Adaptation in case of Inundation of Islands: An Exploratory Study from Indian Sundarbans, A World Heritage Site

Rajarshi Banerji [1], Indrila Guha[2], Chandan Roy[3], Joyashree Roy[4], Somnath Bhattacharya[5]

Abstract

Climate change induced sea level rise will exacerbate changes in landmass or vegetation pattern in the coastal zone through inundation, storm surge, erosion etc. Vital infrastructure, settlements and facilities that support the socio-economic well-being and livelihood of island and coastal communities will be threatened. To design adaptive actions it is important to know the magnitude of damages, associated costs and benefits. This study attempts to make such assessment using past experience of inundation. The present study focuses on the Sagar Block, a part of the Sundarban Biosphere Reserve, A World Heritage Site. Two islands, namely Lohachhara and Suparibhanga have already disappeared. Other adjoining islands have also lost land and infrastructure. While this study does not probe into the reasons of inundation, the loss of property and consequent distress due to land loss is obvious and our objective is to trace and analyze the responses of the affected population to identify the ideal pathway for remedial policies. Past studies demonstrate that a large number of people have migrated to Sagar Island. Reactive and proactive actions are analyzed to assess private costs and social costs to this migrant population who appear to be amongst the first climatic refugees of the world. The assessment and cost estimates are based on secondary information as well as field level information gathered through Focused Group Discussions and Rapid Rural Appraisal. Data on physical changes over time in the selected case study areas through conjunctive use of GIS technique and Survey of India topographic sheets have been used. The study wants to use the results to assess impact on poverty of predicted climate change induced risk of inundation and to identify appropriate adaptation strategies.

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[1] Affiliated Researcher and Climate SMART Initiative Member, Global Change Program, Jadavpur University, Kolkata, India – Presenting Author

[2] Associate Professor in Economics, Vidyasagar College for Women, University of Calcutta and Climate SMART Initiative Member, Global Change Program, Jadavpur University..

[3] M.Phil, Dept. of Economics, Jadavpur University

[4] Professor of Economics, Coordinator –Global Change Programme, Jadavpur University.

[5] Senior Scientist at Institute of Environmental Studies and Wetland Management, Deputy Director (Technical), ICZM Project, West Bengal.

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Background

Climate Change induced sea level rise predictions of IPCC 2007 are getting revised with refined research methodologies worldwide everyday. Sea levels, which rose on the average 1.8 mm/year between 1961 and 2003, doubled between 1993 and 2003 – rising by 3.1 mm/ year. A one meter rise would inundate many coastal areas throughout the world: The US National Oceanic and Atmospheric Administration (NOAA) reported in August 2000 that the World's oceans were warming much faster than anticipated, contributing to sea level rise and global climate change. Over the past several decades the world ocean has warmed by 0.3^0C, representing a huge increase in the heat content of the ocean. Ocean warming, including coral bleaching and rising seas are already impacting on coastal population and ecosystems. In India, climate change could represent additional pressure on ecological and socio-economic systems that are already under stress. With its huge and growing population, a 7500-km long densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, India is considerably vulnerable to the impact of sea level rise.

Sundarbans is the largest delta in the world consists of 10,200 km ^{2} of Mangrove Forest, spread over India (about 4200 km ^{2} of Reserve Forest) and Bangladesh (6000 km ^{2} approx of Reserve Forest) and is also the largest Mangrove Forest in the world. Currently it is highly affected by coastal flooding and erosion, - over one decade, mangrove area in Sundarbans has declined from 420 hectares (1987) to 212 hectares (1997). Indian Sundarbans had 102 islands but now 100 islands. Out of 100 islands, 48 are entirely forested and 52 are variably inhabited (WWF India, 2009). Two islands namely Lohachhara and Suparibhanga have already submerged and people migrated to other islands. Other adjoining islands (like Ghoramara & Sagar Island) have also lost land. The Indian Sundarbans is located between $21^0$30' – $22^0$15' north and between $88^0$10' - $89^0$10' east, within north and south 24 parganas districts of the state of West Bengal. Total area of Sundarbans region in India is 9630 km ^{2} (both forest and non-forest area) which forms the Sundarbans Biosphere Reserve which was constituted as National Biosphere Reserve by UNESCO during November 2001. The Indian Sundarbans lying south of Dampire – Hodges Line, comprises 13 blocks in 24 parganas south district and 6 blocks in 24 parganas north district and has a total population of 4.1 million as per 2001 census (UNDP, 2003). As mentioned earlier,Indian Sunderbans, 48 islands are entirely forested and 52 islands are variably inhabited. People from inundated Islands come and get rehabilitated on Sagar Block creating population pressure on land, - population density is 366 per square km in 2001 (census report- 2001). Under such circumstances our study is an attempt to assess island inundation induced problems and past adaptation strategies.

Rationale of the Study

This region is home of many endangered wildlife species and a large and burgeoning human population. It is an endangered ecological system that is highly populated as well as fragile and economically valuable. Sundarbans has been losing its natural capital -land area, mangroves, and human and wildlife species due to coastal flooding. Sagar Island is also a place in India where pilgrims come every year and a major part of the livelihood of the local people depends on this seasonal event. For Sundarbans there cannot be any unique adaptation strategy. We need different strategies for different islands given the biophysical characteristics. Coastal flooding in this region is leading to,

(i) High pressure on land due to migration.

(ii) Loss of livelihood.

(iii) Loss of Islands.

(iv) Loss to agricultural production and lead food crisis.

(v) Loss of assets and poverty increase.

Past Studies

The trend of geomorphic changes and related changes in land use pattern of the estuarine island in response to the natural and anthropogenic activities has been documented in many studies. Sea level rise, neotectonic effects and human interference have a strong impact on the land use and geographic changes within Sagar Island at the confluence of River Hoogly with the Bay of Bengal **(**Hazra. Ghosh, Bhandari, 2001). This paper shows that geographical area on Sagar Island has shown a sharp decline over past 35 years: 236 sq. km in 2001 as against 273.53 sq. km in 1968. The annual rate of erosion in shoreline has been estimated to be 4.54 m per annum in pre 1995 scenario, which increased to 18.75 m per annum in 1999. The temporal analyses of the variations help to formulate the strategic planning for the sustenance of the island. Satellite data shows that tidal height does not follow certain fixed trend, it started increasing for four years starting from 1996, rose up to 1999 but shows a sharp fall in 2000 again: 2.35 meter in 1996, 5.10 meter in 1998, 5.27 meter in 1999 and 2.15 meter in 2000. It recognized coastal erosion has been one of the major problems of this island using multi-temporal satellite data incorporating tidal information. This paper aimed at formulating an integrated coastal zone management plan for Sagar Island, Bay of Bengal, East coast of India using satellite data and GIS. Preventive measure has been suggested taking into account the local geomorphology, current, wave and tidal conditions. The notification of the ministry of Environment of Forest; Govt. of India has been consulted for delineating the coastal regulation zone around the Island (Mitra, Mishra, Phuong, Sudarshana 2002).Another paper found that erosion in this island is taking place due to natural process and to a little extent by anthropogenic activities over a long period. The northeastern, southwestern and southeastern faces of the Island are severely affected by erosion. Deposition is experienced mainly on the western and southern part of the Island. The Island is built primarily by silt and clay, which can more easily be eroded by the waves, tides and cyclonic activities than a sandy coast. Historic sea level rises accompanied by land subsidence lead to differing rates of erosion at several pockets, thus periodically establishing erosion planes (Gopinath, Seralathan 2005). However, the available literature does not offer an empirical study of adaptation in case of inundation of Islands in sagar block of Indian Sundarbans.

Objectives and Methodology

Sundarbans due to its international status of unique ecosystem and vulnerability is sometimes appears to be highly visited, researched site but systematic holistic study has not been carried out so far (Roy 2007). Limited evidence is not able to show with high

level of confidence in study area the level of vulnerability. Biophysical aspects are fairly well documented. But an integrated study has not been carried out to determine what can be alternative development pathway for this unique ecosystem, what adaptation strategy over short through long run can yield welfare enhancing results. No assessment of adaptation aspects is available. The present study aims to fill up this gap with an integrated framework for evolving better policy interactions for enhanced management of the case study site. The specific objectives are as follows:

(i) To assess vulnerability through physical damage analysis of coastal erosion and coastal flooding. This has been done using topographic sheets and satellite imagery.

(ii) To make an economic assessment of this environmental damage based on first hand exploratory survey.

(iii) To have an overview of prevailing adaptation strategies already taken based on questionnaire based survey.

(iv) Assessment of externality cost of such adaptation strategy. Simple response based quantification will be used here using LIFE approach (Ghosh and Roy 2006).

Physical Vulnerability Assessment

To assess vulnerability through physical damage analysis of coastal erosion and coastal flooding we use data from literature, topo sheets and satellite imagery.

Damage to Natural capital

Lohachara Island was submerged in 1982, Ghoramara Island is already losing 2/3 portion land area and in recent past (2008 to 2011), Sagar island is also losing a large part of land area (Shibpur-Boatkhali zone) and people are migrating to other places. Important observations were made from our study of the GIS map of Sagar Island. Sagar Island is an inhabited island and its major part is agricultural land. Mainly South-East part and some part of south and south-west are mangrove forest. A large area part of Eastern side and small part of Western side is deforested. Northern part and North- East part of this island is highly affected by coastal flooding and erosion. Western part, Southern part and South-East part are high tide area. All southern part and some part of South-East and South-West part are sand beach. Some places of western part are open/ vacant.

Economic Assessment of the Damage: Exploratory Survey

Inundation by coastal flooding in two islands - Lohachara and Ghoramara in Sagar Block and affected communities have been traced, Impacts / responses are studied through livelihood, institutions, food security, and empowerment (LIFE) approach (Ghosh and Roy 2006) so as to assess welfare impact. There are information on families who have been rehabilitated and some who have not. Hence it will be interesting to understand pro-active and reactive adaptation strategy, cost and associated socio economic implications.

Study Site

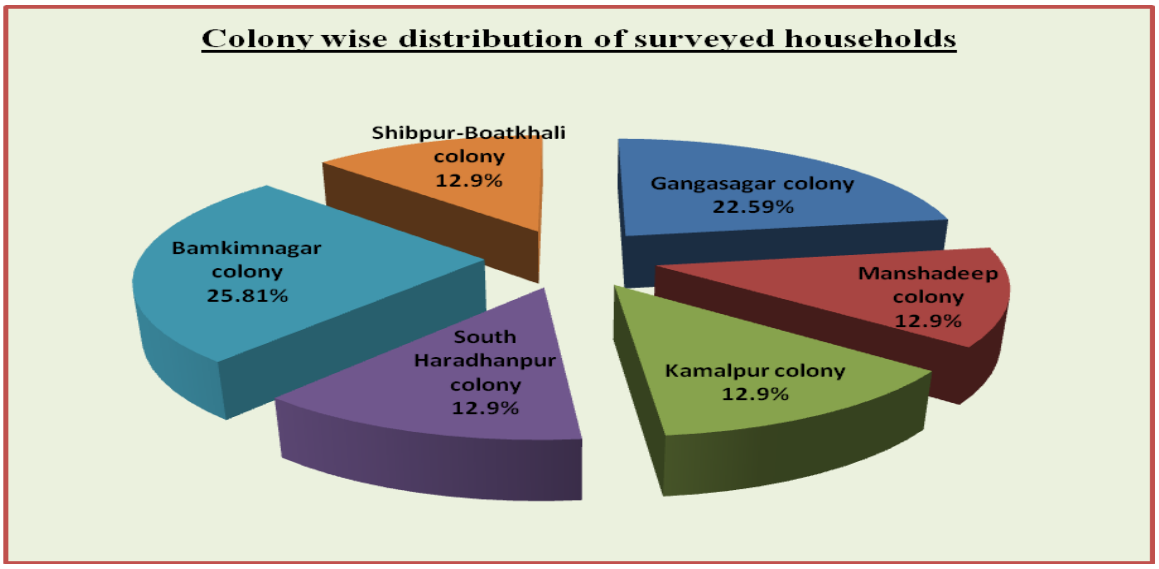
Sagar Block used to have three islands namely Sagar, Ghoramara and Lohachara but now has two islands because Lohachara island has completely submerged in 1982. Presently Ghoramara Island has lost two-third (2/3) portion of land area. The total land area of Sagar Island is 504 km ^{2} in 2001 (Govt. of West Bengal, 2001). Sagar Island is continuously losing land area by coastal erosion, tidal waves and cyclone. In recent past, on 16th July 2008 Sagar Island was affected by a huge cyclone and about 1300 families became homeless in Shibpur-Boatkhali area. Those people are presently living on D.M Road – a street on Sagar Island, having lost everything.

According to Sundarbans Affairs department, Govt. of West Bengal 2001, total population on Sagar Island is 185644, of which 95547 are male and 90097 are females. On Sagar Island, population growth rate is 2.04% and population density is 368 per sq km. Literacy rate on Sagar Island is 77.9 % and male – female ratio is 1000**:**942. Total number of villages is 44, ferry services – 8, bus route – 1, and length of river embankment is 150 km on Sagar island. Total length of the roads is 617 km in which 157 km is surfaced roads and 460 km is non-surfaced roads. Out of 44 villages, total electrified villages were 17 in 1997 (38.64 %) and 35 in 2007 (79.55 %).

Primary data from exploratory study mainly depends on household survey. For primary data, we first went through some previous literatures on Sagar Block, Sundarbans and prepared questionnaires and applied the same to 310 households. It was found that people came from Lohachara, Ghoramara and some part of Sagar and got settled in 6 colonies. Those are mainly Gangasagar colony, Manshadeep colony, Kamalpur colony, South Haradhanpur colony, Bamkimnagar colony and Shibpur-Boatkhali colony. We collected these information from Focused Group Discussion with local Panchayat Pradhan (head of local government), ex-Member of Legislative Assembly of the state representing that area and past records. Table 1 below shows the colony-wise distribution of the surveyed households.

Table-1: Colony wise distribution of surveyed households

Name of the colonies	Number of surveyed households	% in total
Gangasagar colony	70	22.59
Manshadeep colony	40	12.90
Kamalpur colony	40	12.90
South Haradhanpur colony	40	12.90
Bamkimnagar colony	80	25.81
Shibpur-Boatkhali colony	40	12.90
Total households	310	100



Out of 310 households, 120 households came from Ghoramara Island, 110 households came from Lohachara Island and 80 households came from another part of Sagar Island. The method of data collection was by face to face interview.

Findings

By LIFE approach (Ghosh and Roy 2006) we tried to assess loss of livelihood, empowerment through asset loss, food and institutional support. We also tried to assess the human capital stock looking into educational attainment and skill available to the flood affected people. Table 2 below shows asset loss due to coastal flooding and inundation.

Table-2: Asset loss due to coastal flooding and inundation

Assets	Livestock resources				Human Life loss in no.	Rice (kg)	Stock of Paddy	Boat	Land loss (Bigha[6])	Fishing Net	TV & Solar
	Cattle in no.	Goats in no.	Poultry in no.	Sheep in no.							
Total amount	2440	1760	2130	2980	30	20800 kg	40000 kg	50	7440	50	10 & 10

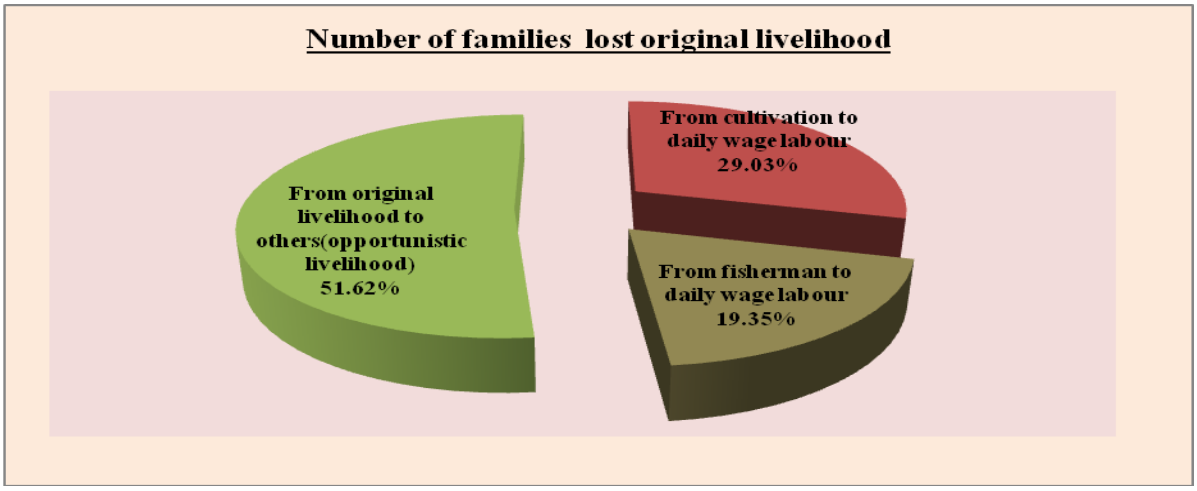
From the above data we see that migrants do not only lose land and house but also a huge amount of livestock resources. They are not only financially very weak but also physically weak due to malnutrition as the amount of rice and paddy loss shows a big volume and they now have to sustain on food stuff bought from the market place which they cannot afford to buy all the time and they are deprived of two square meals a day. The number of people died during migration and immediately after has also been reported at 10% appx.

[6] One Bigha = 0.33 Acre

This table-3 shows that 64.5% of the people had to change their original livelihood when they migrated from inundated island to Sagar. 19.35% people change from cultivation to daily wage labour, 6.45% people change from fisherman to daily wage labour and 35.39% people change to other opportunistic (job: whatever and whenever available for subsistence)livelihood.

Table-3: No. of families lost original livelihood

Lost of original livelihood	From cultivation to daily wage labour	From fisherman to daily wage labour	From original livelihood to others(opportunistic livelihood)
No. of households	60	20	120
Percentage (%)	19.35	6.45	35.39



Out of 310 households, 20 households are proactive migrants, - those people who leave there living place *before inundation* and 290 are reactive migrants, - those people who leave their living place *after inundation*. Since most of the migrants are reactive migrants cost of inundation in terms of migration is very high. Lohachara was inundated completely in 1982 but the majority part of people migrated in 1972-1975 and are now living at Bankimnagar colony, South Haradhanpur and Gangasagar colony on Sagar Island. Table 4 shows the type of institutional support they received while migrating and after getting rehabilitated.

Table-4: Institutional Support

Name of the institutes	Type of facilities
Government	House, land, dry food, Canvas, tube well, trawler fare and road in locality where they are rehabilitated
Non Government	Dry food and information on natural calamities

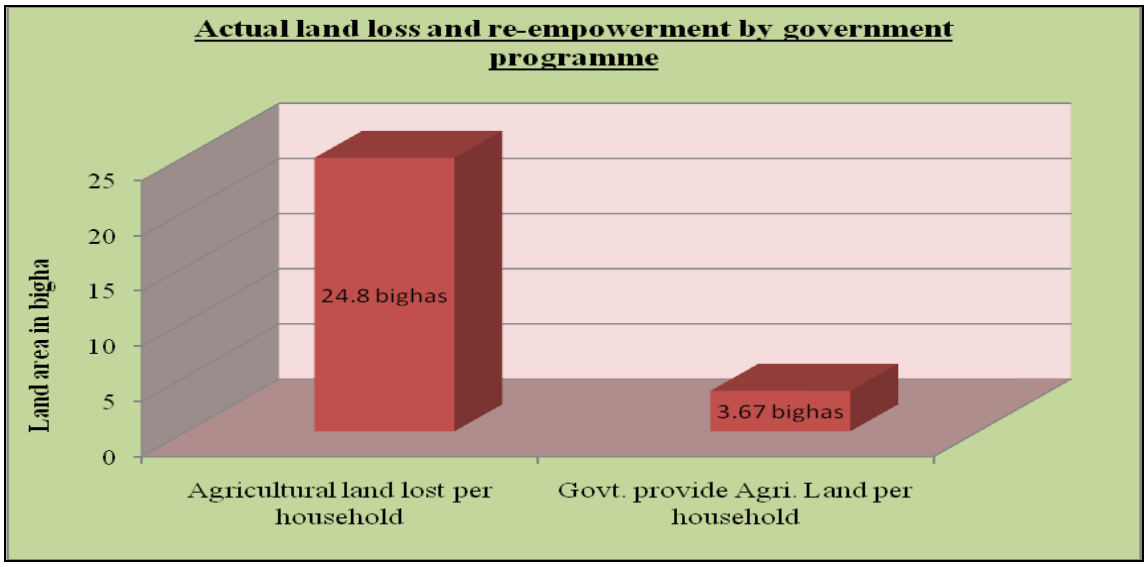
Govt. rehabilitations include giving away land to these migrants along with house, dry food, canvas, local road and tube well in locality. Govt. provides maximum land of 6.25 bighas per family in 1972 and minimum land of one bigha per family in 1998. Those people who came from Shibpur-Boatkhali to Gangasagar colony in 2002 are landless. However, major parts of the people have no Patta (ownership). The land provided by the Govt is not fertile so they are going to other places in search of job. Their standard of living is very low because major parts of the people are daily labourer and possess low fertile land. Govt. builds mud embankment which gets damaged every monsoon by flood, - resulting increase in soil salinity. As a result there is loss of crop and decrease in fish production. In Sagar block, all the embankments are mud embankment and average height is 7 feet and length is 25-30 feet. Those embankments which are built in line with the river and Bay-of Bengal are most affected ones. At Boatkhali, about five km of embankment was totally broken by coastal flooding in 2008 because it was a weak construction on the Bay-of Bengal. Soil salinity has increased in Boatkhali due to the broken embankment. However, people of South Haradhanpur, Bamkimnagar, Mansadeep, Gangasagar Colony, & Kamalpur enjoy low salinity due to the existence of stable embankments at those locations. Source of drinking water is tube well and people use pond water for other purposes.

To analyze the current status of migrated people the following table is very informative,-

Table–5:- Actual land loss and re-empowerment by government programme

	Agri. Land loss (Bigha)	**Govt. provide Agri. land (Bigha[7])**
Total land	7440	880
Average per household	24.8	3.67

[7] One bigha = 0.33 Acre

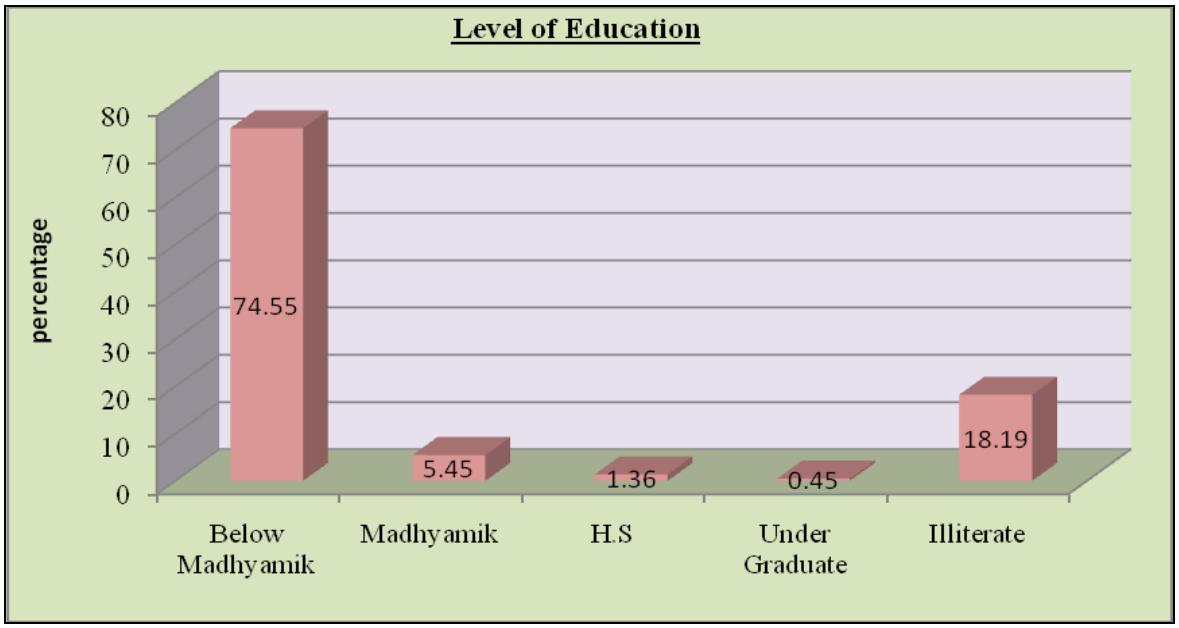


From table-5 above we see that migrants lost total agricultural land of 7880 bighas and they got only 880 bighas from the government, which is really negligible.

In the following table the present education level on Sagar Island is discussed -

Table-6:- Level of Education

Qualification		Total no. of people	Percentage (%)
Literate	Below Madhyamik (Secondary Level)	1640	74.55
	Madhyamik	120	5.45
	H.S	30	1.36
	Under Graduate	10	0.45
Illiterate		400	18.19



In Sagar block, education of majority of people is Below Madhyamik (74.55 %). Percentage of Illiterate people in Sagar Block is 18.19. Number of drop out in school increases because they can not maintain the cost of education and send children for work to give financial support to the family, creating child labour.

To calculate the value of asset loss, the volume of asset loss is being converted in monetary term which is shown in table below-

Table-7:- Valuation of household assets

Name of the assets	Physical damage	Valuation of damage (in Rs.)	Percentage (%) `
Land	7440 Bighas	595,200,000	97.98785
Cattle	2440	4,880,000	0.803395
Goats	1760	2,288,000	0.376674
Poultry	2130	159,750	0.0263
Sheep	2960	2,960,000	0.487305
Cash	427500	427,500	0.070379
Rice	20800 kg	312,000	0.051365
Stock of paddy	40000 kg	320,000	0.052682
Boat	30	600,000	0.098778
Fishing net	50	75,000	0.012347
T.V	10	50,000	0.008232
Solar	10	150,000	0.024695
Life	30		
Total		**607,422,250**	

From table-7- we see that maximum loss of asset is land (97.99%) and followed by livestock resources. Other assets like loss of crop, boat, TV etc are much less as compared to that of land and livestock. The total value of damage of those 310 households is Rs. 607,422,250 (about USD 12 Million) which is a huge amount and very alarming. The security and rehabilitation given by the institutions do not compare favourably at all with such a huge loss to an already impoverished community. No formal research/study has been made till date to assess this loss in detail. The strategies taken up by the Government or NGOs are ad hoc and hence it creates unrest among people. Table 9 below will show the peoples' suggestions towards improvement of their present conditions. But before we proceed to that it is important to make an assessment of vulnerability of migrants.

Vulnerability of migrants settled in various colonies is assessed by LIFE framework in Table- 8 below. The colony-wise vulnerability assessment has been carried out on the basis of the survey of responses of the migrant households on Sagar Islands. In the Sagar Island, Vulnerability Indices based on Livelihoods (VIL) is very high. 64.5% of the migrant households are vulnerable as they lose livelihood due to inundation. All the surveyed households also experienced more than 10% decline in their monthly expenditure. It was observed that the decline in monthly expenditures was higher for families who are reactive migrants compared to proactive migrants.

The Vulnerability Indices based on Food security (VIF) estimates show high vulnerable monthly food expenditure for 93.55% of the households and all households show a more than 10% decline. All the households also reported loss in agricultural output and fishery. The Vulnerability Indices based on Empowerment (VIE) shows that water borne diseases are common in the area during flood and afterwards. 77.42% of the surveyed households reported the incidence of water borne diseases. The education scenario is also poor in the area. Dropout rates are high at the primary level (38.71% dropout has been reported in the 4^{th} standard). 25.81% of the surveyed population has suffered from poor accessibility of safe drinking water.

The maximum loss has been reported in the South Haradhanpur colony, so this block is extremely vulnerable from the livelihood aspect. Most of the colonies are reported to be extremely vulnerable with respect to food security. The maximum loss has also been reported in the South Haradhanpur colony as far as empowerment is concerned. From this analysis it is evident that food security and livelihood are the most vulnerable aspects of these people. So rehabilitation programme may be taken up accordingly.

Table-8 : Vulnerability Assessment through Indices in the Colonies

Category		G.C[1]	M.C[2]	K.C[3]	B.C[4]	S.H.C[5]	S.B.C[6]
VIL	Percentage of loss of original livelihood	57.14	50	50	50	100	50
	Fall in monthly expenditure > 10 %	100	100	100	100	100	100
VIF	Percentage loss of crops and fisheries	100	100	100	100	100	100
	Fall in monthly food expenditure > 10%	100	100	75	100	100	75
VIE	% of dropout of children at 4th standard	28.57	50	0	37.5	75	50
	Percentage of water borne disease	57.14	100	100	62.5	100	75
	% of Scarcity of drinking water	57.14	0	0	0	100	0

The *suggestions* from the vulnerable/rehabilitated people of Sagar Island on improvements of facilities needed for day to day life is recorded by one to one discussion from migrants. The following table represents their perception in this context.

[1] G.C = Gangasagar Colony

[2] M.C = Manshadeep Colony

[3] K.C = Kamalpur Colony

[4] B.C = Bankimnagar Colony

[5] S.H.C = South Haradhanpur Colony

[6] S.B.C = Shibpur-Boatkhali Colony

It was a rewarding experience for the authors to obtain suggestions from the suffering community itself for improvement of their overall plight and the same provided a unique insight on the correct path to policy prescriptions. The responses of the people in this connection are detailed in Table 9 below:

Table-9:- **Suggestion for improving condition**

Name of the facilities	Total no. of respondents	Percentage (%) of respondents
House	150	48.39
School in locality	60	19.35
Tube well in locality	110	35.48
Road	100	32.26
Loan for pisciculture & Agriculture	20	6.45
Health centre in locality	30	9.68
Bridge (Bamkimnagar)	30	9.68
Concrete embankment	100	32.26
Electricity	30	9.68
Direct hand (Govt. facilities)	20	6.45
BPL(Below Poverty Line)card	40	12.90
Hostel facility (Free) for SC student	10	3.25
Afforestation to stop soil erosion	20	6.45
New job opportunity	20	6.45
Agricultural Land	50	16.13

According to migrants' response, demand for housing is in 1st position (48.39%) on their priority list, demand for safe drinking water from tube well is in 2nd position (35.48%), both road and concrete embankment comes in 3rd position (32.26%), school in 4th position (19.35%), agricultural land in 5th position (16.13%). BPL (Below Poverty Line) card by help of which they would get necessaries (e.g., rice Rs.2/kg) at very cheap rate is in 6th position (12.9%). Health centre, bridge (Bankimnagar), electricity is in 7th position (9.68%), new job opportunity, afforestation, loan for pisciculture & agriculture and Govt. facilities (direct hand) is in 8th position (6.45%), and free hostel facility is in last position (3.25%). From the above table it is clear that their demands are very basic and legitimate for maintaining the very minimum standard of living.

Conclusion

This study does not probe into the reasons of inundation, the loss of property and consequent distress due to land loss is obvious and our objective is to trace and analyze the responses of the affected population. Past studies demonstrate that large number of people has migrated to Sagar Island. Reactive and proactive actions are analysed to assess private costs and social costs. The assessment and cost estimates are based on secondary information as well as field level information gathered through Focused Group Discussions and Rapid Rural Appraisal. From physical data one can identify the vulnerability of this island due to coastal flooding and natural calamities. We tried to assess the volume of damage due to inundation and found that as compared to the rehabilitation facilities whatever if being given to the people of this island is virtually inadequate and negligible for their sustenance in the long run. They don't possess land and cannot continue with same occupation as before. This study identifies loss of livelihood. People are not educated enough to get job elsewhere. There exist severe drop outs in primary schools. Children are unable to continue school in search of unskilled jobs to support family creating child labour which is uncalled for. On the basis of vulnerability indices we found that the VIF (Vulnerability Indices based on Food security) is highest amongst all other indices. On the basis of such findings appropriate adaptation strategies may be taken up. In this context this paper can be used as a baseline study for proper adaptation strategy in future.

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