods were used for collection of primary data. Both structured and semi structured interview were conducted for collection of data. Case method, different PRA tools and technique like mapping and matrix ranking were also used for enriching the information. Methodologically, the study applies a descriptive-analytical approach to assess the vulnerability of smallholder farmers to climate change, including socio-economic data. This data set represents different individuals as well as social and economic situations of households, and was mostly used to determine indicators of sensitivity and adaptive capacity.

Statistical tools used

The analysis was carried out by using advance statistical tools and techniques like PCA analysis, ANOVA, and multiple linear regression. SPSS 16 and SAS software were used for the present vulnerability analysis.

RESULTS AND DISCUSSION

Socio-economic profile of Himachal Pradesh:

Analysis of socio-economic profile of respondents provides an idea about the characteristics of the respondents studied and their background. The findings on socio-economic condition of farmers revealed that that most of the farmers were old (23%). The preliminary investigation revealed that young generation were no more interested in farming which is a matter of serious concern. Majority of the farmers were male (86%) as against 14 per cent female farmers. Almost half of the respondents (47%) belonged to General Caste followed by other backward class-OBC (34%), Scheduled tribe-ST (10%) and Scheduled caste-SC (9%). In the village, caste still holds significance in term of accessing different services and social participation. The tradition of joint family was less in the study area as only 32 per cent farmers told that they lived in joint family. The distribution of farmers according to their annual income reveals that majority of the respondents belonged to middle class (41%) category followed by poor (38%) and rich famers (21%). Most of the farmers were small farmers with landholding between 3.02-8.02 acre followed by marginal farmer (less than 3.02 acre) and large farmer (more than 8.02 acre). The primary experience revealed that availability of land is not an issue but availability of cultivable fertile land with irrigation source was the major problem of the area. The majority of the respondents (44%) completed up to primary school level education, while 25 per cent respondents completed their secondary level education and only 8 per respondents completed up to college level education. Still, 23 per cent respondents were illiterate in the area. A majority of the farmers (53%) showed medium level of dependency on different resources like community land, forest, neighourborhood, village institutions etc. for different purposes followed by low dependency (28%) and high dependency (19%).

Majority of the farmers (65%) were original inhabitant and about 23 per cent were old time migrant, which demonstrates their strong linkage with the region. Similarly kinship ties for majority of them (52%) were local, which further strengthened the bonding in the household networks. Healthy interdependence was observed in the village as reflected by reciprocity in labour exchange and food exchange, besides the systems of share cropping and contract farming. Forty one per cent respondents showed medium degree of cohesiveness followed by high (39%) and low degree of cohesiveness (20%). Such type of cohesiveness may help the community during extreme climatic events. Donatti *et al.* (2019) also reported that social ties and cohesiveness played an important role in determining the vulnerability of farmers towards climate change. However, their individual personality trait in terms of innovativeness was matter of concern as most of the farmers showed low level of innovativeness (63%), which could make them more vulnerable to climate change because of their inability to adopt different newly developed technology like heat tolerant variety, soil management, water efficient crops and irrigation methods *etc.* Similarly, majority of the respondents (38%) showed very low risk orientation which indicates their inability to take any risk for adaptation towards climate change.

Table 1: Socio-economic profile of the respondents

n=100

Variable	Categories	Percentage	Variable	Categories	Percentage
Age	Very young (<27.93 year)	14	Dependency	Low (<11.49)	28
	Young (27.93-36.13 year)	18		Medium (11.49-14.49)	53
	Middle (36.13-44.33 year)	21		High (>14.49)	19
	Old (44.33-52.53 year)	23	Cohesiveness	Low (<3.11)	20
	Very old (>52.53 year)	14		Medium (3.11-4.11)	41
Sex	Male	86		High (>4.11)	39
	Female	14	Innovativeness	Low (<8.05)	63
Caste	ST	10		Medium (8.05-9.65)	17
	SC	9		High (>9.65)	20
	OBC	34	Risk orientation	Very low (less than 10.63)	5
	GB	47		Low (10.64-14.83)	38
Income	Poor (<2 lakh)	38		Medium (14.83-19.03)	21
	Middle (2-4.44 lakh)	41		High (19.03-23.23)	12
	Rich (>4.44 lakh)	21		Very high (more than 23.23)	24
Area	Marginal (<3.02 acre)	37	Education	Illiterate	23
	Small (3.02-8.02 acre)	40		Primary	44
	Large (>8.02 acre)	23		Secondary	25
Family type	Nuclear	68		College	8
	Joint	32			

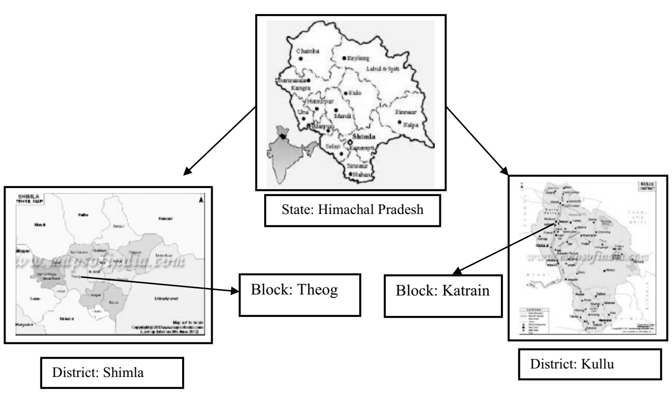

Fig. 1 Map showing the study area of Himachal Pradesh

Identifying and prioritizing the indicator of vulnerability through PCA analysis:

The vulnerability index was calculated based on the above mentioned 29 socio-psychological and economic variables. PCA analysis was employed to find out few principal components which explained majority of the variation of dependent variable. From the Table 2 it was clear that 82.01 per cent of total variance was explained by first 10 principal components. So, PCA score of only first ten principal components was taken for calculation of final vulnerability index.

Vulnerability level:

Based on the PCA score of 10 components, finally the mean vulnerability score for each respondent was calculated. Then, overall mean vulnerability score of the state was calculated which was 0.82 indicating a very high level of vulnerability of the Himachal Pradesh. The variable like income, age, family size, landholding size, physical resources, livestock resources, economic motivation, risk orientation, egalitarianism and dependency level played an important role in explaining the overall variance of sample data. Barua, A. *et. al.,* (2018-19) also expressed similar view and said that the variable like per capita income, area under irrigation, dependency on forest resources were the major factors in determining the vulnerability of the Himalayan state.

After calculating the vulnerability score of each respondent, they were categorized into different level of vulnerability through cumulative cube root frequency method which is a standardized tool to categorize the data for continuous variable. Following figure shows the distribution of respondents according to their level of vulnerability.

From the Figure 2, it is understood that 31 per cent of the respondents were highly vulnerable to climate change followed by moderately vulnerable (43%) and less vulnerable category (26%).

Table 2: Eigenvalues of the principal components

Variables	Eigenvalues	Difference	Proportion	Cumulative
Income	0.52734959	0.18676025	0.2362	0.2362
Age	0.34058934	0.08923966	0.1525	0.3887
Family member	0.25134968	0.07996313	0.1126	0.5012
Size of landholding	0.17138654	0.04692019	0.0768	0.5780
Physical resources	0.12446635	0.02078237	0.0557	0.6337
Livestock resources	0.10368399	0.01204076	0.0464	0.6802
Economic motivation	0.09164322	0.01039422	0.0410	0.7212
Risk orientation	0.08124901	0.00605384	0.0364	0.7576
Egalitarianism	0.07519517	0.01073907	0.0337	0.7913
Dependency level	0.06445610	0.00530064	0.0289	0.8201
Cohesiveness	0.05915545	0.01402884	0.0265	0.8466
Communication	0.04512661	0.00573857	0.0202	0.8668
Social participation	0.03938805	0.00514442	0.0176	0.8845
Pessimism	0.03424362	0.00288469	0.0153	0.8998
Fatalism	0.03135893	0.00554929	0.0140	0.9138
Stress	0.02580964	0.00130089	0.0116	0.9254
Sustainability	0.02450875	0.00209184	0.0110	0.9364
Production orientation	0.02241691	0.00109011	0.0100	0.9464

Attitude	0.02132680	0.00267665	0.0096	0.9560
Value	0.01865015	0.00279804	0.0084	0.9643
Innovativeness	0.01585211	0.00187854	0.0071	0.9714
Achievement orientation	0.01397358	0.00160172	0.0063	0.9777
Openness	0.01237186	0.00193606	0.0055	0.9832
Adaptive behaviour	0.01043579	0.00196838	0.0047	0.9879
Education	0.00846741	0.00132980	0.0038	0.9917
Awareness	0.00713762	0.00158431	0.0032	0.9949
Knowledge	0.00555331	0.00213640	0.0025	0.9974
Perception	0.00341691	0.00096191	0.0015	0.9989
Risk perception	0.00245500		0.0011	1.0000

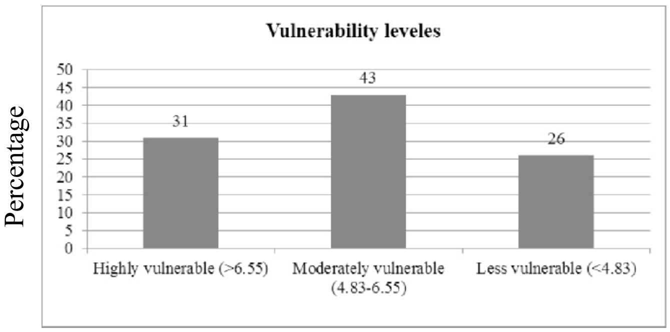

Fig. 2 Distribution of respondents according to their vulnerability level (n=100)

Determining the factors of vulnerability using multiple linear regression analysis

Multiple linear regression analysis was carried out for identifying predictor variables for the dependent variable *i.e.* vulnerability and to test the validity of the regression model. The R2 value of 0.932 indicates the model is able to explain 93.2 per cent variation in the dependent variable. The adjusted R square value of 0.919 showed that the significant portion of variation in the dependent variable was explained by the model was 91.9 per cent. To test the significance of model we employed F test, the result of which has been displayed in the following table-

The P value of <0.001 indicated that the model is highly significant at 1 per cent level of significance. The regression coefficients for each variable were calculated to predict the future vulnerability level and their significance was tested. The results have been presented in the following Table.

The finding of regression analysis indicates that the variable like income, education, adaptive behavior, communication pattern and pessimism were found to be significant predictor variables at 1 per cent level of significance whereas area, age, achievement motivation, stress and knowledge were found to be significant variables to predict the vulnerability level at 5 per cent level of significance. Further, the variable likes income, landholding size, education, adaptive behavior of farmer, achievement motivation, attitude towards climate change, value orientation towards climate, innovativeness, openness in farming, knowledge about climate change, communication behavior and awareness on climate change showed inverse relation with vulnerability indicating that with increase in these variables the vulnerability level goes down. Whereas, the variable like age, family members, stress, pessimism and fatalism showed positive relation indicating that the vulnerability level will increase with increase the score of these variables. So, from regression model, the function of vulnerability could be expressed in the form of following equation-

$$Vulnerability=0.021-1.32X1-0.958X2+0.790X3-1.078X4+1.846X5-1.095X6-1.678X7-1.072X8-0.123X9-1.962X10-1.611X11+1.231X12+1.896X13+0.194X14-1.009X15-1.457X16-0.272X17$$

The results pointed at differential risks for farmers with different socio-economic and psychological profile. The results of vulnerability index indicated a very high level of vulnerability (0.82) for Himachal Pradesh. A large section of the respondents from Himachal Pradesh (31%) belonged to highly vulnerable group due to their low adaptive capacity in terms of socio-economic and psychological indicators. The high level of vulnerability in Himachal Pradesh is due to its more exposure toward climatic hazards like change in snowfall and rainfall pattern coupled by low socio-economic adaptation capacity. The view of Negh (2012) supports the present findings as he reported that mountain ecosystem and communities were more vulnerable and faced greater risk of climate change impact than other ecosystem. The findings of present study again proved the hypothesis that social variables like education, land holding, income, communication pattern and psychological determinants like knowledge, achievement motivation, stress and fatalism were instrumental in determining the vulnerability level of people towards climate change. The findings revealed that economic factors specially income (Beta co-efficient=-1.32) had strong influence in determining the vulnerability level of farmers towards climate change. The findings of Botero and Salinas (2013) supported the present findings and they mentioned that the income or financial component had the largest contribution to the vulnerability of the community with a value of 0.77. The importance of economic factors particularly income in determining vulnerability was also mentioned by Botero and Salinas (2013) and Dumenu and Tiamgne (2020). In international context, Ezea *et al.* (2018) also reported that low adaptive capacity of the farmer was due to poor access to loan, low income diversification, high illiteracy rate, poor adoption of agroforestry and improved crop varieties. It appears that poverty and vulnerability to climate shocks are linked (Shewmake, 2008, Deressa *et al.* 2008, Islam *et al.* 2014). This is because of the fact that access to sufficient income or a sense of financial security helps to overcome external climatic risks and shocks. Therefore, it can be inferred that rich farmer of the region was comparatively less vulnerable than the poor farmers. Another important predictor of vulnerability was land holding size or area available for farming with a beta co-efficient value of -0.96. Jamshidi *et.al.* (2019) similarly reported that most smallholder farmers were more vulnerable to climate change. Beside these, other important socio-economic factors which played an important role in determining the vulnerability were age (0.79), education (-1.078), communication (-1.457), adaptive behavior (-1.095) and awareness (0.675). Specific examples from developing countries have also highlighted the fact that high vulnerability level is mainly influenced by socio-economic factors of the region. For example, Das (2013) in his study mentioned that very high level of vulnerability is mainly influenced by socio-economic factors like high rate of poverty, illiteracy, asset ownership, accessibility to common services and infrastructural supports including communication networks. In this regard, O'Brien *et al.* (2004) talked about socio-economic factors like wealth, technology, education, and skills to raise adaptation capacity and to reduce vulnerability to overcome the impact of climate change. The study found that education has negative relation with the vulnerability indicating vulnerability increases as the education level decreases. The preliminary experience revealed that household in very high vulnerability group were featured by illiterate households, farming as primary occupation and lacks in job diversification. The reports of Diyawadana (2017) supports the present findings as he reported that the household with less educational level, farming as main occupation and high rate of unemployment showed more vulnerability. In this regard, Harvey *et al.* (2014) opined that the use of adaptation measure was positively correlated with farmers' education level, use of diversified agriculture practices and diversified cropping system and livestock ownership. The study found that the people who are most affected by the impact of climate change are often those with the least access to information on climate change. Hence, communicating climate change effectively is an essential step towards creating an enabling environment for widespread societal adaptation to climate change. Yadav (2011) reported that communication media plays a vital role in educating and enlightening the people and the governments to protect and conserve the natural resources. Hence, mobile phone based weather forecasting system, disaster warning system and agro-advisory service has the potential to raise the awareness level of farmers on climate change and to reduce the vulnerability level of farmers towards climate change. Finally, Lokonon, Boris O. K. (2017) highlighted the fact that highest vulnerability does not necessarily coincide with highest exposure and sensitivity of the region. The adaptive capacities of the people in the region become instrumental in determining their vulnerability level. The region with highest human and social capital showed high adaptive capacity and less vulnerability. Hence, socio-economic empowerment of the people in terms of better education, assured income, adoption of diversified farming, strong communication system, high awareness level and adaptive behavior should be the policy direction to reduce the vulnerability level of farming community towards climate change.

It was further derived from the findings that psychological factors played an equally important role in determining the adaptive capacity and to reduce the vulnerability of the region. The study reveals that the psychological factors like stress (1.231), pessimism (1.896), achievement (-1.678), fatalism (1.950) and knowledge (-1.009) strongly influenced the vulnerability level of farming communities in the region. The importance of psychological factors was highlighted by Leiserowitz (2005) and Besel *et al.* (2017) in their study and viewed that public support or opposition to any climate policies are greatly influenced by public perceptions of the risk and dangers associated with climate change. Further, Tessema and Simane. (2019) captured the role socio-psychological variables like norms, values and attitudes the predispose people to cooperate, building trust, reciprocity and obligation and establish common rules and sanctions for reducing vulnerability. Hine *et al.* (2013) reported that people tend to form groups of individuals who share similar views and understandings about climate change. Maibach *et al.* (2011), Leviston and Walker (2010) highlighted the role of cognitive construct like attitude, knowledge, self-efficacy and concern about climate change for adaptive climate change response. The emotional connection to nature and sustainability orientation of an individual has been associated with pro-environmental behavior of an individual. They are ready to adopt any actions to address climate change if it matches with their psychological orientation. Hence, a community which possessed scientific knowledge about climate change, have favorable attitude and value orientation, with low stress and pessimism level is expected to show high resilience towards climate change.

Thus, a sound extension system taking into account the socio-economic and psychological profile of farmers in mind need to be formulated by the policy makers to reduce their vulnerability towards climate change. It is found that on an average the frequency of access to extension services influences significantly the vulnerability level of the farmers (Lokonon, Boris O. K. 2017). It is reported that more the farm households have access to extension services, more they are better off in terms of vulnerability to climate shocks (Asfaw *et al.* 2016). Jyoti Parikh (2015) further highlighted the fact about poor extension service in the region as only 50 per cent farmers were using improved varieties of crops or fruit sapling or vegetables because of lack of awareness and poor extension service. Hence, it is derived from the findings that emphasis must be laid upon developing strong extension system with socio-economic and psychological empowerment of farmers for effective adaptation towards climate change.

Table 3: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1.160	17	.068	66.634	.000
Residual	.084	82	.001		
Total	1.244	99			

Table 4: Output of regression coefficients analysis

Model	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
(Constant)	0.021	0.015	.828	0.410
Income (X1)	-1.320	0.301	4.386	0.000
Size of landholding (X2)	-0.958	0.278	2.005	0.048
Age (X3)	0.790	0.238	3.313	0.001
Education (X4)	-1.078	0.269	4.003	0.000
Family member (X5)	1.846	0.153	1.601	0.113
Adaptive behavior (X6)	-1.095	0.301	3.633	0.000
Achievement motivation (X7)	-1.678	0.416	2.057	0.043
Attitude (X8)	-1.072	0.369	1.002	0.319
Value orientation (X9)	-0.123	0.031	.119	0.906
Innovativeness (X10)	-1.962	0.521	1.751	0.084
Openness (X11)	-1.611	0.413	1.448	0.152
Stress (X12)	1.231	0.489	2.519	0.014
Pessimism (X13)	1.896	0.469	4.045	0.000
Fatalism (X14)	0.194	0.045	0.134	0.894
Knowledge (X15)	-1.009	0.287	3.512	0.001
Communication (X16)	-1.457	0.397	3.667	0.000
Awareness (X17)	-0.272	0.019	0.851	0.397

CONCLUSION

It can be concluded from the study that the livelihood of farmers in Himachal Pradesh were highly vulnerable due to climate change. A large section of farming community (31%) in Himachal Pradesh, belonged to highly vulnerable group. The finding of regression analysis showed that socio-economic and psychological characteristic of individuals plays an important role in determining their adaptive capacity. Income, area, education, achievement motivation, knowledge, stress, pessimism and communication pattern of respondents were the major factors in determining their vulnerability towards climate change. Adaptive capacity, age and awareness level of the farmers were other important determinants of vulnerability in Himachal Pradesh. The study proved the importance of technology development *viz.* development of heat tolerant apple variety as the major adaptation strategy towards climate change. Therefore, a strong extension system based on existing socio-economic and psychological characteristic of farmers can enhance their adaptive capacity and reduce their vulnerability. However there is a need to integrate the social vulnerability with bio-physical vulnerability to address the challenges more effectively. The development and integration of social, environmental and climatic hazard indicators together can improve the assessment of actual vulnerability and can justify the selective group of communities for adaptation and mitigation more accurately. So, the future research should be focused in that direction.

Paper received on : January 17, 2021
Accepted on : March 19, 2021

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