

Technology Fact Sheet for Adaptation

Sand Dune Rehabilitation ⁱ

34. Sector: Coastal

35. Technology characteristics

35.1 Introduction to restoration of coastal sand dunes:

A sand dune is a mount, hill or ridge of sand that lies behind the part of the beach affected by tides. Soil washes from inland rivers and finds its way to the sea. When this happens, soil layers – for example, humus, clay and sand – separate. Sand deposits on beaches, while clay, which is heavier, reaches open oceans. This deposited layer of sand is shifted constantly by wind and waves. Waves wash sand onto the beach. At low tide, this sand dries and the finest fraction of sand is blown further landward by winds, and can not now be reached by normal waves. The wind keeps pushing this sand landwards in a motion like a sheet moving. The moment the sand reaches the side away from the wind, it settles and forms sand dunes. Some of this sand collects behind rocks or clumps of seaweed. Here, the roots and underground parts of grasses and other vegetation anchored on the dunes trap the sand from being blown away. The leaves of the dune vegetation trap sand promoting dune expansion. Without vegetation, wind and waves regularly change the form and location of dunes. They are formed over many years. The wind then starts eroding sand particles from the windward side and depositing them on the side protected from the wind. Gradually, this action causes the dune to move inland, accumulating more and more sand as it does so. Subsequently, more vegetation grows on these dunes (Hesp, 2000, Mittapala, 2008; www.des.nh.gov/coastal). Sand dunes form in intertidal zones of coastal beaches, where there is enough sand and adequate wind. Sand dunes range in size from ridges less than 1m in height and width, to massive dune fields that extend inland for many kilometres (Hesp, 2000). They are found worldwide but are less developed in tropical and subtropical zones (where wind velocities are lower and the soil is damper) (Packham & Willis, 1997)

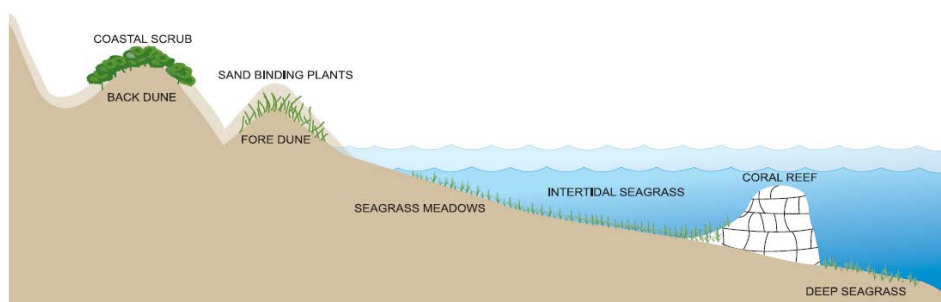


Figure1: typical structure of coastal sand dunes (adapted from Short et al., 2007, quoted by Mittapala, 2008)

Dune vegetation has adaptations to stand the harsh conditions prevail in the coastal environments and the unstable conditions of the substratum on which they are anchored.

Sand dune plants grow in areas where the temperature is high and the winds and waves are strong. This leads to lack of firm anchorage, drying up of plant tissue and breakage (Packham & Willis, 1997). These plants have developed specialised adaptations which help them cope with these problems. They are adapted to stand the strong winds and waves in this environment, although the sand is loose and porous and constantly shifting the substrate. Therefore, plants closest to the sea have roots and shoots that grow sideways and hug the ground. These roots and shoots form a dense mat on the surface as seen in Goat's Foot (*Ipomoea pes-caprae*) and Spinifex (*Spinifex littoreus*). Further inland, where dunes are more stable, plants grow more upright. Dune plants also possess adaptations that prevent desiccation. On clear, sunny days, the temperature in sand dunes can rise to as much as 50°C. There is also a lack of fresh water. Because of this, sand dune plants have evolved xeromorphic characteristics. The outer layer of leaves is very thick and leaves are often reduced to spiny projections (as seen in Spinifex) or rolled up (as seen in Goat's Foot) aiding in preventing water loss (Mittapala, 2008). Dune plants such as *Pandanus* sp. Which has ... effectively provided protection to certain areas in the Hambantota District where natural dune vegetation was not removed due to human influence (Plate 1)



Plate1: *Parts of the coastal belt in Hambantota protected from 2004 tsunami wave due to dense dune vegetation dominated by Pandanus sp.*

Pandanus sp. propagates readily from seed, but it is also widely propagated from branch cuttings for human activities. It grows fairly quickly, and all parts from the nutritious fruits of certain edible Varieties (in pacific island), to the poles and branches in construction, to the leaves for weaving baskets, etc. *Pandanus* sp. could be planted on the sand dunes by making a terraced structure along the sand dunes. Plantings should be encouraged in protected areas and in well maintained public areas. For example, in Hawai'i plantings of *Pandanus* on hotel grounds were utilized and greatly appreciated by local weavers, due to good access and ease of harvesting. Special attempts should be made to collect and replant endangered varieties with an economic value. The root system of *Pandanus* plants is dominated by thick, slightly spreading prop roots originating from the lower part (1–1.5 m) of the trunk. The prop roots penetrate and are mainly concentrated in the surface soil layers which helps to stay erect and steadily anchored to the unstable soil.

35.2 Technology Characteristics/Highlights

As an adaptation against coastal erosion and inundation, which could be expected to occur due to sea level rise as a result of climate change, these natural sand barriers with their vegetation could be used and wherever they have been removed as a result of human activities these plants should be replanted. Propagation of plants could be done by using seeds.

7 Institutional/ organisational requirements

Facilities for collection of seeds of *Pandanus* and to establish nurseries should be provided at academic or research institutes or at centres established with community participation to propagate these plants. In areas where dune sand has been removed for anthropogenic activities, such as construction work, these plantations could be carried after beach nourishment to improve the quality of the substratum to speed up the establishment of dune vegetation. In addition to replanting of *Pandanus* other species of dune plants should be introduced to the same area or they should be allowed to naturally established with time, due to improvement of environmental conditions as a result of replanting *Pandanus* sp. Terraced plantations should be introduced

8 Operations and maintenance

8.1 Endorsement by experts

Pandanus plantations are widely practiced in Pacific islands and it has been accepted by the local communities due to its economic value. Under the tsunami rehabilitation programme funded by the CIDA (Canada) assisted the coastal communities in reestablishing *Pandanus* sp. Which was not given sufficient attention after the implementation due to the lack of sufficient government patronage to promote such projects. If the funding is made available this project will be a feasible one and would provide opportunities for cottage industries based on *Pandanus* leaves.

8.2 Adequacy for current climate

Plant species that grow on dune sand are abundant in Sri Lanka and scientifically organised terraced plantations would not only provide protection to the coastal sand dunes against coastal erosion, storm surge, tsunami and other harmful coastal activities, but it will provide alternative income sources for coastal communities and also will give a more attractive appearance to sandy beaches. It will also provide nesting sites to turtles and sea birds, which would attract nature lovers and local and foreign tourists.

Mittapala (2008) has indicated the danger of establishing exotic species such as Whistling Pine (*Casuarina equisetifolia*), which could cause additional problems - such as the prevention of marine turtles from nesting. During a survey conducted by a group of scientists in Matara & Hambantota districts revealed that although *Casuarina equisetifolia* would provide some stability to sand dunes when the plants are small and their branches are touching the ground, fully grown plants will not provide any protection to the sand below (Plate 2). This is due to the resistant resulted by the *Casuarina* needles that would not allow an under growth of weeds and shrubs Plate 3. Further

Casuarina needles form a mat which takes a long time to degrade and bind with the underlying sandy layers unlike the leaf litter of natural dune vegetation. This mat of undegraded needles will slip over the sandy substratum making it unstable during strong winds and waves, which was evident during the 2004 tsunami (Plate 4)



Plate 2: Protection to sand dunes in Hambantota provided by young Casuarina plants (Lect) and unprotaected dunes with fully grown Casuarinas plants (Right) during the 2004 tsunami. ((phottotographs by P.R.T. Cumaranatunga)



Plate 3: Left- Casuarina plantations on the sanddunes of Hambantota without an undergrowth. Right- natural dune vegetation with a protective undergrowth (Photographed by P.R.T. Cumaranatunga)



Figure 4: Soil profile under natural sand dune vegetation (Left) and the soil profile under Casuarina plantations (Right) (Photographed by P.R.T. Cumaranatunga)

8.3 Size of the beneficiary group

Coastal communities living in the vicinity of sand dunes in the North, North-western, South-eastern and Eastern coastal belts will benefit out of this technology. It will provide a protection from coastal erosion and also will act as a wind belt in areas where strong winds persist. In addition to that *Pandanus* plant will provide an alternative income source for coastal communities. With the improvement of soil conditions, as a long term adaptation many other plant communities also will establish in the areas having sand dunes improving its biodiversity.

9 Costs

4.1 Cost to implement adaptation options

Activity	Cost	
	Unit cost (US \$)	Total cost (US \$)
Field surveys to decide the suitable sites (duration 6 months)		10,000
Training workshops 10 Nos	3,000	30,000
Material for replanting <i>Pandanus</i> 2 ha within the each existing sand dune with a maximum of 50 ha at the initial stage	10,000 per ha	500,000
Allowances for persons (100) involved in the replanting programme and maintenance for 2 year		420,000
Transport & other miscellaneous costs		10,000
Unforeseen expenses		95,000
Total cost without beach (sand dune) nourishment	2.13/m ²	1,065,000/50ha

9.1 Additional costs to implement adaptation option, compared to “business as usual”

This technology will provide opportunities to establish cottage industries and therefore funds should be provided for training and establishment of small scale enterprises for women and school leavers in the coastal districts where *Pandanus* plantations are to be introduced . This will help the self sustasinability of the plantation programme and the related industries.

In addition to the above turtle hatcheries (*ex situ* and *in situ*) to conserve turtles and to encourage their nesting in restored sand dune ecosystems. Futher, concurrently with such projects necessary steps should be taken to improve eco tourism.

10 Development impacts , indirect benefits

10.1Economic benefits

- **Employment**

This project will provide employment opportunities to women & school leavers and those who are willing to involve in activities related to eco-tourism.

- **Investment :**

- Establishment of small & medium scale industries
- Improvement of tourism
- If the soil condition improves, dry zone agricultural practices could be established towards the landward area beyond the series of sand dunes

10.2Social benefits :

- **Income**

- o Improvement of economy of coastal communities due to
 - a. Establishment of SMEs
 - b. Improvement of eco-tourism
 - c. Due to provision of protection to the properties of coastal communities from erosion, strong winds and waves.
- o Socioeconomic status of coastal communities will improve as a result of improved income
- o Increased income to persons involved in tourism (especially in eco-tourism), coastal resource management and hotel sectors.

- **Education**

- o Improvement of awareness on the importance of conservation, management and restoration of sand dunes

- o Use of natural vegetation to improve the ecological status of sand dune communities.
- o Improvement of scientific knowledge on the sensitivity and complexity of sand dune ecosystems among coastal communities
- o Adaptation to natural phenomena by scientifically maneuvering the natural coastal ecosystems
- o Knowledge on the artificial propagation of indigenous dune vegetation to establish green belts to reduce the impacts from sea level rise due to climate change
- **Health**
 1. Improved security of coastal dwellings will naturally improve the health conditions of coastal communities
 2. Sustainable management of coastal ecosystems by controlling harmful anthropogenic activities such as destruction of dune vegetation and removal of dune sand would provide coastal communities much stable livelihoods, which would improve their socioeconomic standards that help them to lead a healthy life.

10.3 Environmental benefits

- Protection to all living terrestrial communities from coastal inundation
- Provision of shelter and breeding sites for turtles, sea birds and other endangered and ecologically important organisms, which would in turn improve the biodiversity in dune habitats
- Utilisation of CO₂ for photosynthesis by the dune vegetation belts will reduce the CO₂ concentration in the atmosphere, reducing its impacts on global warming
- Reduce the impact of sea breeze

11 Local context

11.1 Opportunities & Barriers

- **Opportunities**
 - o For coastal scientists 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 dune ecosystems will get an opportunity to obtain a training to sustainably manage the coastal resources for their own benefit.
 - Provide opportunities to unemployed or less income groups to improve their economy through SMEs.
 - Academics and researchers will get an opportunity to conduct useful scientific research to reduce the impacts of climate change to coastal ecosystems and communities
 - 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.
- **Barriers**
 - High cost incurred on rehabilitation of dune ecosystems through beach nourishment and replanting of dune vegetation.
 - Unsustainable utilization or destruction of dune vegetation by certain individuals of the community
 - Lack of or insufficient political commitment for coastal resource conservation and management.
 - Insufficient or lack of motivation and knowledge of certain sections of the coastal communities for conservation and/ sustainable management of coastal ecosystems and resources.
 - Reluctance of older generation of the coastal communities to acquire new knowledge and to accept that certain practices adopted by them could cause serious threats to sensitive coastal ecosystems and their biodiversity.
 - Hotelliers and beach resort owners prefer an open beach than a sheltered on.

11.2 Status

Knowledge on technology to be adopted for propagation of dune vegetation and beach nourishment is available. Trained and motivated persons for such activities are very few in numbers and therefore prior to implementation of the project thorough training should be provided.

Beach nourishment is presently carried out in Negombo.

11.3 Time frame

	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 with respect to inundation with SLR	X											
Awareness/training		X										
Establishment of nurseries for dune plants		X	X									
Planting and monitoring and the growth rate & its effect on stability of dunes and maintenance			X	X	X	X	X	X				
Establishment of SMEs for industries related to dune vegetation community participation & government patronage								X	X	X		
If successful adoption to wider area with careful monitoring						X	X	X	X	X		
Evaluation of success/self sustainability					X		X		X			

11.4 Acceptability to local stake holders:

- Depending on the protection against the coastal erosion and the socioeconomic benefits there is a strong possibility of acceptance by the local stake holders
- Dune vegetation will be a barrier to access to the beach, which will not be acceptable to tourist industry.

12 References

- Hesp, P. A (2000). Coastal sand dunes form and function. *Coastal Dune Vegetation Network Technical Bulletin No. 4*. Rotorua: New Zealand Forest Research Institute Limited. 28p.
- Linham, Mathews M. & Robert J. Nicholls((2010). Technologies for Climate Change Adaptation –Coasta Erosion & Flooding- (Xaanil Zhu ed.). UNEP Riso Centre, University of Southampton. ISBN978-87550-3855-4

- Miththapala, S (2008). Seagrasses and Sand Dunes. *Coastal Ecosystems Series* (Vol 3) pp 1-36 + iii. Colombo, Sri Lanka: Ecosystems and Livelihoods Group Asia, IUCN.
- Packham, J. R. and Willis, A. J (1997). *Ecology of dunes, salt marsh and shingle*. 352 pp. New York, NY: Springer. 352 pp.
- Species Profiles for Pacific Island Agroforestry *Pandanus tectorius* (pandanus) Pandanaceae (screwpine family) www.traditionaltree.org

ⁱ This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Adaptation – Sri Lanka. You can access the complete report from the TNA project website <http://tech-action.org/>