Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

An Appraisal of Mangrove Management in Micro-tidal Estuaries and Lagoons in Sri Lanka

IUCN Sri Lanka Country Office

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Published by : IUCN (International Union for Conservation of Nature), Sri Lanka Office.

Citation : IUCN (2011). An Appraisal of Mangrove Management in Micro-tidal Estuaries and Lagoons in Sri Lanka. IUCN Sri Lanka Country Office, Colombo. viii + 116pp.

ISBN : 978 - 955 - 0205 - 05 - 9

Cover Photographs : Mangroves in the Negombo Lagoon (Ranjith Mahindapala)

Produced by : IUCN Sri Lanka Office

Designed and layout by : K. Amila Tharanga

Printed by : Karunaratne & Sons Ltd.
67, UDA Industrial Estate,
Katuwana Road,
Homagama, Sri Lanka.
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Available from : IUCN
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Preface

This study was inspired by observations and experiences from post-tsunami (2004) mangrove planting and 'restoration' work in the country. Since the tsunami, IUCN Sri Lanka supported a number of initiatives for improving mangrove management in the context of the structure and functioning of the parent ecosystems – estuaries and lagoons. In 2009, several mangrove planting and 'restoration' initiatives were supported under the Small Grants Programme of the Mangroves for the Future Initiative (MFF) in different parts of Sri Lanka. Inconsistent results from the Small Grants Programme together with other observations on changes to lagoon and estuarine ecosystems compelled us to undertake an appraisal of mangrove planting initiatives in the country.

Many have helped us in this study. Observations of grantees and the critical questions they posed obliged us to seek the scientific basis for some of the mangrove related work, otherwise considered as routine.

This appraisal had two main components, namely, colloquia and field observations. IUCN organised the main colloquium in Colombo and a satellite colloquium in Batticaloa with stakeholder state agencies, academia, researchers, practitioners and policy makers to discuss and debate a number of themes relating to mangrove replanting (and 'restoration'), their successes and failures, and possible effects on ecosystem health and productivity. The practitioners were appreciative of the opportunity to share their experiences with the scientists, as there were hardly any opportunities in the past for such a discourse. The field observations were collated and analysed by Drs Jayampathi Samarakoon and T Jayasingam and Professor Senevi Epitawatta, supported by the team at IUCN.

The Sri Lanka National Steering Committee of MFF, ably chaired by Ms L P Batuwitage, Additional Secretary, Ministry of Environment, supported this study as a priority. The contributors at the two colloquia readily provided information and data from their respective areas of work, without which this report would have been impossible. The participants at the two colloquia provided valuable information and opinions. Drs Jayampathi Samarakoon and T Jayasingam and Professor Senevi Epitawatta provided excellent technical support, analyses of field observations, and writings in compiling this report. Dr Steven Creech provided a synthesis of the Colombo colloquium.

It was the consensus amongst the participants that mangrove planting and restoration should be scientifically based and with due regard for the resilience of ecosystems to regenerate themselves with minimal interventions after natural disasters. This report captures the main observations and findings from the study, and provides recommendations for mangrove planting and 'restoration' in the future. The report was critiqued and edited by Dr Tilak Wettasinghe, whose assistance is gratefully acknowledged.

IUCN Sri Lanka
December, 2010

(Kumudini Ekaratne)

1. Introduction

In Sri Lanka, over the past few decades, mangrove-related activities have attracted considerable interest. The interest in mangroves heightened in the aftermath of the Tsunami of 2004 in view of their potential as a physical barrier for wave surges, storms etc. In some areas of Sri Lanka, heavy mangrove growth was seen as having reduced the impact of the Tsunami. Officials of many state agencies associated with natural resources management, coastal ecologists, national and international NGOs, CBOs and coastal communities have shown interest in mangrove-related activities for different reasons. In this scenario, international funding agencies, bilateral donors as well as government agencies have provided considerable financial support for numerous mangrove projects aiming to improve ecosystems and save life and property during coastal disasters. These mangrove projects have taken diverse forms and approaches, including mangrove conservation and restoration, planting of mangrove bioshields, mangrove education and protection, among others.

Way before Sri Lankan scientists and organizations showed interest, members of coastal communities traditionally used mangroves and their products for livelihood activities and land development in urbanized settings. Many of these traditional practices continue in certain geographic settings and date back centuries.

The institutionalization of interest in mangroves, in Sri Lanka, started in the 1980s. Some of the major milestones are:

- Partnership between the Asia-Pacific Regional Mangrove Project (UNESCO) and the Government of Sri Lanka, executed by the then Natural Resources and Science Authority of Sri Lanka (NARESA)

- Establishment of a Mangrove Conservation Project Office in the Forest Department supported by IUCN

- Inclusion of mangroves as a critical habitat in the Sri Lanka Coastal Zone Management Plan of the CCD

Whilst institutionalisation gave rise to a number of mangrove related projects, there has been little critical attention to the consequences of these projects. IUCN Sri Lanka has recently had the opportunity to review a number of mangrove replanting initiatives, including those supported under the Small Grants Programme of the Mangroves for the Future Initiative (MFF), which have shown uneven success. These reviews have surfaced questions on the choice of sites for replanting, choice of species for different localities and conditions, perception of societal values and benefits, effect of newly-planted mangroves on sedimentation and hydrology, and the expected benefits for

maintaining ecosystem health and productivity and its contribution to biodiversity. Some findings raise concerns about the value of project outcomes in particular to society, coastal ecosystems, integrated coastal zone management, and biodiversity interests.

These issues were deliberated at the National Steering Committee of the MFF. The submissions made pertain primarily and specifically to the ecological and geographical context of Sri Lanka. In general, problems regarding the form and content of mangrove projects being implemented in Sri Lanka were articulated and disaggregated as follows:

- There are inconsistencies in the practices employed in mangrove projects already implemented and/or being implemented (as expressed in their visible and measurable consequences). The inconsistencies stem from markedly different perceptions of the structure and functioning of ecosystems, within which mangrove planting has occurred/is occurring.

- Harm to ecosystems, as a result of mangrove projects is already apparent in some cases. The long term consequences to the coastal ecosystems are likely to be irreversible and lead to a reduction of their multiple values. In such situations, the 'state' will not be in a position to bear the cost of reversing the adverse consequences to the coastal ecosystems and the resulting losses will be of a permanent nature, including economic and development opportunities.

Some of the related questions raised are:

- Lack of credible information on economic and financial values of mangroves to Sri Lanka's coastal populations. Information on the measured and measurable impacts of mangroves, in both their natural and cultivated states, is also lacking

- Information on site-specific features relating to the abundance and distribution of mangroves is inadequate

- Lack of clear evidence on the positive and negative aspects of mangrove planting, as currently practised in Sri Lanka, particularly the benefits and harm to society and coastal ecosystems

- How do mangroves impact on other sectors such as fisheries, agriculture, tourism, urban planning for flood protection and drainage, biodiversity, hazard mitigation etc?

- Inadequate participatory planning and decision making (good governance) with due regard to the subsidiarity principle, in implementing mangrove projects

- Operationalizing mangrove projects based upon participatory planning and decisions

- Lack of information on the predictable relationships between mangroves (as bio-shields) and impacts of climate change, specifically in regard to protection from

coastal hazards such as cyclones, erosion, floods; and on food security through their impact on drainage, soil salinization, water-logging, etc.

- Due recognition has not been accorded to examining issues relating to mangroves in the larger context, including the different models that need to be developed (causal, mathematical, hydro-morphological, socio-ecological system, etc.)

- There is a need to develop guidelines for good practices, monitoring indicators, accountability mechanisms and case studies of poorly integrated mangrove plantings with scientific and quantitative interpretations

- Mangroves should be properly integrated with the structure and functioning of coastal ecosystems. However, appropriate multi-disciplinary models (including hydromorphological, mathematical, socio-ecological, etc) to guide integrated mangrove planting are not available.

The deliberations also brought forth the need for sound science in answering many of these questions. Comparisons with specific international settings should be rigorous and adhere to scientific principles.

The National Steering Committee of the MFF considered the current situation, and decided it was opportune to undertake an in-depth appraisal of mangrove rehabilitation efforts in Sri Lanka's micro-tidal coastal areas, to address the issues noted above. The process involved several steps including a literature review, an appraisal of past experience, including field experience, and a review of various scientific and practical aspects, in two colloquia, with the participation of concerned scientists, practitioners, policy makers, stakeholder agencies etc.

IUCN Sri Lanka arranged the main colloquium in Colombo, on 6 November, 2009, and a satellite colloquium in Batticaloa, in the Eastern Province, to seek the views of stakeholders and scientists in the Eastern Province, on 24 November, 2009.

The main tasks assigned to the colloquia were: to critically analyse the benefits to be derived from the mangrove replanting initiatives; and to ascertain and agree on best practices in mangrove rehabilitation to prevent negative externalities. These outputs are to be based on the ground experience from various mangrove planting initiatives, and on scientific and geo-morphological considerations. They were also to deliberate on optimal utilization of funds in the public interest, and the accountability of implementing agencies in regard to the consequences of their actions, in a manner that would benefit coastal ecosystems and coastal communities in the long-term (a period greater than 30 years), and to examine the indicators for evaluation and measurement of the consequences of mangrove projects.

Ideally, the colloquia should have examined some of the larger issues such as the geographic setting with particular reference to micro-tidal environment; coastal

processes, tidal prism, tidal volume, tidal circulation within coastal water bodies highly favourable to sediment entrapment; hydro-morphology of estuaries and lagoons – the geo-morphological context; rivers and sediment loads and discharges; as well as aspects of brackish water biology etc. However, in a short colloquium, it was not possible to address all these aspects.

The presentations at the colloquia covered many topics, which ranged from the current status of mangrove conservation in Sri Lanka, including the northern areas of the country, to mangrove restoration efforts and to understanding failures or successes in mangrove restoration projects.

The rich deliberations at the colloquia resulted in a number of recommendations as a way forward to address the relevant issues. This report contains these recommendations enhanced with recent field observations and a commentary on several related aspects such as physiography of Sri Lanka's coastal plains, behaviour of micro-tidal barrier-built estuaries and lagoons, and their sedimentation with mangrove planting and other land uses.

2. Outputs of the Colloquia

The two colloquia held in Colombo and Batticaloa reviewed the current status of mangroves in different parts of the country and the recent efforts at rehabilitating or restoring mangroves, with a view to selecting and documenting the better practices for integrated management of barrier-built estuaries and lagoons[1].

A. The Colloquium held in Colombo on 6 November, 2009[2]

The colloquium provided an opportunity to reflect deeply on the opinions and experiences of government and non-government organisations, academia, and practitioners, and generated lively and thought-provoking debates. It was gratifying to note the presence of several heads of the relevant government departments throughout the colloquium

Collectively, presenters and participants extended the debate well beyond the organizer's original expectations, to encompass not only mangrove rehabilitation following the tsunami, but also to address much broader issues concerning the past, present and future conservation and management of mangroves in Sri Lanka. The discussions brought forth several new perspectives on the conservation and management of mangroves in Sri Lanka and highlighted a number of issues that need immediate attention.

Colloquium held in Colombo (Kumudini Ekaratne)

1 See Annex 1 for Participants at the two colloquia.
2 See Annex 2 for the Programme and Annex 3 for the presentations made available by the authors.

B. The Colloquium held in Batticaloa on 24 November, 2009[3]

The colloquium was graced by the District Secretary, Batticaloa and the Mayor of Batticaloa. A much respected citizen of Batticaloa, Mr Prince Casinader reminisced about the landmark of Batticaloa – the Batticaloa Lagoon and its richness.

Several presenters highlighted the issues pertaining to mangroves. The practitioners described in detail the planting procedures they adopted and justified the need to plant mangroves. The diversity of mangroves and the need to conserve mangroves was stressed. The need to adopt a systems approach to resolve the various issues was also proposed. The lack of an authoritative body for mangroves was highlighted as a major issue.

Colloquium held in Batticaloa (Kumudini Ekaratne)

The main issues emphasized by the resource persons and those that arose in the rich discussion and debate, in the two colloquia, can be categorized as follows:

1. Lack of basic information about mangroves in Sri Lanka
2. A national plan for mangrove conservation and management is essential
3. Lessons to be learnt from the post-tsunami mangrove rehabilitation and restoration programmes
4. Assessing the 'success' of mangrove planting programmes
5. A National Mangrove Coordination Centre is an urgent need.

3 See Annex 4 for the Programme and Annex 5 for the abstracts prepared by IUCN, based on the presentations.

1. Lack of basic information about mangroves in Sri Lanka

Several presenters and participants drew attention to the fact that basic infor-mation on mangroves and related aspects is not available. Specific attention was drawn to the following:

(a) *Area under mangroves in Sri Lanka*: Even the most basic data such as an accurate estimation of the area under mangroves is not available. In the Eastern and Northern Provinces, the conflict situation did not permit any survey or research work to be undertaken in the recent times.

The latest available mangrove distribution map is the Coast Conservation Department's (CCD) Coastal Zone Management Plan prepared in 1996. This map shows the locations of the principal lagoons and estuaries around the coast of Sri Lanka and marks the mangroves known to be associated with them. It was pointed out that this map includes lagoons where the associated mangroves have now been considerably reduced (e.g. Mundel Lagoon). On the other hand, this map does not depict the smaller lagoons and estuaries where mangroves are common. Furthermore, the map has not been produced by consolidating detailed field information, from individual lagoon or estuary specific studies, and is out of date. And yet, despite these obvious limitations, the CCD's 1996 map of 'Mangroves in Sri Lanka' is still used as the principal source of reference by managers, academics and practitioners. As a small country with less than 12,000 ha of mangroves this situation is regrettable.

(b) *Administration of Mangrove areas:* The Forest Department (FD) did not regard mangroves as 'forest resources' till recent times. Up to 1995 all mangrove forest areas were classed as 'marginal lands' and were under the purview of the Divisional and District Secretaries. The attitude towards mangrove forests in Sri Lanka began to change only when selected mangrove forests were handed over to the Forest Department and subsequently designated as Conservation Forest Areas[4]. This initiative of the FD was subsequently supported by the bi-laterally funded Mangrove Conservation Project[5], which pioneered mangrove management and conservation, in three locations on the west coast of Sri Lanka, and formulated mangrove forest management plans.

Unfortunately, these developments came too late. Between 1990 and 2000, large tracts of mangroves in the northwest of Sri Lanka were indiscriminately converted into shrimp farms and salt pans, with permission granted by the local-level authority. Even today,' protected status' only applies to mangrove forests designated as Conservation Forest Areas by the FD, and mangroves found in the Wildlife Protected Areas under the Department of Wildlife Conservation (DWLC). All other mangroves remain categorized as 'marginal lands', and come under the jurisdiction of the Divisional and District Secretaries.

4 Under the Forest Department's Circular No.5 of 2001
5 Co-financed by Norwegian Agency for Development Cooperation between 2001 and 2003.

Notwithstanding the lack of accurate data, it can be safely assumed that more than half the extent of mangrove forests is located outside the conservation and protected areas of the FD and DWLC, and thus remain highly vulnerable to being encroached, damaged or destroyed.

(c) *Diversity of Mangroves:* Species diversity and the approximate area under each species and related information are not available. A complete record of 'true' and 'associate' mangroves species has not been compiled and how categories have changed over time in different places throughout the country is not clearly known.

The absence of fundamental information and data, particularly of 'what', 'where', 'which' and 'how many' mangroves there are or were in Sri Lanka, is an impediment to making critical management decisions and is perhaps the most significant constraint limiting the choice of best options to promote the future conservation and management of mangroves in Sri Lanka.

2. A national plan for mangrove conservation and management is essential

The meeting noted that the coastal area[6] in Sri Lanka, which amounts to approximately 24% of the country's total land area, is home to 32% of the population, creating intense demand for even the most marginal land resources. The coastal area contains 65% of all urban areas, 65% of the country's industrial production and accommodates about 80% of the island's tourism industry[7]. It is therefore no surprise that highly competitive and often conflicting demands for land in the coastal areas are constantly brought up at the local, regional and national levels.

As Sri Lanka continues to develop socially and economically over the next 20 years, inevitably, natural habitats such as mangroves in many coastal areas will continue to be degraded, damaged or destroyed. For example, rapid post-war development in the Northern and Eastern Provinces is likely to impact on the remaining mangrove areas in these provinces. Plans are afoot to develop shrimp farms, based on the National Aquaculture Development Authority's (NAQDA) studies on the potential for shrimp farming and hatchery locations in selected coastal lagoons and estuaries on the east coast.

Other current development plans that may have adverse impacts on mangroves are: the Urban Development Authority's development plans for the Trincomalee Harbour area which is a potential threat to the second largest single stand of mangroves in the country in Tambalagamam Bay; the Kalpitiya Integrated Development Project proposed by Sri Lanka Tourism Development Authority which may endanger coastal resources,

6 Here defined as the area under Divisional Secretary Divisions which abut the shore (i.e., Coastal DS Divisions) and distinct from the Coastal Zone which is defined under the Coast Conservation Act 2004 as 300 m landward of the Mean High Water Line; 2 km seaward of the Mean Low Water Line and 2 km perpendicular to the straight baseline between the natural entrance points of rivers and lagoons.

7 GOSL Initial National Communication to the United Nations Framework Convention on Climate Change

including mangroves in Puttalam Lagoon, in Sri Lanka's northwest; and road expansion in the north and east in particular.

Considering the above, the meeting recommended the following steps:

(a) In the light of imminent challenges facing future conservation and management of mangroves in Sri Lanka, there is an urgent need to undertake a comprehensive analysis of the current status and future risks to Sri Lanka's mangroves;

(b) It is imperative that the most 'critically important areas' of mangrove vegetation are identified. These nationally agreed 'critically important areas' should become the focus of future efforts to conserve and manage mangroves in Sri Lanka;

(c) A national strategy for mangrove conservation and management is required. This plan should include and address issues such as land tenure, particularly in the north and east; issues related to private land ownership in mangrove areas; the revision of existing management plans and preparation of new management plans; review of relevant gazette notifications relating to new Conservation Forest Areas; and updating the CCD guidelines for conservation and management of coastal vegetation and mangroves[8]. Such a strategy would provide a renewed impetus and energy to strengthen coastal zoning activities for the most 'critical mangrove areas'. It was also agreed that for the strategy to be effective, the following conditions should be met.

- The leading government agencies such as the Forest Department, Department of Wildlife Conservation and the Coast Conservation Department should endorse the national strategy.
- Political will is required for an effective strategy.
- The donor agencies and researchers should be committed to implement the strategic plan, and channel their funding and research resources to address conservation and management issues in the 'critically important mangrove areas'.
- Ensure that non-government organizations and practitioners implement their conservation and management interventions in the 'critically important areas'.

3. Lessons to be learnt from the post-tsunami mangrove rehabilitation and restoration programmes

The December 2004 Tsunami that struck over 60% of the Sri Lankan coastline was both a natural process and a national disaster. This often overlooked fact was emphasised by both presenters and participants. In terms of human suffering (over 30,000 deaths) and

8 Guidelines were prepared by the CCD in 1990 and IUCNSL in 2007

destruction and damage to property and assets (over 100,000 houses), the impact of the tsunami in Sri Lanka was colossal and elicited a hitherto unprecedented national and international humanitarian response.

However, in ecological terms, the impact of the tsunami was significant only in the immediate aftermath of impact, and especially at the most vulnerable locations. The ecological impact of the tsunami diminished rapidly with increasing distance from the shoreline, and time since impact. In contrast to the devastation caused to housing and infrastructure, no irreparable damage to any of Sri Lanka's coastal ecosystems was reported, nor was any substantive damage noted to any coastal landform (e.g., beaches, sand bars, spits[9] and sand dunes), nor to any natural coastal vegetation (e.g., mangroves, screwpines and ironwoods) due to the impact of the tsunami (Samarakoon *et al.*, 2005).

Unfortunately, the national and international humanitarian response completely failed to take note of the disparate and unequal nature of the tsunami impact on the coastal communities and the coastal environment. Consequently, relief workers applied the standard disaster response paradigm - emergency relief, relief, rehabilitation and reconstruction - to the coastal communities as well as the coastal ecosystems. In the case of coastal communities, measures to save their lives and livelihoods were indisputably essential and undoubtedly saved many lives. Humanitarian assistance since December 2004 has supported coastal communities to recover from the tsunami devastation and build new futures. However, applying the same disaster response paradigm when rehabilitating and restoring coastal ecosystems was critically adjudged by presenters and participants at the colloquia, as a completely inappropriate, futile exercise with possibly negative consequences.

Some of the important lessons are:

(a) ***Prospects for Planting/Rehabilitating mangroves:*** A presenter drew attention to the little-known fact that mangrove restoration and rehabilitation, by planting propagules and seeds, are extremely difficult endeavours. The global success rate for mangrove restoration and rehabilitation is around 33%. Generally, success rates are higher in high tidal environments than in the low tidal regimes. In Sri Lanka, with its low tidal regimes, the survival of propagules and seedlings might be even lower than 30%, due to greater environmental stresses associated with low tidal regimes (e.g., hypo and hyper salinity, drought and grazing).

A good example of the futility of post-tsunami mangrove rehabilitation and restoration activities, implemented by various agencies, is the Rekawa Lagoon. As per available data, 75,000 propagules and seedlings had been planted by state agencies and non-government organisations involved in the restoration and rehabilitation of mangroves in Rakawa Lagoon. The agencies involved claimed that an area equivalent to 24% of the entire mangrove coverage in Rekawa Lagoon had been planted. However, damage to the mangroves in Rekawa Lagoon was marginal

9 The Sand Spit that was breached in Bentota, potentially threatening a number of hotels, was rapidly repaired with imported sand and aggregates.

and limited to a small area around the lagoon mouth, which had begun to recover naturally within nine months of the tsunami.

(b) ***Systems Approach:*** Contrary to expectations, mangrove planting in Sri Lanka's micro-tidal barrier-built estuaries and lagoons produced some disturbing results such as:

- Mangrove planting/rehabilitation had an adverse impact on the hydrology of barrier-built estuaries (attenuation of buffer volume).
- Mangrove planting for livelihoods development results in diminished fish habitats, and land filling for housing.
- Mangrove planting as bio-shields entrains progressive sediment accumulation, eventually resulting in the loss of productive habitats.

Mangrove planting mostly takes place in the barrier-built estuaries such as Batticaloa Lagoon, Negombo Lagoon, Chilaw Lagoon and Puttalam Lagoon where urbanization and property values are high. It is in these estuaries that the poorest segments of local communities earn a subsistence income. A valuable lesson that emerged from Segara Anakan Cilcap, Indonesia, serves as a warning. In this barrier-built estuary, fishery collapse occurred when the hydrology diminished below a threshold due to sediment entrapment. And restoration measures are prohibitively expensive.

Clearly, it is necessary to move away from belief-based good intentions (and traditional perceptions) to science-based procedures for ecosystem management (best practices).

Water surface area of the Batticaloa lagoon, has decreased due to it being filled to accommodate various projects (road and bridge construction, military base expansion, etc.). These activities are gathering pace and continually undermine the hydrodynamics of the lagoon. To ensure the sustainability of the remaining lagoon resources, adopting a systems approach in managing the lagoon is a must. This entails mapping and restoring the micro-catchments and controlling all sources of sediment. Accessing available records (both oral and written) will provide a historical and evolutionary perspective that will facilitate in forming the eco-hydrological systems 'big picture'. Piecemeal solutions are meaningless because lagoons such as the Batticaloa Lagoon function as a system, and therefore modest changes can produce major system-wide outcomes.

(c) ***Failure of Restoration and Rehabilitation efforts:*** Some common reasons for the failure of post-tsunami mangrove restoration and rehabilitation projects are:

- There is no real need for mangrove restoration/rehabilitation interventions in most lagoons and estuaries.

Most organisations planted mangroves merely because donor funds were available for post-tsunami relief work. In many cases the needs were not assessed.

- Inadequate site assessment and poor understanding of local hydrology, including the seasonal changes in water level (particularly on the east coast).

  Organizations planning to undertake mangrove planting should possess a sound technical background regarding all aspects of mangrove ecology and have a thorough understanding of the hydrological processes at each planting location.

  The needs of each location should be correctly assessed at the outset of the project - should it be natural regeneration or restoration. Organisations and agencies planning to plant mangroves (and other coastal vegetation) should possess a precise, science-based knowledge about the ecology and hydrology of the location.

- Incorrect choice of species due to poor understanding of the biomechanics of mangroves.

- Inadequate post-planting care; little or no protection of seedlings and propagules from grazing and submergence. This is primarily due to the short term nature of most, if not all, post-tsunami mangrove restoration and rehabilitation projects; some are as short as six months.

  Mangrove planting and aftercare are essentially medium term ventures. Commitment to the long term processes involved in mangrove rehabilitation and restoration is essential. The organizations should be able to provide sound technical guidance to the communities and promote awareness and local ownership of the mangroves. However, most organisations planted mangroves and left the scene.

- Failure of organisations to successfully mobilize and engage the local community.

- Lack of technical expertise among NGO staff engaged in post-tsunami mangrove restoration projects.

- Clearly, natural recruitment of mangroves is the preferred approach. Enhancing natural hydrology and removing barriers and stresses would allow natural recruitment. Supplementary planting of mangroves should only be considered if such interventions are unsuccessful. This must be emphasized because mangroves are ecological systems that recover easily. The most appropriate and urgent interventions are conservation and management, as opposed to planting propagules and seedlings.

Managers, academics and practitioners can learn a great deal from the mistakes made in the course of national and international post-tsunami efforts to rehabilitate coastal ecosystems. How well these lessons have been learnt will be seen over the next few years in the north and east of Sri Lanka, already showing interest in the 'restoration and rehabilitation' of coastal communities and coastal habitats affected by the conflict. With the benefit of hindsight, managers, academics and practitioners should have the confidence to recommend the most appropriate interventions to conserve and protect coastal habitats, including mangroves. They should promote natural regeneration and restoration, and resort to planting mangroves (i.e., rehabilitation) only if the barriers, stresses and threats that prevent natural recovery cannot be overcome.

4. Assessing the 'success' of mangrove planting programmes

The Turtle Conservation Project (TCP) and the Small Fishers' Federation (SFF) made presentations on their experience in planting mangroves in the Puttalam lagoon areas.

Turtle Conservation Project:

TCP commenced working with coastal communities in Puttalam Lagoon in 1999. A TCP study showed that the main threats, past and present, to the mangroves along the Kalpitiya Peninsula were encroachment, solid waste disposal, extraction of fuel wood, shrimp farming and salt production. Since planting mangroves, the main threats TCP had to overcome were goat and cattle grazing, landing of fishing craft and the use of push nets.

Between August 2005 and December 2006, TCP worked with nine Community-based Organisations (CBO) and planted over 150,000 mangrove propagules (predominantly *Rhizophora sp.,)* covering approximately 15 ha of the Kalpitiya shoreline of the Puttalam Lagoon, under the United Nations Development Programme's (UNDP) Promote Tropical Forest Project (PTFP). During project implementation, TCP staff raised the awareness of Kalpitiya coastal communities about mangroves; increased their access to micro finance; supported alternative livelihoods training; gave technical assistance to CBO members to develop local home-stay tourism; conducted environmental education programmes with schools, youth groups, fishermen and women's societies and conducted a successful turtle rescue programme.

Four years after the successful conclusion of PTFP, TCP continues to work closely with the CBOs managing the planted areas, where individual mangrove plants are now about 4 m tall. According to TCP, these newly planted areas are highly regarded by local people as having successfully contributed to increasing their fish catches, particularly prawns. Before planting, fishermen had to travel much greater distances to get a similar catch. TCP's field data shows that planting mangroves has led to an increase in the biodiversity of the inter-tidal area, by way of natural recruitment

of 'true' and 'associate' mangrove species and a variety of sessile, sedentary and mobile molluscs, crustaceans, fish and birds which live in, on and around the newly planted *Rhizophora*.

TCP has begun discussions with the Forest Department to reach an agreement on appropriate measures to sustainably manage the 15 ha of mangroves planted by the nine coastal communities. A key issue is to work out a *modus operandi* for CBO members to extract timber from the planted areas without infringing the rules and regulations administered by the Forest Department as well as local authorities.

Small Fishers Federation:

SFF began its work on mangroves in 1994, in response to local fishermen's appeal to address the increasingly negative impacts of the shrimp farming industry in Chilaw, Mundel and Puttalam Lagoons. Over a ten year period, mangrove coverage dropped from 3,210 ha to 1,590 ha in Chilaw Lagoon, causing a dramatic reduction in fish and wild prawn production. Sediment discharged by prawn farms contributed to increasing siltation rates in all three lagoons, particularly in the Hamilton and the Dutch Canals, further affecting water quality and fisheries productivity in the three lagoons. Since 1994, SFF has strived to raise awareness among the local, provincial and national government agencies and authorities, including the police and politicians, regarding the threat to lagoon ecosystems and local livelihoods posed by the destruction of mangroves, and specifically from the unregulated expansion of prawn farming.

Over a period of 15 years SFF has planted over 198,600 seedlings and propagules, in an area covering approximately 185 ha of Chilaw, Mundel and Puttalam Lagoons and along the banks of the Dutch and Hamilton Canals. SFF had successfully propagated and planted 18 of the 21 'true' mangroves species in Sri Lanka, including several endemic species. SFF's mangrove planting programmes have been implemented in collaboration with the Ruhuna University and National Aquatic Research & Development Agency (NARA). In recognition of SFF's experience, their technical knowledge has been sought by others, notably in the Eastern Province.

The success achieved in the mangrove planting programmes described by TCP and SFF stood in stark contrast to the failure of most post-tsunami mangrove restoration and rehabilitation projects. The success of these ventures can be attributed to:

- Both organisations have demonstrated a strong and lasting commitment to their mangrove replanting programmes of over 10 years, by intelligently using donor funding to continue and expand initial project-based interventions

- TCP and SFF have also demonstrated their loyalty to a small number of coastal communities, working in a few lagoons (less than four), enabling their staff to build solid links and to develop and strengthen the trust and understanding between them and the communities

- Both organizations have built up the technical capacity of their staff and brought in technical specialists from universities and research agencies to supplement and enhance their knowledge

- Both organisations have been meticulous in their selection of sites and species to be planted in the areas in which they have worked

- Both TCP and SFF have extensively documented their activities, and have learnt from their failures and built upon their successes.

In contrast to the array of failed post-tsunami mangrove restoration and rehabilitation programmes, TCP and SFF have demonstrated beyond any reasonable doubt that mangroves can be successfully planted in Sri Lanka. This presented a challenge to managers, academics and practitioners to focus their attention on how to assess the 'success' of a mangrove planting programme. The discussions brought forth two important points, as follows:

Ecological Approach versus Plantation Approach

The two cases examined represented different approaches. The meeting was of the view that SFF adopted a more 'ecological approach' to mangrove planting, whereas TCP employed a 'plantation approach'.

The TCP accepted that its approach could be compared to that of establishing a 'mangrove plantation'. However, in the long-term, TCP plans to work with local communities and the Forest Department to initiate a programme for sustainable extraction of mangrove poles from these 'plantation areas'. Allowing controlled and sustainable extraction of timber by coastal communities from the areas planted by the TCP would result in a significant reduction in the damage caused to nearby natural mangrove areas from unregulated and usually destructive timber extraction. Furthermore, a key objective of the project was to increase the products and services provided by mangroves to the local community. But it is only now, four years after the closure of the project that its key objective is in sight.

The predominant practice of planting monocultures cannot be considered as rehabilitation of mangrove ecosystems; at best it would produce a plantation that is not likely to deliver much of the ecosystem services. Care is needed to ensure species diversity. Evidence was also presented to show that 'ecosystem restoration' cannot be approached solely through the planting of mangroves.

Encroachment and Land Accretion

The meeting discussed the possible impact of planting mangroves in the inter-tidal area, as done by TCP. Similar mangrove planting programmes in the Negombo Lagoon had been a key factor that allowed coastal communities to further encroach the borders of the Negombo Lagoon (Fig. 2.1). As the mangroves get established,

they trap sediment and stabilize the soils. Mangrove planting programmes enabled families to build houses in what was previously the inter-tidal area of the Negombo Lagoon.

The meeting was agreed that planting mangroves in the inter-tidal areas of Puttalam Lagoon could, in the future, lead to siltation and further encroachment by coastal communities. However, the TCP mangrove planting in the Kalpitiya Peninsula (over 40 km long, an inter-tidal area exceeding 1.5 km and at least 6,000 ha in extent) is not expected to have a significant negative impact. The TCP mangrove plantings amounted to only 0.0025% of the inter-tidal area of the western shoreline of the Puttalam Lagoon. Hence, TCP felt that the 15 ha of mangrove planted by them along the Kalpitiya Peninsula is unlikely to significantly change siltation rates or promote encroachment. Elaborating further, TCP indicated that if the communities and the Forest Department approve, they will thin out the stands or if appropriate, clear fell selected areas, in the future. This would cause a reversal of any localized siltation, through natural processes such as wave action and erosion of the inter-tidal area during subsequent monsoons.

Fig. 2.1 Negombo lagoon - mangroves and constructions (Ranjith Mahindapala)

It was noted that while there is merit in planting mangroves it is necessary to examine the hydrological aspects before planting or undertaking any rehabilitation programmes to clearly understand the hydraulic dynamics of the lagoons and estuaries.

5. A National Mangrove Coordination Centre is an urgent need

Several incidents were cited during the presentations and discussions that showed the lack of an overall authority or controlling body is an impediment to mangrove conservation and management in Sri Lanka. It was pointed out that this was a significant factor in contributing to the failure of most post-tsunami mangrove restoration and rehabilitation projects. The need for greater control over future interventions in the conservation, management, restoration or rehabilitation of mangroves in Sri Lanka was the general consensus.

It was also noted that mangrove management js currently under several agencies, notably the Forest Department, Dept. of Wildlife Conservation, Coast Conservation Department, Provincial Authorities etc. Of course, this calls for a great deal of coordination among those organisations which is not all that easy to achieve. Whilst acknowledging the important role played by government departments in regulating future interventions, it is also necessary to enlist the support of other agencies such as NARA, NAQDA, Fisheries Department, academia, and NGOs to provide technical guidance, management support and critical evaluations of future programmes.

The colossal failure of post-tsunami replanting efforts calls for greater scrutiny of future programmes by government authorities. They should especially ensure that the proposed interventions are the most appropriate for the given location. It was also felt that future proposals that include planting mangroves should have the approval and recommendation of a relevant authority.

In this regard, it was felt that there should be one agency to coordinate and approve mangrove replanting/restoration activities. Coordination will be facilitated by revising the Coast Conservation Act, so as to include 'planting and replanting of mangroves' under the activities that require a permit from CCD. CCD stated that they were indeed in the process of revising the CCD Act; one objective being to better integrate the existing legislation applicable to the management of coastal ecosystems, of which mangroves are, no doubt, an integral part.

The call for a National Mangrove Coordination Centre also received a positive endorsement from the participants, underscoring the general agreement for a central body capable of gathering and sharing information, providing technical guidance and leadership, and with authority to coordinate the future of conservation, management, restoration and rehabilitation of mangroves in Sri Lanka.

(Kumudini Ekaratne)

3. Field Observations[10]

This chapter analyses some post-tsunami field observations and complements the presentations and discussions at the two colloquia. The field observations are mostly photographic records depicting post-tsunami efforts to develop bioshields, mangrove habitat restoration, rehabilitation of ecosystems, etc. In some instances, photographs of the same locations in 2007 are included for comparison. Photo captions and the accompanying text explain the long-term consequences of these interventions, and seek to bring out inherent flaws vis-à-vis land use and legal requirements.

Mangroves as Bioshields

Box 1 presents some design features for mangrove bioshields culled from the proceedings of a regional technical workshop held in 2006 (FAO, 2007). These design features can serve as a reference to assess the utility value of mangrove bioshields planted in Sri Lanka after the 2004 tsunami.

Fig. 3.1 shows the form of an adult mangrove tree, *Rhizophora mucronata,* to illustrate the development of the root system, and to visualise how a collection of these trees can form a bioshield. In regard to bioshields, it is also necessary to consider the following aspects:

- Technical design specifications and other aspects in site selection, and the width and length of the proposed belt of vegetation.

- Land preparation is very important but often neglected due to cost considerations. Sometimes, the existing sediment shoals may have been removed prior to 'implantation' of mangrove seedlings. Such an intervention, at least temporarily, would have increased the surface area of water that is critical in hydrodynamics.

- Check the chosen site for impeded water circulation and sedimentation. For example, Fig. 3.2 is a site partially enclosed by a road resulting in impeded water circulation and increased sedimentation.

- Ability and capacity of those who planted mangroves to provide after-care, including removal of trapped debris, until the plants acquire a girth and size that can withstand the force of flowing water.

These aspects are illustrated in Figs. 3.2 and 3.3.

10 This section is based on field observations of Dr J I Samarakoon, Dr T Jayasingam and Prof. S Epitawatta.

Box 1. Some design features of bioshields ***(Source FAO, 2007)***

Effectiveness of mangroves vegetation in mitigating a tsunami or storm surge can be estimated from numerical simulations using roughness coefficients such as Manning's roughness, drag force and inertia. Simulation results of an inundated area show that vegetation can reduce tsunami and storm surge wave height, and current pressure up to a certain degree. The inundated area and tsunami wave or surge wave run-up will decrease when the coastal forest density increases. Studies show that the effectiveness of mangroves as a protection measure from wind generated waves depends on mangrove age, which correlates with mangrove density (Latif and Hadie, 2007).

Width of bioshields: Mangroves constitute excellent wind bioshields for protection against typhoon winds; a 500 meters wide belt may suffice. Empirical evidence from an actual cyclone suggests that a much wider coastal forest (up to one or two kilometres), is required to measurably protect the hinterland. However this has not been scientifically tested. To arrest coastal erosion by typhoon waves, field evidence indicates that in shallow coastal waters, a coastal belt of **adult** mangroves, 500 to 1,000 meters wide, is necessary as the first line of defence, to protect small coastal dykes that can halt further coastal erosion. Thus, the protection is a two-step process: first, the mangroves absorb the brunt of the wave energy, and then a small coastal dyke absorbs what's left (Wolanski, 2007).

Planning for mangrove planting:

An integrated approach is necessary in planning disaster management in coastal areas, to accommodate, as far as possible, conflicting objectives such as ecosystem management, housing and economic development. This should reduce the exposure to disasters. Possible occurrence of multiple hazards should not be ignored in planning for coastal areas. Coordinated, integrated and participatory planning is an effective way to enhance coastal area management and the role of trees and forests in coastal protection.

Planting Mangroves for Ecosystem Restoration

The deliberations at the colloquia emphasized that a great deal of planning should go into planting mangroves. Perhaps, the rush to plant mangroves, in the aftermath of 2004 tsunami, did not allow sufficient time for integrated planning and serious consideration of the recommendations for mangrove rehabilitation (MENR/UNEP, 2005). Figs. 3.4 and 3.5 illustrate such hasty plantings done by government agencies with donor support. These initiatives are scientifically unsound, and unlikely to benefit the ecosystem.

Fig. 3.1 - The form of an adult 20 years old mangrove tree *(Rhizophora mucronata)*

This kadol tree (*Rhizophora mucronata*) stands at the edge of the Municipal playground, Puliantivu South, Batticaloa. It is one of several planted by Mandru, an NGO in the early 1990s (Mano Rajasingam, President, Mandru, personal communication). This plant, about 10 meters in height, almost 20 years in age, has acquired adult dimensions since it was protected and maintained. Note that the well developed root system, almost as extensive as the tree canopy, has expanded and built up a stabilized platform of sediment. This should serve as a reference, to visualize the form of the 'bioshields' planted in the post-tsunami period, in the long term. The impending loss of water surface area can be easily imagined (J I Samarakoon).

Fig. 3.2 - Form of some post-tsunami 2004 mangrove (*R. mucronata*) bioshields in Batticaloa Lagoon

Left – Photograph of a patch of mangroves soon after planting in 2007 (J I Samarakoon).

Right – Situation in 2009 (J I Samarakoon).

Evidently, survival has been poor. These mangroves were implanted as a part of a bioshield project after the 2004 tsunami. Note the position along the lagoon edge where sedimentation occurs readily. The width, length and density of trees in a vegetation belt are critical factors that determine the effectiveness of a bioshield (FAO, 2007). Perhaps these aspects were not taken into consideration at planting.

Left - mangrove seedlings planted along the lagoon edge in 2007. A few have survived with their spreading roots. The site is in a part of the lagoon where the hydrology is already impeded by a new road that transects the water. Garbage dumped at the site will add to the trapped sediment load (J I Samarakoon).

Right – photo taken in 2009. The signboard declares 'mangrove bioshield project'. Undoubtedly, the debris being trapped among the seedlings, would eventually add to sediment deposition. With time the grass would creep into the water and create a fringe of land (J I Samarakoon).

Fig. 3.3 - Mangrove bioshields: always planted at the lagoon edge where sedimentation is fastest - Batticaloa Lagoon

Photograph taken in 2009. Mangrove seedlings fronting an already sedimented strip between the road and the water spread. As the mangroves grow, more water surface will be lost (J I Samarakoon).

Photograph taken in 2007. Mangroves fronting an extensive strip of grass which has spread over and stabilized deposited sediment. Sedimentation is faster along the edges where the current speed is slower (J I Samarakoon).

Photograph taken in 2009. Traditional small scale shrimp fishing with cast nets. Some mangroves have been planted at the fringe. The seasonal upsurge in shrimp production is associated partially with abundant, submerged seagrass beds (J I Samarakoon).

Photograph taken in 2007. A patch of mangroves planted as a bioshield (note the signboard on the left). Trapping of debris is evident (J I Samarakoon).

Fig. 3.4 - Unplanned mangrove rehabilitation in Batticaloa Lagoon

Batticaloa Lagoon 2009 & 2007. The permanent structure on the left now (2009) stands on a filled part of the lagoon. Note the Neem tree on the right as a reference. The project originally intended to plant two ha of mangroves, but sedimentation is evident (J I Samarakoon).

Fig. 3.5 - Mangrove seedlings planted as a component of a project to rehabilitate coastal ecosystems

Post-Disaster Rehabilitation of Coastal Ecosystems in Batticaloa District' - a project to plant 60 ha of mangroves. Photo shows only a patch of about 60 mangrove seedlings.

Here again, the already sedimented area, stabilized by grass, remains intact while an additional strip would shortly become silted. Whether attempts such as these will result in a 'rehabilitated ecosystem' is questionable (J I Samarakoon).

Fig. 3.6 is from a project in the Pottuvil Lagoon, a small brackish water body which supports a small scale traditional fishery. It is protected on the seaward side by a dune system. It is difficult to understand how this small lagoon, already severely silted, was selected for planting mangroves. This mangrove planting and the encroachment by a poor landless resident into an area about 25 m^2 (i.e. 0.02% of 12 hectares planted by the project) are equally harmful to the ecosystem.

Fig. 3.6 - A poor householder capturing land in Pottuvil Lagoon

Pottuvil Lagoon – 2009. The photo on the left shows the attempt made by a poor resident to stabilize a piece of land captured from the lagoon. A project has now pledged to plant 25,320 mangrove seedlings covering 12 ha along the fringes of this small lagoon. The long-term hydrological consequences of these two actions, encroachment by the poor local resident and mangrove planting by the project, will be no different (J I Samarakoon).

An instance where mangroves might actually impede natural drainage is shown in Fig 3.7.

Mangrove planting interventions gathered momentum following the tsunami. Some inferences that emerged from observations made in the field are as follows:

- Hurriedly implemented interventions, without planning, and in short project periods of 12-24 months, do not bring the desired results. According to expert opinion *(Box 1)*, it takes about five years for proper integrated and participatory planning and implementation. This was also reflected at the colloquia.

- Many mangrove projects have been 'abandoned' after planting when the donor withdrew on project completion. Essentially, long-term commitment of the implementing agency is required for monitoring and maintenance to address negative externalities.

Fig. 3.7 - Mangroves planted along the eastern boundary of the Tirukkovil Lagoon

Tirukkovil 2009. Mangroves planted along the fringe of the lagoon. If the mangroves fronting the exposed land in the foreground survive and create a 'hydrological unit' that impedes drainage, it would certainly contribute to the backflow of saline water into adjoining paddy fields. If the sedimented marsh was dredged to prepare the land for mangrove planting, the hydrology and hydraulics at this location would have been enhanced and thereby expanded the surface water spread (J I Samarakoon).

Fig. 3.8 illustrates the 'hydrological units' resulting from various man-made interventions.

Fig. 3.8 - Examples of hydrological units, of recent origin, that influence drainage and flood protection in Batticaloa Lagoon. The role of mangrove units in the long term must be viewed in the perspective of their progressive transformation into hydrological units that impact the forces controlling the movement of water and sediment.

Batticaloa Lagoon 2010, Vavunativu: New paddy fields being constructed encroaching on sections of the lagoon included within the existing surface spread (J I Samarakoon).

Batticaloa Lagoon 2010, Koddaikallar: completed bridge which demonstrates its efficiency in the obstruction of hydraulics resulting eventually in increased sedimentation. A significant hydrological unit! (J I Samarakoon).

Batticaloa Lagoon, 2010, Kokkadicholai. Shrimp ponds with water control structures which influence hydrology and hydraulics (J I Samarakoon).

Batticaloa Lagoon 2010, Some paddy fields at Mandoor bordering the lagoon. These influence hydraulics, while imposing a need for maintaining freshwater conditions (J I Samarakoon).

Similar situations are evident from other locations in the Eastern Province (Figs. 3.9).

Fig. 3.9 - Mangrove planting at some locations in the Eastern Province (other than Batticaloa Lagoon).

Location unknown. This mangrove planting shares common features with the other photos - the planting fronts existing mangroves, evidently without any form of land preparation or consideration given to water flow, fish habitat or hydrology (T Jayasingam).

Kinnya, Trincomalee: 2009. Mangrove seedlings have been planted fronting an eroded strip of coast which evidently was stable in the past. The coconut stumps suggest that coconut palms were grown along this strip of land. The concrete wall on the right is evidently a protective structure constructed after the 2004 tsunami to protect the road infrastructure seen further to the right. Perhaps, the mangrove seedlings were planted as a part of a bioshield project or specifically to protect against erosion. It would be necessary to verify the dimensions and layout of the initially planned intervention (T Jayasingam).

Fig. 3.10 - Rekawa Lagoon, mangrove rehabilitation in the post-tsunami period

The photos here were taken in January 2010 at the boat landing site (thotupola), while the photos below of newly-planted seedlings (Rhizophora sp.) were taken, at the same site, in October 2007. The seedlings were planted in the water adjacent to the shore but without any form of land preparation. Sediments have already been stabilized by mangroves and grass. Evidently, some seedlings have grown well into stands that will continue to trap sediment and build-up land. From a drainage standpoint, the well developed mangrove clumps now rank as 'hydrological units' that influence the forces that control the movement of water and sediment (hydraulics) (J I Samarakoon).

The following sections carry illustrations from the Rekawa Lagoon, Tangalla.

Rekawa Lagoon is a 270 ha relatively small lagoon, which supports a few small scale fishing households. Some householders declared that their income from fishing is meagre. Mangrove planting offers a very attractive income opportunity. Some agencies pay, on average, Rs. 10/= per planted mangrove seedling and in some months their income rose to about Rs. 10,000/=. These same 'beneficiaries' are now concerned by the narrowing of their 'thotupola' (=boat landing site) in particular, and shrinkage of the water body, in general. The communities are now helpless and feel they have been misled into believing that planting mangroves will improve their catch (Fig. 3.10).

The issues in Rekawa lagoon are depicted in Figs. 3.11 and 3.12.

Fig. 3.11 - Rekawa Lagoon - Kapuhenwala bridge, a significant 'hydrological unit', which impedes hydrology and hydraulics in Rekawa Lagoon. Mangrove planting requires integration with its impacts on sediment movement.

The Kapuhenwala Bridge has been implicated in diminishing fishery in Rekawa Lagoon. The bridge obstructs recruitment of early stages of fish and shrimp into the body of the lagoon when the connection to the sea opens during the rainy season. Diverse interventions have been implemented to improve the hydrology and fishery but lasting impacts are missing. Serious socio-political analysis, based on costs and benefits, is essential at the planning stage, to avoid such blunders (S Epitawatte).

Fig. 3.12 – The interaction between mangroves and the sedimentation processes in Rekawa lagoon.

Rekawa Lagoon, 2010. Row of mangroves planted since the tsunami 2004. The row fronts another species of mangroves (Avicennia sp.) which has already formed a land platform (S Epitawatte).

Rekawa Lagoon 2010. At some locations reed beds front mangroves (Avicennia sp.) and contribute to sediment build-up in the low salinity environment. Tidal exchange is cut off most of the year (S Epitawatte).

Luxuriant, stand of mangroves species, suggestive of excellent soil conditions. Filamentous algal blooms indicate availability of nitrates. Sedimentation is evident (S Epitawatte).

Rekawa Lagoon 2010. Seagrasses (probably Halodule sp.) grows submerged as extensive meadows. Seagrasses synergistically stabilize sediment with mangroves (S Epitawatte).

Rekawa Lagoon 2010. Extensive patches of partially decayed filamentous green algae, a good indicator of eutrophication in brackish water bodies. Decaying algae eventually add to organic deposits (S Epitawatte).

Rekawa Lagoon 2010. An extensive sediment shoal (note the egret). A clump of mangrove (R. mucronata) stands sentinel over the neighbouring sediment shoal. What is the destiny of these stabilized shoals? (S Epitawatte).

Interviewing members of bodies with financial interests in mangrove planting revealed that:

- Donors were supportive of the way mangrove planting was carried out recently, after the tsunami
- There was general lack of understanding of the negative externalities such as accelerated sedimentation encountered in the mangrove plantings done recently
- There is a need for clear guidelines on how to plant mangroves in the future. Integrated planning prior to the commencement of planting is a must.

Conclusions

The following conclusions were drawn from field observations and other discussions:

(i) Planting mangroves in the barrier built estuaries and lagoons has contributed to sediment build-up in these water bodies.

(ii) Bioshields seem to have been planted without any reference to technical criteria, readily available in the relevant literature.

(iii) Recently planted bioshields do not show any evidence of being properly maintained, with long term commitment, at least until they attain the appropriate girth.

(iv) Mangroves have been planted on some sites with a conspicuous deposition of sediment. By planting the seedlings slightly away from the existing sediment strips, fresh land creation has been facilitated.

(v) Casual interviews with some special interest groups involved in mangrove planting in the Puttalam, Batticaloa and Rekawa Lagoons revealed that planting took place without any permits from the relevant authorities.

(vi) On occasion, regulatory bodies were partners in mangrove planting projects. Perhaps, a conflict of interest.

(vii) The burden of negative externalities is placed squarely on the livelihood interests of the poorest segment of the communities that depend on the fishery productivity of the barrier-built estuaries and lagoons. This is also the segment of society with the least power and organizational capacity to engage in public protest.

(Ranjith Mahindapala)

4. Appropriate Mangrove Restoration in Barrier-built Estuaries and Lagoons[11]

Introduction

This chapter addresses the options and considerations for appropriate mangrove planting based on the outcomes of the colloquia, literature survey and field observations.

Site selection is key to appropriate mangrove restoration in barrier-built estuaries and lagoons. As a prelude to a discussion of the principles applicable to site selection the definitions of some important terms are set out below.

- **A site** is defined as a landscape feature which has inherent ecological and geomorphological attributes. A particular barrier-built estuary or lagoon may be a unitary entity, where uniform conditions prevail at all locations within its water boundary, or it may have a high diversity of conditions within its boundary. The former situation, 'unitariness', does not exist in barrier-built estuaries and lagoons in Sri Lanka owing to the micro-tidal nature of these water bodies and very weak mixing within the water mass by way of tidal currents. The barrier-built estuaries and lagoons are highly diverse and exhibit site-to-site variation within their boundaries. Therefore, the term site is applied with high specificity; it is not adequate to state that mangrove restoration is done in a particular lagoon, but the mangrove restoration site should be specified by its coordinates.

- **Hydraulics**: The forces that influence the movement of water and sediment, particularly the influence of hydrological units on drainage through barrier-built estuaries and lagoons.

- **System**: A natural or artificial composition of interacting and interdependent parts. Barrier-built estuaries and lagoons are complex systems in which mangroves constitute a component.

- **Closed System**: A system that is partially or completely enclosed and separated from the wider environmental setting in which it is situated. The barrier-built estuaries and lagoons are situated on the 'submergence' coastal plains of Sri Lanka where they emerged by way of sediment barrier formation that automatically led to semi-enclosure.

11 This section was compiled by Dr J I Samarakoon, based on the outcomes of the colloquia, literature survey and field observations.

- **Mangrove Restoration**: Whenever mangroves are planted in barrier-built estuaries and lagoons in Sri Lanka it has been labelled as 'restoration' or 'rehabilitation', or as bioshields. Therefore, it is necessary to be clear about the meaning of restoration. In this reassessment, restoration means 'to bring back to its former state'. This is the same sense in which the literature on mangroves uses the word restoration (Lewis, 2005). This is also the sense in which the term restoration applies in every field of human endeavour, ranging from health to archaeology. Restoration never means an action that changes the original state or creates a novel one. Therefore, using titles such as 'mangrove restoration', 'mangrove rehabilitation' and 'ecosystem restoration' to describe mangrove planting on sites where mangroves were not found before is deliberately misleading. Thus planting mangrove seedlings in a site where mangroves did not exist before, **is not restoration** (see Fig. 4.1) - it is simply planting of mangroves.

  Mangroves planted as 'bioshields' for protecting life and property from coastal hazards have to conform to certain standards and specifications, particularly in regard to the width of the planted area.

Guidelines for Mangrove 'Restoration'

Several guidelines and best practices are available to steer mangrove planting generally, in a range of tropical countries and specifically, in Sri Lanka. Lewis (2005) provides a comprehensive review of mangrove restoration worldwide and presents the basic guidelines and the technical foundation for mangrove restoration. Some of the recent guidelines for Sri Lanka have been inspired by the upsurge in post-tsunami mangrove planting activities. The first task then is to examine the most recent guidelines and assess how appropriate they are for mangrove restoration in the sense proposed in this re-assessment. It is significant that most of these guidelines are for '**restoration**', i.e. **'re-establishment where they existed previously'**. And equally significant is that mangrove seedlings were mostly planted where mangroves did not exist previously. Evidently, there is a serious discrepency between what the guidelines preach, and what the implementers practice, in Sri Lanka.

Erftemeijer and Lewis (2000) note thus, "… for the majority of papers written on mangrove restoration, there is an immediate assumption that mangrove restoration means mangrove planting. This leads then to ignoring hydrology and natural regeneration via volunteer mangrove propagules, and many failures in attempts to restore mangroves."

This section examines the Guidelines available both internationally and locally.

International Guidelines

Two examples of guidelines are provided from the international technical literature to serve as references. The authors are very senior technical specialists from Australia and India with long experience in the subject. Their suggestions will be useful in assessing the guidelines for Sri Lanka set out subsequently.

Fig. 4.1 - Mangrove seedlings planted in Batticaloa Lagoon at a site where mangroves were not known to exist for many decades

Mangrove seedling implantation in sites that did not host mangroves before is quite typical of mangrove 'restoration', mangrove rehabilitation, ecosystem restoration and 'bioshield' establishment projects in Sri Lanka's barrier-built estuaries and lagoons. These cannot be considered as restoration projects as the sites were devoid of mangroves before (J I Samarakoon).

(a) Prof. Peter Saenger: Sustainable Management of Mangroves

Saenger (1993) covers the basic orientation required in mangrove management:

Ecological Sustainability

- Maintaining the genetic diversity of the area involved
- Maintaining the resilience of the ecological systems affected
- Maintaining the biological productivity of the area

Economic Sustainability

- Satisfy basic needs of the resident population and reduce poverty
- Enhance equity through ownership, management responsibility and participation in decision making

- Increase the useful goods and services used in the area or region

Sustainability of the Social System

- Maintaining the cultural diversity of the region
- Sustaining local and national institutions and traditions
- Ensuring social justice
- Ensuring full participation through decision making, employment and training

Truly sustainable systems of mangrove management need to address each of the above objectives (Saenger, 1993). From a global perspective, dating back to the early 1990s, mangrove specialists viewed mangrove management as a part of complex systems, including bio-physical, economic and social components.

(b) Prof. K. Kathiresan: Conservation and Management Strategies – Restoration Technologies

Major goals of restoration of mangrove habitats are three fold:

1) Conservation of rich biodiversity
2) Sustainable utilization for fishery, forestry and other products
3) Protection of coastal areas from the fiery effects of tidal waves and cyclones

Restoration of an ecosystem can be defined as the act of bringing it back nearly to its original conditions. Several other terms used for this purpose are rehabilitation, regeneration etc. (Field, 1998). There are two types of activities in planting of degraded areas, namely natural regeneration and artificial regeneration.

Natural regeneration may be by way of establishment of seeds of mangroves and/or by way of changes to hydrodynamics:

- Natural regeneration involves the natural process of establishment of 'seeds' of mangroves. This method is advantageous because it produces the forest pattern similar to the original forest, and it is cheaper and less disturbing to the habitat. It may not be successful in places where the seeds are not readily available, and in places where there is excessive weed growth, debris, poor soil and disturbed hydrodynamic conditions.

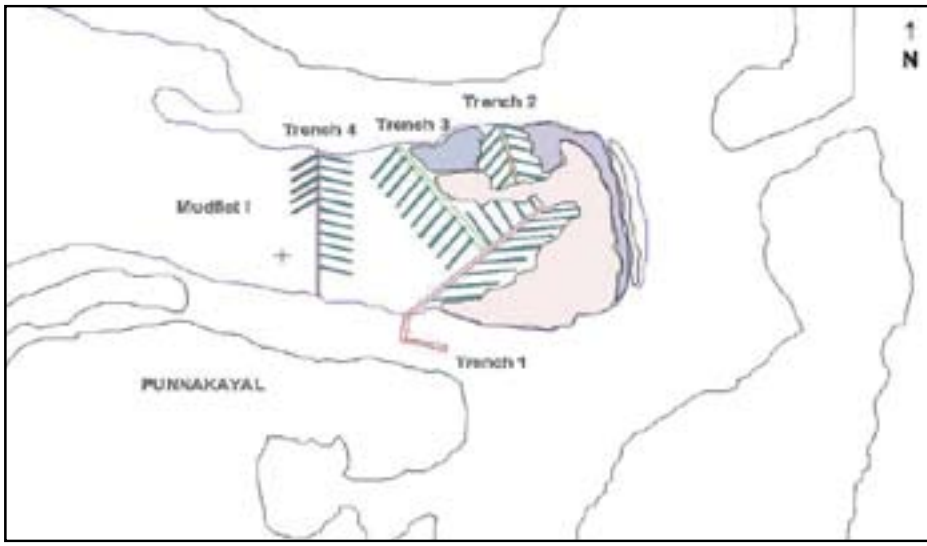
- Hydrological manipulations are of great help in natural regeneration. For example, in USA, mangrove restoration was achieved over 500 ha at a site in West Lake, Florida. This succeeded even without any artificial planting, by simply using a combination of excavation of dredged material and hydrologic restoration (Lewis

1990a, Lewis and Streever 2000). Another form of this hydrologic restoration is to reconnect impounded mangroves to normal tidal influence (Turner and Lewis, l997). The cost of restoration was maintained at a minimum of US$250/ha with careful placement of culvert openings to impounded mangrove wetlands along the Indian River Lagoon, USA (Brockmeyer *et al*., l997).

Artificial regeneration involves planting of seeds or seedlings in areas where planting material is inadequate. Hence, the seedlings are transplanted or seeds collected from other areas are planted directly or after raising saplings in nurseries. If the source of these planting materials is too far away, then vegetative propagation techniques are required to produce planting materials at the site to be restored. This is a labour-intensive method. The rare species that occur in small numbers may be micropropagated through tissue culture techniques. However, this is a costly and challenging process. Artificial regeneration has its own merits: species composition, distribution and density of seedlings can be controlled; genetically improved stocks can be developed; degraded areas can easily be regenerated; and the objectives of afforestation such as conservation, sustainable yield, and protection of coastal areas can be pursued.

Mangroves for the Future (MFF) National Strategy and Action Plan (NSAP) India (Revised draft) recommends the "Canal Bank Planting System (Fish bone design)" for mangrove restoration in low tidal-amplitude sites *(Box 4.1)*. The technique, reportedly, has been applied with good results in Tamil Nadu where tidal amplitude is low (http://envfor.nic.in/divisions/cs/mangroves/NSAP/NSAP.pdf). The particular hydraulic benefit of this mangrove restoration system, for Sri Lanka, may be its contribution to increasing the surface water spread of a micro-tidal barrier-built estuary. This technique should be applied only after proper and meticulous site selection for mangrove restoration, in consultation with the local communities, and verified using aerial photographs. From a fishery enhancement standpoint, the 'fish bone' design of the canal system extends the habitat for early stages of fish and crustaceans, which prefer the shelter of inter-tidal mangroves.

Box 4.1. Recommended technique for mangrove restoration in low tidal amplitude areas



Low tidal amplitude areas such as Tamil Nadu and Andhra Pradesh have developed a planting technique called "Canal Bank Planting' for restoration of mangroves. The 'Fish bone' design is the latest and most successful design for canal bank planting. This technique involves the construction of the feeder canal (3 m top width x 1 m bottom width x 1 m depth) and distribution canals (2 m x 0.75 m x 0.75 m) in the mud flats, and planting propagules directly in the inter-tidal zone of the canal banks. Biodiversity enrichment, however, is left to nature, and nature does it very efficiently. In a nutshell, wherever tidal amplitude is low, the canal bank planting technique using the fish bone design is the preferred system for restoration (J I Samarakoon).

Source Prof. K. Kathiresan, Annamalai University. http://www.padgom.org/mangroves.html

Sri Lankan Guidelines

Comments on the appropriateness of two sets of guidelines, specifically formulated for Sri Lanka, are presented in tabulated form.

(a) Best practice guidelines on the restoration of mangroves in Sri Lanka[12], published by The Green Coast Project, The Netherlands

The concept and guidelines are summarized in *Table 4.1.*

Table 4-1: Comments on the appropriateness of Green Coast's 'Best Practice Guidelines on the Restoration of Mangroves in Sri Lanka'.

Concept & Definitions	Output	Comments
Definition of mangrove restoration	Re-introduction and re-establishment of assemblages of native mangrove species to sites that can support them, to be developed into mangrove ecosystems, which perform similar functions as those that were there originally	Key expressions: Re-introduction; and 'those that were there originally'. Shortcoming: Absence of techniques to achieve the defined output
Objective of mangrove restoration	Re-establishment of habitats (structure) and functions such as coastal protection, contribution to fishery production, enhancement of aesthetic quality of the landscapes that have been lost.	Key expressions:Rre-establishment, coastal protection, enhancement of lost aesthetic quality. Shortcoming: Absence of techniques to achieve the desired outputs
Objectives of the guidelines	Dissemination of appropriate knowledge and understanding of the following aspects of mangrove silviculture (planting) for coastal protection: 1. Uniqueness of mangroves and the potential benefits of their cultivation 2. Identification of appropriate land for mangrove cultivation 3. Selection of mangrove species and combinations for planting 4. Methods of mangrove cultivation 5. Technical know-how on establishment and maintenance of mangrove nurseries 6. Factors that affect success of mangrove plantations 7. Techniques of after-care 8. Strategies to mobilize communities for mangrove silviculture	Shortcoming: Absence of indicators to monitor, and mechanisms to ensure, the long-term outcome.

12 http://www.wetlands.org/WatchRead/tabid/56/ArticleType/ArticleView/ArticleID/2041/PageID/1251/Default.aspx

(b) Guidelines issued by the Sewalanka Foundation

These guidelines for mangrove restoration in Sri Lanka were formulated at the training workshops organized jointly by the Mangrove Action Project, an international NGO, and the Sewalanka Foundation, Sri Lanka. Roy R Lewis, Certified Professional Wetland Scientist, President Lewis Environmental Services Inc., USA provided seminal inputs to the workshops.

An analysis and assessment of these guidelines, in the context of Sri Lanka's micro-tidal, barrier-built estuaries and lagoons, is presented in Table 4.2. It may enable the identification of criteria that have been ignored.

Box 4.1. Difficulties Encountered in Drawing Lessons from Failed Mangrove Restoration Projects

Unsuccessful (or only partially successful) projects are rarely documented (Lewis, 2005). Field (1998) reports that after contacting numerous international organizations to get an overview of mangrove restoration work worldwide - "(T)he response was almost complete silence". He attributed this to bureaucratic sloth, proprietary reluctance to reveal important findings, inadequate dissemination mechanisms and a myopic view of the general importance of rehabilitation programmes. Few scientists or organizations wish to report or document failures. In summary, a common ecological engineering approach should be applied to habitat restoration projects. The simple application of the five steps to successful mangrove restoration outlined by Lewis and Marshall (1997) would at least insure an analytical thought process, and less use of "gardening" of mangroves as the solution to all mangrove restoration problems. Those involved could then begin to learn from successes or failures, act more effectively, and spend limited mangrove restoration monies in a more cost-effective manner.

Table 4.2 – An analysis of the Guidelines formulated at the workshop held by the Mangrove Action Project and the Sewalanka Foundation, Sri Lanka

Concept & Definitions	Output	Comments
Definition of mangrove restoration	"...process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed". The goal of this process is to emulate the structure, functioning, diversity and dynamics of the specified ecosystem, using reference ecosystems as models.	Thus, for the majority of papers written on mangrove restoration, there is an immediate assumption that mangrove restoration means mangrove planting. This leads then to ignoring hydrology and natural regeneration via volunteer mangrove propagules, and many failures in attempts to restore mangroves (Erftemeijer and Lewis, 2000). Also see *Box 4.1*)
Objective of mangrove restoration	"… development of sustainable livelihood alternatives and non-timber forest products uses of mangroves …" (Sewalanka Report)	Restoration or rehabilitation may be recommended when an ecosystem has been altered to such an extent that it can no longer self-correct or self-renew (Lewis, 2005).
Objectives / Guidelines	1. Understand the autecology (individual species ecology) of the mangrove species at the site, in particular the patterns of reproduction, propagule distribution and successful seedling establishment. 2. Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species. 3. Assess the modifications the original mangrove environment underwent that currently prevents natural secondary succession. 4. Design the restoration program to initially restore the appropriate hydrology and utilize natural volunteer mangrove propagule recruitment for plant establishment. 5. Only utilize actual planting of propagules, collected seedlings or cultivated seedlings after determining, through Steps 1–4, that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization or rate of growth of saplings, established as goals for the restoration project. (Lewis and Marshall, 1997)	The term 'hydrology' is used in the workshop proceedings. In this re-assessment the more specific and confined term 'hydraulics' is used since its implications are more readily measured and monitored.

Lessons for Revising Guidelines for Mangrove 'Restoration'

The following general lessons have been identified:

Lesson 1	Do not plant mangroves where they did not exist previously.
Lesson 2	An integrated systems approach, which includes ecology, economics and sociology should be used for site selection.
Lesson 3	Do not undertake mangrove restoration without adequate knowledge of the site history based on careful mapping that spans adequate and verifiable time sequences (e.g. from aerial photographs).
Lesson 4	Hydrological manipulation, by itself, can be adequate for natural mangrove restoration, by enabling hydraulic forces to create conditions suitable for natural mangrove seed fall to establish
Lesson 5	Thorough after care and monitoring, ensure that the ecological role of restored mangroves is similar to that of the original mangroves. A reference site must be identified for the purpose of technical comparisons.
Lesson 6	Planting of thin belts of mangroves may not provide the protection of 'bioshields' effectively. In barrier-built estuaries and lagoons it is practically impossible to create belts of the required width (e.g. 500 meters).

Revised Basic Guidelines for Mangrove Restoration in Barrier-built Estuaries and Lagoons in Sri Lanka

Guidelines are not suggested for planting 'bioshields' within barrier-built estuaries and lagoons. It is physically impossible (no space is available) to grow mangrove belts that are about 500 meters wide and several hundred meters long without displacing small-scale fishing activity. The potential for effective bioshields in these water bodies is minimal in Sri Lanka. Indiscriminate planting of mangroves in barrier-built estuaries and lagoons can result in irreversible damage to the ecosystem.

Guidelines need to address the morphodynamics (evolution of structure) of barrier-built estuaries and lagoons. Thus, revision of existing guidelines should take into account both an integrated planning and governance framework. Guidelines also need to take into account the regulatory functions of the state institutions mandated with mangrove management (see elsewhere).

Guidelines suggested below are for mangrove restoration at sites where they already existed and have been degraded owing to diverse natural and anthropogenic factors.

Planning

(i) Participation

Barrier-built estuaries and lagoons are life support systems for some of the poorest members of coastal communities. It is prudent to ensure their participation in any intervention in these ecosystems, which may affect their livelihoods. Participation may be voluntary or induced by cash incentives. It is noteworthy that mangrove planting is done, almost exclusively, by entities whose livelihoods do not depend on the aquatic system being planted.

- Community participation, in mangrove planting projects reported earlier, was promoted by incentive payments to members (about Rs. 10/= per planted seedling). A local resident claimed earning around Rs. 10,000/= per month by planting mangrove seedlings in Rekawa Lagoon, after the 2004 tsunami, which is impossible from fishing in the same lagoon. Whether such participation will bring the commitment necessary to care and protect the newly planted areas is questionable.

- Participants need to have a proper understanding of the structure and functioning of the particular barrier-built estuary or lagoon. This has to be achieved through awareness building. Interviewed community members who had participated in mangrove planting in the Batticaloa and Rekawa Lagoons were completely unaware of the consequences of sedimentation. They appear to have been misled into the belief that they were doing something 'good' for the life support system.

(ii) Imparting legitimacy

The decision to plant mangroves at a particular site must pass the test of legitimacy in development planning by answering pertinent questions and meeting certain criteria. Where long-term environmental consequences are involved what is of relevance is ecological time spans; not the project life spans for which funds are obtained by various entities. The legitimacy criteria are:

- Optimal benefit from a development opportunity: Is mangrove restoration the best way of benefiting from a development opportunity? As shown earlier, barrier-built estuaries and lagoons are in various stages of infilling. Therefore, mangrove restoration may be regarded as a benefit obtained from a development opportunity, only to the extent that it creates a proportionate expansion of the surface area of the water spread.

- Equitable distribution of benefits: Will all those who depend on the barrier-built estuary or lagoon for their livelihood activities obtain a share of the benefits, in the long-term. Or, will only a small segment of the dependent population receive a temporary/instantaneous cash benefit through their participation in mangrove planting?

- Environmental consequences: Can the long-term benefits to the structure and functioning of the entire barrier-built estuary or lagoon ecosystem be proven on the basis of appropriate technical indicators, monitored in the long term (ecological time)?

- Prevention of negative externalities: Will those who benefit from incentive payments for restoring mangroves, do so at the expense of those who do not benefit, and will continue to depend on that particular barrier-built estuary or lagoon for their livelihoods?

Site Selection and Accountability:

Proper site selection is the key to appropriate mangrove restoration. An impact assessment matrix to determine the suitability of a site is proposed at (Table 4.3). Responses to the attributes/questions indicate the suitability/unsuitability of the site for mangrove restoration.

Appropriate species and planting systems:

Although some general information on appropriate species, nursery techniques and planting is available (IUCN, 2007)[13], there is a clear need for further research, particularly to address local-level issues. Some universities (e.g. University of Ruhuna) have current research programmes on these areas, but the knowledge base needs to be expanded.

13 Best Practice Guidelines on Restoration of Mangroves; IUCN Sri Lanka; 2007

Table 4.3 - Proposed impact assessment and accountability matrix

Attribute/Question	Response	Remarks
Geomorphology: Is the site a barrier-built estuary	Yes/No	The site is unsuitable if it is a lagoon where the tidal inlet is closed during most months of the year. It may be made suitable by way of an engineering intervention to maintain an open tidal inlet.
Is the site a lagoon	Yes/No	
Did mangroves exist there before	Yes/No	If yes, it must be substantiated by aerial photographs and oral histories of local residents. If no, the site must be rejected.
Hydraulic regime: was the current speed measured at locations near the tidal inlet and at the point farthest from it	Yes/No	If the current speed at the farthest point from an open tidal inlet is less than 1 meter per second, the site is unsuitable since sediment deposition is inevitable. In that event, the surface spread of water at a location where current speed is adequate must be dredged and expanded.
Is there a tidal effect and adequate salinity	Yes/No	If there is no tidal effect the site must be rejected.
Ecological regime: Eutrophication: Do filamentous green algae exist (e.g. *Chaetomorpha sp.*)	Yes/No	If filamentous green algae (blooms) exist, it is a certain indication of eutrophication stemming from excess nutrient entrapment. Mangrove planting may aggravate the situation resulting eventually in fish kills. The nutrient loads (particularly nitrate) need to be measured and interventions put in place to reduce particular nutrients at the source
Food web: What are the dominant species of fish and crustaceans? Are fish catches dominated by *Oreochromis sp.*	Yes/No	If yes, mangrove planting may further aggravate the situation since it would impede water circulation.
Economic justification: How many fisher households depend upon the particular system for livelihood.	• < 10 • < 100 • < 1,000 • > 1,000	Serious consideration toward mangrove restoration may be given on the basis of cost-benefit assessment only where the size of the dependent population of household exceeds 100.
Socio-politics Was an assessment made of the potential and risk of co-optation (commandeering) of restored areas for property development	Yes/No	If such an assessment was not made, the entity responsible for mangrove restoration must become legally accountable for safeguarding the restored area.
Developmental legitimacy Were all four legitimacy criteria taken into consideration	Yes/No	Mangrove restoration must not occur if the legitimacy criteria are not fulfilled.
Other pertinent questions where positive responses would favour acceptance of the venture: ***Monitoring indicators***: Were monitoring criteria identified and supplied to the regulatory body or implementing agency (e.g. CCD, Pradeshiya Sabha)? ***Accountability:*** Is there a commitment to safeguard the restored site at least in the medium term? ***Sustainability***: Is there a sustainability plan based upon returns on the investment, and cost/benefit assessment?		

(Ranjith Mahindapala)

5. Conclusions and Recommendations

Conclusions:

The reappraisal surfaced issues relating to mangrove 'restoration' and allied work. Barrier-built estuaries and lagoons, the main sites in Sri Lanka for natural mangroves and for mangrove planting, are closed systems. The colloquia highlighted the fact that these closed systems can only shrink in shape, size and productivity due to sediment entrapment arising from their situational character i.e. the physiography of the coastal plains, geomorphologic origins and continuing change processes, the micro-tidal regime, and detrimental land use in the catchment.

The failure to understand the nature of degradation and its complex aetiology is a major obstacle to corrective action. '***Creeping normalcy***' or the acceptance of a major change as normality when it occurs slowly and in unnoticed increments, is at the root of the problem. Progressive infilling is causing the barrier-built estuaries and lagoons to gradually die from sedimentation coupled with pollution. This progression is neither adequately recognized nor understood by (i) authorities responsible for their regulation and management, (ii) various households involved in day-to-day livelihood activities, (iii) infrastructure development sectors, and (iv) conservation-oriented organizations involved in activities such as mangrove planting[14]. Failing to recognize or disregarding creeping normalcy, slowly but surely, leads to environmental degradation.

The sediment budget for Negombo Lagoon prepared in 1990, together with other relevant measurements, show that sedimentation grows exponentially i.e. at a compounding rate. If sedimentation gets accelerated due to inappropriate mangrove planting, sooner will the barrier-built estuaries and lagoons cease to exist, and sooner will the communities be deprived of their diverse benefits. Unfortunately, the worst affected will be the poorest coastal residents who are highly dependent on these water bodies.

Considering the situational reality of mangroves in Sri Lanka some underlying misconceptions associated with mangrove planting should be dispelled. For instance, mangroves on shorefront deltas do not exist in Sri Lanka. Also, correlations among barrier-built estuaries and lagoons, mangroves, fishery and livelihoods should not be confused with linear cause-effect relationships, to justify indiscriminate mangrove planting.

Sedimentation facilitated by haphazard mangrove planting, which in the long term contributes to destruction of barrier-built estuaries and lagoons, is logically similar to

14 Please see the explanatory paper titled ***Physiography of Sri Lanka's Coastal Plains, Origin and Behaviour of Micro-tidal Barrier-built Estuaries and Lagoons and their Sedimentation with Mangrove Planting and other Land Uses*** prepared by Dr J I Samarakoon at Annex 6.

erosion facilitated by infrastructure development on beaches. This aspect, examined in the reappraisal, was independently supported by evidence from diverse sources, ranging from the better studied barrier-built estuaries and lagoons, to remote sensing, sediment budgets, and comparative photographic documentation. The evidence, based on planned studies and original research, is independently verifiable.

In course of the discussions it transpired that mangrove 'restoration' has been undertaken haphazardly without authorization or control from the agencies responsible for regulating the planting of mangroves in Sri Lanka. The failure of most post tsunami mangrove restoration and rehabilitation projects was attributed, in no small measure, to this serious lapse.

Recommendations:

Control over mangrove planting

1. Greater control should be exercised over future interventions in the conservation, management, restoration or rehabilitation of mangroves in Sri Lanka, and proper guidelines should be formulated. Until these guidelines are made available, future proposals that involve mangrove planting should be carefully scrutinized by government authorities, especially in order to select and recommend the most appropriate interventions at a given location. Prior approval for planting mangroves, from the relevant authority, should be mandatory.

2. The Forest Department, Department of Wildlife Conservation and the Coast Conservation Department are the three main state agencies managing mangrove areas. By agreement, one department should designated as the Competent Authority to grant approval for mangrove planting.

3. The Coast Conservation Department should consider including mangrove 'planting and replanting' under the list of activities that require a permit from the CCD, based on a technical appraisal. The Coast Conservation Act should be revised accordingly.

A central mangrove coordinating centre

4. A national mangrove coordination centre should be established. This should be a central body capable of gathering and sharing information, providing technical guidance and leadership, and have the authority to coordinate the conservation, management, restoration and rehabilitation of mangroves in Sri Lanka. It could be an arm of an existing government institution. This body should be well placed to mobilise and coordinate the large number of organizations and academics with mangrove-interests, and have the capacity to mobilize research and investment in mangrove conservation. Its efforts may also be oriented towards coupling mangrove planting with de-sedimentation, implemented in harmony with hydrology and hydraulics. Such a centre can coordinate and manage mangrove planting, which at present is fragmented and without proper, technically sound guidance.

Research and Studies

5. Commission, without delay, a comprehensive analysis of the current status of, and future risks to, Sri Lanka's mangroves in view of imminent challenges facing mangrove conservation and management.

6. Verify, objectively and scientifically, the total mangrove coverage, past and present, in Sri Lanka, as a key first step. Precise information on site-specific abundance, distribution and species composition, supported by ground-truthed maps are not available since the CCD maps of 1996. To overcome this foremost constraint to conservation, information on the exact location of mangroves, using both historical and contemporary remote sensing technology (i.e., aerial photographs and satellite images) should be collated[15] and analysed using a geographic information system. At each location where mangroves were and are still found, the species diversity needs to be reviewed, and where appropriate investigated further. It is only then that a meaningful dialogue is possible on the present status of, and best options for, conservation and management of mangroves.

7. Address problems affecting natural resources, subject to 'creeping normalcy', without delay to prevent them from crossing a potentially dangerous threshold.

8. An appropriate platform may be created to further verify the findings in this report. This may be done by a technical review panel which includes: a coastal engineer, experienced in sedimentary processes in barrier-built estuaries and lagoons; a geologist/geomorphologist familiar with coastal processes and the physiography of the coastal plains; a coastal ecologist familiar with the structure and functioning of complex socio-ecological systems including barrier-built estuaries and lagoons; a specialist who could integrate hydrological and hydraulic processes into mangrove ecology; and representatives of the Ministry of Environment, Coast Conservation Department, Forest Department, NARA and NAQDA. Meanwhile, a preliminary examination of the hydrology of estuaries and lagoons may be undertaken through colloquia, as for this reappraisal.

9. Carefully review the work done by the Small Fishers Federation and Turtle Conservation Project, who have planted about 200 ha of mangroves, in order to elicit key lessons in mangrove 'restoration'. Although their projects would have gained from a fuller integration with hydrological, ecosystem, and socio-economic processes, there are many elements that may be regarded as 'successes'.

Mangrove Planting

10. Undertake the conservation and management of mangroves as a matter of priority; these actions are more appropriate and urgent than planting propagules and seedlings. Mangroves are resilient and will recover easily.

15 A number of remote sensing surveys of mangrove have been conducted by the Forest Department, Integrated Resource Management Project in Wetlands, Coastal Resource Management Project, Ruhuna University and North East Coastal Community Development Project and the Survey Department has an archive of aerial photographs dating back to 1956.

11. No mangrove planting should be carried out without careful planning, based on a scientific understanding of the hydrology of the site. Allot a minimum of five years to complete the rehabilitation or restoration process.

12. Develop a strategic plan focused on 'critically important areas' for mangrove 'restoration', in view of the demand for land for development purposes, particularly tourism. Prioritize the key mangrove areas for conservation, as an urgent matter.

13. As an interim measure, the relevant authority should consider a moratorium on all mangrove planting projects in barrier-built estuaries and lagoons, until project proponents agree to compensate the potential loss of functional hydrology, through sedimentation, by dredging or de-silting already filled up areas.

14. Revise the available Guidelines on Mangrove Restoration in the light of the observations in this reappraisal.

15. To ensure success in mangrove planting mobilize and enlist the support of the local community, provide technical guidance, and adequate post-planting care such as the protection of seedlings and propagules from grazing and submergence.

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(Ranjith Mahindapala)

7. Annexes

Annex 1	List of Participants at the two colloquia
Annex 2	Programme of the Colloquium on *Mangrove Rehabilitation Efforts in Sri Lanka* held at the Hector Kobbekaduwa Agrarian Research & Training Institute (HARTI), Wijerama Mawata, Colombo 7 on 6 November, 2009
Annex 3	Presentations made at the Colombo Colloquium (only those made available by the authors are presented)
Annex 4	Programme of the Colloquium on *Mangrove Rehabilitation Efforts in Sri Lanka (Eastern Province)* held at the Hotel Bridge View, New Dutch Bar Road, Kallady, Batticaloa on 24 November, 2009
Annex 5	Summaries of the presentations of the Batticaloa Colloquium (prepared by IUCN)
Annex 6	*Physiography of Sri Lanka's Coastal Plains, Origin and Behaviour of Micro-tidal Barrier-built Estuaries and Lagoons and their Sedimentation with Mangrove Planting and other Land Uses* – Paper prepared by Dr J I Samarakoon

(Ranjith Mahindapala)

Annex 1

Participants at the two colloquia

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No	Name	Organisation
1.	Mrs Pathma Abeykoon	District Forest Office, Kalutara
2.	Ms Gothami Abeygunawardane	Lanka Jathika Sarvodaya Shramadana Sangamaya (Inc.)
3.	Mr Hasantha Amarasekara	MCRCF, Puttalam
4.	Mr A A Athula	NAQDA
5.	Mr Dineth Chameera	Green Movement of Sri Lanka
6.	Mr Amila Chanaka	Green Movement of Sri Lanka
7.	Dr Steve Creech	Sri Lanka Nature Forum
8.	Mr Sarath Dissanayake	Department of Wildlife Conservation
9.	Mr Adam Shareef	MFF Maldives
10.	Mr H R L Fonseka	District Forest Office, (NW/W)
11.	Mr H G Gunawardena	Forest Department
12.	Dr T Jayasingam	Eastern University
13.	Mr Charmara Jayasooriya	Small Fishers Federation Lanka
14.	Prof L P Jayatissa	University of Ruhuna
15.	Mrs Uthpala Kalansooriya	Distirct Forest Office, Gampaha
16.	Mr Thushan Kapurusinghe	Turtle Conservation Project
17.	Mrs Shireen Samarasuriya	UNDP
18.	Mr Udaya Liyanage	Sewa Lanka Foundation
19.	Dr Susil Liyanarachchi	CARE Sri Lanka
20.	Mr C D Manawasekara	University of Moratuwa
21.	Mr Nalin Munasinghe	FAO
22.	Dr Wasantha Pahalawatte - Aarachchi	NARA
23.	Mr D P Prasad	District Forest Office, Puttlam
24.	Mr Anil Premaratne	Coast Conservation Department
25.	Mr Douglas Ranasinghe	Wildlife and Nature Protection Society of Sri Lanka
26.	Mr Harsha Ratnasooriya	University of Moratuwa
27.	Mr Ananda Wijesooriya	Department of Wildlife Conservation

No	Name	Organisation
28.	Dr Mrs Sivamathy Sivachandiran	University of Jaffna
29.	Mr H M Thalagala	University of Moratuwa
30.	Mr Douglas Tissera	Small Fishers Federation Lanka
31.	Mr K G Wasantha	Forest Department
32.	Ms Chamila Weeratunga	Environmental Foundation Ltd.
33.	Mrs Gayani Wickramarachchi	Sewa Lanka Foundation
34.	Dr Jayampathi Samarakoon	Consultant, IUCN
35.	Prof Senevi Epitawatta	Consultant, IUCN
36.	Dr Ranjith Mahindapala.	IUCN
37.	Ms Roshanara De Croos	IUCN
38.	Mr Sarath Ekanayake	IUCN
39.	Mrs Kumudini Ekaratne	IUCN
40.	Mr Kapila Gunaratne	IUCN
41.	Mr Sampath Goonetilake	IUCN
42.	Mr A Hettiarachchi	IUCN
43.	Mr Bandula Withanachchi	IUCN
44.	Mrs Padmi Meegoda	IUCN
45.	Mr Vimukthi Weeratunga	IUCN
46.	Mrs Dilhari Weragodathenna	IUCN
47.	Mr Dilup Chandranimal	IUCN
48.	Mr Sanjeewa Lelwala	IUCN
49.	Ms Angela Fernando	IUCN

The Colloquium held in Batticaloa on 24 November, 2009

No	Name	Organization
1	Lady Mayor Mrs S Prabaharan	Municipal Council, Batticaloa
2	Mr A Arunnathi	NECCDEP
3	Mr E L A Careem	Lanka Jathika Sarvodaya Shramadana Sangamaya (Inc.)
4	Mr Prince Casinader	
5	Dr P Vinobaba	Eastern University
6	Mr S Gritharan	Divisional Secretariat, Valaichenai
7	Mr R G Gunathilake	Distrcit Forest Office, Baticaloa
8	Mr H G Gunawardena	Forest Department
9	Mr M Jasoor	Coast Conservation Department
10	Dr T Jayasingam	Eastern University
11	Mr P R Jeevananthan	Department of Fisheries and Aquatic Resources Development
12	Mr V Kamalthas	District NGOs Consortium (Inayam) Batticaloa
14	Mr R D G Karunaratne	District Forest Office, Trincomalee
15	Mr A Koguladheepan	Coast Conservation Department
16	Mr S Kogulan	Central Environmental Authority, Kantale
17	Mr Kumar Suresh	Department of Wildlife Conservation
18	Mr T Lavankumar	Sewa Lanka Foundation
19	Dr M Manobavan	University of Jaffna
20	Dr T Mathiventhan	JUGAS Professional Services
21	Mr M H M Mussamil	Divisional Secretariat, Kattankudy
23	Mr H M M Rwaith	Divisional Secretariat, Valaichenai
24	Mrs K Patmarajah	Divisional Secretariat, Manmunai North
25	Mrs R Ragulanayaki	Divisional Secretariat, Vakarai
26	Mr A Rajakone	Fisheries Societies' Representative Batticaloa
27	Prof Mano Sabaratnam	Mandru, Batticaloa
28	Mr S Santharooban	Eastern University

No	Name	Organization
29	Mr I Thenansajen	Department of Fisheries and Aquatic Resources Development
30	Mr R M Wijepala	Forest Department (Ampara and East)
31	Mr S Thayananth	UNDP, Batticaloa
32	Mr S Rishitha	NAQDA
33	Mr C Vamakalasingam	Coast Conservation Department
34	Mr W A C Weragoda	Forest Department
35	Mr S Udayarajan	Central Environmental Authority
36	Mr V Alagaratnam	Divisional Secretariat, Thirukkovil
37	Mr B H J Premathilake	Coast Conservation Department
38	Mr Jegatheswari Gunasingham	Eastern University
39	Mr M A L Hakeem	Regional Forest Office, Batticaloa
40	Mr S Kannaraj	Mandru
41	Mr R Sivatharshan	UNDP, Batticaloa
42	Mrs M Baskaran	Coast Conservation Department, Batticaloa
43	Mr A Arunnathi	NECCDEP
44	Dr Ranjith Mahindapala	IUCN
45	Mr Shamen Vidanage	IUCN
46	Mrs Kumudini Ekaratne	IUCN
47	Dr Jayampathi Samarakoon	Consultant, IUCN
48	Prof D Senevi Epitawatta	Consultant, IUCN
49	Ms Angela Fernando	IUCN

Annex 2

Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

Colloquium on Mangrove Rehabilitation Efforts in Sri Lanka

Hector Kobbekaduwa Agrarian Research & Training Institute (HARTI),
Wijerama Mawata, Colombo 7
6 November, 2009
Programme

09 00 – 09 10	Address of Welcome **Dr R Mahindapala, Country Representative, IUCN Sri Lanka**
09 10 – 09 30	To be or not to be.....Mangroves in the Eastern Sri Lanka **Dr T Jayasingam, Eastern University of Sri Lanka**
09 30 – 09 50	Mangrove Conservation in Sri Lanka – Current Status **Mr H G Gunawardene, Deputy Conservator of Forests, Forest Department**
09 50 – 10 00	Discussion
10 00 – 10 20	Experiences in Mangrove restoration in the Puttalam lagoon **Mr Thushan Kapurusinghe, Turtle Conservation Project, Sri Lanka Nature Forum**
10 20 – 10 30	Tea
Chair – Dr J I Samarakoon	
10 30 – 10 50	Minimizing failures in mangrove restoration projects in Sri Lanka **Professor L P Jayatissa, University of Ruhuna**
10 50 – 11 10	Impact of man and natural disasters on mangroves and mangrove rehabilitation **Professors Mangala and Padma de Silva, University of Peradeniya**
11 10 – 11 30	Discussion
Chair – Dr Susil Liyanarachchi	
11 30 – 11 50	Tsunami Impact Mitigation by Coastal Vegetation **Dr Harsha Ratnasooriya, University of Moratuwa**
11 50 – 12 10	IUCN's post-tsunami experiences on mangrove rehabilitation **Mr V Weeratunga, Mr Shamen Vidanage & Ms Kumi Ekaratne, IUCN Sri Lanka**
12 10 – 12 30	කඩොලාන හා ධීවර කර්මාන්තය (Mangroves and Fisheries) **Mr Douglas Tissera, Small Fishers' Federation, Pambala**
12 30 – 13 30	Discussion followed by Lunch
Chair – Dr T Jayasingam	
13 30 – 13 50	Current status of mangroves in the Northern Peninsula **Dr Sivamathy Sivachandran, University of Jaffna**
13 50 – 14 20	Mangrove Rehabilitation in Micro-tidal Barrier-built Estuaries and Lagoons: Science, Contradictions and Possible Futures **Dr J I Samarakoon & Professor Senevi Epitawatta**
14 20 – 14 30	Discussion
14 30 – 15 00	Distilling the Best Practices; Facilitated Discussion
15 00 – 15 15	Summing up **Dr Steven P Creech**

(Ranjith Mahindapala)

Annex 3 Presentations made at the Colombo Colloquium

(only those made available by the authors)

1. **To be or not to be… Mangroves in the Eastern Sri Lanka**
   T Jayasingam

2. **Mangrove Conservation in Sri Lanka – Current Status**
   H G Gunawardane

3. **Experiences in mangrove restoration in the Puttalam Lagoon**
   Thushan Kapurusinghe

4. **Minimizing failures in mangrove restoration projects in Sri Lanka**[1]
   L P Jayatissa

5. **Impact of man and natural disasters on Mangroves, and Mangrove rehabilitation**
   Mangala de Silva & Padma K de Silva

6. **Tsunami Impact Mitigation by Coastal Vegetation**
   Harsha Ratnasooriya, Samantha Hettiarachchi and Saman Samarawickrama

7. **IUCN's Post-tsunami Experience on Mangrove Rehabilitation**
   Vimukthi Weeratunga, Shamen Vidanage and Kumudini Ekaratne

8. **Mangroves and the Fishing Community**
   Douglas Tissera

9. **Current Status of Mangroves in the Northern Peninsula**
   Sivamathy Sivachandiran

10. **Mangrove Rehabilitation in Micro-tidal Barrier-built Estuaries and Lagoons: Science, Contradictions and Possible Futures**
    J I Samarakoon and Senevi Epitawatta

11. **Current Status of Mangrove Conservation in the Eastern Province of Sri Lanka – Forest Department Perspectives**
    R G Gunathilake

12. **Batticaloa Lagoon – A Systems' Perspective**
    Manoharadas Manobavan

13. **Mangroves and Fisheries: a perspective from Batticaloa district**
    P R Jeevananthan and I Thenansajen

14. **Mangroves in Batticaloa: A struggle for existence**
    T Mathiventhan

1 Paper/Abstract not submitted.

(Kumudini Ekaratne)

To be or not to be… Mangroves in the Eastern Sri Lanka

T Jayasingam
Eastern University, Batticaloa

"The east coast nevertheless offers a more striking development, as one may see at Batticaloa. The rivers along that stretch of sea board have helped in forming an indented network of waterways, fully 50 miles in length, which stretch from Valaichenai to Sammanthurai. How very few persons realise what delightful waterway excursions these still river-stretches on the east coast offer. The shores are embowered with the richest vegetation, or fringed by dense thickets of evergreen mangroves. Only filtered light penetrates into this maze of curiously arched and spreading roots hanging over a dark morass of smelly mud." (R.L Brohier, 1933)

The mangroves of the Eastern Province described above by Brohier lingers along the maze of waterways that litter the eastern coast of Sri Lanka, trying to survive, between the increasing demand by humans and decreasing space due to siltation and pollution. In adition, the 2004 Tsunami sent shock waves to those who cultivated the mangroves, for various reasons, little knowing how it would impact these systems in the future. Between the dying and decreasing waterfronts and rising and increasing land fill, a choice has to be made, to have or not to have the Mangroves in the east for future generations to enjoy.

Mangroves are differently described as an ecosystem, a vegetation type, a plant formation, etc. They are predominantly made up of trees that thrive in the fragile environment between land and water, in the intertidal zone of the tropics. This ecosystem is highly productive, nutrient rich and also holds a rich and specific biodiversity. Many of the mangrove species are trees and amount to more than 50 species. An equivalent number of associated species, which are not true mangroves, are also found near mangrove systems. Sri Lanka has about 20 true mangrove species and 18 associated species. The Eastern Province has about 18 true mangroves and about 15 associated species. The mangrove ecosystem serves many eco functions: filters and traps sediment, provides a habitat for avifauna, nutrients to the growing fish and shrimp and also their protection from predators, buffers storm surges, etc. Furthermore, it provides wood, timber and edible fruits and leafy vegetables. Extensive mangrove areas are found in the large deltas in India, Bangladesh etc. Sri Lanka has a relatively small extent of around 12,000 hectares distributed throughout the island; the extent in each district has not been accurately determined.

The landscape of the Eastern Province is unique with a maze of water bodies along the coast such as estuaries, lagoons, marshes and thonas. Mangroves of varying shape, size and composition, are associated with these coastal water bodies, from bar mouth to many kilometers inland. Riverine mangroves thrive close to the river mouths at Yan Oya, Gangai, Verugal etc. Estuarine mangroves are more abundant and are found at Batticaloa, Panama, Vakarai, Ullakelle, Trincomalee etc. However, there are only few large patches of mangroves. Most have been fragmented over time probably by natural and anthropogenic factors. Following the Asian Tsunami in 2004, tsunamis were also recognized as an important factor in mangrove dynamics.

Tsunami 2004 made drastic changes to the coastal morphology; it created many new openings (eg. Kallar) in the coast and also widened and deepened the existing waterways (eg. Pasikudah). The tree front was also severely damaged. Front line mangroves and coastal forests were affected. Palmyrah was, perhaps, the worst affected and more than 80% of trees on the coast were lost. Mangroves became champions of the season being credited as the buffer that stood between the villages and the surge. Major mangrove rehabilitation programmes were initiated and large sums of money became available overnight. Mangroves were planted everywhere and anywhere. Unfortunately, little or no planning went into this exercise. Planting was done mostly on the shores of the lagoons and estuaries (5 m from the shore) and only with a few species that

could be collected easily. Sooner or later most mangrove saplings died, for various reasons. No detailed study of this failure was made.

Restoration and rehabilitation of mangroves took a prime spot in post-tsunami rehabilitation measures. Donors allocated a lot of money as mangroves were seen as a strong buffer against a potential tsunami. Many institutions took to this and began planting mangroves, not just in places damaged by the tsunami but elsewhere, as well. There was no proper regulation and control and only a few species were planted in most places. Except for a few cases, most of the saplings were lost within a year or two. Tsunami affected mangrove areas, which had not been at the receiving end of donor funds, were coming back with vigour, by way of natural rehabilitation.

Kokkadicholai, where a shrimp farm was abandoned in 1986, still remains a barren land with no natural regeneration. Following the liberation of the east in 2007, plans were developed for shrimp farming in the eastern coast and potential sites were identified by NARA, in consultation with other agencies. It is indeed unfortunate that a similar plan was not developed for mangrove rehabilitation. This is a serious shortcoming, which shows the lack of importance given to the mangrove ecosystem, as a whole.

It is evident that,

a) Although the issues in regard to mangroves are complex, there is no single authority responsible for the well-being of the mangrove areas. (This is needed)

b) The planting of the mangroves is not regulated. All and sundry are planting mangroves under the pretext that it is a good and noble venture (This needs to change)

c) Questions such as where to plant, what to plant, how to plant, how much to plant, who should plant, remains open. (Need regulations).

d) Information on the mangroves such as the total extent, district-wise distribution, … , etc. is lacking (Research and extension is important).

e) Research on the functioning of the ecosystem, which is fundamental for informed decisions, is lacking. Bridges built across lagoons had slowed down the water flow, fillings have reduced the water front and pollution has affected the health of the system, itself. In short, the system is choking in many places.

In parallel, the destruction of mangroves continued on different fronts. Encroachments, establishment of shrimp farms, pollution, clearance for security reasons and extraction of timber were the most damaging. Many places hitherto considered as mangrove reservation areas, and where many studies had been performed, had been fenced recently, and the soil excavated and removed. New 'shrimp farm' like structures had been built into the lagoon shores in Batticaloa. However, none of these activities raised an alarm, anywhere.

Collectively, the mangroves are not well placed for survival despite the huge campaign for mangrove restoration. In essence, we (and the mangroves) are now at a critical cross roads. So with the mangroves: to have or not to have them is our choice. If we choose to have the mangroves, we must play by the rules of nature, and study, understand and manage them. It is of foremost importance to set up an authority to steer the process of mangrove restoration and rehabilitation and for the management of mangroves in the country at large. In my opinion, non-disturbance of the existing mangroves would allow them to restore themselves. Fragmentation of mangroves and its relevance for conservation should be studied as done for the wet zone forests, many years ago, under the National Conservation Review Project. Planting may be necessary at specified sites for specific purposes viz. rehabilitation of former shrimp farm sites, demarcating

the boundaries of lagoons and estuaries, commercial plantations to supply poles and timber to fishermen; not planting as a means of restoration, in the real sense. Even in these cases, species composition must be well planned before implementation. It must be remembered that removal of 'seed material' from a natural site, in large quantities, could affect the dynamics of the species at that site. We understand the dynamics of the mangroves ecosystems and act accordingly. Or else it will be the choice of the Mangroves, TO BE OR NOT TO BE in the Eastern province.

Mangrove Conservation in Sri Lanka – Current Status

H G Gunawardane
Forest Department, Colombo

In Sri Lanka, mangroves are located around lagoons, estuaries and river mouths that are affected by tidal fluctuations. They cover around 10,000 ha amounting to 0.01% of the land extent. Mangroves are biologically highly productive, socio-economically important, aesthetically highly attractive and ecologically indispensable tropical ecosystems. These highly specific plant assemblages provide varied services such as breeding grounds for fresh water animals, protection from storms and cyclones, filtering of sediments and pollutants, and reducing the erosive force of waves. In addition, the provisional services are enormous: fruits and vegetables for human consumption; other domestic requirements like fuel wood, tannins and thatching materials; and fishermen's requirements. Despite these valuable provisional and regulating services people have exploited most of the mangroves for a long time. As a result, hardly any undisturbed areas exist today. Cutting trees, encroachments, land filling, waste dumping, pollution and constructions are the major threats to mangrove ecosystems which have greatly contributed to the dwindling of this valuable resource.

Until 1990, mangrove resources were considered as waste land, and concern for conservation of these indispensable resources were minimal. All mangrove areas were then under the purview of the Government Agent. Demand for land, especially in the north-western coastal belt increased dramatically mainly for the rapid expansion of prawn and crab farms. Consequently, about 1,000 ha of mangrove vegetation was sacrificed for these farms creating serious environmental hazards and biodiversity destruction. At that time, protection for these ecosystems was negligible. Considering the importance of mangrove ecosystems, the Forest Department, supported by the Ministry of Forestry and Environment (MOFE), took charge of some environmentally sensitive areas. This was the first step towards mangrove conservation. Also, two management plans for mangrove areas in the south-western region south of Colombo (SWR) and in the north-western region of Sri Lanka (NWR) were prepared with technical assistance from IUCN.

In 2001 MOFE, by way of Circular (No 2001/5), empowered the Forest Department to manage all the mangrove resources in the country and take necessary action for their protection and development. The management plan prepared for NWR had identified 3 clusters of mangrove vegetation, each with a different management prescription. The management recommendation for Cluster 1, which includes three mangrove areas namely, Eththala, Wanathawillu, and Seguwanthive, was preservation; Cluster 2, which includes Pambala and Thalawila, was conservation and management; and Cluster 3, which includes Munnakkara and Mundalama, was participatory utilization. The management plan for SWR grouped the ten mangrove areas in this region into three clusters. Cluster 1 includes six mangrove areas namely, Kaluwamodara, Ollewa, Meegama, Ittapana, Maduganga and Galathara; Cluster 2 includes Hikkaduwa, Magalla and Rakawa; and the Kaluwamodara area constitutes Cluster 3. The management recommendation for mangroves in all three clusters was conservation.

The Mangrove Conservation and Management Project (MCMP), funded by NORAD, was launched in1995. In common with the projects in NWR and SWR, MCMP also carried out awareness creation, training, social mobilization, establishment of CBOs, community empowerment, and training on alternative income generating activities, in selected areas. Fourteen mangrove areas, in all, were surveyed and their boundaries demarcated. These areas were declared as Conservation Forests by Gazette Notifications No 1152/13 and No 1258/03 dated 4th October 2000 and 14th October 2002, respectively. Under the MCMP, community nurseries were established to raise plants to restore degraded sites; community centers were established in a few selected areas to conduct training and awareness programs; and essential

facilities for visitors were provided in selected important areas. The project was implemented in two phases and completed in year 2002.

A limited number of post-project activities were supported by the Consolidated Fund. These activities were implemented with the assistance of Coastal Conservation Department, Department of Fisheries and Aquatic Resources, National Aquatic Research and Development Authority, Department of Wildlife Conservation, IUCN, Pradeshiya Sabhas, AGAs and many local NGOs.

A large number of local NGOs are currently engaged in mangrove restoration activities with donor funds. After the 2004 Tsunami, foreign funds, in ample measure, were utilized to restore affected areas, including mangroves. Regrettably, these restoration activities were not according to an appropriate plan, but uncoordinated independent initiatives. Also, over the last two to three decades, mangrove conservation in the eastern region has been totally neglected. The Forest Department has therefore decided to take immediate action to resolve these issues. In this regard, work has already commenced on ground checking and verification of mangrove vegetation depicted in satellite imagery, especially in the eastern and northern regions. Revising and updating the NWR and SWR management plans, surveying and demarcation of mangrove areas in NWR and SWR, collecting data on privately owned mangrove areas, boundary demarcation, training officers of the Forest Department and other relevant public sector institutions, and awareness workshops are some of the activities to be carried out over the next few years.

The Forest Department has in place a comprehensive five-year action plan for the conservation of these valuable resources in Sri Lanka, to fulfill its mandate.

Experiences in mangrove restoration in the Puttalam Lagoon

Thushan Kapurusinghe
Turtle Conservation Project, Kalpitiya

Mangrove trees and shrubs form conspicuous wetland ecosystems fringing extensive areas of coastline in tropical and subtropical latitudes. In addition to the mangrove forest itself, waterways (estuaries, creeks, canals, lagoons and backwaters), mudflats, saltpans and islands contribute to the physical dimension of these ecosystems (described by Kjerfve, 1990). True mangroves are mainly restricted to intertidal areas between the high water levels of neap and spring tides (Watson, 1928; Tomlinson, 1986; UNEP, 1994).

Ecologically, Tropical Mangrove Forests are important in maintaining and building the soil, as a reservoir in the tertiary assimilation of waste, and in the global cycle of carbon dioxide, nitrogen, and sulfur. Protection against cyclones is a "free" benefit. Mangroves play a significant role in coastal stabilization and promoting land accretion, fixation of mud banks, and dissipation of winds, tidal and wave energy. The uses of mangroves fall into two categories. Firstly, the use of the mangrove ecosystem as a whole or its conversion to other uses; and secondly, the use of products from the mangrove ecosystem. Re-plantation of mangroves in degraded areas is an alternative erosion control method which is relatively inexpensive and proven to be effective on shorelines. The aerial plant parts dissipate waves, act as a living groyne by accumulating sediment and the tough mat of roots and rhizomes stabilizes the substrate (Broom et al., 1981). They trap sediments and thus contribute to land building and prevent excessive shifting of coastline sand. Relatively recent commercial uses are recreation and ecotourism. The uses of mangroves are many and varied. A fundamental function of all forests has been to supply fuelwood for cooking and heating and timber for constructing dwellings; mangrove forests are no exception (Watson, 1929; FAO, 1982). Traditionally, people have used mangroves for the benefit of the local community, but increasing populations have led to an increasing non-sustainable abuse of the resources.

Mangroves have been exploited for timber for building dwellings and boats and fuel-wood for cooking and heating. Several species are used, especially in Southeast Asia, to construct jetties and other submerged structures because they are resistant to rot and to attack by fungi and borers. *Rhizophora* and, to a lesser extent, *Avicennia* wood have a high calorific value and are excellent fuels. In Indonesia, commercial exploitation of mangroves for charcoal has been reported from 1887. In Central America, exploitation for charcoal production and the extraction of tannin has been responsible for large-scale mangrove removal and degradation. Large-scale conversion of mangroves for wood chip production began in East Malaysia and Indonesia during the 1970s.

The Puttalam Lagoon has the largest mangrove patch (3,210 ha) in Sri Lanka. Coastal communities depend on lagoon fishery and mangrove forests for their survival. Mangroves are heavily exploited by coastal communities for fuel wood, timber for buildings, stains for nets and sails, timber for fencing, etc. Mangroves are disappearing from many areas of the Puttalam Lagoon due to land clearing for large-scale prawn culture, agriculture, including the cultivation of coconuts, and disposal of solid waste from homes and industries. In addition, large areas of mangrove forest in Puttlaam Lagoon have been destroyed to construct houses, hotels, factories, boat landing areas, etc. Therefore, mangrove forests in Puttalam Lagoon are under serious threat of extinction due to overexploitation by coastal communities, aquaculturists and land developers. Therefore, the TCP initiated a mangrove restoration programme with community participation in Puttalam Lagoon in August 2005. The main objective of this programme was to improve mangrove biodiversity; provide sustainable incomes for local lagoon fishermen; reduce human pressure on the existing mangrove forest and to increase the current level of knowledge on managing mangroves

in Sri Lanka. The main activities included re-establishing approximately 15 hectares of mangroves in Eththale, Mudalappali, Palakuda, Palliwasathurai and Kurigngnampitiya North G.N divisions with community participation; conducting research on restored mangroves; conducting community awareness programmes and introducing alternative livelihood activities.

TCP has planted 150,000 mangrove plants in 9 areas of the Puttalam Lagoon. Community education and awareness programmes and training in alternative livelihoods such as sewing were conducted. In addition, fishing vessels were distributed among the lagoon fishermen. Even after four years of project completion, the community members are looking after the restored mangroves and receiving a wide range of benefits.

Impact of man and natural disasters on Mangroves, and Mangrove rehabilitation[1]

Mangala de Silva & Padma K de Silva
University of Peradeniya, Peradeniya

The disastrous tsunamis in the Indian Ocean, on 26 December 2004, opened our eyes to the role mangroves play in mitigating such destructive forces. Before this disaster, governments, NGOs, INGOs, etc., and the general public, the world over, paid scant attention to mangroves. In fact, organizations such as The World Bank, IMF, ADB and FAO have, directly or indirectly, encouraged reclaiming mangroves to develop tourism infrastructure and shrimp farming.

Mangroves

Mangrove forests comprised mostly of halophytic, evergreen trees, shrubs and other plants that thrive in brackish to saline tidal waters, and associated fauna, are a characteristic inter-tidal ecosystem in the tropics and subtropics. They develop in coastal areas that are free from direct wave action and receive some freshwater from inland sources. Mangroves are often water logged and form swamps. Mangrove plants maintain an optimum salinity balance despite varying water salinity and obtain nutrients mostly from terrestrial runoff.

Mangroves in Sri Lanka are confined to the muddy shores of estuaries and lagoons. They are not found on actual seashores in Sri Lanka, as our seashores are not sheltered from the direct action of waves.

Mangroves in Sri Lanka are not extensive; often limited to narrow strips, at times only a few trees deep. Sri Lanka has only about 100 km^2 of mangroves compared to Indonesia's over 21,000 km^2, Malaysia's over 6,000 km^2, Myanmar's over 5,000 km^2, Bangladesh's over 4,500 km^2, India's over 3,500 km^2, and Thailand's over 1,500 km^2. Thus, mangroves in Sri Lanka are extremely fragile and cannot withstand high levels of exploitation as in other countries.

Of the island's 10,000 ha of mangroves, about 4,000 ha are in the Kalpitiya Lagoon region (including Dutch Bay and Portuguese Bay). The Kala Oya-Pomparippu Ara mangrove forest, the largest in this region, is around 1,850 ha. The Kala Oya mangrove forest is about 0.5 km deep and extends about 2 km upstream from the river mouth. The shoreline with mangrove formations in Sri Lanka totals to about 500 km. Most mangrove areas have been subjected to human interference for a long time; undisturbed mangrove forests are seldom found.

Low tidal amplitude in Sri Lanka (< one metre) limits the area available for mangrove development. Nevertheless, mangrove cover in the past had been much more than what it is today. Due to human interference, mangroves are now mostly confined to small patches on shores and small islands of some estuaries and lagoons.

Of the around 15 million hectares of mangroves worldwide, nearly 40% occur in the tsunami-affected countries. In recent years, mangroves and other coastal vegetation have been cleared or degraded along the coastline of many countries, increasing their vulnerability to storm and tsunami damage. Mangroves once covered about 75% of the coastlines of tropical and sub-tropical countries. Today, it is less than 50%, and more than half the forests are degraded. Mangrove areas have been almost halved in Thailand, between 1975 and 1993, and in India, between 1963 and 1977. In Indonesia, since 1960, Java has lost 70% of its mangroves, Sulawesi 49% and Sumatra 36%. The loss of mangroves has been invariably due to logging, aquaculture, and industrial and tourism development. These activities were continuing in most mangrove areas when the tsunami struck. In fact, the Ministry of Fisheries is planning to clear one-third of

1 Not presented at the Colloquium

Indonesia's remaining 2.4 million hectares of mangroves for shrimp farming. This would only bring short-term economic benefits to a few investors.

Development of tourism, shrimp farms, and other coastal industries has destroyed or degraded mangrove forests and other natural sea defences. Indirectly responsible for this devastation are inter-governmental agencies, governments, industry and financial institutions that promote and support coastal developmental activities. The tough environmental protection laws in Asian countries to regulate coastal development and protect coastal forests, are widely ignored by powerful tourism and aquaculture industries with strong political backing. These industries have cleared inter-tidal areas to provide better views and wider beaches for tourist hotels or to establish shrimp farms. While mangrove losses are mainly due to the shrimp aquaculture, tourism and charcoal industries, especially in Indonesia and Thailand, settlements, urban development, port construction, and conversion to oil palm plantations also contribute to losses in the region.

The average operational life of a shrimp pond is 2-5 years as the cumulative addition of chemical feeds, fertilizers and pisicides affects water quality of the pond and renders it uneconomic for shrimp production. The investors move on to clear new areas of mangrove forest and the cycle is repeated. Abandoned shrimp farms usually do not support re-growth of mangroves without appropriate rehabilitation including the removal of dykes and dyke walls for hydrological rehabilitation.

Tsunamis and Storms

The massive 2004 Indian Ocean Tsunami seriously affected the coastal areas of at least 16 nations, including Sri Lanka. As expected, mangroves and other coastal forests and trees were adversely affected. In near-shore areas, seashore *Pandanus* and creeper vegetation was severely damaged. Estuaries often acted as channels of entry for the tsunami, facilitating damage and salt water intrusion far inland. Front-line mangroves were badly damaged, while deeper mangroves were less affected.

Post-tsunami assessments, including remote sensing analysis, showed that coastal vegetation such as mangroves and beach forests had helped to reduce the damage and protect adjacent inland communities. Studies show that mangroves absorb 70-90% of the energy of a normal wave. While there is no reliable data on how trees mitigate the impact of a tsunami, it is clear that the worst damage was in places with no natural protection, and that the communities living behind intact mangrove forests were largely spared. Seashore trees such as *Pandanus,* and sand dunes also moderated the effect of the tsunami. Coastal vegetation may not have prevented catastrophic destruction where the tsunami intensity was very high, but in less hard hit areas, sites with trees suffered less than sites without trees.

Dense mangroves with proper zonation would effectively dissipate the massive wave energy that develops during storms and tsunamis. The first line of protection is the *Rhizophora* zone at the water's edge, with its flexible branches and tangled prop roots, which absorbs the energy of the waves to a great extent. The next line of protection is the zone of tall Avicennia and Sonneratia trees, which function like a wall absorbing much of the remaining wave energy. *Bruguiera* trees would also help to dissipate the wave energy. The third line of protection would be the *Excoecaria* tree zone at the landward edge of the mangrove as well as the trees of the back-mangrove. However, in Sri Lanka, where the mangrove area is small and has no clear-cut zonation, the level of protection offered by mangroves is low.

Simeulue (population around 76,000), an island near Sumatra, was hit directly by the 2004 Tsunami. Loss of life was estimated in the hundreds, and property damage, though significant, was less ruinous than in nearby regions with similar populations. For instance, in Meulaboh city (population 40-50,000) in mainland Sumatra, loss of life was estimated at 10,000 people and 80%

of the city was damaged. The minimal damage to property and loss of life in Simeulue has been attributed, at least partially, to the protective belt of mangroves fringing the island.

According to IUCN, only two people died in Kapuhenwala village, which was surrounded by 200 hectares of dense mangroves and scrub forest. In contrast, nearly 6000 people died in nearby Wanduruppa village, where most of the mangrove forests had been cleared previously. Both villages are on Sri Lanka's southern coast.

In 1960, when a tsunami wave hit a coastal area in Bangladesh where mangroves were intact, not a single person died. These mangroves were subsequently cleared to establish shrimp farms. In 1991, thousands were killed when a tsunami of the same magnitude hit this area. Earlier, the mangroves of Bhiterkanika in Orissa had reduced the impact of the 'super cyclone' that struck in October 1999. The November 1978 hurricane devastated Batticaloa and adjacent areas in Sri Lanka. A well-developed mangrove forest on the shore may well have reduced the damage considerably.

Many more similar reports have testified to the fact that loss of life and property had been mitigated in areas where mangroves were intact; and the devastation was severe where mangroves had been cleared previously.

Mangrove Rehabilitation

Several NGOs were involved in mangrove replanting programmes even before the 2004 Tsunami disaster. However, these replanting programmes in Negombo Lagoon and several other lagoons and estuaries had limited success.Planting mangrove trees in a coastal area, with no record of mangroves in the past, should be undertaken with caution. Mangrove trees would hardly survive in a coastal area which, is directly open to oceanic wave action, has sandy soils and has no significant freshwater land drainage. *Pandanus* is a better candidate for such coastal areas.

Many NGOs and a few governmental organizations are now involved in planting mangrove trees in various coastal areas of Sri Lanka. *Ad hoc* planting of mangroves and seashore vegetation without proper scientific planning is of little value. In these planting or replanting programmes only the wave-resistant trees, mainly *Rhizophora* and to a lesser extent *Sonneratia, Avicennia* and *Excoecaria*, should be planted. Tree species such as *Heritiera* and *Xylocarpus* are rare in Sri Lanka, while *Nypa* grows only along the shallow waters of creeks and rivers. *Bruguiera* could grow into tall trees, but *Rhizophora* seems to grow faster and cover a larger area. In Sri Lanka, *Ceriops, Lumnitzera*, *Aegiceras* and *Acanthus*,are mostly shrubs with little wave resistance, although the first three species could grow to sizable trees. Thus, the planted 'mangroves' would most likely be monotypic stands of *Rhizophora* and the entire mangrove ecosystem (and in turn the biodiversity) will not be restored. In over-populated areas, firewood and timber will be extracted from even the young trees hindering the formation of an effective storm and tsunami barrier. In any event, there is little room in the over-populated coastal areas to grow effective mangroves and seashore vegetation.

Increasing the biodiversity of mangroves and making them effective barriers to storms and tsunamis may be done by,

(a) conserving existing mangrove areas
(b) rehabilitating destroyed mangrove areas
(c) creating new mangrove areas

Due to their maturity and complexity the existing mangroves are more valuable in terms of overall production, biodiversity and shoreline protection than reforested and newly created mangroves areas.

In Sri Lanka, mangroves can be rehabilitated or even created only in limited areas associated with river estuaries and lagoons. These relatively small stands of mangroves would not be very effective in protecting coastal areas from a tsunami or even a storm.

Mangrove management will be effective and successful if it is community-based. Community-based mangrove management involves educating the mangrove associated human communities and gaining their active participation, sustainable mangrove utilization, development of sustainable livelihood alternatives, mangrove rehabilitation, research and designation of conservation areas, etc.

Mangroves are considered by many people as mosquito-infested, foul-smelling, swampy areas. This is true of many mangroves which are not cleansed by the tides. Thus, rehabilitating and replanting of mangroves would hardly be approved by hotel owners, property developers or even the general public. Severe storms affect Sri Lanka only once in many years and tsunamis of the scale experienced in 2004 may arrive in the island once in several hundred years, whereas swampy areas of little apparent use, once established, would be a perpetual nuisance. This aspect also has to be kept in mind by organizations encouraging mangrove growth along the sea coast. It must also be borne in mind that a mangrove area would take many years of care and protection to become an effective barrier against storms and tsunamis.

Tsunami Impact Mitigation by Coastal Vegetation

Harsha Ratnasooriya, Samantha Hettiarachchi & Saman Samarawickrama
University of Moratuwa, Moratuwa

In the aftermath of the 2004 Indian Ocean Tsunami disaster, the protection offered by coastal vegetation was evident in many of the affected countries. Clearly, coastal green belts have a role in mitigating tsunami impacts. Experimental and numerical studies on the influence of vegetation on energy dissipation of the flow and reducing the extent of inundation, were conducted to assess the effectiveness of coastal vegetation in tsunami impact mitigation.

Impact mitigation by vegetation is brought about by forces resisting the flow. The level of resistance depends on individual plant characteristics as well as the overall characteristics of the green belt. A variety of vegetation is found along the coastline of the country. Of significance from a hydraulic standpoint are three distinct features of plant structure, namely, aerial root system, near vertical stem and the branch/leaf structure, which offer varying degrees of resistance. Considering these features along with depth of inundation, four plant types can be identified for further investigation of their resistance characteristics. A coastal green belt is characterized by its location, extent, density, pattern and the types of vegetation.

Small scale physical models were tested in a hydraulic flume in which the coastal vegetation was represented by geometrically similar models. Steady flow tests were conducted to assess the energy dissipation characteristics of vegetation. Unsteady flow tests were conducted to assess tsunami impact mitigation characteristics of vegetation, by energy dissipation. For the unsteady tests, the overland flow was generated by the sudden release of water from a tank in the flume. In this simulation, the tank gate was opened suddenly and the flow was allowed to run over a sloping surface. The maximum inundation distance was measured, with and without the presence of vegetation; the difference being the vegetation influenced reduction of the distance inundated. Numerical studies under steady flow conditions were conducted to determine the overall drag resistance due to vegetation. The water surface profile through the vegetation was used to compare experimental and numerical results.

The effectiveness of coastal green belts, comprised of selected forms of vegetation, was assessed, with % reduction of inundation distance as the yardstick. Reductions up to 40 % were obtained in the experimental studies indicating that coastal green belts have the potential to significantly reduce tsunami inundation. The relative influence of vegetation characteristics, namely location, density, extent and pattern of vegetation in reducing inundation distance were also assessed. There was a good agreement between the experimental and numerical results for the water level profile through the vegetation. In spite of limitations due to the small scale of the tests and the limited range of flow and vegetation conditions simulated, the results can serve as useful guidelines to develop effective coastal green belts for tsunami impact mitigation.

IUCN's Post-tsunami Experience on Mangrove Rehabilitation

Vimukthi Weeratunga, Shamen Vidanage & Kumudini Ekaratne
IUCN Sri Lanka, Colombo

Mangroves, a unique plant community, grows in the inter-tidal zone under very hostile environmental conditions. Continually exposed to high salinity, low oxygen, strong winds, and high light intensity mangroves are remarkably adapted to survive in these harsh environmental conditions. Mangroves, a rich and highly diverse natural resource, is home to many uniquely adapted biodiversity.

Mangroves are one of the major coastal habitats that was damaged by the 2004 Tsunami. Since then, mangrove restoration projects have increased sharply. These projects aim to bring back the damaged mangrove habitats to their pre-tsunami state. Mangrove plants need special environmental conditions to establish and grow, and many different methodologies have been developed to restore mangrove ecosystems. However, it is vital to modify these methods to meet site specific needs.

IUCN Sri Lanka's post-tsunami efforts related to mangroves include awareness programmes on valuation and restoration of mangrove ecosystems. IUCN Sri Lanka facilitated implementing 19 mangrove restoration projects in several coastal regions of Sri Lanka. Sixteen of these projects were funded by Oxfam Novib (Green Coast Project) and Mangroves for the Future Programme (MFF) to restore 44 hectares and 11 hectares respectively. Another 20 hectares were restored through funds from ABN-AMRO, Park Services of Spain (OAPN) and Canadian CIDA. The species planted ranged from *Rhizophora. mucronata, Aegiceras corniculata, Bruguiera gymnorrhiza to Avicennia marina*

The popular community-based restoration approach was widely used by IUCN in mangrove restoration projects implemented through the small grant scheme. Local communities located in mangrove areas are generally aware of the importance of mangroves. The restoration approach employed will engender in the community a special attachment for the mangrove habitats and ensure long term mangrove conservation.

The local community can be organized to participate in collecting seed, setting up and maintaining mangrove nurseries, transporting of planting material, ground preparation, planting and after-care operations. Female members are more appropriate for tasks in the nursery, and seed collection. The daily wage for community participants may be somewhat higher than for labourers engaged in land-based activities.

We regard restoration as being human-centered because restorations are carried out to satisfy the community. Yet our aim should be to design restoration strategies that minimize human intervention. Historical conditions are important to understand the current state of our ecosystems; their composition, structure and function. Information should be sought from as many sources as possible. Ultimately, the experience with the restoration process and site interpretation will contribute to the historical information, because the latter reveals the future trends, while the former provides a basis for understanding the past, present, and potential future.

A clear understanding of the local mangrove ecology and hydrology, and the stress factors that affect them, is indispensable when undertaking their restoration. Although planting mangroves propagules has become a common practice in mangrove restoration, restoring the hydrology and mitigating the stresses have produced better results in bringing mangrove habitats closer to their natural state. Restoration of normal hydrology by creating new tidal creeks to facilitate seed dispersal is one of the best methods to conduct successful ecological restoration of mangroves at a relatively low cost.

It is evident from IUCN experience that further destruction could be avoided through law enforcement, removal or reduction of stress factors, enhanced awareness and community-based conservation actions.

Key best practices are providing a sense of ownership to the local community and utilising naturally available species for restoration.

Mangroves and the Fishing Community[2]

Douglas Tissera
Small Fishers Federation, Pambala

The relationship between mangroves and fishers is intricately interwoven. Therefore, any damage to mangrove ecosystems has a direct bearing on the lives of the fishing communities. Fishermen have long acknowledged the importance of mangroves, particularly as nursery grounds for shrimps and fish. Destruction of mangroves has not only diminished the fishermen's income, but also brought forth a number of other issues.

Aquaculture of shrimps in artificial ponds started in the Northwestern Province in 1982. At that time, there were an estimated 3,210 ha of mangroves in the Puttalam district. In 2004, the estimated mangrove area was only 1,590 ha. Shrimp aquaculture had the blessings of many agencies, particularly the higher echelons of society. However, they were indifferent to likely adverse effects, of opening up artificial ponds, on the mangroves.

From around 2001, there was a sharp decline in shrimp aquaculture. Prior to aquaculture initiatives, Puttalam Lagoon was rich in shrimps, P*enaeus monodon* and *Penaeus indicus,* and fish such as *Epinephelus* spp. and *Lates calcarifer.* However, the naturally occurring fish populations in the lagoon have declined markedly. The destruction of mangroves has affected lagoons in different ways. For example, the resulting algal blooms in the Chilaw Lagoon prevent fishermen from using their nets.

In 1993, the Small Fishers Federation (SFF) with the active support of the fishing community launched a project to conserve mangroves in the Pambala Lagoon. The main activities were the establishment of a mangrove resources centre, conducting awareness programmes, establishing mangrove nurseries, replanting, facilitating research, conservation of rare mangroves etc.

Project work highlighted the need to select appropriate land and species for planting. Lagoon salinity level and the soil type should be considered in planting mangroves. Many agencies planted the commonly available *Rhizophora.* SFF investigations revealed that indiscriminately planted *Rhizophora* was generally unsuccessful. Mangroves adapted to high salinity will fail in low salinity conditions. SFF also collaborated with the University of Ruhuna by facilitating mangrove research by university students, conducting awareness programmes for the fishing community on economic and ecological benefits and on the wise use of mangrove ecosystems.

Another important initiative of the SFF project was the conservation of rare mangroves. *Lumnitzera littorea,* found only in the Maduganga area and *Scyphiphora hydrophyllacea,* found in the Kalpitiya area have been propagated and planted.

After the 2004 Tsunami a considerable effort has gone into planting mangroves. However, this venture has been largely unsuccessful and has turned out to be a wasteful exercise.

2. Translated from the original paper in Sinhalese.

Current Status of Mangroves in the Northern Peninsula

Sivamathy Sivachandiran
University of Jaffna, Jaffna

The term 'mangrove' is commonly used to identify the forest communities in inter-tidal areas of lagoons, river mouths and other coastal water bodies that connect with the ocean. The mangrove ecosystem is a sensitive plant community and a highly productive ecosystem. A significant proportion of the human population around each mangrove habitat is totally dependent on its resources. Although most people are aware of the direct benefits of this unique ecosystem, they know little of the indirect benefits.

Different types of mangrove communities are found in Sri Lanka. Dense localized stands are found in the southern, southwestern and northeastern coasts. The Basin Mangrove Forest type is very dominant in the Jaffna peninsula and very common in the north and Vadamarachchi lagoon. Basin Mangrove Forests lie in depressions and the surrounding soil gets washed into the basin. Some rare species of mangroves such as *Ceriops tagal* have been reported from Jaffna.

The Jaffna Lagoon and a number of rivers and canals in the Mullaithivu coastal regions are well suited for the formation of mangrove habitats. Several mangrove researchers have confirmed the presence of extensive mangrove habitats in Jaffna lagoon and inter-tidal zones.

Over 25 mangrove associate species have been identified and they fall into two categories namely, fore mangroves and back mangroves. Fore mangroves are mainly comprised of sea grasses and are very common in Jaffna, Puttalam and Batticaloa lagoons.

As with all other natural ecosystems, mangrove forests too provide many extractive and non-extractive uses for the benefit of mankind. However, unlike in other regions, detailed studies have not been conducted in the northern region.

Future actions:

- A survey on the present status of mangroves in northern Sri Lanka
- Formulation of a strategy and action plan for replanting mangroves
- Conducting awareness programmes on the importance of mangroves

Mangrove Rehabilitation in Micro-tidal Barrier-built Estuaries and Lagoons: Science, Contradictions and Possible Futures

J I Samarakoon & Senevi Epitawatta

Introduction

1. The Coast Conservation Department (CCD), Forest Department, other government departments associated with natural resources management, coastal ecologists, INGOs, NGOs, local CBOs and coastal communities have shown interest in mangrove-related activities, for diverse reasons. International funding agencies, bilateral donors as well as government agencies have provided considerable financial support for numerous mangrove projects, particularly in the aftermath of the 2004 Tsunami, as a step towards saving lives and property during hazards. Mangrove projects have diverse aims and forms, including mangrove conservation and restoration, planting of mangrove bioshields, mangrove education and protection, among others. Similarly, implementing agencies (particularly INGOs, NGOs and CBOs) have diverse interests. This diversity of approaches and attitudes to mangroves and their management must be understood, in the perspective of the 'bigger picture', to enable appropriate policy development.

2. Coastal communities traditionally use mangroves and their products both for:

   - livelihood activities, and
   - land development in urbanized localities.

Many traditional practices date back centuries and persist to this day in particular geographic settings. Science-based institutions' interest in managing mangroves in Sri Lanka is of recent origin. It is therefore necessary to ensure that institutionalized approaches and attitudes, including laws and regulations pertaining to mangroves, are compatible with the needs and aspirations of local communities and their socio-economic development. This is essential where coastal communities depend upon the productivity of estuaries and lagoons for livelihoods and food security.

Institutional Aspects

3. Institutionalization of interest in mangroves in Sri Lanka mainly from the standpoints of national biodiversity concerns, science, career and organizational self-interest started in the 1980s, with the:

   - Partnership between the Asia-Pacific Regional Mangrove Project (UNESCO) and the Government of Sri Lanka, executed by the Natural Resources and Science Authority of Sri Lanka (NARESA);
   - Establishment of a Mangrove Conservation Project Office in the Forest Department supported by IUCN;
   - Inclusion of mangroves as a critical habitat in the Sri Lanka Coastal Zone Management Plan of the CCD;
   - Promotion of mangrove research by the National Aquatic Resources Agency (NARA) and
   - Enactment of mangrove legislation

4. During the past three decades or so the consequences of mangrove projects received little critical attention. This colloquium flows from recent independent project evaluations (and self-evaluations) that raised concerns about the value of the project outcomes, to:

- Society
- coastal ecosystems
- integrated coastal zone management
- biodiversity

Pertinent Questions

5. The following questions pertain primarily and specifically to the ecological and geographical context of Sri Lanka. However, answers to these questions may also be examined in the context of specific international settings, while ensuring that the comparisons adhere rigorously to scientific principles. The questions of foremost importance are:

   (i) What are the economic and financial values of mangroves to Sri Lanka's coastal populations?

   (ii) What are the particular and site-specific features that account for their abundance and distribution?

   (iii) In Sri Lanka's geo-morphological context are mangroves:
   - coastal ecosystems in their own right, or
   - components of other coastal ecosystems.

   (iv) When and how did interest in mangroves arise within Sri Lanka's science culture?

   (v) What are the measured and measurable impacts of:
   - mangroves in their natural state, and
   - planted (or cultivated) mangroves.

   (vi) Coastal ecologists and resource managers assert that mangrove planting, as currently practiced in Sri Lanka, does more harm than good. More specifically,
   - what are the beneficial consequences to society and ecosystems,
   - what are the harmful consequences to society and coastal ecosystems,
   - in the win-lose situations that arose from the projects, who won, and who lost.

   (vii) How do mangroves impact on other economic activities (sectors): fisheries, agriculture, tourism, urban planning in terms of flood protection and drainage, biodiversity, hazard mitigation.

   (viii) What are the dimensions of the 'big picture' within which mangroves need to be analyzed, including the types of models that need to be developed (causal, mathematical, hydro-morphological, socio-ecological system, etc)

   (ix) Are the mangrove projects currently being implemented based upon participatory planning and decisions (good governance) with due regard to the subsidiarity principle.

   (x) What are the predictable relationships between mangroves and impacts of climate change, specifically in regard to:
   - protection from coastal hazards (e.g. cyclones, erosion, floods, etc.) in their role as bio-shields
   - food security (e.g. drainage, soil salinization, water-logging, etc)

Goal and Objectives of Colloquium

6. Goal:

To formulate and recommend policy, based on the scientific and geo-morphological context of mangroves ***specific*** to Sri Lanka, that would contribute to sustainable development.

7. Objectives:

To develop guidelines for mangrove projects that would ensure:

- Best practices that prevent negative externalities;
- Indicators for evaluation and measurement of consequences of mangrove projects;
- Accountability of implementing agencies for adverse consequences in the long-term (> 30 years), so as to benefit coastal ecosystems and coastal communities,;
- Optimal utilization of funds in the public interest

Mangroves in Sri Lanka – Some Facts

8. Geographic Setting

- Micro-tidal environment;
- Coastal processes, tidal prism, tidal volume, tidal circulation within coastal water bodies highly favourable for sediment entrapment;
- Hydro-morphology of estuaries and lagoons – the geo-morphological context;
- Rivers: sediment loads and discharges;
- Aspects of brackish water biology;
- Human interactions.

9. Ecology of Mangroves

- Abundance and distribution (10,000 – 12,000 ha existing as inter-tidal patches within partially enclosed estuaries and lagoons, except along the Mannar-Pooneryn coastline);
- Species composition;
- Ecological role as an inter-tidal pioneer species;
- Impacts of mangroves in brackish water bodies

Problems

10. The problems in regard to the form and content of mangrove projects implemented/being implemented in Sri Lanka can be disaggregated as follows:

(i) Inappropriate practices have been employed in some mangrove projects. This stems from different perceptions of the structure and functioning of the 'ecosystems' within which, mangrove planting has taken place.
(ii) If these inappropriate actions are not corrected, the long term consequences to society and to the coastal ecosystems will become irreversible, leading to diminishment of their multiple values.
(iii) The 'state' is not in a position to bear the cost of reversing the adverse consequences to the coastal ecosystems thereby resulting in permanent losses, including economic and development opportunities.

Issues

11. Several issues flow from the problems set out above at 10.

    (i) Mapping, on appropriate scale, the areas where irreversible adverse impacts have occurred and/or are occurring.
    (ii) Formulation of guidelines for good practices, monitoring indicators, and accountability mechanisms.
    (iii) Documentation of case studies of scientific and quantitative interpretations of inadequately integrated mangrove planting.
    (iv) Lack of appropriate multi-disciplinary models (including hydromorphological, mathematical, socio-ecological, etc) that can guide mangrove planting integrated with structure and functioning of coastal ecosystems.

Annex 4

Colloquium on Mangrove Rehabilitation Efforts in Sri Lanka (Eastern Province)
Hotel Bridge View, 63/24, New Dutch Bar Road, Kallady, Batticaloa

24 November, 2009

Programme

09 30 – 09 40	Address of Welcome **Dr R Mahindapala, Country Representative, IUCN Sri Lanka**
09 40 – 09 50	Address by the Guest of Honour **Mr S Arumainayaham, District Secretary, Batticaloa**
09 50 – 10 00	Special Address **Mrs S Prabaharan, Mayor, Batticaloa**
10 00 – 10 20	Reminiscences; The Landmark of Batticaloa – The Batticaloa Lagoon **Mr Prince Casinader**
Chair – Dr T Jayasingam	
10 20 – 10 30	Remarks from the Chair
10 30 – 10 50	Current Status of Mangrove Conservation in the Eastern Province of Sri Lanka –Forest Department perspectives **Mr R G Gunathilake, Divisional Forest Officer, Batticaloa**
10 50 – 11 10	Mangroves of the Batticaloa Lagoon - Past and the Present status with special reference to post-tsunami replanting efforts **Professor Mano Sabaratnam, Director, Mandru, Batticaloa**
11 10 – 11 40	Discussion followed by Tea
Chair – Professor Mano Sabaratnam	
11 40 – 12 00	Batticaloa Lagoon – A Systems' Perspective **Dr M Manobavan, Department of Applied Sciences, University of Jaffna, Vavuniya Campus**
12 00 – 12 20	Mangroves and Fisheries; a perspective from Batticaloa district **Mr T George, Mr P R Jeevananthan & Mr I Thenansajen, Department of Fisheries & Aquatic Resources, Batticaloa District Office**
12 20 – 12 30	Discussion
Chair – Dr J I Samarakoon	
12 30 – 12 50	Mangroves in Batticaloa: A struggle for an existence **Dr T Mathiventhan, Department of Botany, Eastern University, Sri Lanka**
12 50 – 13 10	Lessons Learned in Mangrove Ecosystem Conservation in the Batticaloa District **Dr P Vinobaba & Mr S Santharooban, Department of Zoology, Eastern University of Sri Lanka**
13 10 – 13 45	Discussion & Distilling the Best Practices; Facilitated Discussion by Dr J I Samarakoon
13 45 – 14 00	Summing up **Dr T Jayasingam, Eastern University of Sri Lanka**
14 00	Lunch

(Ranjith Mahindapala)

Annex 5 Presentations made at the Batticaloa Colloquium

Summaries prepared by IUCN based on the presentation

1. **Current Status of Mangrove Conservation in the Eastern Province of Sri Lanka – Forest Department Perspectives**
   R G Gunathilake

2. **Mangroves of the Batticaloa Lagoon - past and present status with special reference to post-tsunami replanting efforts**
   Mano Sabaratnam

3. **Batticaloa Lagoon – A Systems' Perspective**
   Manoharadas Manobavan

4. **Mangroves and Fisheries: a perspective from Batticaloa district**
   P R Jeevananthan & I Thenansajen

5. **Mangroves in Batticaloa: A struggle for existence**
   T Mathiventhan

6. **Lessons Learned in Mangrove Ecosystem Conservation in the Batticaloa District**
   S Santharooban & P Vinobaba

Current Status of Mangrove Conservation in the Eastern Province of Sri Lanka – Forest Department Perspectives

R G Gunathilake
Forest Department, Batticaloa

Mangrove ecosystems are comprised of hardy, evergreen vegetation ranging from shrubs to trees and are found in lagoons, estuaries and islets. The specialized vegetation is well adapted to unfavorable conditions such as saline water and anaerobic soil conditions, and are found within intertidal zones with a shallow tidal amplitude of about 1 m.

Mangroves occupy less than 1% of the land area of Sri Lanka and individual blocks of mangroves range in size from less than a hectare to several hundreds of hectares. The fragmented nature of mangrove ecosystems, and most blocks being small in size, makes it difficult to get an accurate estimate of the total extent.

In the Eastern Province, mangroves are found along the coastal belt from Pulmoodai to Panama, covering three districts:

- Trincomalee (Pulmoodai to Verugal)
- Batticaloa (Verugal to Periya Neelavanai)
- Ampara (Periya Neelavanai to Panama)

Mangrove extents

Extent of mangrove habitats in Sri Lanka by districts, and of important mangrove habitats in the Eastern Province are presented in Tables 1 and 2, respectively *(Source – Forest Department Inventory, 1995)*

Table 1

District	Extent (ha)
1. Colombo	39
2. Gampaha	313
3. Puttalam	3,210
4. Mannar	874
5. Kilinochchi	770
6. Jaffna	2,276
7. Mullathivu	428
8. Trincomalee	2,043
9. Batticaloa	1,303
10. Ampara	292
11. Hambantota	576
12. Matara	200
13. Galle	238
14. Kalutara	200
Total	**12,762**

Table 2 - Important Mangrove habitats in the Eastern Province

District	Mangrove habitat	Extent (ha.)
Trincomalee	Kuchchaveli	300
	Muthur	275
	Kinniya	650
	Thampalakam	500
Batticaloa	Sathurukondan	30
	Vakarai	350
	Vavunathivu	150
	Kokkaddichcholai	250
	Vellaveli	530
Ampara	Panama & Urani	100
Total		3135

The Forest Department (FD) was entrusted with the management of all mangrove habitats by Circular No. 05/2001, as per legal provisions in Section 20 of the Forest Ordinance.

Both government and non government agencies are involved in the management of mangrove conservation. Forest Department, Department of Wildlife Conservation, Department of Fisheries and Aquatic Resources, NECCDEP/Ministry of Nation Builders and Universities belong to the first category, while UN organizations (FAO, UNEP, UNDP), IUCN, INGOs (World Vision, etc.) and Local NGOs (Small Fishers Federation, Mandru, etc.) belong the second category.

Current activities of the Forest Department relating to mangroves include replanting (along the edges of lagoons – Panama, Urani, Sathurukondan and Batticaloa); rehabilitation (in degraded mangrove areas); conservation (extension and awareness programmes, formation of CBOs); and law enforcement (under Section 20 of the Forest Ordinance) and against illicit activities (FD officers and Police officers).

Following planting programmes have been carried out by FD in the three districts:

- Ampara (2006 & 2007)
  - Panagala – UNEP (30,000 seedlings)
  - Kunugala – UNEP (30,000 seedlings)
  - Urani – UNDP (20,000 seedlings)
  - Kudakalli – UNDP (10,000 seedlings)
  - Palakkuda – UNDP (5,000 seedlings)
  - Pottuvil – FAO (15,000 seedlings)
- Batticaloa (2005 & 2006)
  - Palameenmadu – FAO (2,000 seedlings)
  - Sathurukondan – FD (10,000 seedlings)
- Trincomalee
  - Uppar lagoon – FD (10,000 seedlings)

Mangroves are threatened by illicit activities. Such activities recorded by FD are:

- Illicit felling, for
  - Fire wood, timber, construction materials, fishing gear, bakery industry, etc.

- Illicit clearing, for
  - Cultivation of paddy,
  - Cultivation of other crops
  - Industries
  - Fishing harbours
  - Construction of dwellings
  - Infrastructure development
  - Shrimp culture
- Setting fire
- Encroachment for settlements and industries
  eg: Sathurukondan mangrove area
- Lagoon fishing
  - Use of mangrove areas as boat yards
  - Fishing with nets
  - Traditional fishing (Brush pile fishing)

When mangroves are destroyed fishery resources get depleted (loss of breeding grounds, fish nurseries and fish fry)

Future activities planned by the Forest Department are:

Identification of Mangrove habitats

Identification of potential planting areas for mangroves in the lagoons/estuaries

Survey and mapping
- Ground surveys by FD
- Detailed surveys and boundary demarcation by the Survey Department

Extension and awareness programmes
- For school children and teachers
  - Seminars, workshops, field trips etc.
- For general public
  - Seminars, workshops, field trips etc.
- For government officers (Police, DSS, GNN and others)
  - Seminars, workshops, field trips etc.
- Preparation of awareness materials
  - Posters
  - Leaflets
  - CD/DVD
  - Books/booklets
- Buffer zone management
  - Formation of CBOs
  - Homestead development
  - Distribution of seedlings of timber/firewood/fruit spp.
  - Distribution of fuel saving stoves
- Training of FD officers and others
- Declaration of selected mangrove areas as conservation forests
- Preparation of management plans for selected mangrove areas
  - Clustering of mangrove areas
  - Development of strategy to prepare management plans

Constraints faced by the Forest Department are:

- Institutional
  - Lack of knowledge in mangrove restoration - reason for failure of most of planting programs
  - Low priority for mangrove conservation activities
- Technological
  Inadequate knowhow on
  - Selection of sites
  - Choice of species
  - Nursery techniques
  - Planting practices
- Legal aspects
  - Inadequate inspections of the mangrove habitat areas
    - FD officers are generally afraid to visit and take legal action
    - Lack of transport facilities

The following actions are recommended to strengthen and enhance the work of the FD.

- Institutional strengthening
  - Provide training, especially in nursery management and planting
  - Awareness creation among the public, schools, government officials, NGOs)
  - Provide enhanced facilities
    - Transport
    - Boats and other vehicles, fuel etc.
- Conduct more research, surveys and field studies.
- Assign more officers for coastal areas
- Provide adequate financial resources
- Coordinate all institutions involved in mangrove conservation activities (Government agencies/NGOs).

Mangroves of the Batticaloa Lagoon - past and present status with special reference to post-tsunami replanting efforts

Mano Sabaratnam
Mandru, Batticaloa

In the past, the lagoon was bordered by a beautiful stretch of mangroves and covered nearly 1672 ha - it was nature's gift to the people of Batticaloa District. The lagoon fishermen enjoyed a very good catch and income and consumers had plenty of a variety of fish.

Mangroves performed many important functions: as a barrier/windbreak they control fast flowing rain water and strong winds; its well established root system stabilizes the shore line and controls erosion; provides nutrients for aquatic fauna and maintains the oxygen supply; acts as nursery grounds for prawns, crabs, fish etc and a resort for migratory birds; and most of all is a source of economic gain to the fishermen.

But people have destroyed these mangroves from time to time, for different reasons. Threats still prevail and this rich and very beneficial vegetation is destroyed through sheer ignorance. As a result, the lagoon has dwindled to 1,606 ha and its beauty and wealth of aquatic life are now on the decline.

Threats to mangrove ecosystem:

The reduction in the extent of mangroves is due to both natural disasters and anthropogenic activities. The 1977 cyclone and the 2004 Tsunami were the major natural disasters that had a serious impact on all vegetation in the entire district.

The destructive anthropogenic activities were many: removal of trees for fuel wood by people living near the mangroves; extraction of mangrove branches by fishermen to construct enclosures in the lagoon, called "*kothu",* to catch fish, crabs, prawns etc; and clearing the vegetation along the lagoon by the Sri Lanka Army as a security measure during the 30-year ethnic conflict.

The increase in population and relocation from villages to the city has raised the demand for land to build houses. To meet this demand the lagoon area has been cleared and filled badly affecting the lagoon system and its vegetation.

After the dawn of peace in 2009, mangroves are being cut down to develop the tourism industry.

Prawn culture boomed in Chilaw, Puttalam and Kalpitiya areas but eventually led to the destruction of very valuable lagoon systems and adjoining paddy fields. Owners of these failed prawn farms are now turning towards Batticaloa and areas are being cleared to establish prawn farms. Development is vital, but not at the expense of our very valuable lagoons.

Destruction of any natural vegetation is contrary to existing laws and the Forest Department should safeguard at least the remaining mangrove vegetation. Adequate awareness–raising, among all those associated with the lagoon, may have reduced this destruction somewhat.

Mandru was involved in conserving mangroves in Batticaloa district over the past two decades, and took a keen interest in reforestation in the late 1990s. Since most of the mangroves were destroyed, seedlings were brought from Vakarai for reforestation. Replanting was carried out at Theelivedduvan, Palameenmadu and Bar mouth,in consultation with the Fisherman - the beneficiaries. This maiden attempt was funded by Mandru, but funds were not adequate to continue the project and follow up.

In 2006, following the 2004 Tsunami, Mandru commenced replanting on a small scale using Mandru funds. Seedlings were collected again from Vakarai, mainly *Rhizophora mucronata,* and planted, as a trial, with permission from the District Authorities. The trial was successful, and the "Green Movement", in 2007, awarded Mandru a grant that enabled replanting on an extensive scale. The funds received from the Mangroves for the Future - Small Grants Facility, through IUCN Sri Lanka Office in 2009, enabled Mandru to extend replanting to Thiruperuthurai.

Mandru will continue with the good work commenced in 1997 until the mangrove vegetation is restored to its pristine status. Batticaloa, as a whole, will benefit through this activity.

Batticaloa Lagoon – A Systems' Perspective

Manoharadas Manobavan
University of Jaffna, Vavuniya

"Fascinating as the district is in many ways… the climatic conditions, the physical features and the inaccessibility of the country, militate against human survival… the district is liable to alternate extremes of flood and drought… with an occasional cyclone. An immense amount of money must be laid out before the floods can be controlled… and low lands drained and protected from the inroads of saltwater. In these circumstances… it is scarcely surprising there has been little marked progress"! [R.A.G. Festing (Esq.), Eastern Province, Christmas of *1918*]. From the Foreword in S. O. Canagaratnam's Monograph of Batticaloa

From Christmas of 1918 to Christmas of 2009…
there has been no marked progress… this year, if it rains cats and dogs, we will drown – definitely!!!
All depends on how effectively we manage the Batticaloa lagoon.
The basic definition of a lagoon is a semi-saline water body connecting to the sea via a small opening.

A lagoon as a (natural) system is:

- Capable of self-regulation (within limits)
- Affected by mangroves and affects mangroves (*as per* Gaia Theory on systems self-regulation)
- Governed by flow – where the ultimate regulator of the flow is the bar mouth…
- Nourished and sustained by peripheral wetlands…

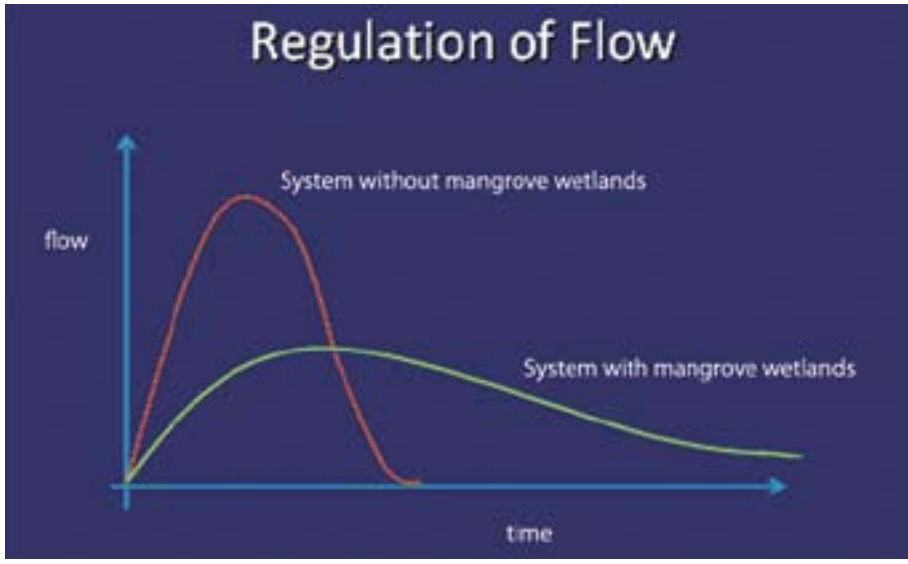
Batticaloa lagoon, the largest of the three lagoons in the district, is a complex and sensitive system.

Managing the Batticaloa Lagoon has always been a thought… not yet fully operationalized. Mandru in the 1990s and Shanmugaratnam in 1995 expressed the *"need for master plan…"*. The current Batticaloa Lagoon Special Management Area (B-SMA) focuses on the system…The B-SMA, by definition, includes the Batticaloa Lagoon and the 89 Grama Niladari (GN) Divisions that border the lagoon.

A good manager will always focus on the system and **not** on the individual component; it is therefore necessary to look for functionality: basic *functional* elements/processes. The basic elements in this case are the lagoon as a water body, inputs of water (fresh/saline), underground water recharge/maintenance, sea surges and protection, peripheral wetlands, local climate and ecosystem maintenance.

All of this is based on, water as the input, as the medium and as something that needs to be excluded (at times). From a homeostasis perspective, vegetation i.e. mangroves, which act as bio-regulators is also important.

As depicted by the following graph mangroves play a major role in regulating the water flow.



Therefore, mangroves are vital in a lagoon ecosystem, but to have mangroves, it is necessary to have the correct natural base i.e. the appropriate natural environment. It is therefore necessary to ensure that the (natural) *functionalities* of the lagoon system are maintained. Mangroves cannot grow on dry land. Batticaloa is a dying lagoon, and it is necessary to manage it better.
The following have been tried in the past:

- Special Management Area Committee – by NECCDEP
- SMA Plans of 2005/6 and onwards
- DELEC (District Environmental Law Enforcing Committee) – defunct?

This is a colloquium on *mangrove rehabilitation efforts;* not a forum for developing the management framework for the Batticaloa Lagoon…!
But to sustain the outputs of all mangrove rehabilitation efforts, sustaining the lagoon and its system is IMPORTANT. To achieve this we have to *start from the management of the lagoon…*

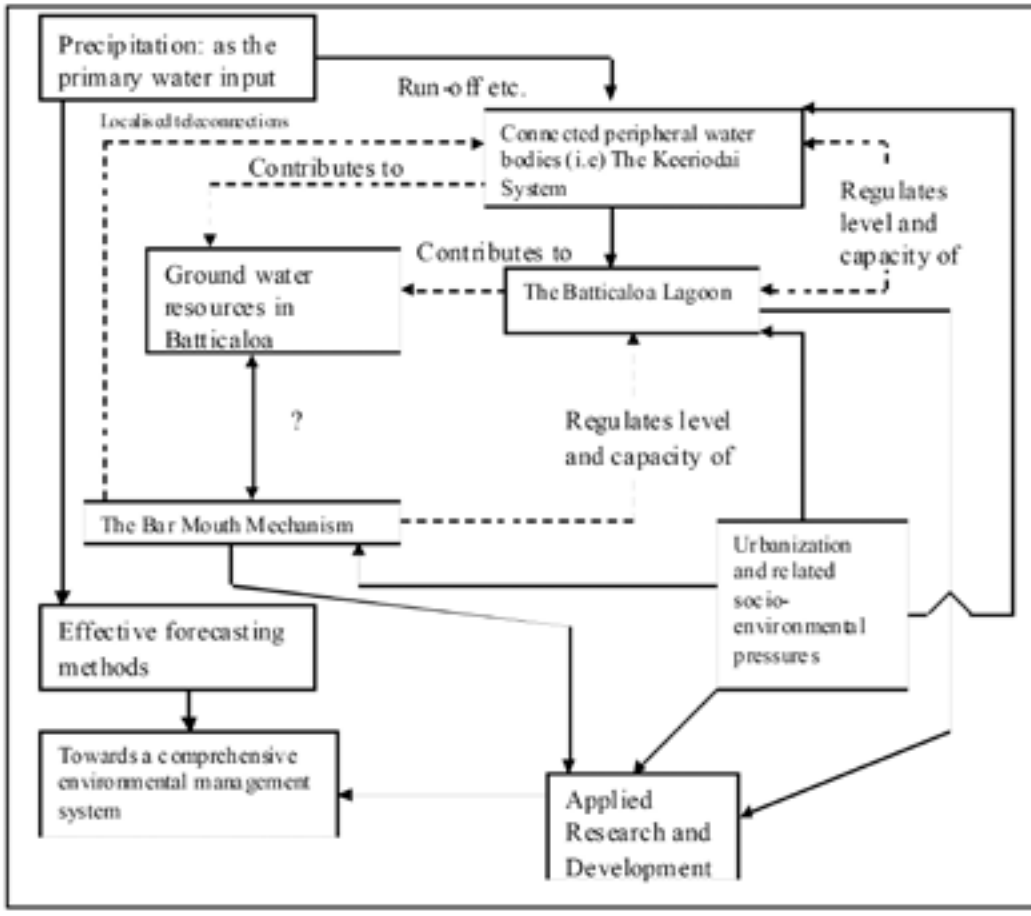
We need

1. A planning process
2. Development of a Management Framework
3. Cross sectoral Networking
4. A conducive environment for research
5. Adequate funding
6. The willingness to carry on…

Mistakes that *affect* the system should be avoided and the following should be considered:

1. Focus on functionalities
2. Flow and Inputs
3. Drainage network
4. Watersheds and management
5. Ecosystem based approach…

A sample model of 'functionality' is given below.



Mangroves and Fisheries: a perspective from Batticaloa district

P R Jeevananthan & I Thenansajen
Department of Fisheries and Aquatic Resources, Batticaloa

Mangroves play a vital role in fisheries by providing functions of ecological and economic importance. The ecologically important functions are the provision of feeding grounds, shelter and breeding grounds for fish and other aquatic organisms. Its economic importance in fisheries is through the provision of a favourable environment for fish stocks, material for making fishing equipment (traps) and dyes for fishing nets. Although aquatic resources are heavily utilized by coastal communities, mangroves and aquatic resources are poorly managed.

Upparu, Valaichchenai and Batticaloa are the three lagoons in the Batticaloa District. The mangroves and aquatic resources of these lagoons and the coastal areas, covering 14 DS Divisions, are utilized by over 1,000 people.

The fishery resources in the Batticaloa Lagoon are utilized by way of:

- Subsistence collection: collection of aquatic products in the mangrove areas (on foot), using simple hand tools
- Fishing: with nets, traps and/or other gear, and usually a boat
- Aquaculture: small scale farming of aquatic organisms

Batticaloa is famous for fresh fish and the species range from fin fish (cat fish and mullet etc) to crustaceans (sesamid crabs, shrimp, mud crab and fiddler crab) and molluscs (oysters, mussels and clams). Many villagers are engaged in fishing; some are full-time and others part-time to supplement income and for food. Traditional methods, nets and traps are generally used to catch fish.

Crustaceans are important socially and economically and fetch high prices. Collecting molluscs, generally found on mud flats, are heavily utilized by the community and is an important subsistence activity for women and children of poor families. Mussels or oyster culture is a low risk alternative to fishing.

Fish stocks are depleting at an alarming rate. Hence, the vital need to manage the aquatic resources. Following options could be considered for the management of aquatic resources:

- Regulate the fishing methods and gear used
- Set a minimum size of individuals harvested
- Regulate fishing during the months when the resources are most vulnerable (closed seasons)
- Regulate the areas/habitats exploited (preservation of habitat)
- Regulate the number of people collecting/fishing
- Stewardship of fishing/collecting areas
- Co-management of aquatic resources utilization
- Restocking milkfish and shrimp

The recommendations that arose from the presentation were:

- Conduct research on key economic species. Local knowledge can give current status and help understand changes
- Economic valuation of aquatic resources - aquatic plants and animals
- Enhance education and awareness among school children and public
- Extension programmes
- Effective communication and enforcement of regulations

Mangroves in Batticaloa: A struggle for existence

T Mathiventhan
Eastern University, Batticaloa

Mangroves are found in all three lagoons in Batticaloa district namely, Batticaloa, Valaichenai and Vakarai lagoons; and large mangrove patches are seen in Pankudaveli, Vaharai, Kandalady, Panichankerny, Sathurukkondan, Nasivanthivu.

Mangrove distribution in Batticaloa district

Size distribution of mangrove patches on the east coast of Sri Lanka

District	Area ha	Units	<5 ha	5-10 ha	10-20 ha	20-100 ha	>100 ha
Trincomalee	1489	147	101	14	18	11	3
Batticaloa	1421	210	150	31	11	20	
Ampara	292	36	24	7	1	4	
Total on the east coast	**3202**	**393**	**275**	**52**	**30**	**35**	**3**

Field studies in Batticaloa revealed:

- There are about 12-15 true mangroves and associates in Batticaloa.
- Major species are: *Exoecaria, Rhizophora, Avicennia, Sonneratia, Lumnitzera, Acrostichum, Acanthus, Clerodentron, Derris and Dolichandrone.*
- Minor species are *Heretiera, Ceriops* and *Bruguiera*
- Associates are *Cerbera, Hibiscus tiliaceus*
- Other species and salt marsh plants are found associated with mangrove species.

Current issues observed in the region are:

- Shrimp farms - clearing for farms and subsequent pollution of water bodies.
- Cutting and felling for fences, betel cultivation, fire wood, security and construction
- Encroachment for establishment of hotels, houses, as a business to sell land, constructions.
- Garbage dumping due to poor awareness and improper SWM activities.
- Natural events such as tsunamis and cyclones
- Planting for protection and conservation of wetlands, to enhance natural dynamics and for fish production, without adopting a scientific approach (species and site selection, past histories)

Recommendation: Consider the following when dealing with mangrove related activities:

- Institutional approaches
- Community approaches
- Legal approaches
- Scientific approaches
- EIA approach
- Different authorities...Forest Department, Department of Wildlife Conservation and Local authorities ... too many?

The difficulties faced in mangrove management are:

- Lack of reliable data on true mangrove cover
- Inaccessibility or security problem
- Inadequate research work/scientific study
- Poor past records
- Inadequate survey maps or digital data
- No continuous monitoring/updates
- Majority of the available documents –have little field oriented information….copied from previous…?

Roadmap to conserve and manage mangroves in Batticaloa:

- Enhance awareness among different stakeholders – from local community to top level decision makers
- Knowledge integration – local and scientific
- Adopt multi disciplinary approach – ecology, economy, ethics, environment, culture
- Understand property rights, user rights, institutional mechanisms, laws & Acts, EIA
- Adopt a scientific approach in rehabilitation/restoration/planting of mangroves and its future impact on existing ecosystem components
- Conduct scientific research and documentation
- Comprehend ecosystem dynamics
- Develop common agenda among different agencies – on ecosystem management and conservation activities
- Clear identification of authority – for decision making and implementation
- Legal action against illegal approaches on wetlands
- Introduce mangrove ecosystem-based development activities – mangrove forest walk, canoe riding, bird watching, field exploration for students
- Introduce sustainable use of mangroves.
- Include local people participation in mangrove protection and management.
- Introduce integrated mangrove forestry-shrimp farm practices.
- Long-term monitoring and reporting

Let's minimize the mangroves' struggle for existence……

Lessons Learned in Mangrove Ecosystem Conservation in the Batticaloa District

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Eastern University, Batticaloa

Mangroves are one of the rich ecosystems found in Batticaloa, Sri Lanka. They provide both economic and ecological benefits to the people and their surroundings. This paper discusses the rehabilitation of mangroves and preservation of existing mangrove vegetation, in two villages: Palameenmadu (Manmunai North DS Division) and Puthukudiyeruppu (Manmunaipattu DS Division).

The mangrove patches in both villages consist of several true mangrove species such as *Rhizophora mucronata, Aegiceras corniculata, Avicennia* sp.*., Lumnitzera racemosa, Sonneratia caseolaris, Excoecaria agallocha;* and mangrove associate species such as *Acanthus ilicifolius, Acrostichum aureum, Clerodendron inerme, Dolichandrone spathacea, Sesuvium portulacastrum,* and *Derris trifoliate.* The dominant species in Palameenmadu is *Lumnitzera racemosa; Excoecaria agallocha* is dominant in Puthukudiyeruppu. Mangrove fauna *Cerithidea cingulata*, *Nerita* sp, *Saccostrea* sp, *Gelonia* sp, *Anadara granosa*, *Balanus* sp, *Penaeus monodon, Penaeus semisulcatus, Scylla serrata,* and *Periophthalmus koelreuteri* are found in both areas; however, species diversity in Palameenmadu is richer.

Mangrove forests in both villages are being continually damaged, at an alarming rate, by several anthropogenic activities that fall into three major categories (Santharooban and Vinobaba, 2008a):

1. Overextraction by local communities.
2. Clearing for security purposes.
3. Unplanned urban development by district administrators

The extent of mangroves in the Batticaloa district, as published by different authors, is presented below

No	Author/s or Organization	Published Year	Area (ha)
01	Pinto, L	1986	1520
02	North-East Report	1993	1390
03	Amarasingha, M	1996	1303
04	*Poikai* magazine, Forest Department, Batticaloa	2001	1672
05	Nallairajha & Jeyasingam, T	2001	1525
06	Eastern Province Coastal Community Development Project Mid Term Report (March 2002)	2002	1421
07	Statistical Handbook, Batticaloa District, Planning Secretariat	2004	1606
08	Statistical Handbook, Batticaloa District, Planning Secretariat	2005	1606
09	Forest Department, Batticaloa	2006	1855
10	Statistical Handbook, Batticaloa District, Planning Secretariat	2006	1606
11	Statistical Handbook, Batticaloa District, Planning Secretariat	2007	1606

However, a recent study indicates that only 996 ha of mangroves are presently found in Batticaloa

(NARA, 2008). Therefore, every attempt should be made to preserve the mangrove forests in the two villages.

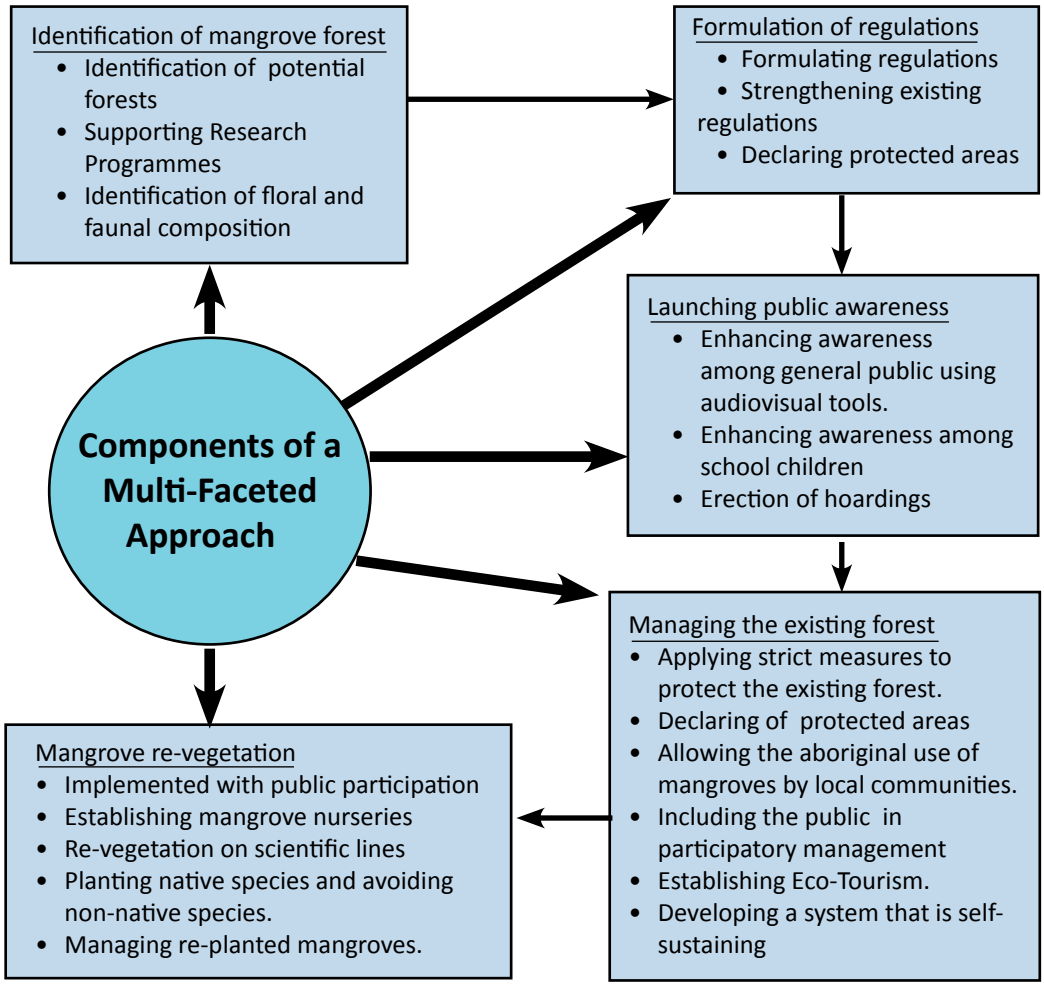
Unplanned development is the most destructive anthropogenic activity, especially after the Tsunami 2004. Incompetent district administrators have permitted some NGOs to implement inappropriate urban development programmes that entailed severe destruction of the mangrove forests (Santharooban and Vinobaba, 2008b). About 30% of the mangroves in Palameenmadu have been destroyed by unplanned developmental activities.

The ongoing mangrove re-vegetation programmes have a one-dimensional approach to preserve the mangrove ecosystem. This will not be effective as they fail to prevent the continuing degradation of the mangrove ecosystem. These programmes focus only on re-vegetation in the allocated area and fail to protect the already existing forest. Merely depending on mangrove re-vegetation is not good enough, it is essential to conserve the existing mangrove forest.

Multifaceted approach in mangrove rehabilitation

A multifaceted approach is crucial to preserve the pristine mangrove ecosystem in the Batticaloa District. This should include mangrove forest identification, formulating appropriate regulations and applying them strictly to conserve existing forests, launching public awareness programmes, and properly planned mangrove re-vegetation programmes with community participation.
The multifaceted approach brings about a win-win situation where the local people will derive economic benefits while protecting the ecosystem. It ensures the sustainable use of natural resources rather than strict conservation. The components of a multifaceted approach, which consists of a series of major activities needed for the rehabilitation of mangrove vegetation, are shown in Figure 1.

Figure 1: Components of a Multifaceted Approach for Mangroves Rehabilitation



Annex 6

Physiography of Sri Lanka's Coastal Plains, Origin and Behaviour of Micro-tidal Barrier-built Estuaries and Lagoons, and their Sedimentation with Mangrove Planting and other Land Uses[3]

The long-term processes of change in complex ecosystems such as barrier-built estuaries and lagoons are easier to comprehend with some background knowledge of how they came into being and evolved. About 10,000 years before present (BP), the interaction between eustatic sea level change and coastal environmental factors caused the formation of sand and sediment barriers where rivers flowed into the sea (estuaries). These factors included (Erb, 1966; Swan, 1983):

- Form of the bedrock at river outfall
- Stabilization of the sea level in its present condition
- Quantity of sediment from land drainage transported by rivers to the sea
- Relative land sinking
- Coastal processes including tides, littoral drift (long-shore currents), waves
- Submergence pattern, etc.

Human interventions that disturb the hydrology and hydraulics of complex barrier-built estuaries and lagoons, may aggravate sediment entrapment and infilling. Therefore, sustainable management strategies for lagoons and estuaries always require careful consideration of sediment trapping as an overarching factor. Mangrove planting, as currently practised, is by no means the sole variable responsible for sedimentation. Ad hoc construction of roads, bridges and buildings etc. that alter the hydrology of these ecosystems have even more disastrous impacts. On the other hand, integrated and systematically planned mangrove planting provides an opportunity to showcase what is possible.

Erb's Interpretation of Sri Lanka's Coastal landforms

Prof. D K Erb, Department of Geography, University of Waterloo, Canada, provided a foundation for understanding the form of Sri Lanka's coastal plains in his seminal paper '*Landforms and Drainage of Ceylon*' (Erb, 1966). His published findings are extensively quoted below in support of the inferences derived in this report.

> *"In general the Coastal Plain of Ceylon may currently be classified as a plain of submergence. It is true that there is evidence of emergence in the form of raised beaches, wave cut terraces, and elevated coral reefs, but it is considered here that the dominant characteristics are those of submergence. The presence of broad, flat alluvial plains, virtually at sea level, behind partly silted up lagoons shut off from the sea by low sand dunes and spits, is indicative of this sequence of events. The fact that most of these alluvial deposits fill depressions with a dendritic outline, and the presence of wave truncated promontories, are also indicative of retrograding shoreline".*

Erb divides the Coastal Plain of Sri Lanka into four sections (Fig. A6.1):

- Mannar Coastal Plain,
- Trincomalee Coastal Plain,
- Pottuvil Coastal Plain, and
- Bentota Coastal Plain.

3 Prepared by Dr J I Samarakoon

A selection of his comments on these coastal plains provides insights into the changes occurring in water bodies situated there, and the physiographic foundation from which planning of development activity such as mangrove planting must proceed.

Mannar Coastal Plain

> *"The inland margin of the Coastal Plain is very irregular, following as it does topography and therefore the dendritic pattern of the various valleys crossing it. The shoreline on the other hand, is strikingly smooth with very few protuberances or major indentations. Beach drifting and to some extent longshore drifting by littoral currents have effectively distributed the sand, of which much of the coastal belt is composed, filling in hollows and cutting off projections. In the process of this distribution, certain features have been constructed which are characteristic of this region. Sand spits and bars are two of the most distinctive. The sand spit at Puttalam and the one at Negombo are excellent examples of these features".*
>
> *"The Negombo spit, which almost completely encloses Negombo Lagoon, has a core of rock which may have been responsible for initiating the deposition of sand. This is apparently an extension of a bedrock ridge or 'reef' called Pamunugama Reef, first noted in the vicinity of Kelaniya just north of Colombo. The Provisional Geological Map of Ceylon also shows rock to be present in the spit of Puttalam and on Mannar Island. Configurations further south along the Bentota Coastal Plain substantiate the probability that most of the major north trending spits of the west coast of Ceylon are rock controlled".*
>
> *"Deltas occur along this coast, primarily where rivers flow into large lagoons. On the exposed coast, unless spit or bar-forming conditions are favourable, the sediment is rapidly swept away and deltas do not form".*
>
> This statement corroborates the argument that in Sri Lanka shorefront mangroves that can serve as a buffer against storm surges and cyclones cannot form deltas, simply because conditions favourable for the formation of deltas are absent.

Trincomalee Coastal Plain

> *"The inland margin of the Trincomalee Coastal Plain follows the dendritic pattern of the numerous river valleys crossing it, in the same way as that of the Mannar Coastal Plain. The shoreline is very smooth and with the exception of Koddiyar Bay at Trincomalee, the channels about the islands west of Jaffna and Jaffna Lagoon, does not have any major indentations or projections. The smoothness of this shoreline is due to the combined action of waves and long-shore currents, caused, for the most part, by the north-east monsoon. These agents apparently pick up and transport the sand, of which much of the coastal area is composed, and deposit it as bay mouth bars across the mouth of rivers which empty at intervals along the coast. Numerous lagoons have been formed in this manner, chief of which are Upaar Lagoon, Ullackalle Lagoon, Kokkilai Lagoon, Nayaru Lagoon, Nanthi Kadal, and the complex association of lagoons, many of them un-named which dot and border the Jaffna Peninsula".*
>
> *"Since the lower reaches of the Mahaweli Ganga are flowing cross a low, alluvial, flood plain, it is logical to suppose that these deposits represent the filling, to the present base level, of an earlier, much more deeply incised valley, which would correspond to the existing submarine canyon topography of the bay. The eustatic lowering of sea level during the Pleistocene period would probably provide the differential in base level required to produce this feature".*

Pottuvil Coastal Plain

The inland margin follows the dendritic valley pattern and is marked by little, if any, structural control. The shoreline is relatively smooth and featureless from Sangamankade Point northward. From there south, it presents a scalloped appearance which is due to numerous small bays facing east and northeast with associated sheltering points. From Tangalla to Kirinda, these points consist of rock ridges striking at approximately right angles to the coast. East of Kirinda, many of the points, and parts of the coastline, are strike ridge controlled, but they generally make an acute angle with the local shoreline and trend in an east or north-east direction.

Along the southern part of the Coastal Plain, the major rivers: Walawe Ganga, the Kirindi Oya, the Menik Ganga, and the Kumbukkan Oya, flow directly into the sea across old lagoons silted up by the large sediment load brought down by them.

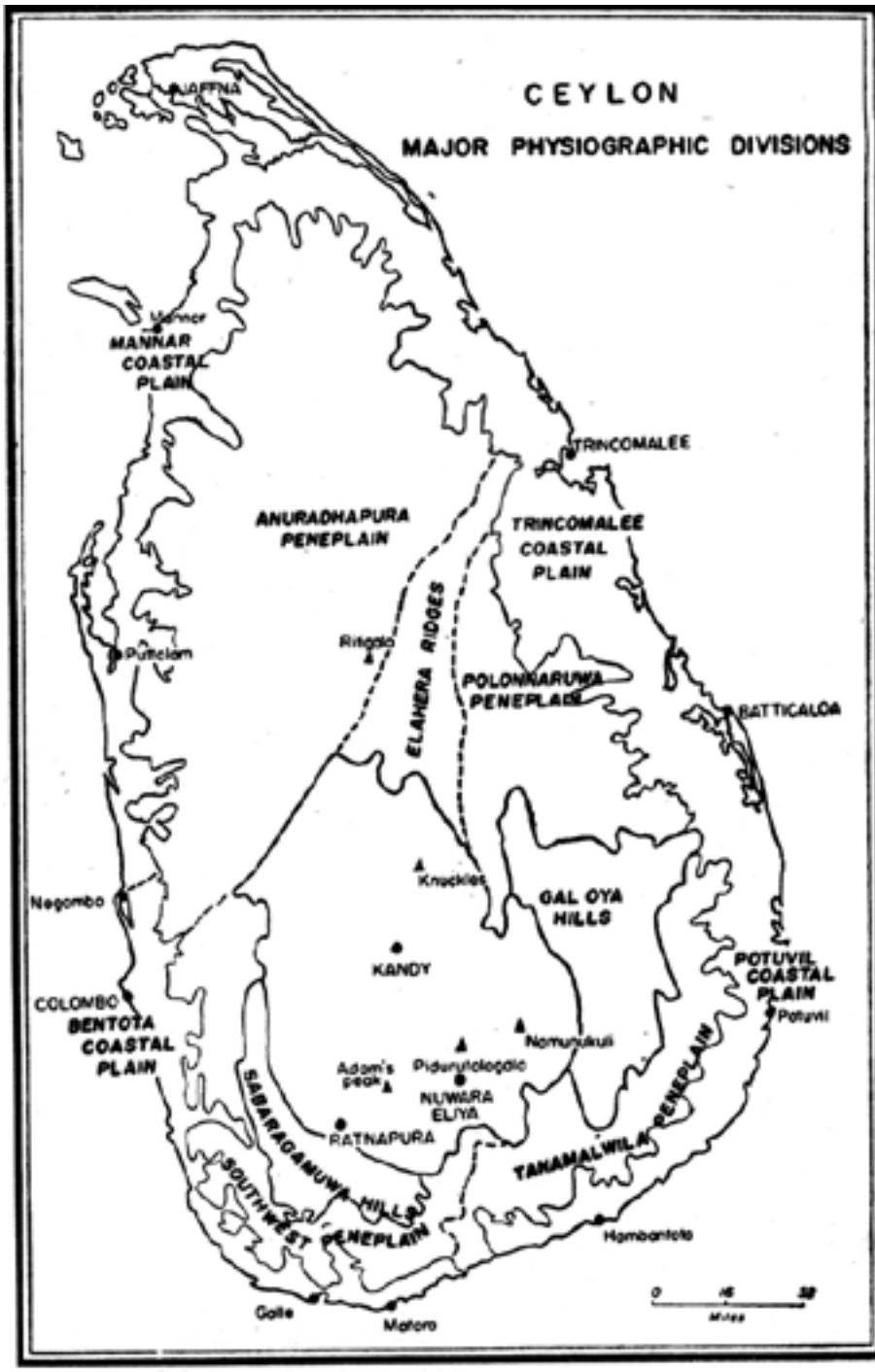
Inland, much of the Coastal Plain consists of the alluvium-choked lower reaches of the rivers mentioned earlier. These rivers flow in broad, flat, valleys with scarcely any local relief, and unless confined by bunds and levees, meander across the plain until stopped by the coastal bars or lagoons. In general the interfluves of the coastal plain, consist of low, rounded, bedrock rises, mantled or thinly veneered with alluvium or residual soils. Knobs or low hills of a more resistant nature occur at intervals".

Bentota Coastal Plain

"The Bentota Coastal Plain extends from the Kirama Oya at Tangalla on the south, to the Kelani Ganga at Colombo on the north. This section of the Coastal Plain of Ceylon differs from the Mannar, Trincomalee, and Pottuvil sections already described, in that it consists almost entirely of drowned river valleys. The proven existence of one hundred feet or more of alluvium in several of the river valleys, forty to fifty miles inland from the coast; the fact that the present bottoms of these valleys are less than one hundred feet above sea level; and the presence of innumerable, steep sided, bedrock ridges rising from flat, alluvium floored valleys which are also at or within one hundred feet of the present sea level, indicate their drowned nature. For this reason also, the inland margin of the plain is very complex. It follows a pattern of strike-, fault-, and point controlled valleys rather than the dendritic pattern common to the plains already described".

"The shoreline also is different. It is, in effect, a rock defended coastline modified by wave and current action. From Galle north, it takes the form of a series of low, bedrock strike ridges projecting in north-northwest direction at a low angle to the general trend of the coast. The projecting ends of these ridges are joined to the next ridge inland by sand bars which have thus blocked off the seaward outlet of the inter-ridge strike valleys. Many of the lagoons so formed have been filled with alluvium to the present base level".

Fig. A6.1. Erb's (1966) depiction of the four coastal plains of Sri Lanka based upon physiographic interpretation into the Mannar Coastal Plain, Trincomalee Coastal Plain, Pottuvil Coastal Plain and the Bentota Coastal Plain.



Ceylon, Major Physiographic Regions

Erb's (1966) interpretation of the form, structure and nature of the coastal plains of Sri Lanka clearly defines the 'sediment trapping' behaviour of the bar-built or barrier-built estuaries and lagoons. Additionally, it supports the two premises that constitute the proposition which formed the basis for this reappraisal. The challenge is to apply this knowledge in managing the barrier-built estuaries and lagoons as complex ecosystems. Land uses that are not fully integrated with hydrology and hydraulics, such as the ill-considered mangrove planting in recent times, accelerate the process of infilling. It is a matter for regret that such irresponsible activities are being persisted with.

The fallacy of shorefront mangroves in Sri Lanka

The sediment loads carried by Sri Lanka's relatively short rivers, traversing restricted catchments, are inadequate to form deltas where the river estuaries enter the sea, especially on a basement of bed rock, as explained by Erb (1966). Alluvial coastal deposits are restricted to short segments along the northwest and the east coastlines (Cooray, 1982). A minimal extent of delta-like shorefront mangrove formations occur at river mouths along the sheltered northwest coastline. As per geomorphologic considerations Sri Lanka does not possess shorefront mangroves on deltas that are in any way comparable with those in Bangladesh, India or in some Southeast Asian countries. Therefore, it is a fallacy to reckon that mangrove concepts from these countries or the tropics in general, are applicable to Sri Lanka without seriously considering and comparing the geographic settings. Generally, when coastal ecosystems in Sri Lanka are discussed, the term 'mangrove' is not clearly defined and understood in relation to its physiographic peculiarity.

Micro-tidal regime

The entire coastal area of Sri Lanka is micro-tidal, that is, the difference between high tide and low tide is less than one meter, throughout the year. Two high tides and two low tides occur daily; alternating high and low tides, at twelve–hour intervals. Therefore, Sri Lanka's tidal regime is micro-tidal and semi-diurnal. Consequently, the currents generated by these tides have a flow speed of less than 1 meter/second, except in the high rainfall seasons when storms occur (Swan, 1984).

The destiny of barrier-built estuaries and lagoons

A search for mangroves in Sri Lanka inevitably ends in the alluvial sediment traps that are classified as riverine estuaries, barrier-built estuaries and lagoons. The foremost setting for mangroves is the barrier-built estuary, a geomorphologic landform, resulting from the formation of a sediment barrier extending into the sea. The sediment barrier partially obstructs the area through which the river flowed to the sea. With the progressive stabilization of the barrier, a partially enclosed basin-like water body, with a permanent tidal connection to the sea, is developed. Negombo Lagoon and Puttalam Lagoon, among others, are barrier-built estuaries (Erb, 1966). Their form and structure (area, depth, and other features) have undergone continuous change since their origin (Swan, 1983; Cooray, 1982). A significant attribute of barrier-built estuaries is that both their birth and eventual transformation into a network of tidal creeks, in ecological time, are determined by sediment. Once formed, a barrier-built estuary continuously traps sediment from land drainage mainly because of the micro-tidal regime. Some original barrier-built estuaries such as Sinna Karchchiya in Trincomalee District, have reached the terminal stage of change into tidal creeks owing to the combined effects of river shift and sedimentation (Erb, 1966). The destiny and ecological life span of a barrier-built estuary is sealed at the time it is born (Perkins, 1974). Size, including water spread, depth and tidal regime are the primary determinants.

The forces that influence the movement of water and the associated sediment (hydraulics) have a major role in the structural evolution of a barrier-built estuary. A small lagoon, such as Rekawa Lagoon is at a late stage of evolution of a relatively small barrier-built estuary where the tidal connection with the sea is usually closed by a natural sand barrier. The sand barrier breaches briefly during the rainy season due to pressure from the build-up of drainage water from the catchment. At other times, the force generated by the high tide alone cannot breach the sand plug at the tidal inlet. The movement of water and sediment within this brackish water body is by wind-generated currents. Speed of currents is not known, but it is highly unlikely that wind-generated currents would exceed 1 meter/second, the speed at which sediments begin to be shifted. In any event, even if strong currents are generated by wind, the sediment can only be redistributed within the lagoon since the tidal inlet is usually closed. Lacking continuous tidal influence makes lagoons such as Rekawa Lagoon highly efficient 'sediment trappers'. Simultaneously, their fishery productivity declines due to non-migration of early stages of fish and crustaceans that breed in the sea. Recent observations (2010) revealed that the major constituent of fish catches is the exotic cichlid fish of the genus *Oreochromis,*introduced to Sri Lanka in the 1950s. Over a period of decades, since the 1960s, the fishery has declined drastically and the typically estuarine species have been displaced (Ganewatte *et al.*, 1995).

In the Negombo Lagoon the forces generated by current speed and wave action are adequate to shift sediment at the tidal inlet, but not within it. This situation, generally encountered in Sri Lanka's barrier-built estuaries and lagoons, makes them highly subject to relatively rapid infilling (Swan, 1983). In barrier-built estuaries, the water spread area at high tide significantly influences the depositional and hydraulic relationships.

Field studies show that river sediment deposits are generally retained in estuaries. Two factors promote retention and prevent offshore transport: flocculation to form, and settle down, as larger composite particles; and the weak circulation in shallow nearshore areas. Biological pelletizing of suspended material during suspension feeding can bring about flocculation. Feeding activities of both benthic organisms and zooplankton also produce pellets that will settle faster than the individual mineral components. Even a slight increase in salinity will initiate flocculation of clay particles. The resistance of cohesive mud deposits to re-suspension is a factor in retaining sediments once they have settled. Only storms and floods generate enough force to move the deposited sediment (Perkins, 1974).

Drainage and flood protection

Drainage and flood protection are two significant functions of barrier-built estuaries, especially for those in urbanized sorroundings such as the Batticaloa, Negombo and Chilaw Lagoons. These are the very sites where mangrove planting is a major investment activity, and where there are signs of sediment building up to eventually create some land that will influence water movement. Simultaneously, it will reduce the living space of aquatic organisms – some of which are valued as a fishery resource. It may be claimed, however, that mangrove species biodiversity is enhanced in a compensatory manner. The more important consideration here is the loss of water surface and its impact on hydraulics. Land built up by mangrove planting imposed serious constraints to planning the hydrodynamic management of Negombo Lagoon to be implemented by CCD under the ADB CRMP Project (*Pers. Comm*. Prof. S Samarawickrama).

(i) Drainage in Barrier-built Estuaries and Hydrological Units.

People inhabit the shores of barrier-built estuaries as they provide food security, favourable conditions for general livelihood activities, relatively inexpensive sites for settlements, a sink for wastes including sewage, transportation and much more. The drainage is effective even during wet seasons since outward flow during low tide rapidly lowers the rising water to a safe level. Low tide also gives adequate time for people at risk to seek safety. Drainage in barrier-built estuaries

and lagoons is influenced by man-made and natural hydrological units. The Negombo Lagoon - Muthurajawela Marsh ecosystem, a barrier-built estuary, consists of five main hydrological units with specific dimensions *(Table 1)*. The extent of each unit and the continuing changes, interact with and influence, all the other units. High ground in the Lagoon (Unit 1) and the Delta-swamp (Unit 2) are mainly mangroves, reed beds and inter-tidal areas, and they influence water flow and sedimentation in the Negombo Lagoon. Planted mangroves eventually change to hydrological units that collectively, as in Negombo Lagoon, impede water flow and aggravate the flood hazard. In planning to dredge the channel segment of Negombo Lagoon, under the Coastal Resources Management Project of the CCD, a major socio-economic problem that had to be addressed was the shoals stabilized by mangrove planting (*Pers. Comm.*, Prof. S Samarawickrema).

(ii) Storage capacity, drainage and floods

In 1990, Negombo Lagoon had a surface area of 35 km^2 (3,500 ha) (see Table A6.1) and a mean depth of 0.65 m, giving it a volume of 22.5 million m^3. The main inlet channel from the sea, with a cross sectional area of 250 km^2, was 2.5 km long. When seasonal flood water or heavy rainfall enters a storage basin such as Negombo Lagoon, some water will be stored. This inflow water will raise the level and cause some water to flow out. The volume retained is the difference between inflow and outflow. Time taken to free the area of excess water greatly depends on the drainage capacity. Drainage capacity is a function of interaction with hydrological units. Any form of mangrove planting in barrier-built estuaries and lagoons must be founded on an analysis of storage and drainage capacity integrated with surface area and hydrological units. Agents and agencies engaged in mangrove planting, not based on such an analysis, should be mindful of the fact that their action exposes the poor coastal residents at the fringe of the water body to an increased risk of flooding.

(iii) Water depth and fishery habitat

Fishing is possible only where fishing appliances can be operated. Water depth therefore is a critical factor in fisheries. The relationship between physical loss of depth and operation of fishing appliances was studied in the Negombo Lagoon, where the stake net fishery operation allocates specific sites for fishers to fix their nets. CEA/Euroconsult (1994) reported the loss of some of these sites *(kattudel padu)* in the channels. The growing problem of 'shallowing' by sediment entrapment is elaborated in the relevant reports (CEA/Euroconsult, 1994; CCD, 2005).

Table A6.1. Hydrological units and their extents (sq.km) constituting the Negombo Lagoon – Muthurajawela Marsh Ecosystem *(Samarakoon & Van Zon, 1991).*

Unit	High Ground	Low Lagoon/ Marsh	Total
1. Negombo Lagoon	7	35	42
2. Delta – swamp north of Ja-Ela	2	12	14
3. Marsh north: Ja-Ela to Jayasooriya Road	6	8	14
4. Marsh south: Jayasooriya Road to Hendala	10	11	21
5. West from Hamilton Canal	5	4	9
Total	**30**	**70**	**100**

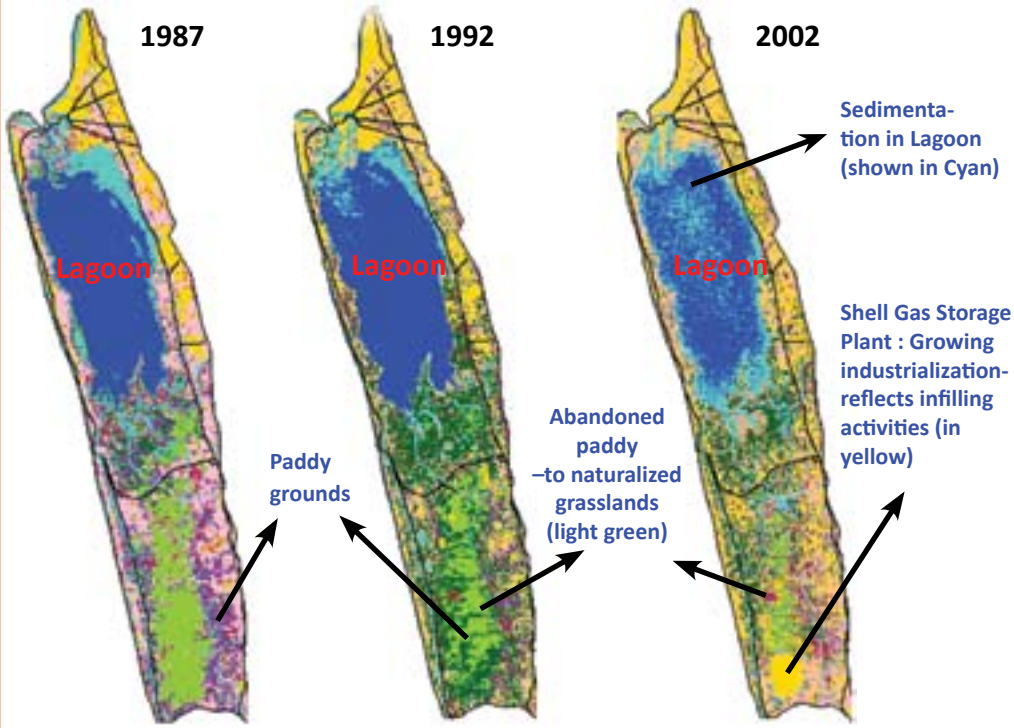
(iv) The Siltation Trajectory of Negombo Lagoon

Fig. A6.2 presents the actual siltation trajectory of Negombo Lagoon based upon satellite images. This study represents an independent verification of predictions for a barrier-built estuary based upon its structure.

Fig. A6. 2 - The Sedimentation Trajectory of Negombo Lagoon

The view looking south into a placid lagoon belies the hydrological reality (1989). The mouth is stabilised by engineering. The set of three geographic information system images below show the state of sediment infilling (cyan – pale blue) in a period of 15 years.

Changes in sedimentation within Negombo Lagoon from Landsat images 1987-2002. The lagoon is deep blue, sediment is a paler blue (cyan)



COMPILED BY INTERNATIONAL WATER MANAGEMENT INSTITUTE (IWMI)- 2007
(Nagabatla *et al*., 2007)

(v) Mangrove – Seagrass Bed – Sedimentation Synergy

The extents under mangroves and sea grass beds, in the Negombo Lagoon, are 320 ha and 684 ha respectively (Samarakoon & Van Zon, 1991; Pahalawatta-arachchi, 1995).

The sea grass beds, more than twice the extent of mangroves, are submerged and rarely noticed. Mangroves are promoted for increased fishery and consequently increased fisher income. However, as noted by CCD (1997), '… the highly productive sea grass beds in the Negombo Lagoon play a major and a more important role in fisheries productivity than the mangroves'. In view of the considerable volume of research information on the ecosystem role of sea grass beds, reed beds, mud banks etc., such a direct relationship between mangroves and fishery is perhaps over-emphasised, and the correlation is often interpreted as the cause and result (*post hoc ergo propter hoc*). The interactions between sea grass beds, mangroves and fishery are highly complex, and cannot be reduced to a linear relationship between mangroves and fish abundance (Yanex-Arencibia *et al*., 2008).

A more soundly based ecological relationship is the synergism between sea grass beds and mangroves in building up the bed of a barrier built-estuary and lagoon. The rhizomatous root system of the submerged sea grass beds aggressively trap and stabilize alluvium at the inter-tidal edge. Along these same margins of barrier-built estuaries and lagoons, the bed that is raised by seagrasses is readily colonized by fringing mangroves, particularly *Rhizophora mucronata*, by way of its spreading root system (Fortes, 1988; Ogden and Gladfelter, 1983).

Barrier-built Estuaries and Lagoons are Socio-ecological Systems (SES)

Sri Lankan's physical relationships with barrier-built estuaries and lagoons, and their associated mangroves date back many centuries. Undoutedly, **all** our major brackish water bodies have been, directly and/or indirectly, disturbed by engineering interventions that alter their hydrology and hydraulics in complex ways. These include water control structures and weirs built within the barrier-built estuaries and lagoons and/or their catchments. Most disturbances have aggravated the sediment depositional processes in these inherently vulnerable ecosystems (Erb, 1966; Swan, 1983), and their consequences can be established with mathematical clarity. However, the most significant relationships are cultural and defy mathematical interpretation. Negombo Lagoon is taken as an example to illustrate some of the complex cultural relationships.

Mangrove planting and settlement expansion

The relationship between mangrove planting and settlement expansion in the Negombo Lagoon has been investigated in-depth (Samarakoon and Van Zon, 1991; CEA/Euroconsult, 1994). These recent findings reflect a longstanding, traditional interaction between people and the barrier-built estuary. The marginalized Negombo Lagoon fisher's very practical livelihood ambitions include the creation of a small mudflat, utilizing the sediment trapping capability of the *Rhizophora mucronata* prop root system. A space of about 25 m^2, consolidated with the minimum soil fill necessary to support a thatched hut, was his aim (Fig. A6.3). It became a relatively secure private shelter, a veritable castle for a landless fisher family – a symbol of identity as an individual, the foundation of human dignity, a capitalizable asset, and security for the next generation (Pieris, 1949; 1956). It became the culmination of the search for permanence of living space, a basic need for satisfaction of the inherent territoriality of all human beings.

The practice still persists although temporary shelters get washed away by every seasonal flood. But never do they mind, as inevitably relief programmes help them to rebuild. Despite the periodic damage caused by floods, possession of 'private property' served as redemption of extreme vulnerability.

There were other economic uses including windbreaks for fragile, temporary shelters. Mangrove parts are used in artisanal fishing for hand-net frames, anchoring poles in the stake net fishery, sail masts, fish aggregating devices, among others. Some of these uses still persist on a small scale.

Mangroves are also a part of coastal mythology. Before intensive urbanization, the swampy mangrove areas were regarded as prohibited terrain inhabited by 'evil spirits'. In the Negombo Lagoon area, a predominantly Roman Catholic setting, all remnants of 'exorcism' ceremonies were cast into this evil terrain. None dared enter dense mangrove areas, other than those in the illicit arrack business. *Clerodendron inerme,* a thorny mangrove associate, was interplanted among mangroves to dissuade outsiders entering the distilleries. The Koggala Lagoon fisherfolk, a Buddhist community, had a different attitude towards mangroves. They were relatively indifferent to the vegetation, except in recounting stories extolling the virtues of mangroves, gleaned from elsewhere.

Fig. A6.3 - Desperate attempts by poor lagoon fisherfolk to 'capture' a patch of land from Negombo Lagoon to establish a cadjan shelter.

Kadolgasnella (a mangrove island) in the tidal channel system of Negombo Lagoon is seen in the background. Sometimes, a desperate family would, virtually overnight, create a piece of 'soil fill' to build a temporary shelter and consolidate it subsequently by planting mangroves at the periphery (Rhizophora mucronata). Thus a 'permanent' place – a private property is developed. Authorities would respond to a cluster of such temporary houses by providing road access (seen as the pale brown elevated strip in the mid-ground). It had a snowball effect and by 1990 the entire patch of water in the foreground was filled to accommodate more houses. In the early 1980s, CCD correctly regarded such activity as destructive to the 'ecosystem'. (J I Samarakoon)

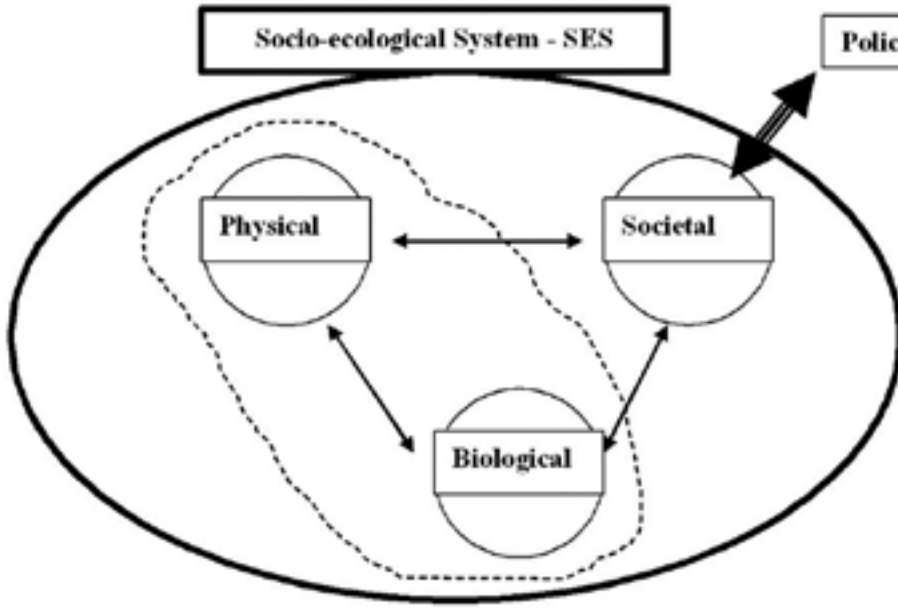
The stake-net fishery in Negombo Lagoon demonstrates the five essential attributes for sustainable common pool resources management. The practice evolved from traditional origins, claimed to date back 300 years, to a more institutionalized form in the 1960s. It persists today without any need for intervention by government bodies because of the inherent resilience of the management system. However, physical forces such as accelerated sedimentation and water pollution, caused primarily by the Ekala Industrial Estate, are undermining both the spatial organization of the fishery and the resource base.

Fig. A6.4 depicts a complex socio-ecological system: a combination of interacting physical features, biological characteristics and sociological attributes. Clearly, the Negombo Lagoon is a SES. Given this complexity, the relationship between an isolated mangrove planting activity

and the lagoon would not be linear. It would, therefore, be unreasonable to deduce the impact of mangrove planting on the long term behaviour of the lagoon, or on human wellbeing, as if it were a linear relationship. The same can be said of all barrier-built estuaries and lagoons taking into consideration the wide range of geographically specific peculiarities.

From the foregoing, it is clear that the fisher communities, as well as other organisations that are not dependant on the lagoon's natural productivity for livelihood or food security, are engaged in indiscriminate planting of mangroves. Their intentions differ; the former to create land, and the latter to improve the fishery habitat. The latter organisations often pay the communities to plant mangroves. In the long–term, both activities diminish the size of a productive water body, and needs to be viewed as such, rather than preferentially legitimizing one activity. Sen (1995) clearly shows that paying poor members of a community to participate in an activity does not purchase legitimacy for that activity, if it is conceptually flawed.

Fig. A6.4 - Components of socio-ecological systems



All complex natural and semi-natural systems are made up of interacting physical, biological and societal subsystems. The physical and biological subsystems are closely linked and therefore interact and change together. The societal subsystem's scope of activity transcends the boundary of the biophysical subsystem. However, the societal subsystem cannot change independently without impacting the biophysical subsystems. Together the three subsystems constitute a socio-ecological system (SES)

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Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

MFF builds on a history of coastal management interventions before and after the 2004 tsunami. It focuses on the countries most-affected by the tsunami; **India, Indonesia, Maldives, Parkistan, Seychelles, Sri Lanka, Thailand** and **Vietnam**. MFF also includes other countries of the Region that face similar issues, with an overall aim to promote an integrated ocean wide approach to coastal zone management.

Its long-term management strategy is based on identified needs and priorities that emerged from extensive consultations with over 200 individuals and 160 institutions involved in coastal management in the Region.

MFF uses mangroves as a flagship ecosystem in recognition of the important role mangroves played in reducing the damage caused by the tsunami, and the implications on livelihoods because of mangrove forest destruction. But **MFF is inclusive of all coastal ecosystems,** including coral reefs, estuaries, lagoons, sandy beaches, sea grasses and wetlands.

Its vision is a healthier, more prosperous and secure future for all sections of the coastal population in Indian Ocean countries. It is a unique partnership-led initiative working in four key areas of influence: regional cooperation, national programme support, private sector engagement and community action.

The initiative undertakes collective actions to build knowledge, strengthen empowerment, and enhance governance through 15 broad programmes of work to address the current and future threats, and to conserve and restore coastal ecosystems. These are implemented through a series of on-the-ground projects, through small and large grant modalities.

MFF seeks more effective and inclusive institutions, policies and mechanisms for cooperation at national and regional levels by prioritising coastal ecosystem management across national development agendas, policies and budgets.

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