The Dynamic change of climate and struggle for existence of Indian Sundarban

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Abstract: Sundarban is the largest space of tidal halophytic mangrove forest in the glove. The dynamic process of changing climate is created the complexity of economic structure of Sundarban mangrove kingdom. Sundarban is a world heritage site and its dynamic ecosystems formed by interaction between land and water. The changing nature of agro-climatic condition in Indian Sundarban and its effect on the economy of the region is noticed. Economy is such an indicator which determines the status o living. The basic character of traditional economy of Sundarban region as well as it also looks into the recent changes that occur in the economic composition of Indian Sundarban region due to this reason. The presented paper deals with climatic change and its impact struggle for existence on the economy of Sundarban. The high rise of sea level increasing tendency of average rainfall in monsoon, domains of cyclonic activity is Sundarban region have been indicating the signs of climatic change of Sundarban. People have been lost their land as the tidal inflow transforms into tidal bores, starts to breach the embankments aggravate the land subsidence in those sea facing land of southern Sundarban. The recorded number of main workers remain constants where as the number of marginal worker has been rapidly increased to content with climatic change. Fishing, aquaculture will be the possible way to survive but the high intensity cyclones and tidal surges created 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 Sundarban region.

Key words: The dynamic change of climate and environment, economy, struggle for existence.

 1. Introduction: Sundarban is covered by the opening of the Ganges, the Meghna and the Brahmaputra. About 26000 sq. KM of thee coastal area of the Bay of Bengal, under six district of India and Bangladesh is enriched with the river-sediments. It is the biggest creative part of Gangatic Island. More or less $1/3^{rd}$ portion is covered under India and $3/4^{th}$ portion is under Bangladesh. The presented paper deals with the Indian part of Sundarban which is comprised of 102 Islands of which 54 Islands are inhabited by human being. About 130 K.M. out of 180 KM coastal area of Sundarban is covered by North 24 Parganas an South 24 Parganas of West Bengal of India. There are 31 numbers small and medium rivers and creeks. Tides are occurred two times every day. In 1984, IUCN recognized it as the world heritage stie. The Indian region is demarcated by the iver Hooghly on the west, the Bay of Bengal on the south, the Ichamati-Kalindi –Raimongal riverson the east and the Dampier-Hodges line on the north. It comprises of 19 Community Development blocks of which 6in North 24-Parganas and 13 in South 24-Parganas districtswith total 190 Gram Panchayats and 1064 villages.Sandeshkhali I, Sandeshkhali II, Hingalgunj, Hasnabad,Haroa, Minakhan belong to North 24 Paraganas and theblocks , like- Sagar, Namkhana, Kakdwip, Patharpratima,Kultali, Mathurapur I ,Mathurapur II, Jaynagar I, JaynagarII, Canning I, Canning II, Basanti and Gosaba belong to theSouth 24-Parganas.

2. Objective of study area: The presented paper deals with the dynamic climate change and struggle for existence of Indian Sundarban region. The economy is such an indicator which determine the status living. So, the presented paper will examine the basic character recently changes occur of traditional economy of Sundarban region. At the same time the paper will give emphasize 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 of Indian Sundarban.

3. 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 Sundarban. Besides, that it try to find out the changes in economic sectors as a part of adaptation with changing environment.

4. Hydro-geomorphic background of study area: The evolution of the coastal area of Sundarban and plate-tectonics are significantly affected according to the system. The creation of Sundarban and coastal site are equally important. The collection of river-sediments in the Bengal Basic area is still going on. Water level rises average 3.5 to 5.5 meter. But in high tides it reaches 7-10 meters above the sea level. Sundarban plains lie mostly over 6 meters above the 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 geo-morphological processes. All rivers in this zone experience tidal surges. Presently this exposed continental Paper ID: OCT1437.

5. Climatic change of Indian Sundarban: The climate of the whole world is changing gradually and Sundarban region is not the exceptional one. If we give stress on the general climatic characteristics of Sundarban, we can observe that the average temperature of the water surrounding Sundarban 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 since1980. 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 Sundarban, 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 Sundarban. MIT said that the average temperature to have increased from 31.0C to 32.6 degree C between 1980 and2007 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 Sundarban. At the same time it has also been observed that the average maximum monthly landmass 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.

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	

Table 1: Decadal change in SST of Indian Sundarban

Source: Data from IMD and calculated by authors

Sea level rise has also been higher than the global average in Sundarban 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 Sundarban is far higher than the global average rise in sea level which was in the range of 1.7mm/year between 1870 and 2000 and 3.27 mm/year between1993 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 cyclone stake place in the span of April to June in recent years.

Month	Mean Maximum Temp. (in degree) 2005	Mean Maximum Temp.(in degree) 2009	Difference in degree C from 2005-2009
Jan	26	28	+2
Feb	29	31	+2
Mar	32	34	+2
April	34	36	+2
May	35	35	0
June	35	35	0
July	32	32	0
Aug	33	33	0
Sept	28	33	+5
Oct	30	33	+3
Nov.	30	31	+1
Dec	27	28	+1

Table 2: Changing clmate of Indian Sundarban:

Source: Data from IMD and 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 1961as per the 1964 records of the IMD indicates that 56cyclones occurred during 1921-1930, while 32 storms were reported for the period 1951-1960.

2000	2003	2007	2008	2009
1	1	3	2	2

Table No.3: Frequency of cyclone in recent past in studied are:

Source: Data from IMD and calculated by authors

6. The changing population growth of Indian Sundarban:

Before 19th century, Indian Sundarban had no human population or habitation. In1771, British collector general Clod Russell initiated a plan to divide the forest land in to 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 neighboring States to come and settle in the Sundarban. These people were put to work on clearing the forests and developing the land (Human development report, South 24 Parganas, 2009).

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

Table No.4 - Growth of population of Indian Sundarban region

Source:Data from census report 2001 and calculated by authors

The growth of population is so remarkable in nature. In1951, it holds only the population around 11.5 lakh and the population figure crosses the figure of 37 lakh in the year of2001. So it is found that 26.0 lakh populations have already been increased in 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, especially after 1971. In short, it can be said that the population increase is not at all satisfactory for the holistic development of Indian Sundarban. 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, Joynagar I &II are highly populated with a greater population density than the district average.

Name of Block	Population 2001	Percentage of Population	Area (in sq.k.m.)	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
Mathutapur-II	198281	5.28	227.4	872
Joynagar-I	219090	5.83	131.0	1672
Jpynagar-II	209145	5.57	186.2	1123
Gosaba	222822	5.93	296.7	751
Basanti	278592	7.41	404.2	689
Kuloli	187989	5.00	306.2	614
Kakdwip	239326	6.37	252.7	947
Namkhana	160627	4.28	370.6	433
Patharprotima	288394	7.68	484.5	595
Sagar	185644	4.94	282.1	658
Total	**3757356**	**100**	**4574.8**	**906.4**

Table No.5– population pressure on Indian Sundarban region

Source:Data from census report 2001 and calculated by authors

7. The economic characteristic of various sectors of study area:

Most of the people of Sundarban area about 88.5 percent are cultivator. Their livelihood depends on cultivation. Besides, they are living with fishing, working as a labour in cultivation to others land, small business, collection of honey and different resource of forest. Sometimes, they are also engaged in canning , making bamboo hampers and other cottage industries. About 58% people are landless. Yearly income is of rRs.2000/- to 2200/- only. Most of the people are very poor. In every year four or five cyclones blows over this area. The river-sediments, saline-water, cyclones harm the cultivating lands of this area. Only Aman paddy is cultivated here. At present betel-leaf, water melon, different of vegetables etc. are also cultivating here. 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 Sundarban has been dominated by agriculture.

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
Mathutapur-II	36698	62.5	0.09
Joynagar-I	42135	33.8	0.04
Jpynagar-II	66004	54.1	0.07

Gosaba	63277	46.7	0.08
Basanti	21303	74.0	0.09
Kuloli	40558	71.6	0.11
Kakdwip	44487	53.2	0.07
Namkhana	55683	63.8	0.11
Patharprotima	43895	65.8	0.13
Sagar	80887	73.9	0.09

Table No.6 – Role of agriculture in economy of Indian Sundarban region

Source:Data from human development, south 24 parganas 2009

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.

Name of Block	Paddy productivity (in tones/hector) 2009	Net cultivated area (in hector) 2009
Canning-I	1.72	15682
Canning-II	1.71	15847
Mathurapur-I	1.6	11980
Mathutapur-II	2.3	17878
Joynagar-I	2.0	9402
Jpynagar-II	1.6	15539
Gosaba	2.7	17000
Basanti	1.7	26151
Kuloli	1.9	19923
Kakdwip	2.1	15973
Namkhana	2.5	16910
Patharprotima	2.3	36429
Sagar	2.2	17436

Table No.7–Net cultivated land and paddy productivity of Indian Sundarban region

Source:Statistical hand book 2009, human development report North and South 24 Pgs. 2009

8. The dynamic changing climate 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 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 Sundarban. Lohachara has completely been disappeared. Thus a real difference has been made in land use of Indian Sundarban. 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 Sundarban has been threaten by such climatic phenomena.

Type of land use	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

Table No.8–Temporal change of agricultural land of Indian Sundarban region

Source:Data from Hazra S, 2010 Temporal change detection (2001-2008) and calculated by authors

Now people of Indian Sundarban 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 Sundarban have been converted into marginal workers with the changing nature of climate.

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	2.9	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
Mathurapur-I	49.23	2.82	1.13	5.48	39.9	3.97	11.53	8.38
Mathutapur-II	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
Jpynagar-II	45.27	1.89	0.67	1.34	40.06	5.10	9.19	9.30
Gosaba	45.21	2.08	1.57	1.59	34.26	2.96	14.18	2.64
Basanti	48.90	2.48	1.02	3.50	42.36	4.20	10.18	6.72
Kuloli	46.75	1.31	0.80	2.45	40.35	2.92	11.01	6.84
Kakdwip	48.44	3.09	2.84	9.85	43.73	8.73	11.26	20.87
Namkhana	48.36	2.55	1.37	5.57	41.39	4.52	11.22	11.72
Patharprotima	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

Table No.9–Transformation from main to marginal labours

Source: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 Sundarban. Gosaba and Basanti are such two blocks in which the positive increase take place most rapidly for the segment of male marginal worker.

Name of the Block	Increase or decrease (1991-201)			
	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
Mathurapur-I	-10.0	1.2	10.4	2.9
Mathutapur-II	-10.5	-0.9	13.3	3.8
Joynagar-I	-4.7	4.1	7.1	3.1
Jpynagar-II	-5.2	3.2	8.5	8.0
Gosaba	-11.0	0.9	1.4	0.7
Basanti	-6.5	1.7	3.2	3.2
Kuloli	-6.4	1.6	2.1	4.4
Kakdwip	-4.7	5.6	5.9	11.0
Namkhana	-7.0	2.0	3.2	6.2
Patharprotima	-5.0	0.8	0.8	-5.22
Sagar	-5.8	2.9	3.4	19.3

Table 10: Decadal transformation of worker in Indian Sundarban region
Sorce: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, itcan be concluded that the inhabitants of Indian Sundarban has been facing great difficulties to live with the identity of a farmer and has been experiencing the curse of poverty and insecurity.

Name of the Block	% of BPL household	Less than one sq. meal a day (%)
Canning-I	31.1	13.7
Canning-II	50.3	20.8
Mathurapur-I	34.4	16.9
Mathutapur-II	39.6	20.4
Joynagar-I	39.6	20.0
Jpynagar-II	42.6	19.0
Gosaba	38.0	15.42
Basanti	64.9	36.9
Kuloli	46.4	15.2
Kakdwip	34.9	16.4

Namkhana	48.2	22.5
Patharprotima	49.2	27.4
Sagar	44.5	28.3

Table 10: Poverty level of Indian Sundarban region
Source:Data from human development report South 24 Pgs. 2009

The above table shows the spatial distribution of poverty or BPL percentage in different blocks of Indian Sundarban. It has been found that Basanti 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.

9. Conclusion

The fate of Indian Sundarban 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 Sundarban to take some captive 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 ortidal boars. So, it can be concluded that neither agriculture nor aquaculture is now possible for the survival of the inhabitants of Indian Sundarban. They have to go for something else, which is suitable and sustained in changing environment of Sundarban 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. The unskilled people have to stay with vulnerable agriculture based economy in the form of disguised labour. Even some of them have already lost their small piece of land to make plough and converted themselves as landless agricultural labour in against of very small daily wage. So, the time has come for the in- habitants of Sundarban to take some adaptive measures to defend the challenge of changing environment. The second 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.

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