

# Climate change vulnerability and resource dependent communities: An empirical study in coastal Sunderban, West Bengal, India

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## ABSTRACT

The present paper attempts to measure vulnerability of different communities who are dependent on coastal resources like fishing and crab collection and also tries to measure such vulnerability for other communities who are in the informal sector, petty business and casual labour in the Indian coastal Sunderbans. The Livelihood Vulnerability Index (LVI) and modified LVI-IPCC index have been used to measure such vulnerability. The paper is based on primary data collected from 197 households from four villages in the district of South 24 Parganas, one of the coastal districts of Indian Sunderbans, West Bengal, India, in 2018 with the help of a structured questionnaire. The results of the paper revealed that the communities who engaged in crab collection and fishing are relatively more vulnerable than that of other communities who are in informal sector, casual labour and petty businessmen. This paper has an important policy implication for conservation of natural resources and reduction of dependency on natural resources by creating of alternative livelihood opportunity to the resource dependent communities.

**Key words:** *Livelihood vulnerability index, Fishing and crab collecting communities, Informal sector, Conservation of resources.*

## Introduction

The coastal communities are dependent on coastal resources like fishing, crab catching and coastal ecosystems for their livelihoods (Harding, 2013; Pörtner *et al.*, 2014; Brander *et al.*, 2018). About 19 million people involved in fisheries in Asia are found to be income poor (FAO, 2002). Global climate change is likely to affect coastal communities and made them vulnerable to climate variability all over the world (IPCC, 2001 and Monirul and Mizra, 2003).

In the Indian coastal Sunderbans about 4.5 million populations are dependent on Sunderbans ecosystem for their livelihood and sustenance through agriculture, fishing and crab collection and honey

collection with high exposure, sensitivity and low adaptive capacity (Hajra and Ghosh, 2018; Danda *et al.*, 2013). Livelihoods in the Sunderbans are threatened by the high levels of risks from cyclonic storms, sea level rise, embankment failures, salinity intrusion, and loss of mangrove forests (Knutson *et al.*, 2010). The degradation of mangrove forests put local populations at risk.

There is limited number of studies available for the measurement of the climate change vulnerability on different occupational groups especially in the context of Indian coastal Sunderbans. This paper attempts to study the impact of climate change on different communities like fishing, crab collection, casual labour, petty business and worker in the in-

formal sector at the household level. This paper has important implications for conservation of natural resources and reduction of dependency of such communities on natural resources by creating of alternative livelihood opportunity.

Given the back drop, the main objective of the paper is to measure degree of vulnerability of different categories of occupational groups like fishing community, casual labour, worker in the informal sector, crab collection community, and Petty business in the coastal Sunderban in the South 24 Parganas district of West Bengal.

## Materials and Methods

### Study area

The study area is on Indian Coastal Sunderbans. The study was conducted in Patharpratima block which is situated in the southern part of the district of South 24 Parganas, one of the districts of Sunderbans, West Bengal, India. It is entirely rural area and closer to the sea. It is highly cyclone affected block. The block Patharpratima is one the vulnerable blocks in Indian Sunderbans (Jana *et al.*, 2017). It is located (Figure 1) at  $21^{\circ}46'24''$ N longitude and  $88^{\circ}20'14''$ E latitude and bounded by Bay of Bengal.

### Method of data collection

The present paper is based on the primary data collected from 197 households from the four villages in the Patharpratima block of Indian coastal Sunderbans, South 24 Parganas district, West Bengal, India during 2018 with the help of a structured questionnaire and group discussions. The sample households are classified by major occupational groups into fishing, crab collection, casual labour, petty business and worker in informal sectors.

### Vulnerability Index

The present paper has utilized index based vulnerability measurement. The first one is Livelihood Vulnerability Index (LVI) of (Hahn *et al.*, 2009) and the second is the modified Livelihood vulnerability index which is known as LVI-IPCC.

In the calculation of livelihood vulnerability index (LVI) eight sub-components of vulnerability like Socio Demographic Profile (SDP), Livelihood Strategies (LS), Food, Social Network (SN), Natural Capital (NC), Water, Health and Climate Variable (C) are taken into consideration. Each of the sub components index is again built with several indicators. The indicators under SDP are percentage of dependent people less than 20 years and more than 60 years, percentage of female headed households, percentage of illiterate household head, percentage

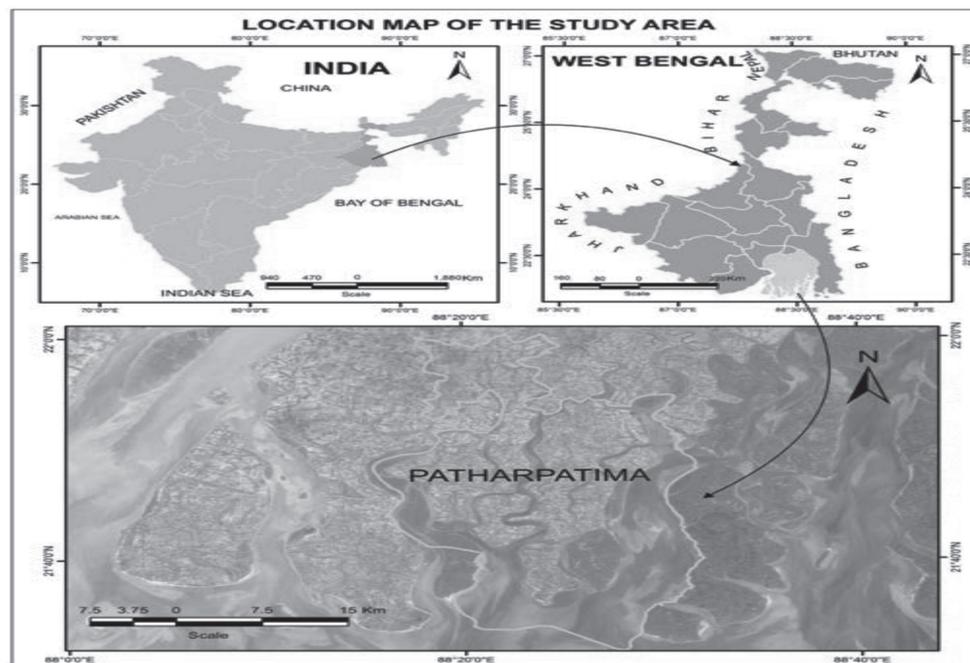


Fig. 1. Map of the study area; Source: (Dhara S, Paul. A.K. 2016)

of female family members. Livelihood strategy (LS) includes percentage of households with family member working outside local area, percentage of households change sowing and cropping schedule, livelihood diversification index, average livestock diversification index and monthly per capita income. Food includes average crop diversity index which is defined as the household who has capacity to grow at least one additional crop such as vegetables or pulse along with traditional crop. Social network incorporates percentage of households not having access to communication media (like TV), percentage of households not associated with any organization (cooperative/ group), i.e. in Self Help Group (SHG), and percentage of households who are non member of 100 days job under Government of India program. Natural capital includes percentage of households using only forest based energy for cooking and percentage of marginal and small farmer households. Water includes percentage of households not having regular drinking water supply, percentage of households that utilize natural water source for drinking water and percentage of households go at least 1 km to fetch water. Health covers percentage of households with family member suffering from chronic diseases, percentage of households does not receive treatment in local health centre and percentages of households do not have toilet facility. Finally climate variable includes percentage of households realize reduction in rainfall in the last 5 years, percentage of households who perceived flood/drought increased in last 5 years, percentage of households who perceived storm increased in last 5 years and percentage of households who did not receive any warning about natural disasters.

The chosen indicators have different units and scales. To bring them into a unit free single scale the study takes the normalize value of each and every indicator which lies between 0 and 1. "0" shows the minimum value and "1" is the maximum value.

Some indicators show positive relationships with vulnerability and others have negative relationship with vulnerability. For positive relationship with vulnerability we have used the following formula.

$$X_{ij} = \frac{X_{ij} - \text{Min}(X_{ij})}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad \dots (1)$$

Min ( $X_{ij}$ ) and Max ( $X_{ij}$ ) are the minimum and maximum values of the j indicator reflecting low and high vulnerability.

On the other hand for negative relationship with vulnerability, the formula is given by

$$X_{ij} = \frac{\text{Max}(X_{ij}) - X_{ij}}{\text{Max}(X_{ij}) - \text{Min}(X_{ij})} \quad \dots (2)$$

The weighted vulnerability index is constituted by Iyenger and Sudarshan (1982).

$$\bar{y}_i = \frac{\sum_{j=1}^k w_j x_{ij}}{\sum_{j=1}^k w_j} \quad \dots (3)$$

Where  $\bar{y}_i$  is the vulnerability Index of the ith sub-component,  $X_{ij}$  is the normalized score of jth indicator.  $w_j$  is the weights of jth indicators such that ( $0 < w_j < 1$  and  $\sum_{j=1}^k w_j = 1$ ).  $w_j x_{ij}$  is the weighted index of jth indicator of ith sub component.

Since  $\sum_{j=1}^k w_j = 1$  equation (3) can be rewritten as

$$\bar{y}_i = \sum_{j=1}^k w_j i_{ij} \quad \dots (4)$$

The weight is determined by

$$w_j = \frac{c}{\sqrt{\text{var}_i(x_{ij})}} \quad \dots (5)$$

Where c is constant such that

$$c = \left[ \sum_{j=1}^k \frac{1}{\sqrt{\text{var}_i(x_{ij})}} \right]^{-1} \quad \dots (6)$$

After calculating 8 sub components, livelihood vulnerability index (LVI) is computed by weighted mean as follows:

$$LVI = \frac{\sum_{i=1}^8 W_i \bar{Y}_i}{\sum_{i=1}^8 W_i} \quad \dots (7)$$

Since weight ( $W_i$ ) of ith sub component is 1 (0), equation (7) can be simplified as

$$LVI = \frac{\sum_{i=1}^8 \bar{Y}_i}{8} \quad \dots (8)$$

The livelihood vulnerability index varies from 0 (lowest value) to 1 (highest Value) (Pandey and Jha 2012).

**LVI-IPCC index:** It is the modified livelihood vulnerability index. The contributory factors of vulnerability are exposure, sensitivity and adaptive capacity. Adaptive Capacity is constructed with four sub components like Socio Demographic Profile (SDP), Livelihood Strategies (LS), Food and Social Network (SN).

$$\text{Adaptive capacity Index} = \frac{\sum_{i=1}^4 W_i \bar{Y}_i}{\sum_{i=1}^4 W_i} = \frac{\sum_{i=1}^4 \bar{Y}_i}{4}$$

$$(\therefore W_i = 1) = \frac{\overline{Ysdp} + \overline{Yls} + \overline{Yfood} + \overline{Ysn}}{4} \dots (8)$$

The sensitivity index is also based on three sub components like Natural Capital, Water and Health.

$$\text{Sensitivity Index} = \frac{\sum_{i=1}^3 W_i Y_i}{\sum_{i=1}^3 W_i} = \frac{\sum_{i=1}^3 Y_i}{3} (\therefore W_i = 1) \dots (9)$$

$$\frac{\overline{Ync} + \overline{Ywater} + \overline{Yhealth}}{3} \dots (9)$$

$$\frac{\sum_{j=1}^4 w_j x_j}{\sum_{j=1}^k w_j} \dots (10)$$

Lastly, LVI\_IPCC index is then calculated as an average of exposure, sensitivity and adaptive capacity. Symbolically,

$$\text{LVI\_IPCC} = \frac{\text{Exposure} + \text{Sensitivity} + \text{Adaptive Capacity}}{3} \dots (11)$$

**Results and Discussion**

The distribution of sample households by major oc-

cupation is presented in Table 1. It is revealed that 14 % sample households belong to fishing, 27% to crab collection, and 31% belong to informal sectors such as cold storage or rice mill or shop and shopping mall / hotels situated in east and west Midnapore and Hooghly district. 9% to petty business and 19% are casual labour (Table 1).

**Vulnerability of different occupational groups of households in Coastal Sunderbans**

The degree of vulnerability is indicated by the livelihood vulnerability index. The livelihood vulnerability indices for different livelihood groups in coastal Sunderban, West Bengal are presented in Table 2. The livelihood vulnerability indices of different occupational groups vary from 0.3719 to 0.5431. It is observed from Table 2 that the crab collecting communities in coastal Sunderbans are most vulnerable (0.5431) followed by the fishing communities (0.4998), the casual labourer (0.3968), and the

**Table 1.** Distribution of different occupational groups of households in the study area

Occupational groups	Description /Example	Sample households (%)
Fishing households ( N <sub>1</sub> )	Households who are engaged in fishing in nearby river	28(14.22)
Crab collecting households (N <sub>2</sub> )	Households who are engaged in collecting crab in nearby river	52(26.40)
Workers in the informal sector (N <sub>3</sub> )	Households who are engaged in rice mill/ cold storage/ shop/ shopping mall in nearby district	61(30.97)
Petty Businessmen ( N <sub>4</sub> )	Households who are engaged in doing small business like fish arat, crab arat, vending vegetable, small grocery /cycle and bike repairing etc.	18(9.14)
Casual labour ( N <sub>5</sub> )	Households who are engaged in agricultural work in other's land, construction of road, building etc.	38(19.29)
	All ( N <sub>1</sub> + N <sub>2</sub> + N <sub>3</sub> +N <sub>4</sub> + N <sub>5</sub> )	197(100)

**Table 2.** Indices of sub components and vulnerability indices for different livelihood groups in coastal Sunderban, West Bengal

Sub-components of Vulnerability	Fishing Communities	Workers in informal sectors	Petty business men	Crab Collecting Communities	Casual labour
Socio-Demographic Profile Index	0.4260	0.2700	0.2537	0.4725	0.3580
Livelihood Strategy Index	0.2367	0.3598	0.3585	0.0027	0.1894
Food Index	0.02	0.0984	0.2778	0.01	0.1579
Social Net work Index	0.6108	0.5693	0.3497	0.9376	0.5448
Natural Capital Index	0.8042	0.6486	0.5327	0.9990	0.7239
Water Index	0.7781	0.0007	0.0082	0.8151	0.0092
Health Index	0.6087	0.5192	0.3682	0.4743	0.5630
Climate Variable Index	0.5340	0.5089	0.4718	0.6429	0.6279
Livelihood Vulnerability Index (by Hahn <i>et al.</i> , 22009)	0.4998	0.3719	0.3276	0.5431	0.3968

Sources: Computed by author from field survey primary data

workers in the informal sectors (0.3719). It is also revealed that the petty businessmen is least vulnerable (0.3276) community in coastal Sunderbans (Table 2).

The fishing and crab collecting communities are more vulnerable than other occupation groups due to higher values of natural capital, social network, water, health and climate variable (Table 2). The high dependency of natural capital, less involvement in social network, salinity of water, inaccessibility to health care facility and less perception about climatic events are responsible for high degree of vulnerability of the fishing and crab collecting communities in coastal Sunderbans. The workers in the informal sector and petty businessmen are less affected by natural capital, social network and water (Table 2).

The modified livelihood vulnerability indices (LVI-IPCC) for different occupational groups are shown in Table 3. It is observed from Table 3 that vulnerability of the crab collecting communities is highest (0.5864) and lowest for petty business men (0.3616). The more vulnerable communities are crab collecting communities followed by fishing communities, casual labour and worker in the informal sector in the coastal Sunderbans. The fishing and crab collecting communities are facing with high exposure and high sensitivity compared to the other occupational groups of households (Table 3). It is also found that the adaptive capacities of each occupational group of households are lower than exposure and sensitivity components of vulnerability.

Some studies are focusing on the measurement of vulnerability in different geographical regions in the global and national levels. It is important to mention that some other studies in flood prone coastal regions (Huyanh and Stringer, 2018), in Himalayan region (Koirala, 2015; Panthi *et al.*, 2015), in African continent (Adu *et al.*, 2017), Small Caribbean Island (Schneider, 2007, McWilliams *et al.*, 2005), and in wet lands of South America (Shah *et al.*, 2013). The

methodology used by the present study is similar to the other studies (Tonmoy *et al.*, 2014, Sisay, 2016).

## Conclusion

### The following conclusions have emerged from the above analysis

First, on the basis of livelihood vulnerability index of (Hahn *et al.*, 2009) the crab collecting communities in coastal Sunderbans are most vulnerable (0.5431) followed by the fishing communities (0.4998), the casual labourer (0.3968), the workers in the informal sectors (0.3719). The petty businessman is found to be least vulnerable (0.3276) community in coastal Sunderbans.

Second, in terms of modified vulnerability index (LVI-IPCC) vulnerability of the crab collecting communities is highest (0.5864) and that lowest for petty business men (0.3616). The more vulnerable communities are crab collecting communities followed by fishing communities, casual labour and worker in the informal sector in the coastal Sunderbans. The high exposure, high sensitivity and low adaptive capacity lead to high vulnerability to the fishing and crab collecting communities.

Third, the high dependency of natural capital, less involvement in social network, salinity of water, inaccessibility to healthcare facility and less perception about climatic events are responsible for higher vulnerability of the fishing and crab collecting communities in coastal Sunderbans compared to other communities.

The State of West Bengal has taken various initiatives for expanding the crop insurance packages for small and marginal farmer's security against crop loss during flood or cyclone in the state (WBSAPCC, 2012). The state has also arranged Early Warning System (EWS) in the coastal Sunderban to combat the stress of cyclones and storm surges under Disaster Risk Reduction (WBSAPCC, 2012). The planta-

**Table 3.** Modified Vulnerability indices (LVI-IPCC) for different livelihood groups in coastal Sunderbans

Components of Vulnerability	Fishing Community	Workers in informal sectors	Petty business men	Crab Collecting Communities	Casual labour
Exposure index	0.5340	0.5089	0.4718	0.6429	0.6279
Sensitivity index	0.7303	0.3895	0.3030	0.7631	0.4321
Adaptive index	0.3184	0.3244	0.3099	0.3532	0.3125
LVI_IPCC	0.5276	0.4076	0.3616	0.5864	0.4575

Sources: Computed by author from field survey primary data

tion and regeneration of mangrove forests on the degraded mud flats are on the top priority in Coastal Sunderban. This gives rise to ensure natural protection of island from cyclone and storms. There are several programs of the central and state governments working in coastal Sunderban like National Rural water and Sanitation Program, National Elementary Education Program (Sarva Shiksha Abhiyan), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), the housing scheme, Indira Awas Yojana, the Food for Work Programme, and the rural road building scheme, Pradhan Mantri Gramin Sadak Yojana. These programs are important for rural development and vulnerability reduction measures. The paper has an important policy for the reduction of vulnerability and poverty of the vulnerable coastal people. In addition, the paper also calls for policy implication for conservation of natural resources and reduction of dependency on natural resources by creating of alternative livelihood opportunity to the resource dependent communities.

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