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STUDY ON IMPACT OF SALINE WATER INUNDATION ON FRESHWATER AQUACULTURE IN SUNDARBAN USING RISK ANALYSIS TOOLS

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ABSTRACT: The impact of saline water inundation on freshwater aquaculture was evaluated through risk assessment tools. Fishponds in low-lying areas of Sagar and Basanti block are prone to saline water flooding. Respondents of Sagar block considered events like cyclone and coastal flooding as extreme risk; erratic monsoon, storm surge and land erosion as high risk; temperature rise, sea level rise, hot & extended summer and precipitation as medium risk. Likewise, in Basanti block the respondents rated cyclone as extreme risk; erratic monsoon, storm surge as high risk; temperature rise, hot & extended summer, land erosion, and precipitation as medium risk; coastal flooding and sea level rise as low risk. Fish farmers of Sagar block classified the consequences of saline water flooding like breach of pond embankment and mass mortality of fishes as extreme risk; escape of existing fish stock and diseases as high risk; entry of unwanted species, retardation of growth and deterioration of water quality as medium risk; and damage of pond environment as low risk. Farmers of Basanti block categorised breach of pond dyke, mass mortality of fishes and entry of unwanted species as extreme risk; escape of fish and diseases as high risk; retardation of growth as medium risk; deterioration of water quality and damage of pond environment as low risk. To reduce the threats against saline water ingression, farmers are taking some coping measures like increase in pond dyke height; repair and strengthening of dyke; plantation on dyke; dewatering and addition of fresh water; application of chemicals/ lime/ dung; addition of tree branches in pond for hide outs etc.

Keywords: Impact, Saline water inundation, Risk analysis, Adaptation.

INTRODUCTION

Sundarban, the UNESCO declared world heritage site, is a fragile mangrove biome which is very vulnerable to climate change. It is world's largest delta spreading across West Bengal state of India and neighbouring country of Bangladesh.The Indian Sundarban is bordered by Bangladesh in the east, the Hooghly river in the west, the Dampier and Hodges line in the north, and the Bay of Bengal in the south. The Climate Change impact is prominent in the delta over last few decades and is adversely affecting the biotic and abiotic integrity of the ecosystem. Sundarban is witnessing rise in mean annual temperature, change in monsoonal pattern and increase in the intensity of tropical depression and cyclones leading to tidal surges. These are leading to sea level rise, land erosion, breach of embankment and saline water inundation. A

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gradual increase in Surface water temperature at a rate of 0.5°C per decade has been recorded over last 30 years (Mitra *et al.* 2009). This rate is much higher than the globally observed warming rate of 0.06°C per decade, and the IPCC (2007) documented rate of 0.2°C per decade in the Indian Ocean during 1970-99.

The tide gauge data of Sagar island observatory for the period 2002-2009 indicated a rise in the Relative Mean Sea Level (RMSL) at the rate of 12 mm/year during the decade (Hazra 2010). Considering the record of past 25 years, the rate of relative sea level rise comes close to 8 mm/year, which of course is significantly higher than the rate of 3.14mm/ year observed during the previous decade (Hazra 2002). Severe cyclonic storms over Bay of Bengal registered 26 percent increase over last 120 years, intensifying in post monsoon (Singh 2007). During last part of the decade (2007-2009), northern part of Bay of Bengal has witnessed four cyclones Sird, Nargis, Bijli and Aila.

Inhabited islands are protected by man-made embankment built around the island against the ingression of saline water. This embankment act as life line for the peoples of Sundarban because it makes agriculture and aquaculture possible in the islands. The earthen embankments constructed in mid 19th century have already been worn out & at the same time the river beds are raised through siltation and there is also sea level rise. All these factors make the embankments more vulnerable and susceptible to breach & overtopping during cyclonic and storm surges which are very common in recent years (Danda 2010). The strong waves influenced by storm surge hit the river embankments causing breaches and inundate the houses, agricultural fields and fish pond with saline water. It devastates many households by taking human lives, washing away domestic animals, damaging standing agricultural and fishery crops and leaving farm land unproductive.

In Sundarban, fishery (fishing and aquaculture) is the second major livelihood option for the people after agriculture. Apart from fishing, the mangrove biome of this region alongwith the numerous creeks, canals & estuarine network have helped aquaculture to develop in a big way. In last few decades, the incidence and intensity of extreme weather events like cyclones have increased over the region. Cyclones cause storm surges which in turn result in saline water flooding in the islands. It is putting enormous risk on aquaculture of Sundarban through saline water inundation, soil erosion, breach of dykes, loss of fish stock, mortality, disease etc. In the present study, an attempt is made to evaluate the impact of saline water inundation on prevailing aquaculture practices in Sagar and Basanti blocks of Sundarban using risk analysis tools.

MATERIALS AND METHODS

A cross-sectional multi-layered questionnaire -based survey was carried out in two vulnerable blocks of Sundarban namely Basanti & Sagar in South 24 Parganas district of West Bengal. The purpose of the survey was to benchmark the socio-economic profile, current aquaculture practices, climate variable pattern and prevailing climate induced coping measures. Two reputed local NGOs (Paribesh Unnayan Parishad for Sagar block & Joygopalpur Gram Vikash Kendra for Basanti block) were engaged for this survey. Using

random sampling technique, total 451 fish farming households (244 households spread across 9 Gram Panchayats in Sagar block and 207 households spread across 11 Gram Panchayats in Basanti block) were surveyed. The entire process was conducted during the months of September to December 2011 with the help of 20 numbers of surveyors & 4 numbers of reviewers. The survey questionnaire was consist of four major categories, *i.e.* (i) socio-economic profile of farmers, (ii) information on aquaculture, (iii) pond management practices and (iv) climate change / environment issues. The collected data were digitized and analysed with the help of an in-house developed software using Microsoft Access 2007.

The impact of saline water inundation (due to extreme weather events like cyclones and storm surges) on freshwater aquaculture was evaluated through risk assessment tools. For this study, risk is considered as the likelihood of aquaculture and livelihood assets being affected as a result of high intensity weather events, and the varying degrees of consequence. The assessment of risk is based on determining the likelihood and consequence of happenings. In present study it involved following steps: (i) determination of qualitative assets (livelihood, fishery, and biodiversity) which is being affected, (ii) determination of consequences of weather event on assets, (iii) determination of likelihood of each asset will be affected and (iv) determination of risk rating through matrix. Above approach is a blend of the ideas outlined by the Australian Greenhouse Office (AGO) report-2007.

RESULTS AND DISCUSSION

Over last few decades, the Sundarban deltaic region is getting more vulnerable to climate-induced risks like sea level rise, salinity intrusion, temperature and rainfall variations, land erosion, cyclone, storm surge etc. and these are adversely affecting the biotic and abiotic integrity of the ecosystem. The incidence and intensity of extreme weather events like cyclones and storm surges have increased over the region making the century old embankments more vulnerable and susceptible to breach leading to saline water inundation of home and farm lands.

Prevailing aquaculture scenario in Sagar and Basanti blocks:

Majority of respondents in two blocks are marginal and small-scale farmers having perennial fishponds and they practise traditional farming methods. Very few farmers (3%) undertake semi-intensive farming and follow modern technologies of farming. It indicates the reluctance of farmers in adopting scientific farming which might be due to lack of education, awareness and finance. In both the islands, brackish water aquaculture is prevalent only in peripheral areas which are adjacent to river or creek and tide-fed. On the contrary, freshwater aquaculture is vast, wide spread and rain-fed. In both the blocks, few farmers culture shrimp exclusively in brackishwater and majority farmers prefer shrimp polyculture with other fish. Farmers mostly culture tiger shrimp *(Penaeus monodon)* alongwith the brackishwater fishes like *Lates calcerifer, Liza tade, Liza parsia, Mugil cephalus, Etroplus suratensis, Scatophagus argus* etc. In freshwater, carp polyculture is popular among the farmers, though in some cases farmers culture high value Scampi *(Macrobrachium rosenbergii)* alongwith carps.

Table 1 : Demographic Profile of the study area*

Profile	Sagar Block	Basanti Block
Geographic Location	21°37'21''N & 88°02'17''E	22°11'21?N & 88°40'14?E
Number of Households	31,461	50,751
Total Population	185,644	2,78,592
Population (Male)	95,547	1,42,705
Population (Female)	90,097	1,35,887
Sex Ratio (females per 1000 males)	943	952
Literacy Rate (%)	77.9	57.0
SC Population	51,588 (27.8%)	107,602 (38.6%)
ST Population	691 (0.4%)	17,462 (6.3%)
Work Participation Rate (%)	52.7	32.0
Main Workers (%)	23.2	22.0
Marginal Workers (%)	17.3	10.0
Non Workers (%)	59.4	68.0
Cultivators to total workers (%)	37.2	26.1
Agricultural labourers to total workers (%)	35.8	47.9

*as per census, 2001

Farmers also culture tilapia (*Oreochromis mossambicus* and *O. niloticus*) both in freshwater and brackish water alongwith other fish / prawn for higher production. During the course of survey, it is noticed that, in Sagar Island, Invasive fish species like Rupchanda *(Pygocentrus nattereri)* and Bighead carp *(Aristichthys nobilis)* are gaining popularity among the farmers due to higher growth rate.

Climate Change associated risk in aquaculture and their assessment:

Sundarban is one of the climate change hotspots. Geographic location and distance from the sea is different in two study sites. Sagar island is located in the western sector of Indian Sundarban at the confluence of Bay of Bengal and Hoogly river. Whereas Basanti block is located in eastern sector of Indian Sundarban and far from sea. Survey results reveal that the inhabitants of Sundarban are experiencing extended & extreme summer, erratic monsoon and short winter. The frequency and intensity of extreme weather events like cyclone and storm surge have increased over the period of time. These have significant bearing on erosion of land mass and saline water ingression in the inhabited areas resulting loss of lives, agriculture and fish crops. Farmers consider aquaculture as a victim of climate change. Sagar being a sea facing island is more sensitive to climate change. It has suffered the bulk of erosion and only marginal accretion. Fishponds in low-lying areas of Gangasagar, Dhablat, Ramkarchar, Daspara Sumati Nagar and Ghoramara Gram Panchayats of Sagar block are prone to coastal flooding during rainy seasons. Ponds located at Jharkhali and Nafargunj Gram Panchayats of Basanti block are sensitive to saline water inundation during monsoonal storm.

Table 2 : Aquaculture practises adopted by the respondents of study area.

No. of Respondents	Sagar (n=244)	Basanti (n=207)	Overall (n=451)
Type of Culture			
Fin Fish	142 (58%)	60 (29%)	202 (45%)
Shell Fish	20 (8%)	8 (4%)	28 (6%)
Both	82 (34%)	139 (67%)	221(49%)
Nature of water			
Freshwater	151 (62%)	170 (82%)	321 (71%)
Brackishwater	23 (9%)	7 (3%)	30 (7%)
Both	70 (29%)	30 (15%)	100 (22%)
Type of farming practised			
Traditional	167 (68%)	165 (19%)	332 (74%)
Modified Extensive	63 (26%)	40 (20%)	103 (23%)
Semi-intensive	14 (6%)	2 (1%)	16 (3%)
Type of cultivation practised			
Monoculture	19 (8%)	3 (1%)	22 (5%)
Polyculture	221 (90%)	171 (83%)	392 (87%)
Integrated	4 (2%)	33 (16%)	37 (8%)
Pond type			
Seasonal	61 (25%)	69 (33%)	130 (27%)
Perennial	183 (75%)	138 (67%)	321 (73%)
Presence of inlet and outlet in the ponds			
Inlet & out let present in Pond	161 (66%)	47 (23%)	208 (46%)
Inlet & out let absent in Pond	83 (34%)	160 (77%)	243 (54%)

Respondents of Sagar block considered events like cyclone and coastal flooding as extreme risk; erratic monsoon, storm surge and land erosion as high risk; temperature rise, sea level rise, hot & extended summer and precipitation as medium risk (Table 3). Likewise, in Basanti block the respondents rated cyclone as extreme risk; erratic monsoon, storm surge as high risk; temperature rise, hot & extended summer, land erosion, and precipitation as medium risk; coastal flooding and sea level rise as low risk (Table 4). Fish farmers of Sagar block classified the consequences of saline water flooding like breach of pond embankment and mass mortality of fishes as extreme risk; escape of existing fish stock and diseases as high risk; entry of unwanted species, retardation of growth and deterioration of water quality as medium risk; and damage of pond environment as low risk. Similarly, in Basanti block farmers categorised breach of pond dyke, mass mortality of fishes and entry of unwanted species as extreme risk; escape of fish and diseases as high risk; retardation of growth as medium risk; deterioration of water quality and damage of pond environment as low risk (Fig.1 & Table 5).

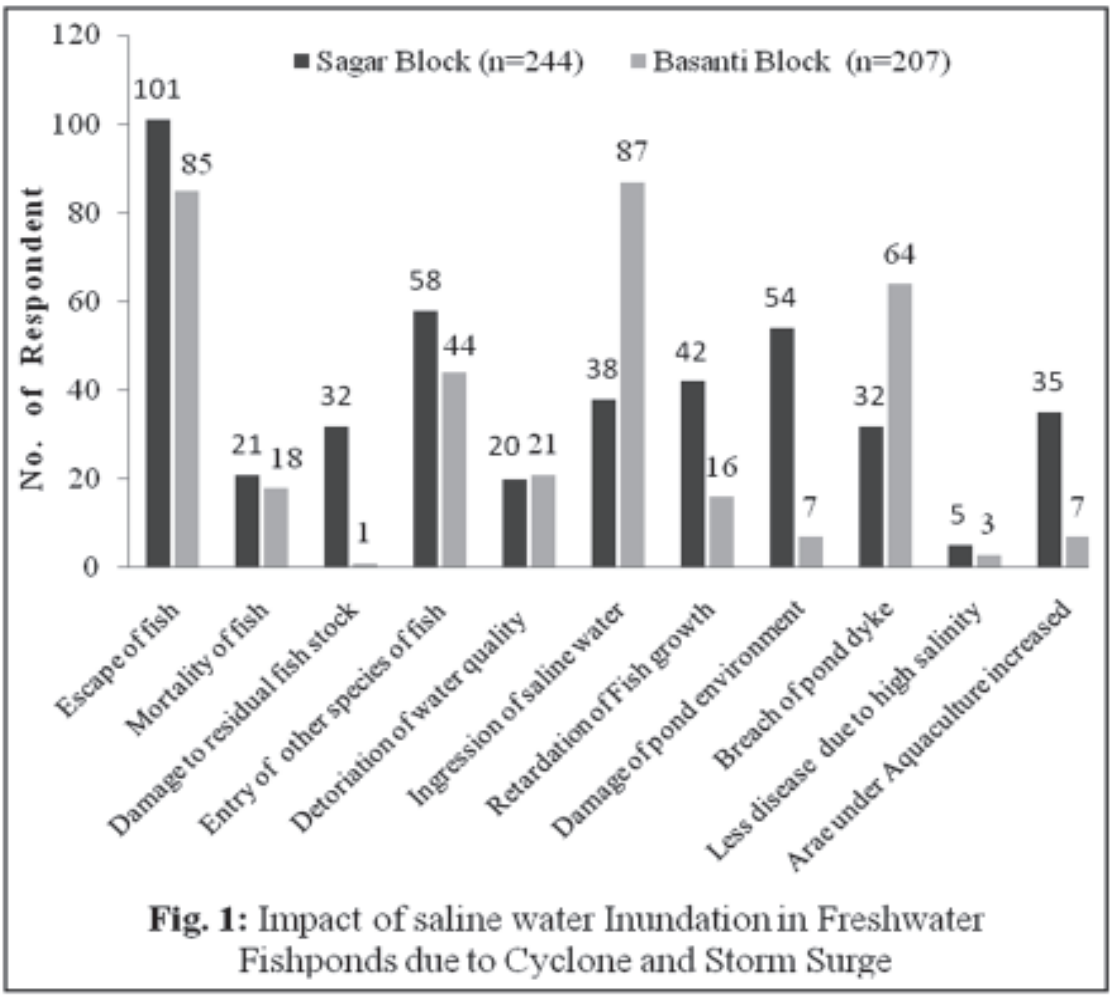

Fig. 1: Impact of saline water Inundation in Freshwater Fishponds due to Cyclone and Storm Surge

Coping measures-an alternate strategy for threat reduction and vulnerability:

The respondents get exposed to one or more crisis situations to which they are vulnerable. To reduce the threats against saline water ingression, farmers are taking some coping measures like increase in pond dyke height; repair and strengthening of dyke; plantation on dyke; dewatering and addition of freshwater; application of chemicals/ lime/ dung; addition of tree branches in pond for hide outs etc.(Fig.2)

CONCLUSION

Aquaculture in the islands of Sundarban is vulnerable to climate change due to high intensity weather events like cyclones and storm surges which inundate the fishponds with saline water. It seriously affects the freshwater aquaculture activities of the islands through breach of pond dyke, mass mortality of fishes, entry of unwanted species, escape of fish, diseases out-break, retardation of growth, deterioration of water quality etc. Farmers are

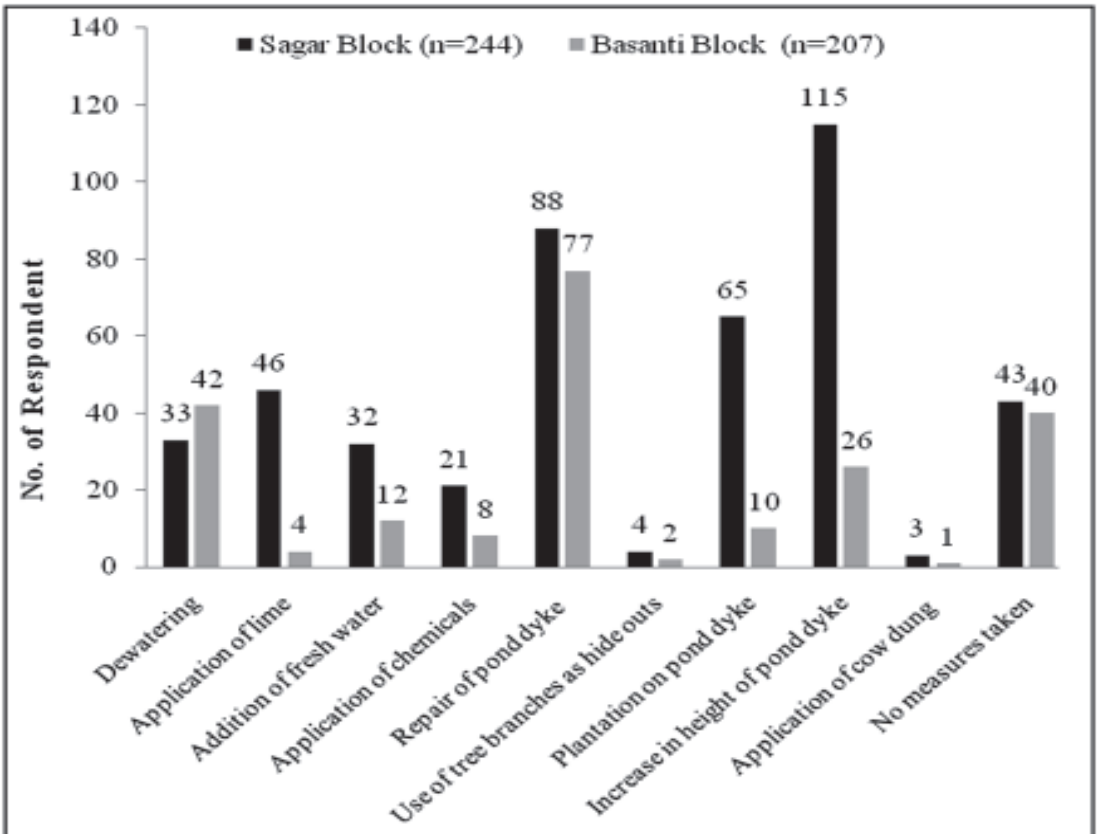

Fig. 2: Coping Measures against Saline Water Inundation

currently tackling the problems through short-term coping measures which need scientific improvements to give long-term relieve to the farmers. This is possible through formulation of adaptation strategies that will reduce the adverse consequences, and increases the positive consequences. The salination of lands and water in the inhabited areas of Sundarban may bring more areas under brackishwater aquaculture (Bheries) given the decreasing viability of fresh water aquaculture and agriculture sectors, thus presenting an opportunity for this sector to capitalize on the changes posed by climate change.

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Table 3: risk rating matrix of climate change variables in Sagar block of Sundarban*.

Likelihood	Consequences				
	Little Negative (1)	Minor Negative (2)	Moderately Negative (3)	Extremely Negative (4)	Disastrous (5)
Almost Certain (5)		Temp. Rise (10) **Medium risk**			Cyclone (25) **Extreme risk**
Likely (4)		Hot & Extended Summer (8) **Medium risk**	Erratic monsoon (12) **High risk**		Coastal Flooding (20) **Extreme risk**
Possible (3)		Sea Level Rise (6) **Medium risk**	Precipitation (9) **Medium risk**	Storm Surge (12) **High risk**	Land Erosion (15) **High risk**
Unlikely (2)					
Rare (1)					

* Figures in the parenthesis represent the matrix score.

Table 4: Risk rating matrix of climate change variables in Basanti block of Sundarban*

Likelihood	Consequences				
	Little Negative (1)	Minor Negative (2)	Moderately Negative (3)	Extremely Negative (4)	Disastrous (5)
Almost Certain (5)		Temp. Rise (10) **Medium risk**			Cyclone (25) **Extreme risk**
Likely (4)	Coastal Flooding (4) **Low risk**	Hot & Extended Summer (8) **Medium risk**	Erratic Monsoon (12) **High risk**		
Possible (3)	Sea Level Rise (3) **Low risk**	Land Erosion (6) **Medium risk**	Precipitation (9) **Medium risk**	Storm Surge (12) **High Risk**	
Unlikely (2)					
Rare (1)					

* Figures in the parenthesis represent the matrix score.

Table 5: Classification of risks associated with aquaculture due to saline water inundation.

Sagar Block		Basanti Block	
Risk attributes	Rating *	Risk attributes	Rating*
Breach of pond dyke		Breach of pond dyke	
Escape of fish stock		Escape of fish stock	
Entry of unwanted species		Entry of unwanted species	
Mortality of fish		Mortality of fish	
Retardation of growth		Retardation of growth	
Deterioration of water quality		Deterioration of water quality	
Damage of pond environment		Damage of pond environment	
Diseases		Diseases	

Risk Rating	Extreme Risk	High Risk	Medium Risk	Low Risk
Colour Code*				

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