CONSERVATION AND MANAGEMENT OF COASTAL RESOURCES AS A POTENTIAL ADAPTATION STRATEGY FOR SEA LEVEL RISE

Final Evaluation Report

Submitted by

M S Swaminathan Research Foundation
III Cross Road, CPT Campus, Taramani Institutional Area
Chennai 600 113

Submitted to

The National Bank for Agriculture and Rural Development (NABARD)
Mumbai

CONSERVATION AND MANAGEMENT OF COASTAL RESOURCES AS A POTENTIAL ADAPTATION STRATEGY FOR SEA LEVEL RISE

Executive Summary

- Climate change and development worldwide are, among other things, a fast-paced process. Emissions/greenhouse gases vis-à-vis the rise in temperature and natural vagaries and their impact are visible worldwide, especially on the coast. Globally, all countries have collectively agreed to reduce/cut emissions, mitigate the rise in mean sea temperature, and bring climate adaptation practices to an acceptable level.

- India is a signatory to the above process and to protect its millions of coastal communities, whose livelihoods are climate-dependent activities- agriculture, fishing and aquaculture. They are significant contributors to the state and national economy. The coastal lands are stressed by the increased exploitation of resources, such as land, water, and sea, in the coastal areas. The Indian coast has become vulnerable to cyclones, storm surges, inundations and floods.

- The livelihood and ecological security of the coastal zone is weakening due to population pressure, urbanisation, industrial development and environmental degradation. Various studies have evidence that extreme events along the coast are increasing. A predicted sea level rise would inundate several kilometres into the landward side and directly impact the coastal communities for every degree change. Thus, both the coastal communities and dependent communities whose lives, livelihoods, infrastructure -social and physical and economies are jeopardised.

Mangroves as a panacea

- It is well established that the coastal communities are dependent on the status and health of the coastal ecosystems such as mangroves, seagrass beds and coral reefs in the coastal areas. These ecosystems will improve the adaptive capacity to climate change, act as a buffer, protect the coast from severe impacts of extreme events, and improve the blue economy and the livelihoods of the dependent communities. There is a significant opportunity to enhance the mangroves – restore, strengthen/rejuvenate in the protected areas and restore in vulnerable areas – across the coastal state and within

the state of Andhra Pradesh – Krishna and Godavari estuarine areas. The mangroves provide ecosystem services to the local communities for livelihood development.

- To strengthen the ecosystem and its services in Krishna district, as it is an ecologically vulnerable hotspot, this project focuses on overcoming the consequences of salinisation and other impacts on the coastal area due to sea level rise and seawater inundation due to increased cyclonic storms. Storm surges through appropriate adaptation strategies such as (i) restoration of degraded mangroves and (ii) demonstration of Integrated Mangrove Fishery Farming System (IMFFS) and (iii) cage culture of fin fishes in brackish water areas of Krishna district, Andhra Pradesh.

A. Inception Workshop

The inception workshop highlighted the project objectives and oriented the stakeholders on the impact of climate change, the adaptive practices, and activities to be initiated to mitigate its effects by restoring and strengthening the mangroves and establishing integrated mangrove-based fishery livelihoods.

- Sensitization on the approach for project planning, implementation monitoring and evaluation
- Refine project approach and expected results based on inputs from stakeholders.

Participants

Representatives from NABARD, Andhra Pradesh State Forest Department and Department of Fisheries, National Center for Sustainable Aquaculture (NaCSA) and Rajiv Gandhi Center for Aquaculture (RGCA), M S Swaminathan Research Foundation (MSSRF), NGO partners, Traditional leaders, SHG leaders, Panchayat leaders, Fisherfolk and Farmers from three project villages and Media representatives participated in the workshop.

The project comprises the following components:

- Component 1: Community mobilisation and organisation
- Component 2: Capacity building for coastal protection and livelihoods
- Component 3: Restoration of mangrove areas for coastal protection
- Component 4: Demonstration of Integrated mangrove-based fishery livelihoods
- Component 5: Knowledge Management for Improved Coastal Protection

B. Project area

The project was implemented in the coastal villages, namely Sorlagondi, Nali and Basavanipalem, in the Krishna district of Andhra Pradesh. The total number of households in these villages is 1,104 and the total population is 3,905 (male: 1,959; female: 1,946). The population depends on agriculture, fishing and aquaculture. Salinisation of agricultural lands, drought, floods, cyclones, degradation of natural resources and overexploitation of fishery resources affect the community's livelihoods.

C. Project Interventions

1. Community mobilisation and organisation

The project's primacy was to conscientise the community, enable their active participation, and build ownership. It has decided to critically engage them from day one and build trust amongst them that the mangrove restoration and other livelihood interventions will have visible impacts on their livelihoods.

Three gender-balanced village-level institutions (VLIs) were formed in Sorlagondi, with 593 men and 613 women; in Nali village, with 397 men and 412 women; and in Basavanipalem, with 55 men and 65 women. These VLIs played a significant role in planning, implementing, and monitoring the project activities.

The community needed to be made aware of the impacts of global warming and sea level rise. However, they were aware of changes in climatic conditions such as an increase in temperature in summer, erratic rainfall, changes in precipitation patterns, increased intensity and frequency of cyclones, floods and drought. Orientation of the climate change vulnerability and their coping strategies were collected during PRA. The community can adapt to conduct livelihood activities such as marine fishing, culture fishery, and agriculture. Since they have an excellent capacity to learn and adapt to the situation, the adaptation strategies implemented in the project will be taken up and continued.

Therefore, confidence-building measures were initiated through the entry point activities.

- Mobilising community from the three villages and engaging them in identified village activities namely
    - De-silting and fencing of freshwater pond - for drinking water, in Basavanipalem

- Low-lying roads – Road height is elevated with project support and community contribution in Sorlagondi.
- Small culvert on the way to sea – Used 8 Concrete cement pipes and completed the road in Nali
- Clearing bushes in the burial ground – Cleared the bushes and levelled the area in Nali
- Solar light – one installed in Nali village

- Participatory Rural/Rapid Appraisal processes (PRA) were initiated, and micro plans were evolved by identifying issues, finding solutions, and resolving them by providing technical, institutional, and financial support.
- The following issues were identified: The infrastructure and development issues were addressed immediately, and the climate change impact issues were taken for long-term project activities.

Infrastructure and development	Climate change
Drinking water, Irrigation facilities, Roads and drainages and canals, sanitation, internal roads and veterinary care	Shoreline erosion, migration, loss of aquaculture, pollutants in creeks,

Knowledge skills among the community as an Adaptive Capacity

- Weather forecasting - elders predict cyclones and rainfall
- Skills to venture into deep sea fishing using improvised gears and crafts.
- They have acquired knowledge and skills in post-harvest techniques to minimise post-harvest losses.
- The transformation from fishing to coastal aquaculture as an alternate livelihood is due to the reduction in fish catch and lower agriculture profits.
- They were converting saline land for shrimp farming. In addition to hatchery-reared juveniles, shrimp juveniles collected from the wild were stocked.
- Traditional practices of storing grain to meet distress needs

2. Capacity buildingfor coastal protection and livelihoods

The capacity-building initiatives formed the fulcrum of project implementation. The community capacity–building focussed on Exposure visits to learn about the process involved

in restoring the mangroves and strengthening livelihoods and knowledge systems. Stereotyping issues were redressed through a gender sensitisation process by involving the village institutions, so the project was implemented collectively, and they collectively improved and secured socioeconomic benefits.

- The Exposure Visit to the Participatory Mangrove Management Program in East Godavari district improved the community's understanding of the project objectives, the importance of the participatory process, and the strategies and methodologies implemented for success. Based on the exposure visit, the community has identified and resolved vital issues, especially the infrastructure issues.
- One hundred twenty community members received training and capacity building on mangrove sylviculture practices. Most of the Sorlagondi community knew these practices; however, the Nali and Basavanipalem communities were not.
- The training covered collecting mature propagules/ seeds, transporting and storing seeds, collecting soil, bag filling, sowing seeds, watering, and other nursery activities.
- Similarly, about 65 members of the government department staff from the forest department and the panchayat raj and rural development were trained in mangrove sylviculture practices. Based on the training, the state forest department has raised multiple species in the mangrove nursery (5 species). Earlier, they were raising only *Avicennia* sp. Similarly, the panchayat raj and rural development have initiated mangrove restoration in East Godavari and Prakasam districts after the training and capacity building.
- Through exposure visits, 200 community members and staff learned the nuance of restoring mangroves and conducting activities. Knowledge was imparted on mangrove restoration techniques such as layout design for canal digging, canal dimensions and depth, mangrove nursery, canal digging, planting and desilting, which were explained to the community. The community was taken to the degraded area, and the area's topography, the reasons for the lack of natural regeneration, and the layout design of the canals were explained. The community was given hands-on experience through these activities. Through hands-on experience, the community learned how to dig canals as per the topography.

3. Restoration ofmangrove areasfor coastal protection – 200 ha

- While implementing the project, MSSRF brought in its expertise and experience and time-tested Models in the restoration of mangroves from mangrove wetlands of Tamil Nadu’s Pichavaram and similarly from Krishna and Godavari in Andhra Pradesh and also from Devi River delta in Orissa.

- After permission and approval of the Department of Forests and Environment, Government of Andhra Pradesh, the project restored 200 ha of degraded mangroves of Sorlagondi Extn. RF with the following steps
  i. Conducting of hydrological studies
  ii. Selection of nursery site and raising of nursery
  iii. Capacity building of community in canal digging and plantation
  iv. Canal digging and plantation work in the selected site

3.1 Hydrological studies

The Hydrological study identified the following.

- The tidal amplitude in the main creek near the degraded area was between 0.5 m and 1.5 m, and it receives daily tidal flushing. The salinity in Krishna mangroves is always higher than in Godavari. The mean tidal amplitude is 90 cm. The maximum height of the water level during high tide is 1.10 m, and the minimum height of the water level during high tide is 0.20m, which defines the water flow dynamics for mangrove growth.
- Natural vegetation is slowly colonising along the creeks.
- The shore is getting eroded due to currents at an alarming rate. The shore has moved more than 2 km inside the land over the last 15 – 20 years, and this needs attention.
- The surface water near the degraded area was assessed for pH and salinity. The creeks had salinity between 26 ppt and 34 ppt. The water's pH was between 7.9 and 8.2, and the soil's pH was between 6.85 and 7.3.
- The soil texture in the degraded area is sandy clay, and the subsurface and surface soil are mostly sandy.
- The topography of the degraded area is smooth and slightly elevated. The main canal, which is 60 cm deep, flushes the entire area. The side canals were also dug to a depth of 60 cm.
- At an alarming rate during the last 15-20 years, the shore has been eroded due to the currents. It has moved more than 2 km inside.
- The degraded area receives daily tidal flushing during the monsoon period, the new moon, and full moon days in other seasons. Natural vegetation is slowly colonising the creeks.
- The mangrove vegetation is sparsely dense in Sorlagondi, Nachugunta, Lankivanidibba, and Yelichetladibba Reserve forests, while it is dense along the coast and sparse on the

landward side. *Avicennia marina and Excoecaria agallocha* are the dominant mangrove species grown.

Based on the topography, canals were designed as the degraded area is smooth and slightly elevated.

Mangrove Nursery

Mangrove nursery plays an important role towards mangrove restoration. Seedlings grown in the nursery have well-established root systems, and the saplings are grown in a saline environment for 8-9 months before transplantation. The nursery was established in the intertidal area near Sorlagondi as it has various advantages, especially since it has natural and artificial canals for tidal water flow. A diesel pump was used to irrigate the saplings during neap tide. The nursery site is well protected from grazing and has access to small boats/tractors for easy transport of saplings to the plantation site. The plantation species raised in the nursery are - *Avicennia marina A. officinalis Bruguiera cylindrical, B. gymnorrhiza, Rhizophora apiculata* and *R. mucronata*. The mature and healthy fruits/propagules were collected from the mangrove forest of Krishna and Godavari wetlands, and care was taken when selecting these seeds. Clayey soil from the nearby creeks is used to fill the nursery bags. The germination varied according to the respective species.

The seeds are sown in the sunken beds dug 20 cm deep and have access to tidal water creeks. The tidal water inundates the saplings, and whenever the tidal water flow is less, the saplings are irrigated with the help of the pumped water. Plant growth is tracked, and periodic causality replacement and grading are done to get healthy saplings. Inorganic fertiliser, namely Di-Ammonium phosphate (DAP), was applied twice (about 1 gm/bag) to secure quality plants.

3.3 Land preparation and canal digging

The degraded area is slightly elevated, and tidal water flows are very rare except during the monsoon. Canals were dug in the degraded area, and the flow of tidal water facilitated the growth of mangrove saplings with high and low tides. The degraded area is almost free from vegetation except for a few stunned *Avicennia marina* and a few halophyte species like *Sesuvium, Salicornia,* and *Suaeda*.

3.4 Planting of mangrove saplings

Mangrove plantation was done using two methods: i) planting nursery-raised saplings (pot

seedlings) and ii) direct planting (dibbling) of propagules or seeds of mangrove plants. About 300,000 saplings were planted with varied species. However, causalities and their replacement were carried out.

Outcome

- The restored mangroves serve as nursery grounds for many juvenile fishes, especially shrimps and crabs.
- Mangroves sequester more than four times more carbon than other terrestrial ecosystems.
- The local fishing community collect fish during low tide.
- The restored mangroves will act as a sink with an average annual carbon sequestration rate between 6 and 8 Mg CO_2 e/ha (tons of CO_2 equivalent per hectare)
- The restored mangroves will be protected from disasters, especially during cyclones.
- The restored mangroves will protect large areas of agricultural lands and aquaculture ponds in 5 villages from disasters. About 2 km of the coastal area will be protected from erosion.
- The restored areas have provided livelihood support to the coastal community, especially the Yanadi tribal community. About 20 families collect mud crabs daily in the restored area.

4. Demonstration of Integrated mangrove-based fishery livelihoods

4.1 Integrated Mangrove Fishery Farming System (IMFFS)

Since the late 1980s, coastal aquaculture has become prominent; more than 1.5 lakh farmers are growing prawns in 0.16 million ha of brackish water area. Andhra Pradesh is one of the largest shrimp producers, cultivating 71,921 ha under brackish water, and in the year 2020-21, it produced 634,672 million tons. The local environment is polluted with widespread cultivation, increased viral attacks, indiscriminate usage of chemicals to control it, and use of commercial feeds and chemicals. The water and soil quality, too, had deteriorated and increased the overall production cost, and thus, farmers were severely impacted.

The integrated mangrove fishery farming system (IMFFS) integrates the growth of mangroves with fish culture. In this farming system, aquaculture ponds are modified by raising mangroves in 40% of the area where bunds were formed and the remaining 60% of the water spread area for culturing fish. The farms receive tidal water, which makes them environmentally friendly and economically profitable. With the gravitational tidal flow, water enters the pond during

high tide and drains out during low tide as it brings plankton as fresh feed and prevents a reduction in oxygen levels and the outbreak of diseases.

In the abandoned 50 ha aqua farms, during the first year, the farmers cultivated crabs, and each farmer got Rs.40,000 as a profit. The project supported farmers in preparing the ponds, planting saplings, constructing the inlet and outlet and procuring crabs. Due to the Rio virus, crab cultivation did not yield much income in the third year. However, a few farmers were able to get additional money as they cultured multiple species. Due to the failure of crab culture in the subsequent years' farmers took up culturing tiger (*Penaeus monodon*) shrimp and sea bass culture. The profit was about ₹25,000 per ha, and there was not much input except the fingerling cost.

The learnings allowed farmers to culture other fin fishes like milkfish and sea bass. Farmers are currently culturing fin fish with low inputs and are getting profits. This project has helped the farmers learn the cultural practices and increase their adaptive capacity through training and demonstrating the culture. The cultural practice will be sustainable within a few years as more hatcheries are being constructed to rear more species like sea bass, mud crabs, gropers, silver pompano, etc.

4.2 Cage and pen culture established for crabs, fish, clams and cockles

Culturing fin fishes in floating cages is a new technology and the local communities were unaware of it. To gain knowledge and skills and to raise fish in cages, eight fisherfolk from the project villages were taken on an exposure/ training visit to the Udupi coast in Karnataka, where sea bass is reared in cages. After a successful training/exposure visit, the project identified Nagayalanka village as a place to initiate cage culture activity. It has many facilities like a deep backwater system, road connectivity and easy accessibility.

Outcome:

- Suitable sites were identified, and ten cages were established.
- Low input organic culture method in cultivating fishes and
- This practice of farming is more extensive as the stocking density is low.
- The local community has adapted this technique and will continue culturing fin fish, significantly reducing the environmental impacts.

5. Knowledge Management for Improved CoastalProtection

To disseminate information, the project developed five brochures in the regional language (*Telugu*) to increase community awareness of climate change, sea level rise, and its impact on coastal areas. The importance and role of mangroves in reducing the effects of climate change integrated mangrove-fishery farming system and cage culture of fin fishes in enhancing the adaptive capacity of the community to sea level rise were given in the brochures.

These brochures were distributed to the community, the forest department, and NGOs. District-level and national-level workshops were conducted, and NGOs and other government departments like fisheries, forests, and rural development staff participated. This project has shown the critical sylviculture practices for a thriving plantation. The integrated mangrove fishery farming system (IMFFS) is one of the low-input sustainable models for culturing crabs, as crabs require hideouts, and the mangrove roots will provide feed and hideouts for the crabs. Similarly, dissemination materials such as video documents were prepared for dissemination.

MSSRF trained 25 Andhra Pradesh State Forest Department field staff on mangrove sylviculture practices. Based on the training, the wildlife division Rajahmundry raised 1 lakh mangrove saplings of different species. In addition, about 40 staff members of the rural development and panchayat raj were trained in mangrove silviculture as they were involved in mangrove plantation under the MGNREGA scheme in East Godavari, West Godavari and Prakasam districts.

In addition, about 50 aqua farmers were trained in the process and aquaculture practices in the Integrated Mangrove Fishery Farming System (IMFFS). About ten members were taken to Udupi for hands-on training on cage culture.

CONSERVATION AND MANAGEMENT OF COASTAL RESOURCES AS A POTENTIAL ADAPTATION STRATEGY FOR SEA LEVEL RISE

EVALUATION REPORT

Since ancient times onwards, India's coast has been linked to its development and the development of global humanity. The resources from the coast or from the hinterlands were always exploited, and commerce was a mainstay to meet the needs of local and international development vis-à-vis social and economic development. However, the onset of industrialisation and its developments have accelerated India’s coastal resources to the industrial development supply chain process. Climate change and development across the globe are inter-alia and are a fast-paced process. Alongside, the emissions/greenhouse gases vis-à-vis the rise in temperature and natural vagaries and their impact are visible across the globe, especially on the Indian coast.

As India's tryst with climate change began quite early, since its independence, the coastal areas have continued to foster economic development and human progress in many ways. Consequently, a rising population across the coastal districts accounts for 14.2% of its population. To meet the domestic and global development contribution, there is an increase in the exploitation of resources – land, water and sea in the coastal areas. Consequently, the coastal lands are stressed out, and the Indian coast has become vulnerable to cyclones, storm surges, inundations and floods. The coast has become vulnerable, and its climate change impacts the ecosystem, life and livelihoods. The livelihood and ecological security of the coastal zone is weakening due to population pressure, urbanisation, industrial development and environmental degradation.

As a developing country, India has been facing or exposed to climate variabilities and vulnerabilities, especially across the coast and the associated risks from climate change. Millions of coastal communities, whose livelihoods are climate-dependent activities—agriculture, fishing, and aquaculture—are significant contributors to the state and national economies.

India has been identified as one of the countries which are most vulnerable to the impact of accelerated sea level rise due to global warming. Various studies have evidence that extreme events along the coast are increasing. A predicted sea level rise would inundate several kilometres into the landward side and directly impact the coastal communities for

every degree change. "Indian National Centre for Ocean Information Services (INCOIS) has estimated the Coastal Vulnerability Index (CVI) for the Indian coastline, which is a cumulative impact of seven coastal parameters- Shoreline Change Rate, Coastal Slope, Elevation, Geomorphology, Sea level Change Rate, Mean Significant Wave Height and Tidal Range. The CVI mapping was to assess the probable implications of sea-level rise along the Indian coast. It has generated maps for each of the coastal states across India. " (INCOIS – Results on Coastal Vulnerability- page 18 Results Report – website incois.gov.in/Incois/cvi/pdfs/Results.pdf). Thus, both the coastal communities and dependent communities whose lives, livelihoods, infrastructure -social and physical and economies are jeopardised.

The Convention of Parties on Climate Change and the 2015 Paris Agreement have drawn all the countries to collectively agree to reduce/cut emissions, mitigate the rise in mean sea temperature, and bring climate adaptation practices to an acceptable level.

Increased consciousness and the impacts of climate change have led India to amend its development agenda. The government of India has developed both Mitigation and Adaptation strategies. The adaptation strategies focus on agriculture, coastal regions, biodiversity protection, and livelihood security. To restore coastal biodiversity, mangroves must be drivers of the coastal ecosystem to address coastal vulnerabilities.

Coastal Vulnerability of Andhra Pradesh and Krishna district

The state has a long coastline from Ichapuram in Srikakulam district to Pulicat Lake in Nellore district (IHS, 2009). A total of 2,482 villages exist along the coastline (Somayajulu, 2005), covering an area of 92,906 sq. km with a total population of 34.2 million, representing an average population density of 368 people per sq km. There are 500 villages situated in the proximity of 5 km from the coast across the Coastal districts of Andhra Pradesh Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and Nellore.

The CVI for Andhra Pradesh the CV indicate that the very high risk in the region is due to coastal slope, elevation, geomorphology and MSWH, whereas the parameters shoreline change rate and tidal range account for a low-risk rate. INCOIS data on The CVI analysis for the state of **Andhra Pradesh state reveals that the Length of 6 km (~0.55 %) is under Very High Vulnerable**. Most of the coastal stretches belong to the Low and

Medium Vulnerable class, recording a length of 465 km and 379 km, respectively (accounting for 43.35 % and 33.27 % of the total coastline, respectively). High Vulnerable class was recorded along 224 km of coastline (~21 km).

The coasts of Krishna, West Godavari, East Godavari, Vishakhapatnam, Vizianagaram, and Srikakulam districts were classified as Medium to High Vulnerable.

Statistics of CVI along Andhra Pradesh - INCOIS		
CVI	**Length (km)**	**% of Length**
Low	465	43.35
Medium	379	35.27
High	224	20.84
Very High	6	0.55
Total	1073	100

A rise of 0.6m of SLR in the Krishna and Godavari delta alone affects 89,400 ha of land, affecting the lives and livelihoods of about 13 lakh people. This demands the community's preparedness, particularly to enhance their adaptation capacity to cope with climate change impacts.

Mangroves as a panacea

It is well established that the coastal communities are dependent on the status and health of the coastal ecosystems such as mangroves, seagrass beds and coral reefs in the coastal areas. These ecosystems will improve the adaptive capacity to climate change, act as a buffer, protect the coast from severe impacts of extreme events, and improve the blue economy and the livelihoods of the dependent communities. There is a significant opportunity to enhance the mangroves – restore, strengthen/rejuvenate in the protected areas and restore in vulnerable areas – across the coastal state and within the state of Andhra Pradesh – Krishna and Godavari estuarine areas. The mangroves provide ecosystem services to the local communities for livelihood development.

What draws to the Project implementation?

Krishna district is in the medium to high vulnerable class and is exposed to rising sea levels. It determined that adaptation measures should be initiated. This project was implemented in the coastal villages, namely Sorlagondi, Nali and Basavanipalem, in the Krishna district of Andhra Pradesh. The total number of households in these villages is 1,104 and the total population is 3,905 (male: 1,959; female: 1,946). The population depends on agriculture, fishing and aquaculture. Salinisation of agricultural lands, drought, floods, cyclones, degradation of natural resources and overexploitation of fishery resources affect the livelihoods of the community in the area.

It is essential to plug in ecologically vulnerable hotspots by the ecosystem and its services to strengthen adaptation practices in Krishna district. Therefore, the project was designed to overcome the consequences of salinisation and other impacts on the coastal area due to sea level rise and seawater inundation due to increased cyclonic storms. Storm surges through appropriate adaptation strategies such as (i) restoration of degraded mangroves and (ii) demonstration of Integrated Mangrove Fishery Farming System (IMFFS) and (iii) cage culture of fin fishes in brackish water areas of Krishna district, Andhra Pradesh.

The project was successfully implemented in 3 villages of Krishna district with the operational methodology.

2. Methodology Implemented

2.1 Project Objectives

The project aims to overcome the consequences of sea level rise and seawater inundation by demonstrating adaptation measures such as (i) restoration of degraded mangroves and (ii) demonstration of mangrove-based livelihood. The following are the project objectives:

- To strengthen the mangroves in the project area with active community participation and management of mangroves in collaboration with Andhra Pradesh Forest Department
- To establish, build and strengthen the livelihoods of the local community in Integrated Mangrove Fishery Farming and raising their family incomes
- Build Communities' Capacity to establish and strengthen mangroves and their management.

2.2. Project Operational Framework

Through the inception workshop, MSSRF has established the following methodology.

1. Engaged stakeholders the stakeholders - State and district administration officials, Representatives from National Institutes, Community, Village functionaries, representatives from local institutions and NGOs in the following areas
2. Seeking approvals from the Government of Andhra Pradesh Forest Department approval for initiating the project
3. Assigned specific Roles and Responsibilities to the respective stakeholders in implementing the project
4. Monitoring structure and Review mechanism – Established community-centric project monitoring and review mechanism

Strategic approach

A strategic approach is implemented in initiating the project activities to overcome the consequences of sea level rise and seawater inundation:

Strategy 1*:* Restoration and conservation of existing mangroves with the participation ofthe community

- Drawn information based on the community's anecdotal evidence on the impacts of cyclones and tsunamis and the importance of dense mangrove forests, which act as a bio-shield and protect the life and livelihoods of people.
- Mangroves as soft structures prevented the intrusion of seawater.
- Increasing substratum will be on par with sea level rise if a continuous supply of sediments and undisturbed forest structures is ensured.
- Mangroves helped increase fishery resources, which fetches high economic benefits.

Strategy 2: Creation of new mangroves in suitable areas with the community as the lead stakeholder

The project has identified potential mangrove sites for new regeneration and restoration

in 200 ha. The demonstrated Joint Mangrove Management (JMM) approach was adopted in the restoration and creation of mangroves in the project villages.

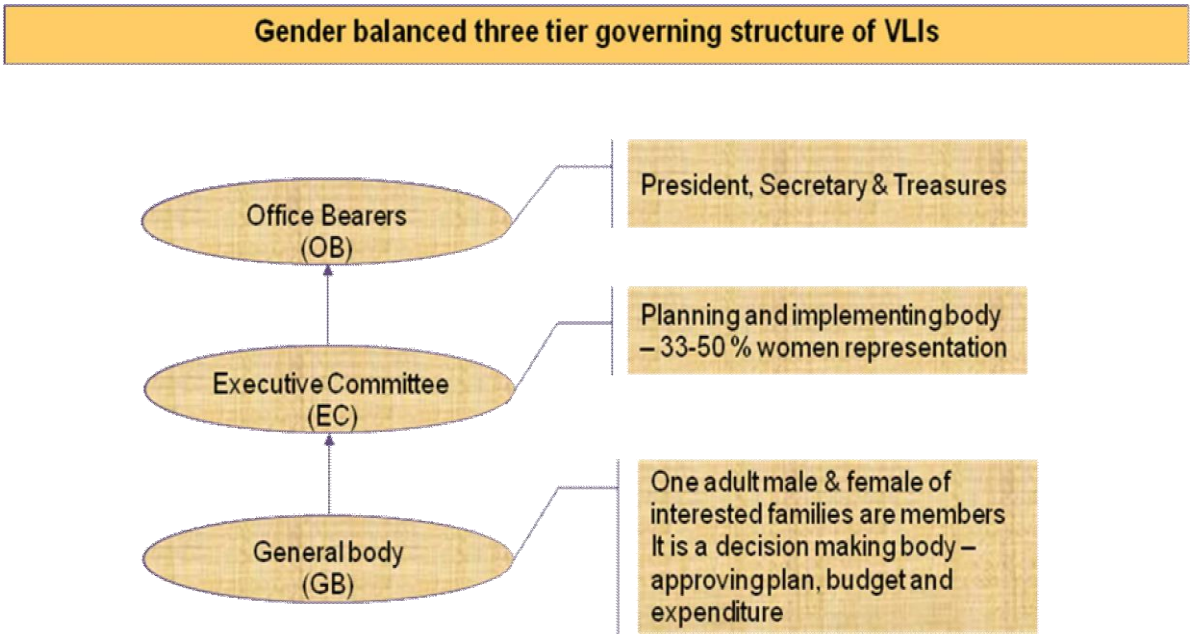
Strategy 3: Development of seawater water-based agro-aqua farming system that integrates the growing of salt-tolerant plants and fish, prawns and crabs.

Converted unproductive, abandoned shrimp farms and saline-affected coastal landsinto productive resources through integrated mangrove fishery farming.

Importance of Stakeholder consultations

Through consultations with stakeholders selected Sorlagondi, Nali, and Basavanipalem as project villages by setting criteria (a) intensive users of mangrove wetlands, (b)socially and economically backward and vulnerable and (c) those villagers willing to play an active role in the project activities. The local community and people's institutions are engaged in each phase of the project implementation process - Community Mobilization and Institution Building, Needs and Vulnerability assessment and the restoration of mangroves and the Integrated Mangrove Fishery Farming System.

Three Gender Balanced Governing structures of VLI were established for active engagement and building ownership amongst the community



Project Monitoring and Results Framework

The following framework was established through consultation with the stakeholders and as defined.

Outcome/Output	**Indicator**	**Target**
Component 1: Community mobilisation and organisation		
Outcome 1: Improved community organisation to undertake climate change adaptation measures	• Number of men and women in 3 villages trained in participatory approaches and • Microplanning and implementing the project • activities • Number of stakeholders participating in the VLI meetings, planning and • implementation of activities	At least 60% of people (of which nearly 50% of women) living in the project villages directly benefited from reduced vulnerability to climate change-related impacts
Output 1.1: Gender balanced village-level institutions formed in Sorlagondi, Nali and Basavanipalem villages	Frequency of VLI meetings organised with quorum	Three gender-balanced VLI institutions for three participating villages
Output 1.2: 1,500 people oriented to CC, SLR and	Number of orientation meetings organised in the three villages	1,500 people, including 50% women

adaptive capacity concepts and measures involving mangroves		
Output 1.3: Annual micro plans prepared for optimal utilisation of resources	Number of micro plans with detailed activities	12 micro plans (3 annual micro plans for each village for four years)
Component 2: Capacity building for coastal protection and livelihoods		
Outcome 2: Trained stakeholders on coastal protection and livelihoods	• Number of members of local self-government, government institutions and local NGOs trained on mangrove • restoration and IMFFS establishment • Number of women, men and youth trained in designing and establishing IMFFS farms	At least 50% of marginalised and vulnerable members of the community and youth trained
	Number of members of local self-government, government institutions and local NGOs trained on mangrove restoration and IMFFS establishment	At least 20% of members of stakeholder organisations working in coastal resource management and improving the adaptive capacity of community to climate change in the project region trained
Output 2.1: 200 stakeholders trained on mangrove restoration	Number of training programmes organised with equal women and men trainees	• At least 120 women, men and youth of community members of the VLI in three • villages trained in mangrove restoration

		• At 60 representatives of local NGOs and local self-government trained • At least 20 field staff of the Forest and Fisheries Department trained
Output 2.2: 50 farmers trained in IMFSS	Number of training organised with equal women and men trainees	50 farmers, including at least 20 women trained in IMFFS
Component 3: Restoration of mangrove areas for coastal protection		
Outcome 3: Restored and healthy mangrove replanted area, contributing to the protection of coastal erosion and sea-level rise	• VLI plan for mangrove • restoration and protection in • each of 3 villages • Mangrove restored with 300,000 mangrove saplings • Conditions of mangrove plantation: 80% survival of planted saplings and growth	200 ha of degraded mangroves restored by the village level institutions through community planning with about 300,000 mangrove saplings
Output 3.1: Replanted mangrove area close to 3 villages for future coastal protection	The area of mangrove restored with multispecies of mangroves	200 ha of degraded mangroves restored
Output 3.2: Established central mangrove nursery serving three villages	The number of saplings of different mangrove species raised	One centralised nursery
Component 4: Demonstration of Integrated mangrove-based fishery livelihood		

Outcome 4: Demonstrated fishery-related sustainable livelihoods integrated with mangroves	• VLI plan for IMFFS establishment and management Reduction in input costs of shrimp and fish farming compared to conventional aqua farms	IMFFS was established in 50 ha in abandoned shrimp farms by participating farmers with a minimum of 600 mangrove plants per ha 300 kilograms of prawn per year per ha of IMFFS
Output 4.1: Two models of IMFFS demonstrated with the participation of the local community and stakeholders	Number of IMFFS ponds	50 ha abandoned shrimp developed into IMFFS farm
Output 4.2: Two cultures of fish or prawn or both undertaken in the IMFFS farms per year	Number of cultures by IMFFS farmers	100 cultures in 50 ha of IMFFS farms in a year
Output 4.3: Cage and pen culture established for culture of crabs, fish, clams and cockles	Number of cages and pens established for the culture of fishes	A large extent of suitable water bodies for cage and pen culture
Component 5: Knowledge Management for Improved Coastal Protection		
Outcome 5: Prepared and published material on ways to up-scale coastal protection and	• Awareness materials on CC, SLR Vulnerability and Adaptive capacity prepared in the local language and distributed to the community and other stakeholders	• brochures and pamphlets on • CC, Vulnerability and • Adaptive capacity, • Mangroves and IMFFS • prepared

livelihood systems in mangrove areas	• Number of meetings and workshops held • Number of brochures and pamphlets prepared and distributed	• Organised workshop for district-level stakeholders • Organised National level • workshop
Output 5.1: Resource materials prepared for dissemination among various stakeholders	No of pamphlets were distributed to multiple stakeholders	Awareness materials (2,000 each) prepared
Output 5.2: Stakeholders brought together and knowledge on CC, SLR, Vulnerability and measures to improve adaptive capacity shared	Number of workshops organised Number of stakeholders participated	Two workshops, one at the district level and the other at National level organised

Key achievements from project implementation vis-à-vis results framework

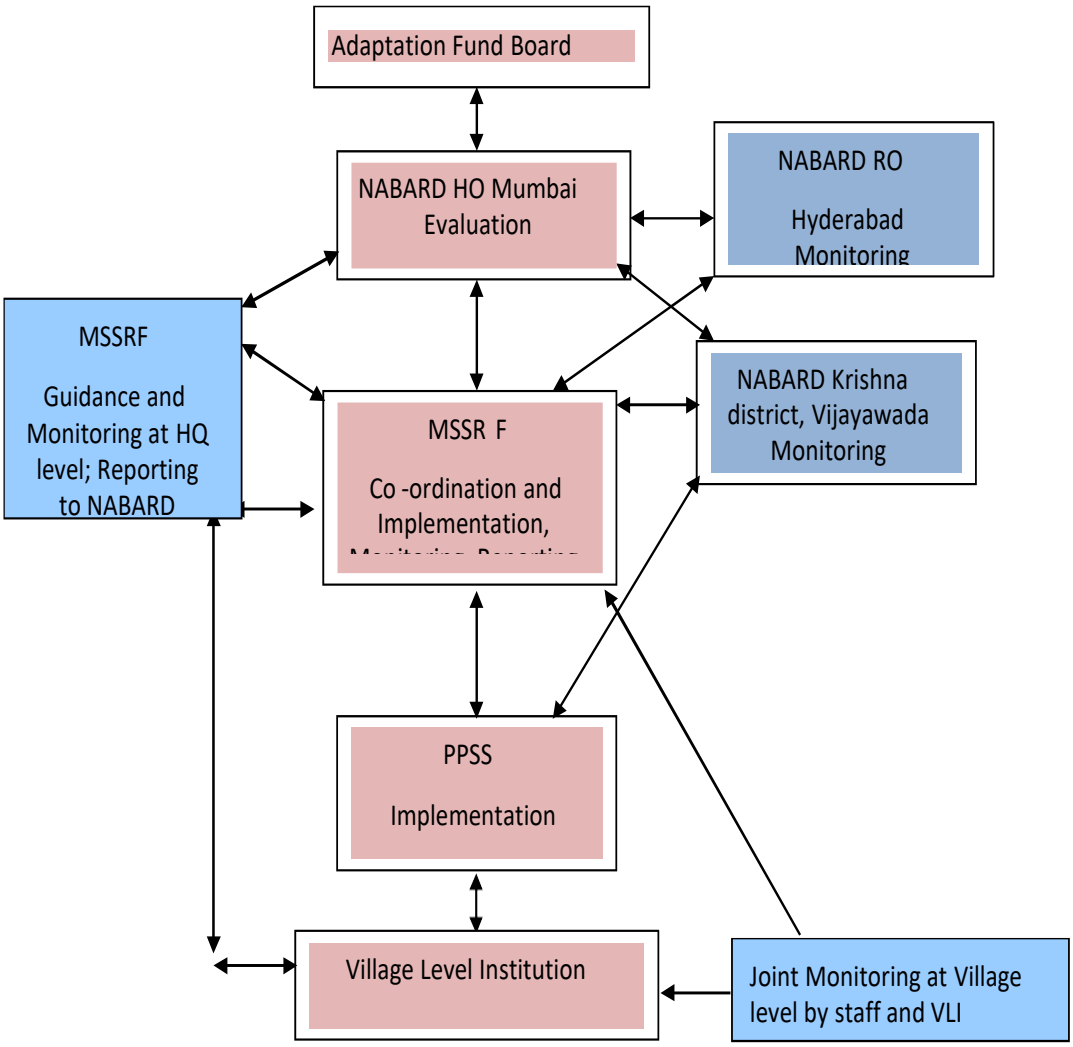
- Through community consultations identified three project villages
- Formed Gender balanced village-level institutions in planning, implementing and monitoring project activities.
- Capacities of the communities, locally elected representatives, NGOs and Government officials were built in coastal protection and livelihoods
- 50 aqua farmers were trained in IMFFS aquaculture practices.
- Restored **200** ha of mangroves with three lakhs of mangrove saplings raised in the nursery.
- Planted mangroves on the bunds and stocking of fishes/shrimps/crabs done in the ponds.
- Livelihood support was provided to the landless and vulnerable families. Ten cages were established for the culture of fish. Fish and crab juvenileswere stocked, and lessons were learnt from crab cultivation.

- Developed knowledge-based material for dissemination in Telugu.
- IMFFS farms were established in 50 ha.

MSSRF Responsibilities in implementing the project

- It has established a collaborative mechanism amongst the stakeholders with a win-win approach to ensuring the project's success.
- It has established environmental management practices in mangrove restoration and IMFFS.
- Strategic compliances were adhered to by all the stakeholders
- It has established the agreed monitoring structure as follows

Monitoring Structure



3. Status of Activities Implemented

Component 1 Community mobilisation andorganisation

1. Participatory Rural Appraisal (PRA) in Sorlagondi, Nali and Basavanipalem **Villages**

The participatory process was used to build a strong community-based institution, enabling the community to own the process, collectively restore the mangroves, and establish integrated mangrove farming. This process established a solidarity mechanism in collectively addressing their issues.

The secondary evidential information was used to establish ecological rehabilitation of degraded mangroves, utilise saline lands for livelihood development, and prepare the communities to face climate change challenges through adaptation measures. The PRA tools enabled the community to delineate the issues that affect them the most and identify means to adapt to natural disasters and sea level rise and mitigate the eventuality. The following issues were identified, and actions were initiated collectively with the engagement of all the stakeholders.

Sorlagondi	Nali	Basavanipalem
Housing	Housing	Silting of drainage canals
Drinking Water	Roads and drainage canals	Drinking water
Water for irrigation	Drinking water	Coastal erosion
Roads (internal village roads)	Sanitation	Migration
Sanitation	Water for Irrigation	Veterinary care
Pollution in fishing creeks	Pollution in the drainage creeks	
Migration	Migration	
Loss in Aquaculture	Loss in Aquaculture	

By applying various participatory tools, the project collected primary information on the household profile, socioeconomic status, community's exposure to natural vagaries and adaption their adaption measures and dependency on coastal resources. Based on the information generated by the project enabled the community to develop micro-plans, including livelihood and developmental concerns.

Participatory Methods

- **Space-related:** Social and resource maps, Transect, etc.
- **Time-Related:** Timeline, Trend analysis, Seasonal Calendar etc.
- **Relation Related:** Cause and effect, vulnerability assessment, VENN diagram, Livelihood analysis

Adaptive Capacities

Through the participatory process, the adaptation capacities of the community were identified

- Elders in the village have bequeathed traditional Knowledge and wisdom on weather forecasting, seasonality, and rainfall, particularly about cyclones.
- With the improvised skill sets for securing incomes, the fishing community has transformed their skills from canal fishing and shallow marine fishing to deep sea fishing. The community, which benefits from government and local institutions, has secured gear and crafts. Also, they have acquired skills in post-harvest techniques such as dry fish making, salting, and using ice boxes to minimize post-harvest losses.
- With the new skills acquired, the fisherfolk were also engaged in cultivation as a seasonal activity. With the dwindling fish catch, the fisherfolk learnt cultivation from the neighbourhood. Also, the saline-affected land has been used for shrimp farming. Shrimp juveniles collected from the wild were stocked apart from hatchery-reared juveniles.
- The villagers are aware of traditional practices for storing grain during disasters. They traditionally stake the paddy in the fields after harvest and thrash it after the rainy season.

Agriculture

The villagers initiated paddy cultivation after the establishment of the canal irrigation system in 1940. Before this, they were cultivating rain-fed crops such as millets, groundnuts, and vegetables. Initially, they were cultivating low-yielding saline-tolerant traditional paddy, and later, in the 1970s, they started cultivating high-yielding varieties. After the aquaculture boom in the 1990s, almost all paddy fields were converted to aquaculture, as the profits were many folds higher. However, many reconverted their lands after the outbreak of viral diseases and subsequent losses in aquaculture.

Aquaculture

The community engages in brackish water aquaculture. They have replaced diesel engines with electric motors, which has reduced the operation cost. By blending traditional and advanced aquaculture practices, they are receiving better profits by culturing crabs, shrimp, and fish.

Migration

Some vulnerable

and marginalized families have not generated incomes from fishing and seasonal agricultural activities; consequently, distress migration is visible in the community. Some families migrate to the Nellore and Prakasam districts for agricultural work. However, migration has come down significantly now as they perform multiple livelihood activities.

Profiles of three villages are annexed

2 Building community capacities

Across the three villages, the community was mobilized, the issues were collectively identified, and action plans were drawn and implemented. This instilled confidence in the community's ability to respond collectively to the problems that confronted them. The community was organized into a village-specific institutional body to address its issues. Hence, gender-balanced Village-based Institutions (VLIs) were discussed to plan, implement, and monitor the project activities.

The community and VLIs capacities were built on:

- Gender and development
- Leadership and community development

- We conducted an exposure visit to the villages in East Godavari district on Participatory Mangrove Management. Based on the exposure visit, the community implemented the participatory process, strategies, and methodologies as per the project design.

They had identified their household-specific and community-based issues for action

3 Community Initiatives

Entry Point Activities – a tool for community mobilization and collective action

The project enabled the community, VLIs, to identify the issues that confront them daily. The listed issues were drilled down to short—and long-term and immediate action. To build confidence, the issues for immediate redressal were taken up across the villages. The entry point activities had built trust between the project team, community, and other stakeholders. Also, this project established a structured relationship between stakeholders.

3.1 Basavanipalem village

The village has a traditional freshwater pond and piped drinking water facility. The pipeline issues could not be resolved as often the pipeline is broken and contaminated enters the pipeline during seasonal floods and monsoon periods. There is no concerted action from the local institutions; the community is drawing water from nearby water tanks. Therefore, drinking water was identified as the main issue. To resolve the problem, the traditional freshwater body should be desilted to increase the storage capacity. There should also be collective measures like fencing the pond to prevent cattle from entering the area. Also, *Prosopis* and other bushes in the bund were removed with the help of JCB. The members of the VLI and the project staff monitored the activity. The pond was desilted through MGNREGS work in which the entire village participated. The members worked for 12 days. One foot of soil was desilted. The community earned Rs1,15,960 as wages.

The entire area is fenced with Rock pillars. Poles are erected at a distance of 3m from each other, and 1600 mts of barbed wire were used for fencing. The VDC procured cement, gravel, and sand to fix the poles with the concrete

mixture. An amount of 66,800 was spent on fencing. The community worked voluntarily to fix the poles and barbed wire fencing.

3.2 Sorlagondi Village

During the community consultation, the issue of low-lying roads across 11 streets was raised. To boost the community's confidence, the project agreed to provide support. The paddy farmers contributed to the sand removed from their farm fields, as they would remove the top layers of sand every year in the cultivation practice. The road height was raised to 0.6 m from 0.3m. More than 500 tractor-loads of sand were provided for laying the road.

3.3 Nali Village

During community consultation, the villagers requested that the freshwater pond be desilted and the fence be fenced. However, the drainage canals were encroached and only bund strengthening and drainage pipes were placed. However, it was decided to use the remaining money for

1) The small ditch on the way to the sea – Used 8 Concrete cement pipes and completed the road
2) Clearing bushes in the burial ground – Cleared the bushes and levelled the area
3) Solar light – one installed near Nagidi Kotaiah house Skylives Private Limited installed the solar light with the cost of 24,300.

Also, some common issues are elevating the low-lying street roads, removing scrubs/bushes along the bunds of the freshwater storage tank, and fencing them. The community members were sensitized on gender issues and the importance of women's participation in the project activities. About 1500 members were oriented on climate change impacts such as sea level rise and cyclones and adaptive responses to reduce those impacts.

4. Exposure Visit

As part of the community and stakeholders capacity-building initiative, the Village Level committee of three villages, as well as staff members of Praja Pragati Seva Sangham (PPSS) and M S Swaminathan Research Foundation (31 members), visited Coringa Wildlife Sanctuary. The aim is to understand the biodiversity of the flora and the mangrove restoration activities carried out by the state forest department and MSSRF. The exposure helped the community:

- To understand the community mobilization and organization carried out in the villages where men and women were given equal representation.
- Understanding of species diversity, restoration techniques and the involvement of EDCs in forest department activities.
- Understanding of ecotourism.

Lessons learnt were as follows:

- The mangrove vegetation in Coringa is healthier than the mangroves in Krishna due to clay soil and the availability of more fresh water
- Compared the flora between the two sites area with that of Coringa
- The VLI members also witnessed the tourist flow inside the sanctuary and the facilities created for tourists. The members realized that ecotourism in the mangrove forest is a potential source of income for the local community.

- The forest department staff showed the mangrove nursery and the mangrove plantation raised in 1994 and briefed the mangrove restoration techniques.
- Stakeholders' interaction with the local communities in
    - Kobbarichetupet: Importance of mangrove restoration and livelihood activities as well as ecotourism initiatives and community engagement in raising of plantations in the sanctuary.

Component 2: Capacity buildingfor coastal protection and livelihoods

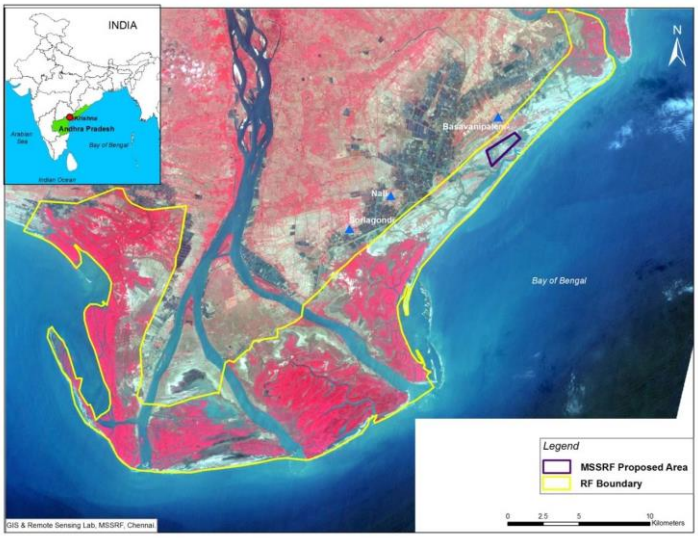
The project has trained 200 community members and other stakeholders – staff from the Departments of -the Forest Department and rural development as well as NGOs on mangrove restoration activities. The training focussed on:

- Mangrove restoration techniques - layout the design for canal digging, dimensions of the canal and the depth, mangrove nursery, canal digging, planting and desilting.
- Stakeholders were exposed to the degraded area and explained its topography, reasons for the lack of natural regeneration, and canal layout design. They were also given hands-on experience in these activities.
- 25 Andhra Pradesh State Forest Department field staff were trained on mangrove sylviculture practices.
- The project provided staff training for raising multiple species of mangrove nurseries; subsequently, the wildlife division Rajahmundry raised 1 lakh mangrove saplings of different species based on the training.
- Forty staff members of the rural development and panchayat raj were trained in mangrove silviculture. They were involved in mangrove plantation under the MGNREGA scheme in East Godavari, West Godavari and Prakasam districts.
- Fifty aqua farmers were trained in the process and aquaculture practices in the Integrated Mangrove Fishery Farming System (IMFFS). About ten members were taken to Udupi for hands-on training on cage culture.

Component 3 Restoration of degraded Mangrove area in Sorlagondi Extn RF

3.1 Krishna Riverine System and Estuary

Krishna mangrove wetland is located between 15° 42’ - 15° 55’ N and 80° 42’ - 81° 01’E in Krishna and Guntur Districts of Andhra Pradesh (Fig. 1) the extent is 250 sq km. The Krishna Wildlife Sanctuaryis a part of the Krishna mangrove wetland. The total area of this sanctuary is about 19,481 ha. Geomorphologically, the Krishna Delta comprises a bay, tidal creeks, extensive tidal mudflats, spits and sand bars. Two distributaries, namely Gollamattapaya, Nadimeru, and the main Krishna River flow southward and join the sea near False Divi Point. The total area of the drainage basin of theriver Krishna is about 2.6 x 10^5 km^2 and the mean annual discharge is 6.0 x 10^{13} liters.



Krishna starts from Mahabaleshwar in the Western Ghats (Maharashtra State) and runs in the southern direction for about 1401 Km.

The river's catchment area is 2,58,818 sq km, of which 29.45% is in Andhra Pradesh. Krishna Delta receives fresh water six months a year, but the quantum is low compared to the River Godavari. Despite the construction of many dams on the upstream Krishna river. This reduced inflow is due to constructing many dams upstream across the Krishna River. The salinity level in the Krishna mangroves is always high since evaporation in the Krishna River is 15 % more than in the Godavari. The mean tidal amplitude in the Krishna mangroves is only 90 cm. The maximum high water level during the high tide is 1.10 m, and the minimum high water level in the high tide is 0.20 m. The mangrove vegetation is sparsely dense in Sorlagondi, Nachugunta, Lankivanidibba and Yelichetladibba Reserve forests. The mangrove vegetation is dense along the coast, and on the landward side, the vegetation is sparse. *Avicennia marina and Excoecariaagallocha* are the dominant mangrove species. In Andhra Pradesh, *Aegialities rotundifolia, Ceriops tagal,* and *Xylocarpus granatum* are available only in Krishna mangrove wetland. The degraded area is a fairly large mudflat located eastern side of the embankment.

MSSRF has successfully restored 200 ha by replicating the elements of the Pichavaram mangrove wetlands of Tamil Nadu, Krishna and Godavari mangrove wetlands of Andhra Pradesh, and Devi river delta in Orissa is used to restore the mangroves. The Forest Department (Government of Andhra Pradesh) permitted the restoration of 200 ha of degraded mangroves in Sorlagondi Extn. RF.

The local fishing communities in Sorlagondi, Nali, and Basavanipalem depended on mangrove wetlands for their livelihoods.

3.2.

Hydrology

Krishna River hydrology plays an important role in the flow dynamics in defining the tidal amplitude. The drainage of waters with high flows reduces the tidal highs and vice versa. There is a reduction in the river flow due to the construction of dams upstream. Various studies have been conducted to understand the geomorphology, coastal erosion, landform, and soil analysis and map the processes that impact the Krishna wetland vis-à-vis climate change. However, the efforts made by the project are to limit its efforts to the restoration of mangroves and, however, a long-drawn process to understand the catalysis of riverine system hydrology and tidal wave impacts on the soils vis-à-vis impacting the livelihoods of the local communities.

The project recorded information on the following aspects and restored the mangroves on the site. These aspects accelerated the change process through corrective measures, such as planting suitable species based on the salinity of the soil and the quality of water inflow and outflow.

Tidal amplitude

The tidal amplitude in the main creek near the degraded area was between 0.5 m and 1.5 m. The degraded area receives daily tidal flushing during the monsoon period, the new moon, and full moon days in other seasons. The local community informed us that natural vegetation is slowly colonizing along the creeks. They also told us that the shore is getting eroded due to currents at an alarming rate. The shore has moved more than 2 km inside the land in the last 15 – 20 years.

Topography and designing of canals

The project studied the topography of the degraded area and classified it as smooth and slightly elevated. The main canal, 60 cm deep, will flush the entire region. The side canals

were also dug to a depth of 60 cm.

Water Analysis

The surface water near the degraded area was assessed for pH and salinity. Hanna pH meter and Atago refractometer were used to measure these parameters. The creeks had salinities between 26 ppt and 34 ppt, and the water had a pH between 7.9 and 8.2.

Soil analysis

The soil's pH was between 6.85 and 7.3. The texture of the soil in the degraded area is sandy clay. The clay content was observed in the subsurface, and the surface soil is mostly sandy.

3.3.1 Mangrove Nursery

The community was engaged in nursery development after getting trained. The women actively collected the seeds for the nursery development. The nursery played an essential role in the species selection, and the project identified seven specific species for plantation. The rate of survival of nursery-raisedsaplings is higher than direct dibbling of seeds. The nursery-raised seedlings have the advantage of a healthy, well-established root system. Also, the saplings are grown in a saline environment for 8-9 months before being transplanted in the degraded area. Hence, the survival of nursery-raised saplings in the mangrove plantation is more than direct dibbing of seeds.

Selection of site for the mangrove nursery

The mangrove nursery site was selected near Sorlagondi village as it had natural and artificial canals for tidal water flow and the other characteristics are

- It is located in an Intertidal area with periodic inundation
- It has access to good-quality brackish water
- It has access to a road/creek to transport the saplings
- The project had set up a Diesel pump facility to pump water during neap tide. The nursery site is well protected from grazing. The mangrove nursery also had access to small boats/tractorsfor easy transport of saplings from the nursery to the plantation site.

Selection of mangrove species

Mangrove species were selected based on the salinity of the degraded area. *Avicennia marina* is the most suitable species for the location chosen. *A. officinalis Rhizophora* and *Bruguiera* were also raised in thenursery.

Collection of propagules and seeds

The community was actively engaged in the collection of propagules and seeds. The Mature and healthy fruits/ propagules were collected from the mangrove forest area. Local fishermen and women are knowledgeable about the availability of the seed material. The fruiting season for a majority of the mangrove species is between July and October. However, *Bruguiera gymnorrhiza, Rhizophora apiculata* and *R. mucronata* bear fruits throughout the year, though the peak fruiting season is August to November. Seeds of *Avicennia marina* and *Avicennia officinalis* were collected from the creeks as the float.

Good quality sprouted seeds were collected and sorted. They were also collected in the ground beneath the trees during low tide. Using hand nets, floating propagules of *Rhizophora apiculata, Rhizophora mucronata, Bruguiera cylindrica,* and *B. gymnorrhiza* were collected from the creeks. All the collected seeds were examined for incidence of diseases or pests. *Rhizophora mucronata* can be easily identified from *R. apiculata* by its larger size and green colour. The collected seeds and propagules were kept in either polythene bags or in jute sacks and transported to the nursery.

Soil and bag filling

The community collected the clayey soil from the creeks near the nursery, which was used to fill the nursery bags. After preparing the soil, the seeds were planted in the Standard Polythene bags (5x8") and raised. Watering was done, and the necessary temperature maintenance was established for plant growth, with small perforations at the bottom of the bag to drain off excess water. The bags were kept under the shade. More than 3,00,000 saplings were raised in the nursery.

S.No	Mangrove Species	Seed material	Quantity
1.	*Avicennia marina*	Fruits	70000
2.	*A. officinalis*	Fruits	10000
3.	*Bruguiera cylindrical*	Propagules	2500
4.	*Bruguiera gymnorrhiza*	Propagules	2500

5.	*Rhizophora apiculata*	Propagules	10000
6.	*R. mucronata*	Propagules	5000
Total			100,000

Sowing

The community members learned the technique of sowing mangrove species during the exposure visit and at the site. Seeds of *Avicennia marina, A. officinalis, Rhizophora apiculata, R. mucronata, Bruguiera cylindrica* and *B.gymnorrhiza* were planted directly in the bags. The percentage of germination of all these species was high. *Avicennia officinalis* and *Avicennia marina* germinated within six days. *Avicennia marina* has a wide range of tolerance to salinity, they were raised in large numbers compared to other species. *Rhizophora apiculata, R. mucronata, and Bruguiera* germinated for over 20 days. Large batches of seeds were raised in the nursery beds.

Nursery Beds

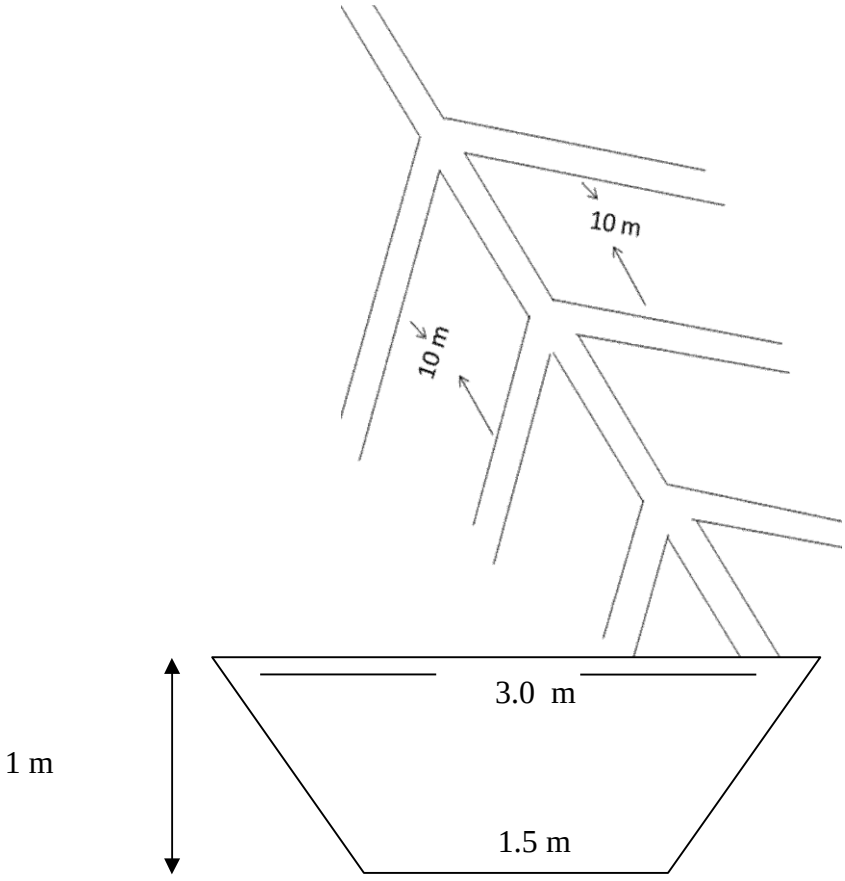
After sporting, *Avicennia* seedlings were transported to the sunken nursery beds dug 10 m long, 1 metre wide and 0.15 cm deep. These beds were prepared in a timely manner and had access to tidal water creeks. The poly bags with plants were kept to get tidal water flow. Whenever the tidal water flows less, the diesel engine irrigates the saplings. Periodic causality replacement and grading were done to get healthy saplings. Inorganic fertilizer, namely Di-Ammonium phosphate (DAP), was applied twice (about 1 gm/bag).

Land preparation and canal digging

The degraded project area is slightly elevated, and the tidal water flow into the area is very rare except during monsoon season. With the traditional wisdom and experience of the project, the community dug the canals, letting tidal water flow freely and improving the growth of mangrove saplings. The tidal water inundates the area during the high tides and recedes during the low tides,

providing space for the absorption of water and plant growth. The absorption process facilitates the encrusted and accumulated salt in the soil. The area is free from vegetation except for a few stunned growths of *Avicennia marina* and a few halophyte species like *Sesuvium*, *Salicornia* and *Suaeda*.

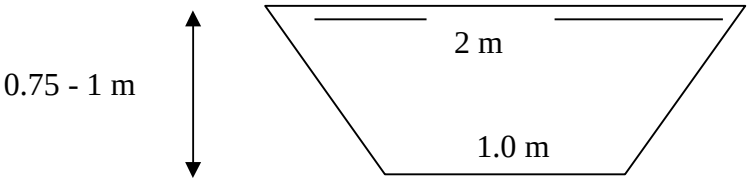
Layout for digging canals Canal dimensionsMain Canal



Side Canal

Distance between side canals

= 10 m



Training and capacity building

A total of 64 members were trained -59 community representatives (29 women, 30 Men) and five project staff). During the training, the trainees were taught mangrove restoration

techniques.

- Seed selection, seed collection, Seed storing and planting works
- The trainees were demonstrated on main and side canals and Canal digging approach using the MSSRF standardized model for restoration. Dimensions of the canal and its depth, mangrove nursery preparation, canal digging, planting and desilting.
- During the on-site training, the trainees were exposed to the degraded area. They explained its topography, the reasons for the lack of natural regeneration, and the layout design of the canals.
- The trainees have imparted knowledge on the approach to digging the canals and the associated morphology of the area, as in the case of the canals dug deeper as the area is sandy and prone to silting. Men were involved in slopping the canals, and women were involved in planting. The demonstrated area comprises three main canals with a total length of about 2600 m. About 72,000 metres of side canals were dug. Totally 90 ha of work have been completed. The villagers earned livelihood through the restoration activity.

Planting of mangrove saplings

Planting of mangroves was done in two methods: i) planting of nursery-raised saplings (pot seedlings) and ii) direct planting (dibbling) of propagules or seeds of mangrove plants. The community was engaged in plantation activity, which generated employment for them. Mangrove saplings were planted in the restored site. The community had planted 3,00,000 raised saplings along the canals with 2 m spacing. The saplings were planted along the sides of the canals at about 20 cm down the slope. The community carefully planted the saplings and the soil without disturbing the root system. The learnt skills were applied to the soil around the plants to prevent the presence of air inside. They were replaced based on the washing away of seeds due to tidal amplitude and water current.

Monitoring of Mangrove Plantation

The mangrove saplings planted along the canals are getting tidal water. However, about 20% of the saplings were dead and had been replaced.

Component 4: Demonstration of Integrated Mangrove-based fishery livelihoods

4.1 Integrated Mangrove Fishery Farming System (IMFFS)

Coastal Aquaculture has become prominent during the last four decades, and several lakhs of farmers are growing prawns in the brackish waters (about 0.16 million ha of brackish water area). Andhra Pradesh is one of the largest shrimp producers, cultivating in 71,921 ha under brackish water and, in the year 2020-21, introduced 634,672 M Tons.

With the imminent potential to raise quick monies, many plays had dominated the coastal aquaculture, and the environment is getting polluted with the widespread cultivation and causatively had increased viral attacks and to arrest it indiscriminately applying chemicals and to generate volumes with quantity commercial feeds and chemicals were used. Consequently, the water and soil health deteriorated as the input cost increased and the overall production cost increased, forcing some farmers into a debt trap.

In this scenario, an alternative for traditional shrimp farmers, the Integrated Mangrove Fishery Farming System (IMFFS), is integrated by growing fish. In this farming system, aquaculture ponds are modified by raising mangroves in 40% of the area where bunds were formed and the remaining 60% of the water spread area for culturing fish. The farms received tidal water, which made them environmentally friendly and economically profitable. With the gravitational tidal flow, water enters the pond during high tide and drains out during low tide as it brings plankton as fresh feed and prevents reduction in oxygen level and outbreak of diseases.

In the abandoned 50 ha aqua farms, during the first year, the farmers cultivated crabs, and each farmer got Rs.40,000 as a profit. The project supported the farmers in preparing the ponds, planting saplings, constructing the inlet and outlet and procuring crabs. Due to the Rio virus, crab cultivation did not yield much income in the third year. However, a few farmers were able to get additional money as they cultured multiple species. Due to the failure of crab culture in the subsequent years' farmers took up culturing tiger (*Penaeus monodon*) shrimp and sea bass culture. The profit was about ₹25,000 per ha, and there was not much input except the fingerling cost. The learnings allowed farmers to culture other fin fishes like milkfish and sea

bass. Farmers are currently culturing fin fish with low inputs and are getting profits. This project has helped the farmers learn the cultural practices, and their adaptive capacity has increased due to training and demonstration of the culture. The cultural practice will be sustainable within a few years as more hatcheries are being constructed to rear more species like sea bass, mud crabs, gropers, silver pompano, etc..

2 Cage and pen culture established for crabs, fish, clams and cockles

Culturing finfish in floating cages is a new technology, and the local communities were unaware of it. To gain knowledge and skills and to raise fish in cages, eight fisherfolk from the project villages were taken on an exposure/ training visit to the Udupi coast in Karnataka, where sea bass is reared in cages. After a successful training/exposure visit, the project identified Nagayalanka village as a place to initiate cage culture activity. It has many facilities like a deep backwater system, road connectivity, and easy accessibility.

Outcome:

- Suitable sites were identified, and ten cages were established.
- Low input organic culture method in cultivating fishes and
- This practice of farming is more extensive as the stocking density is low.
- The local community has adapted this technique and will continue culturing fin fish, greatly reducing the environmental impacts.

Component 5: Knowledge Management for Improved CoastalProtection

To disseminate information, the project developed five brochures in the regional language (*Telugu*) to increase community awareness of climate change, sea level rise, and its impact on coastal areas. The importance and role of mangroves in reducing the effects of climate change integrated mangrove-fishery farming system and cage culture of fin fishes in enhancing the adaptive capacity of the community to sea level rise were given in the brochures. These brochures were distributed to the community, the forest department, and NGOs. District-level and national-level workshops were conducted, and NGOs and other government departments like fisheries, forests, and rural development staff participated. This project has shown the

important sylviculture practices for a successful plantation. The integrated mangrove fishery farming system (IMFFS) is one of the low-input sustainable models for culturing crabs, as crabs require hideouts, and the mangrove roots will provide feed and hideouts for the crabs. Similarly, dissemination materials such as video documents were prepared for dissemination.

The Project and MSSRF trained 25 Andhra Pradesh State Forest Department field staff on mangrove sylviculture practices. Based on the training, the wildlife division Rajahmundry raised 1 lakh mangrove saplings of different species. In addition, about 40 staff members of the rural development and panchayat raj were trained in mangrove silviculture as they were involved in mangrove plantations under the MGNREGA scheme in East Godavari, West Godavari, and Prakasam districts.

In addition, about 50 aqua farmers were trained in the process and aquaculture practices in the Integrated Mangrove Fishery Farming System (IMFFS). About ten members were taken to Udupi for hands-on training on cage culture.