Integrated Coastal Zone Management Project Republic of India

Restoration and conservation of mangroves, coral reefs transplantation along the coastline of Gujarat and Orissa regions

Abstract

The ICZM project aimed at the conservation and protection of coastal resources among other different objectives such as transplantation and regeneration of coral reefs, waste and sewage treatment plants. In term of climate mitigation, regeneration of mangrove and shelterbelt plantation, about 18,000 ha, represent a potential net carbon sequestration of -5 million tCO2-e over 20 years.

Schiettecatte, LaureSophie (ESA)

lauresophie.schiettecatte@fao.org

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1. Project description

1.1 Project context

India has a coastline of about 7,517 km and hosts 17% of the national population, i.e. nearly 250,000,000 people live within 50 km of the coastline. It is endowed with a wide range of ecosystems such as mangroves (680,000 ha), coral reefs, seagrasses, salt marshes, sand dunes, estuaries, lagoons and associated fauna and flora species. Coastal areas and shallow offshore zones also host most of the gas and oil reserves in India, as well as there is a huge in offshore, coastal and ocean renewable energy. Coastal fishing employs a million people full time and the post-harvest fisheries sector employs another 1.2 million in 3,638 fishing villages and 2,251 fish landing centers. Nevertheless coastal and marine areas are under threats from urban and industrial development. 34 % of the mangrove disappear within the last five decades for land reclaiming for agriculture or infrastructures investments, and the continuous coastal resources depletion will impacts the livelihood, health and well-being of the population. Climate change (storms, flood, vector-borne disease…) will also impact infrastructures, coastal agriculture, accelerate erosion. A one meter sea level rise as already predicted would flood nearly 6,000 km^2 in India and potentially displace 63 million people living in low coastal areas.

The weak institutional framework and unplanned activities have contributed to the degradation of coastal environment and will continue to put at risk ecosystems and livelihoods as the demand for infrastructures (port, tourism, aquaculture, mining…) is increasing

Taking into account all these stakes, the Integrated Coastal Zone Management (ICZM) project aimed at supporting the Government of India and selected states to develop and implement an improved strategic and integrated management approach for India's coastal zones.

1.2 Project objectives

The project development objective is to assist the government of India in building national capacity for implementation of comprehensive coastal management approach in the country, and piloting the integrated coastal zone management in three states: Gujarat, Orissa and West Bengal. While the first component of the project will support at guiding and coordinating coastal zone management at the national level, components II to IV will support at state level authorities the institutional strengthening of state level coastal zone authorities, pilot investments consistent with local ICZM priorities around

Primary objective of the ICZM is to focus on protecting life and property of vulnerable coastal communities as continuous depletion and degradation of coastal areas will impact their livelihood, health and well-being, and so prospects for India's sustained economic growth. Then this includes conservation, restoration, preservation and development of coastal and marine ecosystems/resources. With that purpose pilot activities are launched in Gujarat, Orissa and West Bengal, chosen for their varying levels of development and different coastal zone management challenges (coral reef management, degree of industrialization…) so that lessons learnt can be used and replicated in other Indian coastal states. On field technical activities will include (1) construction of coastal protection infrastructure (2) bioshield solutions associated with mangrove plantations and casuarina trees (3) rehabilitation of coral reefs (4) sewage treatment plant.

The project should be implemented over a period of 6 years with a total cost estimates of **$285.67 million**, and will be 3 coastal states (Gujarat, Orissa and the West Bengal) and **benefits directly to 7.65 million people** and **indirectly up to 82 million** people living in the low elevation coastal areas in India, table 1.

Table 1: Key project information

Component	Cost (US$ million)	% IDA financing	Direct beneficiaries	Indirect beneficiaries
Component I: National ICZM Capacity Building	87.3	77.7	12,500,000	63,000,000
Component II: Piloting ICZM approaches in Gujarat	74.1	77.7	5,000,000	16,100,000
Component III: Piloting ICZM approaches in Orissa	49.3	77.7	2,900,000	82,400,000
Component IV: Piloting ICZM approaches in West Bengal	12.3	77.7	2,600,000	2,600,000

2. Data used for EX-ACT analysis

2.1 Inputs in EX-ACT

a) Agro-ecological variables

As on-field intervention will in majority take place in Gujarat, agro-ecological variables are set-up according to its agro-ecological characteristics, and tier 1 data will be corrected if needed for the other states.

While the Gulf of Kachchh (GoK) in Gujarat is characterized by tropical climate with a dry moisture regime, Orissa and West Bengal states are characterized as tropical moist. The dominant soil type is defined as HAC soils according to the IPCC classification.

The project is implemented over a period of 6 years, and EX-ACT takes into account an additional 14 year period of capitalization, which is needed in order to capture the full impact of introduced changes in land use and management on soil and biomass carbon stocks.

b) Mangrove restoration and shelterbelt plantation

Mangrove restoration in Gujarat and Orissa will benefit directly 2,717,650 people and will target 17,845 ha.

We used the rewetting and forest management modules of EX-ACT, considering the following as the without- and with project scenario: (1) In the absence of project, no restoration activities are engaged[1] ; (2) for the with-project situation we considered that the industrial and urban activities in the vicinity of the area still put under pressure coastal ecosystems and thus allowing only large mangrove (80% of biomass is restored), screenshots 1.

EX-ACT screenshot 1: Restoration of mangrove (management of coastal wetlands)

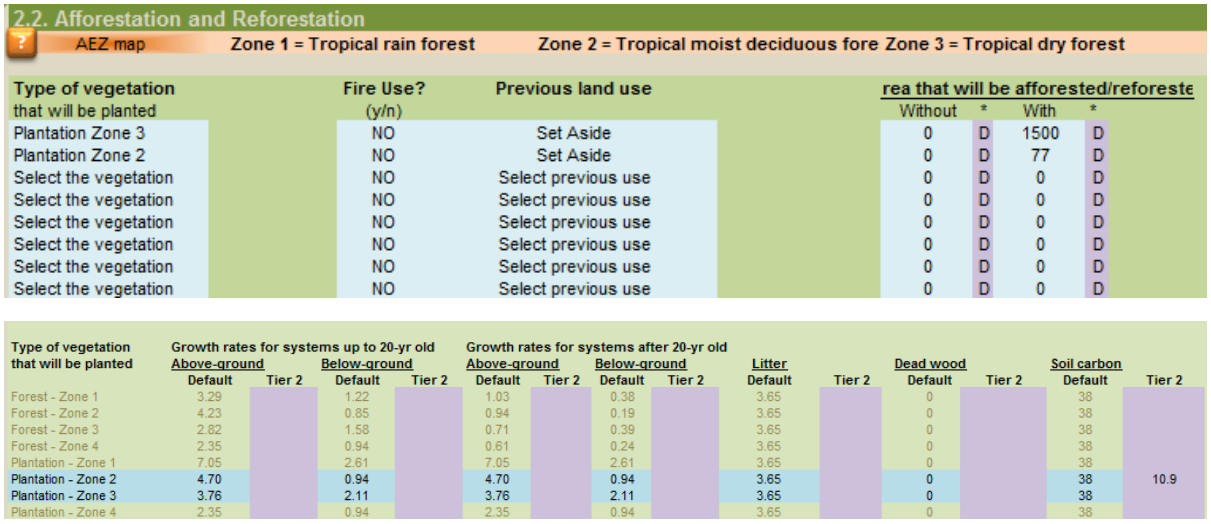
6.1.3. Rewetting

Type of vegetation	Area rewetted (ha) Start	Without		With		Percentage of nominal biomass restored Without	With
Mangrove	0	0	D	16268	D	0%	80%
Tidal marsh	0	0	D	0	D	0%	80%
Seagrass meadow	0	0	D	0	D	0%	50%

[1] As mentioned in the project appraisal document, "*all mangrove and shelterbelt plantations are proposed in areas which do not have any forest cover for a long time (p.136). No synthetic or chemical pesticide or herbicide will be used in any plantation or during deweeding or* clearing operations. No excavation work" (pp.136-137).

We considered the same scenario for the shelterbelt plantation but using the afforestation module as shelterbelt plantation are taking place on soil devoid of vegetation since a long time. 1,500 ha of casuarina trees are planted in Gujarat and others 77 ha in Orissa. We also corrected the soil carbon stock at Tier 2 for the region of Orissa, i.e. 10.9 tC ha^{-1} (Bohmia, personal communication[2])

EX-ACT screenshot 2&3: Afforestation with casuarina trees and Tier 2 modifications.



2.2. Afforestation and Reforestation

AEZ map | Zone 1 = Tropical rain forest | Zone 2 = Tropical moist deciduous fore | Zone 3 = Tropical dry forest

Type of vegetation that will be planted	Fire Use? (y/n)	Previous land use	rea that will be afforested/reforeste Without	*	With	*
Plantation Zone 3	NO	Set Aside	0	D	1500	D
Plantation Zone 2	NO	Set Aside	0	D	77	D
Select the vegetation	NO	Select previous use	0	D	0	D
Select the vegetation	NO	Select previous use	0	D	0	D
Select the vegetation	NO	Select previous use	0	D	0	D
Select the vegetation	NO	Select previous use	0	D	0	D
Select the vegetation	NO	Select previous use	0	D	0	D
Select the vegetation	NO	Select previous use	0	D	0	D

Type of vegetation that will be planted	Growth rates for systems up to 20-yr old Above-ground Default	Tier 2	Below-ground Default	Tier 2	Growth rates for systems after 20-yr old Above-ground Default	Tier 2	Below-ground Default	Tier 2	Litter Default	Tier 2	Dead wood Default	Tier 2	Soil carbon Default	Tier 2
Forest - Zone 1	3.29		1.22		1.03		0.38		3.65		0		38	
Forest - Zone 2	4.23		0.85		0.94		0.19		3.65		0		38	
Forest - Zone 3	2.82		1.58		0.71		0.39		3.65		0		38	
Forest - Zone 4	2.35		0.94		0.61		0.24		3.65		0		38	
Plantation - Zone 1	7.05		2.61		7.05		2.61		3.65		0		38	
Plantation - Zone 2	4.70		0.94		4.70		0.94		3.65		0		38	10.9
Plantation - Zone 3	3.76		2.11		3.76		2.11		3.65		0		38	
Plantation - Zone 4	2.35		0.94		2.35		0.94		3.65		0		38	

c) Information, gaps and assumptions

From on-field activities, only carbon sequestration from mangrove plantations and casuarinas trees can be assessed in the present analysis for Orissa and Gujarat, as there is no information of the surface area concerned with additional mangrove plantation in the West Bengal states. Indeed if the project is seeking for mangrove conservation it would be interesting to add mitigated emission from mangrove conservation and protection. Therefore we would need the mangrove surface area within each state and their state of degradation.

2.2 EX-ACT results

The following table (screenshot 4) summarizes the greenhouse gases (GHG) sequestration and the share of the balance per GHG from the project. Results are given in tonne CO_2 equivalent (tCO_2-e). Positive numbers represent sources of CO_2-e emission while negative numbers represent sinks. It summarizes estimated CO_2-e emissions and sinks from the scenario without-project (left column), from the scenario with-project (middle column) and the total balance (right column).

Components of the project	Gross fluxes Without	With	Balance
	All GHG in tCO2eq		
	Positive = source / negative = sink		
Land use changes			
Deforestation	0	0	0
Afforestation	0	-580,316	-580,316
Other LUC	0	0	0
Agriculture			
Annual	0	0	0
Perennial	0	0	0
Rice	0	0	0
Grassland & Livestocks			
Grassland	0	0	0
Livestocks	0	0	0
Degradation & Management	0	0	0
Coastal wetlands	0	-4,366,799	-4,366,799
Inputs & Investments	0	0	0
Fishery & Aquaculture	0	0	0
Total	0	-4,947,115	**-4,947,115**
Per hectare	0	-280	-280
Per hectare per year	0.0	-14.0	-14.0

EX-ACT screenshot 4: EX-ACT results, gross fluxes and balance of greenhouse gases (GHG) of the without- and with-project scenario.

2 Carbon stock in Bhitarkanika

In order to overall evaluate the impact of The "Integrated Coastal Zone Management Project" for GHG mitigation, it is necessary to consider the difference between the gross fluxes of the with- and without-project scenario, which is given by the Carbon Balance (light green column): The implementation of the project leads to an overall **Carbon Balance** of around **-5 million t CO_2-e** over the full analysis duration of 20 years. This is equivalent to **-280 t CO_2-e per hectare or -14 t CO_2-e per hectare and year**. With this impact the project can be characterized as having very high benefits for climate change mitigation based on our assumptions. When translating the qualitative uncertainty assessments by the IPCC into a quantitative estimation as done by EX-ACT, the here indicated Carbon Balance is associated to an uncertainty level of 38.4 %.

2.3 General Discussion & recommendations

The ICZM project aimed at the conservation and protection of coastal resources among other different objectives such as transplantation and regeneration of coral reefs, waste and sewage treatment plants, ICZM capacity building and improvement of fish auction…. Coastal wetlands and in particular mangroves are known to be able to store and sequester large amount of carbon in soil, up to 1600 tC ha^{-1} in the first 1m depth (Ajonina et al 2014[3], Alongi et al 2015[4]), unless disturbed. Continuous degradation of these ecosystems have consequences on the stored organic carbon and also on the dissolved inorganic carbon exchange with adjacent ecosystems such as coral reefs, as it is the case on the gulf of Kachchh. Transplantation of coral reefs in these region (200 ha associated to artificial reef) cannot be taken into account in term of climate mitigation. Indeed, the balance between organic and inorganic carbon processes (precipitation of calcium carbonate) in these ecosystems is normally in favor of calcification, thus it generates CO_2, according to the following equation:

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O \qquad \text{Equation 1}$$

However coral reefs provide other ecosystems service such as fishery resources (spawning grounds for fish), wave breakers, dissipate energy from storm, protect coastline from erosion... As interconnected with neighboring natural habitats such as seagrass and mangrove, their sound management will have cumulative positive impacts and will benefit also to coastal communities who are highly dependent on ecological resources from these ecosystems. It can be expected for example reconstruction of fish stock and coastal protection by energy attenuation of storm waves before they impact coastal natural habitats and communities.

Indeed, environmental and pollution management with implementation of sewage treatment plant of Paradip (Orissa) and Jamnagar city (Gulf of Kachchh) should also positively impact coastal ecosystems such as mangroves and coral reefs. The high discharge of nutrients associated to urban waste in coastal waters are often causes of eutrophication with potential shift in phytoplankton communities and changes of the trophic network. High nutrient concentration also favor algae growth reducing light on coral reef. This process is also magnified by high content of organic matter from municipal waste and lead to degradation of coral reefs and loss of biodiversity.

In conclusion, the ICZM project, with mangrove and shelterbelt plantation and conservation, coral reef transplantation and artificial reef, should lead to important climate mitigation output and recovery of numerous coastal ecosystems services such as reconstruction of fish stock, allowing positive impacts on the well-being, livelihood and health of coastal population.

[3] Ajonina et al 2014. Carbon pools and multiple benefits of mangroves in Central Africa: Assessment for REDD+. 72pp.

[4] Alongi et al 2015. Indonesia's blue carbon: a globally significant and vulnerable sink for seagrass and mangrove carbon. Wetlands Ecol. Manage. DOI 10.1007/s11273-015-9446-y