Considering the economic feasibility of activities that could be adapted to Sri Lanka to reduce the impact of climate change on the coastal belt, three most socio economically important adaptive technologies with an economic feasibility were identified and accordingly, following project ideas were developed.
The table shows proposed projects for each of the three prioritized technologies:

Technology	Project Idea
1. Restoration of Sand dunes	1. Rehabilitation and restoration of sand dunes in North Western, Southern & Eastern Provinces of Sri Lanka as a soft barrier against sea level rise, while improving socioeconomic status of coastal communities.
2. Rehabilitation of Mangroves	2. Rehabilitation of mangroves as soft barriers against sea level rise in the North Western, Eastern and Southern coastal belts of Sri Lanka, while maintaining the ecological balance and sustainability of socioeconomic activities, ,
3. Restoration of Coral Reefs	3. Restoration of coral reefs of southern and south-western coastal belt of Sri Lanka, as a soft barrier against sea level rise and coastal erosion and as a tourist attraction to promote eco-friendly tourism.

4.2 Project Idea for Technology 1: Restoration of Sand dunes

Project Idea:

'Rehabilitation and restoration of sand dunes in North Western, Southern & Eastern Provinces of Sri Lanka as a soft barrier against sea level rise, while improving socioeconomic status of coastal communities'

4.2.1 Introduction/Background

A sand dune is a mount, hill or ridge of sand that lies behind the areas affected by tidal action. Sand separates out from the soil that washes off to the coastal belt from inland rivers, due to density variations of different components such as clay, humus, etc. and deposits on beaches. The series of mounts/hills/ridges formed by this continuous landwards pushing of the sand by wind, are known as dunes and are formed over many years. Sand dunes are distributed along the South-Western, South-Eastern and Eastern coasts of Sri Lanka. As an adaptation against coastal erosion and inundation, due to sea level

rise, these natural sand barriers with their vegetation could be used. Wherever they have been removed as a result of human activities, dune vegetation should be replanted.[14]

Coastal dune flora plays an important role in dune stabilization and restoration due to their root and vegetative systems, which are adapted to hold the dune sand. Their economic and medicinal values also have been reported. *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 (Candada) assisted the coastal communities of Matara District (Southern Province, Sri Lanka), for re-establishing *Pandanus* sp. Medicinal value of dune flora has been reported by a study in Puducherry in India, where 52 species of medicinal herbs, belonging to 34 families have been identified[15]. Since Sri Lanka's closest neighbour is India, with floral species common to both countries, most of the above medicinal plants could be indigenous to Dune ecosystems of Sri Lanka.

Restoration of sand dunes and its vegetation were given least attention, until the destructive tsunami struck the coastal districts of Sri Lanka. In certain areas where the natural sand dunes and vegetation existed, it provided protection to coastal infrastructure and human dwellings. Coastal communities are depending on resources extracted from dune ecosystems for their socioeconomic gains and they are reluctant to give up such activities, due to absence of alternative income sources available in the area. Extraction of dune sand for construction purposes, extraction of dune vegetation for cottage industries and clearing of dune areas for economic activities (tourism, fisheries, etc.), are the most important destructive anthropogenic activities that affect the dune ecosystems. This is a result of the general lack of awareness on the non-extractive importance of sand dunes & its vegetation and/or the selfish attitudes of persons involved in economic activities. Destruction of sand dunes are reported quite often in the North-Western Province of Sri Lanka, due to uncontrolled anthropogenic activities, such as use of heavy vehicles for operation of beach seines, illigal removal and transportation of dune sand for construction purposes, disturbance of dunes for coastal constructions such as tourist resorts, etc. . In addition to the above *Pandanus* plants with a root system that helps to stabilise the dune sand is used for cottage industries and its flower is used for religious activities which will be a serious threat to the genetic diversity within *Pandanus* plantations.

Propagation of plants could be done by using seeds or propagules of indigenous dune vegetation. Choudury et al., (2003) (as quoted by Mittapala, 2010) have highlighted the additional problems when exotic species such the Whistling Pine (*Casuarina equisetifolia*) are planted; viz. prevention of marine turtles from nesting. Some of the coastal plantations of *Casuarina equisetifolia* in Matara and Hambantota

[14] Joseph, 2001

[15] Padmavathy & Anbarashan, 2011

Districts proved to be unsuccessful as green belts during tsunami in 2004. Best protection against tsunami was given by natural dune vegetation such as *Pandanus spp.*

This project will be conducted in the South-Western, Southern and Eastern coastal districts of Sri Lanka and from each of the districts one sand dune site is selected and they are Kalpitiya, Hambantota and Pottuvil. Issues to be addressed are, Inadequate funds for dune restoration; Lack of awareness among stakeholders on non-extractive uses of sand dune ecosystems; Inadequate knowledge on suitable vegetation to be used for restoration programmes; Lack of alternative livelihoods for communities depend on dune resources for socioeconomic activities and Poor coordination/cooperation among stakeholders, when rapid development programmes are introduced to the coastal area.

4.2.2 Objectives

The objectives of the proposed project are as follows;

- Restoration of sand dunes and its vegetation subjected to anthropogenic destructions to develop soft barriers against SLR, storm surges, inundation, etc. and as wind belts where ever it is applicable.
- Conserve natural sand dunes and turtle nesting sites in their vicinity.
- Reduce unemployment among coastal communities depend on dune resources and improve their socioeconomic status through sustainable management of sand dunes and their resources.
- Uplift the country's economy through eco-friendly tourism within coastal belts with sand dunes

4.2.3 Outputs and measurables:

Rehabilitation of sand dunes with dune vegetation in 10 suitable sites with an area of 2 ha in each site. Train at least 100 persons from all three coastal districts as trainers for rehabilitation and sustainable utilisation of sand dunes and its resources, tissue culture, SMEs related to dune resources, ecotourism, etc. Establishment of 3 tissue culture laboratories in research/academic institutions, establishment of at least four SMEs in each of the coastal districts selected. Establishment of sand dune nature trails and herbal gardens with clusters of tourist resorts. In areas affected by strong winds development of wind belts using dune vegetation 25% reduction of sand dune extraction for construction purposes.

Measurable output of the project would be around 25% reduction of unemployment among coastal communities by 4th quarter of year 2005 (Second year). Elevation of the coastal belt at least by 10cm height.

4.2.4 Relationship to the country's sustainable development priorities

As expected by the National Environment Policy (NEPO, 2003) protect and sustainably manage of coastal environment and resources of dune ecosystems, by maintaining transparency and public accountability, securing sustainable socioeconomic development, healthy and peaceful life style of all coastal communities and stakeholders by developing a pleasant coastal environment and securing the human dwellings and their properties and by providing employment opportunities while reducing destructive anthropogenic activities. Conserve the natural biodiversity of sand dunes as reservoirs as laid down by the National Policy on Wild Life Conservation (2000), and maintain resources, soils, water and aesthetic values, to increase the tree cover and productivity of the natural dune vegetation to meet the protection from the impacts of natural hazards and SLR to present and future generations for their products and services and to enhance the contribution to the welfare of the coastal communities and by strengthening the national economy, with special attention paid to equity in economic development. Conserve, protect and manage the coast & its resources for the wellbeing of the coastal communities and to improve the socio-economy of coastal communities and the country's economy according to the Conservation Act No. 57 & Act No. 64, Coastal zone management plan (CZMP1997 & 2004), conservation Act. 1990 an Mahinda Chinthena (2005) pp 61 & 64 and *Mahinda Chinthena* way forward (2010)– Vision for the New Future, the Government of Sri Lanka's Ten Year Development Policy Framework[16]..

4.2.5 Project Deliverables

- Protection to the coastal communities from impacts of SLR and strong winds, while providing security to their socioeconomic activities, protecting their dwellings, providing alternative employment opportunities and necessary training to eco-friendly economic activities.
- Improvement of tissue culture technology for production of dune plant prapagules.
- Conservation and protection of coastal dune biodiversity.
- Improvement of ecotourism and attraction of foreign exchange earnings.
- Improve the aesthetic values of the coastal belt through rehabilitation of indigenous dune vegetation and through introduction of beneficial exotic plants species.

4.2.6 Project Scope and Possible Implementation

Three successful sand dune rehabilitation programmes will be established in the Southern, North-Western and Eastern coastal districts of Sri Lanka and information on most suitable plant species and technology to

[16] Mahinda Chinthana Policy Framework, 2005.

be used will be made available through detailed publications for future expansions of such projects. Economically feasible tissue culture techniques and SMEs based on dune products will be developed through research and such information will be published. Most of the activities will be conducted with community and stakeholder participation and it will ensure socioeconomic sustainability of the community while rehabilitation the dune ecosystems.

4.2.7 Project Activities

1. Selection of suitable sites each with an area of 2 ha of sand dunes for restoration
2. Awareness/training for all stakeholders
3. Establishment of tissue culture laboratories & nurseries in three coastal districts selected
4. Planting sand dune vegetation (2ha in each site selected) and monitoring of performance of restored sand dunes
5. Establishment of Small and medium scale enterprises (SMEs) and community participatory programmes using products from sand dune vegetation
6. Adoption to wider areas (to 10 ha)in each site selected within the sand dunes selected from the coastal belt
7. Evaluation of success

4.2.8 Timelines for the proposed activities

Table 4.2: Proposed Timelines for Implementation of project activities

Activity	Year/ Quarter																											
	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
1. Selection of suitable sites																												
2. Awareness/training																												
3. Establishment of tissue culture laboratories & nurseries																												
4. Planting sand dune vegetation and monitoring performance (2ha in 3 sites)																												
5. Establishment of SMEs and development of community participatory																												

programmes																											
6. Adoption to wider area (10ha in each of the 3 sites)																											
7. Evaluation of success																											

4.2.9 Budget/Resource requirements

Table 4.3: Approximate Budget Estimate for the Proposed Project

No.	Activity/Sub Activity	Budget (US $)		
		Domestic	International	Total
1	Selection of suitable sites	50,000		50,000
2	Awareness/training	138,500	537,500	676,000
3	Establishment of tissue culture laboratories & nurseries	260,000	590,000	850,000
4	Planting sand dune vegetation and monitoring performance (2ha in 3 sites)	30,000	120,000	150,000
5	Establishment of SMEs and development of community participatory programmes	101,000	354,000	455,000
6	Adoption to wider area (10ha in each of the 3 sites)	52,000	103,000	155,000
7	Evaluation of success	59,000	-	59,000
Subtotal: Cost of Project Activities		**690,500**	**1,704,500**	**2,395,000**
8.	Project management cost	239,500	-	239,500
Total budget for Technology 1		**930,000**	**1,704,500**	**2,634,500**

The cost of project activities would be approximately US $ 2.395 million and the project management cost would be around 10% of the cost of project activities (US $ 0.24 million). Estimated total cost of the proposed project including the project management cost would be approximately US $ 2.635 million. Required funds will be obtained through domestic (US $: 0.93 million) and international (US $: 1.705 million) sources as indicated in the budget estimate.

4.2.10 Measurement/Evaluation:

An internal monitoring programme (quarterly) and periodic external evaluation (biannually and mid-term) would be implemented for project monitoring and evaluation. Quarterly internal monitoring will be carried out by the planning unit of the Coast Conservation Department. External evaluation will be carried out by

an independent panel of experts appointed by the line ministry (Ministry of Fisheries and Aquatic Resources) in consultation with the donor agency.

Monitoring and evaluation of project activities will be done as follows;

- **Awareness** can be evaluated by the level of involvement of different stakeholders in conservation/ rehabilitation and knowledge dissemination programmes.
- **Annual expansion of sand dunes/dune vegetation** can be measured by the expansion of area covered by dune vegetation. Aerial photographs could be used.
- **Efficiency as a soft barrier against SLR** could be measured by the increased elevation of the coastline and by the stability of dunes and their vegetation under harsh conditionsc.
- **Success of dune plantations** can be evaluated by the numbers of dune plantations/herbal gardens, numbers of propagules of dune plants produced per year by each nursery
- **Success of nurseries established and their performance** could be evaluated by the numbers of nurseries and the quality of propagules produced
- **Effect of training** given on tissue culture could be evaluated by umbers of persons with respective training
- **Quality of propagules** could be evaluated by their survival and growth rate
- **Effect on reduction of unemployment** can be evaluated by numbers employed in sand dune related socioeconomic activities
- **Impact on tourism** could be evaluated by the number of tourists visit nature trails, turtle hatcheries, herbal gardens, etc. every year and through the foreign exchange earnings
- **Improvement of socioeconomic standards** could be evaluated by the increase of average annual income of coastal communities involved in sand dune related activities.
- **Reduction in use of dune sand for construction work** can be evaluated by the invention of new material in place for dune sand for construction purposes.

4.2.11 Possible Complications/Challenges

Inadequate funding for initiation and continuation of the project until it reaches, self sustainable levels; Inadequate international donor funding; Inadequate involvement of local communities, NGOs & INGOs; Resistance from the community to give up their unsustainable socioeconomic activities that are harmful to dune ecosystems; Inadequate patronage at provincial and national government level; Inadequate funding for capacity building at research & higher education institutions for research activities related to plant tissue culture, tissue culture and genetic studies to produce propagules which are temperature and salinity tolerant and with a high growth performance; Unavailability of easily adaptable species of dune flora with a high growth rate and with a high temperature and salinity tolerance; Slow performance/ progress of the project which is politically not attractive; Insufficient collaboration/cooperation among, different stakeholders

Frequent occurrence of extremely harsh environmental conditions such as strong wave action, storm surges, strong winds, etc., prior to establishment and strengthening of dune ecosystems

4.2.12 Responsibilities and Coordination

Stakeholder	Responsibility	Collaborations
CCD	ICZM, Coastal Protection & coordination of coastal projects & development plans	Stakeholders of coastal belt
M/Environment & Natural resources	Policy decisions, financial planning & administration related to coastal environment	All stakeholders, line ministries & treasury
Universities	Training, awareness & research	R & D institutes, CCD, CBOs, NGOs
Tourist Board	Coastal eco-tourism related to dune ecosystems	Tourist hotel owners, CCD, CEA, M/Indigenous medicine
Tourist hoteliers	Coastal eco-tourism related to dune ecosystems, establishment of nature trails among dune vegetation, turtle nesting sites & herbal gardens, reduce environmental impacts to sand dunes	Tourist Board, M/ local government and provincial councils, CBOs, NGOs,
National Physical Planning Department/	Identification of suitable development plans for the coastal belt to reduce impacts on sand dune ecosystems	CCD, M/Tourism, Tourist Board, M/Local government & Provincial Councils
CEA	Conducting IEEs & EIAs	CCD, MEPA,. Research & Higher Educational Institutes
M/Agricultural Development,	Policy decisions related to Agricultural activities, development of dune plantations of economic importance, promote agrarian research	M/Technology & Research, Higher educational & Research Institutes
M/ Indigenous medicine,	Identification of medicinal plants among dune vegetation to establishment of herbal gardens & develop make value added medicinal products from dune plants	M/Tourism, Tourist Board, M/Industrial Development, CBOs, Higher Educational & Research Institutions
M/ Industrial Development,	Awareness and introductions of SMEs	Higher educational & Research Institutions, SMEs, NGOs, CBOs
M/ local government and	Planning of development plans and socioeconomic activities for the well being of	CCD, M/Environment & natural Resources, CBOs, NGOs,

provincial councils.	coastal communities and provide sources of funding for dune rehabilitation activities and to establish CBOs	
M/Technology &Research	Providing funds for R&D activities related to sand dune ecosystems and their resources	M/Finance & Planning, Higher educational & Research Institutions, National & International funding sources
Agrarian research institutes,	Research on establishing suitable environmental conditions (soil, irrigation, fertilizer, etc.)for dune plantations with suitable plant diversities,	Higher educational & other research institutions
SLCARP	Preparation & introduction of relevant agrarian research policies	M/Agricultural Development, Higher Educational & Research Institutes related to Agrarian Services & Research
Botanical garden	Identification of dune plants and awareness & training on maintaining nurseries & dune plantations	Higher educational & Agrarian Research Institutions
Coast Guard	Protection of coastal belt from harmful activities	CCD, MEPA
CBOs	Involvement of community for rehabilitation of sand dunes, establishment & maintenance of dune plantations , awareness on the importance of dunes and dissemination of knowledge on sand dunes, its vegetation, SMEs related to dune resources, etc.	CCD, Higher Educational & Research institutions, NGOs, INGOs, SMEs, M/Industrial Development, M/Tourism,Tourist Board, Tourist Hotel owners
MEPA	Protection of coastal & marine environment from pollution and man-made hazards	CCD, CEA, Coast Guard, Higher Educationmal & Research Institutions
INGOs & NGOs	Organising community participatory workshops, training, finding finances, etc. for dune rehabilitation & socioeconomic activities	CCD, CBOs, M/ local government and provincial councils, Universities/Research Institutions
ICTAD	Development of alternatives for dune sand for construction work & conduct training & awareness programmes about them	NSF, NBRO,
NBRO		NSF, ICTAD
SLLRDC	Beach Nourishment & Dune rehabilitation	CCD, M/National Planning & Development
NSF	Establish Research priorities related to sand	M/Finance & Planning, Higher

	dune restoration, sustainable utilization of resources & provide funding for projects	Educational & Research Institutions, International funding agencies

Duplication of roles will be minimized by **Coast Conservation Department who is the organization responsible for Integrated coastal zone management serving as the main stakeholder and project implementing organization** to conduct the project in collaboration with the participation of all other stakeholders shown above, developing the project proposals with their cooperation and collaboration and by identifying the specific responsibilities of each stakeholder within each project. Preparation of multidisciplinary development projects, with identification of sub projects to be handled by different stakeholder groups/ institutions/organizations and make separate budgetary allocations according to the tasks to be handled, inclusion of key officials from relevant stakeholder institutions/establishments when forming a project coordinating body, participation of all stakeholders, during project progress review meetings also will minimize duplication of roles.

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