Impact of climate change on farmer's vulnerability in different altitude regions of Anantnag district of Kashmir, Indian Himalayas

Abstract

Agriculture is vital to India's economy. Climate hazards and amplifying factors make farmers vulnerable. Climatic volatility threatens agricultural productivity and rural livelihoods. Climate instability and climate change disrupt food supply, accessibility, and quality. This research assessed the farmers' vulnerability in Anantnag district of Jammu & Kashmir, using a multi-stage sampling technique with 120 farmers across three altitudinal strata. The socio-economic analysis indicated that majority of the respondents in the study area belonged to middle age group, 94 per cent of them received some education, majority (48.4%) were having annual income of rupees (0.8-2.1 lakh), and majority (64.7%) had marginal land ownership of less than (0.29 ha). The evaluation uses 11, 14, and 6 indicators to measure exposure, sensitivity, and adaptive capacity. Pahalgam and Larnoo, which are in higher altitudinal zones, had higher vulnerability, while Vessu and Anantnag, in lower altitudinal zones, had lower vulnerability. The Climate Vulnerability Index ranged from 0.86 in high-altitude areas to 0.29 in low-altitude areas. Exposure (0.72) plays an important role in ranking high altitude regions at the first position, followed by sensitivity (0.47) and adaptive capacity (0.33). The findings highlighted the need forgovernment strategies to lessen farmers' climate change vulnerability. Policies and initiatives aimed at promoting sustainable farming and climate-smart practices can enhance farmers' climate change awareness and boost agricultural growth.

Keywords: Climate change**,** Exposure, Sensitivity, Adaptive Capacity, Vulnerability Index (VI).

INTRODUCTION

Global development debates often focus on the urgent issue of climate change, its detrimental effects on human livelihoods and the environment. Climate change is expected to significantly impact agricultural systems, affecting productivity, efficiency, and profitability of farming operations. Vulnerability, a multifaceted concept, varies in definition across various fields such as engineering, psychology, and economics. Research on vulnerability focuses on understanding factors that expose individuals and locations to risk while reducing their ability to respond effectively to threats (Cutter, 2003). Füssel and Klein (2006) defined vulnerability asthe extent to which geophysical, biological, and socio-economic systems arevulnerable to and unable to mitigate the negative impacts of climate change. Vulnerability assessments are vital in policy-making (Patt *et al.,* 2005), but remain debated (Esteves *et al.,* 2016). Vulnerability analysis has long been linked to external influences that can negatively impact a system's value, with natural calamities being a significant factor (Dwyer *et al.,* 2004). Asfaw *et al.* (2021) argue that vulnerability is dynamic and determined by socio-economic processes (Rajesh *et al.,* 2018). The

Intergovernmental Panel on Climate Change (IPCC, 2014) has introduced a new approach to vulnerability assessment, viewing it as an inherent quality of a system.

Agricultural sector is highly susceptible to climate changes, as noted by Field *et al.* (2014). The Indian agriculture sector has shown its resilience to external shocks, such as the COVID-19 pandemic, in recent growth trends, but is highly susceptible to climate shocks, as evidenced by Choudhary & Sirohi (2020). The Indian Himalayan Region is a significant source of food, fruits, and medicinal crops. The Himalayan people heavily rely on agriculture for their subsistence. Many people rely on industries such as food processing, horticulture, and post-harvest management. Climate change in the Himalayan regions is causing strain on agriculture and livelihood systems due to altered temperatures, melting glaciers, snow, precipitation patterns, and more frequent extreme weather events. The Himalayan region's agriculture faces limited scientific research on climate change's impact, primarily focusing on climate sensitivities (Tiwari and Joshi, 2015). Climate change is expected to significantly impact Himalayan agriculture, leading to increased uncertainty in crop production in the near future (Bhat *et al.*, 2021). Small size of land holdings accentuates the sensitivity of the agricultural production system. The role of farm collectives can be crucial for enhancing the livelihood security of smallholders (Chaudhary & Sirohi, 2022). The present study was aimed to evaluate farmers' vulnerability to climate change in Anantnag district, Himalayan region of Jammu & Kashmir. The assessment serves as a foundation for policy development aimed at enhancing farmers' ability to adapt and mitigate changes effectively. The study significantly aids in policy-making by informing on strategies to enhance the agricultural sector's resilience to climate events.

METHODOLOGY

The study was conducted in the Anantnag district of J&K during the year 2022-2023. The respondents were chosen using a multistage random sampling technique. Six blocks (Pahalgam, Larnoo, Verinag, Hiller Shahabad, Vessu, & Anantnag) out of 16 blocks were chosen based on their altitude, with two blocks chosen from each altitude region (high, mid and low) in the first stage. In the 2nd stage of sampling, two villages from each block, were chosen based on maximum population, and a list of 120 respondents was prepared using proportional allocation method. The investigation collected primary data to achieve the study's objective, by personally interviewing 120 selected respondents from Anantnag district of J&K UT. The respondents received a thorough explanation of each query, with equal emphasis. The study significantly minimized the selfinfluence of the respondents. Informal discussions and observations were conducted to gain a comprehensive understanding of the respondent and the situation, which in turn improved the interpretation of the results. Analytical tool employed for the study was descriptive statistics. For vulnerability assessment, the data was collected using a 5-point Likert- type scale.

Vulnerability Assessment

Vulnerability is understood as a function of three components, i.e., exposure, sensitivity and adaptive capacity, which in turn is influenced by a range of biophysical and socio-economic factors (Hiremath and Shiyani, 2013). While it is increasingly accepted that the vulnerability of farmers due to climatic conditions cannot be solely understood through the quantification of biophysical impacts, only few climate change studies consider the social aspects of farmers' vulnerability, examining socio-economic and institutional factors that influence their response to climatic hazards. The study assessed farmers' vulnerability to climate change using three components and calculated vulnerability indices for different altitude regions in Anantnag district.

Indicator normalization using a functional relationship was adapted from the Human Development Index (HDI), which has been employed by both United NationsDevelopment Programme (UNDP) and the Organization for Economic Co-operation and Development (OECD). This methodology entails ensuring that all indicator values can be effectively compared and harmonized, resulting in their standardization within a uniform range, typically spanning from 0 to 1 (Akanbi *et al.*, 2022).

$$Zij = \frac{Max\{Xij\} - Xi}{Max\{Xij\} - Min\{Xij\}}$$

Where,

Z_{ij} = normalized value of indicator iX_{ij} = value of indicator i
Max $\{X_{ij}\}$ = highest value
Min $\{X_{ij}\}$ = lowest value

Aggregation of indicators: This is a linear summation aggregation method. Index (I) of the indicator Y for a farming community/village (i) was calculated by multiplying its weight (W_y) to its normalized value (N_{yi}), which is the standardized value of the indicator.

$$I_{yi} = W_y \times N_{yi}$$

Where,

I_{yi} = Vulnerability index of i household
W_y = Weight of the indicator
N_{yi} = Standardized value of the indicator

After computing the normalized scores, the vulnerability index was constructed by assigning equal/unequal weights to all indicators/components. The Vulnerability Index (Iv) of each component of vulnerability (Exposure, Susceptibility and Capacity) was computed as the arithmetic mean of the values of all indices of the component for farmers. Given a component of vulnerability with indicators Y, measured for a farmer/farming community/village (i), then the Vulnerability Index (Iv) of the component of vulnerability in that particular farmer/farming community/village (i) is given by:

$$Iv = \sum (W_y \times N_{yi}) / n$$

Where, n = number of indicators of the component of vulnerability.

Vulnerability increases with exposure and susceptibility but reduces with adaptive capacities. The vulnerability index so computed lies between 0 and 1, with 1 indicating maximum vulnerability and 0 indicating no vulnerability at all. From the review of different studies, it was observed that the vulnerability of a given system largely depends on its exposure and sensitivity, which combined provides the potential impact and the capacity for effectively coping with the impacts and associated risks. Therefore, vulnerability can be formulated as follows:

$$V = I - AC$$

Where,

I = Exposure + Sensitivity (potential impact)
V= vulnerability, and
AC=adaptive capacity.

Therefore, the Climate Change Vulnerability Index (CVI) of the farmerswas calculated as follows:

$$CVI = We \times IvE + Ws \times IvS - Wc \times IvC$$

Where,

CVI = Composite Vulnerability Index of the farmer's

We = exposure weight = 1;

Ws = susceptibility weight = 0.5;

Wc = adaptive capacity weight = 0.5

IvE = vulnerability index of farmers due to exposure

IvS = vulnerability index of farmers due to susceptibility

IvC = Index of adaptive capacities of farmers in the study area

RESULTS AND DISCUSSION

Socio-economic characteristics of the farmers

Table 1 indicates that 53.4 per cent of the respondents in the study area belonged to middle age group (30–55 years), 26.5 per cent were of young age group, and the rest, i.e., 20.1% were of old age group. Older farmers are more likely to perceive climate change due to their prolonged exposure. Majority (30.8%) of the respondents were having education up to 10+2 level, followed by 22.5 per cent of secondary school, 21.7 per cent were graduates, 10.8 per cent were illiterates, 7.5 per cent were primary school pass outs and 6.7 per cent had above graduate level of education qualification. Thus, it can be concluded that 94 per cent of the respondents received education and only 6 per cent of the respondents were illiterates. The possible reasons for more number of educated people might be due to their realization of the importance of education in one's life, also high contact with educated people might have motivated few of them to pursue higher education.

Table 1 also indicates that majority (58.4%) had family size of 4-7 members, 28.4 per cent had more than 7 members and 13.4 per cent were having family members less than four. The implications for the family size of between 4-8 members, and more than 7 is that there will be more hands to help in household chores and also to improve the living condition of their family. Households with large family members may be forced to divert part of the labour force to off-farm activities in order to ease the consumption pressure imposed by a large sized family.

Majority (43.4%) of them practiced agriculture with labour followed by agriculture and service (28.2%), 18.4 per cent of the farmers practiced agriculture and business, and 10 per cent of the respondents were purely dependent on agriculture only. The possible reason for majority of respondents practicing agriculture with other work might be due to the fact that most of the farmer's belonged to the category of marginal farmers having land holding <0.29 ha, so practicing agriculture alone is not sufficient for them to fulfill the needs of their family.

So far as the income earned from all the sources per year basis of the respondents was concerned, it was found that majority (48.4%) were having annual income of rupees (0.8-2.1 lakh), 34.1 per cent had annual income more than 2.1 lakh and 17.5 per cent were having annual income less than 0.8 lakh. It is inferred from the above result that majority of the respondents had medium level of income. The probable reason might be that medium and high-income groups are more enthusiastic to improve their standard of living, by engaging themselves in other economic activities as well. If the average farm income is high, the farmer can go for adaptation of new technologies.

Table 1 shows that that majority (64.7%) of the respondents had marginal land of ownership of less than (0.29 ha), 30.84 per cent had small land ownership of (0.30 - 0.72 ha) and only about 3.4 per cent of the respondents had medium land ownership of more than 0.72 ha. It can be concluded from the study that overall majority of the respondents had marginal to small sized landholding, and majority of respondents belonged to marginal category.

Table 1: Socio-economic characteristics of farmers

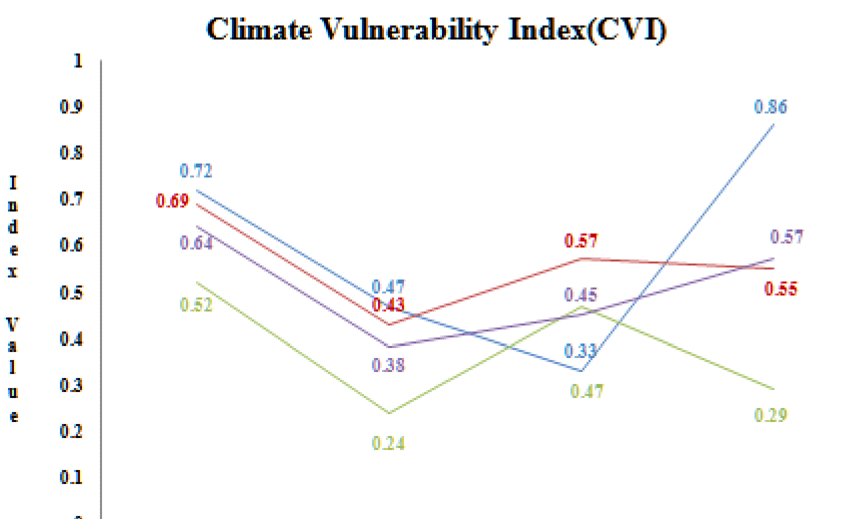
Variables	F	P
Age		
Young (<30)	32	26.5
Middle (30-55)	64	53.4
Old (>55)	24	20.0
Education Status		
Illiterate	13	10.8
Primary education	9	7.5
Secondary education	27	22.5
10+2	37	30.8
Graduate	26	21.7
Post Graduate	8	6.7
Family Size		
Small (<4)	`16	13.4
Medium (4-7)	70	58.4
Large (>7)	34	28.4
Main Occupation		
Agriculture	12	10.0
Agriculture + Labour	52	43.4
Agriculture + Business	22	18.4
Agriculture + Service	34	28.2
Annual Income		
Low income (< 0.8)	21	17.5
Medium income (0.8-2.1)	58	48.4
High income (> 2.1)	41	34.1
Land Holding		
Marginal farmers (<0.29 ha)	77	64.17
Small farmers (0.30-0.72ha)	37	30.84
Medium farmers (>0.72 ha)	4	3.40

F: Frequency, P: Percentage (%), Source: Survey

Vulnerability Assessment Index Score

Fig 1 shows the exposure, sensitivity and adaptive capacity index values of high, mid and low altitude regions of Anantnag district. The vulnerability was calculated for the farmers belonging to high, mid and low altitudinal regions of Anantnag district. It was found that the climate vulnerability index of high altitude regions, such as Pahalgam and Larnoo is 0.86, similarly for the mid altitudinal regions, such as Verinag and H. Shahabad is 0.55, and also for low altitudinal regions, such as Vessu and Anantnag, the CVI is 0.29. High altitude regions were found to be highly vulnerable in the district. The value of the vulnerability index varied from 0.86 (high altitude) to 0.29 (low altitude). The high value (0.89) of CVI of the high altitudinal regions might be because they are highly exposed and susceptible to climatic induced hazards coupled with low adaptive capacity. The results of the different indices are shown in tables 2, 3, 4 and 5.

Fig. 1



	Exposure Index Values	Sensitivity Index Values	Adaptive Capacity Values	Climate Vulnerability Index
High	0.72	0.47	0.33	0.86
Mid	0.69	0.43	0.57	0.55
Low	0.52	0.24	0.47	0.29
Mean	0.64	0.38	0.45	0.57

Table 2: Altitude-wise exposure index values

S. No.	Exposure Indicators (Rainfall and Temperature)	Variance value of indices X	Normalized values of exposure indices (N_y)	Weight of exposure (W_y)	Index of exposure indices (Wy) × (N_y)
High Altitude					
1.	Exposed to changes in the onset of rainfall	1.106	1.32	1	1.32
2.	Exposed to shift in the monthly rainfall	1.770	1.65	1	1.65
3.	Exposed to more dry spells	0.988	0.16	1	0.16
4.	Exposed to changes in the rainfall during crop growth periods	0.789	0.46	1	0.46
5.	Exposed to uneven distribution of rainfall throughout the rainy season	1.067	0.38	1	0.38
6.	Exposed to increased temperature	1.770	0.18	1	0.18
7.	Exposed to decreased temperature	0.409	1.23	1	1.23
8.	Experienced summer was getting warmer	2.346	0.9	1	0.9
9.	Noticed winter was getting warmer	0.880	0.23	1	0.23
10.	Delayed Kharif season	0.632	0.26	1	0.26
11.	Delayed Rabi season	0.252	1.2	1	1.2
Sum of Indices					7.97
Exposure Indices = Sum of indices/ no. of indicators					0.72
Mid Altitude					
1.	Exposed to changes in the onset of rainfall	1.120	0.7	1	0.7
2.	Exposed to shift in the monthly rainfall	1.630	0.52	1	0.52
3.	Exposed to more dry spells	0.232	0.21	1	0.21
4.	Exposed to changes in the rainfall during crop growth periods	0.299	0.25	1	0.25
5.	Exposed to uneven distribution of rainfall throughout the rainy season	0.285	0.25	1	0.25
6.	Exposed to increased temperature	0.205	0.24	1	0.24
7.	Exposed to decreased temperature	0.409	0.31	1	0.31
8.	Experienced summer was getting warmer	0.229	0.29	1	0.24
9.	Noticed winter was getting warmer	2.346	1.72	1	1.52

10.	Delayed Kharif season	0.680	1.68	1	1.51
11.	Delayed Rabi season	1.170	1.38	1	1.34
Sum of Indices					7.55
Exposure Indices = Sum of indices/ no. of indicators					0.69

Low Altitude					
1.	Exposed to changes in the onset of rainfall	0.252	0.89	1	0.89
2.	Exposed to shift in the monthly rainfall	0.108	1.1	1	1.1
3.	Exposed to more dry spells	0.367	0.25	1	0.25
4.	Exposed to changes in the rainfall during crop growth periods	0.066	0.23	1	0.23
5.	Exposed to uneven distribution of rainfall throughout the rainy season	0.852	0.21	1	0.21
6.	Exposed to increased temperature	1.870	0.18	1	0.18
7.	Exposed to decreased temperature	0.326	0.26	1	0.26
8.	Experienced summer was getting warmer	0.502	0.12	1	0.12
9.	Noticed winter was getting warmer	0.922	0.6	1	0.6
10.	Delayed Kharif season	0.760	0.62	1	0.62
11.	Delayed Rabi season	0.088	1.3	1	1.3
Sum of Indices					5.76
Exposure Indices = Sum of indices/ no. of indicators					0.52

Exposure index value was calculated based on the Exposure Index (EI) formula, using scores obtained by each respondent to the individual statements, i.e., under Rainfall and Temperature changes. The index value is between 0 and 1. A value near to zero reflects low level of exposure and towards one shows high level of exposure of farmers to climate change particularly rainfall and temperature changes. Data in the table reveals that the average exposure index value of farmers in the three altitude regions was 0.644. Nearly similar proportion of exposure index value was observed in high (0.72), mid (0.69) and low (0.52), altitude regions. This implies that, the majority of the farmers were highly exposed to changes in rainfall and temperature.

Table 3: Altitude-wise sensitivity index values

S. No.	Sensitivity Indicators (Socio-demographic factors, crop growth periods, inter-cultivation, harvesting and marketing activities)	Variance value of indices X	Normalized values of exposure indices (N_y)	Weight of exposure (W_y)	Index of sensitivity indices (Wy) × (N_y)
High Altitude					
1.	Climate change affects on the type of growing crop and season of sowing	0.593	1.76	0.5	0.88
2.	Less farming experience adversely affects on the crop production due to climate change	0.448	0.6	0.5	0.3
3.	More aged family members are unable to respond to the climate change situations	0.623	1.81	0.5	0.90
4.	Without subsidiary occupation have more economic crisis during climate change conditions	0.527	0.56	0.5	0.28
5.	Timely planting of crops were adversely affected by climate change	0.471	0.48	0.5	0.24
6.	More rainfall adversely affects on the applied fertilizers and pesticides which badly impact on cost of cultivation	0.497	0.49	0.5	0.24
7.	Delayed rainfall adversely affects on the germination that leads to crop loss	0.534	0.56	0.5	0.28
8.	Adverse effects of climate change decrease the crop yield	0.517	0.47	0.5	0.23
9.	Timely crop production practices were affected by climate change	0.538	1.53	0.5	0.76
10.	Climate change affects on the inter cultivation activities	0.462	0.45	0.5	0.22
11.	Timely harvesting of crops was affected by climate change	0.475	0.58	0.5	0.29
12.	Quality of the produce was affected by climate change	0.454	0.56	0.5	0.28
13.	Immediate rainfall after crop harvest affects on the availability of fodder	0.448	1.43	0.5	0.71
14.	Climate change affects farmers to sale their produce at the lower prices to fulfill the family needs	0.623	1.8	0.5	0.9
Sum of Indices					0.54
Exposure Indices = Sum of indices/ no. of indicators					0.47
Mid Altitude					
1.	Climate change affects on the type of growing crop and season of sowing	0.326	1.62	0.5	0.81
2.	Less farming experience adversely affects on the crop production due to climate change	0.537	0.53	0.5	0.26
3.	More aged family members are unable to respond to the climate change situations	0.490	0.93	0.5	0.46
4.	Without subsidiary occupation have more economic crisis during climate change conditions	0.496	0.52	0.5	0.26

5.	Timely planting of crops were adversely affected by climate change	0.449	1.48	0.5	0.74
6.	More rainfall adversely affects on the applied fertilizers and pesticides which badly impact on cost of cultivation	0.420	0.42	0.5	0.21
7.	Delayed rainfall adversely affects on the germination that leads to crop loss	0.571	0.52	0.5	0.26
8.	Adverse effects of climate change decrease the crop yield	0.457	0.5	0.5	0.25
9.	Timely crop production practices were affected by climate change	0.465	0.48	0.5	0.24
10.	Climate change affects on the inter cultivation activities	0.682	0.7	0.5	0.35
11.	Timely harvesting of crops was affected by climate change	0.558	1.52	0.5	0.76
12.	Quality of the produce was affected by climate change	0.453	0.42	0.5	0.21
13.	Immediate rainfall after crop harvest affects on the availability of fodder	0.671	1.7	0.5	0.85
14.	Climate change affects farmers to sale their produce at the lower prices to fulfill the family needs	0.527	0.8	0.5	0.4
Sum of Indices					6.07
Exposure Indices = Sum of indices/ no. of indicators					0.43
Low Altitude					
1.	Climate change affects on the type of growing crop and season of sowing	0.482	0.59	0.5	0.30
2.	Less farming experience adversely affects on the crop production due to climate change	0.224	0.37	0.5	0.19
3.	More aged family members are unable to respond to the climate change situations	0.867	0.43	0.5	0.22
4.	Without subsidiary occupation have more economic crisis during climate change conditions	0.677	0.47	0.5	0.24
5.	Timely planting of crops were adversely affected by climate change	0.147	0.52	0.5	0.26
6.	More rainfall adversely affects on the applied fertilizers and pesticides which badly impact on cost of cultivation	0.289	0.48	0.5	0.24
7.	Delayed rainfall adversely affects on the germination that leads to crop loss	0.354	0.58	0.5	0.29
8.	Adverse effects of climate change decrease the crop yield	0.714	0.48	0.5	0.24
9.	Timely crop production practices were affected by climate change	0.811	0.5	0.5	0.25
10.	Climate change affects on the inter cultivation activities	0.455	0.45	0.5	0.23
11.	Timely harvesting of crops was affected by climate change	0.574	0.48	0.5	0.24

12.	Quality of the produce was affected by climate change	0.433	0.39	0.5	0.20
13.	Immediate rainfall after crop harvest affects on the availability of fodder	0.822	0.47	0.5	0.24
14.	Climate change affects farmers to sale their produce at the lower prices to fulfill the family needs	0.368	0.43	0.5	0.22
Sum of Indices					3.32
Exposure Indices = Sum of indices/ no. of indicators					0.24

Sensitivity index value was calculated based on the components wise scores obtained, due to adverse effects of climate change on socio demographic factors and other activities on crop production practices. The index values obtained was presented in the Table 20 and it implies that, the index value is between 0 and 1. As value near to zero reflects low level of sensitivity and towards one explains the high level of sensitivity of farmers to climate change. Data in the table reveals that, the average sensitivity index values for the three altitude regions was 0.38 and maximum sensitivity index value was observed in high altitude regions (0.47) followed by mid altitude regions (0.43) and then low altitude regions (0.24). This implies that, the majority of the farmers were highly sensitive, i.e., adversely affected by climate change.

Table 4: Altitude-wise adaptive capacity index values

S. No.	Adaptive Capacity Indicators (Management of resources and soil & water conservation)	Variance value of indices X	Normalized values of exposure indices (N_y)	Weight of exposure (W_y)	Index of adaptive capacity indices (Wy) × (N_y)
High Altitude					
1.	Changed planting dates to avoid crop loss	1.006	1.86	0.5	0.93
2.	Adapted to grow drought resistant crops/ varieties	1.366	0.67	0.5	0.34
3.	Adapted timely application of plant nutrients	1.001	0.48	0.5	0.24
4.	Adapted subsidiary activities- poultry, livestock, etc to overcome the ill-effects of climate shock	1.485	0.38	0.5	0.19
5.	Adapted soil and water conservation practices	1.098	0.27	0.5	0.14
6.	Constructed farm ponds and water harvesting scheme to enhance the water source	1.508	0.24	0.5	0.12
Sum of Indices					1.95
Exposure Indices = Sum of indices/ no. of indicators					0.33

Mid Altitude					
1.	Changed planting dates to avoid crop loss	1.466	0.51	0.5	0.25
2.	Adapted to grow drought resistant crops/ varieties	1.560	1.57	0.5	0.78
3.	Adapted timely application of plant nutrients	1.814	0.94	0.5	0.47
4.	Adapted subsidiary activities- poultry, livestock, etc to overcome the ill-effects of climate shock	1.664	1.49	0.5	0.74
5.	Adapted soil and water conservation practices	1.819	1.66	0.5	0.83
6.	Constructed farm ponds and water harvesting scheme to enhance the water source	1.612	0.7	0.5	0.35
Sum of Indices				3.43	
Exposure Indices = Sum of indices/ no. of indicators				0.57	

Low Altitude					
1.	Changed planting dates to avoid crop loss	1.382	0.85	0.5	0.42
2.	Adapted to grow drought resistant crops/ varieties	1.620	1.05	0.5	0.52
3.	Adapted timely application of plant nutrients	1.741	1.2	0.5	0.6
4.	Adapted subsidiary activities- poultry, livestock, etc to overcome the ill-effects of climate shock	1.224	1.34	0.5	0.67
5.	Adapted soil & water conservation practices	1.935	0.94	0.5	0.47
6.	Constructed farm ponds and water harvesting scheme to enhance the water source	1.448	0.3	0.5	0.15
Sum of Indices					2.84
Exposure Indices = Sum of indices/ no. of indicators					0.47

Adaptive capacity index value was calculated based on the components wise scores obtained under adaptive capacity of farmers. The index value obtained was presented in the Table 27 and Fig 16 and it implies that, the index value ranged between 0 and 1. A value near to zero reflects low level of adaptive capacity and towards one explains the high level of adaptive capacity of farmers to climate change. Data in the table revealed that the mean Adaptive Capacity Index value of the study area was 0.45. In case of three altitude regions, interestingly the mid altitude region was having the highest adaptive capacity (0.57), followed by the regions of low altitude (0.47), and then the regions of high altitude (0.33), which implies that the farmers of high altitude regions, although being highly exposed and sensitive to climate change, have low adaptive capacity in comparison to mid and low altitude regions.

Table 5: Altitude-wise exposure, sensitivity and adaptive capacity index values

S. No.	Altitude Region	Exposure Index Values	Sensitivity Index Values	Adaptive CapacityIndex Values	Climate Vulnerability Index
1.	High (Pahalgam & Larnoo)	0.72	0.47	0.33	0.86
2.	Mid (H. Shahabad & Verinag)	0.69	0.43	0.57	0.55
3.	Low (Vessu & Anantnag)	0.52	0.24	0.47	0.29

After assessing the Exposure, Sensitivity and Adaptive Capacity Indices of the farmers with respect to the different altitude regions (high, mid and low) they belong, a cumulative index value for all farmers of each region were worked out, which showed that the farmers of high altitude regions had 0.72, 0.47 and 0.33, farmers of mid altitude regions had 0.69, 0.43 and 0.57, and the farmers of low altitude regions had 0.52, 0.24 and 0.47 of exposure index, sensitivity, and adaptive capacity Indices, respectively. In general, irrespective of the altitude, all farmers had more or less equal level of exposure, sensitivity and adaptive capacity Index. However, with respect to exposure, farmers of high altitude regions were highly exposed to the climate changes. In case of sensitivity, the farmers of low altitude regions were least sensitive to the changes in the climate and had the Index value of 0.24. Furthermore, in Adaptive Capacity, farmers of mid altitude regions had the index value of 0.57 which is better than others marginally. The level of farmer's exposure, sensitivity and adaptive capacity to climate change would reflect in their vulnerability to climate change. Finally, by using the index value of exposure, sensitivity and adaptive capacity of farmers of each region, vulnerability index was worked out. It showed that 0.86, 0.55 and 0.29 were the Climate Vulnerability Index (CVI) of farmers of high, mid and low altitude regions, respectively. The overall CVI value of all the three regions was 0.57. As per the result, all these three regions were severely vulnerable to climate change, since the index value was nearer to 0.6.

CONCLUSIONS AND POLICY IMPLICATIONS

The unpredictable nature of the weather serves as a compelling justification for strengthening community and ecosystem's resilience so that they can better withstand sudden change. In the study area, especially with regard to water resources, rising temperatures and dwindling precipitation, already started to have detrimental social effects. Farmer's perception, exposure and vulnerability must all be taken into account when implementing policies to mitigate these negative effects. According to the results of study, farmers of the Anantnag district were aware of the fact that the climate is changing and these changes are having an adverse effect on their way of life. As a result, if traditional water resources were restored and maintained, farmers would be more resilient during dry spells. Construction of water harvesting tanks, one of the technologies for managing water scarcity, can be done to provide supplemental irrigation. According to the results of the study, farmers of the Anantnag district were aware of the fact that the climate is changing and these changes are having adverse effect on their way of life. In general, irrespective of the altitude, all farmers had more or less equal level of exposure, sensitivity and adaptive capacity Index. As a result, if traditional water resources are restored and maintained, farmers will be more resilient during dry spells. Construction of water harvesting tanks, one of the technologies for managing water scarcity, can be done to provide supplemental irrigation. Following policy suggestions are put forth on the basis of the study:

- Climate change has affected farmers in the study area, with most having moderate to low adaptive capacity. Policymakers and development departments should implement programs to boost farming confidence and make it a lucrative profession.
- Improving early warning systems and raising public awareness about climate change is crucial to reduce its vulnerability in the near future.
- Some of the suggestions offered by the farmers to mitigate adverse effect of climate change were government measures to fill water bodies, provide subsidies and compensation for crop failures, ensure timely delivery of production inputs, and raise awareness about climate change and adaptation measures, and provide early warnings about environmental changes.

These suggestions need to be considered in government's development programmes to reduce farmers'vulnerability to climate change.

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