J Krishi Vigyan 2023, 11 (2) : 28-35 DOI : 10.5958/2349-4433.2023.00004.1

Climate Change Vulnerability in Agriculture on Rural Farmers

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ABSTRACT

The impact of climate change in agriculture depends on the level of vulnerability. This study shows the level of vulnerability in agriculture on rural farmers due to climate change and its variability in the Cooch Behar district of West Bengal. The approach estimates the vulnerabilities index in terms of exposure, sensitivity and adaptive capacity. The data are based on a survey of 200 farm households through a personal interview, complemented with secondary data on temperature, relative humidity and rainfall. Results of the study showed that relative exposure of the study area was 0.62; whereas the average sensitivity value was 0.33 and the aggregated adaptive capacity was 0.28. As a result, the study area showed a considerable subsistence level of vulnerability. Results show that Tufanganj block was the most exposed region to climate change vulnerability in respect of flood than Cooch Behar block.

Key Words: Agriculture, Adaptive capacity Climate, Exposure, Sensitivity, Vulnerability.

INTRODUCTION

India, being a developing country, is also going to be majorly impacted by climate change. The impact will be more profound because of the heavy dependence on agriculture by a large percentage of the population. Climate change and variability pose a serious threat to the agriculture sector as the sector is highly volatile towards any change in climatic parameters. Climate change impacts are observed directly on agriculture and indirectly impacted on social aspects such as poverty, education, pollution and health. Morton (2004) noted that some of the most important impacts of climate change in developing countries will be felt by the category of people, mostly referred to as smallholder farmers. India is predominantly on a smallholder in agriculture and 90 per cent of the farmers have their farm holdings being less than 2 ha in size and producing under rain-fed conditions. Vulnerability to climate change depends on the rate of change of the climate and the extent to which a system is exposed, its sensitivity, and adaptation capacity (IPCC 2007; FAO 2009; UNEP 2009).

Exposure's threats is without delay linked to the fame of human settlements and the ecosystems on which they depend on the ocean and the affected regions (Smit and Wandel, 2006). Sensitivity is more or less equivalent to exposure and its depends on the number of people, their infrastructure and the ecosystems exposed to the hazard, and level of dependendent on natural resources of the considered population (Tuler *et al,* 2008). Adaptive capacity for human populations is dependent on a range of factors related to access to assets. The capacity danger because of weather trade and variability does not rely most effective on climatic parameters however also varies as according to the inherent vulnerability of the arena itself. The risk due to climate change and variability is not best a characteristic of climatic variability and change however also equally a function of the vulnerability of the elements, which might be uncovered to climate exchange threat.

Agriculture is the arena most susceptible to climate exchange because of its high dependence on weather and weather situations. Weather alternate is

the primary challenge for agriculture, meals security and rural livelihoods for hundreds of thousands of human beings in India. Appropriate knowledge application is critical for mitigating the adverse effects of climate change(Saravanan *et al,* 2021). Agricultural structures which might be currently problem to intense climatic inter-annual variability (drought, flood, storms, and many others.) are probable to end up even extra prone beneath the maximum usually predicted scenarios of climate alternate (elevated temperatures, increased rainfall variability). This sector is specially susceptible to gift-day climate variability. Hence, an attempt was made to investigate the vulnerability to climate alternate inside the Cooch Behar district of West Bengal.

MATERIALS AND METHODS

To research with a good methodological perspective multi-stage, purposive and random sampling procedures were followed in the present study. The Cooch Behar district of West Bengal was selected for the study purposively. In the district Cooch Behar, the blocks Cooch Behar – II and Tufanganj –I was purposively selected due to the availability of diversified and innovative farmers for accessing the information services related to climate change in agriculture and allied sectors. Four villages namely Chilakhana and Maruganj under Tufanganj –I block and Singimari Pachimpar and Pedbhata Chandanchowra villages under Cooch Behar – II block were randomly selected to carry out this study. According to the information received from the village, Singimari pachimpar has 355 numbers of households, Pedbhata chandachowra has 357 numbers of households, Chilakhana has 351 households and Maruganj has 365 numbers of the household. An exhaustive list of agricultural producers from each household was prepared with the help of the local people, local administrators (*Panchayat* Pradhan), block-level agriculture extension officials and Krishi Vigyan Kendra (KVK), Cooch Behar. So from the exhaustive list, 50 numbers of agricultural producers from each village were randomly selected for the present study to constitute the total 200 numbers of agricultural producer's respondents. The approach estimates the vulnerabilities index in terms of exposure, sensitivity and adaptive capacity.

Exposure

It is operationalized as risks that have a probability to impact on assets and livelihoods and measured by frequency and severity of natural disasters over the last 10 years based on the perception of the community members; and variability in climatic parameters over the last 10 years or more (Standard deviation was calculated on monthly basis). Frequency and severity of natural disasters *viz.,* landslide, earthquake, flood, drought and cyclone over last 10 years were measured. Variability in climatic parameters *viz.,* average monthly minimum temperature, average monthly maximum temperature and average monthly precipitation over the last 10 years or more were represented by the standard deviation of these indicators over the last 10 years or more.

Sensitivity

It is operationalized as the susceptibility of assets and household conditions to previous risks. The assets and household conditions which may be directly affected by climate extremes like the nature of housing, sanitation, drinking water facilities and food access were taken into consideration. Sensitivity creates a feeling of negative impact, measured the contributing variables with a positively directional scale; viz. more the scale value, less the sensitivity(IPCC, 2007). So, the sensitivity score was obtained by deducting the aggregated score from a standard value (1.00 in the present study). Percentage of houses made of wood or brick concrete, percentage of families having latrines, percentage of families having safe drinking water (connected with pipeline or deep tube well) and percentage of families having square meal per day throughout the year was the indicator variables for housing sensitivity, sanitation sensitivity, drinking water sensitivity and food sensitivity respectively.

Adaptive capacity

It is the capability and situation of the community which directly or indirectly resists risks or creates resilience to risks. It is represented by the aggregated values of the literacy level of the community (per cent of household heads having at least primary education), occupational stability in the community (per cent of families having a stable occupation), access to a social organization (per cent of families having membership of social organizations like a youth club, farmers' club, self-help groups, etc.), the economic stability of the community (per cent of families having surplus income i.e. saving after expenditure) and community skill on disaster/ climate risk management (percentage of families of which at least one member has undergone training on disaster/climate risk management).

Data Processing and Aggregation

The present study used an index-based approach of measurement of vulnerability which requires the development of indices with the help of many sub-indices and variables. This method required the processing of data. Different variables were measured with different types of scales (in percentage, numbers, or scores). So, different scale values were transformed to unitary values, wherever necessary by the following formula

So, the transformed value will lie between 0 and 1.

Value of exposure, sensitivity and adaptive capacity was taken as the average of transformed values of all the indicator variables under each component.

Climate change vulnerability was calculated by Vulnerability Index (VI). The VI was measured as:

$VI = (E\text{-}AC) \times S$

Where E = Exposure; AC = Adaptive Capacity and S = Sensitivity.

The value of VI varies from -1 (least vulnerable) to +1 (most vulnerable) and is grouped as:

Sustainable (VI ranges from−1 to−0.34), Subsistence ((VI ranges from−0.33 to 0.33) and Vulnerable ((VI ranges from 0.34 to 1).

The data were based on a survey of 200 farm households through a personal interview, complemented with secondary data on temperature, relative humidity and rainfall for 10 years since from 2010 to 2019. Different statistical tools such as frequency, percentage and Chi-square etc are used for analyzed the collected data.

RESULTS AND DISCUSSION

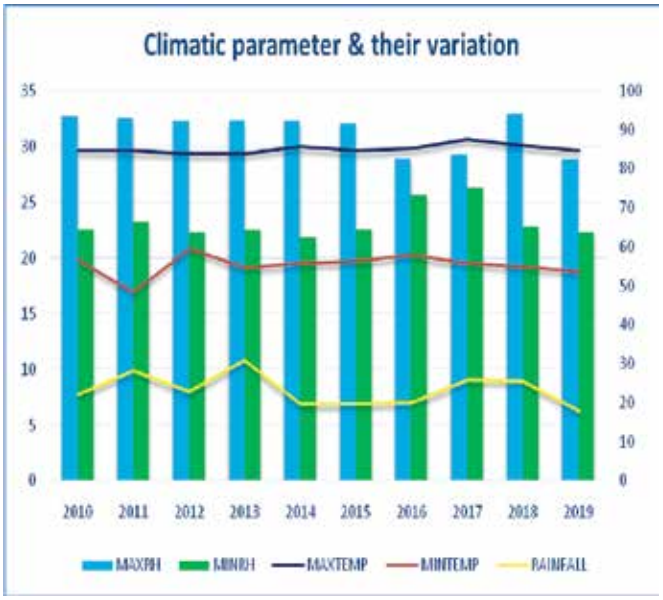

Fig 1. **Variation of maximum and minimum temperature, relative humidity and rainfall of Cooch Behar district (last 10 years)**

Source: Deputy Director of Agriculture, Cooch Behar

The above figure 1. shows that there is a little rise in average maximum temperature in the year 2014 and 2017, whereas the average minimum temperature rises in the year 2012. The average maximum relative humidity rises in the year 2010, 2011 and 2018, whereas the minimum relative humidity risen in the years 2016 and 2017. There is a lot of fluctuation in the rainfall and the highest rainfall was observed in 2013.

Table 1. Variability in climatic parameters (Monthly) of exposure to vulnerability for last 10 years since from 2010-2019 of a selected block of Cooch Behar district

Month	Actual Value					Transformed Value				
	Max. Temp	Min. Temp	Max. Humid	Min. Humid.	Rainfall	Max. Temp	Min. Temp	Max. Humid	Min. Humid.	Rainfall
January	1.36	0.67	2.54	10.31	0.22	1.00	0.00	0.00	1.00	0.02
February	1.05	4.07	5.23	7.95	0.26	0.66	1.00	0.46	0.68	0.02
March	0.69	0.84	8.34	5.34	1.22	0.25	0.05	1.00	0.33	0.13
April	1.09	0.92	5.80	7.37	2.28	0.70	0.07	0.56	0.61	0.24
May	0.46	1.52	3.16	2.84	2.68	0.00	0.25	0.11	0.00	0.29
June	0.79	2.02	2.82	3.06	8.12	0.37	0.40	0.05	0.03	0.89
July	0.71	2.27	2.87	3.11	9.10	0.28	0.47	0.06	0.04	1.00
August	0.92	2.25	3.34	3.82	7.23	0.51	0.47	0.14	0.13	0.79
September	1.10	2.51	4.77	3.79	4.05	0.71	0.54	0.38	0.13	0.44
October	0.74	1.24	7.28	4.26	3.42	0.31	0.17	0.82	0.19	0.37
November	0.68	2.23	7.43	7.76	0.12	0.24	0.46	0.84	0.66	0.01
December	1.17	2.41	7.79	8.35	0.07	0.79	0.51	0.91	0.74	0.00
Average	0.85	2.02	5.35	5.24	3.50	0.58	0.44	0.53	0.45	0.42

Table 1 indicates the variability climatic indicators to exposure of the study site. The above tables show the actual value and transformed values of different indicators under exposure related to climate change vulnerability.

The data (Table 2) show different indicators of exposure to vulnerability and its transformed value. Aggregating all the exposure factors, it was seen that the exposure value is 0.62 which indicates that the study area has a high level of climate change vulnerability in terms of exposure. A study was conducted by Botero D G and Salinas A B(2013) on assessing farmers' vulnerability to climate change: a case study in Karnataka, India and recorded that the vulnerability exposure contributing factor is 0.69.

The values(Table 3) show the different indicators of adaptive capacity to vulnerability and its transformed value. Aggregating all the adaptive capacity factors, it was seen that the adaptive capacity value is 0.28 which indicates that the study area has a medium level of climate change vulnerability in terms of adaptive capacity.

The different indicators of sensitivity to vulnerability and its transformed value. Aggregating all the sensitivity factors, it was seen that the sensitivity value is 0.33 which indicates that the study area has a medium level of climate change vulnerability in terms of exposure.

The Vulnerability Index (VI) advocated by Hann et al.(2009) and aggregating of all the components such as exposure, sensitivity and adaptive capacity, it was found that the vulnerability index of the study area is 0.11 which indicates a subsistence level of vulnerability. Awolala and Ajibefun (2015) was conducted a study at Nigeria on rice farmers and the results of vulnerability index was found is 0.11

Blockwise distribution of vulnerability component

The above (Table 6) shows that 96 per cent of the respondent have a low level of vulnerability to exposure due to climate change followed by 90 per cent of the respondent having a high level of vulnerability to exposure. The results also indicate that block Tufanganj is high-level exposure than

Table 2. Various components of exposure to vulnerability and its transformed value

Component	Actual value	Transformed Value
Monthly average maximum temperature variability *(°C)* during last 10 years	0.85	0.58
Monthly average minimum temperature variability *(°C)* during last 10 years	2.02	0.44
Monthly average maximum Humid variability(%)during last 10 years	5.35	0.53
Monthly average minimum humid variability(%)during last 10 years	5.24	0.45
Monthly average rainfall variability(mm) during last 10 years	3.50	0.42
Occurred number of flood, drought and hailstorm during last 10 years	6.50	0.5
Occurred land degradation by climate-related extremes and disaster during past 10 years	7.75	0.55
The fertility status of the soil is poor	0.96	0.96
Do not have a consistent water supply	0.98	0.98
Having dependent members in family (age < 14 yrs and >65yrs)	2.90	0.41
Water scarcity experienced in a productive season	0.99	0.99
Vulnerability exposure based on the transformed value		0.62

Cooch Behar due to climate change. From the value of the Pearson chi-square test ($\varkappa^2$ = 188.571 and *P*=0.00), it shows that it shows that exposure is significant at a 1% level of significance in respect of vulnerability to exposure

The above table 7 shows that 78 per cent of the respondent have a low level of vulnerability to adaptive capacity due to climate change followed by 68 per cent of the respondent having a high level of vulnerability to adaptive capacity. The results also indicate that block Cooch Behar has is high-level adaptive capacity than Tufanganj due to climate change. The value of the Pearson chi-square test ($\varkappa^2$ = 78.86 and *P*=0.00), shows that adaptive capacities are significant at a 1% level of significance in respect of vulnerability to adaptive capacity.

The above table 8 shows that majority of the respondent(104) has a medium level of vulnerability to sensitivity due to climate change followed by 49 per cent of the respondent having a high level of vulnerability to sensitivity. The results also indicate that block Tufanganj is high-level sensitivity than Cooch Behar due to climate change. From the value of the Pearson chi-square test ($\varkappa^2$ = 5.001 and *P*=0.082), it shows that it shows that sensitivity is significant at a 5% level of significance in respect of vulnerability to sensitivity.

CONCLUSION

The study exhibits that the look at area is under subsistence stage of vulnerability magnificence, this means that any minor alternate within the strength of exposure or sensitivity or weak point in adaptive capacity may force the rural farmers to be susceptible. Even though the village Maruganj is slightly more vulnerable in comparison with the opposite three villages. Based at the findings of the prevailing look at, it is able to be said that the study region has a fine stage of adaptive ability but extra impetus must take delivery of to reduce sensitivity by secure housing infrastructural development, food safety and sanitation improvement.Efforts to reduce livelihood vulnerability in rural farmers

Table 3. Different indicators of the component adaptive capacity to vulnerability and its transformed value.

Sr. No.	Indicator	Actual value (in per cent)	Transformed value
1.	Access to input subsidies	87.5	0.44
2.	Access to good road	86.0	0.43
3.	Access to public transport	98.5	0.49
4.	Owned livestock or poultry	70.0	0.35
5.	Owned farming cultivated lands	95.5	0.48
6.	Owned grain cribs	62.5	0.31
7.	Access to radio/TV services	77.5	0.39
8.	Access to cooking stove	81.5	0.41
9.	Use of rainwater harvesting structure	25.5	0.13
10.	Access to improved seeds/ HYV	92.0	0.46
11.	A family member has taken any kind of vocational training	11.5	0.06
12.	Family members are members of any cooperative society	7.0	0.04
13.	Practice crop rotation	93.0	0.47
14.	Practice crop diversification	54.0	0.27
15.	Access to financial services to any financial institution	36.5	0.18
16.	Family member working outside the village	16.0	0.08
17.	Access to the nearest health center	99.0	0.50
18.	Had higher education facility nearby	97.0	0.49
19.	Access to mobile service	92.5	0.46
20.	Access to climate change information	30.0	0.15
21.	Use of drought/ flood tolerant variety	74.0	0.37
22.	Use of pest/disease resistance variety	37.5	0.19
23.	The practice of Soil testing	34.0	0.17
24.	Application of limited dose of fertilizers	44.0	0.22
25.	Good linkage with extension personal	38.5	0.19
26.	Access to market information	85.5	0.43
27.	Access to veterinary clinic	77.0	0.39
28.	Owned improved farm power	29.0	0.15
29.	Having sufficient savings to cope with an adverse situation	42.5	0.21
30.	Participated in demonstration programmes	44.0	0.22
31.	Participated in training programmes	65.5	0.33
32.	Received good price of produce	33.0	0.17
33.	Use of crop insurance	9.5	0.05
34.	Use of livestock insurance	8.5	0.04
35.	Vulnerability adaptive capacity based on the transformed value		0.28

Table 4. Various indicators of the component of sensitivity and its transformed value.

Sr. No.	Indicator	Actual value (%)	Transformed value
1.	Practicing rain-fed rice farming	97	0.49
2.	Productive resources i.e. land/water /animals affected by adverse climate in last 10 years	99.5	0.50
3.	No access to safe drinking water	92.5	0.46
4.	Do not have a pucca housing system	45.5	0.23
5.	Do not have pucca sanitation/toilet facility	49.5	0.25
6.	A family member had an absence from work or school due to illness in the past 6 month	66	0.33
7.	Family members is infected by a communicable disease in the past 6 month	59.5	0.30
8.	Face the problems of firewood scarcity in around the year	78.5	0.39
9.	Collect water directly from rivers, streams, ponds etc.	67	0.34
10.	Had loan/debt from financial institution/ friend etc.	30	0.15
11.	Conflict on water (irrigation/ drinking) in the village last year.	41.5	0.21
12.	Death/ injury of a family member due to climate-related disaster i.e. cyclone, earthquake etc. last year.	1	0.01
13.	Change in yield of crops	92	0.46
14.	More infestation of pests and diseases	96.5	0.48
15.	Vulnerability sensitivity based on the transformed value		0.33

Table 5. Climate change Vulnerability Index of the study area.

Exposure	Adaptive capacity	Sensitivity	Vulnerability Index
0.62	0.28	0.33	**0.11**

Table 6. Block-wise categorization of the extent of Exposure. (Exponent is in percent)

Category	Blocks		Total respondent	Statistical hypothesis
	Tufanganj-1	Cooch Behar-2		
Low	0.00	96.00	96.00	$\varkappa^2$ = 188.571* (*P*=0.000)
Medium	10.00	4.00	14.00	
High	90.00	0.00	90.00	

Table 7. Block-wise categorization of the extent of adaptive capacity. *(Exponent is in percent)*

Categories	Blocks		Total respondent	Statistical hypothesis
	Tufanganj-1	Cooch Behar-2		
Low	68	10	78	$\varkappa^2$ =78.862* (*P*=0.000)
Medium	22	32	54	
High	10	58	68	

Table 8. Block-wise categorization of the extent of Sensitivity. *(Exponent is in per cent)*

Categories	Blocks		Total respondent	Statistical hypothesis
	Tufanganj-1	Cooch Behar-2		
Low	17	30	47	χ^2 =5.001* (*P*=0.082)
Medium	58	46	104	
High	25	24	49	
Total	100.00	100.00	200	

by using the improvement businesses have to be initiated/strengthened to simultaneously tackle publicity, sensitivity, and adaptive capability for the well-being of these rural farmers.

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Received on 16/1/2023 *Accepted on 13/4/2023*