Micro level vulnerability assessment of estuarine islands: a case study from Indian Sundarban

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DELTAS
SUSTAINABLE DELTAS 2015

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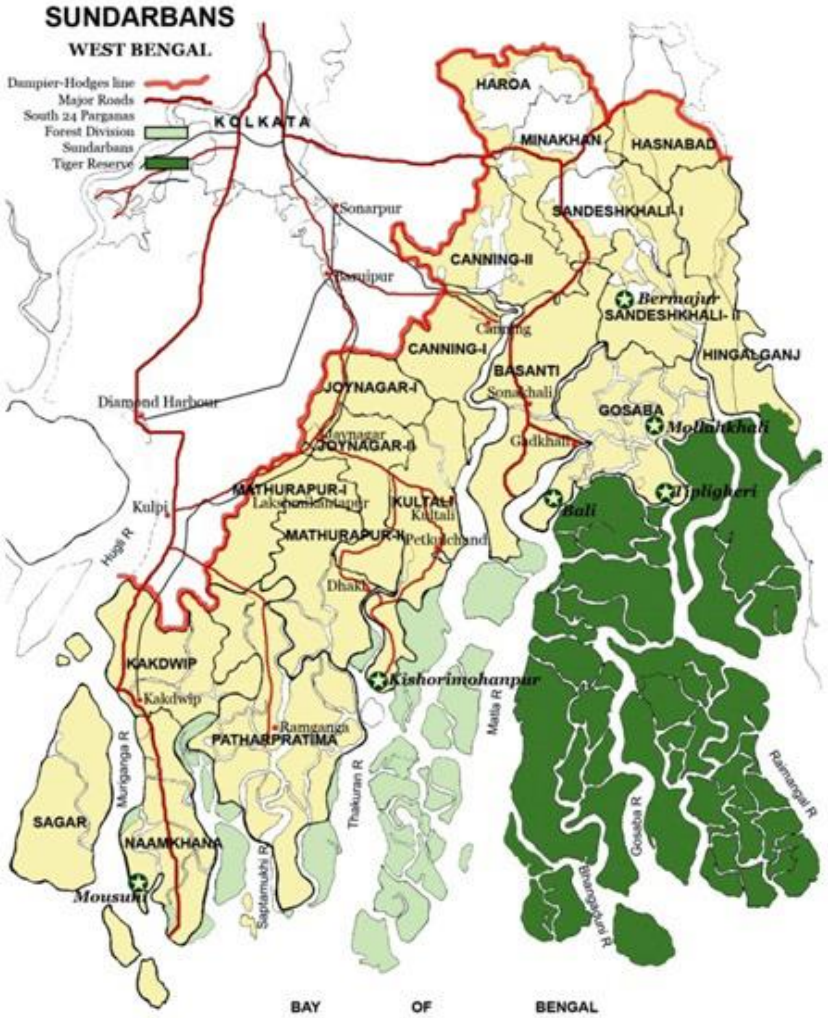
CPC
centre for population change

Indian Sundarban



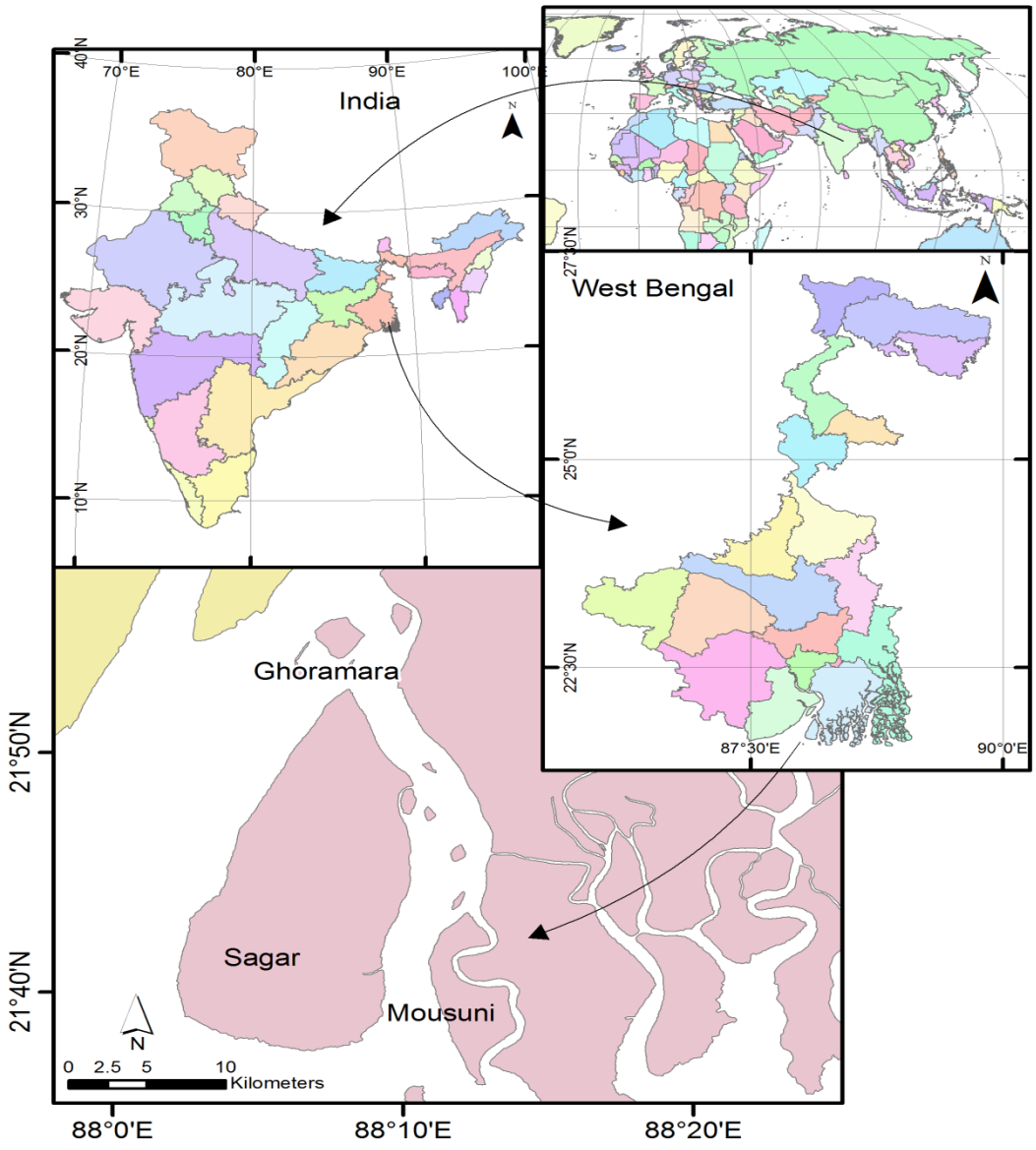
- World heritage site
- Largest mangrove patch(4.3%)
- Rich biodiversity- flora, fauna
- 4.6 million population
- 34% under poverty
- 99% rural areas
- Poor access to infrastructure



Sundarban biodiversity



Location of study area



- Three islands- Sagar, Ghoramara and Mousani
- Western part of Indian Sundarban Island system
- Extended from 21˚37’ North to 21˚55’North and 88˚2’ East to 88˚15’ East

Sagar Island

- Situated under administrative jurisdiction of district South 24 Paraganas of West Bengal, have 42 mouzas/ villages
- Largest among Sundarban Island- area of 245.33 km^2
- 206844 population (Census, 2011)

Ghoramara Island

- Situated under administrative jurisdiction of Sagar Block of district South 24 Paraganas of West Bengal
- Has an area of 4.4 km^2 with population 5193(Census, 2011)

Mousani Island

- Mousuni Island is under administrative jurisdiction Namkhana CD Block of West Bengal, have 4 mouzas/ villages
- Covering 29 km^2 area with population 22073(Census, 2011)

Vulnerability context: study islands

- The temperature increase rate has been reported about 0.019˚c with a projected 1 ˚C by the year 2050 (Hazra et al. 2002)
- Sea level rise 1990- 2000: 3.14 mm/year (Hazra et al. 2002)
- Change in river hydrodynamics
- During 1969 to 2009 Indian Sundarban had total landloss of around 210 km^2 (Hazra et al. 2013)
- During the last part of decade (2006-2009) : experienced four major cyclones viz. Sidr, Nargis , Bijli and Aila

- Cyclone '***Aila'*** of 2009 was the most hazardous of the climatic disasters to have recently hit the Sundarban Delta
- High population growth
- Development constraints: road connectivity, access to health services

Research questions

- What are the trends in physical and anthropogenic changes?
- What are the key elements of vulnerability in the study area in respect to both the natural and socio-economic factors?
- What is the extent of social and environmental vulnerabilities in the study area?

Data

Primary and secondary data sources:

- Survey data: Direct interviews with 783 households, selected by cluster random sampling
- Published data: Indian Meteorological Department; Directorate of Census, Govt. of India; WWF
- Satellite images: Landsat data

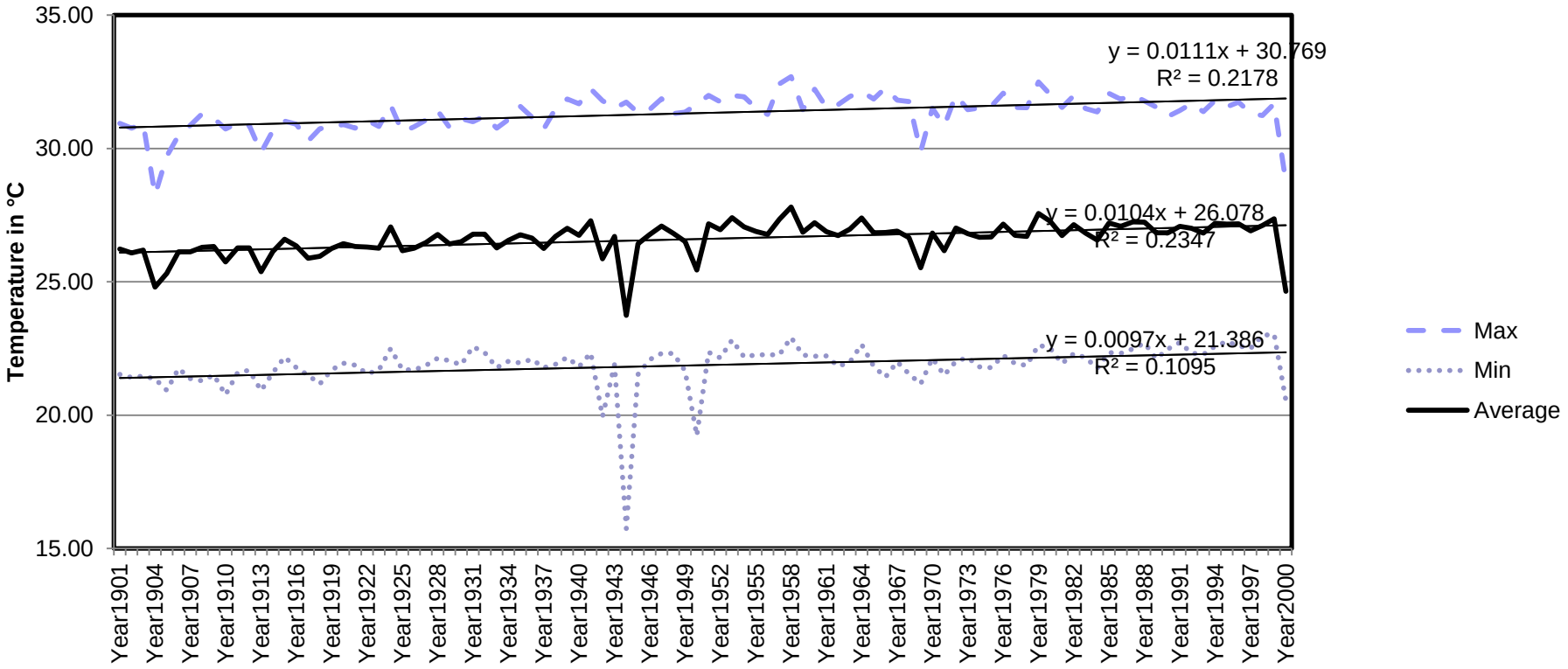
Analytical approach

- The data analysis have been done in two stages
- Stage 1: Trend analysis to get change pattern as background of vulnerability analysis
- Stage 2: assessment of actual scenario along with vulnerability mapping

Trend analysis of study islands

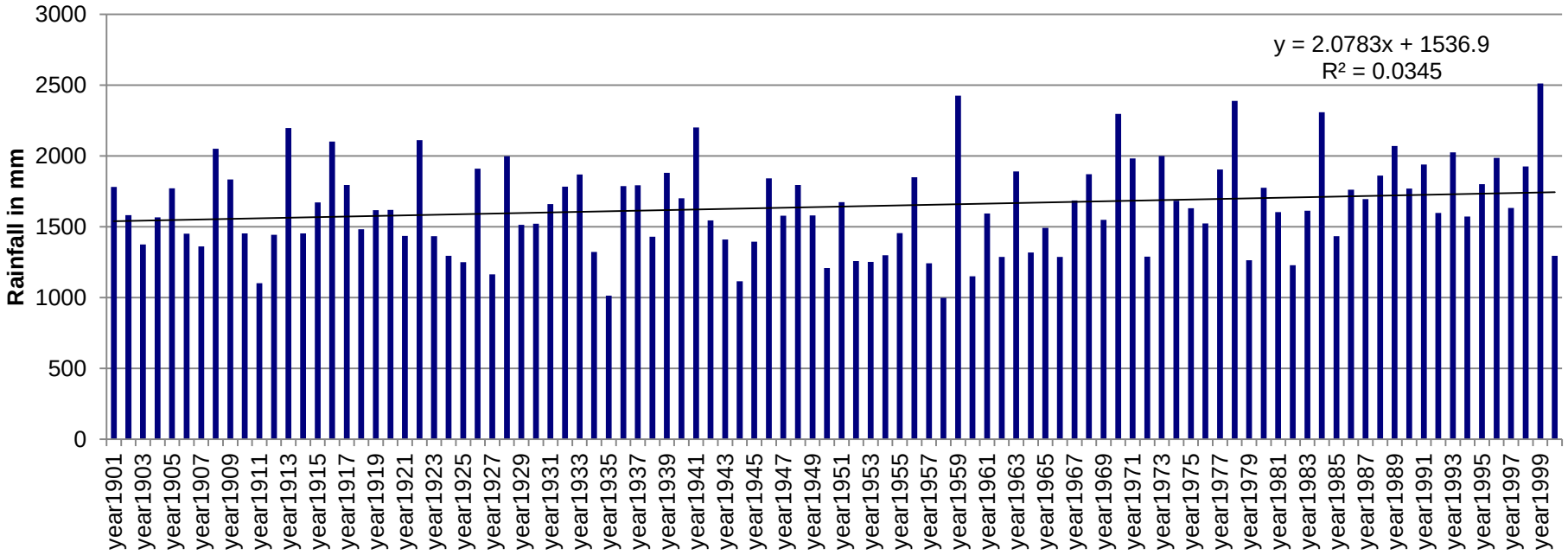
Temperature

- Average surface temperature increase: 0.011°C per year



Change in surface temperature pattern during 1901 to 2000. Source: IMD data

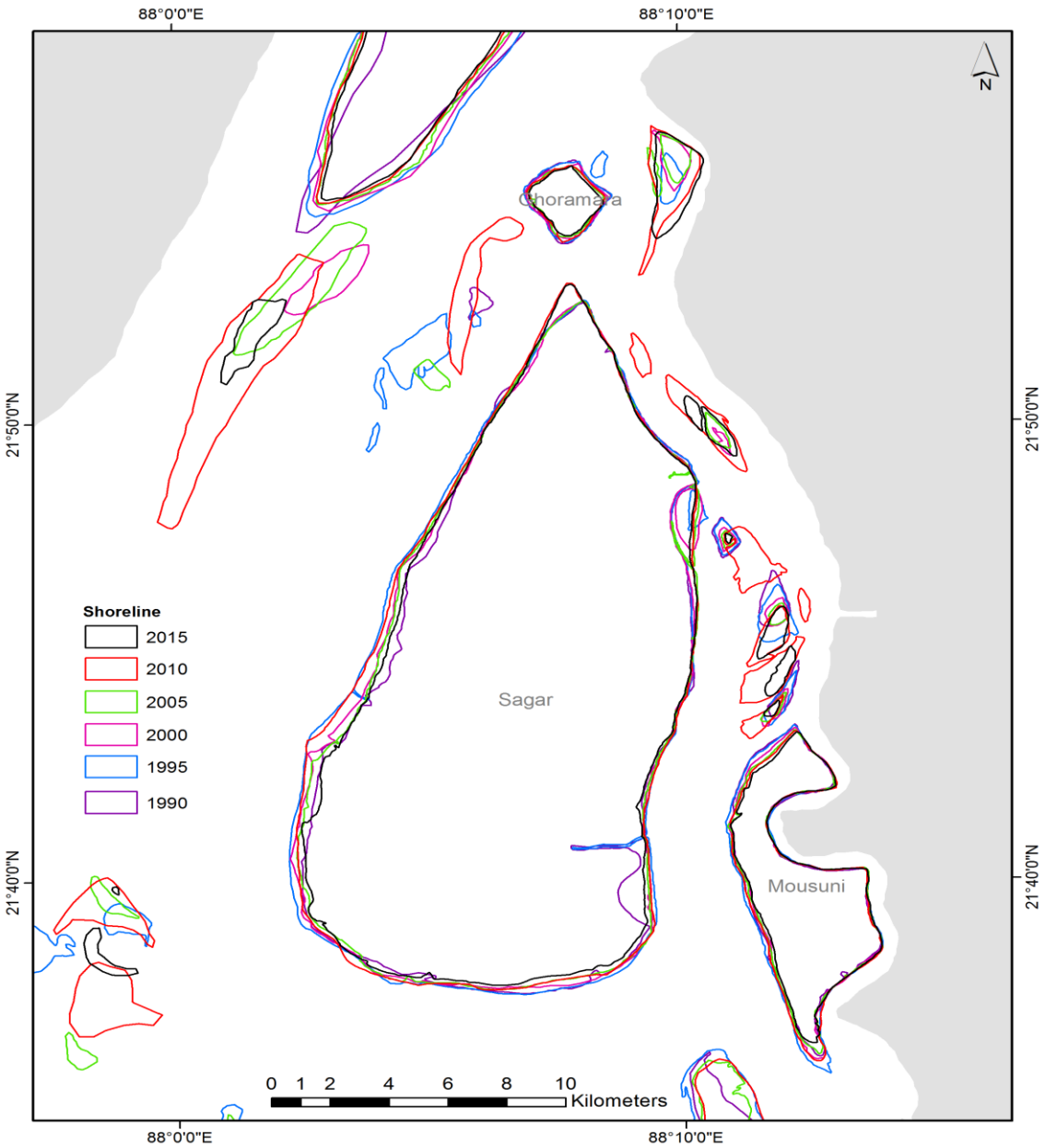
Rainfall



Change in rainfall pattern during 1901 to 2000. source: IMD data

- Amount of rainfall has increased :rate of 2.08 mm per year (1901 to 2000)
- Number of rainy days have decreased implies the increase in intensity of rainfall.

Morphological change in study islands(1990 to 2015)



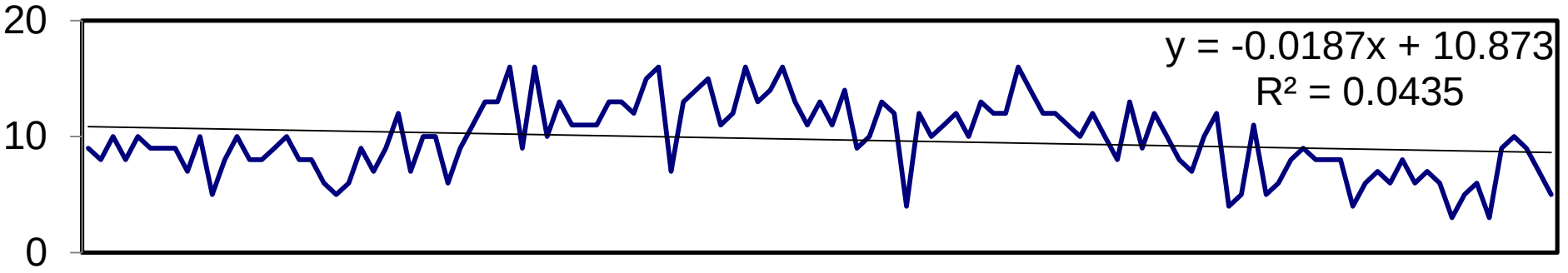
Erosion

- During the time period of 1990 to 2015: higher rate of land loss
- **Sagar Island**: Erosion rate estimated 0. 2 km^2 per year
- **Mousani Island**: Considerable land loss: rate of erosion almost 0.08 km^2 per year
- **Ghoramara Island**: Experienced huge land loss, maximum loss between 1975 to 1990

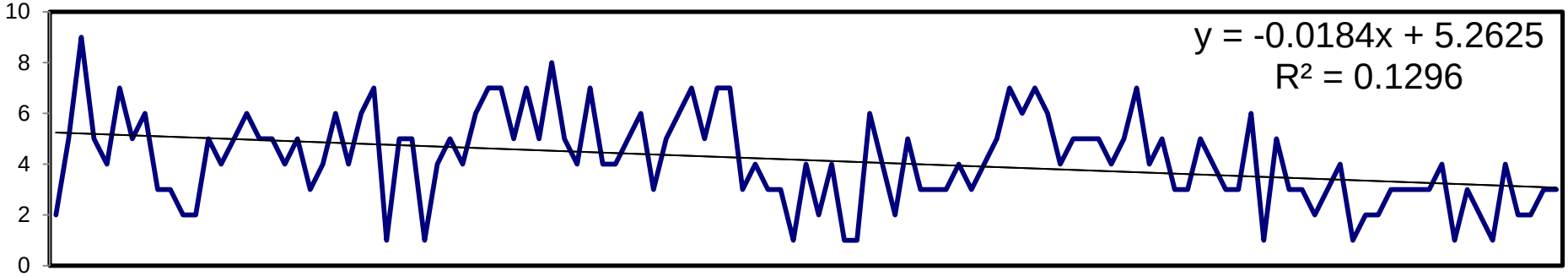
Total Land Area and Land Loss of Study Islands during 1990 to 2015

Island	Time window	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2015
Sagar	Erosion in sq km	0.43	9.35	3.8	0.55	5.79
	Accretion in sq km	17.13	1.59	0.86	7.56	0.39
Ghoramara	Erosion in sq km	0.11	0.61	0.61	0.09	0.46
	Accretion in sq km	0.35	0.00	0.02	0.29	0.05
Mousani	Erosion in sq km	0.18	2.85	0.86	0.42	1.02
	Accretion in sq km	2.48	0.05	0.45	1.21	0.37

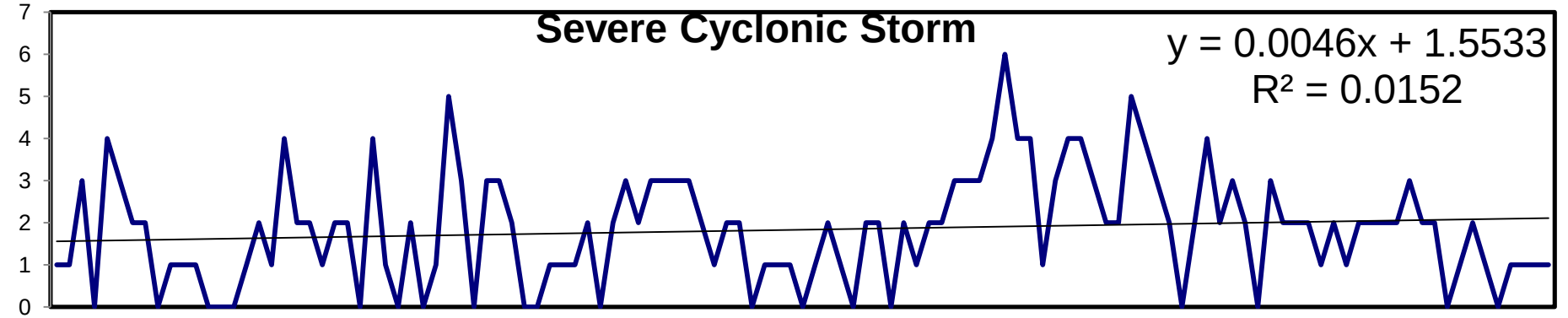
Cyclonic Depression



Cyclonic Storm



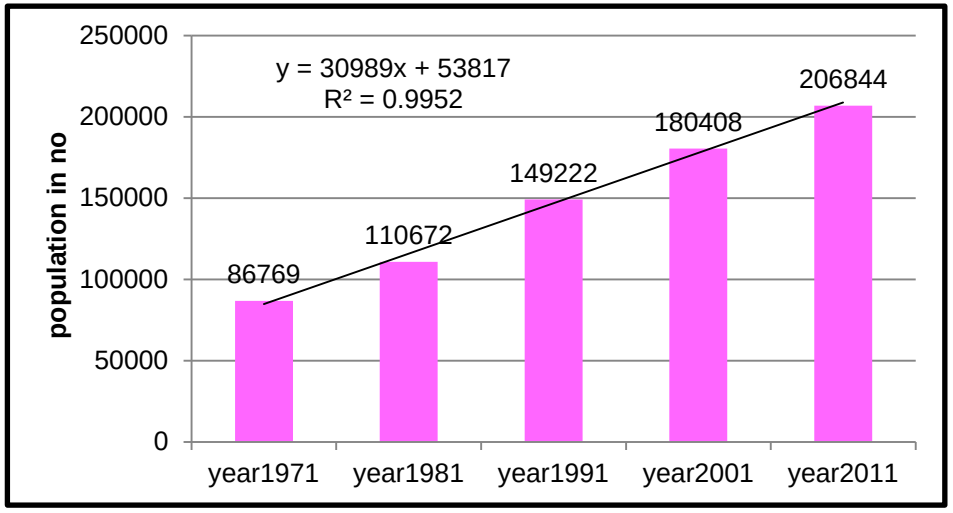
Severe Cyclonic Storm



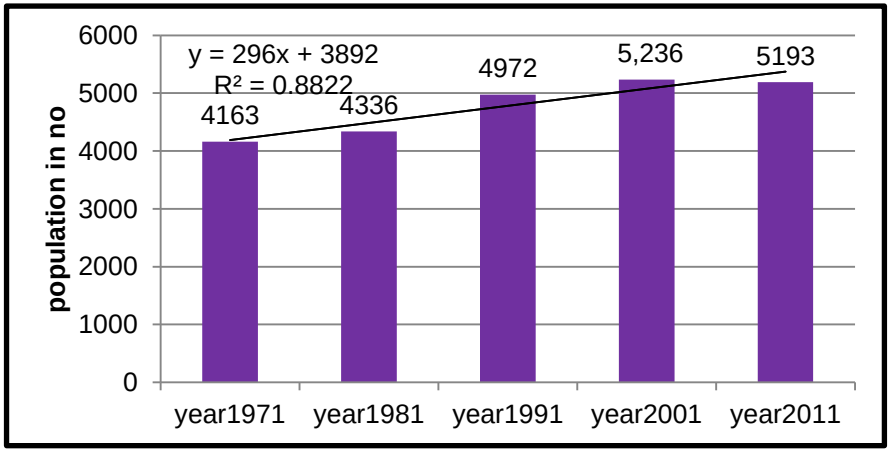
Population growth

- Sagar Island: population growth of 2.1% per annum
- Ghoramara Island experienced little growth, 0.55% per annum and -0.08% growth rate at 2011
- Mousani Island experienced population increase at 2%growth rate per annum

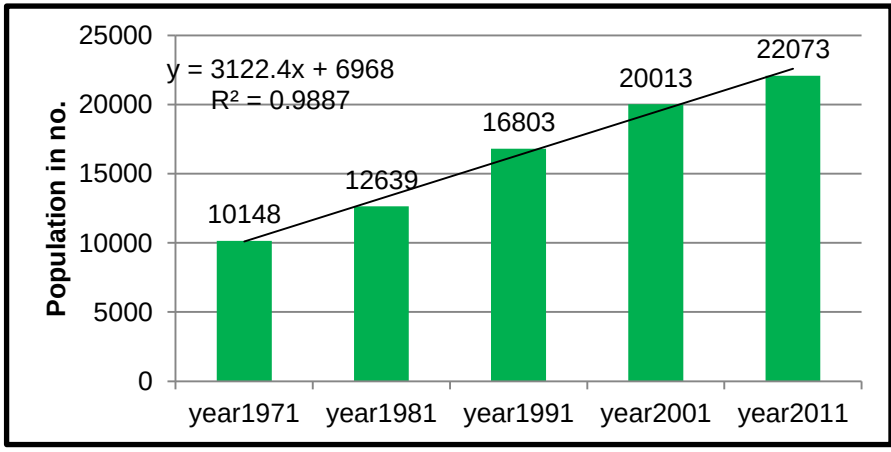
Total population change pattern in Study Island during 1971 - 2011



Sagar Island

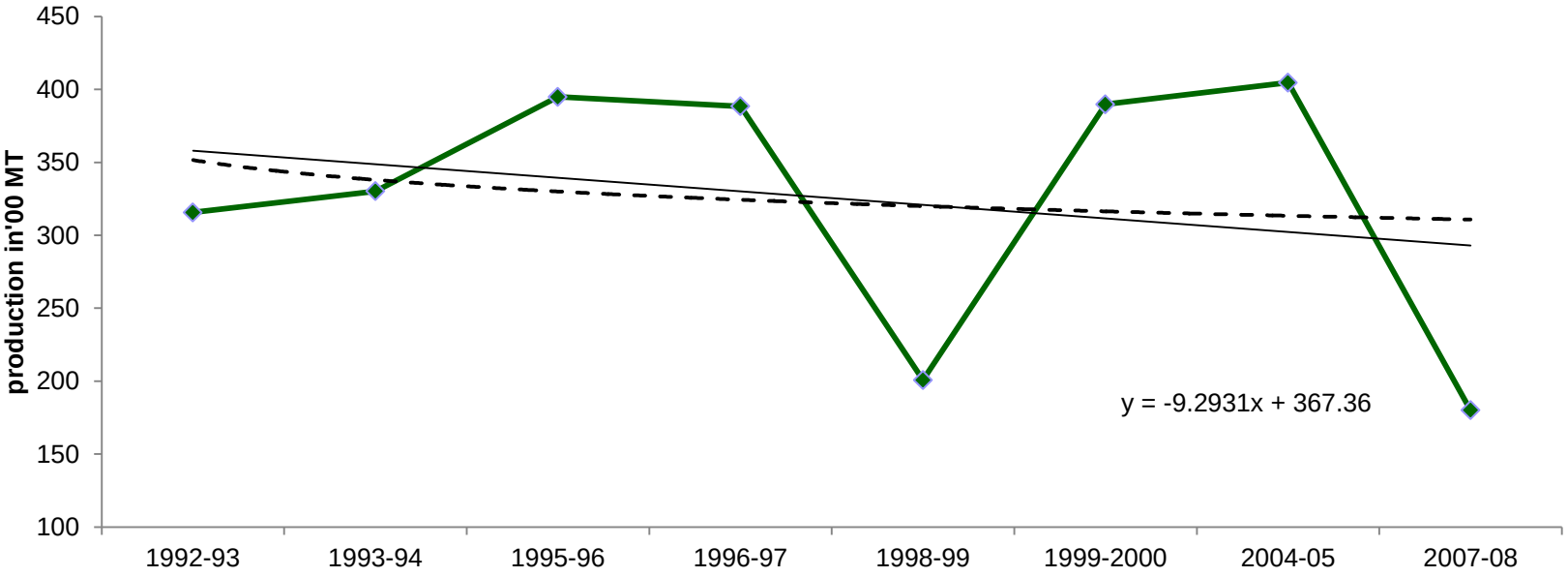


Ghoramara Island



Mousani Island

Crop productivity



- Production decreased
- Reason: salinization, over cropping, fertilizer, production failure

Vulnerability assessment

- Vulnerability= f(exposure, sensitivity, adaptive capacity)
- Risk depends on the exposure of the system and adaptive capacity of the system reduces the risk from threats.
- Residual Threat = Adaptive capacity – Risk
- Residual threat determine the extent of vulnerability

Vulnerability assessment methodology (1)

- Composite Vulnerability Index: assessment based on both physical and socio- economic variables
- Assessment done following the methodology developed by Ramakrishna Mission in 2009 and report prepared by Hazra et. al., 2013.
- Normalization of variable by percentage
- Ranking as high- medium- low

Vulnerability assessment methodology (2)

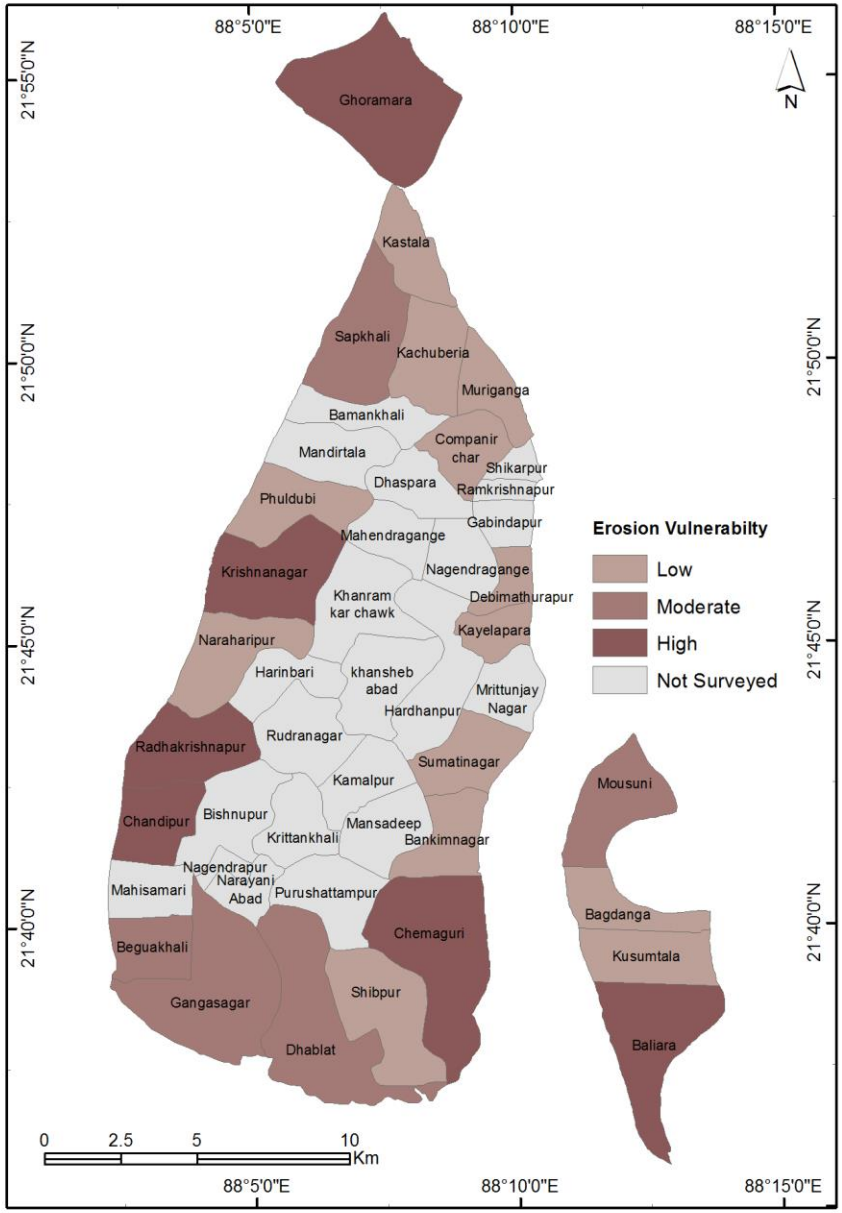
- The geometric mean of different vulnerability classes with rank has been derived to assess mouza level Vulnerability Rank (VR)-

$$VR = \sqrt[7]{V_1 * V_2 * V_3 \ldots\ldots V_7}$$

- Vulnerability maps of study islands have been prepared separately in interactive GIS platform.
- Finally overlying the maps to get Composite vulnerable zones or ‘hot spot’ mouzas

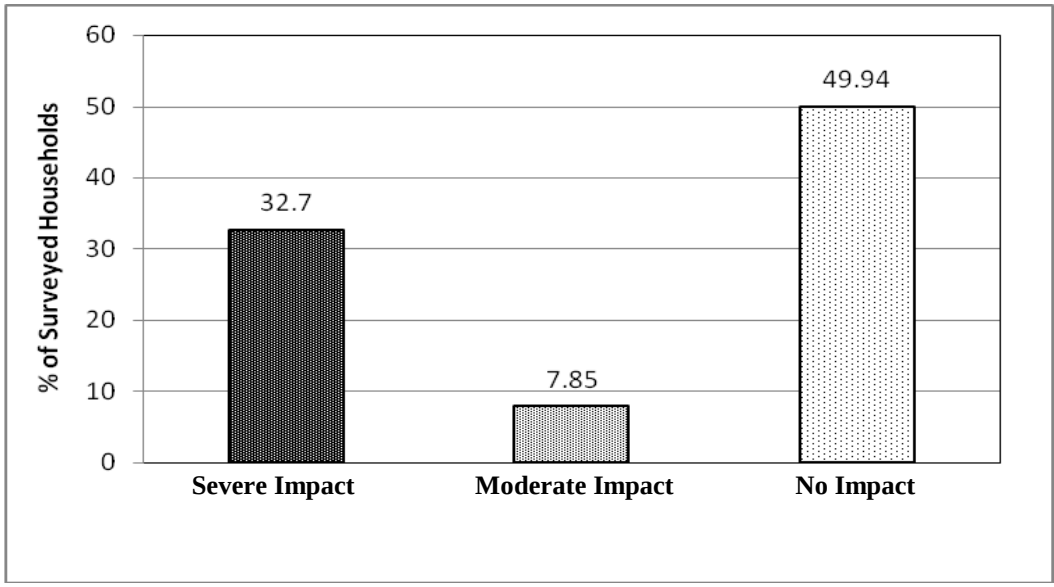
Erosion

- Vulnerable mouzas: Ghoramara, Baliara, Radhakrishnapur,Chandipur, Chemaguri
- Landloss
  - Low: <0.04 Km^2 per year,
  - Moderate: .041 to .08 Km^2
  - High: >0.081 Km^2 per year

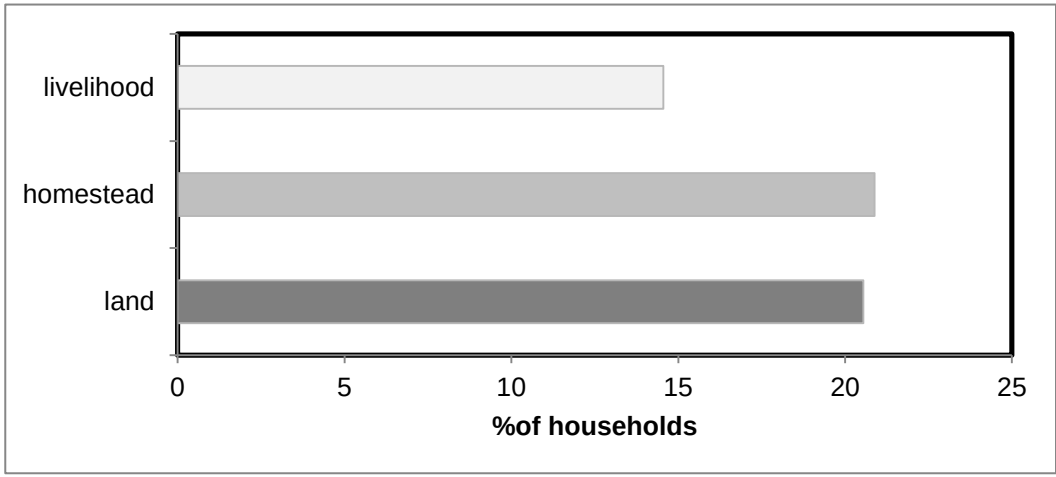


- 33% household are severely being affected by erosion
- Loss of land. Homestead, livelihood

Impact of erosion on local inhabitants



Types of Loss Due to Erosion



Boatkhali, Sagar Island, September- 2012

Breached embankment

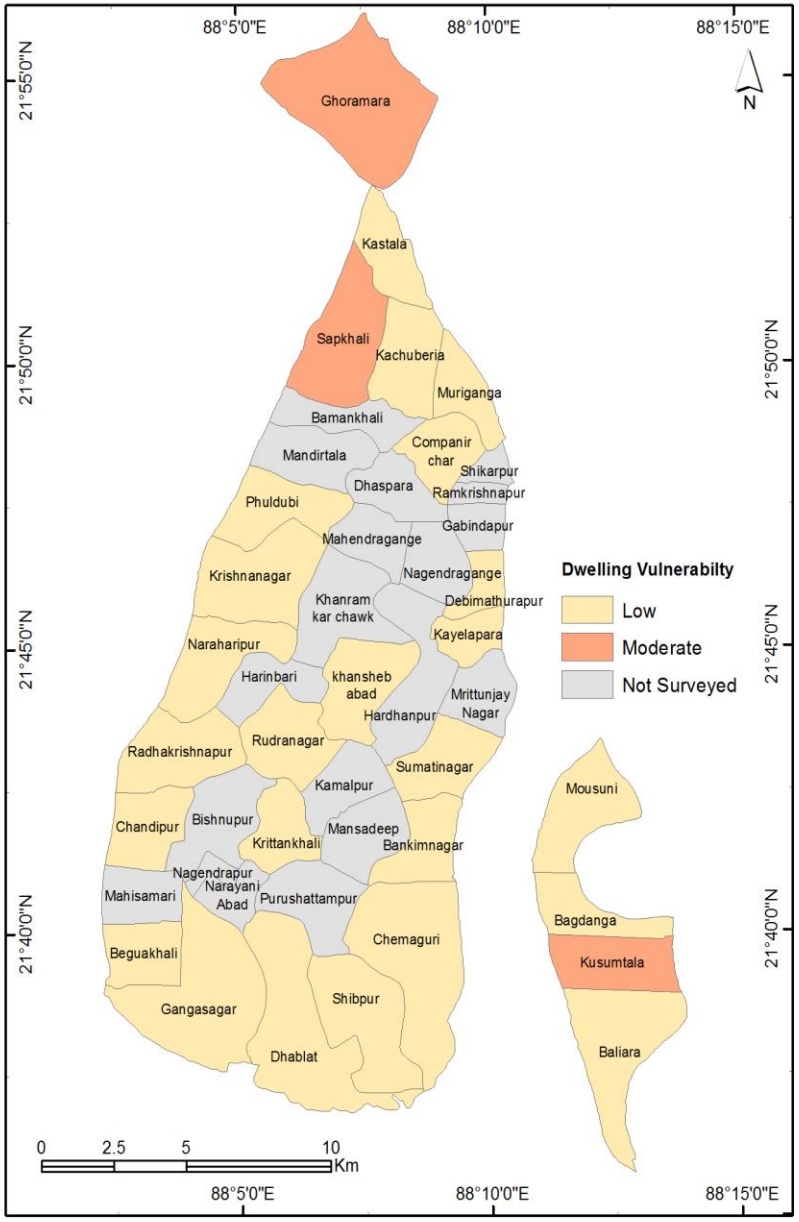
Inundation during high tide

Village under water

People took shelter above embankment

House structure

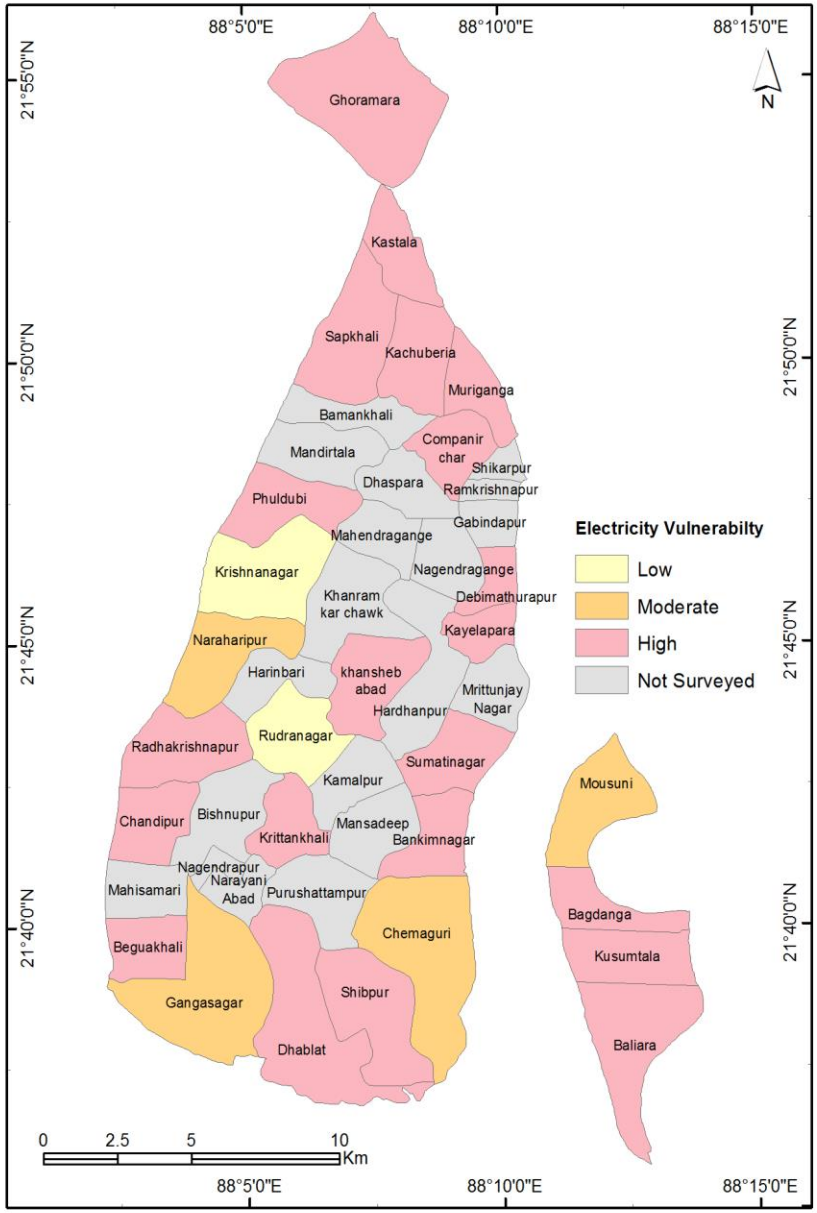
- Vulnerable house structure
  - Low- <40% kachcha house,
  - Moderate- 41- 70% kachcha,
  - High- 71% kachcha houses
- Sapkhali (50%), Kusumtala (44%), Ghoramara (43%): most vulnerable to damage during storms and coastal flooding.



Electrification

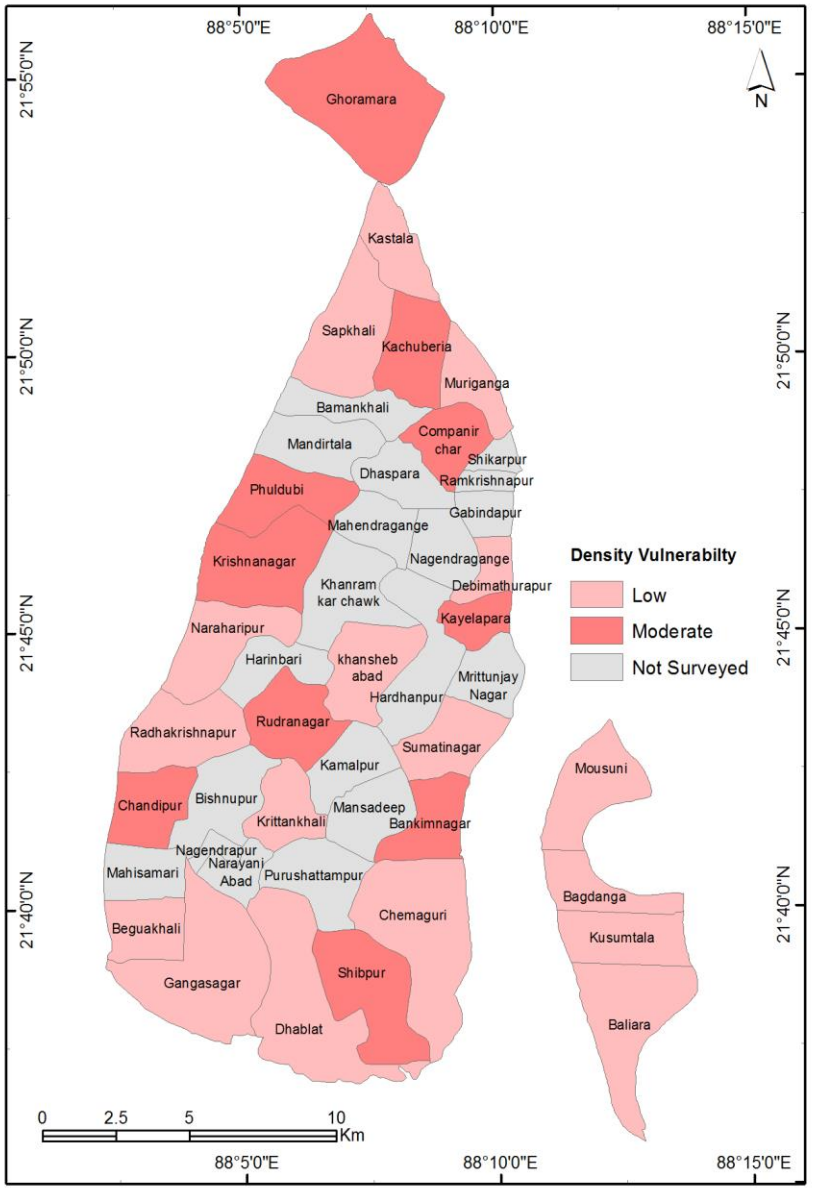
- Low- <10% left electrification
- moderate- 11- 30%
- high- more than 31% left electrification

- Most of the villages don’t have electricity
- Few mouzas of Sagar have grid connection since 2011



Population density

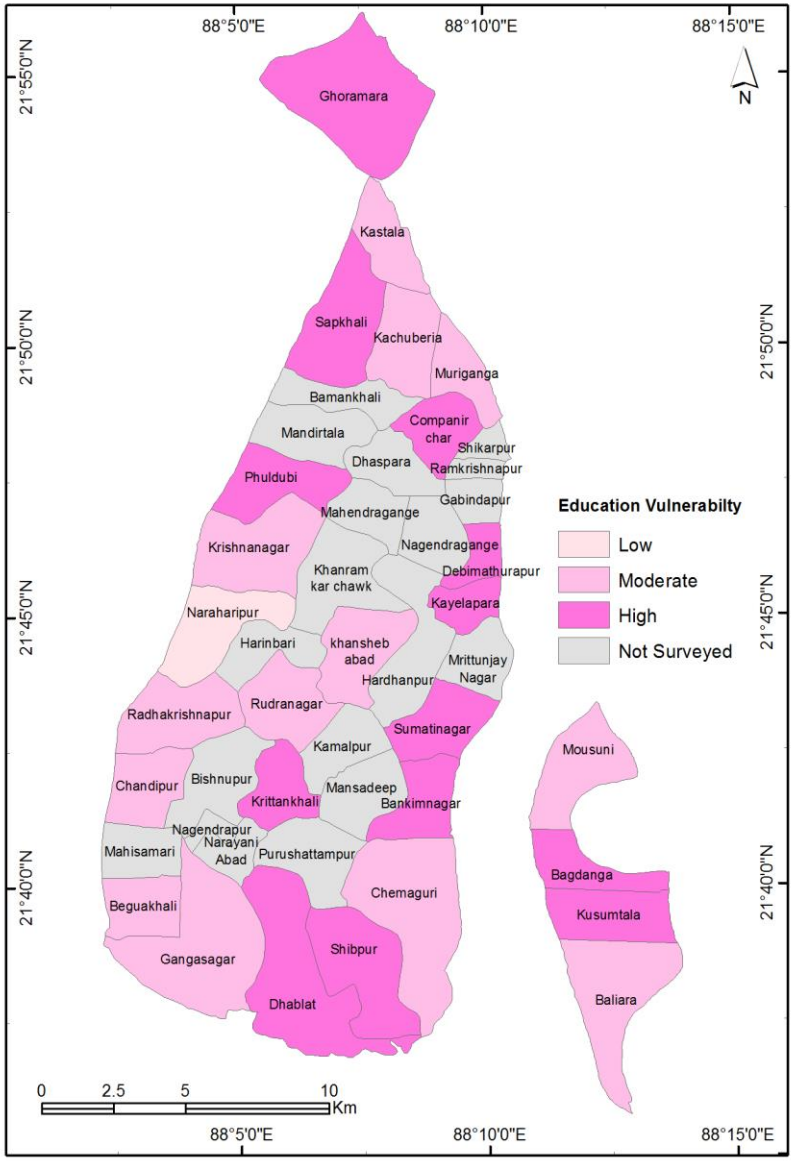
- Low- less than 900 persons/ Km^2
- Moderate- 901- 1300 persons per Km^2 area
- High- greater than 1301 persons/ Km^2 area



Education achievement level

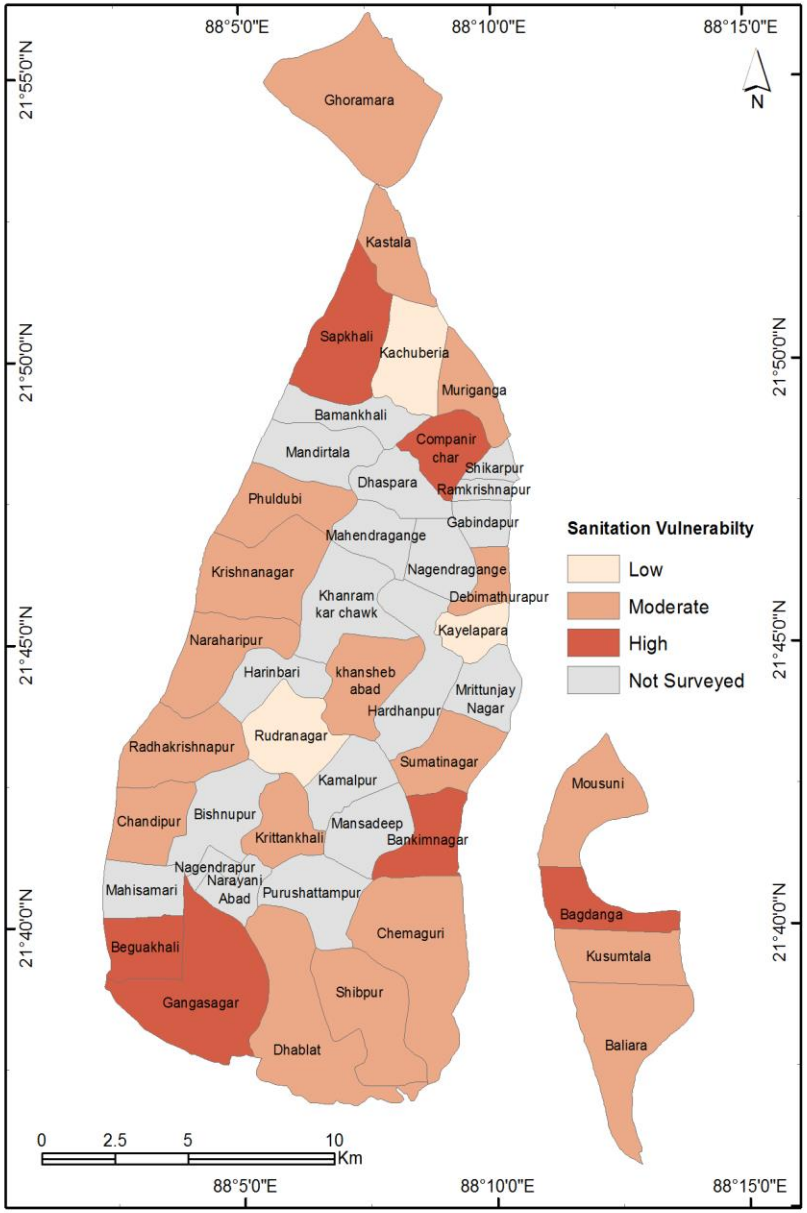
- Low- more than 41% adult educational attainment
- High- less than 20% attainment
- Moderate- rest (21- 40)

- Lack of alternate skill and low educational attainment leads to more vulnerable situation



Level of sanitation

- Low- more than 81% houses having good sanitation
- Moderate- rest (51- 80)
- High- less than 50% houses having good sanitation

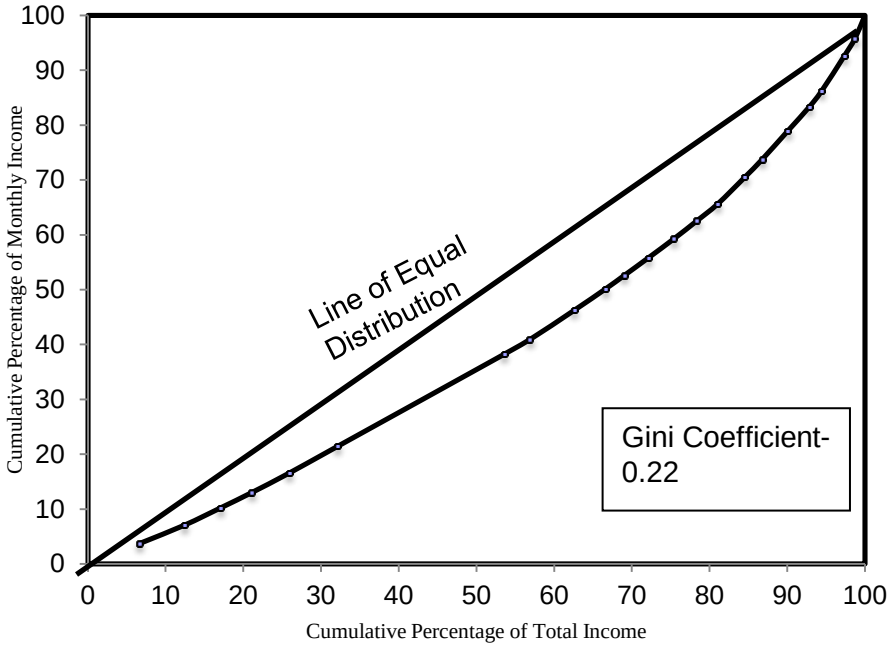


Economic status

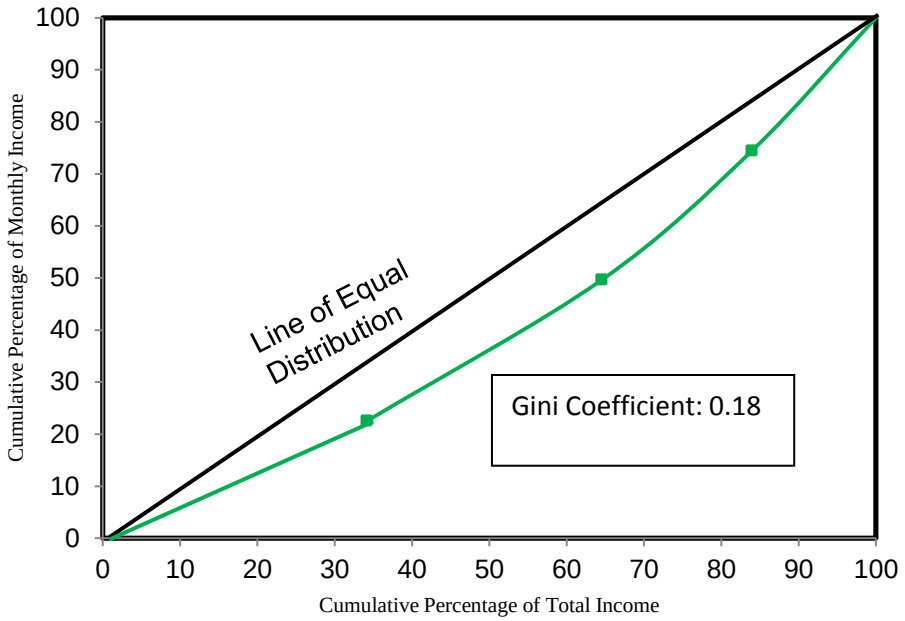
- Only around 40% of population is employed- major share unemployment
- Female work participation is very low around 25%
- Decreasing productivity- less profit in agriculture
- Increasing poverty
- Shift to daily labour- quick money; out migration
- Increasing income inequality
- 38%, 37% and 25% surveyed families of Sagar Island, Ghoramara Island and Mousuni Island respectively are under below poverty level

Lorenz curve & Gini- coefficient showing income inequality among surveyed mouzas of

Sagar Block



Mousani Island

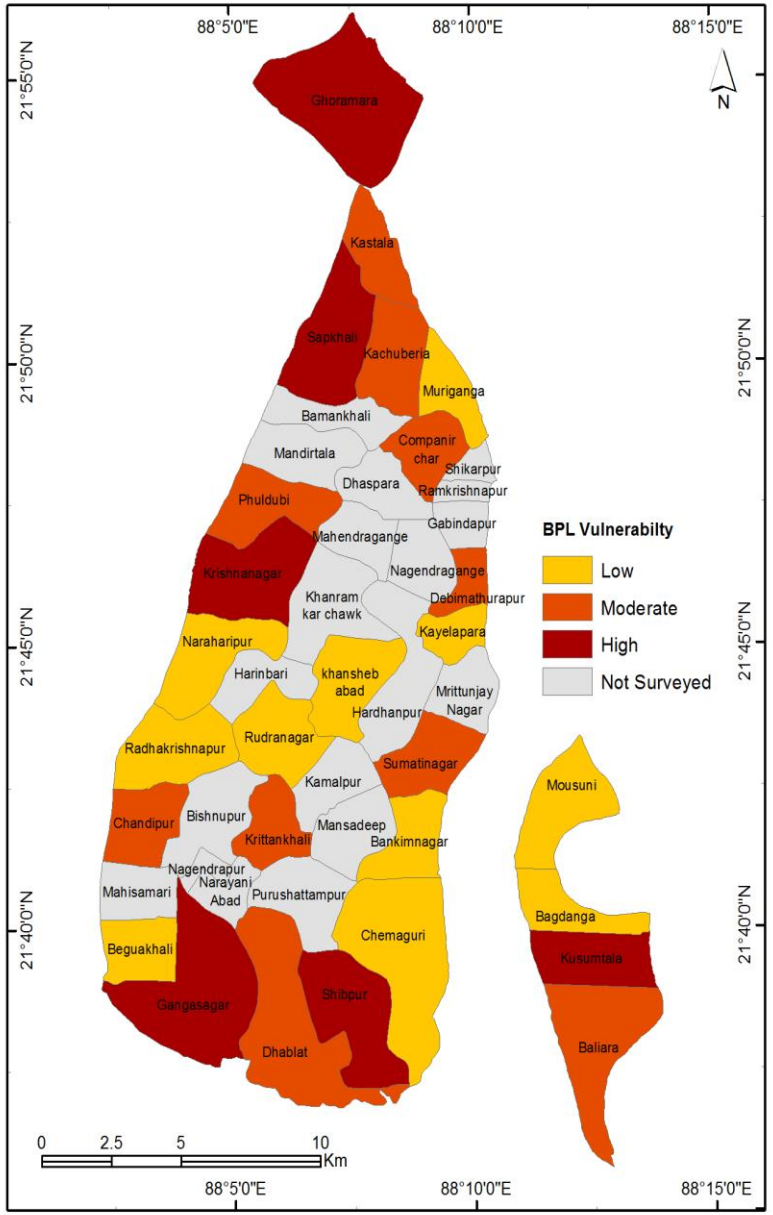


- Striking income inequality has been found in study islands

Poverty

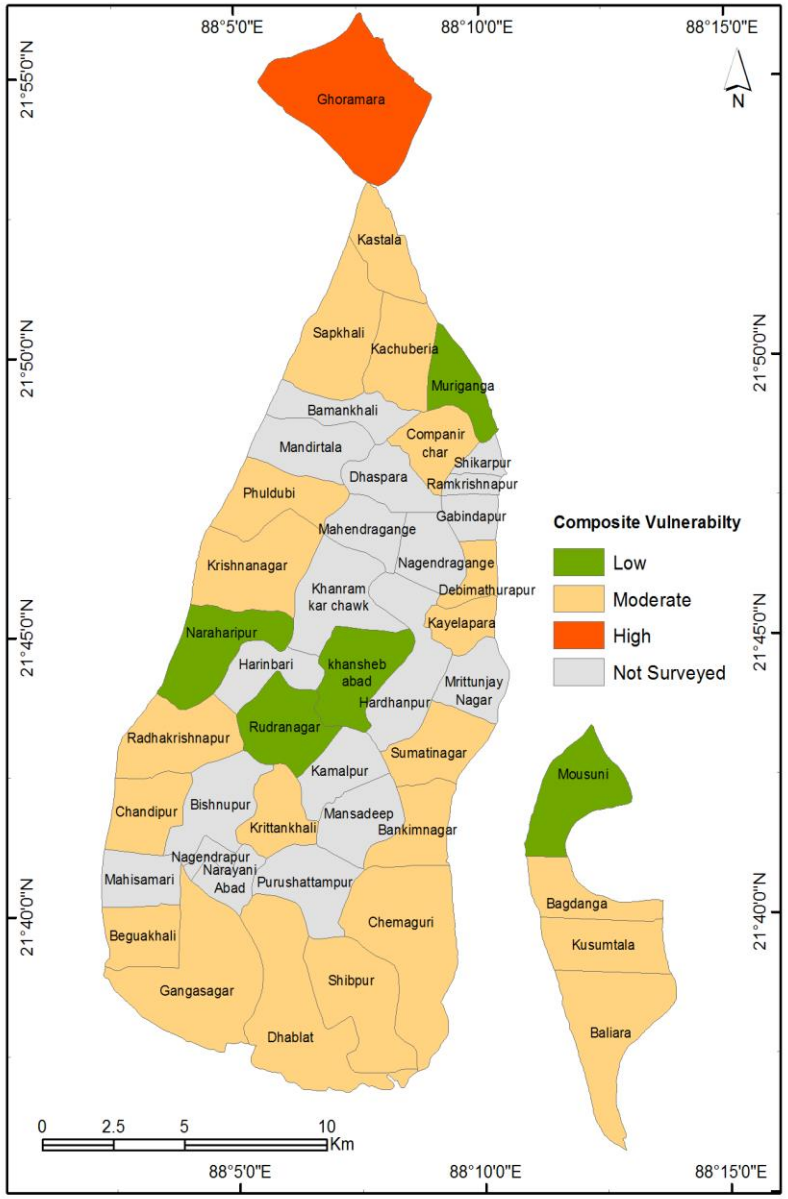
- Low- <50% Below Poverty Level(BPL) families
- Moderate- 51- 65% BPL families
- High- >66% BPL families

- BPL families- average income, assets considered



Estimation of composite vulnerability

- Composite vulnerability map- 27 surveyed mouzas
- Ghoramara highly vulnerable
- Sapkhali, Baliara, Shibpur- also close to highly vulnerable condition




Delta in distress!!

Conclusion & recommendations

- 21% mouzas highly vulnerable to erosion
- Social vulnerability is higher among the surveyed villages
- Educational attainment is lacking for 46% mouzas
- 21% mouzas need immediate economic assistance
- Around 66% mouzas are standing at the edge of vulnerability

Recommendations(1)

- Regular maintenance of embankment in the coastal villages
- Proper warning and evacuation plan for cyclone
- Planned housing structure: Ghoramara, Sapkhali, Kusumtala
- Expansion of non- conventional source of energy to meet the deficiency: tidal energy, wind energy, solar energy
- Night school, vocational training, technical schools for adults; involvement of school children of locality
- Raising awareness about sanitation; monitoring and upgrading sanitation condition from gram panchayat

Recommendations (2)

- Initiatives from local authority to give prior attention to economically vulnerable mouzas to reduce poverty
- Reduction of income inequality: stable occupation; labour law for informal sectors
- Focus on traditional practices- improve productivity through climate- resilient agricultural practices
- Stakeholder participation

Life in extremes..

Questions please????

Thank you for your kind patience