# REVIEW ARTICLE ON CLIMATE INDUCED MIGRATION: RISK ASSESSMENT AND MANAGEMENT --A CASE STUDY OF SAGAR ISLAND OF INDIAN SUNDARBAN

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**ABSTRACT**

The effects of climate change are causing large scale human displacement all over the World. Natural disasters and slow onset environmental changes addressed the direct human cost; the Climate Refugees.The most vulnerable groups are poor in the developing countries due to poor adaptive capacity such as high level of poverty, lack of education, health care and sustainable livelihood; and thus lots of people of coastal areas and small islands have been and will be forcefully migrating in near future.

**KEYWORDS:** Climate Refugees, sustainable livelihood, Sagar Island, Environmental changes, Vulnerability

## INTRODUCTION

19.3 Million People were displaced Worldwide in 2014, which could be one billion by 2050 (Internal displacement monitoring Centre, Geneva). Geographically diverse Indian sub-continent is particularly vulnerable to a wide variety of natural disasters and India, as the largest country in this region, is the destination for those migrants being displaced by floods, storm surges, salt water intrusion, droughts, earthquakes, cyclones, and riser in sea level.

Moreover, the vulnerability of these migrant populations goes beyond the physical risk of the disaster. There are also economic, social and cultural fall outs which demand broader aspects of adaptation strategies and effective management policies.

### Reducing vulnerability through Sustainable livelihoods:

This requires an understanding of how local livelihoods are conducted and sustained as these are often shaped by poverty and their ability to reduce it. These dynamics determine the effects of impacts, how they respond with the resource they have and how community resilience can be built for successful adaptation strategies. The combination of a secured natural resource base, diversified livelihood activities, ecosystem management, restoration and reduced exposure to natural hazards has the capacity of meeting immediate development needs while contributing to long term capacity development for reducing future vulnerabilities.

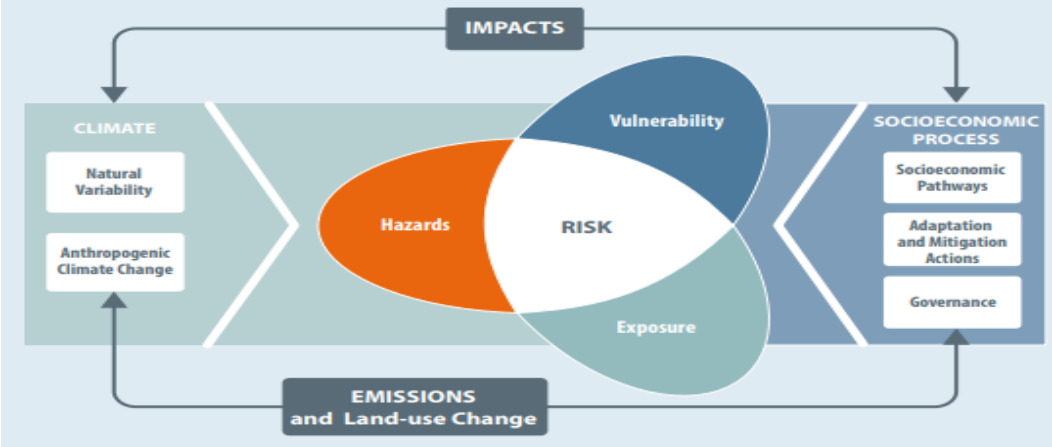


**Fig:1- Risk Assessment Model (Source: IPCC 5th Assessment Report)**

**PRESENT SCENARIO :**

Sundarban, World's largest contiguous mangrove forest; a UNESCO World Heritage site and one of the most highly modified and vulnerable deltaic estuaries in the World is already reeling under the impacts of climate change in the form of more turbulent seas, increasing saline soil and violent cyclones. Nearly 1.4 million people residing in 53 islands are facing serious threats of becoming climate refugees due to accelerating rate of sea level rise and coastal erosion.

**Table 2: Major climatic and geomorphological problems**

| | |
|---|---|
| Isostatic sea level rise | Localized sinking of the delta causes an implicit annual sea level rise of 3–8 millimeter (mm) depending on location, translating to 30–80 centimeter (cm) per century |
| Eustatic sea level rise | Global thermal expansion of the oceans from climate change is forecast to result in up to 59 cm of sea level rise in the coming century |
| Cyclonic storms | The region experiences about nine cyclonic storms every decade, with a third classified as "severe;" these are expected to increase in energy intensity by 15 percent over the coming century |
| Saltwater intrusion | All 19 blocks of the Sundarbans have seen persistent saltwater intrusion, which limits drinking water availability and decreases soil fertility |
| Tidal flushing from aquaculture | Inland tidal aquaculture over expanses of more than 40,000 ha creates a daily tidal flushing, which erodes embankments and channels seaward |
| Embankment undercutting and channel erosion | Historical embankment alignments have prevented natural geomorphological processes from creating wider channels and larger meanders to accommodate long-term easterly migration of the delta. As a consequence, embankments have weakened. A century of neglect has contributed to fragility. Almost 1,000 km of the 3,500-km system were destroyed by Cyclone Aila (2009) |
| Embankment overtopping and failure | |

**(Source: World Bank Report No- 88061)**

Indian Sundarban originally consisted of 102 islands, but now consists of 98 islands as 4 islands have been submerged and nearly 6,000 families became homeless and turned into environmental migrants (WWF India, 2009).

Based on the current habitation and density, over 70,000 people will be homeless in next 13 years due to rising sea, an d by 2020, more than 30,000 people residing in Sagar Island will be displaced from their habitat (S. Hazra 2002).

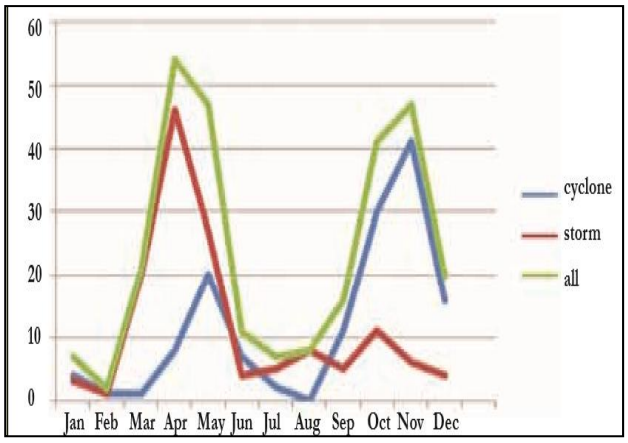


**Fig:2-Frequency of Cyclone over Bay of Bengal (Source:IMD)**

Vanishing lands mean displacement and loss of livelihood and coupled with high population and lack of other development choices are making food security, public, health ecological balance, sustainability, economic viability of the population are under threat.

## LITERATURE REVIEW AND CONCEPTUAL BACKGROUND

i) Risk Assessment and Vulnerabilities:

Risks related to climate change arise from climate-related hazards (climate trends and extremes) and the vulnerability of exposed societies, communities or systems (in terms of livelihoods, infrastructure, ecosystem services and governance systems). Effective measures to adapt to climate change and reduce the risks can address all three aspects of risk: hazard, vulnerability and exposure. The vulnerability and exposure of societies and ecological systems to climate-related hazards vary constantly because of changes in economic, social, demographic, cultural, institutional and governance circumstances. (5$^{th}$ IPCC Report).

Island vulnerability depends on climatic factors but also socio-economic, physical and ecological stressors, and the interactions between them. To understand climate vulnerability on islands, it is necessary to assess all of these dimensions of vulnerability. Islands faced with multiple stressors can be assumed to be at more risk from climate impacts (5$^{th}$ IPCC Report).

The recommended measures address the most important necessary groundwork for long-term socioeconomic development and vulnerability reduction in the region. While there is great urgency attached to implementing some of the interventions (such as repairing embankments or meeting basic human needs), the pace of the overall strategy reflects a multigenerational time horizon (World Bank Report No-88061).

Sundarban offers the intricate challenge of striking the right balance in respect of developmental activities in one of the most backward regions, providing infrastructures & livelihood to the poor but enterprising inhabitants and simultaneously protecting one of the most fragile but bountiful and unique eco system perhaps in the entire world (Dept. of Sundarban Affairs, W.B.).

This paper observed that climate change is an important driver of migration. Lots of people have migrated during last few decades forced by climate change in Indian Sundarbans. Research shows, in

future thousands of people will be migrated from the same. This study has tried to identify two groups of migrants: proactive and reactive; and comparative analysis of losses of these two groups during migration and thereafter. (Guha et.al. 2016).

This paper enquires the increasing rate of coastal erosion plays an important role in shoreline change and we can find its imprint on Bengal basin through the erosion of deltaic plains like Ghoramara, Sagar islands etc. Since 1851 Sagar Island was eroded and its impact was found on changing land use pattern and occupational activities(Roy Chowdhury and Sen 2015).

This paper evaluates the possible increase in cyclone frequency in the Bay of Bengal, lying south of Bangladesh, due to climate change is looked at by analyzing the cyclone data for 119 yr. Both qualitative and quantitative discussions are made on cyclone intensity increase for a sea surface temperature rise of 2 and 4°C. Different scenarios of storm surges under different climate change conditions are developed by using a numerical model of storm surges for the Bay of Bengal. (Ali 1994).

This paper suggests five dimensional community resilience assessment frame work and a composite resilience index against climate related disasters in the Sundarbans; typical example of complex and dynamic socio-ecological system with high population density, dense mangrove forest and recurrent climate disasters (Dasgupta 2015).

This paper suggests greater degree of certainty can be achieved while applying the output as a blue print for the coastal managers and planners. It is increasingly recognized that both the catchment and coast should be treated as an integrated whole on environmental, socio-economic and political system (Moudal et al. 2017).

This paper enquires that in the Indian coast past observations on the mean sea level indicate a long-term rising trend of about 1.0 mm yr-1 on an annual mean basis. However, the recent data suggests a rising trend of 2.5 mm yr-1 in sea level rise along Indian coastline. The east coast of India is more vulnerable to sea level rise in comparison to that of the west coast (Shetye et al. 2015).

This paper assesses that in the Indian Sundarban delta, some islands are fast vanishing from the map rendering thousands of people permanently homeless and displaced from their original habitat. The rate of relative sea level rise is presently approaching 3.14 mm per year near Sagar Island (88°03'06.17" longitude and 21°38'54.37" latitude), the largest island in the western sector of Indian Sundarbans and this could increase to 3.5 mm per year over the next few decades due to global warming, including the other global and local factors. (Mitra et al. 2005)

**i. GIS Approaches to Risk Management and Sustainability**

Climate change induced sea level rise (SLR) added with anthropogenically altered environment leads to rapid land dynamics in terms of erosion and accretion; and alteration in species diversity and productivity, more pronouncedly in sensitive ecosystems such as river deltas. These papers analyzed the historical records to understand the SLR

with respect to hydrological conditions, sedimentation and morphological processes.

This paper analyzed the land transformation of few islands in Indian Sundarbans using maps and satellite images in increasing order of temporal frequency between 1924 and 2008, which revealed that both the erosion and accretion processes go hand in hand. Increase of downstream salinity due obstruction in upstream has led to decrease in transparency of water causing decrease in phytoplankton and fish, density and diversity in the central sector of Indian Sundarbans. The study reveals the cumulative effect of climate change and anthropogenic disturbance on the diversity and productivity in World's largest ecosystem. (Misra et al. 1983). Spatial data collected through field survey, satellite images of IRS-1C LISS III, and topo maps. Spatial data include coastal geomorphological landforms, land-use and land cover, shoreline change, sandy beaches, coastal erosion sites, agricultural fields, aquaculture sites, and coastal riparian vegetation. The main critical environmental issues of the island This paper computed an integrated database of the island using spatial and non-are: (1) degradation of mangrove forests and coastal erosion; (2) overpopulation and over-exploitation of living resources; and (3) destruction of seawalls. (Mitra et al. 2013).

This paper states that compared to the last 30 years 14% homesteads land cover areas are increased. There was not any astonishing changed in mangrove vegetation. Some mangroves areas were shattered and some other mangroves were full-fledged again in delta areas. The harmful land cover changes are not expectable for the natural environment (Rahman et al. 2003).

This paper interprets the changes in mangroves and LU/LC environment of ISD since last 15 years. High-resolution Remote Sensing (RS) satellite data from 1990 to 2016 of equal intervals of ten years has been processed and analysed with Geospatial Information System (GIS) environment. Comparatively change detection in LU/LC of ISD has been prudently studied over the years 1990, 2000, 2010 and 2016 by using two image processing techniques: Normalized Difference Vegetation Index (NDVI) which is used in detecting the temporal changes in vegetation and Maximum Likelihood Classification (Supervised Classification) technique is used for Land Use/ Land Cover (LU/LC) analysis (Kumar et.al. 2006).

This paper examines that the shoreline position is difficult to predict but the trend of erosion or accretion can be determined by geospatial and statistical techniques. Shorelines have been delineated by using Tasseled Cap Transformation techniques from the Landsat MSS (1975), Landsat TM (1989, 1991) and Landsat ETM+ (1999, 2002, 2005, 2008, and 2011) images. The rate of erosion was -7.91 and −7.01 m/year for the periods 1975–2002 and 2002–2011 respectively. The mean shoreline change rate was high in Segment B (South Sagar) with values of −6.46 m/year (1975–2002) but the rate was decreased into −5.25 m/year during the later period (2002–2011). The study

reveals that most of the southern part of Sagar Island is vulnerable to high rate of shoreline erosion (Dutta et al. 2016).

This paper detected shoreline by using PCA and non-directional edge techniques from Landsat images. The study focuses the shoreline change and in future prediction from satellite derived multi-temporal Landsat MSS, Landsat TM, Landsat ETM+, Landsat OLI data using GIS; it is used to determinate or to estimate the change rate of shoreline in Sagar Island by End Point Rate, and Linear Regression models (Dhara et al. 2017).

An attempt has been made in this paper to see whether the same method is applicable to IRS, LISS-III data for the discrimination of land/water boundary using semi-automated methods. Semi-automated algorithms such as level slicing of Band 5, ISODATA, PCI, NDVI, WI techniques were taken for the present study. In this connection, an example of Sagar Island along the east coast of India has been taken for the present study as their coasts is composed of several sub-tidal and inter tidal mudflats and constantly experiencing severe erosion/accretion (Ghosh et al. 2012).

The extent of coastline changes is made by comparing the topographic maps of 1967 and satellite imageries of 1996, 1998 and 1999 in this paper. Between 1967 and 1999 about 29.8 km2 of the island has been eroded and the accreted area is only 6.03 km2. Between 1996 and 1998 the area underwent erosion of 13.64 km2 while accretion was 0.48 km2. From 1998 to 1999, 3.26 km2 additional areas were eroded with meagre accretion. Erosion from 1997 to 1999 was estimated at 0.74 km2 /year; however, from 1996 to 1999, the erosion rate was calculated as 5.47 km2/year. (P. Seralathan 2005).

This paper enquires that the Bengal Basin and this part of the deltaic plain is gradually tilting towards east. This has probably caused the main fresh water discharge to shift gradually eastward (through Bangladesh) imposing severe stress on freshwater budget for Hoogly-Matla estuary (Morgan and Mclntire 1959).

In this paper it has emerged from the analysis of remote sensing data and field mapping that a significant reduction of land area (around 86Km2) has occurred in the estuarine island system over the past 3 decades. This has happened in spite of huge sedimentation by the river Hugli and increased freshwater inflow by the river after construction of Farakka barrage (Hazra et al. 2002).

## FINDINGS FROM LITERATURE REVIEW

This literature review paper would enable the researcher to better understand the problem scenario and implement the policy measure on an integrated platform to allow Govt. NGOs, agencies planners, researchers, stake holders to develop a better support system.

- Climate induced migration was once presented as a pathology to be prevented, but now presented as a rational strategy of resilience on an empirical level. Relocation of million is rendered acceptable and conflicts, vulnerabilities, challenges, societal instability,

policy and politics, insecurities, injustice- all these issues are along with existing geopolitical and economic relation being handled with the perspective of human rights and climate justice.

- This constantly sinking and shrinking landmass of Sundarban by served cyclonic storms, rising seas, coastal flooding and erosion is also threatened by unmanageable demographics, marginalized livelihoods, limited sustainable economic and ecologic development which needs immediate inclusive and fool proof action plans and management strategies.

- Along with geospatial techniques in risk monitoring and holistic management, various statistical models and framework of analyzing vulnerability, adaptive capacity and livelihood sustainability like LIFE framework, climate vulnerability index (CACI), strength, weakness, opportunities and threats (SWOT), sustainable livelihood framework (IPCC) can supplement or complement the existing policy decision management system.

## CONCLUSION

World's largest contiguous mangrove forest and one of the most highly modified delta Sundarban is facing grave socio-ecological risks if it fails to adapt to climate change. It has attracted a steady stream of researchers from home and abroad, but the outcomes and findings have often not been appropriately communicated to the subjects of the research or to policymakers. This fragile wetland is at environmentally alarming situation and all the challenges and opportunities are linked to proper Assessment, response, recovery, mitigation, planning and implementation on both spatial and temporal scales of its endangered habitation.

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