Science-based and community-centred approach to restore and sustain mangrove wetlands of India

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Abstract

Mangroves of India remained degraded for many decades, and attempts to restore them yielded no appreciable results. Systematic studies revealed for the first time that changes in the biophysical condition due to past unscientific management practices are the real causes of mangrove degradation rather than utilisation of mangrove resources by the local community. Based on this finding, a simple and cost-effective method that improves the soil and hydrological conditions of the degraded areas to support the growth of mangroves was developed and demonstrated. For upscaling, a community-centred Joint Mangrove Management approach was developed and piloted in major mangroves along the east coast of India. Replication of this approach by government agency resulted in a large scale increase in Indian mangrove forest cover. Present issues relating to the participatory management of mangroves are also discussed.

Keywords: mangrove restoration, participatory research, tidal flushing, joint mangrove management, village level institutions

Apart from protecting the lives and properties of coastal communities from cyclonic winds and storm surges, mangroves play a vital role in safeguarding the livelihood and food security of millions of artisanal fishing families through supporting fishery production. A review of the fisheries associated with mangroves indicates that annually one hectare of mangrove produces fishery resources worth USD 106[1]. Communities living around the mangroves have been utilising these resources traditionally and, through this process, gain knowledge about the intricate ecosystem structure and function. These values and functions were brought to the notice of forest administrators and managers only in the 1980s when UNESCO implemented a major mangrove research and management and training programmes. Before that mangroves were considered a wasteland by the administrators and cleared on a large scale to expand agriculture. For example, between the 1790s to 1870s, nearly 280000 ha of mangrove forest of Bengal was cleared by the British for rice cultivation[2]. Later, the Imperial Royal Forest Department ofBritish India considered mangroves a source of good quality firewood and started exploiting them in the late 1880s. According to the Annual Administration Report of the Forest Department of the Bengal and Madras Presidencies published from the 1880s and 1940s, every year, mangrove trees in thousands of acres were clear-felled and supplied as firewood to railways, steamers, as well as for consumption in nearby areas. This practice continued by the State Forest Departments after independence. Large scale organised felling of mangrove trees was stopped only in 1980 when the Indian Forest (Conservation) Act was passed.

Restoring mangroves in the clear-felled areas was a major challenge for foresters of both colonial and independent India. Attempts to restore mangroves during the colonial period yielded limited results, and the British foresters blamed uncontrolled grazing by cattle as the major factor that affected restoration efforts. During the post-colonial period, Indian foresters

tried to restore degraded mangroves but with little success. This issue was discussed in detail in 1957 when the Central Board of Forestry, Government of India organised the first symposium on mangroves in India[3]. The working plans of mangroves prepared by the State Forest Departments after 1960 to 1970s show that no serious efforts were taken and finally efforts to restore degraded mangrove areas were abandoned in the 1980s.

At this juncture, Dr M S Swaminathan in a lecture at the International Symposium on the Human Response to Global Change, 1988 explained far-reaching consequences of sea level rise due to climate change and suggested the initiation of anticipatory research to utilise the mangrove ecosystem and its genetic resources to enhance adaptive capacity to rising sea level[4]. In the same year, M S Swaminathan Research Foundation (MSSRF) was established with conservation, management and sustainable utilisation of mangrove as one of its major programmes. This article provides an account of i) how the technical issues of mangrove restoration, which eluded both the British and Indian foresters for many decades, were resolved through participatory research, ii) what kind of community-centric approach was followed to engage and enhance the capacity of the local communities to play a lead role in mangrove restoration and management iii) how policy interventions played a key role in large-scale replication of the restoration model. The challenges faced at various stages are also discussed.

Development of a science-based mangrove restoration method

The development of a science-based and cost-effective mangrove restoration method was initiated first in the Pichavaram mangroves in Tamil Nadu. In 1990, the Forest Department, Government of Tamil Nadu (TNFD) and MSSRF joined together to establish a mangrove genetic resources centre in about 50 ha in the Pichavaram mangrove in Cuddalore District.

Out of 50 ha, mangroves in about 20 ha was totally degraded. The TNFD also wanted MSSRF to develop and demonstrate suitable methods and strategies to restore degraded mangrove areas.

Participatory research and identification of the real cause of mangrove degradation

As a first step, consultative meetings were held with the primary stakeholders, artisanal and small-scale fishing and farming community and managerial and field level officials of the Forest Department, to identify the causes of degradation of mangroves and options available for restoring degraded areas. The officials of the TNFD emphasised that grazing by cattle from nearby villages and illegal felling of trees by local people were the primary cause of degradation. This is a kind of conviction that foresters held for a long time as Venkatesan, Forest Working Plan Officer in 1965, wrote: "though man is largely responsible for the deterioration of mangroves by his illicit cuttings, greater damage is done by the cattle which eat away the seedlings and thus prevent the establishment of natural regeneration"[5]. On the other hand, both fishing and farming communities denied that these factors were the lead causes of mangrove degradation. To support their arguments, they informed that i) only dead wood and twigs were collected from the mangroves for domestic use, that too only by a small number of families, ii) no one was eking out a living on selling mangrove wood and iii) cattle were grazed only in the periphery of the mangroves, where previously the Forest Department allowed grazing on a fee. Further, they claimed that mangroves were severely degraded only in the interior part of the mangroves, which were not accessed by the local community and cattle.

Since the claims by the primary stakeholders on the causes of degradation were contradictory, joint visits to mangroves with the members of the local communities and field staff of the

Forest department were organised by MSSRF to verify their claims. During the field visit, it was found, as informed by the community, that degradation was severe in the interior part of the mangroves. In the degraded areas, the presence of a large number of stools was observed, and in many places, there was a stagnation of tidal water (Fig 1). Stagnation of tidal water is an uncommon feature in mangroves; free flushing of mangrove forest by tidal water is a prerequisite for a healthy mangrove. Hence, observation of stagnant tidal water in degraded mangrove areas led to a hypothesis that some changes might have happened to the topography, causing stagnation of saline tidal water and finally degradation of mangroves. To test this hypothesis, the relationship between topography, tidal inundation, groundwater and soil salinity and the health of the mangroves was investigated.

The microtopography of the mangrove was measured in 8 randomly selected transects following the method described by Emery[6]. Four transects each in healthy and degraded mangroves. The lowest low tide level was taken as 0, and from this benchmark, topographic readings were taken at 5 m interval, covering the entire length of each transect. The frequency and extent of tidal flushing of different parts of each transect were observed for a whole tidal cycle. Groundwater was collected using a PVC extractor with a metal porous end tip, as described by Gordon[7]. Soil samples were collected in all the transects at three depths, 0-5 cm, 20-30 cm and 40-50 cm, and soil salinity was measured by saturated soil past technique[8]. All the data were collected during the peak months of April and May.

The typical profile of microtopography of the healthy and degraded mangrove areas is shown in Fig 2a and b. In the healthy mangrove areas, microtopography was smooth and flat, and land elevation was about 20 to 45 cm above the zero level. As a result, it was observed that the tidal water entered freely into the healthy mangroves during the high tide and drained

completely during the low tide. In contrast, the topography of the degraded mangroves was "trough" shaped with elevated margins and a sunken middle portion (Fig 2b) and the depth of the troughs varied from 12 to 48 cm below the level of low tide. As a result, tidal water which entered into the trough-shaped area during the high tide was unable to drain out during the low tide due to elevated margins, resulting in stagnation. During the summer, the stagnant tidal water evaporated, resulting in an increased level of groundwater as well as soil salinity. In the healthy mangrove areas, groundwater salinity varied from 22 to 64‰, whereas in degraded areas, it varied from 70 to 120‰ and the average value of 32 samples was 93‰, which is lethal to even high saline tolerant mangrove species[7]. Similarly, soil salinity was also high in the degraded areas (46 to 104‰) and low in the healthy mangroves (12 to 24‰)[9]. Such high soil salinity in the degraded of Pichavaram was also recorded by Blasco *et al.*[10] The above observation clearly showed that the development of hypersaline condition due to stagnation of tidal water, which was a result of the development of trough-shaped topography, was the primary reason for the degradation of Pichavaram mangroves. This conclusion was well supported by the remote sensing data (Fig 3).

The conclusion arrived from the study raised an important question; why the middle portion of the degraded areas had become trough-shaped instead of being flat as in the healthy mangroves? Againthe clue came from the community, who informed that in most of the degraded areas, mangrove trees were clear-felled by the Forest Department in the past. The Pichavaram mangrove was though notified as a Reserved Forest in 1893 organised exploitation of mangrove trees by the Forest Department was introduced only in 1949. The system adopted was a clear-felling with 40 years rotation, and the method of treatment followed was simple coppice[11]. The meaning of this system is that the mangrove forest will be divided into 40 plots (called annual coupes) of more or less equal in size. In the first year,

trees in the first plot will be clear-felled. During the felling of trees, the lower portion of the stem with roots (called stools) will be left undisturbed for new shoots to come from it. This method of regeneration is termed simple coppice. In the second year, mangrove trees in the second coupe will be clear-felled with stools for regeneration. This will continue until the mangrove trees in the 40th annual coupe felled on the 40th year of the rotation. In the 41st year, the first coupe will be ready with a stock of trees of 40 rotational age for the second felling cycle.

As per this system, the Pichavaram mangrove forest was divided into 40 annual coupes, which varied in size from 24 to 40 acres[11]. The mangrove trees in the first coupe were felled in 1949-50, and it continued till clear-felling completed in the 7th coupe in 1955-56 when it was noticed that regeneration of mangroves from stools was not satisfactory. Hence, in 1956 another treatment method, simple coppice with standards, was introduced[12]. As per this treatment method, 15 mother trees were retained per acre of clear-felled areas for regeneration from seeds. With the second treatment method, clear-felling in the 8th coupe commenced in 1956-57, which continued till clear-felling completed in 16th coupe in 1963-64. During this time, it was observed that regeneration from stools and seeds was not satisfactory and clear felling was stopped in the mid-1970s. This clear-felling system of management was found the primary cause of mangroves degradation. Since nearly 80% of the mangrove soil is water, clear-felling of mangrove trees exposed mangrove soil to sunlight, causing evaporation of soil water, which caused subsidence of sediment in clear-felled areas. Subsidence of sediment is common in wetland soils, which are exposed to prolonged solar radiation[13,14]. Due to the subsidence of sediment, topography in the clear-felled areas had become trough-shaped, causing stagnation of tidal water. Its subsequent evaporation led to the failure of regeneration of mangroves species in the clear-felled areas.

Since the foresters of both the colonial period and independent India were not cognizant of the above chain reaction triggered by clear felling system of management, their attempts to restore the mangroves in clear felled areas were not successful[15].

Tidal water canal system for mangrove restoration

Having understood that development of hypersaline condition in the clear-felled areas as the primary cause of degradation, it was hypothesised that these trough-shaped degraded clear-felled areas could be easily restored if facilities were provided for regular flushing by tidal water. To test this hypothesis, a 10-ha degraded area was selected jointly with the Tamil Nadu Forest Department and the local people. The topographic map of this area was prepared, and on the basis of the topography, a canal system was designed and established to ensure the free flow of tidal water in and out of the degraded areas during the high tide and low tide. The canal system consisted of the main canal with 3m (upper width) x 1.8m (bottom width x 1m (depth) dimension and feeder canals with 1m x 0.60 m x 1m dimension. The feeder canals were aligned at 45 degree to the main canal (Fig 4). The main canal, in turn, was connected to a deep natural channel located close to the degraded areas. The canal system was established before the onset of the north-east monsoon season, expecting that during the monsoon, low saline water or freshwater will flood the degraded areas, which would help in reducing the salinity level rapidly.

In the 10 ha demonstration site, 4800 propagules of *Rhizophora*spp and 28000 of *Avicennia marina* planted were planted as per the distribution of these species in healthy mangroves. The growth performance of the plantation was observed for three years continuously and also at the end of 6 years, which is shown in Table 1. The survival of *Rhizophora* and *Avicennia* plantation was 66% and 72% respectively in the first year, but

from the second year onwards, a large number of propagules of these species were brought into the demonstration site by tide currents and started establishing themselves. Before setting the tidal water canal system, the soil of the demonstration site was unsaturated with water, and hence, groundwater was collected from 6 points, and its salinity varied from 82 to 94‰. After tidal flushing was established, the soil was saturated with water, and hence, pore water was collected in five randomly selected points after a period of one year, and its salinity showed values ranging from 17.8 to 53‰. The observation of natural regeneration, good growth and reduced level of salinity in soil water clearly showed that the canal system is the effective method of restoring the degraded clear felled areas of Pichavaram mangroves[16,17] Since the field staff of the State Forest Department and local community were involved from the beginning, they were also involved in regular monitoring of the restoration demonstration.

Community-centered Joint Mangrove Management approach

The results of the studies on the real cause of mangrove degradation and scientific method of restoration were communicated and shared with all the stakeholders, including higher officials of the Forest Department and leaders of the local community, through formal and informal meetings and by organising field visits to the demonstration site. During these interactions, the following three important questions were raised by the stakeholders: i) how to upscale mangrove restoration efforts? ii) how the canal system for tidal flushing, which is artificial and prone to siltation, will be maintained? and iii) how social pressure, if there is any, on restored and other healthy mangroves will be handled?

In response to the above concerns, a community-centred Joint Mangrove Management (JMM) approach was worked out in Pichavaram mangroves on the lines of the Joint Forest

Management principles. The primary aim of the approach was to engage and empower stakeholders, particularly the local communities, socially, technically, and organizationally to restore and sustain and manage mangrove wetlands. To achieve the same, a process, which consists of several steps, as described below, was followed.

*a) Situation analysis***:** The purpose of situation analysis was to understand i) land use and land cover within and near to mangroves, ii) degree and causes of mangrove degradation, iii) assessment of forestry and fishery resources associated with mangroves, vi) degree of the dependency of the local community on mangroves, vii) the traditional and changing systems of resource utilisation and their perception about the past and present status of the resources, viii) current management practices and xi) level of participation of the community and other stakeholders. A combination of scientific and participatory tools was used to analyse the situation.

*b) Selection of project hamlets***:** Hamlets rather than revenue villages were selected as the social unit to implement mangrove restoration and conservation activities because in hamlets i) community is mostly homogenous, ii) traditional controlling system is dominant rather than the political system, iii) there is trust among different groups of the community and iv) decision-making and conflict resolution are comparatively easier. For selecting the hamlets, socio-economic backwardness, the intensity of utilisation of mangrove resources and willing to take active participation in JMM were used as criteria.

c) Participatory Rural Appraisal (PRA): In the project hamlets, a set of participatory methods such as social mapping, historical timeline, seasonality calendar, organising transect walk in the mangrove wetland, resource mapping, livelihood analysis, matrix rankings, etc., were

used.These methods ensured active participation of the women and menin the appraisal and to express their perceptions and perspectives relating to the complex interrelationships between mangrove environment and livelihood of local people, governance and dynamics in the resource availability and management of mangroves[18]. It also helped in the identification and prioritisation of major concerns of the mangrove dependent community that need to be resolved to improve the socio-economic condition of the communities and conservation and sustainable management of mangrove. The participatory rural appraisal also provided ample opportunities to establish rapport with the men and women of the hamlets, which was an unintendedresult but provided a very strong base to mobilise the people and organise them to form a community-based organisation.

*d) Organising community-based institution***:** A gender-balanced community-based organisation called Village Development and Mangrove Conservation Council (VDMC) was organised in each of the identified hamlets. It provides a platform for all the stakeholders to jointly discuss the major concerns identified through participatory rural appraisal and take collective decision to address them. The structure of this village-level organisation included a General Body in which one adult male and female from each willing family were enrolled as members. It functioned as the decision-making body. The second tier of this institution was an Executive Committee in which, apart from the local community other stakeholders such as the Forest, Fisheries, Rural Development Department and MSSRF were also participated as members. It was made compulsory to give33 to 50% representation in the Committee to women. The Executive Committee functioned as the planning and implementation body. The kinship ties, shared lineage and the socio-economic homogenous nature of the hamlet community form a good basis for forming this institution and embark in collective actions.

The VDMC helped to engage the people as active participants. Community engagement in the intervention planning and implementation of the activities is essential to ensure effective and equitable socio-economic development and longterm conservation and management of mangroves. The VDMCs were created primarily to prioritise issues to be solved, to arrive consensus as a basis for action, and to ensure all sections of the community is participating in the planning and implementation. The VDMC also provided the opportunity for women, other marginalised and powerless sections of the community to become part of the decision making structure and process.

e) Mangrove management unit: For each participating hamlet, a mangrove management unit was identified jointly by the community and the Forest Department. The mangrove management unit is an area of mangrove wetland, which was traditionally utilised by the people of that hamlet for livelihood and subsistence before mangroves were declared as Reserved Forests. The identified unit consisted of both degraded and healthy mangroves.

f) Preparation of micro-plan: For each of the hamlet that participated in the Joint Mangrove Management, micro plans were prepared jointly by the community and the stakeholders. In the process, responsibilities were delegated to the communities, which created an opportunity for the community to take the informed decision' about the local issues related to their livelihoods and management of the mangrove resources.

The plan contained details of the actions to be taken to solve the issues relating to mangrove restoration and conservation and interventions needed to address the socio-economic concerns of the community identified and prioritised through PRA. In some villages, mangrove restoration was not in the foremost priority of the communities, there were other

more pressing economic and social concerns which the communities wanted to address first, and as a principle of participatory development, it was accepted, and plans were prepared as per the priority list by the community. In some villages, socio-economic concerns and issues relating to mangrove restoration and conservation were addressed simultaneously. The plan helped in mobilising funds from internal and external resources and manpower from the hamlet. The micro plan also provided details of the timeline and the roles and responsibilities of each stakeholder in the implementation of the micro-plan.

*g) Implementation of the micro-plan**:*** The Executive Committee implemented activities as per the micro plan with the support of stakeholders; MSSRF facilitated the processes. Funds obtained as per the micro plan were directly deposited in the accounts of the community-based institution, which took responsibility for proper utilisation of the funds. The active participation of local people in decision-making, planning and taking responsibilities in the activities always improved the effective implementation of plans, enhanced results and reduced the time required and the investment in the long term.

Piloting mangrove restoration method and JMM approach

When the JMM approach was being worked out, the causes for degradation of Muthupet mangroves of Tamil Nadu, Krishna and Godavari mangroves of Andhra Pradesh and Bhitarkanika and Devi mangroves of Odisha was analysed by participatory research. The records of the State Forest Department showed that most of the mangrove forests of the Godavari delta such as Coringa andUpputeruand Yellichettidibba, Nachugunda and Sorlagondi regions of the Krishna delta were declared as fuel Reserved Forest during 1886-1887[19]. The largescale clear-felling of mangrove trees in these mangroves was started immediately after their notification as Reserved Forest. In all these mangroves, as in the case of Pichavaram mangrove, clear-felling was the system implemented to exploit mangrove

trees. For example, during 1893-94 and 1894-95 mangroves trees in 5130 and 3358 acres respectively were clear-felled in the Krishna mangroves and the felled trees were supplied as firewood to railways, cotton mills, brick kilns and for consumption in nearby towns. In the clear-felled areas of Muthupet, the Godavari and Krishna mangroves soil subsided as in the case of the Pichavaram mangroves causing topography to become trough-shaped, resulting in the development of the hypersaline condition and failure of regeneration of mangrove species[20]

Since the primary cause of degradation of most of the mangroves of the east coast of India was similar to that of Pichavaram mangroves, it was decided to extend the mangrove restoration method, and JMM approach developed and demonstrated in the Pichavaram to these mangroves on a pilot scale. As shown in Table 2, the mangrove restoration method was pilot tested in 1400 ha with the participation of the local communities and State Forest Department of Tamil Nadu, Andhra Pradesh and Odisha. Apart from restoration, healthy mangroves of about 12000 ha were also brought under participatory management[21]

Challenges

The canal method of mangrove restoration faced limited challenges. When the mangrove restoration method was developed, it was predicted by the stakeholders that the artificially dug canals would collapse in due course of time, which may again restrict free tidal flushing of the degraded areas. However, silting of canals was not observed in areas where the soil is clay and wherever feeder canals are aligned about 45degree to the main canal. In fact, in many places, the breadth of canals found increased. Though the increase in breadth of the canals was due to erosion of the banks of the canal, the silt thus generated was removed out of the canal by tidal currents. In sandy soil, both primary and feeder canals collapsed within a

short period because of the loosely arranged sand grains, indicating that this method is not appropriate in sandy areas. Similarly, wherever feeders were aligned at or near 90 degree to the main canal, the speed of the flow of water was reduced, which resulted in the deposition of silt[22]

In the community-centric approach, many challenges were faced, particularly in establishing village level organisation and balancing the socio-economic aspirations of the community and objectives of mangrove restoration and conservation. Each hamlet, where the pilot-scale community-centric mangrove restoration and conservation activities were implemented, has its own traditional controlling system for a long time with an established line of leadership, norms for functioning and decision-making processes. It usually focuses on keeping peace and harmony within the hamlet, maintaining a cordial relationship with other hamlets, organising festivals and rituals for village deities etc. This traditional controlling system felt that establishing a new institution at the hamlet level would undermine their power and roles and responsibilities and hence, refused to provide consent to develop a multistakeholder based village level institution. It took considerable time to convince the traditional leaders that the functions of the proposed village level institutions would focus on socio-economic and mangrove management related issues and would not intervene in the functions of the traditional controlling system[23]. In many of the hamlets, village level institution had representatives from the leaders of the traditional controlling system.

The socio-economic concerns of the community were many, and balancing focus on solving these issues and integrating them with restoration and sustainable management of the mangroves posed a great challenge. However, the participation of the government agencies as member in the village level institution provided the opportunity for the government and the

community to work together, which helped in improved understanding of the concerns of the community, identifying interventions to solve the concerns and planning, implementation and monitoring of the results of interventions[24].

The understanding of the Forest Department that the primary cause of degradation of mangrove was the past unscientific management practices rather than the utilisation of mangrove resources by the community played an important role in reducing the animosity between the Forest Department and the local community. Secondly, the learning of the Forest Department from Joint Forest Management experiences that community participation is the key for the long-term sustainability of both restored and healthy mangroves drew them close to the community and made them accept the local community as a partner in Joint Mangrove Management.

Policy support for large-scale replication

The Ministry of Environment and Forests (now Ministry of Environment, Forests and Climate Change), Government of India formed a four-member Sub-Committee (Office Memorandum vide Letter No. J-22012/19/92-CSC(M) dated 20.03.2000) to take stock of mangrove restoration, afforestation, conservation and different aspects of mangrove management. The Sub-Committee visited mangrove sites in Tamil Nadu, Andhra Pradesh and Odisha, where a science-based and community-centred mangrove restoration and conservation approach was being pilot tested. The Sub-Committee recommended the inclusion of this approach in the guidelines for National Mangrove Conservation and Management[25] and replication of the same in restoring saline blanks that exist in the mangroves of Tamil Nadu and Andhra Pradesh. Later, the same approach was applied to the restoration of mangrove wetlands of Odisha[26] and Maharashtra. According to the Forest

Survey of India[27], mangrove forest cover of India has been increasing since 1993, and the present approach developed and demonstrated by M S Swaminathan Research Foundation on a pilot scale in all the major mangroves along the east coast of India played a catalytic role for such positive changes in the mangrove cover of India.

Conclusion:

The results clearly show that in the participatory research and management of natural resources, including mangroves, local and traditional knowledge, observations and perspectives of local people form the basis for designing sound applied research and development and demonstration of practically feasible and sustainable management practices.A major factor for the success of this JMM initiative was that in the tripartite arrangement between the Facilitating Agency (MSSRF) -Government Agency (State Forest Department)-Local People (Mangrove user communities) each partner recognised and respected and contributed and complemented to the strength of the others, which needs to be extended to restore remaining degraded mangroves and sustain healthy mangrove areas. However, a recent review indicates that the village level institutions established (variously named as Village Development and Mangrove Council, Eco-Development Committee and Village Forest Council) for Joint Mangrove Management are being increasingly marginalised in decision making and planning and they have the feeling they were being used by the NGOs and Forest Department to implement projects[28]. The review also shows that there was no major change in the conviction and attitude of the communities to JMM, but the Forest Department in almost all the states is distancing itself from genuine participatory management. One of the reasons could be the quality of the human resources available at the disposal of the Forest Department. When the present JMM was initiated in the late 1990s, Joint Forest Management (JFM) was at its peak and there was huge political and

administrative support to JFM; both managerial and field staff of the Forest Department were constantly exposed to the concept and thoroughly trained on the process to be followed to achieve true participation of the community. The present younger generation of both managerial and field level staff have limited exposure to the participatory approach and practical training in JFM. Hence, they are not very much convinced that people's participation is necessary for the long term sustainability of the mangroves. Moreover, declaring all the mangroves as Wildlife Sanctuaries also complicated the participatory process further. To improve the situation, the State Forest Department has to enhance the understanding and capacity of the younger generation of officials to participatory management, which can be achieved by more and more formal and informal training. There is a need to revisit the curriculum of the Indian Forest Service and Range Officers and other field staff training, which reflect the colonial legacy aimed at exploiting the forest rather than the present need for participatory sustainable management.

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Table 1. Growth performance of *Avicennia marina* propagules planted in the restoration demonstration site

Parameters	**Months***					
	8	**12**	**18**	**24**	**36**	**72**
Survival (%)	**84%**	**78%**	**77%**	**72%**	**72%**	**72%**
Net increment in height (cm)	35.16±1.54** (22-58)***	61.65±2.66 (44-82)	137.1±2.66 (92-165)	163.86±5.61 (102-214)	262.85±5.72 (196-345)	415.06±13.20 (324-488)
Number of internodes/plant	7.03±0.31 (4-12)	11.37±0.43 (9-18)	22.5±0.66 (14-30)	25.43±0.82 (17-35)	29.13±1.05 (16-44)	No data
Number of branches/plant	8.7±0.46 (3-12)	10.93±0.62 (6-21)	25.33±0.99 (16-40)	27.56±0.98 (18-48)	32.83±1.21 (17-56)	No data
Diameter of first internode (cm)	0.82±0.05 (0.4-1.5)	1.12±0.07 (0.6-2.1)	2.16±0.78 (1.3-3.6)	2.78± 0.09 (1.9-3.9)	3.71±1.33 (1.8-5.8)	6.38±0.39@ (4.56-8.99)

****Mean with standard error; *** Minimum and maximum; @ Diameter at breast height (DBH); - data could not collected**

Table 2: Area of degraded mangrove restored and healthy mangroves brough under conservation during pilot testing of new Joint Mangrove Management approach

State	Name of the mangroves	Area restored (ha)	Healthy mangrove under JMM (ha)	No villages participated	Total families participated in JMM
Tamil Nadu	Pichavaram	250	200	4	697
	Muthupet	375	800	4	506
Andhra Pradesh	Krishna	355	2600	4	930
	Godavari	165	6840	6	884
Odisha	Devi	257	1560	10	1435
		1402	**12000**	**33**	**4452**

Figure 1. Clear-felled mangrove area with stools and stagnant tidal water

High resolution photos of all the figures attached separately

Figure 2. Profile of the topography and vegetation structure in healthy and degraded mangrove areas

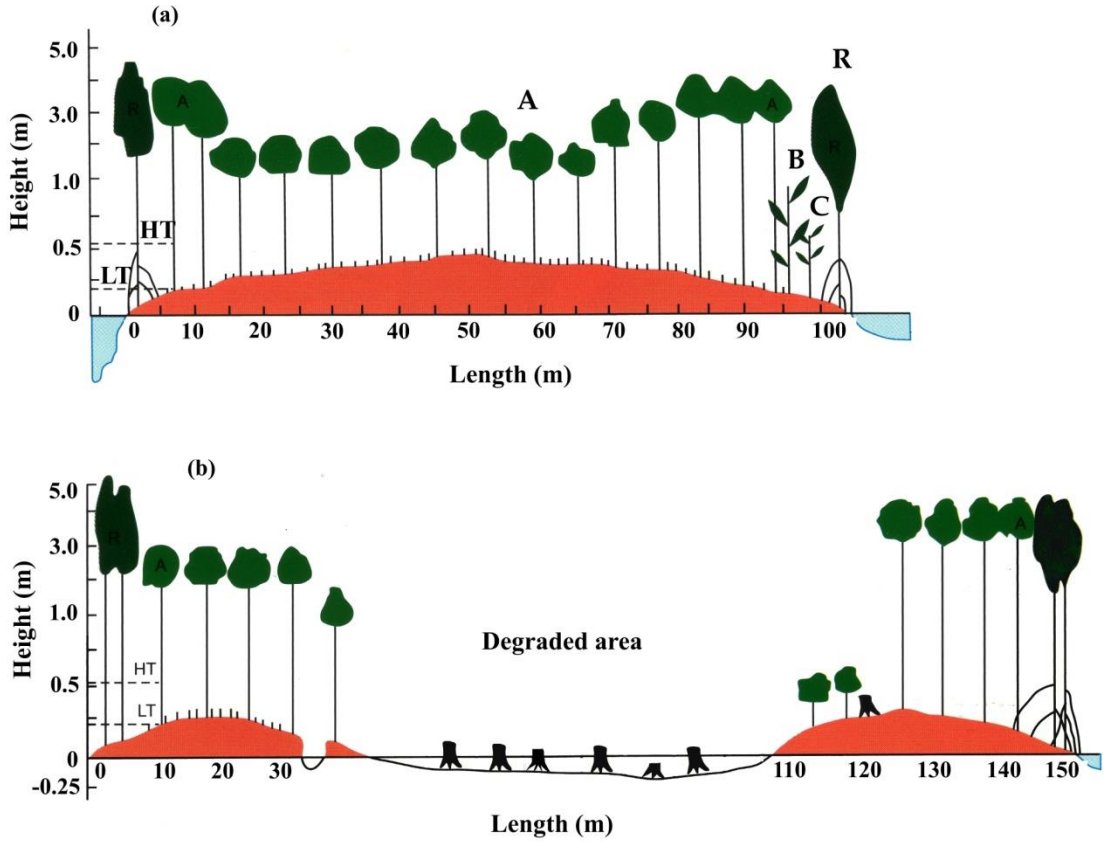

Figure 3. Satellite imagery of the Pichavaram mangroves (Landsat 5 TM of 1986) showing healthy mangroves (m) and trough-shaped clear felled degraded areas (c)

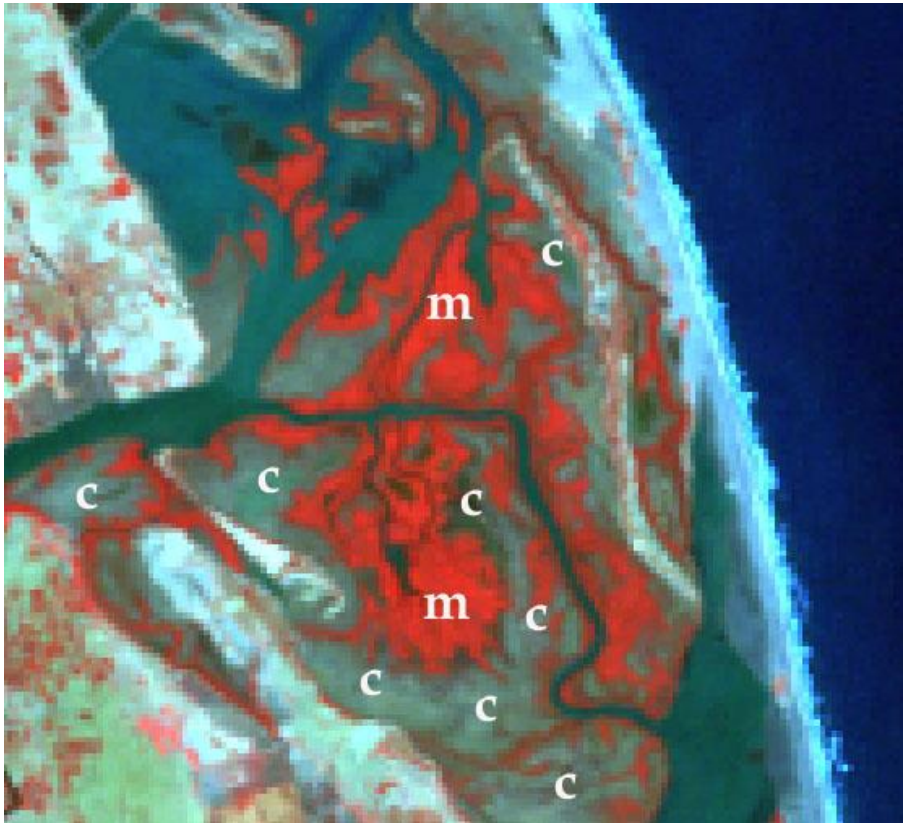

Figure 4. A typical canal system established in the degraded areas for regular flushing by tidal water