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Climate Change and Economic Adaptability of Indian Sunderban

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Abstract
Sunderban, a World Heritage Site, is the largest block of tidal halophytic mangrove forest in the globe. It is a delta of the rivers Ganga, Brahmaputra and Meghna and located in West Bengal state of India and neighbouring country of Bangladesh. It is dynamic ecosystems formed by interactions between land and water, and is considered as one of the most productive wetlands on earth. The entire Sunderban is about 26000 sq. km, the one-third of which falls in India. The present paper deals with the Indian part of Sunderban which is comprised of 102 islands; of which 54 islands are inhabited by human being.The Indian region is demarcated by the river Hooghly on the west, the Bay of Bengal on the south, the Ichamati-Kalindi –Raimongal rivers on the east and the Dampier-Hodges line on the north. It comprises of 19 Community Development blocks of which 6 in North 24-Parganas and 13 in South 24-Parganas districts with total 190 Gram Panchayats and 1064 villages. Sandeshkhali I,Sandeshkhali II, Hingalgunj, Hasnabad, Haroa, Minakhan belong to North 24 Paraganas and the blocks , like- Sagar, Namkhana, Kakdwip, Patharpratima, Kultali, Mathurapur I ,Mathurapur II, Jaynagar I, Jaynagar II, Canning I, Canning II, Basanti and Gosaba belong to the South 24-Parganas. The present paper deals with climate change and its impact on the economy of Suderban. The sharp rise of sea surface temparature, high rise of sea level, increasing tendency of average rainfall in monsoon, dominance of cyclonic activity in Sunderban region have been indicating the signs of climate change in Sunderban. Sunderban people have been lost their land as the tidal inflow tranforms into tidal bores, start to breach the embankments and aggravate the land subsidence in those sea facing lands of southern Sundarban. Overheating after short span of heavy rainfall event changes the fragile economy of this estuarine mangrove ecosystem. The recorded number of main worker remains constant, where as the number of marginal worker has been rapidly increased to contend with climate change. Fishing, aquaculture will be the possible way to survive. But the high intensity cyclones and tidal surges create a new challenge for the poor inhabitants. Monoculture of rice farming has been changing into vulnerable intensive subsistence and indigenous one to adapt with changing nature of climate of Indian Sunderban region. Thus the fate of economy of Indian Sunderban is completely directed by the changing climate of that region. Climate change is a dynamic and complex process which has been changing the basic economic structure of this mangrove kingdom.
Keywords: Climate Change, Economy, Main & Marginal worker, Indigenous

Introduction &Study area

Sunderban, a World Heritage Site, is the largest contiguous block of tidal halophytic mangrove forest in the globe. It is a delta of the rivers Ganga, Brahmaputra and Meghna and located in West Bengal state of India and neighbouring country of Bangladesh. It is dynamic ecosystems formed by interactions between land and water, and is considered as one of the most productive wetlands on earth. The entire Sunderban is about 26000 sq. km, the one-third of which falls in India. The present paper deals with the Indian part of Sunderban which is comprised of 102 islands; of which 54 islands are inhabited by human being.The Indian region is demarcated by the river Hooghly on the west, the Bay of Bengal on the south, the Ichamati-Kalindi –Raimongal rivers on the east and the Dampier-Hodges line on the north. It comprises of 19 Community Development blocks of which 6 in North 24-Parganas and 13 in South 24-Parganas districts with total 190 Gram Panchayats and 1064 villages. Sandeshkhali I,Sandeshkhali II, Hingalgunj, Hasnabad, Haroa, Minakhan belong to North 24 Paraganas and the blocks , like- Sagar, Namkhana, Kakdwip, Patharpratima, Kultali, Mathurapur I ,Mathurapur II, Jaynagar I, Jaynagar II, Canning I, Canning II, Basanti and Gosaba belong to the South 24-Parganas.

Objective

The present paper deals with the climate change in Indian Sunderban and the economy of that region. Economy is such an indicator which determines the status of living. So the present paper will examine the basic character of traditional economy of Sunderban region, as well as, it also looks into the recent changes that occur in the economic composition of Indian Sunderban region. At the same time the paper will give emphasis on the relation between the climate change and its impact on regional economy. Not only that, it will try to find out the changes in economic sectors as a part of adaptation with changing environment.

Methodology

The paper deals with the climate as well as the economy of a geographical space.

So, a number of relevant literatures have been taken under consideration to get secondary information of the studied region. At the same time it also to be said that it is not possible to prepare such a paper without getting secondary data from different official document which has created the database of this present analysis. On the basis of available statistical data, an intensive analysis has been done to represent the relationship between climatic change and its impact on economy of Indian Sunderban.

Hydro-geomorphic background of the studied area

Sunderban plain lies mostly over 6 meters above sea level. The region consists of low-flat alluvial plains in which the process of land making is still going on. The studied area consists of forest and swamp and intersected from north to south, by wide tidal rivers and from west to east, by narrow tidal creeks. All the estuaries, rivers and creeks carry saline water and connected with each other. In the sub-recent geological period, the sea receded southwards and a large area as plain land of very low altitude covered with fine clay of variable thickness got exposed. This required the then existing rivers to extend their courses to meet the receded sea. The recession of the sea face was due to uplift of the basement complex. To regain their profiles of equilibrium, the earlier river channels started getting exhumed afresh. As a consequence, the physiographic zone under study continues to experience the joint impacts of fluvial and marine geomorphological processes. All rivers in this zone experience tidal surges. Presently this exposed continental shelf is getting covered by sediments carried by tidal inflows as well as by the rivers. (Bhusan C., Living with changing climate, Center for Science and Environment, 2012)

Changing climate of studied area

The climate of the whole world is changing gradually and Sunderban region is not the exceptional one. If we give stress on the general climatic characteristics of Sunderban, we can observe that the average temperature of the water surrounding Sunderban, gradually increases over the time. The increase in this sea surface temperature (SST) has been much higher than the global average. The SST in the Bay has increased at the rate of 0.5 degree C per decade since 1980. While the globally observed SST warming rate is 0.06 degree C per decade between 1970 and 1999, that for the Indian Ocean for the same is 0.2 degree C per decade (Chand B.K.,Trivedi R.K., Dubey S.K., Beg M.M., Aquaculture in changing environment in Sunderban, West Bengal University of Animal and Fishery Science, 2012). In according to Indian Meteorological Department (2001), an increase in SST of 0.5 degree C in the eastern part of Sunderban. MIT said that the average temperature to have increased from 31.0C to 32.6 degree C between 1980 and 2007 in the pre-monsoon periods. Higher SST affects the process of evaporation, condensation, cloud formation and rate of precipitation etc. The following table shows that the average decadal change in SST is greater than half a degree in recent time in Indian Sunderban. At the same time it has also been observed that the average maximum monthly land mass temperature also denotes a positive trend in last decade, particularly from the month of September to April. The range varies from 2.0 degree to 5.0 degree for the span of 2005 to 2009.

Table -1: Decadal change in SST of Indian Sunderban

Year	SST (in degree C)	Decadal difference (in degree C)
1980	31.0	
1990	31.3	0.3
2000	31.8	0.5
2007	32.6	0.8

*data from IMD & calculated by authors

Sea level rise has also been higher than the global average in Sunderban. In according to School of Oceanographic Studies, JU, an increase at 17.8 mm/year in sea level between 2000 and 2009. National Institute of Oceanography (2006) indicates an increase of 5.7 mm/year between the year 2000 and 2004. Earlier, during 1991 and 1999, sea level rise in that area was 3.14 mm/year13.The current rate of sea level increase in Indian Sunderban is far higher than the global average rise in sea level which was in the range of 1.7 mm/year between 1870 and 2000 and 3.27 mm/year between 1993 and 2010. In according to the report of IMD, rate of rainfall has marked a sharp increase in rainy days as well as intensity of rain that enhance the risk of more frequent and disastrous cyclones (Aila, Nargis) in that region. At the same time it can also be observed that most of the severe cyclones take place in the span of April to June in recent years.

Table -2: Changing climate of Indian Sunderban

Month	Mean maximum Tem. (in degree) 2005	Mean maximum Tem. (in degree) 2009	Difference in degree C from 2005-2009	Frequency of severe cyclone				
				2000	2003	2007	2008	2009
January	26	28	+2					
February	29	31	+2					
March	32	34	+2					
April	34	36	+2				1	1
May	35	35	0		1	1		1
June	35	35	0			1		
July	32	32	0					
August	33	33	0					
September	28	33	+5					
October	30	33	+3	1			1	
November	30	31	+1			1		
December	27	28	+1					

*data from IMD & calculated by authors

Severe cyclonic storms over the Bay of Bengal have registered a 26 per cent increase over the last 120 years, intensifying in the post-monsoon period. The intensity of storm has been increasing time to time. The decadal frequency of storms in the Bay of Bengal from 1891 to 1961 as per the 1964 records of the IMD indicates that 56 cyclones occurred during 1921-1930, while 32 storms were reported for the period 1951-1960.

Population growth of Indian Sunderban

Before 19th century, Indian Sunderbans had no human population or habitation. In 1771, British collector general Clod Russell initiated a plan to divide the forest land into plots and lease them out to prospective landlords. At stake were timber and the collection of land revenue. These lease-holding landowners encouraged poor farming communities from other parts of Bengal as well as from neighbouring states to come and settle in the Sunderban. These people were put to work on clearing the forests and developing the land (Human development report, South 24 Parganas, 2009).

Table -3: Growth of population of Indian Sunderban region

Year	Total Population (in lakh)	Decadal increase (in lakh)	Population Growth (in %)
1951	11.5	-	-
1961	14.8	3.3	28.7
1971	19.4	4.6	31.1
1981	24.3	4.9	25.3
1991	31.9	7.6	31.3
2001	37.5	5.6	17.6

*data from Census report 2001 & calculated by authors

The growth of population is so remarkable in nature. In 1951, it holds only the population around 11.5 lakh and the population figure crosses the figure of 37 lakh in the year of 2001. So it is found that 26.0 lakh population has already been increased in the the time span of only 50 years. If the stress is given on the decadal population growth, it has been said that it always keeps it value more than 1.5 times. The main reason which is mostly responsible for such an increase is migration from Bangladesh for a long span of time, specially after 1971. In short, it can be said that the population increase is not at all satisfactory for the holistic development of Indian Sunderban. The following table shows that the mean population density of the studied region is 906.4 persons/sq. km. The blocks, like Haroa, Minakhan, Hasnabad, Canning I, Mathurapur I, Jaynagar I &II are highly populated with a greater population density than the district average.

Table -4: Population pressure on Indian Sunderban

Name of block	Population 2001	% of population of Indian Sunderban	Area (in sq. km.)	Population density (Population/sq. km.)
Hingalganj	156400	4.16	238.8	655
Sandeshkhali I	140476	3.74	182.3	771
Sandeshkhali II	136318	3.63	197.2	691
Haroa	182522	4.86	152.7	1195
Minakhan	168965	4.50	158.8	1064
Hasnabad	177521	4.73	153.0	1160
Canning I	244627	6.51	187.9	1302
Canning II	195967	5.22	214.9	912
Mathurapur I	164650	4.38	147.3	1118
Mathurapur II	198281	5.28	227.4	872
Jaynagar I	219090	5.83	131.0	1672
Jaynagar II	209145	5.57	186.2	1123
Gosaba	222822	5.93	296.7	751
Basanti	278592	7.41	404.2	689
Kultali	187989	5.00	306.2	614
Kakdwip	239326	6.37	252.7	947
Namkhana	160627	4.28	370.6	433
Patharpratima	288394	7.68	484.5	595
Sagar	185644	4.94	282.1	658
Total	3757356	100	4574.8	906.4

*data from Census report 2001 & calculated by authors

Economy of the Indian Sunderban

Most of the people of Indian Sunderban traditionally engaged themselves with the paddy cultivation. Aman cultivation is the mainstay of economy of the inhabitants of that region for a long span of time. There is a favourable condition of rice farming prevails in that region, that is why the local people choose this traditional option and have been enlisted themselves as the main worker of that region. If we give stress on the economic structure of that region, it has been found that agriculture plays as dominant economic feature for most of the development blocks. Basanti, Kultali, Sagar and Canning II are so significant in this case, as they hold more than 70% share as agricultural labour. So, it can be concluded that Indian Sunderban has been dominated by agriculture.

Table – 5: Role of agriculture in economy of Indian Sunderban

Name of block	Agricultural Labour 2009	Agricultural labour as % of total worker	Per capita cultivable land (hector)
Canning I	29369	37.1	0.07
Canning II	43863	73.9	0.08
Mathurapur I	22209	46.3	0.07
Mathurapur II	36698	62.5	0.09
Jaynagar I	42135	33.8	0.04
Jaynagar II	66004	54.1	0.07
Gosaba	63277	46.7	0.08
Basanti	21303	74.0	0.09
Kultali	40558	71.6	0.11
Kakdwip	44487	53.2	0.07
Namkhana	55683	63.8	0.11
Patharpratima	43895	65.8	0.13
Sagar	80887	73.9	0.09

*data from Human development report, South 24 Pgs, 2009

The following table represents the overall picture of paddy production of different blocks of Indian Sunderban. We can observe that Gosaba is most productive block in this context. The other blocks which have a good productivity are Mathurapur II, Patharpratima, Sagar, Jaynagar I, Kakdwip and Namkhana.

Table- 6: Net cultivated land &Paddy productivity of Indian Sunderban

Name of block	Paddy productivity (in tones/hector) 2009	Net cultivated area (in hector) 2009
Canning I	1.72	15862
Canning II	1.71	15847
Mathurapur I	1.6	11980
Mathurapur II	2.3	17878
Jaynagar I	2.0	9402
Jaynagar II	1.6	15539
Gosaba	2.7	17000
Basanti	1.7	26151
Kultali	1.9	19923
Kakdwip	2.1	15973
Namkhana	2.5	16910
Patharpratima	2.3	36429
Sagar	2.2	17436

*Statistical handbook 2009, Human development report, N&S 24 pgs, 2009

Climate change and effect on inhabitants

Population increase with an uncontrolled manner in the studied region creates a complex situation day- by- days. It is not possible for a region to provide proper opportunity for such a growing population with sharp increase. At the same time it should take under consideration that the changing nature of climate creates more complex condition and creates challenge for the inhabitants to live. As we know that the sea level of the studied area gradually rises, it has been found that a number of islands are being disappeared and the others being degraded regularly with the rise of sea level. As example Jambudwip, Dhanchi, Dalhousie, Ghoramara, Mousuni exhibits the trend of gradual erosion and subsidence in the part of Indian Sunderban. Lohachara has completely been disappeared.

Thus a real difference has been made in landuse of Indian Sunderban. It has already been detected that the amount of agricultural land gradually decreasing as a result of landmass sinking and subsidence. The local inhabitants have been facing a real problem as most of the people are engaged with agricultural based economy. They have lost their land and became helpless. If we concentrate on the figure of the people who has no land, we can observe that a significant number of people have been lost their own land of agriculture due to sea level rise. Not only but also a significant number of farmers are unable to plough their agricultural field due to over salinity. The saline water of sea often enters into the agricultural field by overtopping the embankment in the time of severe cyclones. As a result, the productivity of land decreases sharply and paddy production of Indian Sunderban has been threaten by such climatic phenomena.

Table-7: Temporal change of agricultural land of Indian Sunderban

Type of landuse	Year 2001	Year 2009	Area loss (sq. km.) 2001-2009	Area loss (in %) 2001-2009
Agricultural land	2149.6	1691.2	458.4	21.32

*data from Hazra S., 2010, Temporal Change Detection (2001-2008) &calculated by authors

Now people of Indian Sunderban have no option to go with their earlier choice of agriculture. They have to find some other way to get their job in their changing environment. So, a significant change should be observed in occupational pattern of those people. Sharp declines in the number of main workers signify that the poor inhabitants find no way to stay with their tradition of agriculture based economy and they have to shift to other economic sector for their survival. A parallel increase of marginal workers refer that the landless people have chosen an alternate economic system for their livelihood. Thus the main workers of Indian Sunderban have been converted into marginal workers with the changing nature of climate.

Table- 8: Transformation from main to marginal labours

Name of block	Year 1991				Year 2001			
	Main worker (in %)		Marginal worker (in %)		Main worker (in %)		Marginal worker (in %)	
	M	F	M	F	M	F	M	F
Canning I	48.05	2.95	1.15	1.81	40.58	6.68	10.56	5.96
Canning II	49.6	2.81	0.25	1.00	40.40	4.11	8.08	7.05
Basanti	49.23	2.82	1.13	5.48	39.19	3.97	11.53	8.38
Gosaba	51.55	4.91	1.73	12.59	41.03	3.99	15.01	16.41
Joynagar I	45.70	2.00	1.20	1.65	41.00	6.12	8.34	4.74
Joynagar II	45.27	1.89	0.67	1.34	40.06	5.10	9.19	9.30
Mathurapur I	45.21	2.08	1.57	1.95	34.26	2.96	14.18	2.64
Mathurapur II	48.90	2.48	1.02	3.50	42.36	4.20	10.18	6.72
Kultali	46.75	1.31	0.80	2.45	40.35	2.92	11.01	6.84
Patharpratima	48.44	3.09	2.84	9.85	43.73	8.73	11.26	20.87
Kakdwip	48.36	2.55	1.37	5.57	41.39	4.52	11.22	11.72
Namkhana	49.70	5.36	5.38	28.11	44.74	6.14	11.21	22.89
Sagar	46.70	1.58	1.15	3.83	40.86	4.51	11.86	23.16

*data from Human development report, South 24 Pgs, 2009

The transformation from main to marginal worker is taken under consideration for the span of 1991to 2001. The negative increase has been detected for the male main workers. It has been clearly noticed in case of Gosaba. It is the only block for which main worker decreases for both section (male and female). At the same time it is also to be said that the percentage share has quickly been raised for the marginal workers for all the blocks of southern part of Indian Sunderban. Gosaba and Basanti are such two blocks in which the positive increase take place most rapidly for the segment of male marginal worker.

Table-9 Decadal transformation of worker in Indian Sunderban

Name of block	Increase or Decrease 1991-2001			
	Main worker (in %)		Marginal worker (in %)	
	M	F	M	F
Canning I	-7.5	3.7	9.4	4.2
Canning II	-9.2	1.3	7.8	6.1
Basanti	-10.0	1.2	10.4	2.9
Gosaba	-10.5	-0.9	13.3	3.8
Joynagar I	-4.7	4.1	7.1	3.1
Joynagar II	-5.2	3.2	8.5	8.0
Mathurapur I	-11.0	0.9	1.4	0.7
Mathurapur II	-6.5	1.7	3.2	3.2
Kultali	-6.4	1.6	2.1	4.4
Patharpratima	-4.7	5.6	5.9	11.0
Kakdwip	-7.0	2.0	3.2	6.2
Namkhana	-5.0	0.8	0.8	-5.22
Sagar	-5.8	2.9	3.4	19.3

*calculation done by authors

At the same time the point also to be noted that the percentage share of female main workers slowly increases for most of the blocks, which means the local female population has been engaged themselves with the agricultural field and the male people leave their traditional occupation in the adverse situation and try to engaged themselves with some other economic activity. In short, it can be concluded that the inhabitants of Indian Sunderban has been facing great difficulties to live with the identity of a farmer and has been experiencing the curse of poverty and insecurity.

Table – 10: Poverty level of Indian Sunderban

Name of block	% of BPL Household	Less than one Square meal a day (%)
Canning I	31.1	13.7
Canning II	50.3	20.8
Mathurapur I	64.9	16.9
Mathurapur II	38.0	20.4
Jaynagar I	39.6	20.0
Jaynagar II	42.6	19.0
Gosaba	34.4	15.42
Basanti	39.6	36.9
Kultali	46.4	15.2
Kakdwip	49.1	16.4
Namkhana	34.9	22.5
Patharpratima	48.2	27.4
Sagar	44.5	28.3

*data from Human development report, S 24 Pgs, 2009

The above table shows the spatial distribution of poverty or BPL percentage in different blocks of Indian Sunderban. It has been found that Mathurapur I has been suffering by poverty very acutely. The other vulnerable blocks which are also suffering for poverty are Sandeshkhali I, Sandeshkhali II and Canning II. At the same time, it has also to be found that it is very tough for the poor people of Basanti, Sagar even to take their both end meals daily.

Conclusion

The fate of Indian Sunderban is completely directed by the changing climate of that region. Climate change is a dynamic and complex process which has been changing the basic economical structure of this mangrove kingdom. The paper gives stress on the relationship between the changing climate and change take place in economical composition. The time has come for the inhabitants of Sunderban to take some adaptive measures to defend the challenge of changing environment. The other alternative option for which they have shown their preference in the adaptive environment is aquaculture. But now-a-days they have really been tested as the aquaculture farms have been affected by salinization. The pH level of water has been changed and the commercial fish production also been disrupted by the severe cyclones or tidal boars. So, it can be concluded that neither agriculture nor aquaculture is now possible for the survival of the inhabitants of Indian Sunderban. They have to go for something else, which is suitable and sustained in changing environment of Sunderban region. Collection of wood, honey, wax, and crab may be considered as a good option for survival but these options cannot be treated similar to agriculture. They should give stress on the indigenous species of paddy as well as fishes which are able to maintain their life cycle in such a changing environment where salinity is such a problem. They should keep distance from the chemical fertilizers, chemical pesticides, high yielding seeds and go for those traditional, indigenous variety of rice species which have already been successfully tested in such as typical environment. Thus the monoculture of rice has been modified and the agriculture based traditional economy has been gradually changed into multi-faceted and subsistence in nature.

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