agriculture, tourism and other land uses. In addition to this, a variety of human induced stresses and factors such as changes in water quality, soil salinity and sedimentation due to diversion of fresh water in the upstream, conversion of mangrove wetlands for alternative purposes like aquaculture, salt pans and other land use practices are largely responsible for reduction of mangrove vegetation. Indiscriminate use of mangrove resources and clear felling of mangrove forests for rehabilitation, salt pans etc. in the past, are mainly responsible for the present degraded status of the mangrove wetlands.

Conservation action is called for in the best interests of the ecological security of the coastal areas and the livelihood security of the coastal communities. To make such conservation efforts sustainable, it is essential to dovetail them to the livelihood needs of people living in the vicinity of mangroves. Harnessing the economic potential of the mangrove areas for the benefit of the coastal communities thus becomes a high priority as a major driver for conservation and sustainable management of mangroves. To derive maximum economic benefits from mangroves without causing any harm to them, scientific techniques of finfish and shellfish farming need to be demonstrated to the coastal communities. It was in this context that a project for developing such a demonstration site was conceived in Raigad District of Maharashtra.

Project area

The project area is located in Ghat No. 223 in Dighi in Srivardhan Taluka of Raigad district in Maharastra. The extent of the area is about 23.41 ha, which was allotted by the Collector Raigad to M/S Bharati Vidyapeeth, Pune in the year 1994 for promoting prawn culture and hatchery training. However, due to some constraints, Bharati Vidyapeeth could not start the proposed activities in the land. In the context of the increasing global trend towards achieving conservation goals by linking natural resources to sustainable livelihood activities, it was felt appropriate to develop a Centre in this area to demonstrate the economic potential of mangrove areas. Being a first of its kind in the Western Coast of India, it could serve not only the farmers of Maharashtra, but also from other neighbouring coastal States.

Description of Vegetation

Avicennia marina is the dominant species, mostly found in a stunted state. Other true mangrove species, namely *Rhizophora mucronata*, *Sonneratia alba*, *Lumnitzera racemosa*, *Ceriops tagal*, *Aegiceras corniculatum*, *Excoecaria agallocha* and *Acanthus ilicifolius* are also sparsely present in the area but most of the individuals of these species are also stunted in growth. Apart from these true mangroves, some associate species namely *Clerodendron inerme* and *Salvadora persica* are found towards the periphery of the plot. About 1 ha of land is devoid of any vegetative cover. The area receives tidal water directly from the back waters and through a small creek. The soil is sandy with large amount of molluscan shells near the shore, but it is mostly clayey towards landward side from the shore.

Topography

The area in the middle is on a slightly elevated plane, causing obstruction to smooth flow of tidal water. A manmade bund is running parallel to the coast, which is another source of obstruction to regular tidal water flow inside the mangroves. A natural canal traversing the mangroves is inundating substantial area in the land ward side. This section, regularly inundated by tides, is comparatively healthier and has good diversity than the elevated sections.

Anthropogenic factors

The poor villagers living near the mangroves depend on mangroves for fire wood which is evident from the cutting of stems. This may also be contributing to the stunted growth of mangroves. There are also telltale signs of grazing, especially towards the landward side.

Freshwater flow

There are no perennial fresh water sources for the mangroves. The rain water flowing into the mangroves from the nearby hills is the only source of fresh water.

Erosion

The surface soil is being eroded due to high wave action as is evident from the exposed roots near the shore. Large amount of barnacle infestation is also noticed in the stems and leaves of the plants occurring near the shore.

Prognosis

The reasons for the stunted growth of mangroves in the plot appear to be the lack of penetration of seawater deep inside, except during spring tides. Puddles of seawater, which get trapped inside the mangroves during spring tides, slowly evaporate, contributing to the increased salinity of the area. The best species to survive in this highly saline environment is *Avicennia marina,* but even for these plants, high salinity is a growth retarding factor; hence the stunted growth. Closer to the creek, the plants get regularly inundated with tidal waters and therefore we find a few scattered trees of *Avicennia*. The few scattered plants of the other species are thriving because of the tidal waters penetrating inside through the shallow canal.

A suitable management prescription for a plot of land like this should basically aim at providing a stimulus for the stunted plants to grow into mature trees. Left to nature, this may never happen, as the salinity level will increase with every summer and a point may reach beyond which the site would not be able to support any mangrove vegetation. This phenomenon is already noticeable at the landward side of the plot where *Acanthus ilicifolius*, a mangrove associate considered as a sign of degradation in mangrove area, is beginning to gradually replace the true mangroves. If the stunted plants in the plot are to develop into large-sized trees, tidal water should inundate the area **daily** during high tide. During low tide, the water should recede completely, taking away the accumulated salt along with it. The best way to ensure this regular tidal flushing would be to build a network of canals inside the plot. Although this may result in the removal of a few stunted mangrove plants, it could eventually lead to the development of a mature and healthy crop of mangroves in the area.

Project Goal

To establish a Centre to conserve mangroves for enhancing both the coastal security of the area and the livelihood security of the mangrove dependent community through restoration of mangroves

Objectives

- To restore the degraded mangroves through fish bone canals
- To undertake mangrove afforestation in the open mudflats

- To demonstrate the Integrated Fishery Farming System as an environment friendly and sustainable aquaculture system
- To generate awareness among the local community, farmers and students about the importance of mangroves and the need for their conservation

Approach

The project will be implemented jointly with the local community living in Dighi and the Maharashtra State Forest Department with Bharati Vidyapeeth acting as a facilitator. The future training programme for farmers on the site will be conducted by Bharati Vidyapeeth on behalf of the government.

Methodology

Restoration of degraded area through canals

Almost the entire project area has been covered with mangroves. However the areas with lesser tidal water inundation have stunted mangroves. Digging of fish bone shaped canals will facilitate tidal water flow, which is important for mangrove restoration. As described earlier, the elevated area in the middle is preventing free flow of tidal flushing especially during neap tides in summer. The soil salinity will increase due to poor flushing, resulting in degradation of mangroves. Micro-topographic survey will be carried out using level instrument to understand the topography of the area, which will be useful to design the canals. This canal method will be tested in an area of about 10 ha where large extent of stunted mangroves is present. The canals will be designed in such a way that the destruction of mangroves will be minimal as a result of digging.

The field staff of the Maharashtra Forest Department especially the Mangrove Cell will be involved in monitoring the restoration work along with the local community.

Avicennia marina and *Ceriops tagal* will be raised in the nursery as these plants are found in large areas next to the degraded area. Local community will be involved for establishment of mangrove nursery and planting of mangrove saplings which not only provide income particularly to women, but also ensure their ownership of the restored area.

Direct planting of nursery raised mangrove saplings in intertidal areas

Sonneratia alba and *Avicennia marina* mangrove saplings will be raised in mangrove nursery for 2 years in big polythene containers. These saplings will be planted at 2 x 2 m intervals.

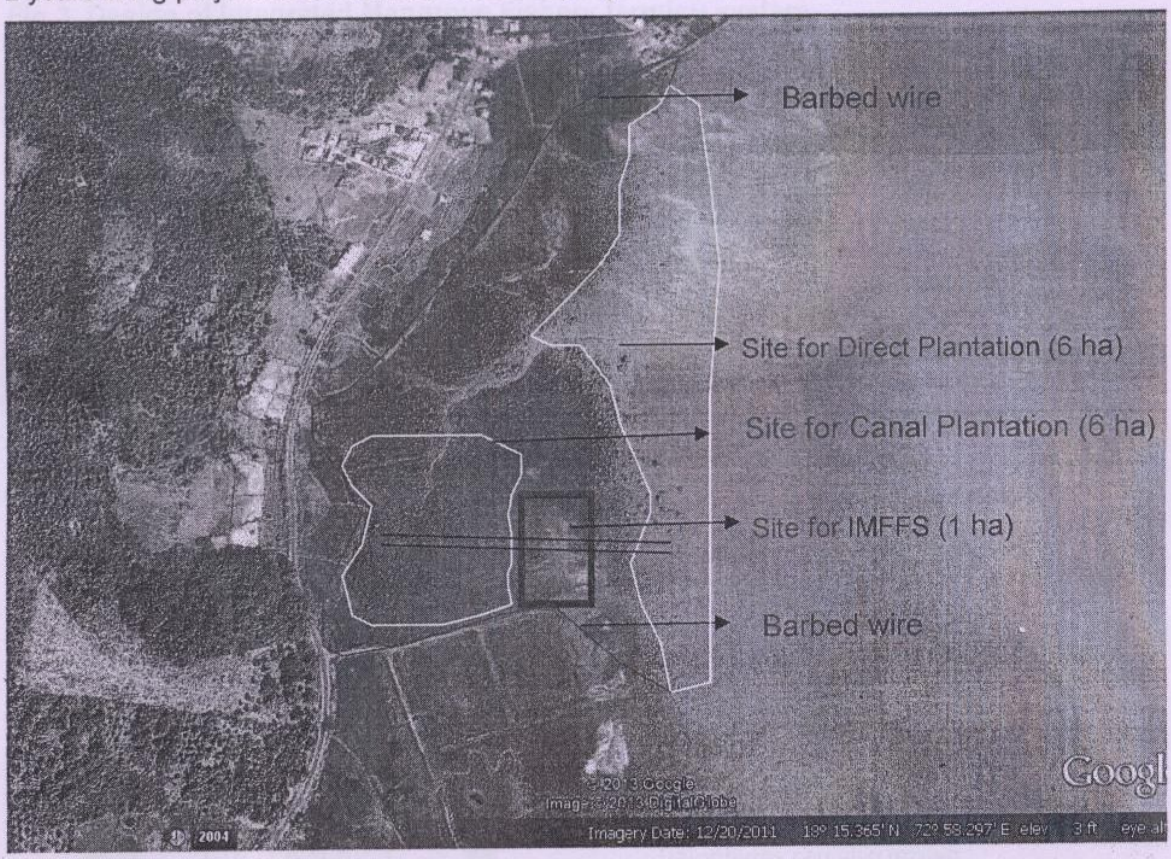


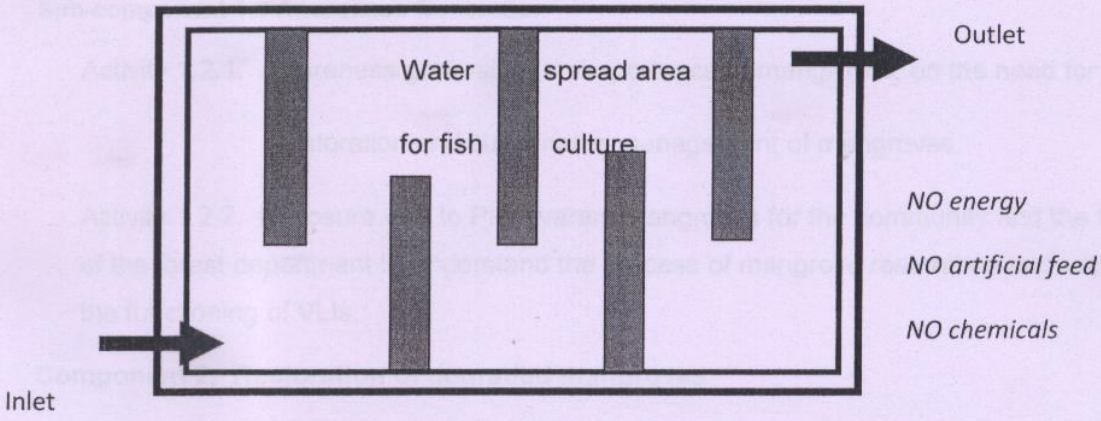
Fig. 2. Area demarcated for different interventions

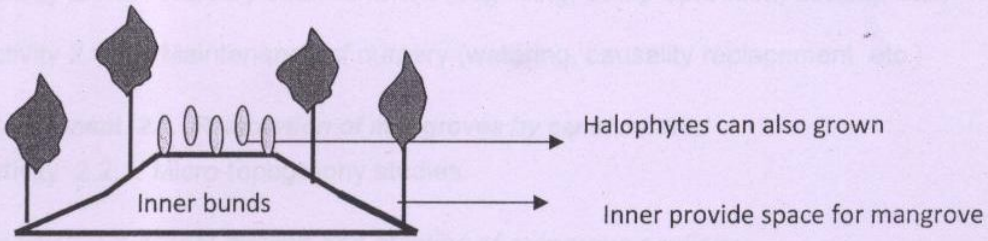
Integrated Fishery Farming System

Change in Land use (Integrated Mangrove Fishery Farming System)

In Integrated Mangrove Fishery Farming System, mangroves are integrated with fish culture wherein conventional earthen aquaculture ponds are modified in such a way to provide about 40% of the area for raising mangrove plantation and 60% water spread area for fish cultivation. Space for growing mangroves and other vegetation is created by constructing linear bunds or mounds inside the pond. These farms can be designed in such a way to be tidally fed (water exchanged during high tide and low tide), which makes them more environment friendly and economically profitable. Above all, the presence of dense mangrove trees would mitigate the impact of sea level rise whereas sustained harvest of fish would take care of adaptive capacity of coastal community. This form of farming will be established in 1 ha of the degraded area.

Fig 3. Design of Integrated Mangrove Fishery farming system





Project activities

Components, sub-components and activities

Component 1. Community mobilization and organization

The local community will be mobilized to implement the activity jointly with MSSRF and the Forest Department. Participatory Rural Appraisal (PRA) will be conducted to assess the available physical and human resources, so as to utilize the same while drawing the micro-plans and implementing the same.

Sub-component 1.1 Community participation

Activity 1.1.1 Conducting PRA, Micro-plan and assessment on the usage of mangroves.

Activity 1.1.2 Organize the community by forming village level institutions

Sub-component 1.2 Awareness Generation

Activity 1.2.1. Awareness generation on importance of mangroves, on the need for restoration and sustainable management of mangroves.

Activity 1.2.2. Exposure visit to Pichavaram mangroves for the community and the field staff of the forest department to understand the process of mangrove restoration and understand the functioning of VLIs.

Component 2. Restoration of degraded mangroves

Sub-Component 2.1. Establishing mangrove nurseries

Activity 2.1.1. Training on mangrove restoration and nursery raising.

Activity 2.1.2. Collection of propagules/ seeds of *Avicennia marina* and *Ceriops tagal*

Activity 2.1.3. Nursery establishment (bag filling, bed preparation, sowing, etc.)

Activity 2.1.4. Maintenance of nursery (watering, causality replacement etc.)

Sub-Component 2.2. Restoration of mangroves by canal method

Activity 2.2.1. Micro-topography studies.

Activity 2.2.3. Canal digging and planting of mangrove saplings.

Activity 2.2.4. Desilting

Activity 2.2.5. Casualty replacement

Sub-Component 2.3. Direct planting of nursery raised mangrove saplings in intertidal areas

Activity 2.3.1. Developing 2 year old Mangrove saplings

Activity 2.3.2. Planting of saplings

Activity 2.3.2. Casualty replacement

Component 3. Conservation of mangroves from cutting and grazing

Activity 3.1. Fencing the area

Component 4. Integrated Mangrove Fishery Farming System

Preparation of layout for IMFFS

Activity 4.1. Preparation of ponds with mounds and bunds

Activity 4.2. Digging of canal for tidal water flow

Activity 4.3. Construction of sluice gates

Activity 4.4. Planting of mangroves

Activity 4.5. Release of fishes and shrimps

Activity 4.6. Monitoring of mangroves and fishes

Component 5: Establishment of a mangrove arboretum (or mangrove genetic centre)

Activity 5.1. Designing of arboretum

Activity 5.2 Land preparation

Activity 5.3 Collection of seedlings/ propagules of all species present in Maharashtra

Activity 5.4 Raising saplings of the above species

Activity 5.5 Planting in the arboretum

Activity 5.6 After care

Expected output

- Community Members aware of mangroves
- Village level institutions in place
- An area of 10 ha of degraded mangroves restored through canal method
- Protection of mangroves in 23 ha
- Integrated Mangrove Fishery Farming system as Livelihood model in 1 ha
- An arboretum of mangroves or mangrove genetic centre is established with 15 true mangrove species

Activity Work Schedule

2 years

Budget

Rupees fifteen lakh eighty thousand.

S.No	Plantation	Rs. Per hectare	Hectare	Total (Rs)
1	Canal Plantation	Rs.40,000	5	2,00,000
2	Foreshore Plantation	Rs.20,000	6	1,20,000
3	Integrated Mangrove Fishery Farming system	Rs. 3,00,000	1	3,00,000
4	Establishing mangrove arboretum or mangrove genetic centre	Rs.1,00,000		1,00,000
	Fencing	2.5 Km length in landward side	-	6,00,000
Total			23	Rs.12,20,000

Mandate of MSSRF and its contribution to conservation, restoration and sustainable use of mangrove wetlands

M.S. Swaminathan Research Foundation (MSSRF) was established as a Trust in July 1988 with a goal to impart a pro-nature, pro-poor and pro-women orientation to a job-led economic growth strategy in rural India. To achieve this goal, MSSRF conducts applied research and development and training programmes through a participatory mode involving scientists, administrators, government agencies, and rural families. The five Programme Areas in which research and training are conducted are 1. Coastal Systems Research, 2. Biodiversity and Biotechnology, 3.Ecotechnology and Sustainable Agriculture, 4.Reaching the Unreached and 5.Education, Communication, Training and Capacity Building. The major areas of concentration under the Coastal Systems Research Programme of MSSRF area i) strengthening the ecological infrastructure of the coastal area and their sustainable management, ii) demonstration of opportunities available for the enhancement of the quality of life of poor people and environment iv) methods of organization and empowerment which will lead to the local communities having stake in safeguarding their environmental assets.

The contribution of MSSRF to mangrove conservation and management including restoration and sustainable use of the mangrove resources can be grouped as follows

1. *Contribution to restoration and conservation of mangrove wetlands:* MSSRF developed a comprehensive science-based, people-centred and process-oriented approach to restore and conserve mangrove wetlands which was implemented in selected areas in six major mangrove wetlands located all along the east coast of India including West Bengal, Orissa, Andhra Pradesh and Tamil Nadu in partnership with the concerned State Forest Department and local community. This project was supported by the Canadian International Development Agency (under Small Project Environmental Fund) and the India-Canada Environment Facility. This approach and methodology to restore degraded mangroves was evaluated by an expert committee of the Ministry of Environment and Forest, Government of India and included in its National Mangrove Action Plan.
2. *Mangrove Genetic resources conservation and utilization:* MSSRF was the first to propose the concept that mangrove plant community can be of invaluable donors of genes that can be utilized to develop saline-tolerant crop varieties through recombinant DNA technology. In this respect, the following activities are undertaken with the support of the International Tropical Timber Organization and the Department of Biotechnology, Government of India

- Mangrove wetlands of Asia-Pacific and West African regions were studied for genetic richness in mangrove plant species and genera and identified four sites located in India, Malaysia, Papua New Guinea and Cameroon as Mangrove Genetic Resource Centres and developed programmes for their conservation.
- Genetic make-up of many of the mangrove species have been analyzed using biotechnology tools and identified salt-tolerant genes. Isolated genes have been characterized and transferred to crops such as rice, mustard and black gram.
- MSSRF has standardized vegetative and micro propagation techniques for large scale production of plantlets of endangered mangrove species and some of them have been field tested

3. *Mangrove databases and training and capacity building:* MSSRF has developed a database namely, Mangrove Ecosystem Information Service (MEIS) which has databases for i) Mangrove Bibliographic Database, ii) Mangrove Resources Database, iii) Mangrove Experts Database and iv) Mangrove Genetic Variability Database. The MEIS has led to the evolution GLOMIS (Global Mangrove Database and Information

System) of International Society for Mangrove Ecosystems. MSSRF serves as the Regional Centre of the GLOMIS. MSSRF conducted an international training course on "Conservation of Mangrove Forest Genetic Resources" which provided training to 20 scientists, managers and administrators selected from 12 countries. Apart from this, orientation and hands on training programmes have been conducted on Joint Mangrove Management to a representatives of a variety of community based institutions as well as Forest Department personnel.

Joint Secretary
Bharati Vidyapeeth, Pune-30.

(Veerdhaval. Ghopade)

Joint Secretary
Bharati Vidyapeeth, Pune-30.

Project proposal on

MANGROVE CONSERVATION AND DEMONSTRATION OF INTEGRATED MANGROVE AND FISHERY FARMING SYSTEM

Submitted to

Mangrove Cell

Maharashtra Forest Department

Government of Maharashtra

Mumbai

Submitted by

M. S. Swaminathan Research Foundation

Chennai

Project proposal on

Mangrove Conservation and Demonstration of

Integrated Mangrove and Fishery Farming System

Introduction

Mangroves are among the most productive ecosystems in the world with great economic potential, but are often subjected to severe exploitation. Mangrove forests form dense thickets near estuarine areas and act as bio-shields against cyclonic winds and storms and protect the life and properties of coastal communities. Mangroves also play an important role in land formation and help to prevent soil erosion. They provide nourishment and shelter and thereby support the breeding and feeding of a variety of fish, prawn and crab, thus enhancing the fishery potential of adjacent coastal waters. The total mangrove forest area in India is about 5,000 sq. km and more than 1,500 villages are dependent on mangroves for livelihood security. Apart from their economic value, the mangroves are rich in bio-diversity, supporting a variety of flora and fauna including a large number of resident and migratory birds.

Mangroves of Maharashtra

Maharashtra has a long coastline of about 720 km, stretching from Dahanu near Gujarat to the Terekhol river near Goa. The coastline of the State is marked by fifteen rivers, five major creeks and thirty backwater areas. Millions of fishermen live near the coasts and their daily lives are linked to the multitude of life forms in the coastal environment. In tune with the global efforts for biodiversity conservation in coastal and marine environment, Maharashtra State has also initiated several steps in recent times for conservation of this rich biological heritage along our coasts.

About 20 species of mangroves are found along the Maharashtra coast. According to Forest Survey of India, the mangrove cover in the State is 186 sq. km, distributed along its 6 coastal districts. However, the total extent of mangrove land in the State is estimated to be above 30,000 ha.

Unfortunately, the mangrove ecosystems are under severe threat due to unsustainable exploitation by commercial interests, genuine basic needs of the poor and diversion for