



# Ecosystem Based Management of Ganges Delta under Global & Climate Change

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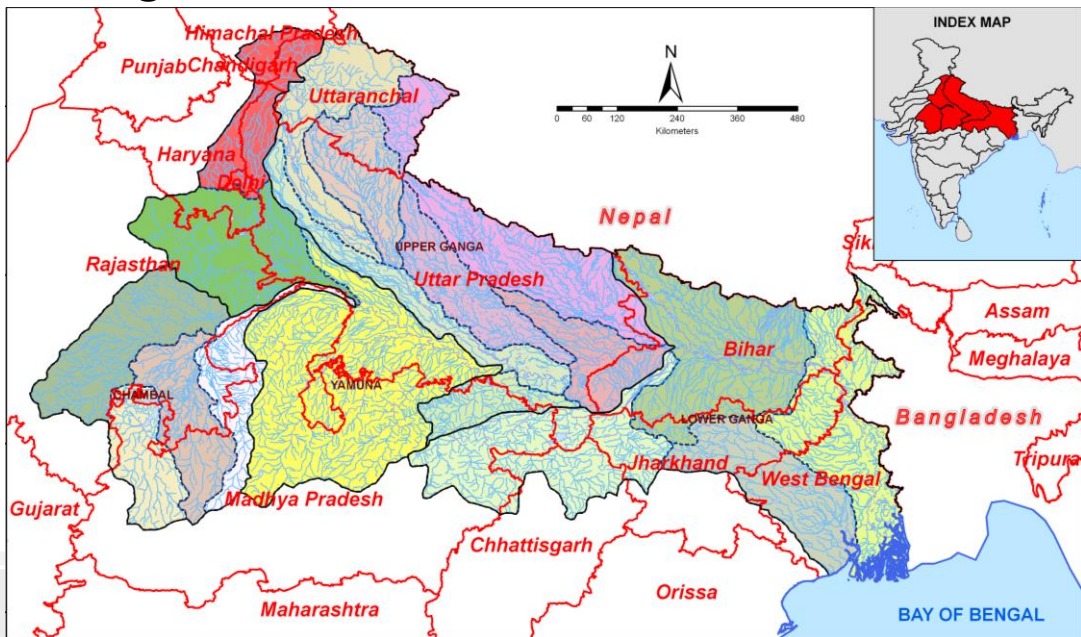


## 1. Major causes for unsustainable development of Deltas

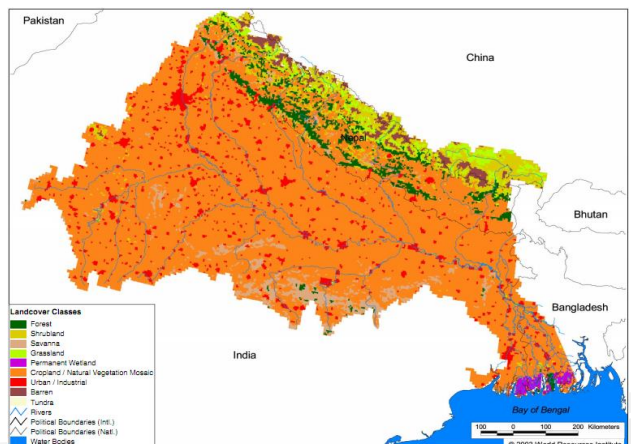
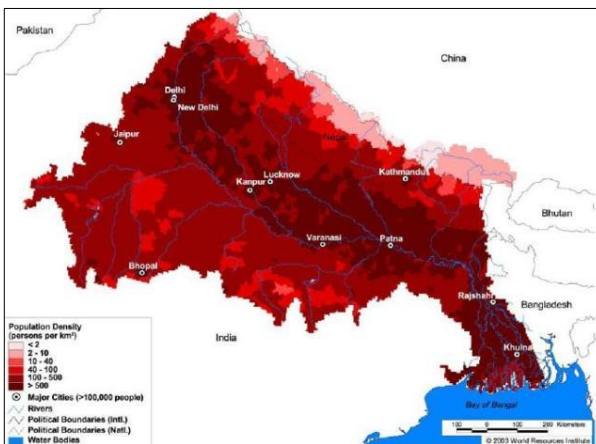
- **High population pressure**
- **High dependence on natural resources**
  - Deltas by nature highly productive because of the constant replenishment of nutrients washed down by flood
- **High poverty levels**
- **Poor understanding of delta processes** – especially the need for water and sediment flow to the sea
  - e.g. reduction in mangrove diversity due to reduced freshwater flows because of upstream dams
- **Increased industrialization** – water availability spurs energy production (hydro, thermal...) which drives industry – leads to water pollution due to poor environmental concerns



## Ganges Basin & Delta



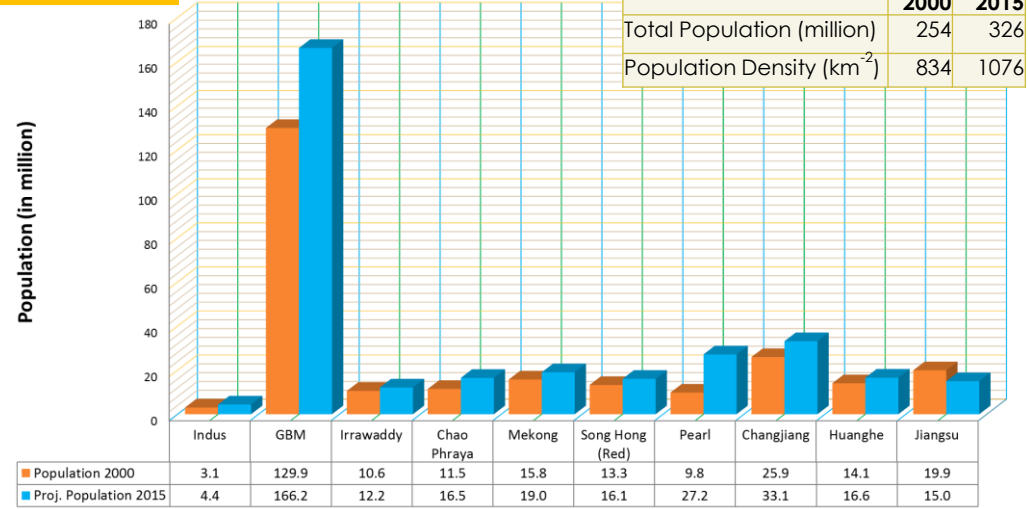
## Population Pressure in Ganges Delta



# Estimates of population within the Holocene deltaic plains of megadeltas

based on GPW-3, 2.5 arc minute gridded population of the world (CIESIN) for 2000 and 2015

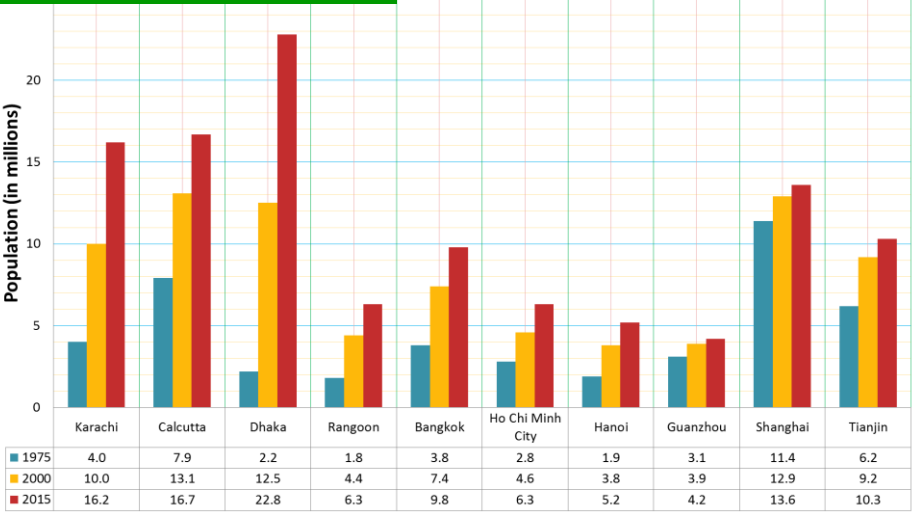
## 10 mega-deltas



# Actual and emerging megacities associated with Asian mega deltas

Growing populations (1975, 2000 and 2015 projected : after UN/DESA, 2002)

## 10 mega-deltas: 82 million people





## 2.Ecosystem Based Management

### Ganges delta- e.g. Sunderban Mangrove ecosystem

- Ganges delta as a collection of interlinked rural communities dependent on natural resources e.g. Mangrove (80,000 km<sup>2</sup>)
- Predominantly artisanal/ small-scale fishery – highly influence by mangroves
  - Support deep sea fisheries – nursery grounds
  - Mitigating storm surge, can control SLR impacts as they 'rise' with the sea level
  - Provide other ecosystem services (e.g. timber, water purification, biodiversity)
- Managing mangroves through participation of local communities ensures their survival and sustainable use



## 3.Societal Adaptations

### Climate & Global Change in Delta Regions

## Sundarbans

**Total Area of Sundarbans :**  
**4,264 km<sup>2</sup> (Indian part)**

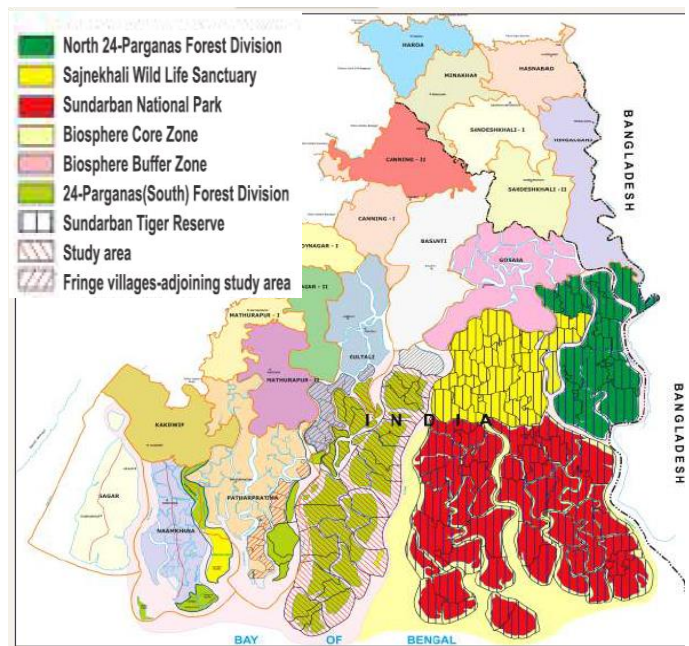
Water area : 1,700 km<sup>2</sup>

Mangrove Area : 2033 sq km

(Ref: SAC, 2012)

Protected area : 1736 sq km

(MNP+S; Ref: WII, 2013)



## Issues Challenging Coastal livelihood

### ■ Unpredictable rainfall patterns

- Rains shifted to post-monsoon period;
- Severe implications on Agricultural Productivity
- Reduced fish catch – Salinity changes; migration affected;

### ■ Rising Sea level

- Low lying islands; Erosion adds pressure on land holdings
- Eg. 1996-Lohachara Island disappeared, dislocating 4000 people
- Mousuni Island lost >14% of its land mass since 1969

### ■ Extreme weather events

- Frequency and intensity increased
- Aila of 2009 – the most dramatic recent catastrophe

## Area Lost

**1969-2009**  
210.47 sq.km

**Last decade alone**  
44 sq.km



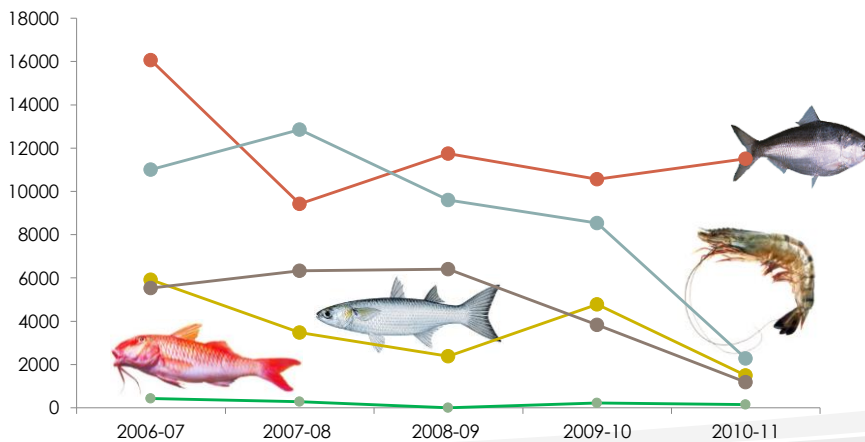
Source:

School of Oceanographic Studies, Jadavpur University;

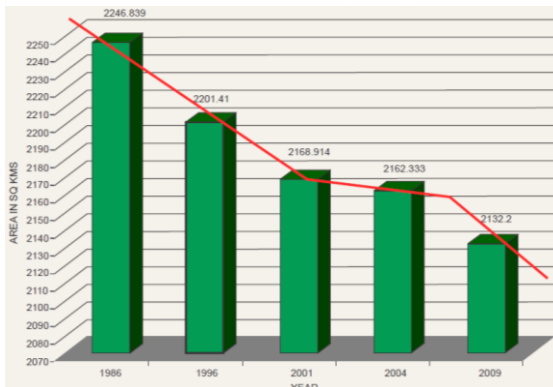
WWF Report, 2010 on Sundarbans: Future Imperfect – Climate Adaptation Report

## Habitat Modification: Changes in fish production of a few Species in Ganges Delta (in Tonnes)

—●— Hilsa —●— Mugilidae (Mulletts) —●— Penaeid Prawns  
—●— Non-Penaeid Prawns —●— Upneus spp (Goat Fish)

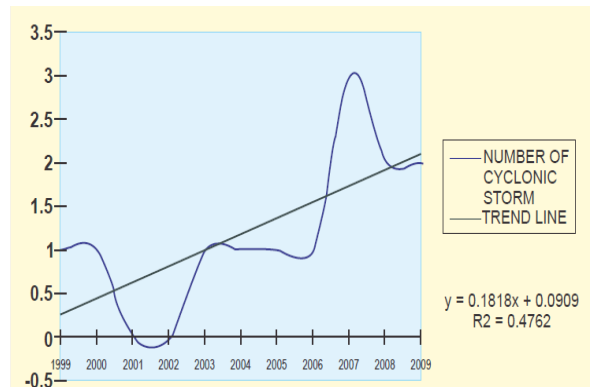


## Change in forest– 1986 to 2009



- Cause for Reduction:
  - (i) Erosion (ii) Land use change

## Change in frequency of Cyclonic Storm – 1999 to 2009



- 2000-08 study shows a 28% increase over last 120 years

## Adaptation Strategies

### • Structural adaptations

- Embankments
- Seawalls – for coastal protection

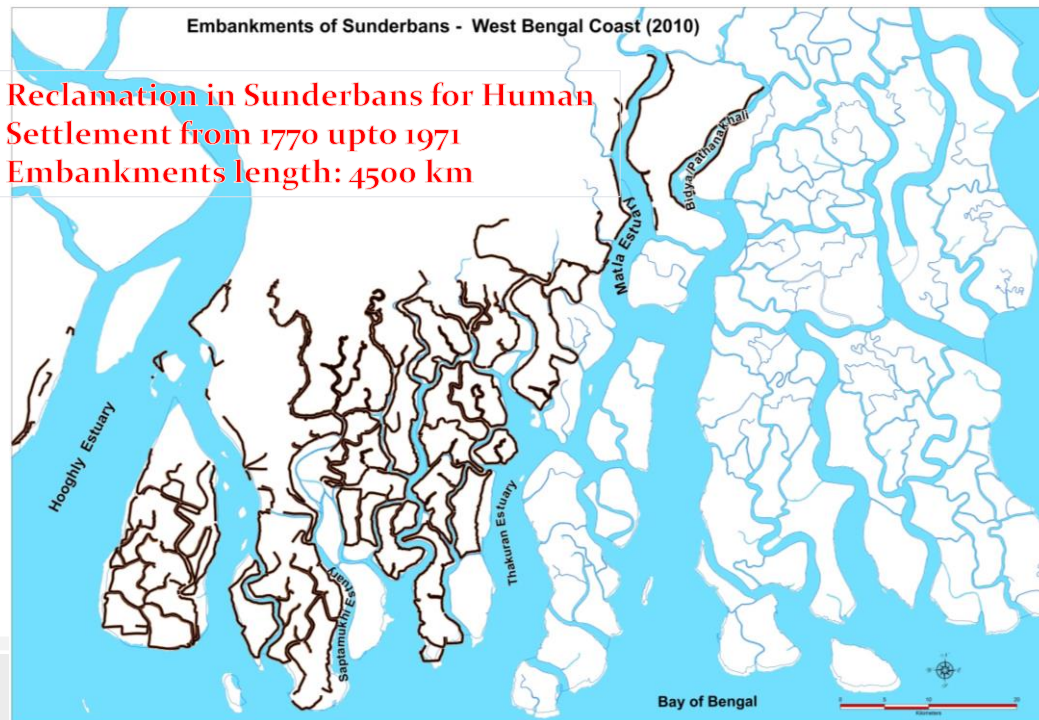
### • Non-structural adaptations

- Designation of Protected/ Conservation Areas
- Mangrove Afforestation
- Improved hazard forecasting & management
- Capacity Building

### • Policy interventions

- ICZM [includes Shoreline, Conservation, Pollution, Livelihood- Management Plans]
- Critically Vulnerable Coastal Areas – Community based management of deltaic resources





## Livelihood in Ganges Delta



## Livelihood in Ganges Delta



## Deltas: Ecosystem Goods & Services

Service category	Estuaries/ Deltas	Lagoons	Coral Reefs	Mangroves	Sand dunes	Mudflats	Salt Marshes	Turtle Nesting grounds	Bird nesting grounds	Seagrass beds	Beaches	Cliffs	Creeks	Horseshoe Crab Habitats	Rock and Shell Reefs
<b>Provisioning</b>															
Food, raw materials															
Biodiversity															
Aquaculture															
Wild plants and Timber products															
Genetic resources															
Biochemicals, natural medicines, pharmaceuticals															
Ornamental resources															
Human habitation															
Human navigation															
Energy(human use)															
Traditional and bio physical products															
<b>Regulating</b>															
Air quality regulation															
Climate regulation															
Erosion regulation															
Water purification															
Disease regulation															
Pest regulation															
Pollination															
Natural hazard regulation															
Carbon sequestration															
Freshwater storage and retention															
Biological regulation															
Soil fertility															

### Legend

	Very Important
	Moderately Important
	Some Importance
	Important
	Not Important
	Not Ranked

# Deltas: Ecosystem Goods & Services



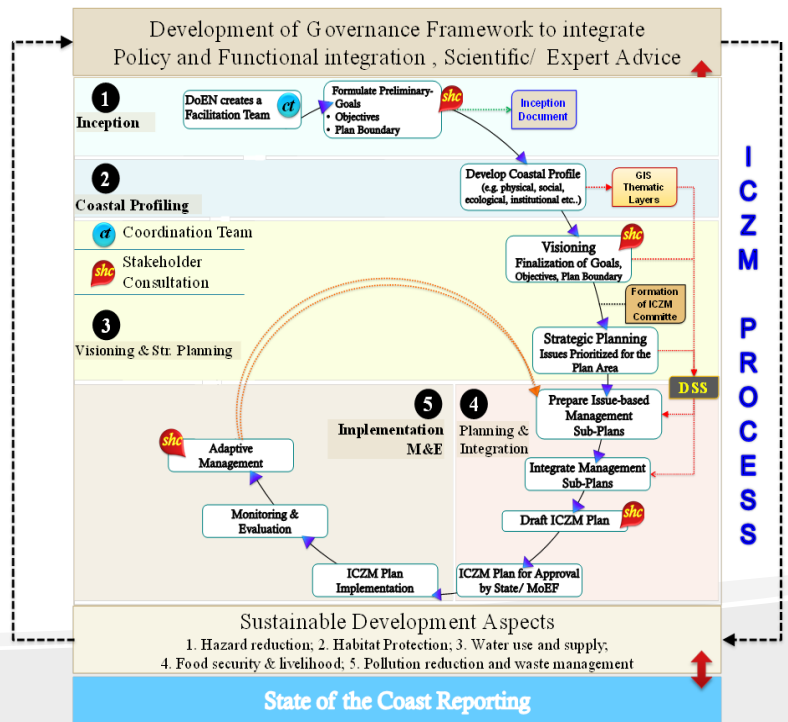
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<b>Cultural</b>															
Cultural Diversity															
Spiritual & Religious values															
Knowledge Systems															
Educational Values															
Employment															
Aesthetic Values															
Social Relations															
Cultural heritage															
Recreation & eco-tourism															
<b>Supporting</b>															
Photosynthesis															
Primary production															
Nutrient cycling															
Water cycling															

## Legend

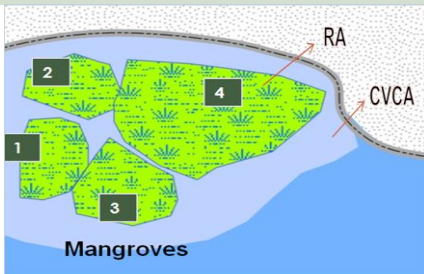
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Zone	Driver	Impact Level 1	Impact Level 2	Exposure		Sensitivity		Robustness
				Ecosystem	Social	Ecosystem	Social	
Tidally Active Delta	Cyclones	Tidal Surges	Coastal Erosion	Land Loss ↑	Population living 5km from coastline ↑	Rate of biodiversity decline ↑	Per-capita GDP	• Percentage of coastline protected
	Sea Level Rise				Occupational diversity ↑		Age-wise population (0-6; >50)	• Percentage of area protected by sand dunes
				Loss of mangrove ↑	Property and infrastructural loss →		Percentage of population not dependent on agriculture and fisheries	• Percentage of people with access to early warning system information
								• Percentage of homes at safe height from storm surge
			Salinity Intrusion	Water quality ↗	Agriculture and fisheries yield ↓	Reduction in fresh water supply ↑	Food insecurity	• Food reserves
				Percentage increase in salinity ↗	Percentage of people with access to clean drinking water ↓	Changes in mangrove species diversity ↗	Per-capita GDP	• Saline resistant species of mangroves
				Percentage of area under saline tolerant crops →	Population density ↓		Percentage of population not dependent on agriculture and fisheries	• Storage, Transportation and Public Distribution System

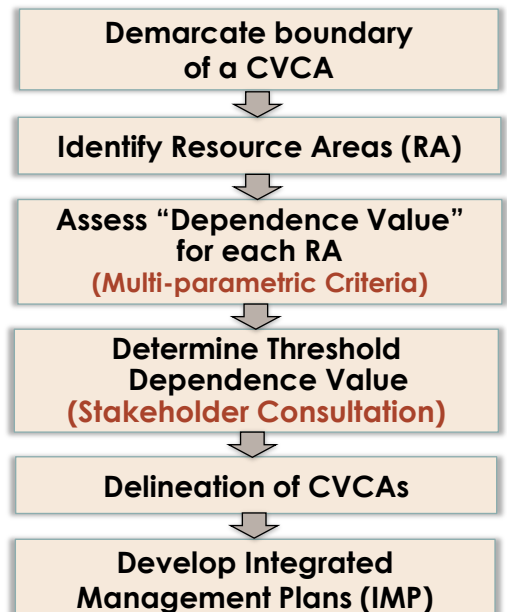
## ICZM Framework: A holistic Approach to Sustainable Management

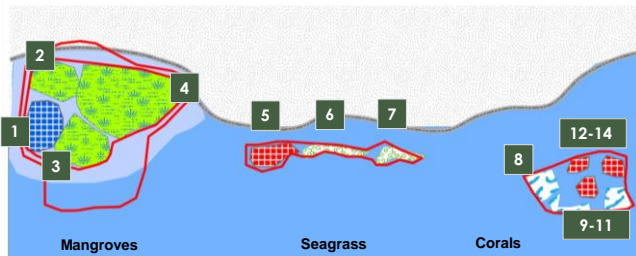


## Critically Vulnerable Coastal Area [CVCA] or EBM Framework



Criteria	Attributes (Illustrative)	Mangroves			
		1	2	3	4
Socio-Economic	% of population dependent on ESA	49	27	18	15
	% of harvest of natural resource to total of region/ state	87	26	12	34
Socio-Ecological	% dependence of community in terms of resource extraction	88	32	42	40
	% of population with knowledge on benefits of the resources	70	35	25	10
Social Capital	% of families with access to education / social networks	62	25	38	47





Study the **conservation and dependence value** of all ecosystem patches

Identify the **highly sensitive areas** with **threshold conservation value**

Identify **CVCAs** with high dependence value

Criteria		Attributes (Illustrative)	Mangroves				Seagrass			Corals						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conservation Value	Biodiversity	Species richness	12	5	8	13	6	2	5	21	14	16	8	35	31	26
		No. of other flora	5	7	4	8	18	13	6	11	5	6	14	20	21	19
		No. of other fauna	20	26	21	14	15	5	6	9	20	23	15	35	41	50
		Endangered species	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		Endemic species	0	0	0	0	1	0	0	0	0	0	0	1	0	2
	Habitat	Sheltering ground	5	5	5	5	0	0	0	0	5	5	5	5	5	5
		Breeding Ground	5	0	0	5	0	0	0	0	5	5	5	5	5	5
		Geological features	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dependence Value	Socio-Economic	% of population dependent on the natural resource	49	27	18	15	39	31	26	20	16	35	28	33	28	21
		% of harvest of natural resource to total of region/state	87	26	12	34	35	52	37	26	20	18	15	13	10	10
	Socio-Ecological	% dependence of community in terms of resource extraction	88	32	42	40	47	33	37	30	24	21	18	9	15	12
		% of population with knowledge on benefits of the natural resources	70	35	25	10	68	61	63	68	54	47	34	40	20	27
	Social Capital	% of families with adequate access to education and social networks	62	25	38	47	35	48	47	31	54	48	53	42	55	46

## Integrated Management Plan Framework

- **Resource Characteristics**
  - Baseline data
  - Threats for the CVCA
  - Indicators for CVCA Health
- **Community Characteristics**
  - Socio-economic status
  - Dependence value
  - Ability to govern

- **Development Plans**
  - Current status
  - Integrated Development Plans
- **Management/Regulatory Options**
  - Structure of Committee
  - Extent of stake for the local community

Guidelines for IMPs : Through Expert Consultations

Location-specific IMPs : Through Stakeholder Consultation

## 4. Improved access to data and international exchange of knowledge and practices

- Improved trans-boundary exchange of information and data
  - e.g. Data sharing between India & Bangladesh for the conservation/ management of Sunderban mangroves in the Ganges Delta
- Capacity building of communities (in local language)
  - Buy-in of stakeholders
- Adopting traditional knowledge systems for best practices from local communities
  - Inclusion of local communities in the integrated management of available resources
  - Provisioning of resources for sustainable livelihood of communities through Community Management Initiatives ([CVCA](#))
- Improved inter-governmental and Inter-departmental cooperation for delta sustainability



## 5. Critical indicators in tracking achievements of SDG

- Tipping Points (*delta vulnerability*)
- Development of critical thresholds (*Deltaic Indices*)
- Developing transition pathways and strategies (*regulatory mechanisms*)
  - *State of the coast*
  - *Extent of co-management &*
  - *community based management systems*

Importance of Deltas	Drivers & Pressures towards Tipping Points	Consequences/ Impacts on Deltas
<ul style="list-style-type: none"> <li>■ Home to 500+ people</li> <li>■ Power Plants</li> <li>■ Ports &amp; Harbours</li> <li>■ Oil and Natural Gas</li> <li>■ Road Network</li> <li>■ Coastal Industries</li> <li>■ Settlements (Urbanization)</li> <li>■ Dredging</li> <li>■ Marinas/ Water front development</li> <li>■ Shipping &amp; Navigation</li> <li>■ Agriculture</li> <li>■ Beach Minerals</li> <li>■ Coal transportation</li> <li>■ Forestry</li> <li>■ Aquaculture</li> <li>■ Salt Pans</li> </ul>	<ul style="list-style-type: none"> <li>■ Coastal Resources</li> <li>■ Ecologically Sensitive Areas</li> <li>■ Wetlands</li> <li>■ Fish/ Fisheries</li> <li>■ Wildlife</li> <li>■ Water quality</li> <li>■ Beaches/ dunes</li> <li>■ Water resources</li> <li>■ Estuaries/ Deltas</li> <li>■ Aesthetics</li> <li>■ Resource Protection</li> <li>■ Living Marine Resources</li> <li>■ Coastal Mineral Resources</li> <li>■ Cultural/Historical/ Archaeological sites</li> <li>■ Barrier Islands</li> <li>■ Marine Protected Areas</li> <li>■ Salt water intrusion</li> <li>■ Natural hazards</li> </ul>	<ul style="list-style-type: none"> <li>■ Erosion/ Accretion</li> <li>■ Environmental impacts</li> <li>■ Conflicting uses</li> <li>■ Floods/ Coastal Flooding</li> <li>■ Oil spills / effects</li> <li>■ Thermal effluents</li> <li>■ Land based pollution</li> <li>■ Marine litter</li> <li>■ Sand mining</li> <li>■ Reduction in freshwater flow</li> <li>■ Change in land use</li> <li>■ Shrinking deltas</li> </ul>



## Summary

- Establishment of climate adaptation knowledge centres
  - Increase the capacity of climate vulnerable communities to deal with climate change
  - Functions : Early warning station / Disaster Response / Relief shelters, etc
- Climate resilient agricultural/fish culture practices
- Capacity Building for EBM
- Using Traditional Knowledge for EBM