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Assessment of Farmer Vulnerability and Adaptation to Climate Change in Sunderbans Ecosystem

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ABSTRACT

Climate change has emerged as one of the most urgent issues of investigation and deliberation among people of walks of life be it statesmen, planners and policy makers; climate, environmental and biological scientists; or actors, activists and academicians. The study was conducted in 24-South pargana district of West Bnegal to assess the level of vulnerability of farming community and their capability and strategy for adaptation to climate change. With the calculated vulnerability index, a majority of the respondents (about 47 per cent) were found in highly vulnerable. Group followed by about 37 per cent in vulnerable group; while about 17 per cent in moderately vulnerable group. Innovativeness, mass media source of information, education and knowledge of technology, occupation of agriculture, social participation, scientific orientation and risk orientation were identified as predictor variables for vulnerability index. Extreme poverty, by lack of education and proper knowledge about adaptive practices, lack of information facilities with forecasting and early warning system, lack of awareness about climate change issues, lack of aptitude towards resource conservation and adaptation needs were reported as the major constraints by the farmers in their adaptation endeavours.

Across the globe there is growing recognition of climate change as the most threatening challenge of the present era and concerted efforts for adaptation and mitigation are being contemplated and put into action. Several global studies have indicated that India is particularly vulnerable to climate change, and is likely to suffer with damage to agriculture, food and water security, human health and cattle populations.

Like most other developing countries, people in India are dependent to a large extent on its natural resources for livelihood and economy. Any adverse impacts on these natural resources will have repercussion on the nation's livelihood security and economy and widen the gap between the rich and the poor. Though research initiatives are afoot in physical and biological sciences, it is imperative to assess the climatic change from socio-economic perspective to prepare a roadmap for capacity building of people for effective adaptation and mitigation of adverse effects for sustainable livelihood and development. Keeping in view the importance of socio-economic investigation in this area, the present study was conducted to analyze farmers vulnerability to climate change and their adaptation strategy.

METHODOLOGY

The study was conducted in coastal ecosystems of West Bengal as fourth assessment report of IPCC mentions that coastal belts are more prone to devastating impact of climate change. With random sampling 120 farmers were selected drawing 20 farmers from each of six villages purposively selected from two blocks (3 villages from each block) of 24 South Pargana district. Primary data were collected with schedule based personal interviews. The collected data were subjected to statistical analysis using SPSS package.

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Drawing from the approaches of TERl (2003) and UNDP (2002), a composite vulnerability index was worked out and respondents were grouped under the categories of highly vulnerable, vulnerable, moderately vulnerable and non-vulnerable. For each component of vulnerability (awareness about consequences of climate change, perception and attitude towards climate change and adaptation orientation, possession of knowledge and skills about adaptation technologies, social cohesiveness, possession of physical resources, and value orientation like fatalism and egalitarianism) sub-indices were worked out. The values of each indicator were normalized to the range of values in the data set by applying the following formula :

Index value = (Actual value – Minimum value)/ (Maximum value – Minimum value)

For the indicator with negative connotation, index value was reversed (1- index value). The overall index was formed from weighted average of the sub-indices, with weights derived from theoretical understanding. The aggregated figure ranged from 0 to 1, where 0 signified highest level of vulnerability. The respective weights for sub-indices were drawn from literature and experts' opinion. The overall equation for the model employed for the study was:

$$VI = \boxtimes (I_i * W_i)$$

Ii = Sub- index and W_i = Weighted of the sub-index

$$VI = I_1 * 12.5 + I_2 * 7 + I_3 * 6 + I_4 * 5.5 + I_5 * 4.5 + I_6 * 17 + I_7 * 16.5 + I_8 * 9 + I_9 * 22$$

I_1 : Awareness

I_2 : Perception

I_3 : Attitude

I_4 : Fatalism

I_5 : Egalitarianism

I_6 : Knowledge of adaptation practices

I_7 : Skills in adaptation practices

I_8 : Social cohesiveness

I_9 : Physical resources

Awareness of the respondents about climate change was measured with their responses on three point continuum of fully aware, somewhat aware and not aware at all with corresponding weightage of three, two and one respectively to a set of statements related to conceptual and implication domains of climate change. Also the modified 'bad consequence' scale of O'Conor et al (1999) was used to assess the level of awareness about consequences of climate change. Individual's perception about climate change was measured by using the modified scale of Leiserowitz (2006). Attitude towards environment and climate change measured by the modified scale of DEFRA (2007). Value orientation was measured by taking into consideration two parameter-fatalism and egalitarianism by using the modified scale of Leiserowitz (2006). Innovativeness was operationalized as socio- psychological orientation of an individual to get linked or closely associated with change, adopting innovative ideas and practices. Modified scale of Prasad (1983) was used to measure the innovativeness. Economic motivation was measured with the help of the economic motivation scale of Supe (1969).

RESULTS AND DISCUSSION

The definition and description of various variables adopted in qualification of vulnerability index as well as identifying its predictors are presented in Table 1.

Table 1. Definition and descriptive statistics of variables

Variables	Description	Mean	S.D.
Awareness (I_1)	Awareness of farmers about climate change measured with index computed on scale of 1-5	2.1567	.5529
Perception (I_2)	Perception of farmers about climate change measured with index computed on scale of 1-5	3.1486	1.0118

Attitude (I_3)	Attitude of farmers towards climate change measured with index computed on scale of 1-5	3.363	.2937
Value–orientation (Fatalism) (I_4)	Value orientation of fatalism about climate change measured with index computed on scale of 1-5	2.8278	1.395
Value–orientation (Egalitarianism) (I_5)	Value orientation of egalitarianism about climate change measured with index computed on scale of 1-5	4.171	.4405
Knowledge of adaptation practices (I_6)	Number of correct answer about adaptation practices (If correct- 1, Incorrect -0)	.3368	.2419
Skills of adaptation practices (I_7)	Number of correct answer about skills related to adaptation practices (If correct-1, Incorrect-0)	1.5639	.2439
Social cohesiveness(I_8)	Sociometry index	.4481	.1048
Physical resources (I_9)	Number of assets possessed	20.9	6.8445
Annual income	Net income in Rupees earned annually; and categorized as:Very low–1; Low-2; Medium-3; High-4; and very High-5	2.1500	1.2137
Education	Farmer's education level; If illiterate-1, Primary-2, High school-3, Collage-4	2.0417	.9649
Occupation	Score pattern: If Farming as main occupation-1; Farming as main occupation and fishery as secondary occupation-2; Farming as main occupation and dairy as subsidiary occupation-3; Sericulture as major occupation-4; and Fishery as main occupation-5	1.4667	.8089
Size of holding	Scoring pattern: If Marginal farmer-1; Small farmer-2; Medium farmer-3; Large farmer-4	2.3250	1.4329
Family type	Scoring pattern as: If nuclear-1; Joint-2	1.7333	.4441
Personal localite communication channel	Index worked out on scale of 1-4	2.5444	.3815
Social participation	Membership in farmer's organization/association; If a non-member-1, member-2	.7250	.4484
Scientific orientation	Index worked out on scale of 1-5	2.5778	1.2372
Extension contact	Average number of contact with extension agent	1.5704	0.2227
Economic motivation	Index worked out on scale of 1-5	2.6500	.9820
Innovativeness	Index worked out on scale of 0-2	1.2810	.4375
Mass media source of information	Index worked out on scale of 1-4	1.6667	.4080
Risk orientation	Index worked out on scale of 1-5	2.7056	1.0485

Vulnerability to climate change

The term vulnerability has its origin in the natural hazards and food security literature, and now being popularly used in climate change impact assessment studies. Blaikie (1994) describes vulnerability as the characteristics of a person or a group to anticipate, cope, resist and recover from the impact of a natural hazard, while for Chambers (1989), vulnerability represents the ability or not to modify the impacts of disaster and the means to cushion risks. On a national level, vulnerability manifests itself in poorer countries due to a lack of resources and capacity to respond. At the community level, class, caste, gender, ethnicity, age, level of education and access to resources all determine vulnerability (Blaike 1994, IPCC 2001). The IPPC Second Report mentioned that the vulnerability of a system increases as the adaptive capacity decreases, highlighting an inverse relationship with each other. Drawing from above relationship vulnerability assessment needs to include the indicators of adaptive capacity like technology, knowledge, wealth, and socio- economic attributes. The IPCC Working Group II, Third Assessment report defines adaptive capacity as a function of factors related to wealth, technology, education, information, skills, infrastructure, access to resources, and determinants of adaptive capacity as indicators for vulnerability assessment. For the present study 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 dimensions of individual (attitudinal, knowledge and skills), social (interconnectedness and cohesiveness), availability of physical resources and other livelihood support systems; an attempt was made to develop an index to measure vulnerability of sample respondents.

It is evident from the table 2 that a majority of the respondents (about 47 percent) were in highly vulnerable group followed by about 37 percent in vulnerable group, while about 17 percent were in moderately vulnerable group. The farmers in the area largely having marginal land holding, having lack of knowledge and skill about adaptation technology and having very high training needs in various areas of adaptation technology could be the factors for their vulnerability. Adequate training programmes in area of adaptation technology need to be organized besides launch of social protection measures to empower them for better preparedness and adaptation technology need to be organized besides launch of social protection measures to empower them for better preparedness and adaptation to the consequences of climate change.

Table 2. Distribution of the farmers according to their level of vulnerability

(N= 120)

Vulnerability Index Intervals	Frequency	Percentage
Highly Vulnerable (Less than 0.428)	56	46.67
Vulnerable (0.428–0.571)	44	36.67
Moderately Vulnerable (0.571 and above)	20	16.67

Mean: 0.456 and SD: 0.1131

Table 3. Regression Coefficients

Parameter Estimates						
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t value**	**Pr > ? t ?**	**Standardized Estimate**
Intercept	1	0.24847	0.08666	2.87	0.0050	0
Annual Income	1	0.00000306	0.00000257	1.19	0.2366	0.22292
Size of land holding	1	0.00844	0.00577	1.46	0.1468	0.25043
Gender	1	0.03124	0.03333	0.94	0.3508	0.08228
Level of education	1	0.03127	0.01118	2.80	0.0062**	0.28634
Family type	1	0.00393	0.02308	0.17	0.8651	0.01657
Occupation (Agriculture)	1	0.08342	0.03466	2.41	0.0179*	0.35156
Occupation	1	0.12242	0.05723	2.14	0.0348*	0.29101
Social participation	1	0.04988	0.02177	2.29	0.0239*	0.21225
Personal localite communication channel	1	0.00178	0.02081	0.09	0.9320	0.00644
Extension contact	1	-0.00837	0.00459	-1.82	0.0711	-0.15266
Mass media source of communication	1	-0.10540	0.03014	-3.50	0.0007***	-0.40812
Economic motivation	1	0.02122	0.01440	1.47	0.1435	0.19776
Scientific orientation	1	-0.04472	0.01988	-2.25	0.0266*	-0.52509
Innovativeness	1	0.26174	0.05818	4.50	0.0001**	1.08662
Risk orientation	1	-0.04259	0.02104	-2.02	0.0455*	-0.42379

R^2=0.6745; **Significant at 1% and * at 5%

Results of Multiple regression analysis

Multiple regression analysis was carried out with Enter method for identifying predictor variables for the dependent variable Vulnerability Index. The R^2 value of 0.6745 shows regression fit as impressive. Innovativeness (P< .01), mass media source of information (P< .01), education (P< .01), occupation (P< .05), social participation (P< .05), scientific orientation (P< .05), and risk orientation (P< .05) were found to be significant predictor variables for vulnerability (Table 3).

The results point to differential risks for farmers with different socio-economic and psychological profile. Specific examples from developing countries have also highlighted the disproportionate risk and danger faced by the poor. In the 1977 floods in Andhra Pradesh, India the deaths were 23-27 per cent for small farmers and fisherman, and there was a 3 per cent death rate for large farmers and local level officials. Morris study on the impact of Hurricane Mitch shows that the lowest income quintile lost 40 per cent of crop value and 18 per cent of asset value whilst those in the higher quintiles lost 25 per cent and 3 per cent, respectively (Morris *et. al.* 2002).

Table 4. Adaptation strategy suggested by the farmers (N= 120)

Sr.No.	Adapting strategy	Frequency	Percentage
1.	Increase in forestation	96	79
2.	Strict legislation relating to reservation of Sunderban forest	55	45.4
3.	Strict laws limiting the amount of CO_2 produced by industry, vehicle etc.	45	37.4
4.	More use of bio-fertilizer	56	46.3
5.	Provision of subsidy	57	47
6.	Training on soil management, organic farming etc.	56	46.3
7.	Farm loan at lower interest rate.	35	28.9
8.	Cultivation of high yielding variety.	36	29.8
9.	Improved forecasting, monitoring and early warning system about climatic variability.	72	59.5
10.	Development of improved scientific technology to predict the short term changes in climatic situation regularly and most efficiently.	41	33.9
11.	Stopping the oil driven boat in river.	44	36.4
12.	Timely supply of input like-insecticide, pesticide, variety etc.	60	50
13.	Stopping spacecraft.	15	12.4
14.	Reduction in application in chemical fertilizer.	48	39.7
15.	Cultivation of paddy through SRI technique.	40	33.1
16.	Cultivation of medicinal plant.	23	19
17.	Regular cleaning of pond water to prevent disease.	57	47.1
18.	Application of lime in pond water.	55	45.5
19.	Change in cropping pattern.	57	47.1
20.	Practice of land shaping.	73	60.3
21.	Government initiatives to increase awareness about climate change at grass root level.	52	43
22.	Change in cropping season.	49	40.5
23.	Introduction of scheme of crop insurance among the people.	33	27.3
24.	Emphasis on non-formal environmental and health education at village level.	50	41.3
25.	Promoting multiple and mixed cropping etc.	45	37.2
26.	Development of salt tolerant variety.	54	44.6

It is further derived from the findings that for developing adaptation strategy the emphasis must be laid upon socio-psychological empowerment of farmers besides developing competencies in acquiring knowledge and skills related to adaptation practices.

Adaptation strategy

Based on their socio-personal, economic and psychological characteristics of the respondents and their vulnerability index, it is deduced that the people in the area need concerted approach in their capacity building for developing their adaptive capabilities. It is imperative to

Table 5. Ranking of constraints in adaptation by the farmers

Sl.No.	Constraints	Ranking	Percentage
1.	Extreme poverty	I	56.7
2.	Lack of knowledge about adaptive practices	II	53.3
3.	Lack of education	VII	54
4.	Lack of awareness about climate change issues	IV	40
5.	Uncertainty of climate	V	43.3
6.	Lack in up to date information	VI	44
7.	Lack of information facilities with forecasting and early warning system	III	76.7
8.	Lack of improved communication facility	VIII	40
9.	Inefficiency and lack of goodwill from government side.	X	40
10.	Lack of aptitude towards resource conservation and adaptation	IX	36.7

make proactive interventions in areas of importance like livelihood mechanism and resource utilization pattern. Thrust areas of intervention for effective adaptation strategy were elicited from the farmers, which included emphasis upon afforestation, legislative measures to check exploitation of Sunderbans, use of eco-friendly technologies for crop cultivation, development of suitable varieties for heat and salt tolerance, measures for educating them in health and environment protection, supply of inputs and services with subsidy, etc. (Table 4).

Constraints in adaptation to adversities related climate change

While identifying the important constraints related to adaptation capacity, there spondents ranked extreme poverty as first followed by lack of education and proper knowledge about adaptive practices, lack of information facilities with forecasting and early warning system, lack of awareness about climate change issues, lack of aptitude towards resource conservation and adaptation needs to be viewed seriously to formulate participatory strategy for adaptation and mitigation as well as sustenance of natural resources (Table 5).

CONCLUSION

The vulnerability index worked out in the study revealed that a majority of the respondents belonged to highly vulnerable category due to climate change. However, there was existence of social cohesiveness as reflected by most of them being old time immigrant having mostly local kinship ties, though the degree could be improved with social intervention for development of associations and self help groups. Existence of reciprocity helps in adaptation. With regression analysis the predictor variables for vulnerability index were identified as innovativeness, mass media source of information, education and knowledge of technology, occupation of agriculture, social participation, scientific orientation and risk orientation, which could be used while devising suitable strategy for capacity building of farmers. Extreme poverty, by lack of education and proper knowledge about adaptive practices, lack of information facilities with forecasting and early warning system, lack of awareness about climate change issues, lack of aptitude towards resource conservation and adaptation needs were reported as the major constraints by the farmers in their adaptation endeavours. The study underlines the importance of capacity building of farmers as well as the extension professionals with educational campaign and trainings or better adaptation capabilities.

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