MANGROVE FOREST RESTORATION IN ANDHRA PRADESH INDIA

R. Ramasubramanian and **T. Ravishankar**

M. S. Swaminathan Research Foundation

Front cover

Digging of canals in degraded area of Matlapalem MMU in 1999

Same area in 2003

Back cover

Planting of Mangrove saplings in the canal of degraded area by Gadimoga EDC members

Mangrove Forest Restoration in Andhra Pradesh, India

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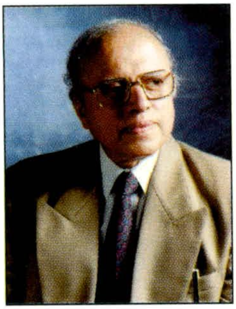

Foreword

I am glad that a manual on Mangrove Forest Restoration in Andhra Pradesh has been prepared by R. Ramasubramanian and T. Ravishankar. The manual contains practical suggestions which can help to foster community conservation and restoration efforts in mangrove wetlands. The multiple benefits conferred by mangrove forests are now being recognized widely. What is now important is for local communities to undertake propagation of planting material and restoration of degraded mangrove areas. I hope the manual will stimulate a programme on the lines of the social forestry movement. Unless restoration of degraded mangrove forests becomes a community movement, we will lose precious mangrove areas, leading to enhanced vulnerability to coastal storms and cyclones and loss of opportunities for sustainable livelihoods. I therefore hope that the manual will be widely read and used.

M.S. Swaminathan

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Contents

List of Acronyms

APFD	-	Andhra Pradesh Forest Department
EDC	-	Eco-Development Committee
GIS	-	Geographic Information System
GPS	-	Global Positioning System
ha	-	Hectare
MMU	-	Mangrove Management Unit
MSSRF	-	M.S. Swaminathan Research Foundation
NGO	-	Non-Government Organization
ppt	-	Parts per thousand
PRA	-	Participatory Rural Appraisal
RF	-	Reserved Forest
Sq km	-	Square kilometres
VLI	-	Village level institution
VSS	-	Vana Samrakshana Samithi

Mangrove Forest Restoration in Andhra Pradesh, India

1. Mangrove forests - an overview

Mangroves are the plant communities occurring in inter-tidal zones along the coasts of tropical and sub-tropical countries. They are one of the most productive ecosystems. Mangroves represent a rich and diverse living resource and are valuable to both the economy and protection of coastal environments. Mangrove plants belong to several families but possess marked similarity in their physiological characteristics and structural adaptations to similar habitat preferences. Mangroves have been variously described as "coastal woodland" and "inter-tidal forest". The term mangrove is loosely used to describe a wide variety of often-unrelated tropical and subtropical trees and shrubs, which share common characteristics. The total mangrove area of the world has been assessed to be approximately 18.15 million hectares. India's mangrove wetlands range from 6,81,000 ha (Sidhu, 1963) to 5,00,000 ha (FSI, 1998).

Mangrove forests perform multiple ecological functions such as production of woody trees; provision of habitat, food, and spawning grounds for fin-fish and shellfish; provision of habitat for birds and other valuable fauna; protection of coastlines and accretion of sediment to form new land. Mangrove areas have high biological productivity, associated with heavy leaf production, leaf fall and rapid decomposition to form detritus. The mangrove ecosystem is dynamic, changing in both location and composition, and has great resilience with the ability to restore itself after heavy damage, as long as seed sources and water flow are maintained. There are also many economic benefits from mangrove resources; like as a source of firewood, self-replenishing areas of fishery resources, for collecting honey and for tourism.

Despite the benefits that they offer, mangrove forests are increasingly under threat and are getting degraded, due to pressures from growing populations, which lead to changes in land use and over-utilization of the resources. The depletion of mangroves is a cause of serious environmental and economic concern to many developing countries.

Until recently, tropical forests have been used as a renewable resource. With the burgeoning human population, urban areas expanded and more land area for agriculture was needed. As a result, forest areas started declining at an alarming rate. Efforts were taken up by the Forest Departments and other agencies to restore, develop and conserve forest resources for sustainable use and management. Nevertheless, these conservation programs were concentrated in the upland forests and not undertaken in mangroves. The Andhra Pradesh Forest Department started restoration activities from 1994 onwards.

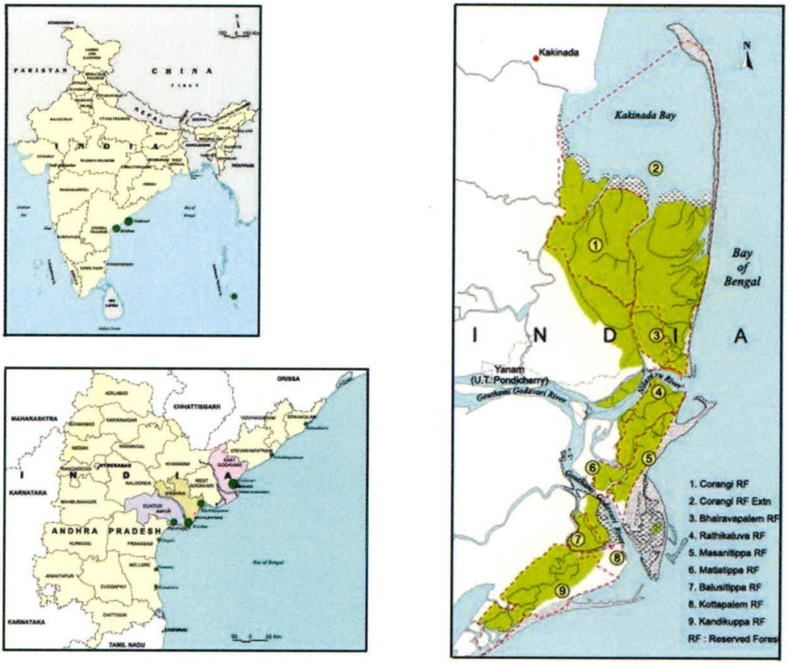
M.S. Swaminathan Research Foundation (MSSRF) started its activities of mangrove restoration and management in Andhra Pradesh from 1997 and restored 520 ha of degraded mangroves and facilitated community participated mangrove management in 9,442 ha.

This publication reflects the process and results of restoration activities carried out over seven years by the project Coastal Wetlands: Mangrove Conservation and Management, implemented in Godavari and Krishna wetlands by MSSRF with its field centre at Kakinada. Hence it will be necessary to make modifications as per the site conditions, mangrove ecosystem, tidal amplitude and topography of the area chosen for restoration. This publication is meant for foresters, field technicians, researchers and others interested in restoration of degraded mangroves.

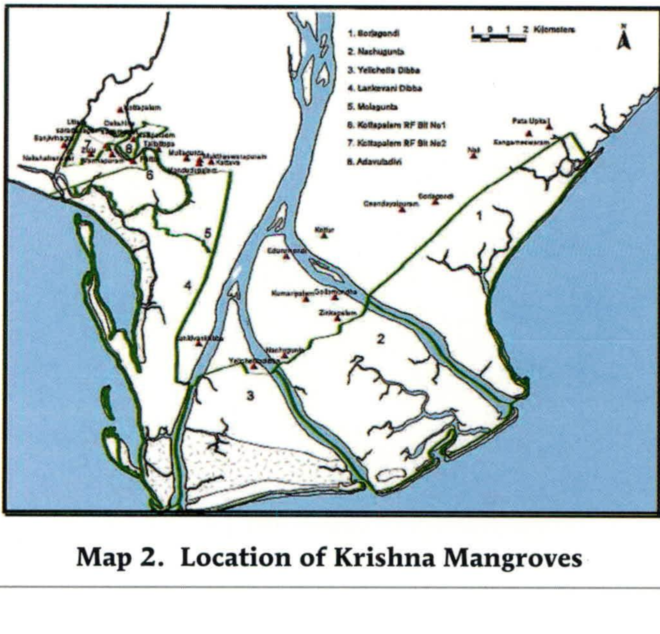
2. Mangrove forests in Andhra Pradesh

The mangrove forests in Andhra Pradesh are located in the estuaries of the Godavari and the Krishna rivers. The Godavari mangroves are located in Godavari estuary of East Godavari district and the Krishna mangroves in Krishna estuary of Krishna and Guntur districts. Apart from these estuaries, mangroves are also found in small patches along the coast of Visakhapatnam, West Godavari, Guntur and Prakasam districts. The total area under Godavari and Krishna mangrove wetlands are 58,263 ha of which 33,263.32 ha are under Godavari and 24,999.47 ha are in Krishna. However, the dense mangroves in Godavari and Krishna are only 17,000 ha and 7,347 ha respectively. The rest are distributed between mudflats, water bodies, sand bodies and casuarina plantations. The Coringa Wildlife Sanctuary has three Reserve Forests, namely Corangi RF, Corangi Extn. RF and Bhairavapalem RF. Most of the mangroves in the Sanctuary are not directly connected with the Bay of Bengal. The mangroves of Coringa Wildlife Sanctuary receives tidal flushing through Matlapalem canal, Corangi river and Gaderu river. The Gaderu and Corangi rivers are the distributaries of the River Godavari. The other six Reserve Forests namely Rathikalava RF, Masanitippa RF, Matlatippa RF, Balusutippa RF, Kothapalem RF and Kandikuppa RF are situated on the southern side of Nilarevu River and fall under non-sanctuary area -Map 1.

The total area of the mangrove wetland declared as Krishna Wildlife Sanctuary is 19,481 ha, which includes Sorlagondi RF,



Map 1. Location of Godavari Mangroves



Map 2. Location of Krishna Mangroves

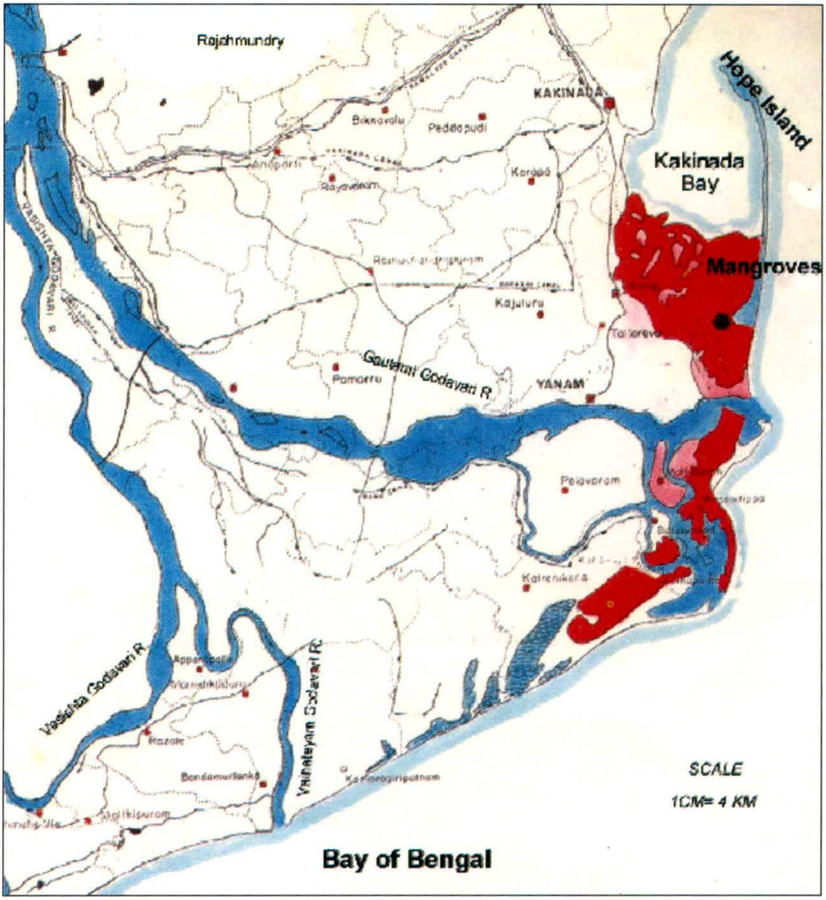
Nachugunta RF, Yelichetladibba RF, Lankivanidibba RF, Molagunta RF, Kottapalem RF Bit-1, Kottapalem RF Bit-2 and Adavuladivi RF (Map 2).

2.1. Riverine systems in Andhra Pradesh

Andhra Pradesh has a geographical area of 2,76,000 sq km, of which 63,770 sq km are under forests. Mangrove forests account for only 582 sq km, representing only about 0.9% of the State's total forest area. An advantage Andhra Pradesh enjoys is that most of the east-flowing rivers pass through the heart of the State and bring in copious sediments from the Western and Eastern Ghats and the Deccan Plateau. 40 major, medium and minor rivers flow through the State. Of these, the most important rivers are the Godavari, the Krishna, the Pennar and the Vamsadhara. Mangroves are found in the estuaries of these rivers but extensive mangrove wetlands are present only in the Godavari and Krishna deltaic regions.

The Godavari river originates in Maharashtra near Nasik and flows towards east into the sea. The Godavari river branches into the Vasishta and the Gautami near Dowleswaram (Map 3) which is considered the head of the delta. The Gautami Godavari river joins the Bay of Bengal at two places one near Bhairavapalem and the other near Kothapalem. The Gautami-Godavari river is connected to the Kakinada Bay by two distributaries, namely the Corangi river which rises at Yanam and Gaderu river which has its origin at Bhairavapalem. There are numerous tidal channels and creeks which feed the mangrove areas and eventually flow into the Kakinada Bay. An important feature determining the health of the Godavari mangroves is the Kakinada Bay, which is very shallow.

The Godavari deltaic region falls under the category of tropical humid climate. The monsoon season commences from June and extends up to December. This area receives fresh water during monsoon season, during which period the salinity is low. From January onwards, the weather is mainly dry and progresses gradually to the hot summer months of April and May.



Map 3. Distributaries of River Godavari

The Krishna river has its origin in the Western Ghats at an altitude of 1,337 metres, north of Mahabaleshwar, about 64 kilometres from the Arabian Sea. It flows across three states, namely Maharashtra, Karnataka and eventually into Andhra Pradesh, before emptying into the sea. The Hamsaladeevi distributary is the first to branch out, 60 km downstream from Vijayawada, near Avanigadda and flows northward into the sea near Machilipatnam. Mangroves have been reported to be less abundant here. The Gollamattapaya and Nadimeru distributaries branch out 25 km downstream from Avanigadda and flow northward to join the sea. The main Krishna canal flows southward to join the sea near False Divi point. Mangroves are mainly prevalent around tidal creeks, channels, lagoons, tidal flats and mudflats of the three distributaries namely Gollamattapaya, Nadimeru and main Krishna canal. The area has a warm, humid and tropical climate with an annual rainfall of around 110 cm.

3. Causes of degradation

The mangroves of Andhra Pradesh are being degraded due to a variety of causes, some of which are similar to those in other mangrove areas in India. As in other places, vast areas of land adjoining the mangroves have been converted to aquaculture ponds. Apart from these general causes, some site-specific reasons also contribute to mangrove loss. The causes of mangrove degradation are described below:

3.1. Past management practices

The mangrove forests were coup felled by the Government agencies for revenue generation till 1972. Some of the clear felled areas could not be regenerated due to topographic changes. Moreover all mangrove species are not of the coppicing type. Chart 1 shows how a chain reaction triggered by coupe felling - caused degradation.

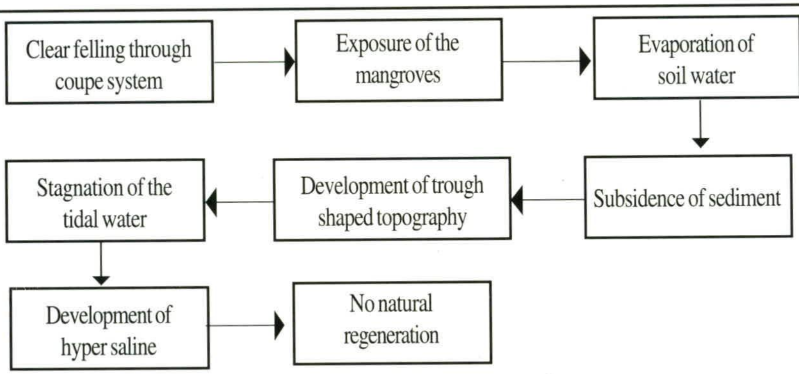


Chart 1. Changes in the biophysical condition of the coupe felled area leading to degradation of mangroves

3.2. Hydrological and geomorphological causes

Reduction in fresh water flow

The Krishna river is one of the highly utilized rivers in peninsular India, for a variety of purposes. As a result, there has been a reduction in fresh water flow over a period of time, which has had a telling impact on the growth and regeneration of mangroves.

Decrease in sediment load into the mangroves

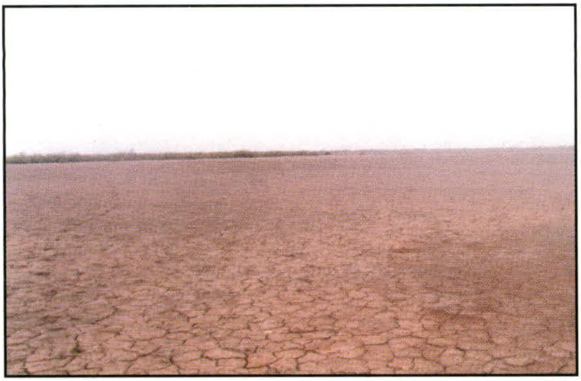
The decrease of sediment load has also had an impact on the ecosystem by way of reduction in sediment supply, due to which the nutrients which are needed for the health of the mangroves have also been reduced.

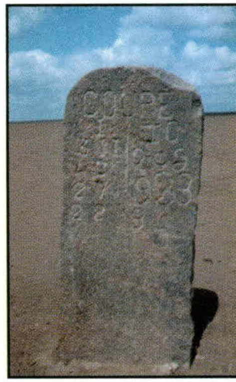
Cyclones and storm surges

The Krishna mangroves have borne the brunt of two severe cyclonic storms in 1977 and 1990. Though the destruction of mangroves due to these cyclonic storms have not been properly documented, the surges associated with these storms have caused extensive sand casting resulting in the area becoming unsuitable for growth and survival of many mangrove species. It has also resulted in the siltation of many drainage channels that were feeding both fresh and tidal water, as a result of which the mangroves have become degraded.

Geomorphological changes

The sand spit in the Kakinada Bay has undergone changes in its morphology with a rapid rate of growth. The spit which had just shown up in the year 1851 has now extended to about 18 km in length. In addition to this, the Kakinada Bay has been undergoing rapid siltation, as evidenced by the hydrographic study. With increased developmental activities and the setting up of fertiliser units, some effluents are being discharged into the Kakinada Bay. The bay waters are now characterized by high amounts of ammonium and nitrate which may contribute to degradation. As the present depth of the Bay is very low, there is hardly any lateral mixing of waters, as





a result of this, there is lot of stagnation of bay waters which may also contribute to degradation. The movement of pollutants in the bay is still not properly studied.

Geomorphologically, the Gautami River has undergone some changes, after the construction of the Cotton Barrage at Dowleswaram in 1852. In 1893, Kothapalem mouth had deepened and widened considerably and hence the major flow of fresh water was taking place through the Kothapalem mouth. By 1985, the Kothapalem mouth had gradually silted up and after 1986, the major outflow of fresh water started taking place through the Bhairavapalem mouth and only very little flow now takes place through the Kothapalem mouth. Due to the change in flow pattern, mangroves occurring in the Kothapalem RF, Masanithippa RF and Balusithippa RF have been affected.

Formation of topographically elevated areas

The land has become relatively elevated at a few places along the river banks and creeks due to silt deposition during floods in the monsoon period. Once the land becomes elevated, the area is unable to have any tidal flushing, as a consequence of which only the fringe areas support mangroves, while the interior areas are devoid of mangrove vegetation.

3.3. Anthropogenic causes

Increase in population, coupled with activities related to economic growth, lead to the use of mangrove lands for various purposes such as construction of roads, ports, harbours and industries.

Alternative uses of mangrove lands, especially conversion of mangrove forests to aquaculture ponds has been increasing. Since 1980, large tracts of mangroves in India are being converted to aquaculture ponds which bring in higher monetary returns within a short period. At the same time, conversion of mangrove forests for salt pans and paddy fields have increased.

Effluents discharged from factories, direct dumping of municipal wastes into the rivers and pesticide run-off from agricultural fields eventually result in the accumulation of heavy metals in the mangrove wetlands, affecting the health of the mangrove ecosystem. Oil pollution is increasing in mangrove areas from shipyards, ship breakers, offshore oil wells, spillage form oil tankers due to accidents and from cleaning of cargo vessels.

Coastal villagers utilize mangroves for their genuine basic needs such as firewood, fodder, fencing, house construction, thatching and fishing poles.

4. Restoration methods

4.1. Restoration of degraded mangroves in the past

Restoration of degraded mangroves was being carried out in the tropical and subtropical estuaries throughout the world (Field, 1996; Qureshi, 1996; Snedaker and Biber, 1996; Soemodihardjo *et al.*, 1996;

Untawale, 1996). Restoration of mangroves started in Indonesia in the early 1960's (Soemodihardjo *et al.*, 1996) and an area of about 38,923 ha of mangroves were restored till 1992. Macnae, (1968) planted *Rhizophora apiculata* in the newly accreted soils in Sri Lanka for better stabilization of the area and to facilitate the trapping of sediments. Goforth and Thomas (1979) have reported the planting of mangroves in Florida for reducing the erosive action of the sea.

In Andhra Pradesh, the Forest Department initiated restoration of mangroves in Godavari by canal digging during 1991. The canals were dug perpendicular to the river and the side canals were at right angles to the main canal. The staff of the Forest Department were taken on an exposure visit to the Pichavaram mangroves where restoration was done by MSSRF. After observing the restoration at Pichavaram, the FD started digging canals at 30^0 from the main canal from 1999 onwards. This reduces the rate of siltation of canals and also facilitates easy flow of tidal water. Till now an area of 2,000 ha have been restored by the Forest Department in Godavari and Krishna Mangroves.

4.2. Methodology for restoration of degraded mangroves at present

A survey of the entire Godavari and Krishna mangroves was carried out to identify the degraded areas. Floristic studies and vegetation survey were undertaken in nine Reserve Forests in Godavari mangroves and eight Reserve Forests in Krishna mangroves using remote sensing FCC images. The floristic study helped in determining the nature of degraded areas and the species composition to include species for genetic composition while planting seedlings in the degraded areas. In this process, degraded patches of mangroves have been identified to an extent of 4,195 ha in Godavari and 12,629 in Krishna. These degraded patches have been plotted with GPS and a GIS database has been developed.

Participatory Rural Appraisal (PRA) was also conducted for identifying the degraded areas through various methods, namely

transact walk, resource mapping and historical analysis. Microplans were prepared in the respective villages for the restoration of these degraded mangroves. Hydrological and geomorphological reasons for degradation were discussed with the community to enhance the scientific awareness of the community on mangrove restoration. The Mangrove Management Units (MMU), which include both degraded area for restoration and the pristine mangroves for management were identified for each Village Level Institution (VLI). The restoration activity was carried out with the VLI, namely Eco-Development Committee (EDC) and Vana Samrakshana Samiti (VSS). The VLIs were trained in nursery raising and digging canals. The topography survey was carried out using theodolite instrument. Contour levels were collected at an interval of 25 m (25x25 m) and the contour map was prepared for 5 cm level, using a computer aided package.

The main canals were dug at an angle of 45^0 to the natural creek. The side canals were dug at an angle of 30^0 to the main canal. Pegs and chalk powder were used for marking the canals.

Canals were designed like fishbone in order to facilitate easy inflow and outflow of tidal water. The design for the canal for mangrove restoration is given in Fig.1. The canal dimensions were

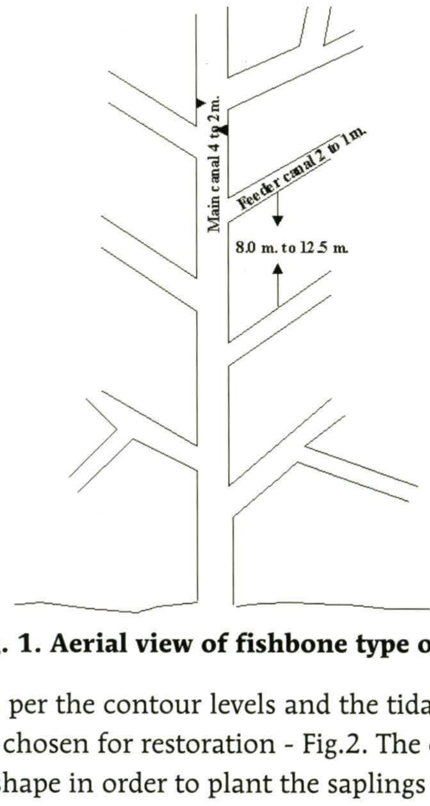


Fig. 1. Aerial view of fishbone type of canal

determined as per the contour levels and the tidal amplitude of the degraded area chosen for restoration - Fig.2. The canals were dug in a trapezoidal shape in order to plant the saplings at the mid level of the canal. This is to ensure that the plants receive tidal water, but at the same time they are not submerged.

4.2.1. Geomorphology and hydrology in mangrove restoration

Based on the contour survey and hydrology study, the canal depths and dimensions are fixed, corresponding to the topography and tidal amplitude of the selected restoration site. The topography study revealed that the areas lying close to the bunds of creeks / rivers are elevated (levee) compared to the areas inside. The levees

Salinity variation in the Saveru creek, Rathikalava RF, varies from 6 ppt during the south-west monsoon to 31 ppt during fair weather season. In the Coringa Wildlife Sanctuary area, at Matlapalem canal, salinity showed a variation from 4.6 ppt during the south-west monsoon to 30 ppt during fair weather season.

Based on the hydrological studies, the depth of canals for restoration was decided to be 0.65 m with reference to mean sea level so as to have adequate tidal flushing (Fig. 5).

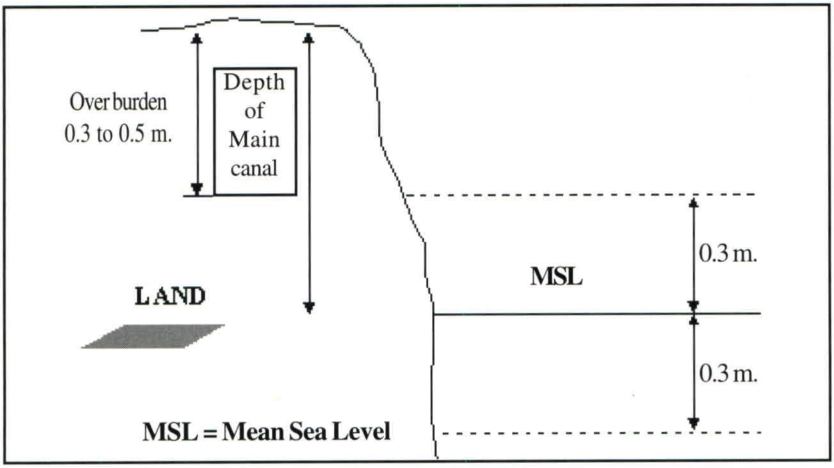


Fig. 5. Topography of a canal bund in non-sanctuary area of Godavari mangroves

4.2.3. Hydrological studies in Krishna

In the Krishna estuary, water level and current data were recorded in the estuary and in the creek at Sorlagundi RF and Nakshatra Nagar during the monsoon and pre-monsoon seasons respectively. One day tidal and current measurements were carried out during the fair weather season at six locations along the three channels of the Krishna river. Measurement of cross sections was carried out using echo sounder. Position fixing was done using GARMIN GPS. Measurement of *in situ* salinity and temperature was carried out along the axis of the three channels of Gollamattapaya, Nadimeru and main Krishna river during monsoon and fair weather seasons at selected stations.

The tidal range along the three main channels of the Krishna varies from 0.7 to 1 metre. Current velocity shows a variation from 0.13 to 0.72m/s which was the maximum velocity that was recorded at Avulaganta. In the creeks adjoining the mangroves, the tidal range was 0.15 to 0.6m at Deenadayalpuram during monsoon. In the creek at Nakshtranagar in Kottapalem RF, the tidal range had a maximum value of 0.25m during pre-monsoon.

During the monsoon season, salinity varied from 8.5 ppt to a maximum of 35ppt near the mouth. During fair weather, the salinity varied from 17 ppt to 36 ppt. Temperature showed a variation from 27 to 30°C along the three channels of the river during the monsoon season, while during fair weather season it varied from 28 to 31°C.

Based on the hydrological studies in Sorlagondi RF, the depth of canals for mangrove restoration was decided to be 0.6m for the main canal. In other RFs adjoining the three channels of Krishna river, namely, Nachugunta RF, Yelichetladibba RF and Lankavanidibba RF, the depth of the main canals was decided to be at least 0.7m .

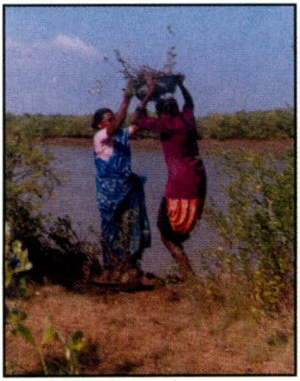
4.2.4. Dimensions of canals

The dimensions of the canals were determined based on the contour levels and tidal amplitude. The canals were constructed with a depth of 0.7 m to 1.0 m near the bunds of the creeks or the rivers and 0.45 m inside. The depth of the main canal varied from 0.45 to 1.0 m and the side canals from 0.6 to 0.45 m as per the contour. The top width of the main canal was between 3.5 m and 2 m and the respective bottom width was between 1 m and 0.4 m The dimensions of the side canals were 2 m top width, 0.4 m bottom width and 0.45 m depth. The distance between the two side canals was 12.5 m during the first year of plantation. The planting of mangrove saplings was done 2 m apart along the canals at about 20 cm down the slope.

In the subsequent years, distance between side canals was reduced to 8 m in order to ensure dense canopy. As the canals were dug closely the dimension of the side canals was reduced accordingly to 1.25 m top width, 0.2 m bottom width and 0.4 m deep.

4.2.5. Selection of species and planting

Based on the salinity levels of soil, mangrove species namely *Avicennia marina, Avicennia officinalis* and *Excoecaria agallocha* were selected for planting in the degraded areas. Reason being that these species could tolerate wide range of salinity. Normally the soil salinity of the degraded area is about 140 ppt during summer. To reduce the high soil salinity, tidal flushing was facilitated by constructing canals as described in the previous pages. Due to this, the soil salts are slowly leached out and the soil salinity is reduced gradually. The reduction in salinity improved the survival percentage and also reduced the saline stress to the young seedlings. The planting was done during October and November, after the southwest monsoon. During that period the rainwater reduces the salinity further. The salinity of the creek water is also low (about 10-15 ppt).



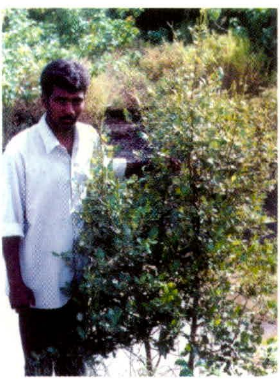
Mangroves namely *Aegiceras corniculatum, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata* and *Xylocarpus moluccensis* were also planted to ensure genetic diversity. Eight-month-old mangrove saplings raised in the nursery were used for planting. The mangrove saplings were planted along the slopes (20-25 cm from the top) of the canals with a gap of 2 m.

4.2.6. De-silting of canals and casualty replacement

The bunds formed by the deposition of the excavated soil during canal digging will silt the canals during the monsoon seasons. The silted canals have to be de-silted before the onset of summer, because during summer the tidal amplitude is generally low. Tidal flushing is very important during summer because the soil salinity will shoot up due to high temperature and cause damage to the roots of the seedlings. Such seedlings will be replanted in the following monsoon season. The survival percentage is measured in the initial period for better monitoring. Initially the growth rate was slow and after 2 to 3 years the seedling growth rate was faster. The natural regeneration of the seedlings also occurs simultaneously. After four years, the planted saplings start bearing fruits, which will regenerate, and the density of the area will increase.

4.3. Mangrove area restored

A total area of 520 ha of degraded mangroves was restored in the Godavari and Krishna mangroves. Restoration was carried out in the Mangrove Management Units (MMU) of Matlapalem, Dindu, Bhairavalanka, Gadimoga and Kobbarichettupeta in Godavari and Dheenadayalapuram, Zinkapalem and Nali in Krishna Mangroves. An area of 9,442 ha is under the management of eight village level institutions. The area restored by each VLI and the management area allotted to respective demonstration village for mangrove protection and management is given in Table 1.



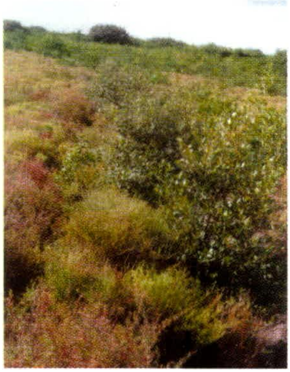
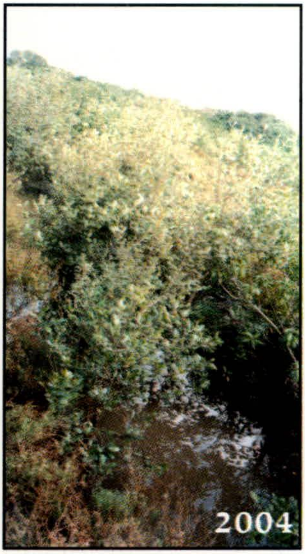


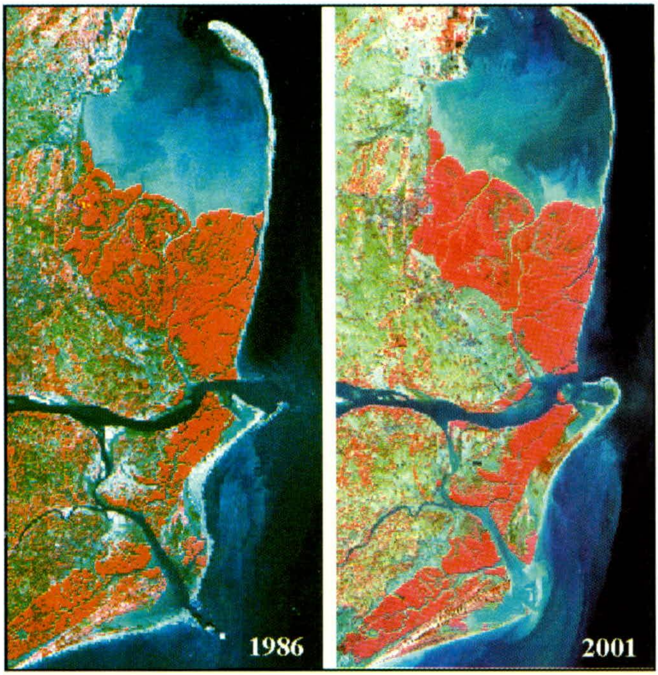
Table 1. Details of area restored and the area under MMU

S.No	Demonstration village	Area Restored (ha.)	Area under MMU (ha.)
1.	Matlapalem	5	502
2.	Dindu	25	900
3.	Kobbarichettupeta	35	3,925
4.	Gadimoga	25	900
5.	Bhairavalanka	75	615
6.	Dheenadayalapuram	236	2,000
7.	Zinkapalem	114	600
8.	Nali	5	----
	Total	**520**	**9,442**

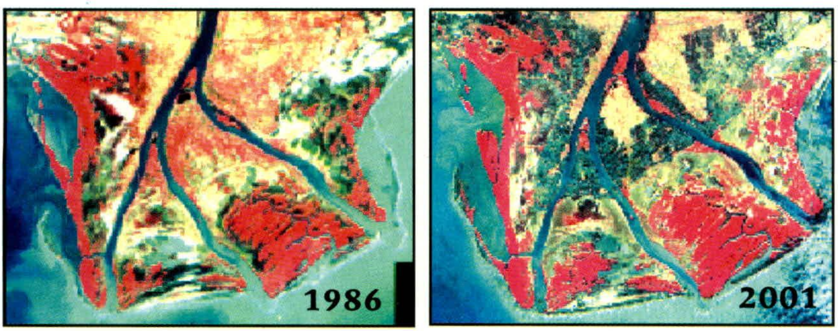


5. Impact of mangrove restoration

Degraded mangroves are being restored to increase the mangrove cover all over the world. In Andhra Pradesh, MSSRF, jointly with eight village level institutions (namely Sri Vigneswara EDC, Matlapalem, Sri Nookalamma EDC, Dindu, Sri Devi EDC, Kobbarichettupeta, Sri Kanakadurga EDC, Gadimoga and Dr. B.R. Ambedkar VSS, Bhairavalanka, Dheenadayaljee EDC,



Godavari Mangroves



Krishna Mangroves

Dheenadayalapuram, Zinkapalem EDC, Zinkapalem and Sri Sita Rama Lakshmana EDC, Nali) and Andhra Pradesh Forest Department, has restored 520 ha Restoration of mangroves has arrested further degradation of mangroves adjoining the degraded patches and also increased the fishery resources. The bio-diversity of the area has improved. The crab population in the restored areas has increased due to the increased water regime. Since the work involves intensive labor, the members of the village level institutions were benefitted by getting employment opportunities. NGOs, namely Sravanthi and Action in Godavari area and Sangamithra Service Society and Coastal Community Development Program in Krishna, were trained in restoration techniques and in participatory approaches in community mobilization and mangrove management. These NGO's have restored 215 ha of degraded mangroves.

5.1. Cost of the restoration activity and long-term benefits

Restoration cost for canal construction and planting of seedlings per unit depends on

- extent of area
- nature of the soil and
- distance between the village and the restoration site

The number of main canals needed for a larger degraded area is less when compared to smaller areas. For example, if the extent of the area is 30 ha it needs only 2 or 3 main canals. The number of main canals needed will be the same even if the area is smaller, that is between 5 and 6 ha.

In the Krishna mangroves, the restoration site near Zinkapalem is very close to the village and the soil is sandy clay. Hence the cost for canal digging was only Rs. 12,000/- per ha. However, in Godavari, the restoration sites are far away from the village and the soil of the degraded area is clayey (hard). Therefore, the cost for canal digging for one ha was Rs. 18,000/- including transport of labour through boats to the restoration sites.

The participatory methods of community mobilization and organization, planning and implementation have to be undertaken before the restoration work is started. The Group formation, PRA, Socio-economic benchmark survey and Microplan apart from awareness generation and entry point activities, have to be undertaken. These exercises involve a cost of Rs. 50,000/-.

A further budget requirement for the socio-economic development of the communities would cost an amount of Rs. 1,00,000 to 2,00,000/-, which has to be leveraged from developmental schemes of the government and the constitution development fund of the peoples representatives and also from the Panchayat Raj schemes. Therefore, the cost of restoration of degraded mangroves in an area of 10 ha which includes survey, nursery raising, advance work in canal construction and planting would require Rs. 2,00,000/- and for desilting in the first three years, it will cost Rs. 1,00,000/-. Hence, Rs. 3,50,000/- will be the total cost for restoration of 10 ha of degraded mangroves through community participation.

Even though as an initial investment the cost appears high, the ecological and socio-economic benefits to the local community will be rewarding in the long run. This is evident from the fact that due to the established water regime, the population of edible crabs has increased in the restored areas,which is a livelihood benefit to the local communities. There is a good growth of fodder grass which has helped the local community in feeding their livestock.

As the biodiversity has come back and the denuded patches have been covered with mangrove restoration, populations of larger animals like otters have increased substantially. In addition to this, the bird population has also increased.

As the water regime has been established, the further degradation of mangroves has stopped. This has resulted in the natural regeneration of mangroves. In addition to this, the canopy cover has become denser which is evident from the remote sensing images.

Hence, as far as restoration of mangroves is concerned even though the initial investment appears high, the delivery cost has to be calculated from the angle of long-term economic benefits that accrue to the local communities and the ecological goods and services that are enhanced due to restoration.

5.2. How the restoration work has improved the socio-economic condition of Bhairavalanka village in Godavari mangroves

The villagers of Bhairavalanka started canal digging during 1999, but due to lack of practice of digging canals, they could not undertake the task. The work was done with the help of Chollangipeta villagers who have been doing canal construction for a long time for the Forest Department. The wages were given to them at a small function, in the form of demand draft after the completion of the work. One of the village elders, who is also a traditional leader, gave the Demand Draft to them and said that if his people had done the work, this money would have come to their village. It was a huge sum, which they were very much in need of, because of the failure in agriculture and aquaculture sectors. This made them think and come forward for the field training in the following year. They were trained by the experienced labour from Chollangipeta. They procured similar types of spades and crowbars and started digging the canals. The timing of work also changed. Earlier they used to work between 9.00 a.m. and 3.30 p.m. But after seeing the nearby villagers go to work at 4.30 a.m. they also changed their timings, which helped them to avoid work under the scorching sun. After this, they have completed nearly 65 ha of mangrove restoration and the money got from the wages was used for house construction, which was started with the help of ARTIC - NGO with the support of OXFAM and State Housing Corporation. Most of the houses were unfinished due to financial problems, which they have to contribute as beneficiary contribution. After this they also got similar type of work from the Forest Department and from Sravanthi an NGO. In the Food for Work Program they could execute tasks like pond renovation, laying roads in the village and earned a large quantity of rice. The district administration has appreciated this work and the change the project has brought.

They also undertook restoration work for the forest department and other NGOs which has fetched them more money. The Forest Department also provided 15 ha of *Casuarina* plantation for the VSS. The revenue form this plantation is being shared by the community through the Village Development Fund.

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