

# Valuing the Services of Coral Reef Systems for Sustainable Coastal Management

## Case Study of the Gulf of Kachchh (India)

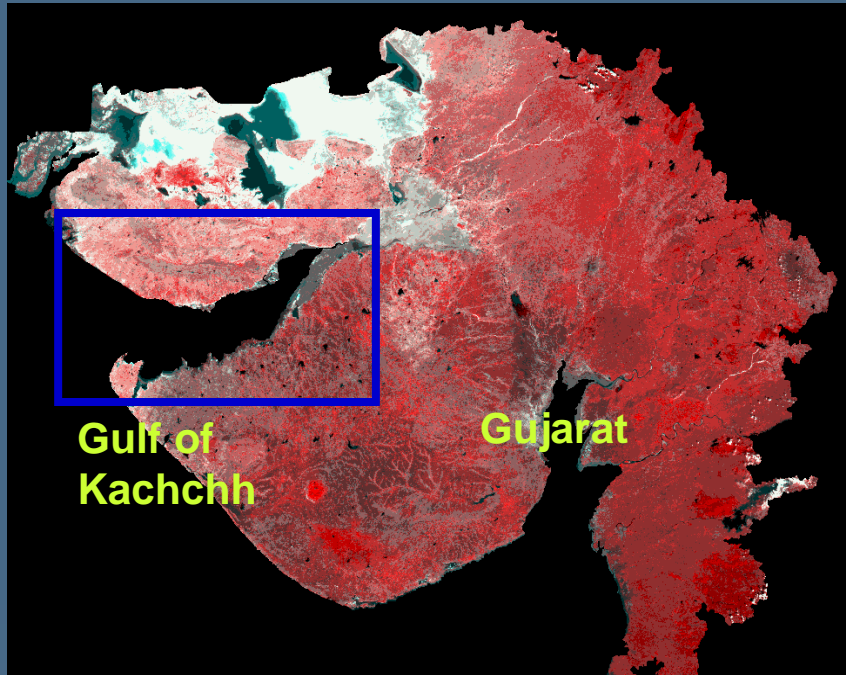
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# Background



- Gulf of Kachchh (GoK)- a biodiversity hotspot & one of the four coral reef systems in India
- Drivers of change like industrial & infrastructure development, excessive fishing, and climate change, threatened Coral Reefs in GoK
- Need special attention in coastal zone planning
- We attempt to value the benefits arising out of functioning of Coral Reefs in GoK

# Importance of Coral Reef System

- Shallow water, biologically diverse, marine ecosystem dominated by hard, reef building 'coral' species
- Globally, covers an extent of about 284,000 sq km (Spalding et al. 2001)
- Represent 0.25% of total ocean area but support over 25% of marine life
- Support more species per unit area than any other ecosystem (Ahmed et al. 2004).
- Important role for human being: tourism, fishing, building materials, coastal protection and providing new drugs and bio-chemicals

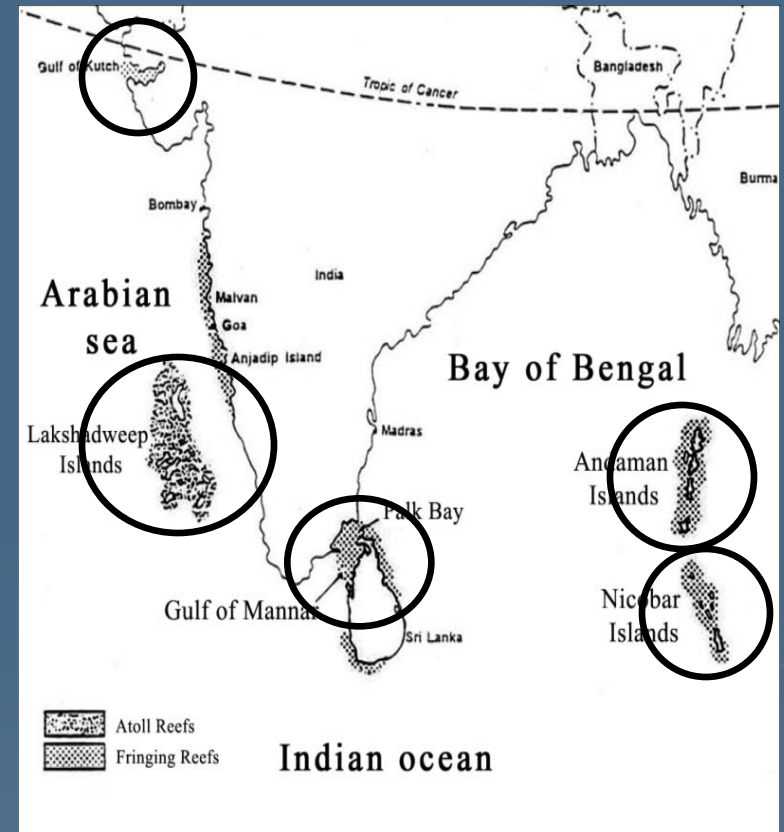
- 500 Million to over one Billion people reliant on coral reefs for their food (Whittingham et al. 2003; Wilkinson 2004)
- 30 million poorest and vulnerable people are totally reliant on reef based resources as their primary means of food production, sources of income and livelihoods (Gomez et al., 1994; Wilkinson, 2004).
- Ironically, 20% of the world's coral reefs have been effectively destroyed and show no immediate prospects of recovery (Coral Reef Status Report, GCRMN, 2004 )

# Coral Reefs in India

## Coral Reefs in four Main Regions

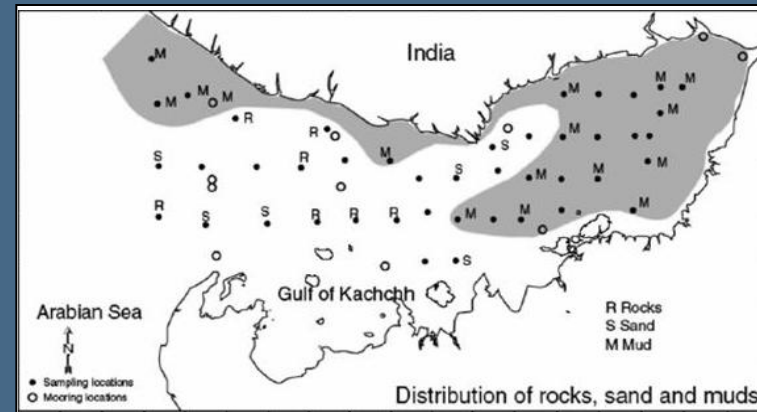
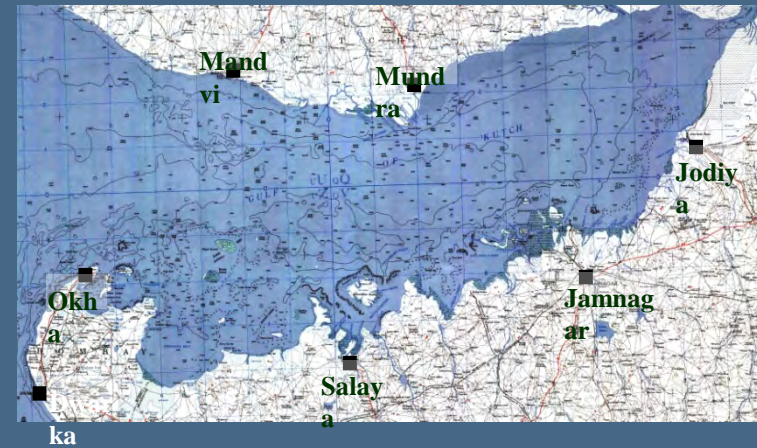
- Lakshadweep
- Gulf of Mannar
- Andaman and Nicobar
- Gulf of Kachchh

Locality	Reef Area (km <sup>2</sup> )	No. of Species
Gulf of Kachchh	460.2	68
Lakshadweep	816.1	103
Gulf of Mannar	94.3	96
Andaman Islands	959.2	82
Nicobar Islands		103



# Gulf of Kachchh

- The GoK encompasses an area of about 7350 km<sup>2</sup>
- Marked difference between northern and southern side in terms of sedimentation,
- Ecological gradients of Depth, Salinity, Tidal amplitude etc in mouth & head.
- The depth ranges from 20 m at the head and 60 m at the mouth
- First Notified Marine National Park and Sanctuary of Country: 458 km<sup>2</sup> in 1980, 1982



# Key Habitats



- 42 Islands and Islets (many fully submerged)
- Intertidal Flats
- Sea Weeds & Sea Grass beds
- Mangroves (~848 km<sup>2</sup>)
- Creeks & Estuaries
- Bays
- Coral Reefs

# Key Threats

## Industrial Development

- Oil & Petrochemical
- Chemical & Fertilizers
- Cement

## Infrastructure Development

- Port & Jetties
- Thermal Power Plants
- Ship Breaking

## Resource Extraction

- Mangrove Cutting
- Excessive fishing

## Climate Change

- Coral Bleaching

## Natural Factors

- Sedimentation
- Calamities like Cyclones





# Coral Reefs in GoK

- Reef Area- no detailed mapping..... 277-km<sup>2</sup>
- One of the most northerly & isolated reefs in the world
- Fringing reefs in intertidal areas
- Reefs survive in extreme environmental condition: **high salinity, frequent exposure, high Temp. fluctuations & relatively high sedimentation**.....Distinct features from other reefs of the country



# Types of Coral Reefs in GoK

- Fringing Reefs are found in 3 distinct forms:
  - Contiguous to Mainland
  - Along the Areal Islands
  - Along the Submerged Islands
- Each is further divided into sub-types
- Carry out different functions and generate different values
- Out of 42 islands, 33 have coral reefs and 20 have mangroves

# Present Study

## Finding Answer of Three Questions

- What are the key benefits of the coral reefs in GoK?
- How can the limited ecological data available in GoK be used for valuing the coral reef systems?
- How these quick valuations of coral reefs can be mainstreamed in the decision making process of coastal zone management?

# Valuation: Goods & Services Considered

- **Fisheries**
- **Recreation and Tourism**
- **Protection of coastal aquifers against Salinity ingression**
- **Protection of coastal lands against erosion**
- **Biodiversity.**

# Approach

- Study Period: November '08 to April '09
- Relevant data collection from Govt. Dept. & Agencies & Research Institutions
- Conducted primary surveys for field based assessment
- Adopted different valuation techniques

# Methodology

<b>Valuation Theme</b>	<b>Adopted Technique</b>
<b>Fisheries</b>	Financial Analysis approach. Market value of fisheries at landing site and value addition from export market
<b>Recreation &amp; Tourism</b>	Extrapolation of expenditure pattern of tourists
<b>Protection of Coastal aquifer against Salinity Ingression</b>	Defensive or preventative expenditure by Govt. agencies; Loss in crop productivity
<b>Protection of coastal areas against coastal erosion</b>	Preventative expenditures by Govt. agencies; Benefit Transfer Method (BTM)
<b>Biodiversity</b>	Benefit Transfer Method (BTM)

# Summary of Estimates

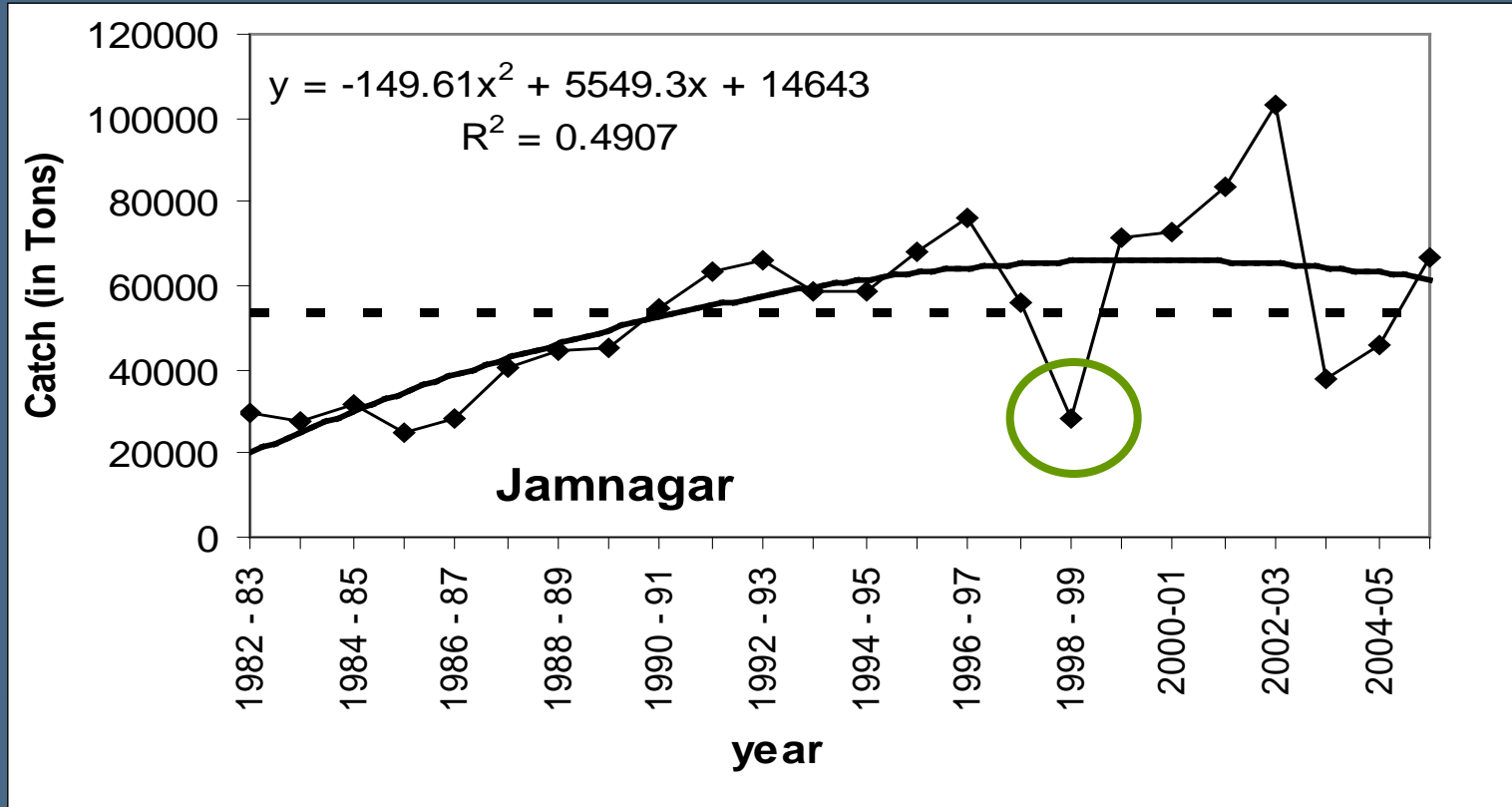
Mainly present the value of Coral Reef system to Jamnagar Coast (342 km length), that cover most of the Southern lip of GoK

# Fisheries

- About 10000 active fishermen in 26 fishing centers of Jamnagar district
- 144 fish, 27 prawn, 4 shrimps, 21 crabs and one lobster species form the fishing resources in GoK
- Main types of fishing: Trawler, Gill Netter (machhuwa), Flat Bottom Boat (hodi), Tony and **Pagadia**
- Dominant fishing: Prawns, Jew fish, Thread fin, Pomphret, Mullet and Crabs
- Molluscan Shell Fishing: Pearl Oyster, Window Pane Oyster, Chank & Bivalves (**Banned in MNPS**)
- 16 fish landing centers in Jamnagar district



# Fishing Trends



- Annual Average Catch is about 53500 tons
- Jamnagar Fish Catch is about 10% of the State total catch

# Coral Reef Associated Fisheries Values

(Considered 3 main streams of revenue)

Parameters	Value (in Million Rs.)
Commercial Fisheries: Gross Revenue (A)	1431
Operating Cost (25% of Gross Revenue) (B)	357
Commercial Fisheries: Net Revenue (A-B) = C	1074
Pagadia Fishing (D)	75
Value Addition for Exports (E)	135
<b>Total Net Value (C+D+E)</b>	<b>1284</b>
Total Coral Reef Area in GoK (sq. km)	277
<b>Coral Reef associated fish Value in GoK (Million Rs. Per sq. km)</b>	<b>4.64</b>

# Tourism in GoK

- In GoK, tourism infrastructure is not developed.
- Pirotan Island and Narara bet- two main tourist destinations for Coral Reefs..... Coral Walk
- Yr 2007-08, 14272 tourists in MNPS (141 foreigners)
- Yr 2007-08, 6830 students attended nature education camps in MNPS
- Adopted "financial revenue" approach and focused on the gross expenditure pattern of coral associated tourists
- Interview of tourists to record the expenditure patterns
- Included expenses incurred by students in nature camps

# Expense Pattern of Tourists in GoK

Type of tourist	Site	Total Tourists (2007-08)	Per Person Expense (Rs)	Total Annual Value (Rs.)
Indian	Pirotan	8278	1144	9470032
Indian	Narara	5853	982	5747646
Foreign	Narara	141	3672	517752
<b>Tourism-Total</b>		<b>14272</b>		<b>15735430</b>
Nature Camp		6830	300	2049000
<b>Grand Total</b>		<b>21102</b>		<b>17784430</b>

Total Annual Tourism Value: 17.8 million Rupees

# Site Specific Tourism Value of Coral Reefs

Parameters	Entire GoK	Pirotan Islands	Narara Bet
Area of Coral Reef (sq.km)	277	10	30
Value of Coral Reefs (Rs./sq.km/year)	64,203	9,47,003	2,08,847

- Recently, No. of Tourists and Students visiting MNPS increased
- Tourism function of coral reef bound to increase, provided infrastructure get improved

# Coral Reefs Associated Biodiversity

- Mangroves & algal beds key associated ecosystems
- More than 1440 species of flora and fauna reported from coral reefs and associated habitats. This include:
  - 174 Sps. of algae
  - 10 Sps. of mangroves
  - 365 Sps. of fishes
  - 129 Sps. of aquatic birds
  - 8 Sps. of reptiles
  - 5 Sps. of marine mammals
  - 69 Sps. of sponges
  - 68 Sps. of coral
  - 357 Sps. of molluscan
  - 71 Sps. of crabs
  - 33 Sps. of prawns
  - 10 Sps. of sea cucumber
  - 6 Sps. of star fish
  - 58 Sps. of minor phyla.

# Calculation of Biodiversity Values :Benefit Transfer Method

Parameters	South-East Asia	Indian Ocean
Reef Area (sq km)	89000	54000
Estimated Biodiversity Value (Million US\$) 2003	458	199
Adjusted Biodiversity Value (Million US\$) 2007	596	301
Adjusted Biodiversity Value -2007 (US\$ per sq km)	6696	5574

# Biodiversity Value

- Based on average of per capita income of South-East Asia & Indian Ocean countries, the adjusted BD values of GoK would be around US\$ 3449 i.e. Rs. 1.655 lakh per sq km.
- Thus BD value of Coral Reefs in GoK:  
$$\text{Rs. } 1.655 \text{ lakh} \times 277 \text{ sq km} = \text{Rs. } 45.86 \text{ million}$$



# Protection of Coastal Aquifer against Salinity Ingression

Salinity ingression in coastal ground water...

- Coral Reefs and Salinity ingression
- Lack of reference on this value in current literature
- **Importance in GoK context:**
  - Coral reefs which are located close to mainland and form rocky layers along the coast assume greater significance in restricting the lateral movement of saline water and thus controlling the problem of salinity ingression, to the certain extent.

# Ground Water Salinity Along GoK Villages

Taluka	No. of Villages			
	Total	Fresh Water	Partially Saline	Fully Saline
Jamnagar	59	34	10	15
Jodiya	41	0	4	37
Kalyanpur	41	7	12	22
Khambhaliya	41	15	8	18
Lalpur	22	18	3	1
Okha Manadal	46	0	12	34
<b>Total</b>	<b>250</b>	<b>74</b>	<b>49</b>	<b>127</b>

Source: SIPC, 2005. Quoted in Hirway and Goswami, 2006

# Change in Ground Water Salinity in Coastal Villages

Type of Village	Salinity Increase in PPM (1980 - 2008)	% Change	Number of Village
Coral & Mangrove Absent	1184.4	122.74	20
Coral & Mangrove Present	282.5	21.04	5
Only Mangrove Present	1065	91.67	9
Only Coral Present	263.8	5.6	2

**Salinity ingressions prevention as ecosystem function of coral reefs is valued by two measures:**

- (i) by measuring agriculture productivity loss and,**
- (ii) by analyzing preventive expenditure by Govt. Agencies to control the salinity ingressions problem.**

# Change in Groundnut Productivity in Sample Villages

Taluka	Village	Productivity (kg/ha)	
		1997	2007
Jamnagar	Gagva	2500	750
Jodiya	Khiri	3125	100
Khambhaliya	Chudeshwar	4375	2500
Khambhaliya	Goinj	3125	375
Khambhaliya	Kalawad simani	2500	1250
Khambhaliya	Nana Mandha	2500	500
<b>Average</b>		<b>3020</b>	<b>912</b>

**Average Productivity Loss = 2108 kg per ha**

# Loss of Groundwater Irrigated Area in Salinity Affected Villages

Concerned Area	Ground Water Irrigated Land (in ha)		Net Loss between 1991 & 2001	
	1991	2001	Area (ha)	%
56 Coastal villages in Jamnagar District	7129	6434	694	9.7
23 Salinity Affected Villages	3752	2402	1350	36

**Overall Net Loss of Irrigated Land for Groundnut Cultivation is 1350 ha**

# Monetary Value of Productivity Loss due to Salinity Ingression

- Land loss (ha) x productivity loss (kg/ha) x Market price of Groundnut (Rs./kg)  
  
= 1350 ha x 2108 (kg/ha) x 20 (Rs. /kg)= Rs. 56916000  
i.e. Rs. 56.9 million per year
- Assuming, coral reefs will able to control only about 30% of the total salinity ingression problem in 23 salinity affected villages, the net monetary loss will be in the nature of Rs. 17.07 million per year.

## Expenditure (in Lakh Rs.) made for Salinity Control Measures (1999 to 2008)

Name of Scheme	Okhamandal	Khambhali	Jamnagar	Lalpur	Total
Bandhara		-	955.82	24.61	980.43
Reclamation		-	114.48	-	114.48
Recharge Reservoir	-	52.59	-	-	52.59
Recharge Tank	-	-	15.19	-	15.19
Checkdam	10.38	11.67	-	15.09	37.14
<b>Total</b>	<b>10.38</b>	<b>64.26</b>	<b>1085.49</b>	<b>39.7</b>	<b>1199.83</b>

Source: Salinity Ingression Prevention Schemes (SIPS) Circle, Jamnagar

# Annual Salinity Prevention values of Coral Reefs

- Coral reefs along the coast would have produced additional crop output of Rs. 17.07 million per year
- It would save annually Rs.12 million in preventive expenditure cost.
- Thus an annual value of Rs. 29.07 millions, assigned to coral reefs of GoK, for the function of controlling salinity ingress in coastal areas of Jamnagar district.
- ***This implies annual salinity ingress prevention value of coral reefs in GoK was Rs. 104,718 per sq km.***
- ***Highly significant in drought prone areas like Saurashtra***



# Protection against Coastal Erosion

- In GoK, literature on the issues related to coastal erosion is almost non-existent
- Local community recognized that due to presence of rocky shores, mangroves and coral reefs (although quite patchily distributed), the southern side of GoK is well protected from the problem like coastal erosion
- In wake of paucity of data related with coastal erosion in GoK, the coastal protection prevention function of coral reefs was valued by applying Benefit Transfer Method (BTM).

# Calculation of Coastal Erosion Prevention Values :Benefit Transfer Method

Parameters	South-East Asia	Indian Ocean
Reef Area (sq km)	89000	54000
Estimated Erosion Prevention Value (Million US\$) 2003	5047	1595
Adjusted Erosion Prevention Value (Million US\$) 2007	6596	2412
Adjusted Erosion Prevention Value - 2007 (US\$ per sq km)	71269	44666

# Erosion Prevention Value

- Based on average of per capita income of South-East Asia & Indian Ocean countries, the adjusted Coastal Erosion Prevention value of GoK would be around US\$ 31735 per sq km i.e. Rs. 15.23 lakh per sq km.
- Thus Erosion Prevention value of Coral Reefs in GoK:

Rs. 15.23 lakh per sq km x 277 sq km = Rs.  
421.95 million

# Net Present Values (NPV) in Million Rs

Coral Functions/ Benefits	Net Annual Benefit (2007) (Million Rs.)	20 years		Infinitum	
		2% DR	4% DR	2% DR	4% DR
Fisheries	1284	20993	17334	64200	32100
Tourism	18	291	240	890	445
Salinity Ingression	29	475	392	1454	727
Coastal Erosion	422	6899	5696	21098	10549
Biodiversity	46	750	619	2293	1147
<b>Total</b>	<b>1799</b>	<b>29408</b>	<b>23877</b>	<b>89934</b>	<b>44967</b>

# Conclusion

- The valuation done here is only a rough guide to the true values of coral reefs because, firstly, not all benefits are quantified and, secondly, inadequacies of data and valuation techniques
- Salinity ingress prevention by coral reefs in GoK is a unique and site specific function quantified in this study. However, it need further research.
- The estimation of Present Value conclusively prove that the coral reefs of Gulf of Kachchh have a very high intrinsic value which is essential for the survival of the local economy of the coastal belt of Jamnagar (located in the semi-arid zone of Saurashtra in Gujarat, where agricultural productivity is low and is totally dependent upon monsoonal rainfall)
- The coral reefs in GoK provide current and long term benefits and assume greater significance for their management and guidance for inter-generational equity.
- Quantifying the benefits of coral reefs in marine protected area system of GoK, is an important contribution for policy makers to balance (cost-benefit) the conservation and development needs of the region

# Thanks

- World Bank, New Delhi
- GEC, Gandhinagar
- MNPS, Jamnagar
- Govt. Dept.
- Village Community