Technology Fact Sheet for Adaptation

Rehabilitation of Mangroves [i]

38. **Sector**: Coastal

39. **Technology characteristics**

39.1 Introduction to rehabilitation of mangroves:

One of the most commonly restored wetland ecosystems for coastal protection are mangroves. Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. They induce wave and tidal energy dissipation (Brampton, 1992) and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilise shore sediments, thus reducing erosion (USACE, 1989). Wetland restoration reestablishes these advantageous functions for the benefits of coastal flood and erosion protection. Restoration is required because many of the world's wetlands have become increasingly degraded through both natural and human activities. Techniques have been developed to reintroduce coastal wetlands to areas where they previously existed and to areas where they did not, but conditions will allow.

Mangrove ecosystems played a vital role in buffering the force of the tsunami waves and in protecting the human inhabitations. Even before the Tsunami, Sri Lanka has been experiencing rapid loss of mangrove ecosystems mainly due to anthropogenic factors including unprecedented growth of the tourism sector. In addition to the provision of ecosystem functions, the mangroves are instrumental in supporting the livelihoods of the local coastal communities. These mangrove systems also perform vital hydrological functions and serve as breeding grounds for fish & other marine species. Almost 40% of the world's mangroves are concentrated in Asia, the region also has accounted for the highest loss of mangrove area over the last decade.

The mangrove systems covering an area of 6000-7000 ha are interspersed along the coastline of Sri Lanka. The largest mangrove system is located in Puttalam Lagoon – Dutch Bay – Portugal Bay complex and covers an area of 3385 ha. The other large concentrations are in Batticaloa and Trincomalee districts. The mangrove forests in Bentota are highly threatened as a result of unchecked growth of the tourism sector. In spite of the known ecological and economic value of mangroves there has been indiscriminate exploitation of mangroves for commercial, industrial, housing needs mainly due to the lack of knowledge of the ecological role of the mangroves amongst the decision-makers.

Until recent times, mangrove areas have received very little or no attention in terms of their conservation or sustainable management. As a result, most of the mangrove areas have been lost due to indiscriminate clearing and reclamation for industrial, urban, tourist resorts, roads, aquaculture ponds, and fishing ports development. Although the legal jurisdiction of the mangrove ecosystem falls

under the Forest Department, Department of Wildlife Conservation, and the Coast Conservation Department, there is inadequate legal protection for mangroves in the country.

This unique ecosystem is home to over 20 true mangrove species of Sri Lanka. The major genera that represent these species are *Avicennia, Rhizophora*, *Bruguiera*, and *Sonneratia*. According to mangrove abundance and distribution, they can be categorized as very common, common, and rare; the very common species of Sri Lankan mangroves are *Avicennia marina, Bruguiera gymnorrhiza, Excoecaria aggalocha, Lumnitzera racemosa, Rhizophora mucronata, Rhizophora apiculata, and Sonneratia caseolaris*. The very common species appear to grow under a wide range of soil and hydrological conditions, and are widely distributed in Sri Lanka indicating that they are the most appropriate species for mangrove reforestation. The common category of mangrove species represent *Aegiceras corniculatum, Avicennia officinalis, Bruguiera cylindrica, Bruguiera sexangula, Ceriops tagal, Heretiera littoralis, Pemphis acidula, Sonneratia alba, Nypa fruticans.* Although these species are widely distributed in Sri Lanka, they are low in abundance. There are few species of mangroves categorized as rare species since they are in low abundance and restricted to few locations in Sri Lanka. The rare species of mangrove namely *Lumnitzera littorea, Xylocarpus granatum, and Scyphiphora hydrophyllaceae* in Sri Lanka.

A reduction in installation and maintenance costs of sea defenses may occur when such structures are located behind large areas of mangroves which absorb the energy and slow the water flow of storm surges (Barbier, 2008). Evidence from the 12 Indian Ocean countries affected by the 2004 tsunami disaster suggested that coastal areas with dense and healthy mangrove forests suffered fewer losses and less damage to property than those areas in which mangroves had been degraded or converted to other land use (Kathiresan & Rajendran, 2005). This was observed in the vicinity of Rekawa Lagoon after the 2004 tsunami incident

Plate 1: Mangroves around Rekawa lagoon before andafter tsunami. Disturbances due to the causeway built across the lagoon was the main reason for damages caused.

Observations indicate that a mature mangrove stand will reduce the costs for dike maintenance by 25-30% assuming a stand width at least comparable to the characteristic wavelength of incident

waves (Tri et al., 1998). In contrast to hard defenses, wetlands are capable of undergoing 'autonomous' adaptation to SLR, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005) provided wetlands are not subjected to coastal squeeze, and the rate of SLR is not too rapid to keep pace, wetlands are capable of adapting to SLR without further investments.

Coastal wetlands also provide a number of important ecosystem services including water quality and climate regulation, they are valuable accumulation sites for sediment, contaminants, carbon and nutrients and they also provide vital breeding and nursery ground for a variety of birds, fish, shellfish and animals. They are also a sustainable source of timber, fuel and fiber (White et al., 2010). The restoration and recreation of wetlands can also reduce or even reverse wetland loss as a result of coastal development. This is important in terms of maintaining the global area of wetlands and in sustaining wetlands in the face of climate change. Wetland creation may also fulfill legal obligations for the compensation of habitats lost through development.

The disadvantages of wetland restoration are minimal. The restoration of natural ecosystem services, including flood and erosion protection benefits, largely outweighs any disadvantages. One possible disadvantage is the space requirement in locations which are often of high development potential. This must be carefully weighed against the range of benefits accrued. Wetland restoration is also likely to require a degree of expertise, especially in locations where wetland recolonisation has to be encouraged by transplanting wetland plants. Some wetland habitats will no doubt be more difficult to recreate than others and could require greater expertise.

39.2 Technology Characteristics/Highlights

- For Collect plant propagules from a sustainable source
- Preparation of the restoration site for planting and directly plant propagules at regular intervals at an appropriate time of year
- Establish nurseries to stockpile seedlings for future planting
- Mangrove re-establishment can also be achieved by planting dune grasses as these grasses are known to provide a stable, protective substrate for mangroves to establish their root systems and after the establishment of mangroves they over grow the sea grasses allowing mangroves to be dominant . (USACE, 1989).

39.3 Institutional/ organisational requirements

- Local organizations should be given the responsibility of maintaining and sustainable utilization of mangroves, which will reduce the cost for restoration.
- Coast Conservstion Department should collaborate with academic & research institutions and local organisations such as fishermen's societies for the sustainability of the mangrove restoration programmes and to reduce costs for such activities

- Regulations should be strictly enforced with respect toe stablishing prawn farms in mangrove areas, which has been the cause for mass destruction of mangroves in the western and North-western provinces of Sri Lanka
- Commitment of the government is essential for restoration, management and sustainable development of mangrove ecosystems through ensuring cooperation among different agencies and ministries performing various development programmes within coastal districts having sensitive ecosystems.

40. Operations and maintenance

40.1 Endorsement by experts

Replanting mangroves is a widely accept technology for restoration of degraded mangrove ecosystems worldwide.

40.2 Adequacy for current climate

The very common species of Sri Lankan mangroves are *Avicennia marina, Bruguiera gymnorrhiza, Excoecaria aggalocha, Lumnitzera racemosa, Rhizophora mucronata, Rhizophora apiculata, and Sonneratia caseolaris* which grow under a wide range of soil and hydrological conditions, and are widely distributed in Sri Lanka indicating that they are the most appropriate species for mangrove reforestation.

The common category of mangrove species represent *Aegiceras corniculatum, Avicennia officinalis, Bruguiera cylindrica, Bruguiera sexangula, Ceriops tagal, Heretiera littoralis, Pemphis acidula, Sonneratia alba, Nypa fruticans* they are also suitable for replantation purposes due to their wide distyribution although found in few numbers (information brief on mangroves of Sri Lanka, IUCN)

40.3 Size of the beneficiary group

- Coastal communities depending on mangroves for socioeconomic activities reef communities
    - Fisher communities
    - Those use mangroves for their fruits, firewood etc.
    - Tourist industry involved in Ecotourism
    - Research & educational institutes

41. Costs

4.1Cost to implement adaptation options

Activity	cost	
	Unit cost (US $)	Total cost (US $) (per year)
Field surveys to decide the sites need extra attention depending on the inundation level due to SLR		8,000
Training workshops 10 Nos	3,000	30,000
Travelling & transportation costs		8,000
Maintenance of nursaries at lease two in the respective districts up to 20 Nos.	1000/year/nursary	40,000
Replantation of mangoves in 20ha (2 ha each in 10 sites) at $4m^2/m$		200,000
For caretakers for 2 years		25,000
contingencies		18,000
Total cost per year	$1.6/m^2$	319,000/20ha

41.1 Additional costs to implement adaptation option, compared to "business as usual"

To receive maximum benefits from this technology, sensitivity on the importance of mangroves should be improved among all stakeholders who are resource utilisers depending on mangroves and those who visit the area for different economic, research and educational purposes. Awareness among coastal communities, school children, hoteliers, industrialists, should be improved and therefore awareness programmes should be conducted from time to time.

Ecotourism and research centres should be established in mangrove areas with high biodiversity in order to ensure conservation of endangered mangrove species and sustainable utilization of mangrove resources. Which will reduce the cost s for monitoring, security and maintenance cost of replanting sites.

42. Development impacts , indirect benefits

42.1 Economic benefits

42.1.1 Employment

- This project will provide direct employment opportunities to person involved in managing nurseries and ecotourism centers.
- In addition to that persons who are collecting propagules, using fruits for making drinks, tour guides, krall owners and other fishers in the lagoon will earn a living due to mangrove replanting and successful establishment of mangroves.

42.1.2 Investment :

- Improvement foreign exchange earnings through ecotourism.
- Income to fisher communities due to improvement of recruitment of fish stocks in to lagoons and estuaries with thick mangrove vegetations
- If ecotourism & research centers are established they will attract foreign and local tourists and conservationists, which would in turn attract foreign exchange for mangerove rehabilitation programmes
- Reduce costs for construction of hard defense structurs for reducing coastal erosion such as dykes, coastal revertments, etc. as the mangroves and their root systems have a mechanism to stablise the soil in the coastal habitats
- Reduce costs for controlling coastal pollution as mangrove roots act as trap pollutant traps

42.2 Social benefits :

- **Income**
    - Improvement of economy of mangrove depending communities.
    - Socioeconomic status of coastal communities improve due to reduced risk of coastal inundation and erosion
    - Increased income to persons involved in mangrove rehabilitation programmes, tourism (especially in eco-tourism) coastal resource management and hotel sectors.
- **Education**
    - Improvement of awareness on the importance of conservation, management and restoration of mangroves
    - Improvement of scientific knowledge on the sensitivity and complexity of mangrove plant communities and associated biotic communities
    - Gain knowledge on adaptation to natural phenomena by scientifically maneuvering the natural coastal ecosystems
    - Importance of using natural barriers against coastal erosion and inundation
- **Health**
    1. Improved security of coastal dwellings will naturally improve the health conditions of coastal communities living there
    2. Proper management of coastal ecosystems by controlling harmful anthropogenic activities such as destruction of mangroves, establish ment of illegal prawn farms will improve the ecological conditions of mangrove habitats and it will platy an important role in human health
    3. Improvement of area coverrd with mangrove vegetation will also indirectly help in increasing the mangrove forest cover and hence the controlling the release of CO_2 the environment

42.3 Environmental benefits

- It was found that as well as providing protection against coastal erosion, mangrove planting also helped creating large areas of land through accretion, provided large quantities of wood and other forest products and provided employment for local villagers throughout the duration of the scheme.
- Although mangrove plantations could damage during significant storms, full recovery occurs within a short period of time because the system is self repairing.
- In terms of climate change adaptation in the coastal zone, the main benefit of wetland restoration is the reduction of incoming wave and tidal energy by enhancing energy dissipation in the intertidal zone. This is achieved by increasing the roughness of the surface over which incoming waves and tides travel (Nicholls et al., 2007b).
- This reduces the erosive power of waves and helps to reduce coastal flood risk by diminishing the height of storm surges.

43. Local context

43.1 Opportunities & Barriers

43.1.1 Opportunities

- Wetland restoration and its ecosystem functions such as habitat provision, food production and water quality improvement.
- Coastal flood and erosion protection
- Helps reduce wetlands losses as a result of climate change.
- Wetland creation can bring about various economic, social, and environmental benefits to local communities. For example, improve the productivity of coastal waters for fishing
- Increase incomes of local communities and contribute toward local sustainable development.
- Other goods and services provided by wetlands, such as the provision of wood and fibres could also prove highly beneficial to local communities, especially in developing countries.
- Wetland recreation can also create opportunities for eco-tourism and increase recreational opportunities.
- Creation of wetlands, especially in or in close proximity to urban areas can even serve to increase awareness of the important functions performed by these habitats.
- Because wetland restoration meets multiple management objectives – such as habitat protection, public access to environmental and recreational resources and hazard mitigation – and is less expensive and more

aesthetically pleasing than some engineering solutions, the approach is likely to find broader public support in the future (Moser, 2000).

- There is also the opportunity to implement wetland restoration or creation together with hard defences such as dikes or seawalls. In such a case, the presence of wetlands on the seaward side of the defence leads to lower maintenance costs over the lifetime of the structure (Tri et al., 1998).
- For coastal scientists, coastal engineers and coastal zone managers will get a very good opportunity to use their knowledge and experience to find solutions for global warming and for sustainable management of coastal resources & coastal ecosystems to be adapted for climate change
- Coastal resource utilisers and those who were involved in destructive activities harmful to coastal ecosystems will get an opportunity to obtain a training to sustainably manage the coastal resources for their own benefit.
- Academics and researchers will get an opportunity to conduct useful scientific research to reduce the impacts related to conservation and propagation of mangroves as an as a climate change adaptation to coastal ecosystems
- Sri Lanka will get an opportunity to make possible contributions to find solutions for local regional and global problems that may faced due to climate change.

43.1.2 Barriers

- Lack of public awareness of the flood and erosion protection benefits offered by these ecosystems.
- Communities press for, hard defence options, for which the protective benefits .
- Incomplete understanding of the ability of a degraded wetland to recover, and of the success rates of wetland creation.
- The establishment of wetlands which provide full coastal flood and erosion protection takes time, and the approach does not offer immediatebenefits.
- A desire to improve wetland habitats also needs to exist before the strategy can go ahead.
- Wetlands only exist under specific conditions and it is not always clear if habitat restoration will be achievable or successful, especially when coastal managers have limited predictive capabilities for shoreline change (NRC, 1994).
- Although studies have shown that it is possible to create wetlands in areas where they did not previously exist (Platong, 1998), sites with the potential for wetland restoration or creation should be identified on a case-by-case basis.
- Identifying individuals and organisations qualified to undertake wetland restoration and recreation work can also prove a barrier to implementation.
- The qualifications and know-how of the implementing organisations directly influence the effective application of scientific knowledge and engineering capabilitiesand

ultimately, project performance (NRC, 1994). To address problems associated with limitations in knowledge

43.2 Status

Technology for mangrove restoration has been successfully implemented in many countries including Sri Lanka and in certain parts of Sri Lanka they naturally replenish if kept undisturbed and also due to reduction of human impacts.

43.3 Time frame

Activity	Year 1 divided to 4 quarters				Tear 2 divided to 4 quarters				Year 3 divided to 4 quarters			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Survey for selection of sites which needs replanting and restorastion	X	X										
Awareness/training		X										
Collection and preparation of propagulers for replanting		X	X	X								
Planting of propagules			X	X	X	X						
Monitoring				X	X	X	X	X				
Evaluation of success as a barrier for coastal erosion and inundation							X	X	X	X	X	X

43.4 Acceptability to local stake holders:

- Mangrove uses for socioeconomic activities will support the programme
- If it helps to reduce erosion and damage from coastal inundation acceptance of coastal communities could be assured
- Conservationists and Coastal zone managers will have have a positive approach

44. References

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