



# **Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation**

**Climate Change Secretariat  
Ministry of Environment and Renewable Energy  
Sri Lanka**

**2014**



# Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation



**Climate Change Secretariat  
Ministry of Environment and Renewable Energy Sri Lanka**

**2014**

Supported by



# **Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation**

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## MESSAGE BY THE HON. MINISTER OF ENVIRONMENT AND RENEWABLE ENERGY



Sri Lanka being an island nation subjected to tropical climatic influences is highly vulnerable to climate change impacts. We are already experiencing significant climatic imbalances manifested through increasing average temperatures, drastic variations in rainfall patterns and extreme climatic events such as heavy rainstorms, flash floods, and extended droughts and weather related natural disasters in various forms and severity. These extreme and sometimes unseasonal events affect not only the human lives and properties but also have long term impacts on the ecosystems as well.

“MahindaChinthana – Vision for the Future”, the Government of Sri Lanka's Ten Year Development Policy Framework assigns a very high priority to the management of the environment and the natural resources sector including addressing climate change impacts. In keeping with the Government's overall vision on tackling climate change impacts, the “National Climate Change Policy (NCCP) for Sri Lanka” identifies the paramount need of undertaking appropriate actions for climate change adaptation in order to build resilience of the country to face the adverse impacts of climate change. The NCCP emphasizes the importance of exploring technologies and best practices already available in the country and globally, and select nationally appropriate innovative technologies, disseminating, and implementation to the extent possible with sound monitoring mechanisms.

The Government and my Ministry in particular recognizes that the Technology Needs Assessment (TNA) Project implemented in collaboration with Global Environment Facility (GEF), United Nations Environment Programme (UNEP), UNEP-Risoe Center (URC) and the Asian Institute for Technology (AIT), as the first comprehensive national exercise undertaken towards addressing our climate change concerns. Thus, the TNA Report provides an assessment of the priority technology requirements and action plans for climate change adaptation activities in food, water, coastal, health and biodiversity sectors. I am convinced that this exercise has been a nationally driven process involving local expertise and knowledge supplemented by international experiences.

In fulfillment of the Government's firm commitment towards taking appropriate national actions for tackling climate change related issues and also collaborative obligations to the international community in this context, I have great pleasure in presenting the **Sri Lanka's National Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation** to the policy makers, potential investors, technology developers, scientists and all other stakeholders who are actively participating in sustainable development efforts of the country. I also recommend this report for consideration and emulation of the world community and invite them to be partners in achieving our economic, environmental and social development goals.

A handwritten signature in black ink, appearing to read 'Susil Premajayantha'.

Susil Premajayantha, MP  
Minister of Environment and Renewable Energy  
Government of Sri Lanka



## MESSAGE BY THE SECRETARY MINISTRY OF ENVIRONMENT AND RENEWABLE ENERGY



Sri Lanka ratified the United Nations Framework Convention on Climate Change (UNFCCC) in November 1993 and acceded its Kyoto Protocol in September 2002. In keeping with the obligations of the UNFCCC, the Government of Sri Lanka submitted its Initial National Communication in 2000 and submitted the Second National Communication in 2012. Over the last two decades, Sri Lanka has made a significant progress towards improving the national policy framework and strengthening the legal and institutional capabilities to facilitate implementation of obligations under the UNFCCC and Kyoto Protocol. These timely actions demonstrate the Government's firm commitment in addressing country's environmental and climate change related issues.

Although Sri Lanka is a low greenhouse gases emitter, it is highly vulnerable to adverse impact of climate change. Analysis of past records suggests that air temperature throughout the island has been on a rising trend during the last century. The future scenarios predict higher levels of emissions and possibility of adverse climate change impacts, if no mitigatory and adaptation actions are undertaken now.

The TNA explores country needs for the reduction of greenhouse gas emissions and adaptation technologies. It also re-affirms the will of the Government along with the international community to contribute to the joint efforts in addressing the climate change threat. It is envisaged that this process will open up access to funds, create an enabling environment for the transfer of priority technologies which will improve the climate resilience of the most vulnerable sectors in the country.

I would like to take this opportunity to extend my gratitude to the Global Environment Facility (GEF) for funding and the United Nations Environment Programme (UNEP) and the UNEP Risoe Center (URC) for implementing this project in collaboration with the Asian Institute of Technology (AIT). A record of appreciation is also extended to the members of the TNA committee, Sectoral working Groups and all other experts who have contributed to this national exercise.

A handwritten signature in black ink, appearing to read 'B.M.U.D. Basnayake'.

B.M.U.D Basnayake  
Secretary  
Ministry of Environment and Renewable Energy



## FORWARD



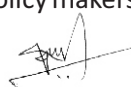
The Technology Needs Assessment (TNA) for climate change adaptation in Sri Lanka was undertaken by the Climate Change Secretariat of the Ministry of Environment and Renewable Energy from June 2011 to April 2013. The main objective of the Climate Change Technology Needs Assessment is to identify and assess environmentally sound technologies that have synergy between reducing the impact of climate change and the rate of GHG emissions in Sri Lanka within national development objectives. The TNA process included an extensive consultative process by involving all key stakeholders. The National TNA committee and technical Working Groups (WG) for each sector constituted the mechanism for stakeholder consultation. TNA process identified (i) the priority sectors for which technologies are needed to sustain national development projects and programs, (ii) identified suitable technologies that contribute to climate change mitigation and adaptation in the relevant sectors, (iii) prioritized the identified technologies, and assessed their cost-effectiveness by using the Multi Criteria Decision Analysis (MCDA) process, (iv) identified barriers for implementation of prioritized technologies and developed enabling frameworks for the development and diffusion of the technologies for relevant sectors. Finally, the TNA process developed project proposals for prioritized technologies to mobilize resources for development and diffusion of relevant technologies.

The TNA carried out an analysis of various technology options for climate change adaptation in Sri Lanka with a view to understand the relative importance or contribution of each of them in negating or lowering the adverse impacts on relevant sector. The TNA process provides multiple benefits at the country level, including the identification of barriers for deployment and diffusion of technologies and facilitate in removing of policy and legal gaps leading to improvement of enabling environments, increasing the capacity of local institutions and experts, and raising public awareness of climate change issues.

The TNA process in Sri Lanka has followed the guide lines and procedures recommended by UNDP/UNFCCC Handbook for Conducting Technology Needs Assessments for Climate Change (November 2010), Organizing the National TNA Process: An Explanatory Note, 2010 and guidelines provided by the Asian Institute of Technology (AIT). The TNA project in Sri Lanka was supported by the Global Environment Facility (GEF), United Nations Environment Program (UNEP) and Asian Institute of Technology (AIT).

The priority sectors identified for climate change adaptation were Food, Health, Water, Coastal and Biodiversity. The food sector included Agriculture, Livestock and Fishery subsectors. Three (03) priority technologies were identified for each sector except for biodiversity sector in which five (05) priority technologies were identified.

It is hoped that this document provides valuable insights to the adaptation technologies for food, health, water, coastal and biodiversity sectors of Sri Lanka. The publication should be of interest to policy makers, planners, practitioners, experts and other stakeholders interested in the topic.

A handwritten signature in black ink, appearing to read 'Herath M. Bandarathillake', written over a faint circular stamp.

Herath M Bandarathillake  
Team Leader  
Technology Needs Assessment Project





## ACKNOWLEDGMENTS



This report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation was the outcome of the project on Technology Needs Assessment (TNA) on Climate Change Adaptation and Mitigation for Sri Lanka conducted by the Climate Change Secretariat of the Ministry of Environment and Renewable Energy from June 2011 to April 2013.

The TNA Project in Sri Lanka was funded by the Global Environment Facility (GEF) and technically supported by United Nations Environment Programme (UNEP) and the UNEP Risoe Center (URC) in collaboration with the Asian Institute of Technology (AIT). First and foremost, my appreciation goes to the GEF, UNEP, URC and AIT for their financial and technical supports.

I wish to take this opportunity to express my sincere gratitude to Hon. Susil Premajayantha, Minister of Environment and Renewable Energy, Hon. Anura Priyadarshana Yapa, Former Minister of Environment, Mr. B.M.U.D. Basnayake, Secretary, Ministry of Environment and Renewable Energy and Mr. Gamini Gamage, Additional Secretary (Environment and Policy) of the Ministry of Environment and Renewable Energy for their leadership, directions and guidance provided to conduct this project successfully.

My appreciation is extended to the members of the TNA committee, sectoral working groups and all other experts who contributed to this project. I am grateful to the various governmental, non-governmental and private sector personnel who took time out of their busy schedules to meet with our consultants and to provide data and information.

I am thankful to all the consultants of the TNA project, namely Mr. H.M. Bandarathillake, Team Leader and sector experts Dr. (Mrs.) S.M. Wijesundara (Food Sector), Dr. N.P. Sumanaweera (Health Sector), Prof. (Ms.) Hema M.K.K. Pathirana (Water Sector), Prof. (Ms.) P.R.T. Cumarantunga (Coastal Sector), and Mr. Shamen Vdanage and Ms. Manishka De Mel representing International Union for Conservation of Nature (IUCN) (Biodiversity Sector).

My special thanks is also extended to the staff of the Climate Change Secretariat of the Ministry of Environment and Renewable Energy, particularly to Ms. Anoja Herath, Coordinator of the TNA project, Ms. Nirosha Kumari and Ms. Surani Pathirana, Environment Management Officers of the Ministry of Environment and Renewable Energy.

Finally, on behalf of the Ministry of Environment and Renewable Energy I would like to thank all those who contributed to make this project realistic. Without their supports this project would never be success.

A handwritten signature in black ink, appearing to be 'R.D.S. Jayathunga', written over a horizontal line.

Dr. R.D.S. Jayathunga  
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### Stakeholder Participation

*National TNA Committee – Annex I*

*The Compositions of the Sectoral Technical Stakeholder Working Groups – Annex II*

*This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP- Risoe Centre (URC) in collaboration with the Asian Institute for Technology (AIT), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the Secretary, Ministry of Environment and Renewable Energy, Government of Sri Lanka.*



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## ACRONYMS

ADB	Asian Development Bank
AIT	Asian Institute of Technology
CBF	Community Based Fishery
CBSL	Central Bank of Sri Lanka
CCD	Coast Conservation Department
CCS	Climate Change Secretariat
CWSSP	Community water supply and sanitation project
CZMP	Coastal Zone Management Plan
DOA	Department of Agriculture
DZ	Dry Zone
GDP	Gross Domestic Production
GEF	Global Environment Facility
GHG	Green House Gas
IAS	Invasive Alien Species
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
MCDA	Multi Criteria Decision Analysis
ME	Ministry of Environment
MOH	Ministry of Health
MSL	Mean Sea Level
NDMC	National Disaster Management Centre
NEM	North East Monsoon
NTFP	Non-Timber Forest Products
PA	Protected Area
REDD	Reducing Emissions from Deforestation and (Forest) Degradation
RO	Reverse Osmosis
RWH	Rain Water Harvesting
SWM	South West Monsoon
TAPS	Technology Action Plan
TFS	Technology Fact Sheet
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WZ	Wet Zone

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## EXECUTIVE SUMMARY

This report describes the Technology Needs Assessment (TNA) for climate change adaptation in Sri Lanka that was undertaken between June 2011 and August 2012. In line with its obligations as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), the Democratic Socialist Republic of Sri Lanka has undertaken a number of actions since ratifying the convention in November 1993 and acceding to the Kyoto Protocol in September 2002. Sri Lanka submitted the Initial National Communication on Climate Change (INC) to the 6th Session of the Conference Of Parties (COP 6) in 2000. The GHG inventory (for 2000) and Second National Communication (SNC) on Climate Change was completed in 2011. Over the last two decades the country has made a significant contribution towards the improvement of national policy, legal and institutional capabilities for implementation of the obligations under UNFCCC and Kyoto Protocol. Some of these policy interventions include development of National Environmental Policy (2003), National Climate Change Policy (2012), National Climate Change Adaptation Strategy (NCCAS) (2010), and Sri Lanka Strategy for Sustainable Development (2007). The National Advisory Committee on Climate Change (NACCC) was also established in 2008.

Under the UNFCCC, developing countries have been encouraged to assess and submit their technology needs for climate change adaptation and mitigation; and developed countries have committed to assisting with the technology transfer. The TNA process in Sri Lanka has followed the guide lines and procedures recommended by UNDP/UNFCCC Handbook for Conducting Technology Needs Assessments for Climate Change (November 2010), Organizing the National TNA Process: An Explanatory Note, 2010 and guidelines provided by the Asian Institute of Technology (AIT). The focus of the assessment has been on technologies that support Sri Lanka's economic development in a sustainable manner, in line with the National Development Policy Framework of Sri Lanka ("Mahinda Chintana: Idiri Dakma" – Vision for a New Sri Lanka, (2010), and vulnerability of relevant sectors to climate change. The methodology adopted in the TNA was a stakeholder-driven process to identify and assess environmentally sound technologies that will, within national development objectives, reduce the impact of climate change and the rate of greenhouse gas emissions in Sri Lanka. The process of conducting the TNA was initiated by the Ministry of Environment and Renewable Energy with establishment of the National TNA Committee which mandated the Project Coordinator, National Consultants and sectoral stakeholder working groups to manage the process.

As the initial step of the TNA process, the priority sectors for adaptation and mitigation were identified in consultation with the National TNA Committee. The priority sectors identified for adaptation were Food, Health, Water, Coastal and Biodiversity. For each sector the TNA process was carried out in four steps, (i) Technology identification and prioritization, (ii) Barrier Analysis for identification of potential barriers and development of enabling framework, (iii) Development of Technology Action Plans (TAPs), and (iv) Development of Project Ideas (PIs). The first three steps are presented in this document and the fourth step is presented in a separate document.

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For technology identification and prioritization, potential list of technologies for each sector were identified, and later the list was prioritized by using the Multi Criteria Decision Analysis (MCDA) process with the participation of stakeholders at separate stakeholder workshops for each sector. The process involved selecting basic criteria for evaluation, deciding on sub-criteria associated with each basic criterion and weighting the criteria and sub-criteria. Then the Performance Matrix was constructed based on the criteria and weighted scores followed by Benefit/Cost analysis which helped determining the most preferred, prioritized technologies. As the second step of the process barrier analysis was carried out for each technology to identify potential barriers and develop enabling framework to overcome barriers for fulfilling the objectives of technology transfer and diffusion. Then as the next step, Technology Action Plan (TAP) was developed for each technology. The TAP comprised the action recommended, priority rank of the action, responsibility for implementation of the action, time frame required to implement the recommended action, cost estimate and performance indicators to evaluate the progress of implementation.

**Food Sector:** The food sector in the current TNA includes agriculture, livestock and fishery sub-sectors. The significant contribution made by the food sector to the Sri Lankan economy as a determinant of economic growth and source of employment to the nation's work force makes its ability to adapt to climate change impacts critical for continued economic growth. The success of crop production in the country is observed to be determined directly or indirectly by several climate parameters such as changing temperature and rainfall regime, availability of irrigation waters, sea level rise, intrusion of saline water, coastal flooding etc. Changes in climatic parameters critical for food production such as the quantum of rainfall received and in the pattern of rainfall showed a declining trend and high variability with an increase in extreme events. Changes in the diurnal variation of temperature, soil temperature and pest populations due to changes in climate factors are likely to exert a significant impact on crop production in Sri Lanka. The combined effects of changes in climate parameters such as those impacts on land degradation are other areas that suggest serious negative consequences resulting from climate change.

The current TNA carried out an analysis of various technology options for climate change adaptation in Sri Lanka with a view to understand the relative importance or contribution of each of them in negating or lowering the adverse impacts on the food sector. Through an extensive consultative process, a list of nine (09) potent technologies available in the food sector to face the challenge of climate change was compiled. The MCDA process ranked these 09 identified adaptation technologies following a scheme that jointly considered technology implementation costs and 19 different benefit characteristics from Environmental, social, and economic spheres. The final benefit/cost analysis ranked **(1) Sustainable Culture-based fisheries, (2) Crop diversification and precision farming and (3) Sustainable land management**, as the most promising technologies for the food sector. The high implementation costs of some technologies considered was the key factor that disallowed their selection.

Then barrier analysis was carried out and enabling framework was developed for all three prioritized technologies stated above. Based on the enabling framework, Technology Action Plans (TAPs) were developed for each prioritized technology in order to implement the actions required for technology transfer and diffusion.

**Health Sector:** There are direct and indirect adverse health effects of climate change. The direct ones are Injury, communicable disease, mental illnesses, health effects due to high or low temperatures of the environment, and diseases of the respiratory system. The indirect effects are food, water and rodent borne diseases due to contamination or scarcity in protracted droughts. Crop failure will lead to food

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shortage causing macro nutrient and micronutrient deficiency nutritional disorders. Loss of live stock will cause similar effects. There is a fair possibility to alter the health of the people due to the effects of climate change. It is imperative to develop policies, legislation, strategic plans and administrative structures conducive to implement adaptation related activities at all levels of health care provisions. For the purposes of adaptation to minimize the adverse health effects some effective technologies are needed.

At the first sectoral stakeholder meeting nine (09) technologies were identified as suitable adaptation options. At the second meeting the technologies were prioritized using Multi criteria Decision Analysis (MCDA). Of the 09 technologies identified, three technologies were selected as implementation priorities following the cost-benefit analysis. These selected technologies were; **(1) Technology for early warning systems and networking for information exchange on extreme events and other climate change related events, (2) Transfer of knowledge and skills to health personnel and (3) Management of health care waste.**

As the next step of the process, barrier analysis was carried out and enabling framework and Technology Action Plans (TAPs) were developed for each prioritized technology in order to implement the actions required for technology transfer and diffusion.

**Water Sector:** More than 90% of the small tank systems in Sri Lanka are clustered into cascades and these tank network systems have been built in water scarce areas particularly in the Dry Zone by ancient kings mainly for agricultural purposes. The vast ancient reservoirs, small and large tanks and canals built by ancestors are supplemented today with many irrigation projects such as Victoria, Randenigala and Kotmale reservoirs.

Air temperature in Sri Lanka has increased by 0.450C over the last 22 years, suggesting a rate of 0.20C increase per decade and possible impacts predicted on the water sector due to climate change are severe droughts, floods, sea level rise etc. It has been predicted that by 2050, the amount of rainfall receive from the north-east monsoon which is the major source of water for the dry zone of Sri Lanka at present, will be reduced by 34% while that received from the south-west monsoon will be increased by 38%. This would make the dry zone districts more vulnerable to droughts and the wet zone districts to floods and landslides. Prominent change due to low rainfall will be the increase in the area belongs to the dry zone. Due to such droughts, surface water availability and per capita water availability will be decreased. The floods due to increase in rainfall intensity will reduce ground water recharge and also would affect quality of surface water, sediment generation and transport of sediments. Studies on the sea level rise have shown an increase trend for sea water intrusion in certain coastal areas. As a result salinity of surface water and ground water in such areas will be increased.

Through an extensive consultative process seven (07) adaptation technologies were selected based on one or several factors such as the impacts of climate change, rainfall, economic, environmental and social benefits. Out of these adaptation technologies, the most preferred three were selected by evaluating the 07 adaptation technologies using MCDA approach. The selected three technologies according to decrease in priority are as follows; **(1) Restoration/Rehabilitation of minor tank net works, (2) Rainwater harvesting from rooftops for drinking and household uses, (3) Boreholes/tube wells as a drought intervention for domestic water supply.**

Then, barrier analysis was carried out and enabling framework and Technology Action Plans (TAPs) were



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developed for each prioritized technology in order to implement the actions required for technology transfer and diffusion.

**Coastal Sector:** Sri Lanka's coastal zone is highly variable in its morphology & ecology and it has many sensitive ecosystems, i.e. coral reefs, mangroves, sea grass beds, sand dunes, lagoons, estuaries, etc. which has been subjected to many changes in the past due to natural phenomena and anthropogenic activities. The impacts of climate change on the coastal zone are expected to be largely site specific, due to the influence of local factors. The impacts of climate change are many and varied, but from a human perspective, the five most important effects of climate change in the coastal zone are: increased probabilities of, coastal flooding and inundation; coastal erosion; rising water tables; saltwater intrusion into surface and groundwater and biological effects. Most important impacts expected to result the coastal zone of Sri Lanka due to climate change are sea level rise (SLR) at an average of 0.5 m, coastal inundation, coastal erosion, loss of coastal terrestrial habitats, saltwater intrusion, changes in coastal biodiversity and changes in coastal morphology.

In consideration of the development programmes undertaken in Sri Lanka and the current socioeconomic status of the country, most important nine (09) adaptation technologies needed for the coastal sector with respect to climate change were identified in consultation with the sectoral stakeholder working group. Thereafter considering the cost and benefits such as, economic (employment, foreign exchange earnings & protection for infrastructure); social (income, education & health) and environmental (land reclamation and reduction of GHG, land loss due to sea level rise & inundation), above selected adaptation technologies were prioritised using the MCDA approach. The selected technologies were; **(1) Sand dune rehabilitation, (2) Restoration of mangroves and (3) Restoration of coral reefs by transplanting corals.**

Then, barrier analysis was carried out and enabling framework and Technology Action Plans (TAPs) were developed for each prioritized technology in order to implement the actions required for technology transfer and diffusion.

#### **Biodiversity Sector:**

Sri Lanka has a varied climate and topography which has resulted in a rich biodiversity, distributed within a wide range of ecosystems. It is one of the most biologically diverse countries in the Asian region and considered as one of the 34 biodiversity hotspots identified in the world. The conservation of biological diversity is of special significance to Sri Lanka in the context of its predominantly agriculture-based economy and the high dependence on many plant species for food, medicines and domestic products.

The biodiversity sector in Sri Lanka has been identified as one of the most vulnerable sectors to climate change. Sri Lanka is vulnerable to the risk of sea level rise and increased frequency of storms that can bring major impacts on coastal biodiversity. Additionally, analysis of climate data indicate a change in rainfall regimes, and a trend for increasing air temperature, which can also have impacts on the country's biodiversity.

Through an extensive consultative process with members of the sectoral stakeholder working group, a list of eleven (11) potent technologies available in the biodiversity sector to minimize the vulnerability to climate change were identified as suitable adaptation options. Out of these adaptation options, the most preferred five (05) technologies were selected by evaluating options using MCDA approach. The first five technologies were selected as implementation priorities based on the request made by the

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stakeholders. The selected technologies according to decrease in priority were; **(1) Restoration of degraded areas inside and outside the protected area network to enhance resilience, (2) Increasing connectivity through corridors, landscape/matrix improvement and management, (3) Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones, (4) Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems, (5) Ex-situ conservation for highly threatened species and possible re-introduction.**

Then, barrier analysis was carried out and enabling framework and Technology Action Plans (TAPs) were developed for each prioritized technology in order to implement the actions required for technology transfer and diffusion.



# CHAPTER 1

## Introduction

Sri Lanka ratified the United Nations Framework Convention on Climate Change (UNFCCC) in November 1993. The primary objective of this multilateral agreement is to achieve the stabilization of Greenhouse Gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic activities from interfering with the climate system. In terms of Articles 4.1(c), (j) and 12 of the Convention, countries are periodically required to submit reports to the UNFCCC on strategies, plans and programmes regarding their attempts to address climate change impacts. In order to fulfill these requirements, Sri Lanka submitted the Initial National Communication to the 6th Session of the Conference Of Parties (COP 6) in 2000. In September 2002, the Government of Sri Lanka acceded to the Kyoto Protocol. Over the last two decades Sri Lanka has made a significant contribution towards the improvement of national policy and strengthening of legal and institutional capabilities for implementation of the obligations under UNFCCC and Kyoto Protocol.

Some of these institutional initiatives include establishment of the Climate Change Secretariat (CCS) within the Ministry of Environment (ME) to serve as the node for the implementation of UNFCCC decisions including the preparation of the National Communications & GHG inventories, and establishment of the Designated National Authority (DNA) for the CDM under the Kyoto Protocol (KP). In addition, the ME has been instrumental in establishing two CDM Centres at University of Moratuwa and University of Peradeniya in order to involve the University system in promoting CDM activities in the country, particularly in the areas of energy and agriculture respectively. Besides these, the Centre for Climate Change Studies (CCCS) has been established within the Meteorological Department (MD) for undertaking research on climate change including analysis of data collected by the MD and make projections of climate change trends based on IPCC findings and assist scientists in other institutes in carrying out impact studies in their relevant sectors. Furthermore, National Capacity Needs Self Assessment on Climate Change (NCSA) and other related assessments have been carried out by the ME in 2007<sup>68</sup>.

The recent policy and legal initiatives undertaken towards meeting the obligations of the UNFCCC include introduction of new environment related policies such as National Environmental Policy (2003), National Climate Change Policy (2012), National Land Use Policy (2007), National Forest Policy (1995), National Policy on Wildlife Conservation (2000), National Watershed Management Policy (2004), National Air Quality Management Policy (2000), National Policy on Wetlands (2006) etc and the new amendments to the Forest and Wildlife laws (Forest Ordinance & Fauna and Flora Protection Ordinance)<sup>80</sup>. In addition, the recently developed national strategies such as *Haritha* (Green)<sup>86</sup> Lanka Action Plan, National Climate Change Adaptation Strategy and Sri Lanka Strategy for Sustainable Development, demonstrate the Government's commitment to address environmental and climate change related issues. Besides, the National Council for Sustainable Development was formed in 2009 under the chairmanship of the HE the President of the Democratic Socialist Republic of Sri Lanka to provide leadership and guidance for sustainable development in the country. The Council is charged with the responsibility of producing an integrated policy, and overseeing and guiding the implementation of the *Haritha* Lanka Action Plan to ensure the sustainability of social and economic development programmes while safe guarding the environmental integrity of the country.

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## 1.1 National Circumstances

Sri Lanka is an island nation in the Indian Ocean, located about 80 km to the southeast of the Indian sub-continent, lying between 5°55' and 9°50' North latitudes and between 79°42' and 81°53' East longitudes. It comprises a mainland of area 65,610 km<sup>2</sup>, including 2,900 km<sup>2</sup> of inland water bodies and several small islands with only six islands having area more than 1,000 ha located off the northwest coast. The mainland has a maximum length of 435 km in N-S direction and maximum width of 240 km in E-W direction. The south-central part of the country is mountainous, while the rest of the country is mostly flat undulating land. The country has a coast line of about 1,585 km, comprising sandy beaches and sand dunes, dotted with many lagoons, estuaries, marshes, mangroves and deltas. There are altogether 103 rivers spread around the country<sup>74</sup>.

The climate of the country depends largely on the monsoon wind pattern. The annual mean surface air temperature of the island has an average value of about 27 oC, with the values varying between 35 oC in the lowlands and about 15oC in the highlands. The country receives rainfall over 2,500 mm annually in the south-west quadrant during the south-western monsoon period, while receiving below about 1,750 mm annually during the north-eastern monsoon period. Based on the rainfall, the country is divided into three climatic zones – wet, dry and the intermediate zones, with the dry and intermediate zones covering the major portion of the country. During the two inter-monsoon periods, there is rainfall spread over the entire country. The annual average rainfall received over the country is about 1,860 mm.

Sri Lanka is faced with many extreme events annually including floods, landslides, droughts and occasional cyclones, causing much damage to property and to human lives. Efforts are being made to minimize such damages through improved monitoring systems providing real time rainfall information from landslide prone areas and also improving mechanisms for information dissemination to people in vulnerable areas. The government has recently established a separate Ministry on Disaster Management to coordinate work on disaster relief and related work.

Wide variation in population density exists across the districts in Sri Lanka. Colombo is overwhelmingly the most densely populated district with 3,729 persons per square kilometer, which is nearly 11 times higher than the national average. According to the 2001 Census of Sri Lanka population density stands at 300 persons per square kilometer whilst 72% of the population lived in rural areas, 22% in urban areas and 6% in plantation estates. The mid-year population estimates in Sri Lanka for year 2010 was 20.65 million people with a population density of 329 persons per square kilometer and it is one of the most densely populated countries of the world<sup>23</sup>. The population growth rate is around 1.1 per cent at present and it is projected that the population will reach the 25 million mark by the middle of the century.

Sri Lanka's economy is based mainly on the service sector which has contributed 59% to the GDP in 2010, with the industrial and agricultural sectors contributing 29% and 12% respectively. The GDP (at current price) in 2010 has been Rs 5,602 billion (US\$ 49.5 billion) with an average annual real growth rate of 8.0% in 2010. The per capita GDP (current price) has grown from about US\$ 800 in 2001 to US\$ 2,399 by 2010<sup>20</sup>. Sectors that have brought revenue to the country are industrial production, agriculture, fisheries, and tourism, mineral exports including gem stones, among others.

The human development indicators are exceptionally high for a developing country. The life expectancy at birth is 74 years and the adult literacy rate, 91.4 per cent. Infant mortality is low (18.57 deaths/1,000 live births), and 93 per cent of the population have access to advanced health care. The Human

Development Index (2010) is 0.658, approaching the level of developed countries, demonstrating a high quality of life. Sri Lanka is a multi-ethnic secular state. The major ethnic groups in the country are Sinhalese (73.9%), Tamils (18.2%) and Moors (7.1%). The majority of the population is Buddhists (69.3%), and the other major religions are Hinduism (15.5%), Muslims (7.6%), and Christians (7.6%)<sup>14</sup>.

Sri Lanka has carried out its Second National Greenhouse Gas (GHG) Inventory for 2000 in accordance with the revised 1996 IPCC Guidelines (RIG, 1996) and reported in the Second National Communication in Climate Change (2012). Based on this inventory, the total aggregate emission is 20,798 GgCO<sub>2EQ</sub> which comprised 65% from the energy, 22.6% from the agriculture, 9.8% from the waste, 2.4% from the industry and 0.2% from the land use change and forestry sectors as shown in Table 1.1. With the 6,254 GgCO<sub>2EQ</sub> from the land use change and forestry sector, the total net emission had been 14,544 GgCO<sub>2EQ</sub>. The composition of this quantity is 45.8% of CO<sub>2</sub>, 46.9% of CH<sub>4</sub> in CO<sub>2EQ</sub> and 7.3% of N<sub>2</sub>O in CO<sub>2EQ</sub>. Transport, Energy, Agriculture, Industry and Waste sectors are the highest GHG contributors.

**Table 1.1 Summary of GHG Emissions / Removals during 2000**

Sector	CO <sub>2</sub> Gg	CO <sub>2</sub> Removals Gg	CH <sub>4</sub> GgCO <sub>2EQ</sub>	N <sub>2</sub> O Gg CO <sub>2EQ</sub>	Total Gg <sub>CO<sub>2EQ</sub></sub> Net	Percentage of total
Energy	10430.01		881.37	251.10	11,562.48	61.4%
Ind. Processes	492.40				492.40	2.6
Agriculture			3,887.94	821.50	4,709.44	25.0%
LUCF Emissions	10.34		35.07		45.41	0.2%
Waste			2,033.22		2,033.22	10.8%
<b>Total Emissions</b>	<b>10,932.75</b>		<b>6,837.60</b>	<b>1,072.60</b>	<b>18,842.95</b>	<b>100.0%</b>
LUCF Removals		6,253.99			-6,253.99	
<b>Total Net</b>	<b>10,932.75</b>	<b>6,253.99</b>	<b>6,837.60</b>	<b>1,072.60</b>	<b>12,588.96</b>	

Source : ME, 2012, Second National Communication on Climate Change

Sector Vulnerability Profiles and National Climate Change Adaptation Strategy (NCCAS) for Sri Lanka: 2011 – 2016<sup>71</sup>, developed by the Ministry of Environment in 2010 have identified the following five key sectors as the most vulnerable sectors in the country:

- Agriculture and Fisheries
- Water
- Health
- Urban Development, Human Settlements & Economic Infrastructure
- Biodiversity and Ecosystem Services

## 1.2 National Sustainable Development Strategies

The concept of sustainable development is not new to Sri Lanka, though the term itself has come into prominence only recently. The natural resource conservation had been an integral part of the ancient civilization and much evidence to this effect is available in ancient chronicles of Sri Lanka such as Mahawamsa<sup>118</sup>. Our ancestors have had a long tradition of living in harmony with nature in the course of harnessing natural resources for more than 2500 years.

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After the Rio summit in 1992, the Government of Sri Lanka began to follow a more focused and comprehensive policy towards sustainable development. The nation is committed to ensuring environmental sustainability by 2015 as part of its commitment to achieve the Millennium Development Goals. Realizing the need to strike a balance between environmental conservation and economic development, the Government of Sri Lanka in 2003, developed the National Environmental Policy with the vision “to achieve a healthy and pleasant environment sustaining nature for the well being of people and the economy”. The policy ensures a sound environmental management within a framework of sustainable development in the country and provides the direction for the necessary measures to conserve and manage Sri Lanka's environment and natural resources. Successive National Environmental Action Plans (NEAP), recently developed Climate Change Policy and National Strategies such as Haritha Lanka Action Plan, National Climate Change Adaptation Strategy and National Sustainable Development Strategy of Sri Lanka provide a broad environmental framework for sustainable development in the country.

Although Sri Lanka has made substantial progress in economic development over the past few decades, significant challenges to sustainable development still prevails. These challenges have been broadly identified as poverty, land degradation, realization of social well being, sustainability of water supply, sound ecosystem management and clean environment, energy security, heritage and culture and good governance.

Although overall population below the national poverty line has decreased over the last two decades from 26% (1993) to 8.9% (2009/10) along with the growth in per capita incomes, yet there are wide regional disparities within the country<sup>23</sup>. Further, poverty in the 7 poorest districts has increased during the last decade although national per capita income rose during this period;. The urban poverty has halved, and poverty in the estate sector increased 50%. Over half the population is below the minimum level of dietary energy consumption, and there is a higher prevalence of under nutrition in rural and estate sectors than in urban areas. Food security in terms of availability, accessibility and affordability is uncertain notably in the Plantation Estate sector.

The major environmental issues faced by Sri Lanka at present include land degradation, pollution and poor management of water resources, impacts of large scale deforestation in the past, loss of biological diversity due to unsustainable extraction of resources that exceed the recuperative capacities of ecosystems and species, air pollution, declining availability of fresh water, coastal erosion, degradation of marine and coastal habitats, inadequate facilities for solid waste disposal in urban areas, traffic congestion in the main cities, and increasing loss of agricultural productivity<sup>110</sup>.

At the same time, Sri Lanka needs to accelerate economic growth in order to meet the rising expectations of a growing population, of which is still below the poverty line<sup>6</sup>, and on the other hand, there is a need to be judicious in resource use in view of the alarming rate at which the resource base is being depleted.

The Sri Lanka Strategy for Sustainable Development (SLSSD) which was developed by the Ministry of Environment and Natural Resources in 2007<sup>111</sup> aims to meet the country's various development needs as well as its development challenges, and to mainstream environmental considerations in policy-making and policy implementation. According to SLSSD, Sri Lanka's vision for sustainable development is “Achieving sustained economic growth that is socially equitable and ecologically sound, with peace and stability”.

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The SLSSD seeks to achieve this vision through eradication of poverty, ensuring competitiveness of the economy, improving social development, ensuring good governance, and a clean and healthy environment. These five goals prioritize the challenges that have to be addressed in the path to achieving sustainable development.

Following are the general strategies adopted in the path to sustainable development:

- i. Creating an economy for sustainable development.
- ii. Strengthening institutional structure for sustainable development.
- iii. Creating a policy framework for sustainable development.
- iv. Creating a regulatory framework for sustainable development.
- v. Creating a knowledge base for sustainable development.

The SLSSD recommended establishing an implementation mechanism known as the “National Council for Sustainable Development (NCSD)” through a Parliamentary Bill as a policy making, approving and monitoring body under the leadership of His Excellency the President of Sri Lanka. Based on this recommendation, The Cabinet of Ministers of the Government approved the decision to establish the National Council for Sustainable Development (NCSD) chaired by His Excellency the President of Sri Lanka in 2008 and to formulate the Haritha (Green) Lanka Programme. The Haritha (Green) Lanka Programme was thus developed in 2009 and it aims to mainstream the subject of “Environment” into the national development planning process in the country. The NCSD is responsible for overall management and coordination of the programme. Ministry of Environment acts as the Secretariat and the Ministry of Plan Implementation monitors progress of the programme.

### **1.3 National Climate Change Policies and Actions**

The UNFCCC defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over a comparable time period”<sup>124</sup>. Climate change has been heralded as a threat to the global society. It has become a subject of intense interest to public policy decision makers internationally. As a small island nation, Sri Lanka falls into the UNFCCC and IPCC's category of 'vulnerable' small island nations under serious threat from various climate change impacts, such as sea level rise and severe floods and droughts (UNFCCC 1992; IPCC 2001)<sup>50</sup>. These threats are considered to have significant negative consequences on various sectors within Sri Lanka (ME, 2011). Climate change puts extra burdens on the social and economic challenges that the poorest already face, emphasizing and increasing their vulnerabilities due to the dependence of their livelihoods on climate sensitive natural resources and their weak social protection structures. By directly eroding the resources that poor people depend on for their livelihoods, climate change makes it easier for people to fall into poverty and harder for the poorest to escape from it.

Sri Lanka, being a developing country in the tropical region with significant poor population, and located in a disaster prone region, is highly vulnerable to climate change in terms of physical as well as socio-economic impacts. Although Sri Lanka's GHG emissions are negligible compared to levels of developed or larger developing countries, analysis of past records in Sri Lanka have highlighted that air temperature in the island has been rising throughout the country during the last century with a temperature increase of 0.016°C per year between 1961 and 1990 whilst the highest increase of minimum temperature being about 2.0°C at Nuwara Eliya. Night time annual average temperatures have increased in a faster rate than that of the daytime, up to a maximum of 0.02 °C per year. Analysis of rainfall data reveals that the variability has been increasing in the past in most parts of the island resulting in water scarcities in the



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dry zone of Sri Lanka. Extreme weather events such as high intensity rainfall followed by flash floods and landslides, and extended dry periods resulting in water scarcity are now becoming common occurrences in the country.

Therefore urgent action towards implementing adaptive measures is imperative in order to build resilience of the country to enable facing the adverse impacts of climate change, while actively involving in the global efforts to minimize the greenhouse gas emissions within the framework of sustainable development. Sri Lanka has to address these challenges considering the global scenario of decreased financing for infrastructure development, increased volatility of energy markets, problems related to food security, trade, commerce and industrial development together with the climate change challenges.

As climate change is a complex issue requiring action by a varied group of stakeholders, lately the necessity of a national agenda to face this challenge has been well conceived. In this context, the Government of Sri Lanka has developed a policy framework on the basis of UNFCCC guidelines that addressed the need for the nation to engage in climate change mitigation and adaptation measures. This policy framework namely, “National Climate Change Policy for Sri Lanka” was developed in 2012 with a view to provide directions for all the stakeholders to address the adverse impacts of climate change efficiently and effectively.

### 1.3.1 The National Climate Change Policy of Sri Lanka

The national climate change policy is aimed at “mainstreaming climate change issues within the overall national effort towards sustainable development and it creates the conditions necessary to overcome the major gaps existing at present”. See the box for highlights of the National Policy.

THE NATIONAL CLIMATE CHANGE POLICY OF SRI LANKA	
Vision	: A future where climate change will have no adverse consequences on Sri Lanka.
Mission	: Addressing climate change issues locally while engaging in the global context.
Goal	: Adaptation to and mitigation of climate change impacts within the framework of sustainable development
Objectives:	
	o Sensitize and make aware the communities periodically on the country’s vulnerability to climate change.
	o Take adaptive measures to avoid/minimize adverse impacts of climate change to the people, their livelihoods and ecosystems.
	o Mitigate greenhouse gas emissions in the path of sustainable development.
	o Promote sustainable consumption and production.
	o Enhance knowledge on the multifaceted issues related to climate change in the society and build their capacity to make prudent choices in decision making.
	o Develop the country’s capacity to address the impacts of climate change effectively and efficiently.
	o Mainstream and integrate climate change issues in the national development process.

It is an essential pre-requisite to proceed from the present position the country is in now, as far as climate change is concerned. Success of such a national agenda would largely be determined by the effectiveness of measures taken to overcome the main gaps existing at present.

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### **1.3.2 Actions taken by Sri Lanka to counter Climate Change Impacts**

Since ratification of the UNFCCC in 1993, a number of actions has been taken by the Government of Sri Lanka towards complying with its obligations under the Convention<sup>36</sup>.

These actions include inter alia, Ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1993; Acceding the Kyoto Protocol (2002); Preparation of the Green House Gas (GHG) Inventory (1994); Preparation of the Initial National Communication on Climate Change (2000); Undertaking Research Studies on Climate Change; Establishment of the Centre for Climate Change Studies- CCCS (2001); National Capacity Self Assessment for the Implementation of the three Rio Conventions –NCSA (2004-2006); Establishment of Clean Development Mechanism (CDM) under the Kyoto Protocol; Establishment of the Sri Lanka Carbon Fund (2008); Establishment of the National Advisory Committee on Climate Change (2008); Establishment of the Climate Change Secretariat (2008), formulation of National Climate Change Policy for Sri Lanka (2011) and preparation of the National Climate Change Adaptation Strategy (2010).

In addition, issues related to climate change and ozone layer depletion has been integrated into the formal education system of the country by incorporating them in school curricula and some Universities offering separate modules on climate change in their environmental science streams. Government agencies having responsibilities of managing the environment, climate and allied fields have been conducting training and awareness programs in schools and Universities with the view to update the students on climate change and its impacts. The Air Resource Management Centre (Air Mac) of the Ministry of Environment is involved with conducting training programs for government officers, technical officers of Vocational Training Institutes and Automobile Engineering Training Institutes and technicians of garages on reduction of vehicular emissions *vis a vis* control of GHG emission.

The GEF Enabling Activity (Phase II) Project, Strengthening Capacity for Climate Change Adaptation Project, Capacity Development of Clean Development Project Promotion in Sri Lanka, Preparation of Second National Communication on Climate Change Project, are some of the significant project interventions in the recent past through which institutional capacity of respective agencies has been strengthened to enable complying with the national obligations of the Climate Change Convention. As the need for information exchange has been recognized as a priority, actions towards networking of climate change related institutions in the country are in the process of development.

### **1.3.3 Goals of National Climate Change Adaptation Strategy for Sri Lanka (NCCAS)**

Although Sri Lanka's contribution to global warming is insignificant, its vulnerability to climate change appears to be very high. Hence, Sri Lanka has recognized the need for climate change adaptation in order to achieve its economic development goals as articulated in the Mahinda Chintana policy framework while ensuring environmental sustainability. In view of this, the Ministry of Environment in 2010 developed the National Climate Change Adaptation Strategy (NCCAS) defining a prioritized framework for action and an investment plan for the period 2011- 2016 with the overall goal of systematically moving the country towards a climate change resilient future. In order to achieve this goal NCCAS has identified the following strategic thrust areas for action.

- Mainstream Climate Change Adaptation into National Planning and Development
- Enable Climate Resilient and Healthy Human Settlements
- Minimize Climate Change Impacts on Food Security

- 
- Improve Climate Resilience of Key Economic Drivers
  - Safeguard Natural Resources and Biodiversity from Climate Change Impacts

#### **1.4 Objectives of the Technology Needs Assessment (TNA)**

The Technology Needs Assessment is carried out to identify potential measures and practices that would be implemented in different sectors of a country to reduce GHG emissions and vulnerability to climate change and to contribute to overall development goals. It provides multiple benefits at the country level, including the identification of barriers for deployment and diffusion of technologies and facilitate in removing any policy and legal gaps leading to improvement of enabling environments, increasing the capacity of local institutions and experts, and raising public awareness of climate change issues.

The main objective of the Climate Change Technology Needs Assessment is to *identify and assess environmentally sound technologies that have synergy between reducing the impact of climate change and the rate of GHG emissions in Sri Lanka within national development objectives*. The TNA represents a set of country driven activities that identify and determine the most appropriate mitigation and adaptation priority technologies for Sri Lanka. By adopting a consultative process, it identifies the barriers to technology transfer and measures to address these barriers through a sectoral analysis.

The Specific Objectives of the TNA are to;

- a. Define priority sectors for which technologies are needed to sustain national development projects and programmes in light of the UNFCCC and potential impacts of climate change.
- b. Identify suitable technologies that contribute to climate change adaptation in the relevant sectors.
- c. Prioritize the identified technologies, their cost-effectiveness, and barriers to implementation.
- d. Develop an enabling framework for deployment and diffusion of prioritized technologies for relevant sectors.
- e. Develop project proposals for priority technologies for relevant sectors to enable mobilizing resources for implementation of the programme.

#### **1.5 TNA Relevance to National Development Priorities**

In the recent years, the population pressure has brought in wide range of environmental problems in Sri Lanka. Land degradation, pollution and poor management of water resources, impacts of past large scale deforestation, loss of biological diversity, coastal erosion, increasing scarcity of water for agriculture, inadequate facilities for waste disposal in urban areas, wide range of issues in the transport sector and increasing loss of agricultural productivity are some of such major issues faced with. Besides these environmental issues, inequalities in income distribution and access to essential services in different districts, in increasing income disparities and malnutrition are the significant economic and social challenges prevalent at present<sup>12</sup>.

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In spite of these challenges, Sri Lanka has already made an impressive progress towards meeting the Millennium Development Goals in key areas of human development such as education and health. Being a developing country, graduating to the middle income country status it is remarkable achievement despite the severe social and economic setbacks of the 2004 Asian Tsunami and long years of civil conflict.

The Government's new National Development Framework ("*Mahinda Chintana: Idiri Dakma*" - Vision for a New Sri Lanka, (2010) aims at accelerating growth, with particular emphasis on equitable development, recognizing that there has been a perpetuation of income disparities both among income earners and across geographic regions. It focuses on three main areas: (i) achieving more equitable development through accelerated rural development; (ii) accelerating growth through increased investment in infrastructure; and (iii) strengthening public service delivery.

In view of this, Sri Lanka needs to accelerate economic growth in order to meet the rising expectations of a growing population, about a quarter of which is still below the poverty line. Therefore, a sustainable high level of economic growth must be ensured without causing irreversible damage to the environment. The country's national development framework and SLSSD seeks to achieve this vision through eradication of poverty, ensuring competitiveness of the economy, improving social development, ensuring good governance, and a clean and healthy environment.

Simultaneously, the TNA aims to reduce GHG emissions and vulnerability to climate change in priority sectors of Sri Lanka and to contribute to overall national development goals. It provides multiple benefits at the country level, including the identification of barriers for deployment and diffusion of technologies and facilitate in removing of policy and legal gaps leading to improvement of enabling environments, increasing the capacity of local institutions and experts, and raising public awareness of climate change issues.

The TNA process starts with an identification of a country's development and sustainability priorities with particular attention to GHG emission reduction potentials and adaptation needs in the context of the appropriate country scenarios on climate change. The priority sectors and technologies are identified on the basis of the GHG emission reduction potential, contribution from low carbon technology investments and vulnerability to climate change impacts. Accordingly, five (05) priority sectors have been identified for climate change adaptation. These sectors are; **Food, Health, Water, Coastal Resources and Biodiversity.**

Two main objectives expected from the TNA process:

- To meet Sri Lanka's national development priorities, and
- To maximize the sustainability outcomes of the country, particularly through GHG emission reduction and protection against projected climate change damage.

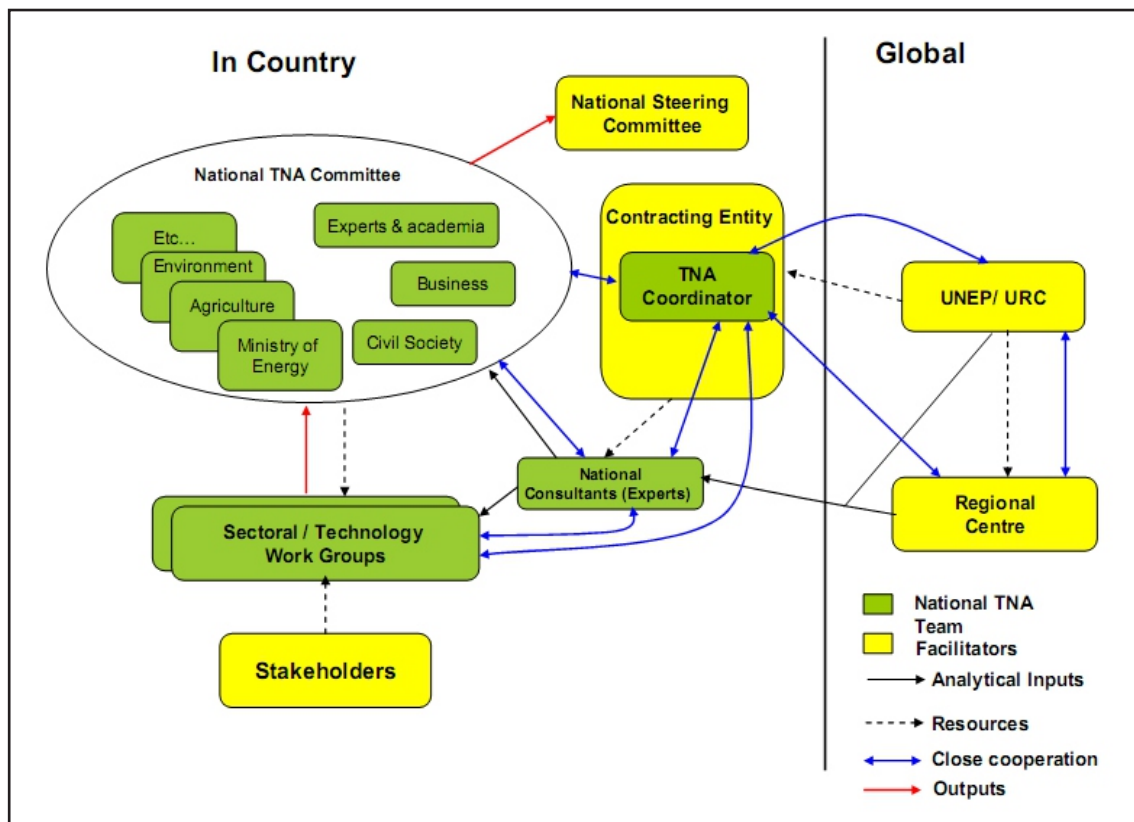


## CHAPTER 2

### Institutional arrangements for the TNA and the stakeholder involvement

#### 2.1 Institutional arrangements

The Sri Lankan TNA has followed the guidelines from the UNDP/UNFCCC Handbook for Conducting Technology Needs Assessments for Climate Change (November 2010), Handbook for Conducting Technology Needs Assessments for Climate Change (2009) and Organizing the National TNA Process: An Explanatory Note, 2010<sup>16</sup>. Overview of the institutional arrangements involved in the TNA process proposed by UNDP/UNFCCC Handbook for Conducting Technology Needs Assessments for Climate Change is shown in Figure 2.1.



**Figure 2.1 Institutional Arrangements for the TNA Project**

Based on the guidelines proposed by the UNDP/UNFCCC Handbook, following initial steps were taken in forming institutional arrangements for the implementation of the TNA project:

- Identification and establishing the lead agency for TNA project implementation.
- Exploring objectives and scope of the Project through a consultation meeting.
- Identification of relevant stakeholder agencies and personnel for the TNA Committee.
- Identification of a core team involving the lead technical institutions and representing participants, and other technical experts for all the sectors.

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- Appointment of the TNA Coordinator and National Consultants.
  - Define a process for stake holder consultation by establishing the TNA committee and Technical Sectoral Stakeholder Working Groups for all the priority sectors.

The **Ministry of Environment (ME)** being the focal point for UNFCCC and Kyoto Protocol was designated as the lead agency responsible for the TNA process. **The National TNA Team** comprised of the inter-ministerial **National TNA Committee, Project Coordinator, National Consultants** and **Sectoral Technical Working Groups**. The “National Advisory Committee on Climate Change”, the highest level multi-stakeholder decision making body of the Ministry of Environment, functioned as the **National Steering Committee** for the Project. This Committee comprised of senior officers from all relevant line Ministries, members from Non-Governmental Organizations and the private sector.

**TNA Committee:** The TNA Committee that included senior representatives from relevant Ministries led the TNA process. The Committee chaired by the Secretary of the Ministry of Environment comprised of 21 members. (*List of members of the National TNA committee is provided in Annex I*). The composition of the National TNA team remained flexible to enable including any other members as required during the TNA process. Members of the National TNA Committee were those who are familiar with national development objectives and sector policies, overall insights of climate change, and potential climate change impacts and adaptation needs for Sri Lanka. This National TNA committee functioned as a Task Force overseeing the TNA process and it provided the leadership for project implementation. As agreed at the initial TNA meeting, the specific responsibilities of the TNA committee included the following;

1. Identify national development priorities and priority sectors for the Technology Need Assessment.
2. Decide on composition and constitution of sectoral technical workgroups.
3. Review and approve technologies and strategies for mitigation and adaptation as recommended by sectoral workgroups.
4. Review and approve the TNA Report, Report on Barrier Analysis and Enabling Framework (including a roadmap of policies that will be required for removing barriers and creating the enabling environment), and National Technology Action Plan for mitigation and adaptation and Project ideas for all sectors.

**The Project Coordinator:** A senior officer attached to the Climate Change Secretariat with adequate scientific background, facilitation skills and familiar with the climate change negotiations and activities functioned as the Project Coordinator who was vested with the responsibility of managing the overall TNA process while providing vision and leadership for the overall exercise as the focal point. This included facilitation of communication with the National TNA Committee and Consultants, coordination and communication with sectoral technical working groups and stakeholders, recruitment and coordination with Consultants, formation of networks, information acquisition, preparation of Work Plans and monitoring of the progress of the Project etc. Facilitation of TNA activities including administrative support, organization of TNA Committee meetings, organization of technical stakeholder working group meetings and workshops as well as implementation of the Work Plan of the Project was through the Project Secretariat under directions of the TNA Coordinator.

**National Consultants:** A Team of five (05) national experts and a Team Leader provided the required technical expertise for the adaptation component of the Project. The responsibility of each expert included identification and prioritization of technologies, carryout barrier analysis, enabling framework & market assessment and preparation of draft Technology Action Plans (TAP) & draft project ideas for



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their respective area of expertise. The Team Leader functioned under the overall guidance of the TNA Committee and the Project Coordinator. The responsibility of the Team Leader included providing overall guidance to sector experts, preparation of that consolidated Technology Needs Assessment (TNA) reports for Mitigation and Adaptation.

**Sectoral Technical Working Groups:** Functioning of Sectoral Technical Working Groups is discussed under the section on “Stakeholder Engagement Process”.

## 2.2 Stakeholder Engagement Process

The stakeholder involvement has been considered very crucial to the TNA process as it reflects national response to climate change technology, and implementation of activities at all levels. In order to ensure widest possible stakeholder participation in the TNA process, five (05) technical stakeholder working groups were established on sectoral basis. These stakeholder working groups represent Food, Health, Water, Coastal Resources and Biodiversity Sectors. The stakeholders for the technical working groups have been identified from the relevant organizations and institutions as recommended by the UNDP/UNFCCC Handbook (2010). The stakeholders in the working groups included representatives of the Government departments with responsibility for policy formulation & regulation, private & public sector industries, technology distributors, users & suppliers, organizations involved in the manufacture, import & sale of technologies and other relevant institutions such as universities, research organizations & relevant NGOs. The Sector Working Groups were mandated with the responsibility of taking decisions with regard to the technologies appropriate for respective sectors, undertake barrier analysis, market assessment and enabling framework for relevant sectors, and contribute to development of TAP and project ideas.

As recommended by the UNDP/UNFCCC Handbook, following steps have been followed in the stakeholder involvement process;

- Identification of stakeholders for sectoral working groups.
- Defining the goals and objectives of working groups.
- Clarification of stakeholder roles.
- Establishment of an ongoing process for stakeholder engagement.
- Involvement of stakeholders in each stage of the process.

The goals, objectives and the working arrangements of the participatory process was discussed and agreed with all sectoral stakeholder working groups at the **National Inception Workshop**. This consultation also included defining objective of the TNA Project and purpose of stakeholder participation. The main purpose of the stakeholder participation is to get their involvement throughout the TNA process for selecting priority sectors, technology identification and prioritization, barrier analysis, market mapping and development of enabling framework, Technology Action Plans (TAPs), project ideas etc, as they will be intimately involved in implementation of recommended technologies. Therefore, an ongoing arrangement has been established to get continuous and adequate involvement of stakeholders at each stage of the TNA process.

Each sectoral stakeholder working group included around 15-20 persons representing related organizations in the respective sectors. The compositions of the sectoral working groups were flexible with the provision for including additional members depending on the requirement. The Project Coordinator together with the consultants facilitated the sectoral working group discussions ensuring



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maximum output from the deliberations. *(The compositions of the Sectoral Technical Stakeholder Working Groups are provided in Annex II).*

# CHAPTER 3

## Sector Prioritization

### 3.1 Development Priorities and Overview of Priority Sectors

The sector prioritization process for adaptation started from identification of development and sustainability priorities of Sri Lanka, with particular attention to vulnerability of different sectors to climate change. The following are the main criteria adopted for selecting and prioritizing sectors for the climate change adaptation;

- Contribution to the development priorities of the country.
- Contribution to minimize vulnerability to climate change.
- The market potential.
- Access to/availability of technologies in the sector.
- Other criteria as appropriate to national circumstance

The Development Policy Framework of the Government of Sri Lanka – “Sri Lanka Emerging Wonder of Asia: *Mahinda Chintana* – Vision for the Future” – presents Sri Lanka's economic policy strategies, actions and the roadmap for the next six years<sup>13</sup>.

The economic development philosophy of *Mahinda Chintana* is that economic growth alone would not bring prosperity to the society but social, cultural, religious and environmental development are equally important. The development goals of the Government will be achieved by transforming the country to a modern, knowledge-based, environmentally friendly and well connected rural-urban network that benefits all citizens of the country through equitable access to development<sup>5</sup>.

The main strategies as stated in this policy framework are;

- A Prosperous Country: A Land of Plenty
- Enterprises with Strength to Conquer the World
- Developed Road Network and Transport System
- Focus on Modern Education and Knowledge Systems
- A Healthy Society
- Comforts, Convenience and Satisfactory Lifestyle
- Shared Values and Rapid Development

The development priorities identified based on the above strategic directions in the policy framework are as follows;

- Agriculture: feeding the nation
- Fisheries and Aquatic resources
- Self reliance in Livestock industry
- Irrigation: Water is our heritage and Life and
- Water services Perspective
- Healthy Society
- Housing for All – Prosperous and healthy Lifestyle

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- Environment
  - Modern Education and Knowledge Systems
  - A Modern Economy Through Science and Technological Innovations
  - Electricity for everybody, everyday
  - Industry sector: Towards Global Competitiveness
  - Developed Road Network and Transport System

Climate change vulnerabilities cut across many sectors in the economy, and threaten to compromise the significant achievements the country has recorded in the last 20 years in increasing incomes and reducing poverty, as well as country's ongoing development drive. Investments currently being deployed for the development efforts are also at risk due to climate change. The sector vulnerability profiles developed for Sri Lanka in 2010 has identified following sectors where climate vulnerabilities are expected to be critical. These sectors include;

- a) Agriculture and Fisheries
- b) Water
- c) Health
- d) Urban Development, Human Settlements & Economic Infrastructure
- e) Biodiversity and Ecosystem Services

The overview of the relevant key sectors is given below;

#### **a) Agriculture and Fisheries Sectors**

Agriculture plays a major role in the economy as source of income for the majority of rural poor, source of national growth, provider of opportunities for private investment, and a driver of agriculture related industries. In 2010, the agriculture sector contributed 11.90% to the national GDP<sup>13</sup>. The sector provided direct employment to 31.3% of the total labor force in 2009. Furthermore, it is estimated that the agriculture-related activities provide the major source of employment and livelihood for nearly 72% of the Sri Lankan population. In national income statistics, agriculture is defined as including crop production, animal husbandry, fisheries and forestry. The contribution to the GDP from agriculture sector comes predominantly from crop production which accounted for 77% in 2010. In comparison, the contributions from livestock, forestry and fisheries sectors were 7.1%, 5.7% and 10.5% respectively<sup>47</sup>

In view of the increasing demand for fishery products, and potential for income diversification and increasing utilization capacity of scarcely used or degraded lands, aquaculture has emerged as one of the key strategic sectors. Reservoir based fresh water fishery provides significant contribution to food and nutritional security of the rural areas of the country. With the development of inland fishery, per-capita fish consumption in the land-locked regions such as Anuradhapura and Polonnaruwa districts has exceeded the average national per-capita fish consumption. This has been primarily achieved especially through culture-based fishery (CBF) in medium size perennial reservoirs and small village tanks.

#### **b) Water Sector**

In Sri Lanka there are 103 distinct natural river basins that cover approximately 90% of the island. River basins originating from the wetter parts of the up country are perennial while many of those in the dry zone are seasonal. According to the Agrarian Services Act No. 58 of 1979, tanks having an irrigated command area of less than 80 ha (1 ha = 2.47 acres) are categorized as small or minor tanks. More than

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90 percent of the small tank systems are clustered into cascades and these tank network systems have been built in water scarce areas by ancient kings mainly for agricultural purposes.

Water is mainly used for domestic, irrigation, hydropower generation and industrial purposes. Protected wells, deep & tube wells, protected springs and pipe borne municipal supplies are considered as safe drinking water sources and water from unprotected wells, rivers, tanks and canals are considered as unsafe. According to Mahinda Chinthanaya policy framework, 90% of people will have access to safe drinking water by year 2016. It further envisages 100% of urban population, 90% of rural population and 80% of estate sector to have access to safe drinking water by year 2016.

### **c) Health Sector**

In general, the Health sector has a well established preventive and curative care network throughout the country despite the fact that there are differences between the different geographical areas, especially with regard to the adequacy of human resources in the public health service sector. Although the public hospitals are satisfactorily equipped to provide communicable disease prevention services, their impact in controlling such diseases appear to be minimal.

There are 1,042 Government hospitals in the country with 13,280 doctors and 26,629 nurses and other related staff<sup>81</sup>. In addition there are 147 Private Hospitals mainly in urban centers. There are 316 Medical Offices of Health areas in the island. The preventive care services provided by the public health officials include Maternal and Child health, immunization, nutrition supplementation, health education, sanitation, communicable disease prevention and many other related services.

Many communicable diseases are under control and diseases such as Malaria and Japanese Encephalitis are almost eradicated. However, recently Dengue has achieved an epidemic level resulting nearly 20,000 persons been affected in 2011 out of which 155 have died of complications due to dengue. The main reason is irregular precipitation pattern and collection of clean water in an around the human dwellings. Therefore, climate change and related extreme weather events are likely to have both direct and indirect impacts on health of the people.

### **d) Biodiversity and Ecosystem Services**

Sri Lanka has a varied climate and topography, which has resulted in rich biodiversity, distributed within a wide range of ecosystems. The biodiversity of the country is recognized as being globally important. Sri Lanka along with the Western Ghats of India has been identified as one of the 34 biodiversity hotspots in the world<sup>84</sup>. Biodiversity provides a multitude of ecosystem goods and services to people of the island, including watershed services, regulation of climate, carbon sequestration and supply of non-timber forest products such as rattan, wild foods, fruits, medicinal plants etc., among many others.

The biggest threats to the Protected Area System and biodiversity in general come from encroachments, conversion of critical ecosystems into other land uses, illegal extraction of natural resources, shifting cultivation, forest fires, haphazard development projects, poaching, pollution, gem mining, siltation and sedimentation in coastal and marine ecosystems, sewage and solid waste disposal, development of aquaculture and illegal sand/coral mining. However, it is estimated that about 15% of the islands forests and scrublands lie within the country's Protected Area (PA) system<sup>79</sup>, while some marine protected areas have also been set up in addition to these terrestrial areas.

The Sector Vulnerability Profile (SVP) for the biodiversity sector (which is a supplementary document to Sri Lanka's National Climate Change Adaptation Policy) has looked at the impact of climate change on this sector. It states that, as an island nation, Sri Lanka is vulnerable to the risk of sea level rise and increased frequency of storms that can bring major impacts on coastal biodiversity. Further, analysis of climate data indicates a change in rainfall regimes, and a trend of increasing air temperature, which can also have impacts on the country's biodiversity.

### 3.2 Process and Criteria of Sector Prioritization

In the process of prioritizing the sectors, the development and sustainability priorities, potential for applying adaptation technologies and their vulnerability to climate change were deliberated with the stakeholder groups and the TNA committee.

The steps undertaken by the stakeholders for prioritization of sectors are summarized in Table 3.1. The list of the stakeholders participated in the deliberations is provided in Annex II.

**Table 3.1: Strategic Choice of Priority Sectors for Adaptation**

Steps	Description	Development Priorities <sup>(Step 1)</sup> / Most Vulnerable Sector <sup>(Step 2)</sup> / Prioritized Sectors <sup>(Step 3)</sup>
Step 1	Identifying Development Priorities	Agriculture, Fisheries & Aquatic resources, Livestock development, Water, Healthy Society, Housing for all, Healthy Lifestyle, Environment, Education and Knowledge Systems, Modern Economy Through Science and Technological Innovations, Electricity for everybody, Industry sector: Towards Global Competitiveness, Developed Road Network and Transport System
Step 2	Identification of Sectors with high vulnerability to climate change (Identification was primarily based on the Sector Vulnerability Profiles) <sup>47</sup>	Agriculture & Fisheries, Water, Health, Urban Development, Human Settlement & Economic Infrastructure and Biodiversity & Ecosystem Services <sup>9</sup> (Ref: Sector Vulnerability Profiles)
Step 3	Prioritizing sectors in terms of development priorities, and vulnerability to climate change	Food, Health, Water, Coastal Resources and Biodiversity Sectors.

Accordingly, five (05) priority sectors are identified in the context of the national development priorities identified in the policy framework “Mahinda Chintana–Vision for the Future” vis-a-vis sustainable development goals of Sri Lanka, vulnerability of potential sectors to climate change based on the vulnerability profiles,. In view of its cross sectoral significance to fisheries and biodiversity, coastal sector was selected although it has not been recognized as highly vulnerable to climate change in the sector vulnerability profiles. The sectors thus prioritized and subsequently endorsed by the National TNA committee are;

- Food
- Health
- Water
- Coastal
- Bio diversity

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### 3.3 Current status of technologies in the Food Sector

Technological advancements and utilization of improved technologies is strong in certain areas such as genetic improvement of crop species, particularly rice and in pest & disease control. Scientific methods of crop protection and integrated pest management technologies have been made popular through farmer education by the national extension service. Furthermore, Sri Lanka is widely known for development and operation of integrated irrigation systems based on water harvesting in man-made reservoirs and by river diversions.

However, further development of technologies for improved efficiency in irrigation water management is an urgent need. Other high priority areas for climate change adaptation in the food sector include conservation & management of land & water resources, preserving the genetic resilience of crop varieties & animal breeds, strengthening the resilience of inland aquaculture and development of more-resilient varieties of crops to counter adverse effects of climate change.

Some of the technologies used at present in the Food Sector of Sri Lanka are as follows;

- Plant and animal breeding
- Pest and disease control including promotion of bio-pesticides and integrated pest management
- Promoting precision farming and traditional varieties of crops
- Conservation of plant and animal genetic resources
- Conservation of crop wild relatives
- Ex-situ conservation of plant genetic resources
- Surface water harvesting
- Soil and water conservation
- Reduction of land degradation in agriculture areas
- Protecting agriculture from alien and invasive species
- Promoting quality seeds and planting material
- Promotion of organic and bio-fertilizers
- Promotion of organic farming
- Development and improvement of post harvest technologies
- Irrigation and water management
- Promotion of inland aqua culture

**Note on Technology Selection for the present TNA:** Prioritization of adaptation technologies in the food sector has been done with the primary concern of sustaining the current levels of food production from the ill effects of Climate Change in the short to medium term. The other important consideration was the cost of technology. Despite the fact that these selected technologies have been in existence for some time and requires minimal financial inputs for implementation, such technologies have not been utilized to their full potential due to various operational/institutional constraints i.e. precision farming and traditional varieties of crops; soil and water conservation.

The short and medium term technologies which are proven and readily available, but not fully utilized at present were selected whereas, some of the newer technologies that are costly i.e. solar-powered drip irrigation solutions and technologies taking a longer period to produce results such as development new varieties, breeding of new animals were not selected.

### 3.4 Current status of technologies in the Health Sector

There are many issues related to the application of the available technologies and such issues impede achievement of the expected outcomes in times of need. Some of the issues are purely financial and some are non-financial, and still some others are both financial and non-financial. However, the main issue is that the adverse health effects of climate change are not yet perceived as a priority in the health sector. The current focus is on disasters and emergencies. Therefore, the resources including financial as

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well as non-financial, such as equipment, human resources, training, are provided when there is a disaster or an emergency. In addition, technologies are expensive and acquisition and sustainability of such technologies are not feasible. There is an acute shortage of qualified trainers and the attitude of health personnel is also not conducive towards climate change adaptation activities. A paradigm shift in approach at the top policy making level and subsequent diffusion down to the grass root level shall make a difference over time. A brief description of technologies implemented by the health sector in Sri Lanka is given below.

- Transfer of knowledge & skills to Preventive & Hospital Health care workers.
- Mobile services including, Clinical, laboratory, water quality surveillance, in times of extreme events.
- Disease prevention activities including surveillance (active & passive), identification of cases, isolation, vector monitoring, health education, food sanitation/waste management. Immunization, prophylactic measures.
- Early warning on communicable diseases. Active collection of data, implementation of outbreak control mechanisms. Supported by Ministry of Health and World Health Organization.
- Development of National Climate change Adaptation Strategy for Sri Lanka (2010-2016) with an objective of Enabling Climate Resilient & Healthy Human Settlements. The interventions are directed at 1) Mobilization of stakeholders for climate change adaptation of settlements 2) Improve planning to include climate change considerations 3) ensure adequate quality and quantity of water for settlements 4) Combat climate change-related health concerns in settlements 5) Increase awareness on vulnerabilities and adaptation of settlements.

**Note on Technology Selection for the present TNA:** It is noteworthy that all three technologies prioritized in the Health Sector are not new technologies. A minimal to substantial instigation has been accomplished in all three prioritized technologies in the country since the Asian tsunami and even before. Frequent explosions occurring in many populated areas and during rush hours in the urban and sub-urban areas have prompted the government to take precautionary actions by establishing an entity to train personnel from different sectors as early as 1995. The training included basic four phases of a disaster and how to prepare plans, report writing etc. The emphasis was on natural disasters like floods, cyclones, landslides, epidemics and droughts etc. The accidents and events such as lightning, animal attacks and tsunami were not included.

There is a well established early warning system throughout the island for early detection of communicable diseases, where the information from the periphery is relayed to the Epidemiology Unit of the Ministry of Health for necessary follow up actions to contain the disease. Health Care Waste Management is done in a prescribed way in larger institutions, especially large public and private hospitals in urban areas.

Current inputs for *Transfer of knowledge and skills to Health Personnel* are satisfactory though it is not substantial. While the main focus is on Emergency/Disaster management, some training is being provided for hospital workers and preventive health staff. However, absence of proper cohesion between the two groups real life situation sometimes become chaotic. There is little or no emphasis on the effects on human health due to climate change. There is also an acute shortage of trainers and absence of measures to retain the available personnel.

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Considerable technological inputs are being made available for *Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events*. However, the main emphasis is on Emergencies/Disasters only. The emphasis on health related climate change issues are not adequately addressed. Networking between principal stakeholders is lacking. There is no focal point or structure available in the Ministry of Health to address climate change related issues. Lacks regular information exchange is resulting poor awareness and knowledge at all levels from policy makers to general public.

In view of the above, *“Transfer of knowledge and skills to Health Personnel”* and *“Early Warning Systems”* have been identified as potential technologies for the sector.

### 3.5 Current status of technologies in the Water Sector

Following are the currently used adaptation technologies in the water sector;

- Diversification of water supply through rainwater harvesting from rooftops for drinking and household uses,
- Restoration of minor tank networks (cascade systems)
- Harvesting of surface runoff – unlined ponds and lined ponds
- Tube wells and Boreholes
- Major tanks
- Wells
- Desalination of brackish water by reverse osmosis

**Note on Technology Selection for the present TNA:** Most of the above technologies have been selected as potential technologies to be considered for the water sector. Although most of the technologies have been in use in the past, they have not yielded satisfactory results due to multifaceted issues. All the three technologies prioritized in the Water Sector have been implemented in Sri Lanka since time immemorial.

The tradition of management, repair and maintenance of minor tank systems by farmers has been in existence for nearly 1500 years. Considering the importance of rural development in the Dry Zone, there have been numerous small tank rehabilitation projects and efforts, but most of them have achieved poor results as such work has been focused on individual tanks without considering the cascade hydrology. For example, ad hoc raising of bunds and spillways of minor tanks in recent development programs has seriously disrupted the delicately balanced hydrology between the respective tanks within a cascade.

There are no public health regulations for construction, maintenance and testing the quality of water collected in Rainwater harvesting systems in Sri Lanka. As a result, collection of domestic roof top rain water for drinking has caused direct health concerns due to biological and chemical contamination and indirect health issue due to disease causing insect vector breeding in the tanks. Many roof top rain water harvesting systems in Sri Lanka have become failures due to lack of proper maintenance.

Most of the boreholes have been installed in the past without giving due consideration to major factors affecting their sustainability. It is estimated that 40% of the tube wells constructed in the last decade are abandoned due to contamination with iron/ manganese/ fluorides. Contamination of ground water due to bacteria, NO<sub>3</sub><sup>-</sup> and salt intrusion also has been reported. Therefore, the adaptation technologies proposed will also explore measures to overcome such issues and problems.



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### 3.6 Current status of technologies in the Coastal Sector

In coastal management in the country both “hard” and “soft” structural solutions are applied depending on the level of vulnerability and level of protection required. They are applied separately or in combination, depending on the specific conditions of the site.

Hard defences are the traditional approach to coastal defence. It utilises structures which provide a solid barrier between the land and sea and resist the energy of the tides and waves, thus preventing any land/sea interaction. Examples of hard defences include seawalls, sea dikes, revetments, armour units and breakwaters. Hard defences such as dikes & revetments are used in Sri Lanka to protect certain coastal belts which are severely affected by coastal erosion (e.g Hikkaduwa of Southern Sri Lanka) and break waters are the commonly used structures in harbours and coastal cities which needs protection from wave action, storm surges and inundation (harbours in Colombo, Galle & Hambantota and cities of Colombo & Galle are the best examples). Although hard defense mechanisms provide quick solutions against coastal erosion and inundation, they can impede the recreational use of beaches and are costly to construct and maintain. In addition, hard structures do not protect the natural beauty of the coastal environment and they change the natural balance of coastal ecosystems.

On the other hand the soft defences have not been widely used or non-existent as defence mechanisms against coastal erosion, although they need less financial inputs when compared to construction of hard structures. Mangrove replanting programmes in areas where mangrove habitats have been destroyed due to establishment of prawn farms have shown that it is the best possible method to protect and stabilize the coastal belts adjacent to lagoons and estuaries. The coastal habitat restoration studies carried out after 2004 tsunami event have proved that coral transplanting could be implemented for restoration of reefs which have been degraded due to natural phenomena such as *El Nino* and anthropogenic activities such as coral mining and destructive fishing practices. Furthermore, it was evident that the coastal belts of south eastern coast (Hambanthota) where the sand dune vegetation is not disturbed by anthropogenic activities suffered no damage or less damage during the 2004 tsunami incident. Underwater observations before and after tsunami incident in the southern coastal belt (Weligama) indicated that sea grass beds suffered very little or no damage during tsunami.

**Note on Technology Selection for the present TNA:** Rehabilitation of sand dunes and restoration of mangrove vegetation are not new technologies for Sri Lanka. These technologies have existed over last several decades in small scale and more emphasis have been provided after 2004 tsunami disaster. Currently, rehabilitation of sand dunes involves planting Whistling Pine (*Casuarina equisetifolia*), which was proved to be a failure during tsunami in 2004 as these plantations could not offer adequate protection to coastal infrastructure. The programme under the present TNA proposes to select economically important plants (medicinal plants, *Pandanus* sp. etc.) which are more sites specific and to plant with community participation in order to uplift the socio-economic status of the coastal communities, while encouraging them to deviate from unsustainable sand dune destructive activities.

At present, mangrove rehabilitation is a widely practiced activity, but planting mangrove vegetation is done in a very haphazard manner. The mangrove replanting programs are carried out without a proper zonal plans and the natural propagation of mangrove plants. In certain places, plants are being selected for replanting without considering the natural biodiversity and composition. Therefore, this proposal suggests that mangrove replanting should be carried out by preparing zonal plans by giving due consideration to the diversity and composition of the mangrove communities existed prior to destruction. In addition to the replanting programmes, community should be provided with some

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training to use the mangroves for economic activities/cottage industries, and nature tourism in a sustainable manner.

### **3.7 Current status of technologies in the Biodiversity sector**

The current technologies adopted in the biodiversity sector are summarized below:

- Restoration of degraded areas inside and outside the protected area network through aided natural restoration, agro-forestry, analogue forestry as appropriate to enhance resilience and monitoring of such restored areas.
- Increasing connectivity through corridors, landscape/matrix improvement and management by establishing forest corridors, corridors/linkages in aquatic environments (fish ladders,). Strengthening management of corridors, and promoting environmentally friendly land uses to facilitate connectivity.
- Managing and monitoring invasive alien species (IAS) by methods such as creating awareness on IAS, eradication or minimizing identified invasive species, prevention by enforcing legislation such as quarantine & imports related legislation and monitoring programs.
- Reducing other stresses on species and ecosystems such as, minimizing pollution of air water& soil, removing encroachments, stop illegal logging/clearing, prevent habitat fragmentation, prevent over exploitation of aquatic & terrestrial species, and stop poaching and enforcement of laws.
- Adaptive management and monitoring programs of species and ecosystems. ie, fieldwork and research to identify on the ground changes, monitoring the effectiveness of management techniques.
- Improve management, and increase extent of protected areas, buffer zones and create new areas in vulnerable zones. ie, creating management plans and its implementation, capacity building of relevant authorities, monitoring conservation activities, identifying areas to establish new protected areas, zoning protected areas.
- Focus conservation resources and carryout special management for restricted ranges, highly threatened species and ecosystems. ie, use red list to identify critical species, species management plans for highly threatened/critical species, monitoring of threatened species, in situ conservation programs targeted at species, habitat enrichment, re-introduction of species, ex-situ conservation etc.
- Reviewing and modifying existing laws, regulations, and policies relating to biodiversity and natural resources management and incorporating climate change adaptation considerations (ensuring implementation).
- Ex-situ conservation for highly threatened species and possible reintroduction through, improving the status of zoological and botanical gardens, establishment of seed banks with a focus on endemic and threatened species, plant propagation etc.

Note on Technology Selection for the present TNA: The proposed technologies are not entirely new to Sri Lanka and most of those technologies are being implemented by the Department of Wildlife Conservation and Forest Department for several decades. In most cases they have been implemented in isolated pockets of forests or protected areas, and community participation in planning and implementation has been very minimal. As a result most of these programmes were not successful. i.e, Restoration of degraded areas is a programme annually implemented in the past, however, in most cases appropriate tree species have not been selected, and community participation had been very marginal in such programmes. Moreover, some of the existing technologies are yet to be implemented

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in a comprehensive manner as relevant to the climate change and for biodiversity adaptation.

Some of those technologies, which are considered 'existing' technologies have been chosen for following reasons:

- The selection of technologies is based on a comprehensive literature review that included international peer reviewed journal articles, international books and current publications.
- The technologies selected is based on their appropriateness irrespective of whether they are 'new' or already in use.

# CHAPTER 4

## Food Sector

### 4.1 Overview of the Food Sector

Food sector which includes agriculture (Rice, Fruits & Vegetables, Other Field Crops, Sugar Cane, Tea, Coconut, Export Agricultural Crops etc.), Livestock (Dairy, Poultry etc.) and Fishery. It is one of the most important sectors of the economy and the most vulnerable sectors to climate change impacts in Sri Lanka<sup>72</sup>. Changing climatic and weather patterns imply potential of negative impacts on food production, food security and natural resources in the country. The impending vagaries of climate change such as intense, uncertain, and highly variable rainfall and temperature and sea level rise, combined with deterioration and dwindling of natural resources stress the need for sustainable climate change adaptation technologies to increase the productivity, stability and resilience of the food sector.

The food sector which includes crops, livestock and fishery plays a multifunctional role in the national economy. Apart from providing food, fodder and fiber, the food sector also significantly contributes to the Sri Lanka's socio-economic development as well. The food sector in the economy is primarily identified as a source of income for the majority of rural poor, source of economic growth, a driver of private investment and a base for agro-industry. Rapid growth of the food sector, particularly the domestic food production, export crops, floriculture, livestock and fishery are necessary to achieve self reliance and food security nationally. It also leads to equity in the income distribution and wealth creation for poverty alleviation.

Contributing 11.2% to the country's GDP, accounting for 17% of all export revenue, employing 30% of the total workforce, and supporting 21 million people directly or indirectly, food sector is vital to Sri Lanka's economy and the livelihood of its people<sup>14</sup>. In the year 2011, 79% of the food sector contribution to national GDP has come from crop production. In comparison, the respective contributions from livestock and fisheries sectors had been 14% and 7% respectively. The livestock and fishery sub-sectors play a vital role in the Sri Lankan economy. The self-sufficiency in milk has been a prime objective of livestock development policy of Sri Lanka. The food sector significantly contributes to the economic development by providing employment, food and income security to agricultural households and alleviating poverty.

The country's dependence on the food sector to meet food needs of the population is much more significant than its relative share as an economic sector. The rural population in particular, which comprises more than 70% of the population, is directly or indirectly dependent on food sector or related activities. Furthermore, it is estimated that the agriculture-related activities provide the major source of employment and livelihood for nearly a third of the Sri Lankan population. Hence, the sector's adaptability to climate change is critical for continued economic growth and for food security.

#### 4.1.1 GHG Emission Level and Trends

Crop production and livestock sub sectors are responsible for the release of a little amount of methane, which originates mainly from ruminant animals and rice cultivation in wetlands. Use of fertilizer contribute to emitting nitrous oxide into the atmosphere while changes in land use such as deforestation and land degradation and unsustainable farming practices also emit significant amount of carbon. Summary of the GHG emission contribution from the food sector for 2000 is given in Table 4.1

**Table 4.1: Summary of GHG emissions from Food Sector in Sri Lanka**

Source	Emissions(Gg)					Emission Removals(Gg)
	CH <sub>4</sub>	N <sub>2</sub> O	CO	NO <sub>2</sub>	CO <sub>2</sub>	CO <sub>2</sub>
Entericfermentation	59.68					
Manuremanagement	6.92	0.12				
Rice cultivation	117.43					
Crop residue burning	1.11	0.08	23.43	1.74		
Direct emission from soils		1.63				
Indirect emissions from soils		0.82				
Carbon stock change in woody biomass						5,883.59
Carbon stock change in soils						370.4
Emission from forest fires	0.05				10.34	
Emission from flooded land/tank	1.62					
Total	186.81	2.65	23.43	1.74	10.34	6253.99

*Source: Sri Lanka's Second National Communication on Climate Change, 2012*

The net effect on GHG emissions from the food sector is negative as the effect of carbon sequestered in the woody biomass and soil is much greater than the GHG emissions from all agricultural activities.

#### 4.1.2 Vulnerability to Climate Change

The production potential and productivity of the sector depends on soils, availability of water & required nutrients, climate, and energy together with the genetic characteristics of crops, fishery and livestock coupled with best management practices. Various elements of the agriculture and food production system are particularly sensitive to climate change. Temperature and precipitation are key drivers of agricultural production which operate on highly site-specific and time-specific basis of the microclimate in which a plant or animal is located.

Food security relies on country's ability to make agriculture and food production systems more productive and more resilient to shocks, such as droughts, floods, and pest and disease outbreaks. The food sector in Sri Lanka depends heavily on climatic conditions and it is sensitive to climate change

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impacts such as variability in monsoon rainfall and temperature changes within a season. Changes in temperature and rainfall have significant negative effects on the production, productivity and the quality of rice, fruits, vegetables, tea, and coconut etc. Pathogens and insect populations are strongly dependent upon temperature and humidity, and changes in these parameters may also alter their population dynamics. Climate change is also contributory for lower yields from dairy cattle, decline in fish breeding, and harvests from culture based fisheries.

In Sri Lanka, more gradual increase in annual temperature has been observed and the rate of increase in mean air temperature is in the order of 0.016°C per year during the period 1961 – 1990 (Premalal, 2009). The nighttime annual average temperature increase (up to a maximum of 0.02°C per year) appears to be faster than that of daytime. The annual average rainfall has been decreasing for the last 57 years at a rate of about 7 mm per year. It has been observed that variability of seasonal rainfall has increased significantly during the last few decades particularly for the northeast monsoon (December – February) and second inter-monsoon period. The results of these climate extremes and changes have been experienced in the form of multiple impacts in Sri Lanka food sector.

It has been estimated that approximately 352,000 ha of paddy lands of the country are highly or moderately vulnerable for drought while 139,000 ha are highly or moderately vulnerable for flood exposure due to the effects of climate change<sup>127</sup>. Also, the saline intrusion affects quality of river waters and degrades arable coastal paddy fields, causing them to be abandoned. It is evident from the crop production data of the Department of Agriculture that, since 2008 Yala to 2010/2011 Maha the Sri Lankan crop production is facing a serious threat from climate change and it is already causing tangible economic losses. According to the Department of Agriculture, Socio Economic and Planning Centre publication in 2009 Yala season, there has been a 47% decrease in production as compared with Yala 2008 due to delay in onset of rains in many districts and prolonged dry period.

As for the livestock sector, it has been observed that the heat stresses has direct influence on reproductive functions and embryonic development of dairy cattle (Wijayagunawardene, 2009). The indirect influences are also mediated through negative energy balance as heat-stressed dairy cows reduce dry matter intake thereby reducing milk productivity.

Fishery sector is also highly vulnerable to the variability of the rain fall. It has been observed that the reduced fish stocks due to stressed freshwater bodies during the drought periods have an impact on the duration of the culture period thereby affecting fingerling production. Lose of fish production and sometimes fish deaths due to pollutants and sediment accumulation due to floods have been observed.

It is clear that the changes in the rainfall pattern is likely to be the most significant factor for the food sector vulnerability. The effects of temperature rise would be more pronounced in the milieu of lowered rainfall, thereby accentuating the strain on the crop and animal species. The modified ecology through effects on pest populations and their virulence would likely create greater pressures on raising crops and animals. Therefore, the national strategy for climate change adaptation needs to endeavor to address all these concerns in an integrated manner.

#### **4.1.3 Existing Policies and Measures Related to the Development of the Food Sector and Technology**

In the absence of any concerted efforts for institutionalizing fixed-term national plans, the food sector policies and programs have often been subjected to changes with the change of governments. A culture

of translating policies into action programs supported by enabling legislative and other enactments appears to be nonexistent.

Table 4.2 presents existing policies related to the key components of the food sector. These policies have been introduced at different times after the election of the present government in 2005. They are in general fashioned after the '*Mahinda Chintana*', the National Policy Framework of 2005.

**Table 4.2: Existing Policies Related to the Food Sector**

Name of the Policy	Year Enacted	Main Contents
National Agricultural Policy	2007	All activities relating to agricultural production and consumption.
National Land Use Policy of SriLanka	2007	Agricultural land use.
The National Fisheries and Aquatic Resources Policy	2006	Inland and marine fishery development.
The National Live stock Development Policy	2011	Development of the major livestock sub-sectors to meet national requirement.

Major agricultural policy and program changes since the introduction of economic policies dominated by liberal market thinking in 1977 are shown in the Table 4.3. Up to 1994, major policy events in general signify a direction of positioning the economy and the agriculture sector within open market regime. However, after the change of Government in 1994 and in particular after 2006, some reversal of the trend can be seen with the state assuming a greater role in the management of the agriculture sector.

**Table 4.3: Agricultural Policy and Program Changes - Major Events after 1977**

Year	Description
<b>1977</b>	Liberal market economic policies of the Government encouraged private sector participation in agricultural production, storage, marketing and processing.
<b>1977-84</b>	Acceleration of Mahaweli River Diversion Program, which was originally planned to complete within 30 years, completed within 6 years. This program covers nearly 30 % of the country's land area. The achievements include increase of irrigated land area by about 200,000 ha.
<b>1990</b>	The Marketing Department, which involved in domestic agricultural product marketing and processing, ceased its operations.
<b>1991</b>	Restructuring of state managed plantation companies. Under this program the management was privatized on a profit sharing basis for a five-year period through the establishment of 13 Regional Plantation Companies.
<b>1995</b>	Shares of Regional Plantation Companies were sold to private sector and plantations were leased to the private sector for 50 years.
<b>1996</b>	Plantation Reform Project: launched with the investment of 100 million dollars in the plantation sector (tea, rubber, coconut and other plantation crops) to increase productivity and profitability of plantation sector.

<b>1997</b>	Seed and planting material import restrictions relaxed.
<b>1998</b>	A Private extension service as a pilot project.
<b>1999</b>	Privatization of Government Seed Production Centers.
<b>1999</b>	Private insurance companies are allowed to engage in agricultural insurance.
<b>2000</b>	Government allocated Rs.100 million (US \$ 1.3 million) to develop seed and planting material sections. Five-year development plans were prepared for fruits, vegetables, rice, livestock and other field crop sectors.
<b>2000</b>	Research, production promotion & extension, supply of seeds & planting material, private sector participation in commercial agriculture, marketing and institutional reforms were identified as six thrust areas for further reforms. Government declared the year 2000 as the year of Agriculture. Various institutions were mobilized to seek ways to improve agriculture sector to enhance economic growth.
<b>2003</b>	Government allocated Rs 100 million (US \$ 1.3 million) to boost the domestic agriculture. Market reforms, enhancing private sector role in agriculture development, food processing, and conservation of natural resources were identified as key areas of interventions.
<b>2006</b>	The government declared a comprehensive policy framework for national agriculture. The key objectives of the policy are to increase domestic agricultural production to ensure food and nutritional security of the nation.
<b>2007</b>	Government proposed a policy package for further development of agriculture. These policies included the duty waiver for milk imports, promotion of agro-processing, credit and tax concessions for machineries.

Thus, the focus has been on increasing food production through setting up and improving the infrastructure requirements. Many Acts and Ordinances have been enacted to create an enabling operational environment (Table 4.4).



**Table 4.4: Existing Acts and Ordinance related to Food Sector**

Name of the Act/ Ordinance	Year Enacted	Revised	Main Contents
Land Ownership Act	1840		After, Sri Lanka became a colony under the British in 1815 and the implementation of the Arid Lands Act of 1897, made changes in the Ordinance introduced in 1840, regarding unauthorized occupation of Crown Lands
State Land Encroachment Ordinance	1840	1931,1947, 1954	Make provision for the prevention of Encroachment in state lands
State Land Ordinance	1947	1949	Make provision for grant and disposition of state lands.; for the management and control of such lands and the foreshore; for the regulation of the use of the water of lakes and public streams. This Ordinance deals with the power of the State to sell, lease, grant or otherwise dispose of State lands for management and control.
Irrigation Ordinance	1946	1951,1953 1973	An Ordinance to amend and consolidate the Law related to Irrigation.
Land Development Ordinance	1935	1946,1953, 1955 1969,1971,	An ordinance to provide for the systematic development and alienation of state lands in Sri Lanka. Land Commissioner’s Department was set up to create the administrative structure
		1973	needed to administer and conserve lands as envisaged by the said Ordinance.
Soil Conservation Act	1951 1953	1996	Act provided provision for the conservation of soil resources for the prevention or mitigation of soil erosion and the protection of land against damaged by floods and drought.
Agrarian Services Act Agrarian Development Act	1979	2000	Matters relating to landlords and tenant cultivators for the utilization of agricultural lands accordance with agricultural policies; For the establishment of agrarian development councils; To provide for the establishment of a land bank; to provide the establishment tribunals; To provide for the repeal of the agrarian services act No 58 of 1979; and matters connected therewith or incidental thereto.
Mahaweli Authority of Sri Lanka Act	1979		An Act to provide for the vesting in the state of agricultural or estate land which is vested in the land reform commission under the land reform law; to enable the transfer free of charge, to the landless, of the lands so vested in the state.
Title Registration Act	1998		This act make provision for the investigation and registration of title to all land parcels for the regulations of transactions relating to a land parcel to registered land for matters connected therewith or incidental thereto.

Land Acquisition Act	1950	1954,1955 1964,1969 1971,1979	An act to make provision for the acquisition of lands and servitudes for public purposes and to provide for matters connected with or incidental to such provision.
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Upon closer examination, it can be seen that the food sector related policies have thus far failed to recognize the potential climate change impacts on agriculture and the food industry and not properly addressed possible adaptations measures. Certain well established climate change impacts affecting agriculture sector have not been factored in drafting the policies. Therefore, a comprehensive assessment of existing and any likely future agricultural policies is imperative to enable addressing climate change impacts effectively.

#### 4.1.4 Future Targets for the Food Sector

The central theme of all plans for food sector development has been on increasing food security, using domestic production as the primary vehicle. In the case of rice, which is the staple commodity, the undisputed goal of all development plans has been attaining self sufficiency. The plans and programs through the most part of the last century has focused on supporting this goal through the development of irrigation, superior varieties and supply of inputs and technical advisory services. With the near-attainment of this goal towards the end of the 20th century, the same strategy was extended to the secondary food crops and other commodities.

The current aim in the food sector envisages developing an export market for rice where a surplus has been recorded in 2011. Becoming self sufficient in secondary food commodities such as onion, chilies, potato, maize and selected fruit and vegetable crops has been taken up earnestly. In the livestock sector, the aim is in increasing domestic production of milk for which a large sum of money is spent on imports. Increasing the production of poultry products, to meet the requirement of eggs and meat has been given priority. In fishery, meeting the national demand for fish while developing an export industry based on other aquaculture products will continue to remain the policy objective.

Policy support towards achieving these targets is given by maintaining a secure domestic market through severe import controls and prohibitive tariffs. This covers all key commodities referred to above and imports of certain commodities are subjected to tariffs that are among the highest for any imports. Also, a very generous fertilizer subsidy scheme where the imported fertilizer is distributed to farmers at price more than 50% below cost is in operation. The irrigation water is supplied free to farmers. A government-funded rice procurement scheme is in operation and during periods of gluts, state procurement has been extended to other minor crop products and eggs as well.

#### 4.2 Identified Adaptation Technologies in the Food Sector

With a view to utilize technological approaches that can be quickly harnessed for developing adaptation technologies to reduce vulnerability to climate change, nine adaptation options were identified as priority technologies for consideration. The identification of technologies has been guided by factors such as the adequacy of information available on the proposed technology, the probability of success or failure of the technology, cost, potential risks and the level of confidence of the sector specialists in the choice of the proposed technology. The technologies thus identified fall under the broad categories of crop/livestock/fishery management, sustainable water use and management, capacity building of stakeholder organization and sustainable land management.

The adaptation technology options identified are as follows;

- a) Sustainable Land Management
- b) Crop Diversification & Precision Farming
- c) Ecological Pest and Disease Control
- d) Rain Water Harvesting
- e) Solar-powered Drip Irrigation
- f) Development of Appropriate Breeds
- g) Development of Appropriate Varieties
- h) Responsive Agricultural Extension
- i) Sustainable Culture-Based Fisheries

All the technologies identified are currently available in Sri Lanka. Of the proposed technologies, Rain Water Harvesting, Solar-powered Drip Irrigation, Responsive Agricultural Extension and Sustainable Culture-Based Fisheries are proposed for short term implementation while the other technologies are to be implemented on long term basis.

#### 4.2.1 An Overview of Possible Adaptation Technology Options and their Adaptation Benefits

**Table 4.5: Overview of adaptation benefits of the proposed Technologies of the food Sector**

Adaptation Technology	Scale of Implementation	Benefits
1. Sustainable Land Management	Large Scale	<ul style="list-style-type: none"> <li>- Increased agricultural productivity and food security.</li> <li>- Employment generation.</li> <li>- Reduced cost of reservoir de-silting and other off-site costs.</li> <li>- Increased profitability from farming leading to reduced cost of commodities.</li> <li>- Improved livelihoods and social sustainability.</li> <li>- Reduced land degradation and downstream sedimentation &amp; siltation.</li> <li>- Build healthy soils and improve surface and ground water quality.</li> <li>- Reduced GHG emissions.</li> <li>- Minimized non point source pollution.</li> <li>- Secured bio diversity and improve ecosystem sustainability.</li> </ul>
2. Crop Diversification & Precision Farming	Large Scale	<ul style="list-style-type: none"> <li>- Increased crop yield, quality and reduced production costs due to efficient use of farm inputs and labor.</li> <li>- Ensured productivity and food security.</li> <li>- Minimized health problems from environmental pollution resulting from indiscriminate resource use.</li> <li>- Increased returns on investments and improving attractiveness of farming, particularly to youth, through</li> </ul>
		<ul style="list-style-type: none"> <li>adoption of high-tech methods.</li> <li>- Prevents soil degradation in cultivable land.</li> <li>- Reduced chemical use in crop production.</li> <li>- Efficient use of water and other natural resources.</li> <li>- Demand driven fertilizer management systems to ensure conservative use of fertilizer contributing to reduced GHG emission.</li> <li>- Facilitate bio diversity conservation.</li> </ul>

3. Ecological Pest And Disease Control	Small Scale	<ul style="list-style-type: none"> <li>- Lowered costs of pest &amp; disease management over time.</li> <li>- Increased value of produce.</li> <li>- Increased environmental Quality</li> <li>- Reduced health risks.</li> </ul>
4. Rain Water Harvesting	Small Scale to Large Scale	<ul style="list-style-type: none"> <li>- Increased profits by reducing crop damages during water scarcity.</li> <li>- Secured ground water quality/quantity.</li> <li>- Reduced land degradation.</li> <li>- Increased employment opportunities.</li> <li>- Promote investments through reduced risks.</li> <li>- Improved rural livelihood.</li> </ul>
5. Solar-powered Drip Irrigation	Small Scale	<ul style="list-style-type: none"> <li>- Reduced costs of production and higher prices enabling realizing better incomes.</li> <li>- Year round gainful employment for the farm family labor.</li> <li>- Use of solar energy provides local and global benefits through the reduction of pollution and emission of greenhouse gases.</li> <li>- Lowered water withdrawal from ground water resources which prevents depletion of ground water table and pollution from infusion of saline and other contaminants.</li> <li>- Reduced use of agricultural chemicals such as weedicides and pesticides contributing to minimize adverse environmental impacts and biodiversity loss.</li> <li>- Drip technology reduces soil degradation from top-soil erosion associated with flood irrigation.</li> <li>- Increased yields and profitability.</li> <li>- Increased availability of food.</li> <li>- Reduced price fluctuations of vegetables and fruits.</li> </ul>
6. Appropriate Breeds	Large Scale	<ul style="list-style-type: none"> <li>- Ensured food security.</li> <li>- Enhanced Productivity and profitability.</li> <li>- Increased employment opportunities in production sector and value chain.</li> </ul>
7. Appropriate Varieties	Large Scale	<ul style="list-style-type: none"> <li>- Ensured food security.</li> <li>- Increased productivity and profitability.</li> <li>- Increased employment opportunities.</li> <li>- Reduced environmental damage resulting from the use of pest control chemicals.</li> </ul>
8. Responsive Agricultural Extension	Large Scale	<ul style="list-style-type: none"> <li>- Increased overall efficiency of resource use.</li> <li>- Improved public awareness and education.</li> <li>- Promote rural development and resource conservation.</li> </ul>
9. Sustainable Culture-Based Fisheries	Large Scale	<ul style="list-style-type: none"> <li>- Ensured food security.</li> <li>- Support to reduced malnutrition of the people.</li> <li>- Create new employment opportunities in the fish value chain.</li> <li>- No ecosystem damage.</li> <li>- Minimal use of external resources for fishery production.</li> </ul>

### 4.3 Criteria and Process of Technology Prioritization

The Multi Criteria Decision Analysis (MCDA)<sup>83</sup> approach was employed for prioritization of potential adaptation technologies. This approach provided opportunity to assess technologies across a range of development and sustainability criteria.

#### 4.3.1 Multi Criteria Decision Analysis (MCDA)

##### a) Determination of Criteria and Weightings

The criteria applied for evaluation of technologies included cost of technologies, and economic, social, and environmental benefits. The scoring system adopted to evaluate the technological options is given in Table 4.2 Accordingly; each option is given a total score on a scale of 0 -100 by using the weight factor assigned for each criterion. The Weight Factor for each criterion is set by apportioning 100 points on the basis of their relative importance. . The each criterion was measured qualitatively based on the impact of the respective option (Rank 1-5). The criterion decided and weightings are provided in Table 4.6 below.

**Table 4.6: Criteria and Weighting Factors identified for the Food Sector**

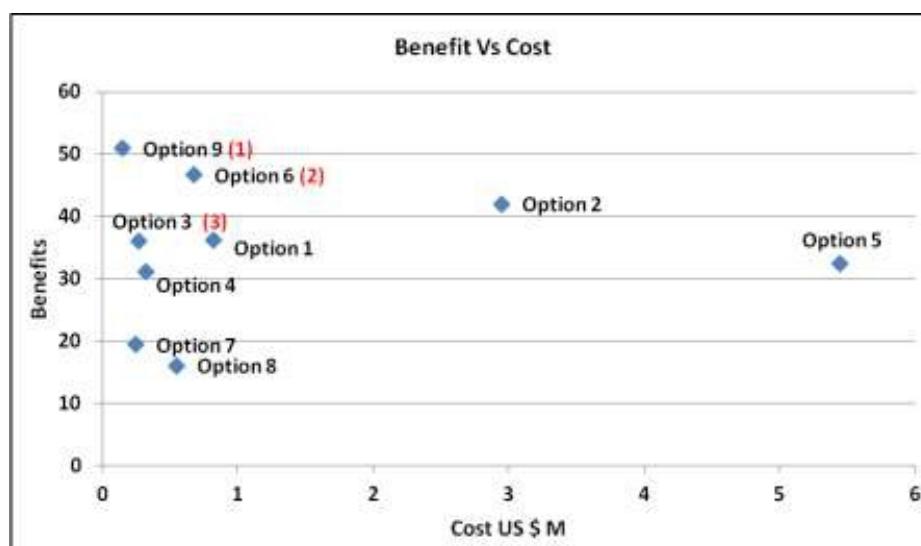
Category	Criteria	Weight Factor	
<b>Benefits (70)</b>	<b>Cost (30)</b>		
	Cost of Technology	30	
	<b>Economic (35)</b>	Impact on Food Security	10
		Effect on Employment generation	5
		Effect on Farmers income/Poverty reduction	10
		Impact on Energy use	5
		Impact on New markets/enterprises/Industries	5
		<b>Social (15)</b>	Household labor involvement
	Gender equity		1
	Impact on Rural Development		5
	Livelihood improvement		4
	Community participation		1
	Health benefits		3
	<b>Environmental (20)</b>	Impacts on ground water quality/quantity	3
		Impact on surface water quality/quantity	3
		Impact on Soil Erosion/Runoff & Sedimentation	5
		Impact on Soil Quality/health	2
		Effect on biodiversity conservation	2
		Quality of Watershed functions	2
		Impact on air pollution	1
Effect on GHG Emissions		2	

b) **Scoring Matrix:** As described in the MCDA Manual, the Scoring Matrix constructed based on the above criteria and weight factors (See Annex III for weighted scores, costs and benefits of technologies) and the results are given in Table 4.7 below.

**Table 4.7: Results of the MCDA - Food Sector**

Technology	Cost of Technologies (US \$ M)	Benefits	Rank
1. Appropriate Varieties	0.82	36.20	5
2. Appropriate Breeds	2.95	42.00	8
3. Sustainable Land Management	0.27	36.00	(3)
4. Drip Irrigation	0.32	31.00	4
5. Rain Water Harvesting	5.45	32.40	9
6. Crop Diversification & Precision Farming	0.68	46.70	(2)
7. Ecological Pest & Disease Management	0.25	19.40	6
8. Responsive Agricultural Extension	0.55	16.00	7
9. Sustainable culture-based fisheries	0.15	50.90	(1)

The Figure 4.1 shown below, illustrates the benefits, estimated as (total score- weighted cost), and plotted against the costs and the results used in determining the most preferred technologies. Accordingly, option Nos. 9, 6 and 3 are selected as the most preferred technologies in order of priority.



**Figure 4.1: Plot of Benefit Vs Cost for identified technology options for the Food Sector**

#### 4.4 Results of the Technology Prioritization for the Food Sector

Ranking of technological options, from most cost effective to least cost effective, based on the results of the multi-criteria analysis is given below:

1. **(Option 9) - Sustainable Culture-based fisheries**
2. **(Option 6) - Crop diversification and precision farming**
3. **(Option 3) - Sustainable land management**
4. (Option 4) - Drip Irrigation- Solar powered
5. (Option 1) - Appropriate varieties
6. (Option 7) - Ecological pest and disease management
7. (Option 8) - Responsive agricultural extension
8. (Option 2) - Appropriate Breeds
9. (Option 5) - Rainwater harvesting –Minor tank restoration

Despite their high potential of reducing vulnerability effects from climate change, the results of the MCDA analysis (*Fig 4.2*) suggests that relatively high cost technologies such as the development of appropriate animal breeds (*Option 2*), appropriate crop varieties (*Option 1*), and rain water harvesting through minor tank restoration (*Option 5*), are not favored by the ranking adopted.

Considering the tendency to disfavor high cost interventions, and to verify the robustness of results, a sensitivity analysis was carried out by lowering the weights assigned to cost of adaptation options by 10% (to 20%) and economic benefits increased by that amount. This did not alter the results of the analysis in a significant manner.

**Table 4.8: Summary Table for Prioritized Technologies for the Food Sector**

No	Technology	Scale of Application (Small, Medium or Large Scale)	Time Scale (Short, Medium or Long term)	Benefits (Output from MCDA)	Estimated total lifetime Cost (US \$ M)
1	Culture-based fisheries Crop diversification and precision farming	Medium Scale	Medium term	50.83	0.150
2	Crop diversification and precision farming	Large Scale	Long term	45.67	0.682
3	Sustainable land management	Large Scale	Long term	35.5	0.273

#### 4.4.1 Categories of the Prioritized Technologies

To facilitate the barrier analysis, it is useful to categorize technologies according to the types of goods and services they belong to or contribute to, as different types of goods and services have distinct market characteristics. The transfer and diffusion of technologies within each category are influenced either by market or political decisions. The diffusion of consumer goods and to some extent the capital goods are generally dominated by market decisions, whereas publicly provided goods and non-market goods are primarily diffused through political decisions. Government institutions therefore have a direct influence on the diffusion of publicly provided and non-market goods.

**Table 4.9: Prioritized Technologies and Categories in the Food Sector**

No	List of Prioritized Technologies	Category of the Technology*
1.	Sustainable Inland Culture Based Fisheries	Consumer Goods
2.	Sustainable Land Management	Other Non Market Goods
3.	Crop Diversification and Precision Farming	Other Non Market Goods

\* (Overcoming Barriers to the Transfer and Diffusion of Climate Technologies, 2012)

The technologies thus selected have been around for long periods and yet not been fully utilized due to various constraints that exist in the operational/institutional area. Short term technologies by definition are proven and reliably available in a similar environment. Sustainable culture-based fishery is categorized a consumer good and the others are as other non-market goods.

#### **4.5 Preliminary targets for technology transfer and diffusion**

Preliminary targets for transfer and diffusion of the selected adaptation technologies in the food sector are discussed below in quantitative terms for each intervention.

(i) The preliminary target for transfer and diffusion of **Sustainable Inland Culture Based Fisheries (SCBF)** is to increase the fingerling production to meet the stocking requirements of 300 village reservoirs with a cumulative surface area of 1000 ha over a period of 2 years. This will involve induced breeding of major carp species, rearing of post larvae to fry stage and raising 3.5 million fingerlings annually.

(ii) Restoration of fertility status of 20,000 ha of rice lands and 10,000 ha of highlands cultivated with other food crops over a period of 3 years is set as the preliminary target for **Sustainable Land Management (SLM)**. The interventions will involve improvement of physical, chemical and biological properties of soil for optimum crop production through soil amelioration and adoption of better land and crop management practices.

(iii) **Crop Diversification and Precision Farming (CD & PF)** will involve conversion of 8,000 ha of land presently under irrigated paddy cultivation into highland crops over a 3 year period and increasing productivity by adopting precision farming techniques.

#### **4.6 Sustainable Inland Culture-Based Fisheries**

##### **a) General description**

Inland Fisheries and Aquaculture has high potential for further development as the country has an abundance of inland water bodies almost island wide. The National Aquaculture Development Authority (NAQDA) estimates fresh water bodies to be of around 260,000 ha in extent and is comprised of large, medium and minor irrigation reservoirs, seasonal village tanks, flood lakes, upland reservoirs/estate tanks and Mahaweli river basins<sup>115</sup>.

There is a need to increase fish production in minor perennial reservoirs, seasonal tanks and brackish water bodies through culture-based fisheries. Reported production from the inland fisheries sector in 2010 is 47,000 mt (MF&AR). Inland fisheries and aquaculture has shown a sluggish growth over the last ten years, with a highest contribution of about 20% to the total fish production, recorded in year 2005.



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However, the contribution by the sector has remained around 14% after 2005.

Reservoir fishery being the main aquaculture activity currently practiced provides significant contribution to food and nutritional security of the rural areas in the interior regions of Sri Lanka and has other benefits such as providing supplementary income for farmers by creating new job opportunities in the communities, and making available animal protein at affordable prices. Statistics indicate that per-capita fish consumption in districts such as Anuradhapura, Polonnaruwa, where reservoir fisheries activities are successfully established is above the national per-capita fish consumption.

Reservoir fishery, SCBF in particular in medium perennial and small village reservoirs is highly vulnerable to the climate change impacts. Unexpected rainfall changes and changes in annual rainfall pattern in recent past have made significant impacts on the water retention of the reservoirs. As SCBF activities depend on the two monsoons, changes in rainfall pattern creates uncertainty of maintaining required water levels for aquaculture.

Fish species that are used for the SCBF are exotics and fish seed is required to be produced in hatcheries through artificial breeding. As climate change is likely exert direct influence on artificial breeding, thus alternative techniques and/or improvement of existing technologies become imperative. Study of different techniques for successful breeding of introduced and local fish species suitable for aquaculture is a major requirement for successful aquaculture in the country under the climate change scenario.

Growing demand for fishery products with rising incomes and availability of natural and manmade inland water resources provide ample prospects for development of environmental friendly, less capital and labor intensive culture based inland fisheries in the country. The potential for Sustainable Culture-based fisheries (SCBF) lies in the extensive network of perennial and seasonal reservoirs developed in the country mainly for irrigation purposes. Sustainable Culture based fisheries is a non-competitive, complimentary resource use that permits maximization of benefits from freshwater resources.

In contrast to aquaculture which involves cultivation of aquatic life within controlled environments or the commercial production of certain aquatic species by managing the major part of their life history under strict controls, culture-based fisheries increase production in natural environments by controlling a part of the life history of certain species and transplanting or releasing their seed or fry into the open waters. The juvenile fish, which are produced in hatcheries and are released into fresh, brackish or marine waters, are allowed to propagate or grow on natural foods until they reach harvestable size.

Since it uses the natural environment itself, unlike aquaculture, culture-based fisheries are not constrained by land or population pressures and do not have to modify or manage the culture system to approximate the natural environment. However, harvests and returns are less predictable as the release of fish to open water bodies result in the number harvestable being reduced. Nonetheless, culture-based fisheries have been increasingly resorted to as means of enhancing the fishery resources, replenishing natural stocks whose populations have declined through over-exploitation or environmental degradation, or simply maximizing the productivity of a reservoir.

The sustainability of CBF in non-perennial reservoirs in Sri Lanka totally depends on the economic viability of the strategies at all level of production. Availability of quality fingerlings, selection of suitable non-perennial reservoirs, and post stocking management are the key factors that influence the productivity. Economic sustainability of the CBF determines the profitability at the each stage of the production.

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Species used for stocking are either indigenous or exotic, and either, herbivorous, carnivorous, or omnivorous. In the tropics, high-yielding herbivores, detritivores and plankton feeders (like tilapia and carp), are commonly stocked in lakes and reservoirs. Sri Lanka's large perennial reservoirs and small seasonal tanks, which constitute the country's main freshwater resource, are regularly stocked with fingerlings of different carp species (Indian, Chinese, and common), which are produced at Government-run hatcheries spread all over the country. Since the Indian and Chinese carps do not spawn in the reservoirs/tanks, they have to be stocked regularly to sustain the fisheries. There is thus a large pressure on the State to accelerate its seed production program to keep pace with the large demand for fingerlings. In Sri Lanka, the National Aquaculture Development Authority under the Ministry of Fisheries is primarily responsible for the production of carp fingerlings for distribution among the various reservoirs and seasonal tanks.

The main reasons for identification of Sustainable Inland Culture Based Fishery as a prioritized adaptation technology are as follows;

- A low cost technology.
- Basic know-how on the technology is already available in the country.
- The technology will be attractive to all categories of stakeholders as it creates new opportunities for rural communities.
- Provide additional income for paddy farming communities in rural areas.
- Ensure food and nutritional security of rural communities.
- Use of available resource for supplementary income generation.
- No serious policy barriers to the introduction of the technology in the country. The technology has acceptance as a means of increasing productivity of reservoirs.
- No GHG emission in Culture Based Fishery.
- No local pollutants and ecosystem degradation.
- Zero impacts on indigenous/endemic aquatic fauna

#### **b) Identification of barriers and measures for Sustainable Inland Culture-Based Fisheries**

The process of identification of barriers and appropriate measures included stakeholder consultations, literature reviews and interviews with sector specialists.

The most critical barriers identified for the diffusion of SCBF is related to financial and economic constraints for want of increased investments. These barriers are inadequate availability of financial resources and high risks on investments.

A set of eight non financial barriers affecting the SCBF operations were identified with two of them are being considered most critical i.e. Insufficient and weak supply arrangements for fingerlings and Inadequate R&D and Training facilities.

Measures identified to overcome the economic and financial barriers are aimed at improving the recognition of SCBF as a promising industry requiring State patronage for providing some assistance for capital development and risks involved at early stages.

Measures to overcome barriers that are of non financial nature are spread over a wide spectrum of activities and are described below.

**Table 4.10: Key Barriers and Measures Identified for the Sustainable Culture - Based Fisheries**

<b>Sustainable Culture Based Fisheries</b>		
<b>No</b>	<b><u>Barriers</u></b>	<b><u>Measures</u></b>
<b><u>Economic and Financial</u></b>		
1	Inadequate financial resources.	Assuring adequate availability of financial resources.
2	High risk of investment.	Lowering the risk of investment
<b><u>Non Financial</u></b>		
<b><u>Market failure</u></b>		
3	Insufficient and weak supply arrangements for fingerlings.	Strengthening adequate supply of fingerlings.
4	Poor marketing infrastructure and low price.	Improving marketing infrastructure and price.
<b><u>Institutional and Organizational Capacity, Information and awareness</u></b>		
5	Inadequate R&D and Training Facilities.	Assuring adequate R&D and Training Facilities.
<b><u>Social, Cultural, Behavioral and information and awareness</u></b>		
6	Non-favorable consumer preferences and social biases.	Improving consumer preferences and overcoming social barriers.
<b><u>Policy, legal and regulatory</u></b>		
7	Inadequacy of Government policy environment.	Improving Policy Coordination.
<b><u>Network Failure</u></b>		
8	Poor institutional arrangements for stakeholder participation in policy making.	Improving institutional arrangements for stakeholder participation in policy making.
<b><u>Technical</u></b>		
9	Inadequate product standards, codes and certification.	Introducing product standards, codes and certification.
<b><u>Information &amp; awareness and other</u></b>		
10	Water quality degradation.	preventing degradation of water quality .

## **4.7 Sustainable Land Management (SLM)**

### **a) General Description**

Sustainable Land Management (SLM) is aimed at sustaining healthy soil and restoring degraded land for ensuring food security, alleviating rural poverty and hunger and building resistance to major environmental challenges. Land degradation has already taken place to various degrees and the objective of sustainable land management has to focus on restoring such degraded land while preventing further degradation of any unaffected land to ensure continued ecosystem health and functions.

Sri Lanka with a population of little over 20 million people living in an area of 65,525 km<sup>2</sup> is one of the 19 countries with high population densities. Land degradation is among the most serious environmental problems in the country which badly affects the economic development. Land degradation is widespread and occurs in all agro-ecological regions at different intensities. Land is interconnected with other natural resources such as the air, water, fauna and flora, which are essential for human survival. Well managed land help to protect environment and natural resources and facilitate continued accomplishment of ecological functions and services in a sustainable manner.

Land degradation in the country has manifested in several ways including heavy soil losses, high sediment yields, soil fertility decline, compaction, crusting and sealing, water logging, lowering of the soil surface, loss of productive functions, landslides, salinization, alkalinization, acidification including both desertification and formation of acid sulphate soils, iron toxicity development, nutrient and agro-chemical accumulation, indiscriminate disposal of waste and eutrophication. Of these, soil erosion/sedimentation and soil fertility decline are the two most significant degradation processes taking place and heavy soil losses and high sediment yields caused by soil erosion are the most severe. At present, 44% of the agricultural lands are facing the problem of soil erosion<sup>25,87</sup>. This is evident in high rates of soil loss i.e; 100 tons/ha/yr in the hill country on sloping lands under intensive cultivation of vegetables and potatoes, poorly managed seedling tea and chena (shifting) cultivation<sup>125</sup>. Hence, human induced land degradation is more significant than that by natural forces in the country.

Synergetic and additive outcomes of sustainable land management (SLM) assure conservation of land associated natural resources and thereby increase agricultural and livestock productivity. All of these directly increase the nation's ability to withstand the negative impacts of climate change and benefits will be widespread. Although, Sustainable Land Management (SLM) is a climate change adaptation technology, it also helps mitigating GHG emission through efficient use of fertilizer, better management of farm yard manure combined with integrated plant nutrient management and by increasing organic carbon content in the soil. Socio-Economic benefits and Environmental benefits of SLM are shown in Table 4.11.

**Table 4.11: Benefits of Sustainable Land Management**

Socio-Economic benefits	Environmental benefits
<ul style="list-style-type: none"> <li>• Increased food security.</li> <li>• Increased profitability from farming.</li> <li>• Reduced food costs to consumers.</li> <li>• Increased land and agricultural productivity.</li> <li>• Creation of employment.</li> <li>• Alleviate rural poverty.</li> <li>• Improved livelihoods, human well-being and social sustainability.</li> </ul>	<ul style="list-style-type: none"> <li>• Lowered reservoir de-silting and other offsite costs.</li> <li>• Reduced downstream sedimentation and siltation.</li> <li>• Reduced contamination of soil and surface and ground water.</li> <li>• Reduced GHG emissions.</li> <li>• Minimize non point source pollution.</li> <li>• Improve ecosystem sustainability.</li> <li>• Sustained ground water quality/quantity.</li> <li>• Secured bio diversity.</li> <li>• Improved health of mangrove ecosystems.</li> <li>• Improved health of coral reefs.</li> <li>• Reduced risks of natural disasters.</li> </ul>

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Despite continuing efforts, land degradation remains a critical constraint for sustainable development of land resources of the country indicating that the SLM technology has not been adopted effectively. Therefore, appropriate corrective action needs to be taken to address issues pertaining to technology transfer and diffusion for adaptation of SLM practices. These issues/barriers are often considered complex requiring a systemic and systematic approach.

**a) Identification of barriers and measures for sustainable land management (SLM)**

The process of identification of barriers and measures included stakeholder consultations, literature reviews and interviews with sector specialists. The results of analysis reported from national and international experiences with managing land degradation and promoting SLM were used for consultation. These prioritized barriers and measures with stakeholder consensus<sup>94</sup> are described below

The adoption of good land management practices are largely determined by economic and financial barriers which in turn affects the level of investments in SLM related activities. With insufficient budgetary allocations, the goal of sustainable land management remains elusive, as it often clashes with competing priorities related to economic development, poverty reduction, health, education, and defense.

The non-financial barriers are either policy, legal, regulatory or enforcement related or resulting from knowledge or skill gaps.

Unless some assistance is provided, awareness raising and education alone cannot entice small producers to undertake appropriate SLM practices. Compared with cost of crop cultivations, SLM practices are generally more expensive. Also, benefits of adopting SLM practices are not immediate and usually spread over several years. Therefore, small producers are not able to undertake such practices without some assistance to compensate related costs. There is also a range of off-site social benefits in terms of broader environmental services associated with SLM activities such as water conservation, ground water recharge, erosion control and prevention of silting of public water bodies etc. Therefore, some SLM practices qualify to receive subsidies and other assistance from the State.

**Table 4.12: Key Barriers and Measures Identified for the Sustainable Land Management (SLM)**

<b>Sustainable Land Management</b>			
<b>No</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost of Implementation for the Target Years</b>
<b>Economic and Financial</b>			
1	High cost of Implementation and long gestation period for realizing return on investments.	Increasing affordability and returns to adoption of land	over a 10 year period is US\$ 11.0 million
2	High economic cost of conservation practices and social constraints in small land holding.	Increasing affordability of conservation practices and reducing social constrains in small lad holdings.	over a 10 year period is US\$ 3.5 million
3	Low Public and private investment on research and development	Raising public and private investment on research and development	over a 10 year period is US\$ 9.0 million
4	High dependency on land for livelihoods resulting in high land pressure.	Lessening dependency on land for livelihoods to reduce pressure on land.	over a 10 year period is US\$ 1.5 million
<b>Non Financial</b>			
<b>Policy, Legal and Regulatory</b>			
5	Insecure land ownership.	Securing land ownership.	over a 5 year period is US\$ 0.05 million
6	Inadequacy and poor enforcement of policies, laws and regulations.	Introduction and enforcement of land management policies, laws and regulations.	over a 10 year period is US\$ 0.5 million
<b>Human Skills</b>			
7	Inadequate knowledge on appropriate land management techniques and new challenges to sustainable management.	Raising knowledge on appropriate land management techniques and new challenges.	over a 10 year period is US\$ 3.0 million
<b>Institutional and Organizational Capacity</b>			
8	Low priority to conservation in non agricultural land uses.	Ensuring proper attention to conservation in non-agricultural land uses.	over a 5 year period is US\$ 3.5 million
9	Poor relevance of broad-spectrum techniques due to diversity of land, weather, soil, terrain, size, land formation and land use.	Improving relevance land management techniques under diverse land, weather, soil, terrain, size and land formation.	over a 10 year period is US\$ 4.0 million
<b>Network Failures</b>			
10	Lack of coordination among stakeholder organization.	Improving coordination among stakeholder organizations.	over a 10 year period is US\$ 0.5 million
<b>Social, Cultural, Behavioral</b>			
13	Single or individual efforts are not effective.	Promoting collective land management measures.	over a 10 year period is US\$ 3.5 million

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## 4.8 Crop Diversification & Precision Farming (CD&PF)

### a) General Description

Crop diversification involves introduction of a range of crops and animal enterprises within a region or catchment area. The barriers to technology transfer and diffusion of diversification are inter-related and parallel across these different enterprises requiring a holistic approach.

Crop diversification (CD) is adding new crops or introducing cropping systems to a particular farm taking into account the different returns from value added crops with complementary marketing opportunities. Forty eight agro-ecological zones that have been identified in Sri Lanka is a major driver for crop diversification. Crop diversification increases nutritional security thereby balancing food demand in lieu of increasing food security. Increasing productivity in specific ecosystems is the only enabling option to meet increasing demand for food and non-food agricultural products. Crop Diversification coupled with Precision Farming (CD&PF) enables improving accuracy and efficiency of inputs.

In the context of climate change adaptation, Crop Diversification and Precision Farming (CD&PF) helps to build resilience in agricultural systems by increasing diversity and enhancing the capacity of crops to withstand climate-related shocks. Diversity increases the ability of agricultural systems to withstand effects of rising climate variability and extreme events by serving as a buffer. For example, engendering diversity can be beneficial in suppressing pest and disease outbreaks likely to be worsened by CC impacts. Climate change impacts are considered to influence crop growing conditions in a manner that reverses economic benefits exploited by mass transformation of agriculture into mono-crop systems.

Precision farming can compliment crop diversification in securing a sustainable agricultural system. Precision farming could match agricultural inputs and practices based on exact need of crops grown in specific eco system to minimize usage while optimizing efficiency of inputs. Precise application of inputs 'as needed and where needed' ensures avoiding overuse or under use of inputs thereby protecting soil health and environment. It also reduces use of water, fertilizer, pesticide, and labor and assures quality produce. In livestock production, precision farming can increase productivity through regulation of micro-environment, improving feed and fodder production, and assuring timely veterinary care. (Ref. Annex D-1 Technology Fact Sheet on Crop Diversification and Precision Farming, Part 1, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka)

### b) Identification of barriers and measures for Crop Diversification & Precision Farming CD&PF

Barriers and measures for effective technology transfer and diffusion of CD&PF were identified through an extensive consultative process including literature reviews and expert inputs. The outcome was validated using recorded national and international experiences to overcome these barriers. These barriers and measures are discussed below under categories of economic & financial and non-financial measures.

**Table 4.13: Key Barriers and Measures Identified for the Crop Diversification & Precision Farming (CD&PF)**

<b>Crop Diversification &amp; Precision Farming</b>			
<b>No</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost of Implementation for the Target Years</b>
<b>Economic and Financial</b>			
1	Price fluctuation due to unstable import policies.	Contain price fluctuation due to unstable import policy.	does not involve any additional costs
2	High cost of cultivation including labor.	Increasing affordability of cost of cultivation including labor.	over a 15 year period is US\$ 8.0 million
<b>Non Financial</b>			
<b>Policy, Legal and Regulatory</b>			
5	Fragmentation of land holdings.	Reducing fragmentation of land holdings.	over a 5 year period is US\$ 0.05 million
6	Land tenancy arrangements obstructive to diversification away from rice.	Making land tenancy arrangements diversification friendly.	does not involve any additional costs
<b>Institutional and Organizational Capacity</b>			
7	Lack of varieties and management packages suitable for diversification.	Provide varieties and management packages suitable for diversification.	over a 10 year period is US\$ 10.0 million
	Inadequate post harvest technologies and processing infrastructure.	Improving post harvest technologies and processing infrastructure.	over a 15 year period is US\$ 8.0 million
<b>Market Failure</b>			
8	High risk of marketing due to seasonal production.	Lowering marketing risk arising from seasonal production.	over a 10 year period is US\$ 5.5 million
9	Under developed marketing system, No penetration of rural markets and lack of timely and accurate market information.	Improving marketing system, Increase penetration of rural markets and providing timely and accurate market information.	over a 15 year period is US\$ 12.0 million
<b>Information and awareness</b>			
10	Poor technical knowledge on cultivation of new crops & precision farming.	Raising technical knowledge on the cultivation of new crops & precision farming methods.	over a 10 year period is US\$ 7.5 million
<b>Other</b>			
13	Irrigation net work designs not conducive for diversification.	Making irrigation distribution designs favorable for diversification.	over a 15 year period is US\$ 10.0 million

#### 4.9 Linkages of the barriers identified

Barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independent of one another. Therefore, analyzing barriers in isolation will be less productive as such an approach tends to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies in the food sector are analyzed so as to ensure maximizing synergies and optimize the benefits of recommended measures.



Most of the barriers and measures to overcome barriers are technology specific and fall within broad categorization for barriers. However, close examination reveals some common elements among them. In the case of quite a number of barriers, certain similar enabling measures seem to occur. However, it is not so in the case of key barriers.

#### 4.10 Enabling framework for overcoming the barriers in the Food Sector

Enabling measures can be non-specific to technologies at the higher level, but becomes more technology specific at a detailed level. The technology-specific enabling measures for the four common barriers are summarized in the Table 4.14.

**Table 4.14: Key Measures Identified for the Common Barriers to the three Prioritized Technologies – Food Sector**

Common Barriers	Technologies Affected	Measures to overcome key barriers
Inadequate Finances	CBF,SLM, CD&PF	<ul style="list-style-type: none"> <li>• Set up financing mechanisms for specific technology packages.</li> <li>• Introduce incentive packages .</li> </ul>
Poor risk management tools	CBF, SLM	<ul style="list-style-type: none"> <li>• Develop insurance schemes.</li> <li>• Extend subsidy schemes for specific technology components.</li> </ul>
Poor policy framework	CBF,SLM, CD&PF	<ul style="list-style-type: none"> <li>• Establish consultative mechanisms with the representation of all stakeholders.</li> <li>• Support development of producer Associations.</li> </ul>
Inadequate R&D	CBF,SLM, CD&PF	<ul style="list-style-type: none"> <li>• Increase support to public and private R&amp;D institutions.</li> </ul>

#### 4.11 Proposed Action Plan for the Food Sector

proposed Action Plans for the identified three technologies for food Sector are in Annex VIII

# CHAPTER 5

## Health Sector

### 5.1 Overview of the Health Sector

The Climate Change has both direct and indirect effects on the human health. The common direct health effects are incidents of vector including rodent and water borne diseases such as Malaria, Dengue, Yellow fever, leptospirosis etc. Conditions associated with extremes of temperature in the form of heat waves and cold spells are also considered as direct effects. The effect of natural disasters and extreme weather events also contribute to many health impacts such as disability, communicable diseases, psycho-social problems etc on humans. On the other hand, protracted or sudden weather events indirectly affect human health through crop failure, loss of live stock, livelihoods etc. Underdeveloped countries and nations will be affected more compared to developed nations as they are capable of implementing required mitigation and adaptation mechanism to minimize human suffering<sup>17</sup>.

Sri Lanka is vulnerable to climate change related factors such as extreme situations of temperature changes and rainfall patterns. These conditions will influence the prevailing ecosystem equilibrium with changes in hydrology and agriculture, which will influence microbial contamination pathways. Transmission dynamics of vectors which are common in Sri Lanka are vulnerable to change depending on environmental factors such as temperature, rainfall regimes, sanitation, etc. The broad categories of health outcomes anticipated due to climate change are, increased incidents of morbidity and mortality through air pollution, water and food borne diseases, vector and rodent borne diseases and impacts of food and water shortages.

Climate change impacts in Sri Lanka are particularly significant in the following areas<sup>72</sup>:

- o Vector borne diseases—essentially mosquito borne diseases
- o Rodent borne diseases
- o Food and water borne diseases
- o Nutritional status
- o Other environment related disorders

The status and development of the health sector in Sri Lanka depends on the ability and capacity of the service providers, aspirations and demands of the people of the country and the vision of the government. There should be a balance between the supply and demand as the major health provider remains to be the public sector though the private sector is rapidly growing. Another factor is that the existence of other systems providing healthcare services to population other than the Allopathic Medicine i.e. Aurvadic, Homeopathy, Unani, Siddhi, and Indigenous. Except for Aurvadic system, the government involvement in other systems is negligible at present. Moreover, currently the country is going through a transition period of economic growth and every sector is expanding and growing. Basically all the aforesaid factors influence the development of the health sector of the country. Currently the country enjoys a better health conditions among the South Asian countries. But due to

various factors it is not a period to be complacent of the state of the health services.

The Government of Sri Lanka has ratified the statements of the Convention of the WHO as a member state and the Ministry of Health (MoH) through its Vision, Mission and objectives which describes the roles of the sector provider, has aligned with the obligations of the Convention. The Vision is “to build a healthier nation that contribute to its economic, social, mental and spiritual development”, and the Mission is “to contribute to social and economic development of Sri Lanka by achieving the highest attainable health status through promotive, preventive, curative and rehabilitative services of high quality made available and accessible to people of Sri Lanka”. The objectives are; to empower community for maintaining and promoting their health, to improve comprehensive health services and health actions, to strengthen stewardship and management functions, to improve management of human resources for health, and to improve health finances, mobilization, allocation and utilization. Currently, the health development activities are conducted according to the *Mahinda Chintana* i.e. the national program on sustainable development which is basically a reflection of the objectives of the MoH.

The sector vulnerability profiles developed for Sri Lanka in 2010 has identified the health sector as one of the most critical sectors for the climate change vulnerability<sup>71</sup>. According to IPCC 2001 report, vulnerability varies with geographical location, time, social, economic and environmental conditions (IPCC.2001). The report also states that, the ability of human system to adapt to and cope with climate change depends on factors such as wealth, technology, education, information, skills, infrastructure, access to resource, and management capabilities.

### 5.1.1 Existing Policies and Laws related to Sector and Technology Development in the Health Sector

The Existing Policies and Laws related to Health Sector are given in table 5.1 & 5.2.

**Table 5.1: Existing Policies related to Health Sector**

Title	Date Enacted/ Revised	Contents
Mahinda Chintana.	2005 and 2010	Strengthening of family, poverty alleviation, provision of shelter, nation building, agriculture and industry development, energy policy, science & technology, health and sustainable development.
National Policy and Strategy on Cleaner Production for health Sector.	2007	Objectives of the policy are (a) to establish eco efficient consumption patterns for optimum resource management in the framework of the health care system (b) to establish environmentally sound waste management practices emphasizing preventive measures in the health care system (c) to promote social responsibility and community participation through eco-friendly consumption and production in the health sector (d) to inculcate CP consciousness among health care workers and professional for better curative and preventive services.

National Environmental Policy	2003	The policy aims to promote the sound management of Sri Lanka's environment balancing the needs for social and economic development and environmental integrity. It also aims to manage the environment by linking together the activities, interests and perspectives of stakeholders and to assure environmental accountability.
National policy on Solid Waste management.		Objectives of the policy are (a) to ensure environmental accountability and social responsibility of all waste generators, waste managers and service providers (b) to actively involve individuals and all institutions in integrated and environmentally sound solid waste management practices (c) to maximize resource recovery with a view to minimize the amount of waste for disposal and (d) to minimize adverse environmental impacts due to waste disposal to ensure health and well being of the people and on ecosystems.
National Climate Change Adaptation Strategy for Sri Lanka (NCCAS)	2011	Strategic Trust areas addressed by the Strategy are; <ul style="list-style-type: none"> <li>o Mainstream climate change adaptation into national planning and development</li> <li>o Enable climate resilient and healthy human settlements</li> <li>o Minimize climate change impacts on Food security</li> </ul>
		Strategic Trust areas addressed by the Strategy are; <ul style="list-style-type: none"> <li>o Mainstream climate change adaptation into national planning and development</li> <li>o Enable climate resilient and healthy human settlements</li> <li>o Minimize climate change impacts on Food security</li> <li>o Improve climate resilience of key economic drivers.</li> <li>o Safeguard Natural resources and biodiversity from climate impacts</li> </ul>

**Table 5.2: Existing Laws related to Health Sector**

	Title	Date Enacted /Amended	Contents
1	Medical Ordinance No 26 and subsequent acts since 1947.	1927 Acts since 1949	Registration of doctors, Dentists, Nurses, Pharmacists and AMOs. Medical Faculty of Colombo, Penal erasure, Medical Council.
2	Quarantine and Prevention of Diseases Ordinance No 3 & subsequent amendments.	1897	Procedures to prevent spread of communicable diseases.
3	National Environmental Act No. 47.	1980/1988/ 2000	Establishment of CEA, prevention of environment pollution, preservation of endangered ecosystems.
4	Lepers Ordinance No. 4 Chapter 560, Vol. 17 of Legislative Enactments & Subsequent amendments since 1952.	1901	Ordinance to provide for the segregation and treatment for lepers. Segregation was done away in a subsequent amendment.
5	Health Services Act No.12 & Subsequent amendments.	1952/1956/ 1977	Constitution and responsibilities of the department of health, establishment of efficient administration by local authorities to ensure adequate Public health.
6	Private Health Institution Registration Act No. 21.	2006	Regulations for registration, organization, monitoring, and further development.

7	National Kidney Foundation of Sri Lanka Act No. 34.	2006	Establishment of the national foundation.
8	Prevention of Mosquito breeding Act No. 11.	2007	Control of mosquito breeding sites, eradication of places of mosquito breeding.
9	Cosmetics, Devises and Drugs Act No. 27 &Subsequent amendments.	980	Production of Cosmetics, devises and drugs, Importation of the same, distribution and trad eregulation and control; establishment of a CCD technical committee for the above, etc.
10	Control of Pesticides Act No. 33.	1980 2011 (amendment)	Control and regulate importation, transport, storage and selling of pesticides in Sri Lanka.

As health sector related activities produce negligible amount of Greenhouse Gases (GHGs), climate change related interventions in the health sector will be confined to adaptation technologies only.

The available adaptation technologies fall within three categories;

- a) New Technologies ie. introduction of new vaccines, drugs and insecticides.
- b) Relatively new technologies being disseminated in developing Countries e.g. well equipped mobile laboratories; Computer based information and reporting systems.
- c) Well established technologies subjected to their sustainability and ability for further improvement.

In Sri Lankan context, it is ideal to support all the above, but when considering use of a particular technology it is imperative to assess its potential risks against the benefits.

## 5.2 Identified Adaptation Technologies in the Health Sector

Following nine (09) adaptation technology options were initially considered for the Health sector as priority technologies.

- a) Transfer of knowledge and skills to Health Personnel.
- b) Diagnostic facilities to detect water borne diseases.
- c) Technology to detect, prevent and control water borne diseases.
- d) Technology for Early Warning Systems and net-working for information exchange on extreme events and other Climate Change related events.
- e) Research to identify the magnitude of diseases and other aspects affecting human health due to climate change.
- f) Drinking water quality improvement through continued surveillance during and after extreme weather events.
- g) Technology to improve urban health inputs to adapt to climate change and extreme weather events related adverse health impacts.
- h) Technology to enhance adaptability of the people to overcome traumatic effects due to climate change related extreme events.
- i) Technology for management of health care waste.

## 5.2.1 An Overview of Possible Adaptation Technology Options and Adaptation Benefits

The technologies identified have various potential benefits towards building resilience for climate change adaptation. Table below gives a brief outline of the potential benefits of the climate change adaptation technologies identified for the health sector.

**Table 5.3: Overview of adaptation benefits of the proposed technologies of the Health Sector**

No	Technology	Adaptation Benefits
1.	Transfer of knowledge and skills to Health Personnel.	<ul style="list-style-type: none"> <li>• This technology will help to adapt or to minimize the adverse health effects of climate change such as vector borne and food borne diseases, injuries and the effects of extreme weather events like floods, landslides, drought, thunderstorms and lightning etc.</li> <li>• Manage and control respiratory conditions due to presence of allergens other particles in the atmosphere due to air pollution.</li> <li>• Training will enhance the ability of the health personnel to reduce the chances of patients getting complications.</li> <li>• In situations of extreme events the injured will be attended skillfully and timely preventing further complications and disabilities.</li> </ul>
2.	Diagnostic facilities to detect water borne diseases.	<ul style="list-style-type: none"> <li>• The technology will enable early detection of pathogens responsible for speedily spreading water borne diseases as well as pathogens in water sources for confirmation.</li> <li>• Ensure prevention of major outbreaks and complications/ carrier states.</li> <li>• Monitor pesticides and other harmful chemical contaminants in water sources.</li> <li>• Complement in flood situation/ protracted drought situation related preventive health activities and other programs.</li> </ul>
3.	Technology to detect, prevent and control water borne diseases.	<ul style="list-style-type: none"> <li>• Transfer of knowledge and skills to health personnel to identify, confirm, treat and prevent of further spread of VBD.</li> <li>• By prevention of large scale outbreaks by early detection and information sharing.</li> <li>• Implementation of control measures at early stages concurrently.</li> <li>• Logistics management with early warnings.</li> <li>• Enhancement of the control and related multi-sector activities enabling containment of the disease at early stages.</li> </ul>
4.	Technology for Early Warning Systems and net-working for information exchange on extreme events and other Climate Change related events.	<ul style="list-style-type: none"> <li>• Risk knowledge gained following risk assessments help to develop preventive mechanisms and further enhance Early Warning Systems and networking among different agencies.</li> <li>• Systems with monitoring and predicting capabilities provide timely estimates of the potential risk faced by communities, economies and the environment..</li> </ul>

		<ul style="list-style-type: none"> <li>• Communication networks are needed for delivering warning messages to the vulnerable locations to alert local and regional governmental agencies. The messages need to be reliable, synthetic and simple to be understood by authorities and public.</li> <li>• Coordination, good governance and appropriate action plans are key elements in effective early warning. Likewise, public awareness and education are critical aspects of disaster management.</li> <li>• The technology will contribute to climate change adaptation through, providing sufficient time for health personnel to prepare action plans based on contingency plans to minimize and respond to expected effects.</li> <li>• Provide Health and administrative authorities to enable early preparations along with the support of NGO, UN agencies, Private sector and Community organizations.</li> <li>• The general public at individual, family, community and country level will be informed to participate in adaptation activities.</li> </ul>
5.	Research to identify the magnitude of diseases and other aspects affecting human health due to climate change.	<ul style="list-style-type: none"> <li>• The knowledge of effect of some known adverse health outcomes of climate change will assist the policy makers to take the priority policy and strategy changes.</li> <li>• The outcome will enable the researchers to identify the magnitude of potential health impacts and recommend appropriate actions.</li> <li>• It also will provide an opportunity to transfer knowledge and practices and behavior to the people at risk.</li> </ul>
6.	Drinking water quality improvement through continued surveillance during and after extreme weather events.	<ul style="list-style-type: none"> <li>• Identification of water sources contaminated with disease causing pathogens by regular testing.</li> <li>• Monitoring of drinking water purification will ensure the quality.</li> <li>• Contaminated sources can be cleaned and used to alleviate local shortages.</li> <li>• The technology can be used to communicate with the local community at different levels, thus improving participation and enhancing hygienic practices.</li> </ul>
7.	Technology to improve urban health inputs to adapt to climate change and extreme weather events related adverse health impacts.	<ul style="list-style-type: none"> <li>• Strengthening urban health services will help the urban populations specially, vulnerable groups like slum dwellers, street people, people living in coastal areas to prevent and /or minimize the adverse health effects of climate change.</li> <li>• Recent extreme weather events like floods, earth slips have regularly affected the urban areas. Air pollution, “heat island effect”, disease outbreaks and mental stress are other health related aspects of climate change. Hence, strengthening the health services is very vital to prevent impacts of climate change.</li> </ul>

		<ul style="list-style-type: none"> <li>• Strengthening the health services in urban areas through providing opportunities to develop skills of health care personnel attached to the local bodies will help the urban people to take better alternatives and practices to avoid undue effects of climate change.</li> </ul>
8.	Technology to enhance adaptability of the people to overcome traumatic effects due to climate change related extreme events.	<ul style="list-style-type: none"> <li>• The technology will help to identify affected people and to provide assistance to improve adaptability.</li> <li>• The families and communities will be regularly provided the services to minimize the health, social and economic impacts.</li> <li>• Health seeking behavior of the community with regard to mental illnesses will be improved.</li> </ul>
9.	Technology for management of health care waste.	<ul style="list-style-type: none"> <li>• Reduce the impacts on human health and wellbeing.</li> <li>• Minimize the adverse impacts on environment (air, water, soil, animals, plants and land).</li> <li>• Reduce the disturbances to public security and order.</li> <li>• Generally, proper HCWM practices do not pose risks as that of the ordinary waste management.</li> </ul>

### 5.3 Criteria and process of technology prioritization

The prioritization of technology options for climate change adaptation in the health sector has been carried out through an extensive stakeholder consultative process utilizing the Multi-Criteria Decision Analysis (MCDA) approach. This approach provided opportunity to assess technologies across a range of development and sustainability criteria. As described in the MCDA manual, the chronological order of events of the MCDA included establishing the decision context, identification of the objectives and criteria, scoring, weighting, combining weight and scores for each technology, examining the results and sensitivity analysis.

#### 5.3.1 Multi Criteria Decision Analysis (MCDA)

##### a) Determination of Criteria and Weightings

The criteria for evaluating potential technologies included cost of technologies, and economic, social, & environmental benefits. The scoring system adopted to evaluate the technological options is given in Table 5.4. Accordingly, each option was given a total score on a scale of 0 -100 by using the weight factor assigned for each criterion. The Weight Factor for each criterion was set by apportioning 100 points based on their relative importance.



**Table 5.4: Criteria and Weighting Factors Identified for the Health Sector**

Category		Criteria	Weight Factor
<b>Cost (25)</b>		(US \$) for implementation of the Technology	25
<b>Benefits (75)</b>	<b>Economic (5)</b>	Minimal energy use for Technology	5
	<b>Social (52)</b>	Access to Services	12
		Long-term health benefits	25
		Local & Multi-sector involvement	9
		Employment Generation	6
	<b>Environmental (18)</b>	Minimize Eco-system Degradation	8
		Impact on Pollution	10

### a) Scoring Matrix

The Scoring Matrix constructed based on the above criteria and the results of the MCDA are given in Table 5.5 below. (See Annex IV for weighted scores, costs and benefits of technologies)

**Table 5.5: Results of the MCDA - Health Sector**

Technology	Cost \$ US	Benefits	Rank
<b>1</b>	50,000	69.00	<b>(2)</b>
<b>2</b>	50,000	29.20	8
<b>3</b>	112,500	32.00	9
<b>4</b>	50,000	71.00	<b>(1)</b>
<b>5</b>	55,000	35.40	4
<b>6</b>	50,000	32.00	5
<b>7</b>	36,000	28.00	7
<b>8</b>	43,750	29.70	6
<b>9</b>	62,500	43.90	<b>(3)</b>

The Figure 5.1 below illustrates the Benefits plotted against the Costs. The Benefit Vs Cost graph helped determining the most preferred technologies. Based on the results of the analysis, option Nos. 5, 1 and 2 were selected as the most preferred technologies in the order of priority. Then a sensitivity analysis was carried out by changing the weights assigned to cost of technologies and social criterion. However, this did not show any significant change to the above results.

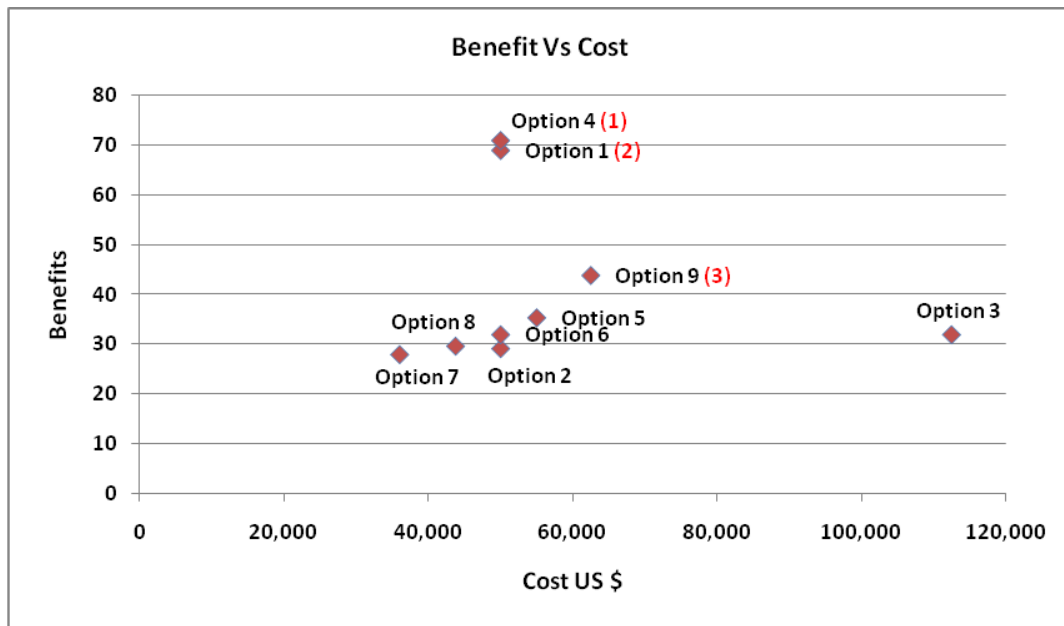


Figure 5.1: Benefit Vs Cost Plot for Identified Technology Options for Health Sector

#### 5.4 Results of the Technology Prioritization for the Health Sector

The results of the Multi-Criteria Decision Analysis ranked the identified technologies in order of priority as shown below.

- a) **(Option 4) Early Warning Systems and net-working for information exchange on extreme events and other Climate Change related events.**
- b) **(Option 1) Transfer of knowledge and skills to Health Personnel.**
- c) **(Option 9) Management of Health Care waste.**
- d) (Option 5) Research to identify the magnitude of diseases and other aspects affecting human health due to climate change.
- e) (Option 6) Drinking water quality improvement through continued surveillance during and after extreme weather events.
- f) (Option 8) Technology to enhance adaptability of the people to overcome traumatic effects due to climate change related extreme events.
- g) (Option 7) Technology to improve urban health inputs to adapt for climate change and extreme weather events related adverse health impacts.
- h) (Option 2) Diagnostic facilities to detect water borne diseases.
- i) (Option 3) Technology to detect, prevent and control water borne diseases.

Accordingly, technological options 4, 1 and 9 were rated as preferred priority Technologies for the Sector.

**Table 5.6: Summary Table for Prioritized Technologies for the Health Sector**

No	Name of the Technology	Scale of Application (Small, Medium or Large Scale)	Time Scale (Approx number of years)	Potential Mitigation (GHG emission reduction) in the Time Scale	Benefits (Output from the MCDA)	Estimated total lifetime Cost \$ US
1.	Early Warning Systems and networking for information exchange	Large	3	NA	71	50,000
2.	Transfer of knowledge and skills to Health Personnel	Large	3	NA	69	50,000
3.	Management of Health Care waste	Medium	3	NA	44	62,500

#### 5.4.1 Categories of the Prioritized Technologies

To facilitate the barrier analysis, it is useful to categorize technologies according to the types of goods and services they belong or contribute to, as the different types of goods and services have distinct market characteristics. The transfer and diffusion of technologies within each category are influenced either by market decisions or political decisions. The diffusion of consumer goods and to some extent capital goods are generally dominated by market decisions, whereas publicly provided goods and non-market goods are primarily diffused through political decisions. Governments therefore have a direct influence on the diffusion of publicly provided and non-market goods.

**Table 5.7: Prioritized Technologies and Categories in the Health Sector**

No	List of Prioritized Technologies	Category of the Technology
1.	Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events.	Non-market goods.
2.	Transfer of knowledge and skills to Health Personnel.	Non-market goods.
3.	Health Care Waste Management.	Publicly provided goods.

#### 5.5 Preliminary targets for technology transfer and diffusion

The preliminary target is the groups that directly benefits from the adaptation technologies. The preliminary targets will vary depending on the particular technology adopted and the subsequent projects implemented based on the respective technology. In general, officials at the national and sub-national levels involved in work related to priority technologies and the relevant projects will be the

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primary target groups for transfer and diffusion of the technologies.

#### **a) Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events**

The target group of this technology will be those personnel who will be specifically engaged in emergency and disaster related activities, health educators (Health education Officers, Public Health Inspectors etc), and health administrators at national and sub-national levels (Provincial, district and divisional). The estimated total number of personnel to be benefited during the project period is 1250-1400. Island wide diffusion of the technology will take place over a time span of eight to ten years.

This technology is not a novel one for Sri Lanka. Some activities related to this technology are already ongoing and the objective of selecting this technology is to sustain and to strengthen the activities in progress and to fill the major gaps identified.

#### **b) Transfer of knowledge and skills to Health Personnel**

The estimated number of beneficiaries of this technology is 2000-2500 health personnel during the project period of 5-8 years. This target will include fifty (50) from health institutions in each district (total of 1250), 750 from different institutions of the Ministry of Health, and 50 from Municipality health workers. The country wide diffusion of the technology will take 5-8 years.

Training of health workers on climate change and effects on human health and other aspects is also an ongoing process and an awareness program is being conducted by the Environmental and Occupational Health Directorate of the Ministry of Health for health workers in the districts. Many other organizations are also conducting, school programs, public lectures, exhibitions etc. The aim of the technology is to go beyond the awareness creation and to provide the health workers with necessary knowledge, skills and attitudinal changes to enhance adaptation measures in the society through health sector initiatives. This program is also aimed at training master trainers for the purpose of training the trainers.

#### **c) Technology for management of Health Care Waste**

The preliminary target for technology transfer and diffusion is 25 selected major health institutions in the island. The number of health workers to be benefited from this component will be 300-350 (5 or 6 persons from each institution). The expected duration for transfer and diffusion of the technology island wide is 12 – 15 years. Institutions in underserved areas will be given priority during program implementation.

### **5.6 General Description, Barrier Analysis and Possible Enabling Measures for Prioritized Technologies**

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### 5.6.1 General description of the "Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events"

Early warning (EW) is “the provision of timely and effective information, through identified institutions, that allows individuals exposed to hazard to take action to avoid or reduce their risk and prepare for effective response.”, and is the integration of four main elements<sup>48</sup>.

1. Risk Knowledge: Risk assessment provides essential information to set priorities for mitigation and prevention strategies and designing early warning systems.
2. Monitoring and Predicting: Systems with monitoring and predicting capabilities provide timely estimates of the potential risk faced by communities, economies and the environment.
3. Disseminating Information: Communication systems are needed for delivering warning messages to the potentially affected locations to alert local and regional governmental agencies. The messages need to be reliable, synthetic and simple to be understood by authorities and public.
4. Response: Coordination, good governance and appropriate action plans are a key point in effective early warning. Likewise, public awareness and education are critical aspects of disaster mitigation.

The rationale behind early warning is to enable prior and accurate prediction of potential short and long-term risks associated with natural and human-induced hazards to facilitate proper management and mitigation of disaster impact on society, economies, and the environment.

Early warning systems help to reduce economic losses and mitigate the number of injuries or deaths from health disasters, by providing information that allows individuals and communities to take precautionary actions to prevent health hazards. If well integrated with risk assessment studies and communication and action plans, early warning systems can lead to substantive benefits for the health sector in preventing health hazards. It is essential to note that “predictions are not useful, however, unless they are translated into a warning and action plan the public can understand and unless the information reaches the public in a timely manner”. Effective early warning systems for the health sector embrace all aspects of emergency management, such as, risk assessment analysis, monitoring and predicting location and intensity of the disaster waiting to happen, communicating alerts to health sector authorities and general public in order to take necessary advance precautionary measures.

The responsibility for development of all hazards Early Warning System lies with the National Disaster Management Centre (NDMC) as per the provisions of the National Disaster Management Act of 2005<sup>35</sup>. Accordingly, the NDMC has developed a Road Map for Risk Management, which includes all hazards EWS.

The aim of multi hazard Early Warning Systems is to generate prior warnings to improve the ability of the decision makers to take appropriate action. The components of EWS are collection, consolidation, analysis and dissemination of risk information. An effective multi hazard EWS needs concerted planning, organizing, and control of relevant information. In addition influencing all concerned stakeholders to ensure that information is disseminated to the right decision makers and vulnerable communities at the right time.

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The present EWS have come into existence in Sri Lanka as a response to the impact of the tsunami disaster in 2004. These should be integrated to promote a multi hazard approach to make the system sustainable. Although there are numerous efforts to develop tsunami EW capacities, efforts towards improving existing capacities for other more frequent hazard are inadequate. The multi hazard EWS needs to be end-to-end linking hazard detection systems with warning communication, and a feedback mechanism that allows post event assessments.

It is also important to note that agencies in Sri Lanka are organized based on the specialized tasks for different hazards. For example, the Epidemiology Unit of the Ministry of Health deals with disease out breaks, the Meteorological Department is specialized in Hydro-meteorological Hazards and the Geological Survey and Mines Bureau is involved with Geological hazards etc., sans effective information sharing or partnership with other agencies. These gaps need to be addressed by bringing together all concerned agencies. Another key issue that warrants attention is the poor state of communication systems and specially their unavailability during times of emergencies<sup>106</sup>.

Basically, what is required under the present context is to transform the existing EWS to an effective one. For this purpose the agencies responsible should follow the directions given in the definition of Early Warning System and fulfill its four components to make the available EWS in the island a reliable, timely, cost-effective, sustainable, user friendly tool for the country and the people<sup>88</sup>.

#### **5.6.1.1 Identification of barriers and measures for the technology**

Through an extensive stakeholder consultation process, barriers for transfer and diffusion of the technology were identified and grouped into 'Economic and Financial' as well as 'Non-financial' categories as provided in the Guide book (Overcoming Barriers to the Transfer and Diffusion of Climate Technologies). Accordingly, one (01) economic & financial barrier and the five (05) non-financial barriers have been identified.

The measures to overcome the barriers are given below.

**Table 5.8 : Key Barriers and measures identified for the Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events**

No	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial</b>			
1	Inadequacy of financial resources and unfavorable financial regulations.	Allocation of required funds by the government and explore for alternative funding sources and mechanisms.	Implementation cost for over a three year period is US\$ 13,000
<b>Non Financial</b>			
<b>Policy, legal and regulatory</b>			
2	Feeble policies and policy reviews.	Regular streamlining and monitoring of policies and creating stakeholder awareness on existing policies and their involvement in policy reviews.	Implementation cost for over a three year period is US\$ 6,000
<b>Institutional and Organizational Capacity</b>			
3	Absence of an established structure for EWS and networking for information sharing across the sectors.	Align with the existing Government structure (National Disaster Management Centre of the Ministry of Disaster Management), establish focal points at the Ministry and sub-national levels to liaise with relevant sectors.	Implementation cost for over a three year period is US\$ 18,000
4	Administrative gaps in relevant sectors.	Identify a focal point and a responsible unit for the purpose. Provide training and assign specific functions and responsibilities.	Implementation cost for over a two year period is US\$ 18,000
5	Poor utilization of novel technologies for EWS.	Identify and introduce appropriate and affordable novel technologies, assign a second line personnel to take the place of regulars due to attrition.	Implementation cost for over a three year period is US\$ 62,500
<b>Human Skills</b>			
6	Underutilization of trained personnel.	Improve and enhance the use of already available trained personnel.	Implementation cost for over a two year period is US\$ 5,500

### 5.6.2 General description of the "Transfer of Knowledge and skills to Health Personnel"

The theme of the World Health Day of 2008 was “climate change and its impact on global health”. It emphasized that the threat of climate change poses to health is evident and if current global warming trends remain uncontrolled, humanity will face more injury, disease and death related to natural disasters and heat waves; higher rates of food-borne, water-borne, and vector-borne illness; and more premature deaths and disease related to air pollution. Moreover, in many parts of the world, large populations will be displaced by rising sea level and affected by drought and famine. With this growing impact of climate change impact on health, the need for increased numbers of skilled, motivated and facilitated health workers is greater than ever. In the response to climate change, increasing the numbers, quality of training and working conditions of health workers must be seen as a priority to help reduce suffering and save lives<sup>130</sup>.

Strengthening of the Human Resources for Health (HRH) in both public and private sector has been emphasized as one of major activities to be undertaken in the implementation of the Health Master Plan, 2007<sup>34</sup>. Though developing a human resources strategic plan has received low priority in the past, lately the need for such a plan has been emphasized in many forums of the Ministry of Health.

Presently education, training and knowledge transfer is done by state agencies through the Universities and other academic institutions and the private sector including non-governmental agencies supported by donors. However, it is the stakeholder consensus that training of the health workers needs to be based on a proper needs assessment. The current policies should be reviewed to retain the trained personnel at all times. The different training institutions should be given mandate to train health workers based on an agreed training calendar.

Health Personnel to be benefited from implementation of this technology includes personnel working in government as well as non-government agencies and in the private sector. Further, personnel providing promotive, curative, preventive, and rehabilitative care will also need to be considered. The article 12 of the National Health Policy states; '**Human Resource Development**' will be supported and strengthened in keeping with contemporary needs' emphasizing the commitment of the government (National Health Policy, Sri Lanka, 1996).

#### 5.6.2.1 Identification of barriers and measures for the Technology

The barriers and enabling measures for transfer and diffusion of the technology are given below.

**Table 5.9 : Key Barriers and measures identified for the Transfer of Knowledge and skills to Health Personnel**

No	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial</b>			
1	Inadequate financial resources for human resource development.	Provide sufficient funds (government and other avenues) and facilities for training and human resource development.	Implementation cost for over a two year period is US\$ 4,500
<b>Non Financial</b>			
<b>Network failure</b>			
2	Poor coordination of training activities.	Establish and strengthen a coordination unit and a mechanism. Preparation and sharing of an annual training calendar, and to solicit technical assistance from other agencies.	Implementation cost for over a one and half year period is US\$ 12,500
<b>Institutional and Organizational Capacity</b>			
3	Training needs are not identified.	Conduct training needs assessments and design trainings accordingly.	Implementation cost for over a eight year period is US\$ 222,500



4	Modern educational technologies are not utilized.	Explore and provide opportunities to use modern educational methodologies and technologies.	Implementation cost for over a period of one year is US\$ 5,000
5	Unavailability of a mechanism/s to monitor diffusion of knowledge and skills, including to the general public.	Develop and integrate a M & E mechanism into an existing system to monitor and evaluate transfer and diffusion of knowledge, and record lessons learnt for incorporation into future M&E purposes.	Implementation cost for over a period of eight years is US\$ 15,000
<b>Human Skills</b>			
6	Shortage of competent trainers.	Provide financial and non - financial benefits, pooling of trainers from other sectors, provision of a due recognition to trainers.	Implementation cost for over a period of two years is US\$ 5,000

### 5.6.3 General description of the "Technology for management of Health Care Waste"

The World Health Organization identifies health care waste management as a measure to reduce the burden of disease, including alternatives to incineration<sup>129</sup>. Of the total amount of waste generated by health-care related activities, about 80% is general waste comparable to domestic waste. The remaining 20% is considered hazardous material that may be infectious, toxic or radioactive.

The major sources of health-care waste are:

- hospitals and other health-care establishments,
- laboratories and research centers,
- mortuary and autopsy centers,
- animal research and testing laboratories,
- blood banks and collection services,
- nursing homes for the elderly,

Estimated total health care waste produced by listed government hospitals is estimated to be between 77, 000 and 171, 000 kg daily. This figure does not include health care waste generated by the private sector managed hospitals. Information on health care waste generated by the private sector health institutions is currently not available and there is no streamlined mechanism to collect such information as well. Using WHO estimates<sup>17</sup> the daily hazardous waste production in the listed government hospitals in Sri Lanka is between 7,662 and 42,697 kg daily. The health care waste generated by the State hospitals in Sri Lanka is currently disposed off through the following methods;

- Collection by Local Authority followed by dumping.
- Burning within the premises.
- Burying within the premises.
- Dumping at a designated site within the hospital premises or at a designated dumping site of the Local Authority.

Although the general health care waste is presently disposed as per the WHO recommendations, the hazardous waste component is disposed along with the general waste in a common disposal system. Hazardous waste is not treated before releasing into the general waste stream to render it non-hazardous. Some major hospitals in the island are collecting waste using the internationally accepted color coded system.

Efforts are now being made by the Ministry of Health to streamline the management of health care waste through a healthcare waste management policy which is now under preparation. At the moment the Local Government Bodies are disposing the non-clinical waste. But, in most of the instances the stages of collection, separation, storage, transportation, and disposal is yet to be in par with the acceptable procedures. Some private sector agencies also provide services to dispose off expired drugs and devices by incineration under high temperature in cement factories. Still the diffusion of knowledge and practices to the periphery has not taken place.

### 5.6.3.1 Identification of barriers and measures for the technology

The barriers identified are comprised of two (02) economic & financial barriers and four (04) non-financial barriers. The barriers and respective enabling measures are given Table 5.9.

**Table 5.10 : Key Barriers and measures identified for the Technology**

<b>Technology for management of Health Care Waste</b>			
<b>No</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost of Implementation for the Target Years</b>
<b>Economic and Financial</b>			
1	Treatment technologies of health care waste are expensive.	Explore funding sources, public - private partnerships and identify low - cost technologies.	Implementation cost for over a period of two years is estimated as US\$ 25,000.
2	Lack of long term sustainability of ongoing activities.	Feasibility studies on different technologies being used and implementation of sustainable technologies.	Implementation cost for over a period of three years is estimated as US\$ 30,000.
<b>Non Financial</b>			
<b>Institutional and Organizational Capacity</b>			
3	Shortage of technical staff to manage regular health care waste management activities.	Provide in - service training to interested and qualified persons, provide opportunities for career development and take measures to retain trained personnel for a stipula	Implementation cost for over a period\ of three years is estimated as US\$ 15,000.

<b>Social, Cultural, Behavioral Barriers</b>			
4	Inadequate commitment of policy planners and administrators.	Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other donors.	Implementation cost for over a period of one year is estimated as US\$ 3,000.
<b>Information and awareness</b>			
5	Poor awareness among health personnel including administrators.	Awareness creation among health personnel and policy makers.	Implementation cost for over a period of one is estimated as US\$ 17,500.
<b>Network failures</b>			
6	Inadequate inter - sectoral coordination.	Establish a mechanism to improve the inter - sectoral coordination.	Implementation cost for over a period of two years is estimated as US\$ 20,000.

## 5.7 Linkages of the barriers identified

Although the technologies proposed are different from each other, yet some general or common characteristics can be identified. Further, barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independently. Therefore, analyzing barriers in isolation will tend to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies are thus analyzed so as to ensure maximizing synergies and optimize the effects of recommended measures.

## 5.8 Enabling framework for overcoming barriers in the Health Sector

The common barriers of the technologies fall within the categories of Economic & financial, Institutional & organizational capacity, Network failures, Human skills and Information & awareness. The barriers under the categories of Technical, Policy, Legal and Regulatory & Social, Cultural & Behavioral are not linked common barriers, although there may be indirect interactions between the technologies of such barriers.

The enabling framework for the key linked barriers could be tabulated broadly as shown in table 5.10 below.

**Table 5.11: Key linked barriers and the Enabling Framework in the Health Sector**

No	Broad/Common barriers	Enabling framework	Technologies
01	Inadequacy of finances and unfavorable financial regulations.	Allocation of sufficient funds from government sources through routine measures and other possible avenues. Exploration of alternative and additional funding sources and mechanisms from government, private sector, national and international development partners and donors. Development of policies conducive to successful transfer & diffusion of technologies by relaxation of financial regulations and developing new policies through assessments.	Technology - 1 Technology - 2 Technology - 3
02	Expensive treatment practices.	Explore private - public partnerships. Implementation of suitable, low - cost technologies identified by research.	
03	Lack of sustainability.	Implementation of feasible and sustainable processes with continued support.	
04	Absence of established structures in the sector.	Assign focal points at all administrative levels where necessary. Align with existing national government structures through the focal points.	
05	Administrative gaps in relevant sectors.	Identify the administrative gaps and take appropriate measures to address them.	
06	Underutilization of available trained personnel.	Make amendments to the HRH Policy to facilitate utilizing currently available human resources in the sector. Design financial and non - financial incentive measures to attract and retain personnel for climate change related health activities.	Technology - 1
07	Poor coordination of training activities.	Appoint a training coordinator in the Ministry of Health. Develop and share an annual training calendar with all stakeholders across the sector. Establish a coordination mechanism with all training institutions by the Ministry of Health.	Technology - 2 Technology - 3
08	Training needs assessments are not conducted.	Conduct regular training needs assessments and design trainings accordingly.	
09	Unavailability of a mechanism to monitor diffusion of knowledge and skills including the general public.	Provide authority to the directorate responsible for monitoring of diffusion of the related technologies. Develop monitoring mechanism with suitable methods and implement on a regular basis.	

10	Shortage of technical staff to manage regular activities.	Training of identified and interested personnel already in service. Pooling of technical personnel from other sectors.	
11	Absence of networking for information sharing across the sectors and within the Health sector at national and sub - national levels.	Regularize the available information sharing mechanisms within the health sector and with other sectors. Extend the existing information generating and sharing mechanisms on disease forecasting and outbreak control to other health issues.	Technology - 1
12	Inadequate inter - sectoral coordination.	Advocacy for policy makers and top administrators. Strengthen the available coordination mechanisms.	Technology - 3
13	Poor utilization of new and innovative technologies.	Identify and implement affordable and appropriate new technologies. Develop policies for maintenance, repair and replacement of equipment used	Technology - 1
14	Shortage of competent trainers.	Make the service HRH for HCWM a closed - service. Identify a set of master trainers from other sectors as well. Establish career development pathways in the service. Provide necessary financial and Non - financial incentives to retain personnel.	Technology - 2 Technology - 3
15	Poor awareness among health personnel including administrators.	Create awareness among health personnel using existing forums and mass media.	Technology - 1

## 5.9 Proposed Action Plans for the Technology

Proposed Action Plans for identified - technologies for Health Sector are in Annex IX

# CHAPTER 6

## Water Sector

### 6.1 Overview of the Water Sector

Water is the most essential ingredient for the sustenance of all living organisms. The total renewable water resources available in the freshwater ecosystems of Sri Lanka is estimated at 49 km<sup>3</sup> as surface water, 8 km<sup>3</sup> as groundwater, and a further 7 km<sup>3</sup> as overlapping water. Surface water includes rivers, villus, man-made reservoirs, minor tanks etc. In Sri Lanka there are 103 distinct natural river basins that cover nearly 90% of the island<sup>47</sup>. Mahaweli River (*Ganga*) is the longest river and it covers about 16% of the island's total area. It is the only perennial river which passes through the dry Zone of the country. The vast ancient reservoirs, small and large tanks and canals built by ancestors are supplemented today with many recently built irrigation and hydropower reservoirs. More than 90% of the small tank systems are clustered into cascades and these tank network systems have been built in water scarce areas by the ancient kings mainly for agricultural purposes.

There are six main types of groundwater aquifers in Sri Lanka. They are shallow karstic aquifers, coastal sand aquifers, deep confined aquifers, lateritic aquifers, alluvial aquifers and shallow regolith aquifers in the hard rock region. In addition to these main aquifers, a large number of small groundwater pockets can be found throughout the country.

In Sri Lanka, water is mainly used for domestic, irrigation, hydropower generation and industrial purposes. Water from protected wells, hand pumps, tube wells, protected springs and pipelines are considered as safe drinking water sources and water from unprotected wells, rivers, tanks and canals are considered as unsafe.

Adaptation technologies already in use in Sri Lanka have been designed primarily in response to decrease in surface water and per capita water availability. These adaptation technologies are important in order to protect health, wellbeing and economic development during the periods of water scarcity. Diversification of water supply by rainwater harvesting from rooftops for drinking and household uses, household drinking water treatment and safe storage, harvesting of surface runoff rainwater, restoration of minor tank networks and desalination of brackish water are some of the measures adopted during water scarcity. The Community Water Supply and Sanitation Project (CWSSP), Lanka Rainwater Harvesting Forum and certain other organizations facilitate rain water harvesting programs in Sri Lanka. When there is a scarcity of surface water, demand for ground water increases, and Boreholes/tube wells are used to extract ground water in such situations.

Based on the average annual rainfall, country is divided in to three climatic zones - wet, intermediate and dry zone. The Dry Zone of Sri Lanka includes much of the east, southeast and northern parts of the country. The southwest monsoon winds bring rainfall mainly to the wet-zone, while the north-east monsoon brings rainfall mainly to the dry and intermediate zones. The two inter-monsoonal periods bring rain spread over the entire country. Out of the total land area of 6.5 million ha, around 4 million ha belongs to the dry zone and it receives the least amount of rain fall. The "dry zone, receives between

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1200 and 1900 mm of rain annually. Much of the rain in these areas falls from October to January; during the rest of the year there is very little precipitation. The arid northwest and southeast coasts receive the least amount of rain - 600 to 1200 mm per year, concentrated within the short period of the winter monsoon (Geography of Sri Lanka). High temperature, prevailing dry winds and non-availability of a plant cover are contributory factors in increasing high evaporation rates in the dry zone to exceed 2000 mm/year.

Most of the cultivations in the dry and intermediate zones is carried out using water from irrigated schemes comprising both ancient systems and modern systems<sup>74</sup>. The vast ancient reservoirs, minor and medium tanks and canals built by ancestors are supplemented with many recent large scale irrigation projects such as Victoria, Randenigala and Kotmale reservoirs. Minor tanks get water from surface water bodies, runoff and from direct rainfall.

### **6.1.1 Vulnerability to climate change**

The rate of increase in the mean air temperature predicted for Sri Lanka, based on the data<sup>3</sup> for the period from 1961 to 1990 is 1.6°C per 100 years and possible impacts predicted on the water sector due to climate change are severe droughts, floods, sea level rise etc. It has been predicted that by 2050, the amount of rainfall receive from the north-east monsoon (December – February) which is the major source of water for the dry zone of Sri Lanka at present, will be reduced by 34% while that received from the south-west monsoon (May–September) will be increased by 38%. This would make the dry zone districts more vulnerable to droughts and the wet zone districts to floods and landslides. Prominent change due to low rainfall will be the expansion of the dry zone. Due to such droughts, surface and per capita water availability will be decreased. The floods due to increase in rainfall intensity will reduce ground water recharge and also would affect quality of surface water, sediment generation and transport of sediments. Studies on the sea level rise have shown an increasing trend for sea water intrusion in certain coastal areas. As a result salinity of surface water and ground water in such areas will be increased.

Night time annual average temperatures have increased faster than daytime, up to a maximum of 0.02 °C per year. National level modeling undertaken by the Sri Lankan Centre for Climate Change Studies has reported that, by 2100 the temperature increase (2.9°C) during the northeast monsoon season (December to February) is more prominent than that of (2.5°C) during the southwest monsoon season (May to September). As temperature increases, evaporation of water increases and it will drive up the demand for irrigation water, contributing to water scarcity especially in the dry zone.

Based on the projections of the IPCC 3<sup>rd</sup> Assessment report and according to the Sri Lanka's second national communication on climate change (2012), the annual rainfall is likely to increase during the south west monsoon rains and decrease in north east monsoon rains. This would make the dry zone districts more vulnerable to droughts. The change in rainfall distribution has caused a shift in the demarcation between the dry and wet zones, with a reduction in the area of the wet zone. Increases in high rainfall events will increase soil erosion, which in turn accelerates the silting up of existing reservoirs, further contributing to water stress. The IPCC has categorized water sector in the South Asian region as one of the highly vulnerable sectors<sup>98</sup>. In addition, the sector vulnerability profiles developed for Sri Lanka in 2010 has identified Water sector as one of the most critical sectors for the climate change vulnerability<sup>71</sup>.

Dry zone receives around 1000 mm rainfall during the Maha season (October – February) and 500 mm in the Yala season (April – July) with a distinct dry season from May to September. The annual average evaporation in the dry zone is between 1,700 mm and 1,900 mm, which exceed the average annual rainfall, implying water stress in the dry zone<sup>47</sup>. The irrigation water demand in the *Yala* season is greater than that of the *Maha* season for the dry zone. The water stress in the dry zone will be further compounded by the impending vulnerability to droughts due to the climate change.

### 6.1.2 Existing Policies and Legislation related to Sector and Technology Development in the Water Sector

The existing policy framework and legislation related to the sector development and technology deployment is given Table 6.1 and 6.2 .

**Table 6.1: Existing Key Policies Involved in the Water Sector**

Name of the Policy	Year		Responsible	Main contents
	Enacted	Revised	Authority	
1. Participatory Irrigation Management (PIM) Policy	1988		Department of Agrarian Development	Full responsibility for O&M of small or minor irrigation schemes given to farmers. Responsibility of managing the head works and the main canal system vested with the irrigation agency. Medium and major irrigation works brought under joint management with FO.
2. The national policy on water supply and sanitation	2000	2011	Ministry of Water Supply and Drainage / NWSDB	Recognized water as a basic human need. Water has an economic value and the user should bear the operational costs of drinking water, sewage and sanitation services.
3. National policy for Rural Water Supply & Sanitation Sector	2001		Ministry of Water Supply and Drainage /	The government to assist promotion of the hygiene education as an integral part of the Rural Water Supply Sector (RWSS) development
4. National Environment Policy	2003		Ministry of Environment	The quality and quantity of surface water, ground water and coastal waters will be managed to balance the current and future needs of ecological systems, communities, agriculture, fisheries, industry and hydroelectric generation.



<b>5. National Rainwater Policy and Strategies</b>	2005		Ministry of Urban Development and Water Supply	Rainwater harvesting made mandatory, yet introduced in phases, in all areas under Municipal and Urban Council jurisdiction within a prescribed time period, as will be prescribed in law, for certain categories of buildings and development works, and shall be strongly promoted in all Pradeshiya Sabha areas.
<b>6. National Policy on Drinking Water</b>				Developing a broad set of strategies to promote the growth of the drinking water sector in terms of the coverage quality as well as the service delivery. Provide guidance to all the actors involved in the sector.
<b>7. Mahinda Chinthanaya</b>			National Planning Department	Strategies to provide safe drinking water to 90% of people by the year 2016 and complete rehabilitation of 10,000 tanks by 2020.

**Table 6.2: Existing Key Laws Involved in the Water Sector**

Name of the Legislation	Year		Responsible Authority	Main contents
	Enacted	Revised		
Urban Development Authority Law No.41,1978	1978	2007	Ministry of Urban Development and Water Supply/ Urban Development Authority	Development plans must incorporate a rainwater harvesting scheme in keeping with National Rain water Policy.
Water Resource Board Act No.29, 1964	1964	1999	Ministry of Irrigation and Water Resources Management/ Water Resources Board	Establishment of the Water Resources Board. Advise the minister on various facets of water resources management. Plans for conservation, utilization, control and development of the groundwater resources of the country.
National Water Supply and Drainage Board (NWSDB) Act (No. 2) of 1974	1965	1978	Ministry of Water Supply & Drainage/ NWSDB	Provide water supply for public, domestic and industrial purposes and to operate a coordinated sewerage system..
Agrarian Development Act 2000	2000		Department of Agrarian Development	Provides a sound policy framework for the establishment and work of FOs,

## 6.2 Identified Adaptation Technologies in the Water sector

Seven (07) potential adaptation technologies were identified as priority technologies through stakeholder consultations and the technologies so identified are focused on the following three aspects.

- Technologies in response to risk of flooding due to increase in rainfall intensity.
- Technologies in response to sea water intrusion into surface and ground water as a result of sea level rise.
- Technologies for resilience to water quantity and quality degradation.

The identified technology options are as follows;

- a) Rainwater harvesting from rooftops for drinking and household uses.
- b) Surface runoff rainwater harvesting.
- c) Household drinking water treatment and safe storage.
- d) Boreholes/tube wells as a drought intervention for domestic water supply.
- e) Solar distillation.
- f) Restoration/rehabilitation of minor tank networks.
- g) Desalination of brackish water by reverse osmosis.

As indicated in the table 6.3, all the adaptation technologies identified fit into one or more typologies because of their ability to contribute to one or more aspect of climate change adaptations. The six typologies are:

- Diversification of water supply.
- Ground water recharge.
- Preparation for extreme weather events.
- Resilience to water quality degradation.
- Storm water control and capture.
- Water conservation.

**Table 6.3: Typologies of the seven adaptation technologies of the Water Sector**

Technology	Typology					
	Diversification of water supply	Ground water recharge	Preparation for extreme weather events	Resilience to water quality degradation	Storm water control and capture	Water conservation
1. Rainwater harvesting from rooftops	✓	✓		✓	✓	✓
2. Boreholes/tubewells			✓			
3. Surface runoff rainwater harvesting	✓	✓			✓	✓
4. Restoration/rehabilitation of minor tank networks	✓	✓			✓	✓
5. Household drinking water treatment and safe storage				✓		
6. Desalination of brackish water by Reverse osmosis	✓			✓		
7. Solar distillation				✓		

The suitable areas/regions for implementation of the proposed technologies are shown in table 6.4 below.

**Table 6.4: Suitable areas/regions for implementation of the proposed technologies for the Water Sector**

Technology Area/Region	Area/Region
1. Rainwater harvesting from rooftops	Island wide as required
2. Boreholes/Tube wells.	Areas where suitable bed rock geology is available for installation.
3. Surface runoff rainwater harvesting.	Dry zone and major cities.
4. Restoration/rehabilitation of minor tank networks.	Dry zone – cascade systems.
5. Household drinking water treatment and safe storage.	Areas where safe drinking water is not available.
6. Desalination of brackish water by Reverse osmosis.	Areas where fresh water is contaminated with saline water.
7. Solar distillation.	Island wide.

### 6.2.1 An Overview of Possible Adaptation Technology Options and their Adaptation Benefits

#### Boreholes/Tube wells as a drought intervention for domestic water supply

Tube wells and Boreholes can be used as alternative domestic water supplies especially during drought periods. Tube wells consist of a narrow, screened tube (casing) driven into a water bearing zone of the subsurface. Tube wells penetrating bedrock with casing not extending below the interface between unconsolidated soil and bedrock is called a Bore hole. Life time is about 10 years.

#### b) Desalination of brackish water by reverse osmosis

During a water scarcity, desalination can be used to produce fresh water from brackish water or sea water. In this technology, high pressure is applied to brackish water/sea water forcing water molecules to pass through a membrane while retaining salts and other larger molecules. This technology contributes to adaptation through diversification of water supply by providing alternative or supplementary sources of water when current water resources is inadequate in quantity or quality Resilience to water quality degradation<sup>116</sup>.

#### c) Restoration of minor tank networks

Ancient tanks “wewa” are primarily rainwater harvesting systems. These tanks get water from surface water bodies, runoff and from direct rainfall. Area of a minor tank is less than 80 ha. and at present 12,120 minor tanks are in working order and the total irrigation potential is about 100,00 ha. In addition, minor tanks provide water for domestic needs, aquaculture and livestock needs<sup>3</sup>. There are a large number of dilapidated and / or silted tanks as well. Restoration of silted or damaged cascade minor tank systems in vulnerable areas is important<sup>107</sup>. This technology contributes to adaptation for climate change in following ways<sup>47</sup>.

- Diversification of water supply.
- Storm water control and capture.
- Groundwater recharge.

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#### **d) Rainwater Harvesting from Rooftops for Drinking and Household Uses**

This technology involves harvesting and storing rain water from roof tops of houses and other public buildings such as /schools, hospitals, industries, other institutions etc. as an alternative water source. This could provide about 30% of drinking and non-potable water for cooking, washing, agriculture etc to enable addressing the water shortage in the dry zone and the intermediate zone. This technology contributes to adaptation for climate change in following ways<sup>116</sup>.

- Reduces water stress during droughts.
- Diversification of water supply.
- Reduce the dependence on ground water and surface water.
- Recharge ground water aquifers.
- Reduce drinking of ground water containing pollutants.
- Storm water control and capture (e.g. collection of rain water from roof tops of flats in Colombo can mitigate flooding).

#### **e) Solar Distillation**

Intrusion of sea water into fresh water will be a problem due to sea level rise. Under such a situation, this technology can be used to produce fresh water. In this method safe drinking water is produced through distillation of fresh water contaminated with sea water/ brackish water by using solar energy. As the water evaporates, water vapor rises and condenses on a glass surface for collection. Life time of the still is about 20 years<sup>132</sup>. This technology would give 44% of drinking water requirement in areas vulnerable to sea level rise. Solar distillation technology can also be used to remove fluoride from fluoride containing water.

#### **f) Surface Runoff Rainwater Harvesting**

In Sri Lanka about 60% of rain water flows into the sea without direct use<sup>102</sup>. Non-availability of adequate rainfall during “Yala” season is a major problem for crop production in the dry zone. In this technology, surface run-off rain water is collected in ponds. This is a micro storage facility and especially suitable for arid and semi-arid regions. It provides supplementary irrigation for about 1-2 ha. of land. Collection of surface runoff rainwater as pokuna/pathaha is presently practiced in certain areas of the country and it has to be expanded. This technology contributes to adaptation for climate change in following<sup>116</sup>.

- Provides additional water supply.
- Reduce pressure on surface and ground water resources.
- Control soil erosion due to rain storm flow.
- Reduce flood inflow to rivers and channels.
- Stabilize ground water table.

#### **g) Household Drinking Water Treatment and Safe Storage**

It is reported that in 2010, up to 88% of waterborne diseases in Sri Lanka were due to consumption of unsafe drinking water<sup>114</sup>. Scarcity of water due to climate change can increase this problem. In 2007, 10% of the total population did not have access to safe water<sup>47</sup>. In 2010, geographical area covered by piped borne water supplies has been around 39 %<sup>116</sup>. Household drinking water treatment is a practical approach to provide safe drinking water. Incorporation of a chemical coagulation for particle removal

(flocculation) and chlorination for disinfection can be used for this purpose. Water purification sachets containing chemicals required for above purpose could either be produced locally or imported and distributed for people who do not have access for safe drinking water. This technology contributes to adaptation for climate change by ensuring a supply of safe drinking water.

### 6.3 Criteria and process of technology prioritization

#### 6.3.1 Multi Criteria Decision Analysis (MCDA)

The methodology used to prioritize the technologies is Multi Criteria Decision Analysis (MCDA) Approach.

##### 6.3.1.1 Determination of Criteria and Weightings

Determination of Criteria and Weightings being the first step of MCDA process, the criteria included cost of technologies, and economic, social, & environmental benefits. Each technological option was given a score against each criterion based on the preference of the respective technology (i.e. the least preferred option getting the lowest score). The weightings assigned for each criterion subdivided into twelve (12) sub-criteria based on the social, economic and environment importance of the adaptation technologies are given in the Table 6.5 below.

**Table 6.5: Criteria Adopted to Prioritize the Adaptation Technologies of the Water Sector**

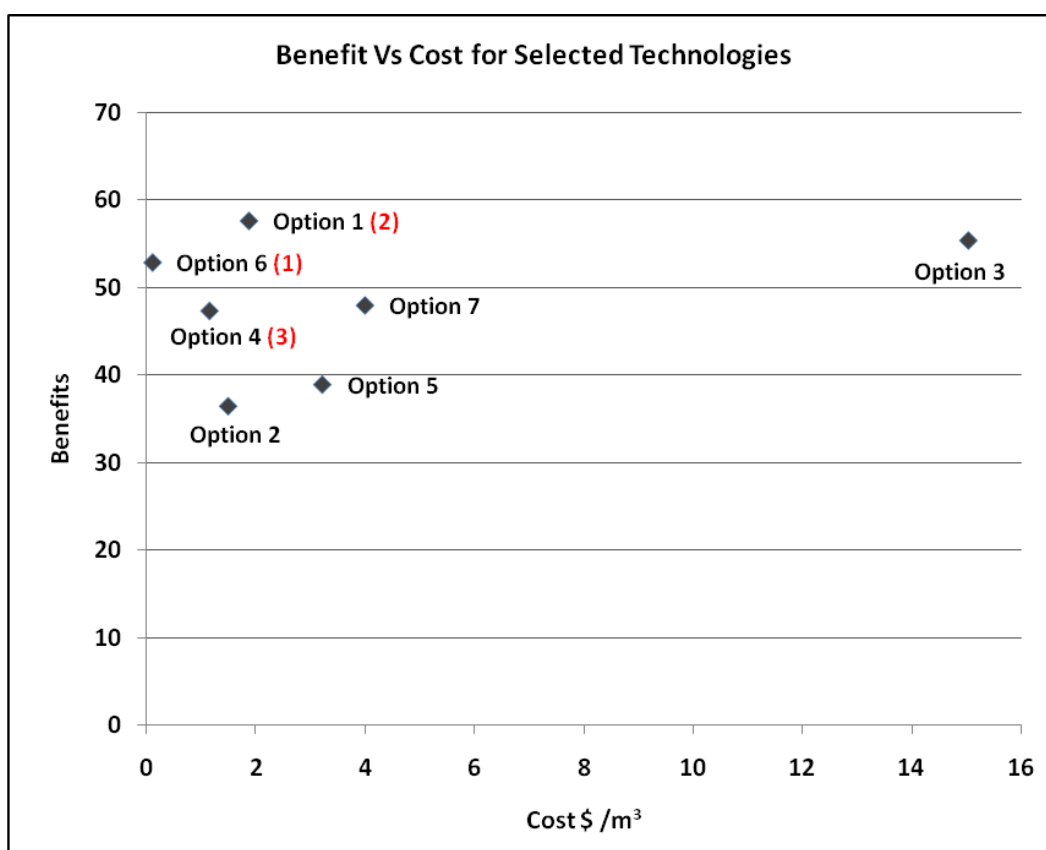
Major Criteria	Sub divisions of criteria selected (Weight factor)		
Costs (20%)	Cost/m3 of water (20%)		
Benefits (80%)	Economic (8%)	Employment (4%)	
		Investment (2%)	
		Low GHG release (2%)	
	Social (54%)	Continuous water supply (15%)	
		Health (20%)	
		Education	Awareness (5%)
			School/University (5%)
			Research (5%)
		Income (4%)	
	Environmental (18%)	Impact on ground water (6%)	
		Impact on surface water (6%)	
		Minimizing flooding (6%)	

#### 6.3.2 Scoring Matrix:

The Scoring Matrix constructed based on the above criteria and weight factors appear in Annex V. The cost and the benefits calculated using the formula “Benefit = Total score – Weighted score of costs” of the selected technologies are given in the Table 6.6 and Figure 6.1 illustrates the Benefits plotted against the Costs. The subsequent sensitivity analysis did not change the results of this analysis significantly.

**Table 6.6: Costs and benefits of the selected technologies and the order of priority with respect to the MCDA - Water Sector**

Adaptation Technology	Cost US \$ /m <sup>3</sup>	Benefit	Rank
(Option 1) Roof top rainwater harvesting	1.88	57.57	<b>(2)</b>
(Option 2) Surface runoff rain water harvesting	1.5	36.51	5
(Option 3) Household drinking water treatment and safe storage	15.03	55.34	7
(Option 4) Boreholes/Tube wells	1.16	47.34	<b>(3)</b>
(Option 5) Solar distillation	3.22	38.97	6
(Option 6) Restoration /rehabilitation of minor tank networks	0.12	52.84	<b>(1)</b>
(Option 7) Desalination by RO	4	47.97	4



**Figure 6.1: Benefit Vs Cost Plot for Selected Technologies for water Sector**

#### 6.4 Results of Technology Prioritization

As per the above MCDA results, the three technologies which received the highest rating in order of priority are (1) Restoration/rehabilitation of minor tank net works (Option 6), (2) Rainwater harvesting from rooftops (Option 1) and (3) Boreholes/tube wells as a drought intervention for domestic water supply (Option 4). Accordingly they are recommended for implementation.

The Multi-Criteria Decision Analysis ranking of the identified technologies in order of priority are as follows:

1. **Restoration/rehabilitation of minor tank networks.**
2. **Rainwater harvesting from rooftops for drinking and household uses.**
3. **Boreholes/tube wells as a drought intervention for domestic water supply.**
4. Desalination of brackish water by Reverse Osmosis.
5. Surface runoff rain water harvesting.
6. Solar distillation.
7. Household drinking water treatment and safe storage.

**Table 6.7: Summary Table for Prioritized Technologies for the Water Sector**

No	Name of the Technology	Scale of Application (Small, Medium or Large Scale)	Time Scale (Approx number of years)	Potential for adaptation in sub sector in the Time Scale	Benefits (Output from the MCDA)	Estimated total lifetime Cost US \$/m <sup>3</sup>
1.	Restoration/rehabilitation of minor tank networks	Large	10	High	52.84	0.12
2.	Roof top rainwater harvesting	Small	7	High	57.57	1.88
3.	Boreholes/ Tube wells	Small	8	High	47.34	1.16

#### 6.4.1 Categories of the Prioritized Technologies

To facilitate the barrier analysis, it is useful to categorize technologies according to the types of goods and services they belong to or contribute to, as the different types of goods and services have distinct market characteristics. Accordingly technologies can be categorized into four generic categories. The transfer and diffusion of technologies within each category are influenced either by market decisions or political decisions. These categories are consumer goods which are specifically intended for the mass market, households, businesses and institutions and capital goods such as machinery, equipment used in the production of goods. The diffusion of consumer goods and to some extent capital goods are generally dominated by market decisions. The publicly provided goods which contribute to the provision of the public services such as roads, bridges, mass transport system, etc, and non-market goods which are non tradable, transferrable and diffused under nonmarket conditions are primarily diffused through political decisions. Government institutions, public or nonprofit institutions, NGOs etc, therefore have a direct influence on the diffusion of publicly provided and non-market goods.

**Table 6.8: Prioritized Technologies and Categories in the Water Sector**

No	List of Prioritized Technologies	Category of the Technology
1.	Restoration/rehabilitation of minor tank net works.	Publicly provided goods.
2.	Rainwater harvesting from rooftops for drinking and household uses.	Non Market Goods.
3.	Boreholes/Tube wells as a drought intervention for domestic water supply.	Capital goods.

## 6.5 Preliminary targets for technology transfer and diffusion

Preliminary target for the proposed technologies aimed at reducing water scarcity in the dry zone due to climate change which, will be implemented through community participatory activities are briefly described below.

(i) The preliminary target for **Restoration/rehabilitation of minor tank net works** is 10 minor tank networks involving 50 minor tanks in the dry zone which are in working condition, but need rehabilitation, within a period of ten years. This would also help rural development in the dry zone.

(ii) The preliminary target for **Rainwater harvesting from rooftops for drinking and household uses** is introduction of 400 roof top rain water harvesting systems for households/schools/hospitals/suitable buildings in the dry zone, within a period of seven years. Priority will be given to areas where surface water is scarce and quality of ground water is poor.

(iii) Preliminary target for **Boreholes/Tube wells as a drought intervention for domestic water supply** is introduction of 50 hand pump boreholes/tube wells in the dry zone where suitable hydro geological conditions are available. The project will be completed within a period of eight years.

## 6.6 General description, barrier analysis and possible enabling measures for Prioritized technologies

### 6.6.1 General Description of the "Restoration/rehabilitation of minor tank net works"

As per the definition of the Agrarian Services Act No. 58 of 1979, tanks having an irrigated command area of 80 ha. or less are considered as minor tanks (small tanks /village tanks). Minor tanks get water from surface water bodies, runoff and from direct rainfall. A cascade system is a connected series of tanks within a micro catchment of the dry zone and used for storing, conveying and utilizing water from an ephemeral rivulet.

Over the centuries, minor tank network systems have acted as insulation against droughts, helped in recharging groundwater, provided crucial irrigation for crop production, functioned as a source of multiple uses for the village community (drinking water, washing, bathing, water for livestock and wildlife, fishing, water for cultural and ritual purposes), and played a role in the maintenance of a good natural environment. Besides, the minor tank network systems and surrounding area served as a resource-base for many other activities such as making bricks, pots, baskets, etc, with women often providing assistance in such processes.



A minor tank comprises the catchment area, feeder channels, water spread area, outlet structures (sluices), flood disposal structures (surplus weir) and command area. Many of the minor tanks are interconnected forming cascades, allowing surplus water from the upstream tanks(s) and return flow from the upstream command area(s) to reach the tank immediately downstream. This facilitates reuse of water in the command area of the downstream tank, and in effect, increases available water for irrigation. These tanks are hydro-geologically and socio-economically interlinked in terms of storing, conveying and utilizing water.

It is necessary to develop technologies to augment the supply of irrigation water to the dry zone. North Western Province (NWP) and North Central Province (NCP) have the highest number as well as the highest density of small tanks in the country. There are abandoned minor tanks in the dry zone and though their restoration would add additional water source but the capital cost will be very high. Ad hoc raising of bunds and spillways of minor tanks in recent development programs has seriously disrupted the delicately balanced hydrology between the respective tanks within a cascade. It is necessary to study the total hydrological relationships between all the bigger tanks within a cascade before restoration/rehabilitating individual tanks. When restoring/rehabilitating minor tanks it will be useful to follow the procedures/instructions given by Panabokke et al, 2002<sup>96</sup>.

Restoration/rehabilitation of silted or damaged cascade minor tank systems in vulnerable areas is important and it contributes to adaptation for climate change by diversification of water supply, storm water control and capture and groundwater recharge<sup>7</sup>.

#### 6.6.1.1 Identification of barriers and measures

The barriers for technology diffusions and transfer include three (03) economic & financial, one (01) technical, two (02) network failures, two (02) policy, legal & regulatory and one (01) information & awareness and “Other” barriers. These barriers are categorized into economic & financial barriers and non-financial barriers. Two economic and financial barriers exist. The non financial barriers are related to information & awareness, technical, network failures, policy, legal & regulatory, institutional & organizational capacity and “Other” barriers<sup>7</sup>.

**Table 6.9: Key Barriers Identified for the restoration/rehabilitation of minor tank net works**

<b>Key Barriers &amp; Measures Identified</b>			
<b>No</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost &amp; Time Period</b>
<b><u>Economic and Financial</u></b>			
1	High capital cost and inadequate allocation of funds in the annual national budget for restoration work.	Obtain additional funds from donor agencies and farmer contributions in terms of labor.	US\$ 5,600.00. 01 year
2	No return/benefit during extended dry seasons for to the investment and lack of cash incentives for communities involved in restoration/rehabilitation activities.	Introduction of alternative employments during extended dry seasons and payments for communities involved in restoration work.	US\$ 18.07 million 09 years
<b><u>Non Financial</u></b>			
<b>Technical and network failure</b>			

1	Lack of sustainability of minor tank systems due to poor tank management practices.	Improve operation and maintenance practices to increase sustainability of minor tank systems.	US\$ 2,000.00 02 - 09 years
<b>Institutional &amp; organizational capacity and Network failure</b>			
2	Lack of understanding on importance of good tank / catchment management practices.	Improve the understanding on importance of good tank / catchment management practices.	US\$ 2,000.00 02 - 09 years
3	Lack of involvement of farmer community in planning and decision making related to restoration and rehabilitation of minor tank network and weak farmer organizations.	Strengthen Farmer Organizations and increase involvement of farmers in planning and decision making related to restoration and rehabilitation of minor tank networks.	US\$ 3,000.00 02 years
<b>Policy, legal and regulatory</b>			
4	Lack of prioritized cascade systems/minor tanks requiring restoration/rehabilitation.	Develop a policy/strategy on selection and prioritization of cascade systems/minor tanks for restoration/rehabilitation.	US\$ 0.05 million 02 years
5	Lack of policy/ clear mandate for distribution of funds among different government agencies involved in restoration/rehabilitation of minor tank network systems.	Development of a revised mandate for Agrarian Service Department and Provincial Councils to enable accessing required funds for restoration of minor tank network systems.	No additional cost
<b>Information and awareness</b>			
6	Poor understanding on cascade hydrology due to lack of R & D and limited institutional and organizational capacity.	Improve understanding on cascade hydrology by promoting R & D and increasing institutional and organizational capacity.	US\$ 0.2 million 02 years
<b>Other</b>			
7	Limitations due to water pollution.	R & D on tank water pollution and strict enforcement of relevant environmental laws/policies/regulations.	US\$ 0.5 million 03 - 09 years

### 6.6.2 General Description of the "Rainwater harvesting (RWH) from rooftops for drinking and household uses"

Rainwater harvesting from rooftops is a simple, inexpensive technology that promotes sustainable water management. Rainwater harvesting means collection, preservation and maximizing utilization of rain water. Many countries in the developed world including Australia, Hawaii, Germany, Japan, USA, Singapore etc. also make use of rain water. Harvesting of rainwater from roof tops can be done as a household project or in hospitals, schools, housing complexes etc. In addition to serving as an adaptation technology for climate change, incorporation of RWH into household water use practices contributes to development by saving money and time. Collected water can be used for non-potable uses or for potable supply with appropriate treatment. The technology requires a little/ or no energy because capture systems often use low-volume, non-pressurized, gravity fed systems or low power pumps. Further, it would reduce runoff that can cause surface water pollution and urban flooding. In drought-prone areas or where the surface water/groundwater is saline or polluted, rooftop rainwater harvesting is the only sustainable alternative for ensuring continued access to safe drinking water.

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Therefore, roof top rain water harvesting (RWH) is the best approach for communities potentially vulnerable to climate change and also for rain water conservation.

In addition to the above, this technology would provide social development, economic wellbeing and environmental sustainability. Construction of rooftop rainwater harvesting systems provides employment to persons having required skills. Local people can easily be trained and mobilized to implement this technology. Construction materials are readily available and system provides water at the point of consumption, and individual families have full control of their own system. The RWH technology helps women by providing easy access to water which would have otherwise brought from distance water sources. The time thus saved can be used for other productive purposes such as domestic work, agriculture and livestock activities, and child care. Rain water harvesting from the roof tops would reduce the total volume of runoff from the roofs. Installing a rainwater harvesting system would reduce the cost of water supply and also provides significant savings as a storm water management tool. Appropriately designed rainwater harvesting systems will have minimal maintenance costs and therefore will show the best long-term relationship between cost and financial benefit. As the rainwater is soft it helps reducing use of detergents thereby helping environmental protection as well. Also, rainwater harvesting systems with a connected vaporization system can raise local humidity levels and create a healthier microclimate. This is ideal for city areas faced with air pollution issues<sup>58</sup>.

A study on the rainfall for the period from 1960 to 2001 has shown that the lengths of dry spells are increasing all over Sri Lanka. This study<sup>104</sup> has also shown that the daily rainfall intensities increases and therefore rain water from roof tops could be harvested within a short period of time. Rainwater could be harvested during the rainy season and the stored rainwater can provide short term security in dry spells. At present in certain areas, rain water harvesting is not carried out in a proper manner and it is necessary to provide necessary technical guidance for improvements through awareness programs.

#### **6.6.2.1 Identification of barriers and measures**

The barriers for the technology include two (02) economic & financial, two (02) technical, two (02) information & awareness, two (02) social, cultural & behavioral, one (01) policy, legal & regulatory and one (01) "Other" barriers. These barriers are also grouped into two categories, as economic & financial barriers and non-financial barriers. Table 6.10 provides the list of barriers and the proposed enabling measures. Non financial barriers include technical, information & awareness, social, cultural & behavioral, and a barrier under the category of "others"

**Table 6.10: Key Barriers Identified for the Rainwater harvesting (RWH) from rooftops for drinking and household uses**

<b>Key Barriers &amp; Measures Identified</b>			
<b>No</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost &amp; Time Period</b>
<b>Economic and Financial</b>			
1	High capital cost.	(i) Obtain additional funds from donor agencies. (ii) Promote R & D on low cost, high quality roof top rainwater harvesting systems.	US\$ 1.025 million 09 years
2	No benefit from the investment during extended dry seasons.	Provide incentives for households/ communities using rainwater harvesting systems.	US\$ 0.01 million 03 - 09 years
<b>Non Financial</b>			
<b>Technical failures, Institutional &amp; organizational capacity</b>			
1	Lack of standards, codes and certification for roof top rainwater harvesting systems.	Formulate a mechanism for establishing standards, codes and certification systems for roof top rainwater harvesting systems.	No additional cost
<b>Information &amp; awareness</b>			
2	Lack of sustainability of roof top rain water harvesting systems due to poor management.	(i) Improve operation and maintenance through increased awareness. (ii) Demonstration of model roof top rainwater harvesting system and dissemination of knowledge on good operation and management practices through audio -visuals.	US\$ 4.5 million 09 years
3	Poor understanding on the importance of rain water harvesting as a means of water conservation to enable facing any potential water scarce situation due to climate change.	Conduct awareness programs on importance of the technology as a water conservation method.	US\$ 4.5 million 09 years
4	Poor accessibility for information on rainfall data.	Revise information and data dissemination policies of Meteorological Department and	
5	Lack of prioritized localities for installation of roof top rainwater harvesting systems.	Identify and prioritize suitable areas in the country for installation of roof top rainwater harvesting systems.	US\$ 0.02 million 02 years
<b>Social, cultural, behavioral and information &amp; awareness</b>			
6	Lack of confidence in roof top rainwater harvesting technology.	Build confidence in roof top rainwater harvesting technology.	US\$ 1.5 million 09 years
7	Due to aesthetic considerations, roof top harvested rainwater has no demand.	Increase the demand for roof top harvested rain water.	US\$ 1.0 million 09 years

Policy, legal & regulatory			
8	Inefficient enforcement of national rainwater harvesting policy.	Strict enforcement of national rainwater harvesting policy .	No additional cost
Other			
9	Limitations due to contamination of water	Good operation and management practices to minimize possible contamination of water within the rain water harvesting system.	US\$ 0.01 million 09 years

### 6.6.3 General Description of the "Boreholes/Tube wells as a drought intervention for domestic water supply"

Tube wells and Boreholes can be used as alternative sources for domestic water supply especially during drought periods. Tube wells consist of a narrow, screened tube (casing) driven into a water bearing zone of the subsurface. Tube wells penetrating bedrock but not extending beyond the interface between unconsolidated soil and bedrock is called a Bore hole. Life time of tube wells are about 10 years. Major components of a tube well are plastic or metal casing (in unconsolidated soils it is necessary to have a screened portion of casing below the water table that is perforated), a sanitary seal consisting of clay to prevent water seeping around the casing and a pump to extract water. Technology should be implemented based on population distribution of the area, ground water resources, water point location and geological environment of the location.

Ground water is used as a drinking water source and also for back-garden agriculture and aquaculture in the dry zone. The borehole efficiency measured in terms of both yield and success rates changes with the bedrock geology. The borehole efficiency changes with the bedrock geology. Boreholes in areas with hornblende biotite gneiss and charnockitic biotite gneiss have shown good efficiencies. Farmers usually tend to extract groundwater at rates ranging between 27 m<sup>3</sup>/hour and 45 m<sup>3</sup>/hour<sup>99</sup> based on their requirements and this would cause over exploitation of groundwater resources either on a local or regional scale.

Boreholes will be provided to small village communities in the dry zone and also to individual houses. Qualified organizations registered with NWSDB/WRB should be engaged in the construction of boreholes where the contractor providing all labor, transport, plant, tools, equipment and materials and appurtenances. The contractor has to ensure successful implementation of all stages of the construction including locating sites for drilling and construction of the boreholes including all related subsidiary activities such as chlorination, installation of the pump, chemical and biological water quality testing etc..

One could become self reliant and sufficient of water by having a borehole. Personal boreholes serve water which is pure and free of added chemicals at all times. Another advantage is that, there is no need to pay water bills. For women in rural areas, burden of carrying water from long distance is reduced because of boreholes, thereby saving their time. In addition to that, they can get water from these boreholes at odd hours, e.g. during night. The time saved can be utilized in doing several activities that would add to their earnings and so improve their socio economic conditions. On the other hand, water from these boreholes can be used for back yard gardens. Due to these boreholes one need not depend on rains for their irrigation purpose and get ample amount of water for all the construction purposes. Moreover, the energy required to extract water from them is less as compared to that in water purification plants.

When providing community boreholes, the consensus of the community should be sought when locating such boreholes. The technical feasibility including suitability of the Geophysical / Geological conditions, vulnerability to flooding, risks of pollution should be established prior to confirming the site for borehole construction.

Groundwater has become very popular among many farmers in the dry zone as a supplementary source for cultivating short-term crops during the frequent dry seasons experienced due to the changes in the rainfall patterns. In addition, groundwater is also used as a drinking water source.

### 6.6.3.1 Identification of barriers and measures

This technology is considered a capital good and the market map is given in the annex-1. The barriers for technology diffusion are comprised of two (02) economic & financial, three (03) institutional & organizational capacity, two (02) policy, legal & regulatory, one (01) information & awareness, one (01) technical, three (03) market failure barriers and one (01) under “Other” category. They are also classified into two categories, as economic & financial and non-financial barriers. Non financial barriers are related to institutional & organizational capacity, policy, legal & regulatory, information & awareness and “other” category and these are discussed below. Barriers and enabling measures are given in Table 6.11.

**Table 6.11: Key Barriers Identified for the Boreholes/Tube wells as a drought intervention for domestic water supply**

Key Barriers & Measures Identified			
No	Barriers	Measures	Cost & Time Period
<b>Economic and Financial</b>			
1.	High cost of capital	Take appropriate steps to reduce the investment (capital) cost through reducing cost of equipment and construction.	
2.	Inadequate funding allocation for diffusion of the technology in prioritized areas (e.g. rural areas).	Provide adequate funding for diffusion of the technology in prioritized areas (e.g. rural areas).	US\$ 0.02 million 01 year
<b>Non Financial</b>			
<b>Institutional &amp; organizational capacity and information &amp; awareness</b>			
1.	Lack of assistance for physical investigations of sites, construction and ancillary activities.	Ensure adequate assistance.	US\$ 0.5 million 02 years
2.	Lack of understanding on negative impacts of over extraction of ground water.	Improve the understanding on negative impacts of over extraction of ground water.	US\$ 2.05 million 06 years

3.	Lack of information on ground water resources.	Survey status of aquifers in Sri Lanka.	US\$ 0.01 million 02 - 06 years
4.	Lack of sustainability.	Providing enabling environment for sustainability.	US\$ 12.005 million 03 - 06 years
<b>Policy, legal and regulatory</b>			
5.	Lack of policies/laws/guidelines for safe and sustainable use of groundwater.	Formulate laws/guidelines for safe and sustainable use of groundwater.	
6.	Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers.	Formulate laws/ guidelines to control drilling of boreholes affecting vulnerable aquifers.	
7.	High interest on loans for importers/producers of tube wells due to lack of policies/strategy to establish low-interest loan scheme.	Establish a low-interest loan scheme for importers/ producers of tube wells.	
8.	High import tax for importers/producers of tube wells due to lack of policies/strategy to establish import tax relief.	Establish an import tax relief for importers/producers of tube wells.	
<b>Information and awareness, market failure</b>			
9.	Lack of prioritization of localities to implement this technology.	Identify vulnerable areas for climate change and study hydrogeology of such areas, need and urgency etc, and prioritization of areas for interventions.	US\$ 0.005 million 02 years
10.	Lack of information on prices of equipment, loan schemes etc.	Awareness campaigns on special facilities provided for tube well constructors.	US\$ 0.005 million 02 - 06 years
<b>Technical</b>			
11.	Lack of R & D on ground water availability and hydrogeology.	Promote R & D on ground water quality and hydrogeology of various sites for suitability assessment.	
<b>Other</b>			
12.	Limitations of the technology due to poor quality of ground water.	Select sites having good quality ground water.	US\$ 0.07 million 03 - 07 years

## 6.7 Enabling framework for overcoming the barriers in the Water Sector

### 6.7.1 Common barriers and their enabling framework

High capital cost, lack of sustainability, weak enforcement of policies/laws, lack of information and awareness, lack of prioritized locations to implement the technology, limitations of the technology due to water pollution and lack of research and development are the common barriers affecting the implementation of the proposed technologies for the water sector.

The enabling framework for these common barriers is given in Table 6.12.

**Table 6.12: Enabling framework for the common barriers in the Water Sector**

No.	Broad/Common barriers	Enabling framework	Technology
1.	High capital cost.	(i) Explore additional funds from donor agencies. (ii) Promotion of research on development of lowcost rainwater harvesting systems. (iii) Tariff concessions and credit on concessionary terms for construction organizations registered at NWSDB/WRB.	1,2 3 3
2.	Lack of sustainability.	(i) Select suitable sites based on hydro-geological conditions. (ii) Improve operation and maintenance practices. (iii) Avoid over extraction and allow recharge ground water. (iv) Avoid sites having poor ground water quality.	1,2,3 3 3 3
3.	Poor enforcement of relevant policies/laws/regulations.	(i) Prepare a clear policy on selection and prioritization of cascade systems/minor tanks for restoration. (ii) Strengthen institutional capacities to implement existing policies/legal frame work. (iii) Introduce a system to issue license on an annual basis. (iv) Tariff concessions and low interest credits. (v) Prepare policy/guidelines for ground water management.	1 2 2,3 3 3
4.	Lack of information and awareness.	(i) Promote R & D to collect data on cascade hydrology and information dissemination. (ii) Improve operation and management practices of rooftop rainwater harvesting systems through awareness creation. (iii) Provide information on assistance provided and process etc. to constructors from rural areas. (iv) Collect island wide information on aquifers in Sri Lanka through surveys by the NWSDB/WRB and ensuring availability of such information to the contractors registered for installation of boreholes and also to decision makers.	1 2 3
5.	No prioritized areas to implement the technology.	(i) Develop a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration. (ii) Identify needs and urgency based on Climate change modeling.	1 2
6.	Limitations of the technology due to water pollution.	(i) Strict enforcement of relevant environment laws/regulations (ii) Research & Development. (iii) Good operation and management practices. (iv) Select suitable alternative sites.	1,2,3 1,2,3 2 3



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7.	Lack of R & D.	(i) Provide necessary funds for R & D to universities, research institutions, NWSDB/WRB etc. (ii) As the annual budget does not allocate sufficient funds for R & D, it is necessary to give priority for R & D related to these fields. (iii) Incentives for research students at NWSDB/WRB to carry out research projects.	1,2,3 1,2,3 3
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### 6.8 Proposed Action Plans for the Water Sector

proposed Action plans for identified three technologies for water Sector are in Annex X

# CHAPTER 7

## Coastal Sector

### 7.1 Overview of the Coastal Sector

Sri Lanka being an island with 25% of its population living in coastal areas, coastal communities both rural and urban are at risk from the effects of rising sea levels, increasing temperatures, disasters such as floods and droughts and salt water intrusion<sup>54</sup>. Apart from the population density in the coastal regions, 62% of industrial units and more than 70% of tourist infrastructure are located on Sri Lanka's coastal areas<sup>66</sup>. "The coastal zone accounts for about 43% of the nation's GDP, so impacts on coastal settlements translate into substantial impacts on the nation's economy"<sup>65</sup>

Large tracts of Sri Lanka's coastal belt are already pressured by a host of human induced environmental threats including pollution, coral & sand mining, erosion and depletion of mangroves and these will be further exacerbated by climate change<sup>95</sup>. Tourism, fisheries and agriculture play a substantial role in livelihoods of coastal communities and are directly or indirectly exposed to coastal vulnerability that in turn increases the effects on poor communities that rely on these enterprises.

Some of the potential impacts of climate change in the Coastal Sector are;

- Sea Level Rise (SLR) of about 0.5 m by 2050
- Coastal inundation
- Coastal erosion
- Loss of coastal terrestrial habitats
- Saltwater intrusion
- Changes in coastal biodiversity
- Changes in coastal morphology

Coastal belt of Sri Lanka is a very dynamic transitional zone and is formed as a result of sea and atmospheric forces on the land mass and the supply of sediments to the coast.

*Coastal zone of Sri Lanka is defined as the area lying within a limit of 300 m landwards of the Mean High Water Line and a limit of 2 km seawards of the Mean Low Water Line and in the case of rivers, streams, Lagoons or any other body of water connected to the sea either permanently or periodically, the landward boundary shall extend to a limit of 2 km measured perpendicular to the straight base line drawn between the natural entrance points thereof and shall include water of such rivers, streams and lagoons or any other body of water so connected to the sea.*

*Coastal Zone Management Project, Coast Conservation Department (Olsen et.al 1992)*

A total of 103 rivers radiating from the hill country flow down to the sea forming estuaries that are important features of the coastal landscape, which provide vital habitats for organisms of socioeconomic importance. They also carry sediments and pollutants that may degrade the quality of coastal waters and habitats. Coastal Zone contains a variety of terrestrial habitats, such as sandy beaches, barrier beaches, sand spits and dunes, rocky shores, mangrove stands & salt marshes and coastal wetlands such as coral reefs, lagoons, estuaries and sea grass beds. These systems help maintaining the vital physical processes, fulfill ecosystem services and functions and provide land, goods and services<sup>30</sup>.

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Coastal zone is defined as the area lying within a limit of 300 m landwards of the Mean High Water Line and a limit of 2 km seawards of the Mean Low Water Line and in the case of rivers, streams, Lagoons or any other body of water connected to the sea either permanently or periodically, the landward boundary shall extend to a limit of 2 km measured perpendicular to the straight base line drawn between the natural entrance points thereof and shall include water of such rivers, streams and lagoons or any other body of water so connected to the sea<sup>20</sup>. It includes several sensitive ecosystems such as, coral reefs, sea grass beds, sand dunes, mangroves, salt marshes and sandy, pebble and rocky beaches.

Coastal belt of Sri Lanka is very important for many socioeconomic activities, some of which play a major role in generating foreign exchange through tourism, ornamental & food fish trade, etc.. Large tracts of Sri Lanka's coastal belt are already pressured by a host of human induced environmental threats including pollution, coral and sand mining, erosion and depletion of mangroves and these will be further exacerbated by climate change. Tourism, fisheries and agriculture play a substantial role in livelihoods of coastal communities and are directly or indirectly exposed to coastal vulnerability that in turn increases the effects on poor communities that rely on these enterprises. In addition to the above, development of harbours, anchorages, groins, revetments, etc. also make a major impact on this sector.

Since all three adaptation technologies proposed encompasses enhancement of natural biodiversity, there will be no impact from GHG emission. Due to replanting of dune vegetation and mangrove vegetation GHG emissions will be at a negative level. Coral transplanting supports growth of corals which contribute to remove carbon dioxide from the aquatic environment.

#### **7.1.1 Vulnerability to climate change**

Climate change effects such as sea temperatures and sea level rise (SLR), increased frequency and magnitude of tropical storms and other extreme events will have negative impacts on both ecosystems (coral bleaching, saltwater intrusion, flooding, erosion) and human well-being (loss and/or reduced productivity in goods and services provided by ecosystems). Sensitive ecosystems such as coral reefs, sand dunes, sea grass beds and mangroves are not only economically and ecologically important to Sri Lanka but they also act as buffers against wave action, storm surge, tidal variations and sometimes against severe conditions such as tsunamis which was evident during the 2004 tsunami. While global mean sea level rise is important, the local or relative sea level is the dominant factor in determining impacts on the coastal ecosystems. Climate change may also cause increases in both extreme wave heights and in the intensity of storms, which can be uncertain, especially in the tropics where storms may become more intense but less common. Sea level rise scenarios for Sri Lanka suggest a shoreline retreat of 10m by 2050. The IPCC has categorized the coastal sector in the South Asian region as one of the highly vulnerable sectors to climate change<sup>98</sup>. In addition, the sector vulnerability profiles developed for Sri Lanka in 2010 has identified coastal sector as one of the most critical sectors for the climate change vulnerability<sup>71</sup>.

## 7.1.2 Existing Policies and Laws related to the Sector and Technology Deployment

### a) Existing Policies Involved

There are four national Policies that are specifically relevant to coastal sector and to the climate change adaptations activities identified for the sector. They are National Environment Policy (NEP) which deals with the Environment, National Forestry Policy (NFP) dealing with the biodiversity and sensitive ecosystems, the National Policy on Wild Life Conservation (NPWLC) deals with the biodiversity and wild life conservation and National Policy on Wetlands (NPW) deals with wetlands. The existing policy framework and laws related the sector's development and technology deployment are given (Table 7.1 and 7.2).

**Table 7.1: Existing policy framework related to the Coastal sector and technology deployment**

Existing Policies	When Enacted and Revised	Responsible Authority	Main contents
1.National Environment Policy (NEP)	Enacted in 2003	Ministry of Environment and Natural resources	<ul style="list-style-type: none"> <li>•Objectives are to protect and conserve the integrity of the nation's environment and natural resources through ecologically sustainable development, with due recognition of the contribution of natural resources to economic development and to the quality of life.</li> <li>•Policy target is to achieve a healthy and pleasant environment sustaining nature for the well-being of the people and the economy.</li> <li>•It also aims to promote the sound management of the environment while balancing social and economic development needs, to manage the environment by linking together the activities, interests and perspectives of different stakeholders with equitable</li> </ul>
2.National Forestry Policy (NFP)	Enacted in 1995.	Ministry of Environment and Natural resources/Forest Department	<ul style="list-style-type: none"> <li>• Objectives are to conserve forests for posterity, with particular regard to biodiversity, soils, water, and historical, cultural, religious and aesthetic values, to increase the tree cover and productivity of the forests to meet the needs of present and future generations for forest products and services and to enhance the contribution of forestry to the welfare of the rural population, and strengthen the national economy, with special attention paid to equity in economic development.</li> <li>•Conservation and sustainable management of forests ensuring continued existence of important ecosystems and flow of forest products and services, conservation of biodiversity, soil and water resources and socioeconomic development of the country</li> </ul>
3.National Policy on Wild Life Conservation	June 2000	Department of Wildlife Conservation (DWLC)	<ul style="list-style-type: none"> <li>• Objective is to conserve wildlife resources, through protection, research, education, sustainable use and benefit sharing, for the benefit of present and future generation.</li> </ul>

			<ul style="list-style-type: none"> <li>• To maintain ecological processes and life-sustaining systems.</li> <li>• To manage all components of genetic diversity, as resources to improve crop plants and farm animals, and to develop in a fair and equitable manner.</li> <li>• To ensure sustainable use and equitable sharing of benefits.</li> <li>• To conserve native and endemic species and their habitats, so as to maintain the overall species richness and ecological integrity of the country.</li> <li>• To encourage the development of biological repositories, for the purposes of conservation education and science.</li> <li>• To encourage the private sector and communities to join as a full partners in all aspects of the wildlife conservation process</li> </ul>
4. National Policy on Wetlands	Enacted in 2005	Ministry of Environment	<ul style="list-style-type: none"> <li>• Protect and conserve wetland ecosystems, to prevent illegal utilization of wetlands, to restore and maintain the biological diversity and productivity of wetlands, to enhance ecosystem services from wetland habitats, to assure sustainable use of wetlands and traditional practices by local communities, and to meet national commitments as a signatory to the Ramsar Convention on Wetlands.</li> </ul>
5. Mahinda Chinthana & Mahinda Chinthana way forward	2005 Amended in 2010	Ministry of Finance & Planning	<ul style="list-style-type: none"> <li>• Aim is to promote sustainable development in close liaison with the land, fauna and flora and to bestow our natural heritage to our future generation.</li> <li>• Conserving the environment, nationally and internationally. Due to the application of the principle that the 'abuser should pay for the abuse,' the Environment Ministry is self-financing reducing the burden on the Treasury</li> <li>• Direct employment generation through development of coastal resources.</li> <li>• An effective integrated coastal zone management framework will be introduced to address widely varying and integrated issues in order to prevent the depletion of coastal resources and ensure effective coastal zone management.</li> <li>• A joint management will be set up with the private sector to sustain coastal vegetation, habitat, landscapes and features which add natural beauty and aesthetic value to the environment.</li> <li>• Coastal and marine environmental degradation, which includes sea erosion, coastal pollution and threats of oil spills to the sustainability of coastal habitats, will be reduced by the implementation of relevant acts and regulations.</li> <li>• By 2020, it is expected to make Sri Lanka a green country in which all the major environmental problems have been solved and a land free of elephant-human conflict, beautiful cities and the most clean and healthy environment in Asia.</li> </ul>

**b) Existing Laws Involved**

The existing legal instruments pertaining to the Sector are summarized in Table 7.2

**Table 7.2: Existing laws related to the Coastal sector and technology deployment**

Existing laws	When Enacted and Revised	Responsible Authority	Main Contents
<ul style="list-style-type: none"> <li>- Coast Conservation Act No. 57</li> <li>- Coast Conservation Act No. 64</li> <li>- Coastal zone management plan (CZMP)</li> <li>- Conservation Act. 1990</li> <li>- Revised CZMP</li> </ul>	Enacted In 1981, Amended in 1988 1990 1997 & implemented in 2004	Coast Conservation Department (CCD)	"Coast Conservation Act is an act to make provision for a survey of the coastal zone and the preparation of a Coastal Zone Management Plan; to regulate and control development activities within the coastal zone; to make provision for the formulation and execution of schemes of work for coast conservation within the coastal zone; to make consequential amendments to certain written laws; and to provide for matters connected therewith or incidental thereto". Accordingly the Coast Conservation Division was upgraded to Coast Conservation Department CCD, in 1984 and the administration, control, custody and management of the coastal zone have been vested with Director, Coast Conservation.

**7.2 Identified Adaptation Technologies in the Coastal Sector**

Nine (09) adaptation technologies were identified through stakeholder consultations considering the important physical and biological properties of different coastal districts and their socioeconomic importance. The identified technologies are as follows;

- a) Restoration of coral reefs as soft defense mechanisms
- b) Replanting of sea grasses as a soft defense mechanism
- c) Sand dune rehabilitation as a soft defense mechanism
- d) Beach nourishment
- e) Restoration of mangrove habitats
- f) Construction of dikes
- g) Floating mariculture for sea weeds
- h) Floating mariculture for fish
- i) Construction of groins & sea walls (revetments)

In addition to above, establishment of salt water barriers, flood hazard mapping and flood warning systems also was considered important. However, these were not taken into consideration for want of detailed information which is not readily available. Table 7.1 depicts the current status of application of the technologies selected.

**Table 7.3: Current Degree of Application of Selected Adaptation Technologies of the Coastal Sector**

Technology	Current degree of application			
	Not applied	Low	Medium	High
1. Restoration of coral reefs		X		
2. Replanting of sea grasses		X		
3. Rehabilitation of sand dunes	X			
4. Restoration of mangroves				X
5. Beach Nourishment		X		
6. Construction of dikes			X	
7. Floating mariculture for sea weeds	X			
8. Floating mariculture for fish	X			
9. Construction of groins & sea walls				X

### 7.2.1 An Overview of Possible Adaptation Technology Options and their Adaptation Benefits

An overview of identified technology options and their adaptation benefits are given in table 7.4 below;

**Table 7.4: Overview of Possible Adaptation Technology Options identified for the the Coastal Sector and their Adaptation Benefits**

No	Technology	Adaptation Benefits
1.	<b>Restoration of coral reefs</b>	This reef re-building mechanism provides protection from expected sea level rise while ensuring ecosystem services to tourism, fisheries and shoreline protection
2.	<b>Replanting of sea grasses</b>	Sea grass beds provide coastal zones with a number of ecosystem services such as, fishing grounds, wave protection, oxygen production and protection against coastal erosion. Sea grass meadows account for 15% of the ocean's total carbon storage. They slow down the water current, maintaining water clarity by trapping sediments to allow light penetration providing shade and habitats for small marine species. They are very useful for forming a protective belt against possible coastal erosion that may occur due to sea level rise and also for removal of CO <sub>2</sub> .
3.	<b>Sand dune rehabilitation</b>	Dune vegetation are capable of withstanding to the harsh conditions prevail in the coastal environments and stabilizes the unstable conditions of the substratum on which they are anchored. They are well adapted to the strong winds and waves in this environment, although the sand is loose and porous and the substrate keeps shifting constantly.
4.	<b>Beach nourishment</b>	Beach nourishment is primarily used in response to shoreline erosion, while it provides flood reduction benefits as well. It helps to dissipate wave energy as the waves lose energy once break on the shore and this interaction will be of different extents depending on the beach profile, shapes and gradients.
5.	<b>Restoration of mangrove habitats</b>	Mangroves perform essential functions in terms of coastal flood protection and erosion management. They induce wave and tidal energy dissipation and act as a sediment trap for materials thus helping to build land seawards. The dense root mats of wetland plants also help to stabilize shore sediments reducing erosion. Mangrove ecosystems play a vital role in buffering the force of the tsunami waves and in protecting the human inhabitations.

6.	<b>Construction of dikes</b>	The primary function of sea dikes is to protect low-lying coastal areas from inundation under extreme conditions. These structures have a high volume which helps to resist water pressure where sloping sides to reduce wave loadings and sufficient crest heights to prevent overtopping of flood waters. Dikes are widely used to protect low-lying areas against inundation in many countries including Sri Lanka.
7.	<b>Floating mariculture for sea weeds</b>	Seaweed farming is a profitable coastal activity which helps to improve the socioeconomic standard of coastal communities. In addition, helps to reducing dissolved CO <sub>2</sub> levels in sea water which is important for reduction of GHG. This is a farming system which does not need the addition of fertilizers or nutrients as they are freely available in the marine environment. Seaweed is harvested throughout the world as a food source as well as an export commodity for the production of agar and alginates such as Carrageenan for a range of products including ice cream, yoghurt, pet food, beauty treatments, etc. It is also used in the preparation of drugs and used as an organic fertilizer and a soil dressing in agriculture and horticulture.
8.	<b>Floating mariculture for fish</b>	Provide opportunities for marine fish farming as sea level rise and salt water intrusion will cause a reduction in the availability of fresh water for aquaculture and also affect the coastal brackish water shrimp farming.
9.	<b>Construction of groins &amp; sea walls</b>	Prevent erosion due to soil sliding as a result of high wave action and coastal flooding. They could be coupled with soft barriers such as artificial reefs and sea grass plots.

### 7.3 Criteria and process of technology prioritization

#### 7.3.1. Multi Criteria Decision Analysis (MCDA)

Multi-Criteria Decision Analysis (MCDA) has been carried out to prioritize the proposed adaptation technologies with a view to identify three most suitable adaptation technologies for the sector.

##### 7.3.1.1. Determination of Criteria and Weightings

The evaluation criteria included cost of technologies, and economic, social, & environmental benefits. In deciding the criteria, adequate considerations had been placed on the potential socio economic importance and also to secure the maximum benefit out of the selected adaptation technologies. Each option has been given a score against each criterion, considering the preference. The weightings for each criterion were allocated taking into account the relative importance of the criterion. The criteria thus selected are given in the Table 7.5 below.



**Table 7.5: Criteria Adopted to Prioritize the Adaptation Technologies of the Coastal Sector**

Major Criteria	Sub divisions of criteria selected (Weight Factor)			
Cost(25%)	Cost/m2 of land area covered (25%)			
Benefits (75%)	Economic (15%)	Employment (5%)		
		Investment/ Long-term benefits	Foreign exchange earnings (5%)	
			Protection for infrastructure (5%)	
		Income (10%)		
	Social (30%)	Education	Improve awareness ((5%)	
			Opportunities for research-based education (3%)	
			Improve environmental sensitivity (5%)	
		Health (7%)		
	Environmental (30%)	Reduction of GHG (7%)		
		Reduction of land losses due to SLR (10%)		
		Reduce inundation (5%)		
		Land reclamation (8%)		

**7.3.2. Scoring Matrix:** The Scoring Matrix constructed based on the above criteria and the weight factors to evaluate how the different technologies rate against various criteria. (See Annex VI for weighted scores, costs and benefits of technologies). Benefits were calculated by using the formula “Benefits = Total Score – Weighted Score of Costs” The cost and the benefits of the selected technologies are given in the Table 7.6.

**Table 7.6: Costs and benefits of the selected technologies of the Coastal Sector and the order of priority**

No	Technology Options	Cost US \$/m <sup>2</sup>	Benefits	Order of priority
1.	Restoration of coral reefs	14.30	54.17	(3)
2.	Replanting of sea grasses	22.94	36.99	6
3.	Sand dune rehabilitation	2.13	56.54	(1)
4	Restoration of Mangroves	10.50	52.22	(2)
5.	Beach Nourishment	25.56	39.16	5
6.	Construction of dikes	37.50	39.65	7
7.	Floating mariculture for sea weeds	31.00	32.20	8
8.	Floating mariculture for fish	50.59	29.85	9
9.	Construction of groins & sea walls	22.5	44.65	4

#### 7.4. Results of the Technology Prioritization for the Coastal Sector

The results of the Multi-Criteria Decision Analysis ranked the identified technologies in their order of priority as shown below.

1. Sand dune rehabilitation
2. Restoration of Mangroves

3. **Restoration of coral reefs**
4. Construction of groins & sea walls
5. Beach Nourishment
6. Replanting of sea grasses
7. Construction of dikes
8. Floating mariculture for sea weeds
9. Floating mariculture for fish

The three technologies thus selected in the order of priority are (1) Sand dune rehabilitation; (2) Restoration of Mangroves; (3) Restoration of coral reefs.

Figure 7.1 shown below illustrates the Benefits plotted against the Costs. The sensitivity analysis carried out by changing the weights assigned to cost of technologies and criterion did not show any significant deviation from the original results.

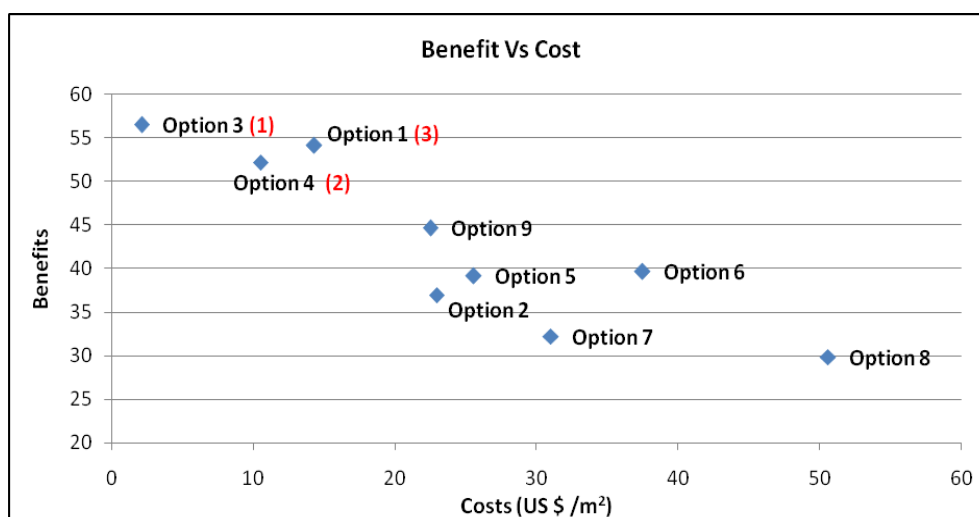


Figure 7.1: Benefit Vs Cost Plot for Identified Technology Options for Coastal Sector

Table 7.7: Summary Table for Prioritized Technologies of the Coastal Sector

No	Name of the Technology	Scale of Application (Small, Medium or Large Scale)	Time Scale (Approx number of years)	Potential for adaptation in the Time Scale	Benefits (Output from the MCDA)	Estimated total lifetime Cost/ ha US \$
1.	Sand dune rehabilitation	Large scale	3 years	High	61.54	21,300
2.	Mangrove restoration	Large scale	3 years	High	55.56	15,950
3.	Restoration of coral reefs	Small scale	3 years	Medium	55.50	429,000

#### 7.4.1 Categories of the Prioritized Technologies

In order to facilitate the barrier analysis, the technologies are categorized according to the types of goods and services they belong to or contribute to, as the different types of goods and services have

distinct market characteristics. Accordingly, technologies can be categorized into four generic categories. The transfer and diffusion of technologies within each category are influenced either by market decisions or political decisions. These categories are consumer goods which are specifically intended for the mass market, households, businesses and institutions; capital goods such as machinery, equipment used in the production of goods; The diffusion of consumer goods and up to some extent capital goods are generally dominated by market decisions, The publicly provided goods which contribute to the provision of the public services such as roads, bridges, mass transport system, etc, and non-market goods which are non tradable, transferrable and diffused under nonmarket conditions primarily diffused through political decisions. Government institutions, public or nonprofit institutions, NGOs etc, therefore have a direct influence on the diffusion of publicly provided and non-market goods. The technologies prioritized fall under non-market goods as shown in Table 7.8.

**Table 7.8: Prioritized Technologies and Categories in the Coastal Sector**

No	List of Prioritized Technologies	Category of the Technology
1.	Sand dune rehabilitation	Non -market goods
2.	Restoration of Mangroves	Non -market goods
3.	Restoration of coral reefs	Non -market goods

## 7.5 Preliminary targets for technology transfer and diffusion

Preliminary target of this programme is to develop strategies to reduce damage to coastal ecosystems and infrastructure due to sea level rise, which is likely to occur due to global climate change. The proposed activities are proposed to be implemented through community participatory socioeconomic activities and they are as follows.

- a) Establish 50 ha of plantations of *Pandanus* sp and other dune species of economic & medicinal value on existing sand dunes in 25 selected sites @ 2 ha in each site within a period of 7 years using tissue culture techniques to produce necessary propagules with the overall objective of sustainable utilisation for socioeconomic development and to maintain ecosystem stability.
- b) Establish 20 ha of mangrove plantations within a period of 5 years in 10 degraded mangrove areas @ 2 ha in each site using proper zonal plans and raising required propagules from mangrove plant species selected from the existing mangrove forests. Propagules will be raised in nurseries with community participation. The overall objectives of the plantations will be for sustainable utilization of the products for socioeconomic development of the communities and to ensure ecosystem stability.
- c) Restore 10 ha of degraded coral reefs within 7 years through replating in 10 sites @ 1 ha from each site selected from different areas around Sri Lanka. High temperature tolerant species selected from the natural reefs found in the selected sites will be used for restoration activities. The local communities and the tourist hotel industry will be permitted to use the restored sites for sustainable socioeconomic activities such as eco-tourism and research.

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## **7.6 General Description, Barrier Analysis and Possible Enabling Measures for the prioritized Technologies**

### **7.6.1 General Description of the "Sand dune rehabilitations as a soft defense mechanism"**

Sand dune vegetation has the ability to withstand the harsh conditions prevail in the coastal environment 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. These plants have developed specialized adaptabilities, which enable them to withstand to these conditions. They are adapted to withstand strong winds and waves in this environment, although the sand is loose and porous and the substrate keeps shifting constantly. Therefore, plants closest to the sea have lateral roots and shoots growing in along the surface. These roots and shoots form a dense mat on the surface as seen in Goat's Foot (*Ipomoea pescaprae*) and Spinifex (*Spinifex littoreus*).

Further inland, where dunes are more stable, plants grow more upright. Dune plants also have adaptations to prevent desiccation. On clear, sunny days, the temperature in sand dunes can rise to as much as 50°C and fresh water is also lacking. Because of this, sand dune plants have developed xerophytic 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) to minimize water loss. Dune plants such as Pandanus sp. have effectively provided protection against tsunami in December 2004, in certain areas in the Hambantota District where natural dune vegetation has not been affected by human interference. Replanting of dune vegetation may not only serve as a soft defense for harsh wave action and storm surges but also will function as traps for GHG.

Natural sand barriers along with their vegetation could function as soft barriers against coastal erosion and inundation due to sea level rise as a result of climate change. Therefore, rehabilitation of degraded dune vegetation due to anthropogenic activities through replanting is considered an important adaptation technology. Propagation of plants could be done by using seeds or tissue culture techniques. Facilities for collection of seeds of Pandanus and other dune plants with economic or medicinal value and to establish nurseries to raise the required propagules should be provided to academic or research institutes or through community participation at centres especially established for this purpose. In areas where dune sand has been removed particularly for construction work, these rehabilitation planting could be carried after beach nourishment to improve the quality of the substratum. In addition to replanting, natural regeneration of dune plants should be allowed to take place under the improved environmental conditions.

Pandanus planting is widely practiced in Pacific islands and it has been accepted by the local communities due to its economic value. Recent post-tsunami rehabilitation programme funded by the CIDA (Canada) in selected sites within the southern coast of Sri Lanka has assisted the coastal communities in successfully re-establishing Pandanus sp. for cottage industries. This initiative has not yielded the desired results for want of government patronage to promote such projects. With adequate follow up funding, this project would have provided opportunities for cottage industries based on Pandanus leaves.

Plant species that grow on dune sand are abundant in Sri Lanka and scientifically designed terraced plantations would not only provide protection against coastal erosion, storm surge, tsunami and other harmful coastal activities, but also will provide alternative income sources for coastal communities and also improve the aesthetic conditions of the sandy beaches as well. It will also provide nesting sites to

turtles and sea birds, which would attract nature lovers and local and foreign tourists. Coastal communities living in the vicinity of sand dunes in the North, North-western, South-eastern and Eastern coastal belts will benefit from this technology.

While the rehabilitation planting will provide protection from coastal erosion and such plantations will also act as wind belts in areas where strong winds prevail. In addition, plants of economic and medicinal value will provide an alternative income source for coastal communities. With the improvement of soil conditions, many other plant communities will get established improving the biodiversity of dune vegetations.

## 7.6.2 Identification of barriers and measures

Ten (10) barriers which consist of one (01) Economic & Financial and nine (09) Non-financial have been identified. These barriers and potential measures to overcome them are listed in Table 7.9.

**Table 7.9: Key Barriers and Measures Identified for Sand Dune Rehabilitation**

<b>Technology 1: Sand Dune Rehabilitation</b>			
<b>#</b>	<b>Barriers</b>	<b>Measures</b>	<b>Cost of Implementation for the Target Years</b>
<b>Economic and Financial</b>			
1	Inadequate funds for restoration of sand dunes through beach nourishment followed by planting of dune vegetation and for public awareness programs.	The respective line ministries & departments to seek project specific annual funding from the government or from the suitable donor agencies by the NGOs & INGOs actively engaged in climate change adaptation activities.	Over the period of 7 years US\$ 0.05 million
<b>Non- Financial</b>			
<b>Policy, Legal and Regulatory Barriers &amp; Measures</b>			
2	Poor enforcement of coastal zone management regulations.	Awareness programs for the law enforcement officers on the importance of strict enforcement of coastal zone management regulations and stakeholder awareness on the existing rules and regulation with the emphasis on the need for abiding by these laws for sustainability of the sand dune ecosystems and their resources.	Over the period of 3 years US\$ 0.171 million
3	Low priority given for funding for environmental protection and for R&D under the existing financing policies.	Request for increasing annual budgetary allocations for environmental protection projects with adequate justifications based on socioeconomic gains of sand dunes restoration and potential economic losses due to nonrehabilitation.	Over the period of 3 years US\$ 0.171 million
<b>Network Failures Barriers &amp; Measures</b>			

4	Inadequate inter agency coordination among government institutions falling under different ministries.	<ul style="list-style-type: none"> <li>(i) Develop multidisciplinary projects with the collaboration of research and academic institutions.</li> <li>(ii) Identify strategies to develop and improve efficient collaborations among agencies to Identify\ problems related to sand dune management and prepare appropriate activity plans to address such issues.</li> </ul>	Over the period of 5 years US\$ 0.059 million
<b>Institutional and Organizational Capacity Barriers &amp; Measures</b>			
5	Inadequate opportunities for research.	<ul style="list-style-type: none"> <li>(i) Capacity building of R &amp; D institutions to enable attending research related to environmental protection, conservation &amp; management efficiently.</li> <li>(ii) Identify in the corporate plans of respective R &amp; D institutions the need for capacity building for environmental protection, management and research activities.</li> </ul>	Over the proposed period of 5 years US\$ 1.35 million
6	Inadequate trained personnel and experts to provide expertise on the technologies.	<ul style="list-style-type: none"> <li>(i) Provide required budgetary provisions to all relevant agencies for staff training at local and foreign research/academic institutions.</li> <li>(ii) Develop mechanisms to retain trained personnel.</li> <li>(iii) Provide facilities to relevant institutions to enable regular knowledge updating through training &amp; research and also using the public domain.</li> <li>(iv) Use the experts/trained personnel available at research/academic institutions to provide advance training to staff of relevant institutions prior to project implementation.</li> <li>(v) Carry out the project work in collaboration with suitably qualified experts.</li> <li>(vi) Focus on awareness and training activities related to conservation &amp; restoration programmes when using donor funds.</li> </ul>	Over the period of 5 years US\$ 0.505 million.
<b>Social, Cultural &amp; Behavioral Barriers &amp; Measures</b>			
7	Lack of commitment by the coastal communities & industries to protect existing sand dunes and rehabilitate disturbed sand dunes in view of their dependence on destructive coastal activities as a source of income.	<ul style="list-style-type: none"> <li>(i) Form a committed group of actors selected from among the coastal communities.</li> <li>(ii) Provide alternative sources of income or employment, within the same region, to those who are engaged in destructive activities</li> <li>(iii) Government departments and their line ministries to develop appropriate strategies to engage NGOs in community participatory programmes for sand dune conservation and restoration programmes.</li> </ul>	over the proposed period of 7 years US\$ 0.605 million
<b>Information and awareness Barriers &amp; Measures</b>			

8	Information and awareness Barriers & Measures 8 General Lack of awareness at all levels of the society on the non extractive uses and other environmental services provided by the coastal sand dunes ecosystems towards national development and protection of the environment.	(i) Conduct stakeholder awareness programmes in the coastal regions on the importance of restoring sand dune ecosystems for the wellbeing of coastal communities and secure assistance of all parties affected to restoration and rehabilitation of sand dunes and associated vegetation. (ii) Involve unemployed coastal youth in eco-tourism, and coastal tourist hoteliers in sand dune restoration & in eco-tourism. (iii) Establish nature trails among dune vegetations and turtle nesting sites under the eco tourism programs. (iv) Establish herbal gardens through rehabilitation of dune vegetation with plants of medicinal importance (v) Encourage floating hotels in the vicinity of coastal sand dunes.	Over the period of 7 years US\$ 0.605 million
<b>Technical Barriers &amp; Measures</b>			
9	Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation.	(i) Encourage rehabilitation of dune vegetations with plants of economic and medicinal importance. (ii) Conduct awareness/training programmes to disseminate knowledge on oPlants suitable for sand dunes. oTissue culture & propagation methods to produce sufficient numbers of plants/propagules for plantation. oSustainable utilisation of dune vegetation for SMEs. (iii) Encourage the government to introduce economically important species such as Pandanus, which are available in the Pacific region, after a well planned feasibility study.	Over the period of 1 - 3 years US\$ 0.85 million
<b>Other Barriers &amp; Measures</b>			
10	Use of Dune sand for construction work.	(i) Encourage off-shore sand extraction for building construction and popularise construction technologies with offshore sand.	over the period of 3 years US\$ 0.005 million

### 7.6.2. General description of the "Rehabilitation of Mangroves"

One of the most commonly restored wetland ecosystems for coastal protection is 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 and act as a sediment traps, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilize shore sediments contributing to reduction of erosion. Wetland restoration reestablishes these advantageous functions for the benefits of coastal flood and erosion protection. Techniques have been developed to reintroduce

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mangrove vegetation successfully to areas where they have previously existed and to new areas with mixed results. Mangrove ecosystems have played a vital role in buffering the force of the tsunami waves and in protecting the human inhabitations. Despite these benefits, most of the mangrove areas have been lost due to indiscriminate clearing and reclamation for development purposes.

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<sup>55</sup>. This was observed in the vicinity of Rekawa Lagoon after the 2004 tsunami incident.

Coastal wetlands also provide a number of important ecosystem functions including improvement of water quality and climate regulation. They are valuable locations for sediment contaminant, carbon and nutrient accumulation and also provide vital breeding and nursery ground for a variety of birds, finfish, shellfish and other animals. They also function as a sustainable source of timber, fuel and fiber for the coastal communities. In addition to the provision of ecosystem functions, mangroves support the livelihoods of the coastal communities as well. Wetland restoration re-establishes these advantageous functions for the benefit of coastal communities in addition to flood and erosion protection. Restoration is required since mangroves have become increasingly degraded through both natural and human activities.

Sri Lanka has been experiencing rapid loss of mangrove ecosystems mainly due to anthropogenic factors including unprecedented growth of the tourism sector (i.e, Bentota area). In spite of the known ecological and economic values 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.

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 3,385 ha. The other large concentrations are in Batticaloa and Trincomalee districts. 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*.

Although the legal jurisdiction of the mangrove ecosystem falls under the Forest Department, Department of Wildlife Conservation, and the Coast Conservation Department, yet there is inadequate legal protection for mangroves in the country.

Replanting mangroves is a widely accept technology for restoration of degraded mangrove ecosystems worldwide. 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* and *Nypa fruticans*, which are also suitable for replanting purposes due to their wide distribution although found in few numbers<sup>49</sup>.

Rehabilitation of mangroves will not only provide protection from potential threats of sea level rise from climate change, but it will also provide other socio economic benefits such as livelihood opportunities



for local communities, development of tourism industry and SMEs based on mangrove products. Improvement of mangroves will also improve the lagoon fish production.

### 7.6.2.1 Identification of barriers and measures

The barriers for transfer and diffusion of the technology and the enabling measures to overcome these barriers are presented in Table 7.10.

**Table 7.10: Key Barriers and Measures Identified for Rehabilitation of Mangroves**

<b>Technology 2: Rehabilitation of Mangroves</b>		
Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers &amp; Measures</b>		
1 Inadequate financial assistance for restoration programs.	(i) Attract funds through properly formulated proposals. (ii) Introduce and facilitate self sustaining economic activities using mangrove products.	Over a period of 07 years US\$ 0.109 million
<b>Non- Financial</b>		
<b>Policy, Legal and Regulatory Barriers &amp; Measures</b>		
2 Inadequate Government patronage and commitment.	(i) Pursue the government to increase the budgetary allocations for sustainable socioeconomic programs.  (ii) Awareness creation on importance of sustainable management of mangroves to facilitate increased government commitment for financing.	Over a period of 03 years US\$ 0.134 million
3 No proper legal authority for protection and management of mangroves and therefore lack of management plans or strategies to protect and manage these resources.	(i) Provide assistance to the responsible agencies to enable preparing appropriate management regimes mangrove systems.  (ii) Awareness programs for senior management of the respective organizations to enable appreciating the need for rehabilitating mangroves for socioeconomic benefits.	Over a period of 03 years US\$ 0.134 million
<b>Social, Cultural &amp; behavioral Barriers &amp; Measures</b>		

4	Unsustainable practices (unplanned developments and projects) within mangrove ecosystems.	<ul style="list-style-type: none"> <li>(i) Awareness programs for those involved in unsustainable practices within mangrove areas.</li> <li>(ii) Strict enforcement of regulations together with appropriate punitive actions against offenders.</li> </ul>	over a period of 03 years US\$ 0.134 million
5	Destructive lagoon fishing techniques.	<ul style="list-style-type: none"> <li>(i) Strict impose of fishery regulations and regulatory mechanisms</li> <li>(ii) Introduce Co-management procedures for mangrove and lagoon resource uses.</li> <li>(iii) Conduct awareness programmes and establish regulatory mechanisms.</li> </ul>	cost of the project period US\$ 0.175 million
<b>Technical Barriers &amp; Measures</b>			
6	Replanting mangroves without establishing proper zonal plans and using unsuitable species	<ul style="list-style-type: none"> <li>(i) Establish regulatory mechanisms for mangrove replanting programmes</li> <li>(ii) Develop zonal plans to identify the mangrove areas required rehabilitation using GIS &amp; remote sensing techniques</li> <li>(iii) Identify most suitable species for replanting</li> </ul>	over a period of 02 years is US\$ 0.06 million
<b>Institutional and Organizational Capacity Barriers &amp; Measures</b>			
7	General lack of public appreciation/awareness on the non extractive uses/importance, and ecological functions of mangroves.	<ul style="list-style-type: none"> <li>(i) Conduct stakeholder awareness programs through mass media involving sector experts.</li> <li>(iv) Encourage projects that help rehabilitation of mangroves at research institutes, universities and schools.</li> </ul>	over a period of 03 years is US\$ 0.134 million
<b>Other Barriers &amp; Measures</b>			
8	Illegal & unsustainable land use practices in the hinterland, which contributes to high sedimentation rates in lagoons and estuaries.	<ul style="list-style-type: none"> <li>(i) River basin management.</li> <li>(ii) Conduct IEE/EIAs for all development programmes in the hinterland.</li> <li>(iii) Regulate land use patterns to reduce erosion.</li> </ul>	over a period of 05 years is US\$ 0.22 million

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### **7.6.3. General description of the "Restoration of Coral Reefs"**

Coral reefs are underwater structures made from calcium carbonate secreted by corals, which are biologically classified as Cnidarians (Coelenterates). Corals are marine organisms in class Anthozoa of phylum Cnidaria typically living in compact colonies of many identical individual "polyps". The group includes the important reef builders that inhabit tropical oceans and secrete calcium carbonate to form a hard skeleton. Coral forming organisms construct the reef by secreting hard skeletons of aragonite (a fibrous, crystalline calcium carbonate). Most coral reefs are built from stony corals, which in turn consist of polyps that cluster in groups. The polyps are like tiny sea anemones, to which they are closely related. But unlike sea anemones, coral polyps secrete hard carbonate exoskeletons which support and protect their bodies. Reefs grow best in warm, shallow, clear, sunny and agitated waters<sup>29</sup>.

Coral reefs often called "rainforests of the sea" and they form some of the most diverse ecosystems on Earth. They occupy less than one tenth of one percent of the world's ocean surface, about half the area of France, yet they provide a home for twenty-five percent of all marine species. (Dali et al. as quoted in [http://en.wikipedia.org/wiki/Coral\\_reef](http://en.wikipedia.org/wiki/Coral_reef)) including other marine vertebrates and invertebrates] paradoxically, coral reefs flourish even though they are surrounded by ocean waters that provide few nutrients. They are most commonly found at shallow depths in tropical waters, but deep water and cold water corals also exist on smaller scales in other areas.

Coral reefs deliver ecosystem services to tourism, fisheries and shoreline protection. The annual global economic value of coral reefs has been estimated at US\$ 375 billion. However, coral reefs are fragile ecosystems, partly because they are very sensitive to water temperature. They are under threat from climate change, ocean acidification, blast fishing, cyanide fishing for aquarium fish, mining for lime industry and overuse of reef resources, and harmful land-use practices, including urban and agricultural runoff and water pollution, which can harm reefs by encouraging excess algae growth<sup>46</sup>.

As an adaptation for climate change induced sea level rise, this natural reef building mechanism needs to be artificially enhanced by providing hard substrata attached with relevant samples of temperature tolerant live corals to produce artificial coral reefs. Transplanting of corals on concrete blocks and tiles has been successfully experimented in the country.

#### **7.6.3.1 Identification of barriers and measures**

Barriers for transfer and diffusion of the technology and the enabling measures Table 7.11.

**Table 7.11: Key Barriers and Measures Identified for Restoration of Coral Reefs**

<b>Technology 3: Restoration of Coral Reefs</b>			
Barriers	Measures	Cost of Implementation for the Target Years	
<b>Economic and Financial Barriers &amp; Measures</b>			
1	Inadequate financial resources for monitoring & restoration programmes.	(i) attract funding from local and foreign funding sources, NGOs etc. through properly formulated proposals with suitable justifications. (ii) Introduce eco-friendly activities with financial gains.	during the first year of the Project is US\$ 0.116 million
<b>Non-Financial</b>			
<b>Policy, Legal and Regulatory Barriers &amp; Measures</b>			
2	Inadequate government patronage and financial provisions at central /or provincial level for coral reef conservation and rehabilitation programs.	(i) awareness creation among policy makers to enable appreciating the potential socioeconomic gains of reef restoration and to provide increased finances for relevant activities.	over a project period of 3 years is US\$ 0.09 million.
3	Poor enforcement of coastal regulations and lack or poor IEE & EIAs when establishing tourist resort complexes in the vicinity of coral reefs.	(i) establish community participatory organizations in the vicinity of coral reefs to ensure sustainability of coral reefs and to monitor the development programs. (ii) Appoint properly constituted credible committees to review the IEE & EIA reports related to development and economic activities in the coastal belt.	during the first year of the Project is US\$ 1.65 million
<b>Social, Cultural &amp; Behavioral Barriers &amp; Measures</b>			
4	Unsustainable resource utilization (e.g. coral mining for lime industry, collection of ornamental fish, use of explosives for fishing).	(i) conduct awareness programmes on the impacts of unsustainable economic activities in reef ecosystems. (ii) Offer alternative livelihoods or training for those engaged in coral destructive self employment ventures.	during the 3 years of the project is US\$ 0.09 million
5	Sedimentation and pollution due to unplanned socioeconomic activities in the coastal belt and hinterland.	(i) river basin management to prevent sedimentation due to unplanned land based activities	cost of implementation during the Project period is US\$ 0.29 million

		<ul style="list-style-type: none"> <li>(ii) Conduct proper IEE and EIAs for all relevant land based activities which may cause soil degradation and sedimentation in coastal areas.</li> <li>(iii) Control of land use pattern to reduce erosion through involvement of National Physical Planning Department.</li> <li>(vi) Carry out stakeholder assisted reef cleaning programs.</li> <li>(vii) Effective enforcement of relevant laws related to coastal development activities.</li> </ul>	
6	Destructive activities against conservation/rehabilitation programs, transplanting, etc.	<ul style="list-style-type: none"> <li>(i) awareness programmes on the significance of coral transplant programs.</li> <li>(ii) Employ/involve the communities engaged in destructive activities when conducting eco-friendly activities.</li> </ul>	during the 3 years of the project is US\$ 0.09 million
<b>Network Failure Barriers &amp; Measures</b>			
7	Inadequate interagency coordination.	<ul style="list-style-type: none"> <li>(i) conduct awareness programs to key officials of relevant agencies to ensure effective inter agency coordination when implementing coral restoration programs.</li> <li>(ii) Train selected personnel from relevant line agencies for reef restoration programs.</li> </ul>	during the 3 years of the project is US\$ 0.09 million
<b>Information and Awareness Barriers &amp; Measures</b>			
8	Inadequate awareness among stakeholders.	<ul style="list-style-type: none"> <li>(i) stakeholder awareness creation on the non extractive uses, roles and functions of coral reef eco systems.</li> <li>(ii) Formulate development plans through stakeholder engagement.</li> <li>(iii) Conduct awareness programs on the need for controlling pollution and sedimentation that may occur due to land-based and costal activities.</li> </ul>	over a 5 year period is US\$ 0.009 million
<b>Technical Barriers &amp; Measures</b>			
9	Inadequate trained personnel to engage in coral rehabilitation programs.	Provide adequate training to members selected from the stakeholder groups and engage them to lead implementation of the respective programs and also use as trainers for the rest of the community.	during the Project period is US\$ 0.2 million
<b>Other Barriers &amp; Measures</b>			
10	Coral bleaching.	Conduct seasonal monitoring programs with the cooperation of stakeholders trained to be on alert on this natural phenomenon.	during the Project period is US\$ 0.09 million

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## **7.7. Linkages of the barriers identified**

Although the barriers are specific to each coastal ecosystem, yet some of the barriers appear to be common to all the technologies identified for the sector. Such barriers common to all or some of the barriers are discussed below.

### **7.7.1 Inadequate financial assistance**

Inadequacy of funds is common to all the three technologies viz; 1) Rehabilitation of sand dunes, 2) Rehabilitation of Mangroves and 3) Restoration of Coral Reefs. However, the quantum of financial requirements differ among the technologies. Rehabilitation of the respective ecosystems under Technologies 1 and 2 and awareness creation under all the three technologies are the key activities that require adequate financing.

### **7.7.2 Inadequate government patronage**

This barrier which falls under the policy, legal & regulatory barrier category is common to rehabilitation of mangroves and restoration of coral reefs under Technologies 2 and 3. Low priority given for funding environmental protection and R&D reflect the lack of government patronage for these technology interventions.

### **7.7.3. Poor enforcement or lack of resource management plans**

Poor enforcement of resource management plans is a common barrier for technologies 1 and 3 and lack of proper management plans or strategies is a barrier for technology 2. Thus this barrier has the potential for causing similar impacts on the success of the technologies.

### **7.7.4. Inadequate inter agency coordination**

Inadequate inter agency coordination among different agencies is a common barrier to Technologies 1 & 3 resulting duplication of activities by several institutions and waste of scarce financial resources.

### **7.7.5. Unsustainable practices /resource utilisation**

This is a common barrier for all three technologies. The barrier identified as “Difficulty in giving up unsustainable resource utilisation” under Technology 1, the barrier expressed as “Unsustainable practices (unplanned developments and projects) within mangrove ecosystems” such as removal of mangrove vegetation for development projects, disposal of municipal waste etc. under technology 2, and unsustainable resource utilisation such as coral mining for lime industry, collection of ornamental fish, use of explosives for fishing etc. under technology 3, fall under this barrier category. The impacts of all these practices are detrimental to the sustainability of the respective ecosystems and the goods and environmental services provided by them.

### **7.7.6. Inadequate awareness**

This barrier is common for Technology 1 & 3. Under Technology 1, it is highlighted as “General lack of awareness on the non-extractive uses of dune resources and lack of awareness on the importance of protecting the ecosystem” whereas it is identified as, “Lack of awareness on the importance of

protecting the ecosystem” under Technology 3.

### 7.7.7. Inadequate knowledge on the technologies

Inadequacy of knowledge is reflected as, “lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation”, “use of technology in an incorrect manner“ and ”inadequate trained personnel to adopt the technology” under Technology1, 2 and 3 respectively. The overall impact of all these barriers is poor rehabilitation/restoration of ecosystems.

### 7.8. Enabling framework for overcoming the barriers in the Coastal Sector

Enabling framework to overcome the Common barriers is provided in Table 7.12.

**Table 7.12: Common barriers and their enabling framework of the Coastal Sector**

No	Broad/ Common barriers	Enabling framework	Technology
1	Inadequate financial provisions.	(i) seek annual government funding using suitably justified proposals and from NGOs & INGOs actively involved in adaptation technologies and conservation of ecosystems & biodiversity.  (ii) Encourage self sustaining economic activities through mangrove product utilization.  (iii) Introduce eco-friendly activities with adequate financial gains.	1,2,3
2	Inadequate government patronage.	Solicit continued government patronage by way of providing adequate funding and other form of assistance through increased awareness on socio-economic and ecological benefits of ecosystem rehabilitation among relevant State officials.	1,2,3
3	Poor enforcement or lack of resource management plans.	Stakeholder awareness creation on the existing coastal zone management regulations, the need for efficient enforcement such regulations and provide technical and other forms of assistance to the respective agencies to prepare suitable management plans for the coastal ecosystem rehabilitation. Establish community participatory organizations to monitor the development programs and appropriate mechanisms to review the EIA reports related to development activities in the coastal zone as deemed appropriate.	1,2,3
4	Inadequate interagency coordination.	(i) development of multidisciplinary projects in collaboration with research/academic institutions.  (ii) Identify strategies to develop and improve fruitful collaborations, to Identify, problems and prepare activity plans to address issues in coastal ecosystems.	1,3

		<p>(iii) Awareness creation among the key officials of different line agencies on the need for efficient coordination in coastal resources management.</p> <p>(iv) Train a core group of personnel from relevant line agencies to be involved in restoration programs.</p>	
5	Unsustainable resource utilization practices.	<p>(i) awareness creation on the harmful; effects of unsustainable resource utilization practices and provide alternate income generating opportunities for those involved in such activities.</p> <p>(ii) Efficient enforcement of coastal zone regulations.</p> <p>(iii) Involve NGOs and community organizations in community participatory programmes related to coastal resources management.</p>	1,2,3
6	Inadequate awareness.	<p>(i) stakeholder awareness creation on the importance of coastal ecosystem restoration and non extractive uses and ecosystem services provide by the coastal ecosystems.</p> <p>(ii) Involve unemployed youth of coastal communities in ecotourism activities in association with coastal tourist hoteliers for development of coastal tourist attractions such as nature trails, herbal gardens etc.</p> <p>(iii) Awareness creation on the impact of land based activities on the coastal ecosystems.</p>	1,3
7	Inadequate knowledge on the technologies.	<p>(i) Encourage plantations of dune vegetations of economic and medicinal importance.</p> <p>(ii) Awareness and training programmes to disseminate information and to provide knowledge on plant species suitable for ecosystem rehabilitation, tissue culture &amp; other propagation methods to produce sufficient numbers of plants/ propagules for plantation and sustainable utilisation of dune vegetation for SMEs</p> <p>(vi) Develop zonal plans to identify areas requiring restoration and develop regulatory mechanisms for rehabilitation activities.</p> <p>(viii) Provide adequate training to suitable members selected from the stakeholder groups and engage as leaders for implementation of the respective programmes and as trainers for the rest of the community</p>	1,2,3

## 7.9 Technology Action Plan for the Coastal Sector

The focus of the climate change adaptation actions to be undertaken in the coastal sector will be to take precautionary measures to reduce the impacts of Sea Level Rise (SLR), coastal inundation and erosion. These actions are mainly focused on the sensitive coastal ecosystems such as sand dunes, mangroves and coral reefs which act as natural barriers against waves, tides, storm surges, tsunami, etc. that could



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cause damage to coastal environment.

Coastal ecosystems have been subjected to destruction not only by the natural causes but also due to anthropogenic activities, which reduce the area covered by sand dunes, mangroves and coral reefs at a rate much higher than the rate of natural replenishment. Therefore, restoration of these ecosystems has been prioritised with a view to develop soft barriers that would help socioeconomic development in the coastal region while providing protection against SLR, coastal inundation and erosion.

The Proposed Action Plans for the identified Technologies for coastal Sector are in Annex XI

# CHAPTER 8

## Biodiversity Sector

### 8.1 Overview of the Biodiversity Sector

Sri Lanka is one of the most biologically diverse countries in Asia. Despite its small size of 6,570,134 hectares Sri Lanka has a varied climate and topography, which has resulted in rich biodiversity, distributed within a wide range of ecosystems. In fact conservation of these resources has been an integral part of Sri Lanka's ancient civilization as stated in ancient chronicles such as the *Mahawamsa*<sup>118</sup>. King Devanampiyatissa established one of the world's earliest wildlife sanctuaries during 247 to 207 BC during the advent of Buddhism to the country, a philosophy that respects all forms of life<sup>28</sup>.

Sri Lanka's biodiversity is considered to be the richest per unit area in the Asian region with regard to mammals, reptiles, amphibians, fish and flowering plants; overtaking several mega diversity countries such as Malaysia, Indonesia and India<sup>90</sup>. The biodiversity of the country is recognized as being globally important. Sri Lanka along with the Western Ghats of India has been identified as one of the 34 biodiversity hotspots in the world<sup>84</sup>. Biodiversity provides a multitude of ecosystem goods and services to people of Sri Lanka, including watershed services, regulation of climate, carbon sequestration, and supply of non-timber forest products such as rattan, wild foods, fruits, & medicinal plants, among many others. It is estimated that about 15% of the islands forests and scrublands lie within the country's Protected Area (PA) system<sup>79</sup>, while some marine protected areas have also been set up in addition to these terrestrial areas. Conservation of country's biodiversity is recognized in national planning, and is highlighted in several policies, legislations and programs set up to protect the country's biodiversity. The *Mahinda Chintana*, national policy framework for Sri Lanka, *Haritha* (Green) Lanka Action Plan, Biodiversity Action Plan for Sri Lanka and the National Physical Planning Policy and Plan<sup>73</sup> are prominent among them.

Despite all these efforts, Sri Lanka's biodiversity remain threatened. While some critical areas are not included in the protected area system, even some of those within the system still face serious threats. The biggest threats to the protected area system and biodiversity in general come from encroachments, conversion to other land uses, illegal extraction of natural resources, shifting cultivation, forest fires, haphazard development projects, poaching, pollution, gem mining, in coastal and marine ecosystems siltation and sedimentation, sewage and solid waste disposal, development of aquaculture and illegal sand/coral mining. According to the National Red List 2012 of Sri Lanka, of the 772 inland indigenous vertebrate species assessed 329 (43 percent) have been classified as Nationally Threatened. Of the threatened vertebrate species, 225 (68 percent) are endemic to the country. Many plant species in the country are also facing threat. Of the 3, 156 indigenous angiosperms evaluated, 1, 383 species (44 percent) were classified as Nationally Threatened, with a total of 894 angiosperms considered to be endemic to Sri Lanka<sup>82</sup>.

Climate change will no doubt be a threat to Sri Lanka's biodiversity. It is unlikely that all impacts of climate change on biodiversity are preventable. However, it is recognized that genetically diverse populations of species, and species rich ecosystems, have much greater potential to adapt to climate change. Conservation of biodiversity and maintenance of ecosystem structure and function may,

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therefore, be one of the most practical climate change adaptation strategies that Sri Lanka can adopt to conserve the country's natural heritage<sup>70</sup>.

The Sector Vulnerability Profile (SVP) for the biodiversity sector (which is a supplementary document to Sri Lanka's National Climate Change Adaptation Policy) has explored the potential impacts of climate change on the sector. Accordingly, as an island nation, Sri Lanka is vulnerable to the risk of sea level rise and increased frequency of storms that can bring major impacts on coastal biodiversity. Additionally, analysis of climate data indicate a change in rainfall regimes, and a trend for increasing air temperature, which can also have impacts on the country's biodiversity. According to this assessment the impact of climate change on biodiversity and possible areas for adaptation are still speculative.

Some of the impacts relating to climate change are salinization of low lying areas due to sea level rise, storm surges and salt water intrusion, loss of coastal land due to sea level rise and increased coastal erosion, loss of coastal wetland area, adverse impacts to mangroves, coral reefs and sea grass beds and associated marine organisms, and changes in salinity of lagoons and estuaries. It is expected that there will be changes in coastal and marine ecosystems, species and ecosystem services due to global warming and ocean acidification. This will impact coral reefs, other shell forming organisms and associated species and fish stocks, rising ocean temperatures and El Nino events that will systematically bleach and impoverish coral reef systems, and there will be an increased spread of marine invasive species.

It is also expected that climate change will cause changes in onset of flowering/fruitletting and flushing in terrestrial plants and breeding and reproduction in animals having implications on species survival, and ecosystems. Forest ecosystems and species in fringe areas between the major climatic zones are expected to be most vulnerable to impacts of climate change. Elevated carbon dioxide level in the atmosphere can cause changes in forest structure while species loss can occur due to structural and compositional changes in habitats and deterioration of ecosystem services.

The SVP has also identified vulnerability enhancing factors for biodiversity, which are identified as the main anthropogenic factors that currently threaten biodiversity and would reduce resilience of ecosystems and species to withstand impacts of climate change. These include habitat loss and fragmentation, ecosystem degradation, over exploitation of biological resources, loss of traditional crop and livestock varieties and breeds, pollution, human - wildlife conflicts, spread of Invasive Alien Species (IAS) and increasing human population density.

### **8.1.1 Existing Policies and Laws Related to Development and Technology Development in the Biodiversity Sector**

The existing policy framework and legislation related the sector's development and technology deployment are given in Tables 8.1 and 8.2.

**Table 8.1: Existing key policies in the Biodiversity sector**

Key policies	Year Enacted	Main Contents
1. National Forestry Policy	1995	The three main objectives of the National Forest Policy are, (a) to conserve forests for posterity, with particular regard to biodiversity, soils, water, and historical, cultural, religious and aesthetic values (b) to increase the tree cover and productivity of the forests to meet the needs of present and future generations for forest products and services (c) to enhance the contribution of forestry to the welfare of the rural population, and strengthen the national economy, with special attention paid to equity in economic development.
2. National Policy for Wildlife Conservation of Sri Lanka	2000	The policy states the vision and mission and also provides an overview at the beginning, and also contains a preamble. The policy details objectives, and also policies on – protected area management and wildlife conservation; institutional support for wildlife conservation; and inter-sectoral linkages. It also includes definitions of key concepts.
3. Climate Change Policy	2012	<p>The vision of the policy is a future where climate change will have no adverse consequences on Sri Lanka, whilst its mission is to address climate change issues locally while engaging in the global context. It has the goal of - adaptation to and mitigation of climate change impacts within the framework of sustainable development.</p> <p>Goal of the policy is Adaptation to and mitigation of climate change impacts within the framework of sustainable development</p> <p>Policy Objectives are (a) to sensitize and make aware the communities periodically on the country’s vulnerability to climate change (b) to take adaptive measures to avoid/minimize adverse impacts of climate change to the people, their livelihoods and ecosystems (c) to Mitigate greenhouse gas emissions in the path of sustainable development (d) to Promote sustainable consumption and production.(e) to enhance knowledge on the multifaceted issues related to climate change in the society and build their capacity to make prudent choices in decision making (f) to develop the country’s capacity to address the impacts of climate change effectively and efficiently (g) to mainstream and integrate climate change issues in the national development process</p>

**Table 8.2: Existing key laws in the Biodiversity sector**

Legislation	Main Contents
Fauna and Flora Protection Ordinance No. 2 of 1937 (as amended).	The Fauna and Flora Protection Ordinance Provides for the conservation of plants and animals, which have been declared as protected species. It also empowers the Minister in charge to declare any area of State Land as a National Reserve or Sanctuary.
Forest Ordinance No. 16 of 1907 (as amended) and the Rules and Regulations under the Ordinance.	The Forest Ordinance consolidates the laws relating to forests and to the felling and transportation of timber. It also empowers the Minister in charge to declare any area of State land as a Reserved Forest, Conservation Forest or a Village Forest.

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## 8.2 Identified Adaptation Technologies in the Biodiversity Sector

Following potential adaptation technologies cum strategies have been identified for the sector;

1. Restoration of degraded areas inside and outside the protected area network to enhance resilience.
2. Modeling the impact of climate change on biodiversity to predict changes for conservation and management.
3. Increasing connectivity through corridors, landscape/matrix improvement and management.
4. Protecting refuges which are less vulnerable to climatic changes.
5. Managing and monitoring invasive alien species (IAS).
6. Reducing other stresses on species and ecosystems.
7. Adaptive management and monitoring programs of species and ecosystems.
8. Focusing on conservation of resources and carrying out special management for restricted range, highly threatened species and ecosystems.
9. Improving management of existing protected areas, increasing extent, creating buffer zones and new areas in vulnerable zones.
10. Reviewing and modifying existing laws, regulations, and policies relating to biodiversity and natural resources and incorporating climate change adaptation considerations (ensuring implementation).
11. Ex-situ conservation for highly threatened species and possible reintroduction.

### 8.2.1 An Overview of Possible Adaptation Technology Options and their Adaptation Benefits

The identified technologies/strategies have various benefits for conserving biodiversity and adapting to climate change. Table 8.3 provides a brief description of the technology and their potential benefits

**Table 8.3: Scope and potential benefits of the technologies for the Biodiversity Sector**

***1. Restoration of degraded areas inside and outside the protected area network to enhance resilience***

This will enable restoring degraded areas inside and outside the Protected Area network to enhance resilience to better withstand the impact of climate change. This not considered a 'new technology' as such and in- country capacity exists. Some potential benefits of the technology are;

- Beneficial for carbon sequestration, which would contribute to climate change mitigation.
- Ensure maintenance of ecosystem services for the benefit of local communities and the larger population.
- Create direct income generating opportunities through the involvement in restoration activities, community conservation, payments for ecosystem services, REDD and ecotourism.
- Employment opportunities as restoration will require manpower.
- Need for policy or legislative reforms will not arise.

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## **2. Modeling the impact of climate change on biodiversity to predict changes for conservation and management**

This will enable forecasting climate change impacts on biodiversity to enable undertaking appropriate conservation and management measures. Potential benefits of the technology are;

- Most climate change adaptation strategies will be based on prediction thus the technology provides ability for better future planning.
- Adaptation strategies could be made effective provided they are based on climate models and existing data.
- It will ensure proper planning and implementation of adaptation strategies.
- Sustainability of biodiversity and associated ecosystem services will be ensured through resilience thereby benefiting the communities dependant on ecosystem services for livelihoods.
- Would allow ecosystems to be more resilient, and minimize risks on ecosystem services. .

## **3. Increasing connectivity through corridors, landscape/matrix improvement and management**

This is an important mechanism to connect fragmented areas as many Protected Areas are isolated from each other. Increased connectivity through corridors will provide for landscape/matrix improvement and management. Legal provisions are already available for the establishment of such corridors in wildlife legislation and are referred to as 'jungle corridors' hence no legal reforms are required. Some of its benefits are;

- Availability of ecosystem service benefits for the larger population.
- The enhancement of the landscape will increase conservation related employment opportunities and income.
- Direct employment opportunities resulting from restoration, monitoring or conservation requirements.
- Accrued benefits from ecotourism, community conservation and sustainable utilization of NTFP, REDD etc.
- Environmental benefits include maintaining genetic diversity, allowing migration for species with large home ranges, seed dispersal, carbon sequestration and other ecosystem services.
- Improved resilient to climate change through enhanced conservation measures.

## **4. Protecting refuges which are less vulnerable to climatic changes**

This technology will focus on protecting those refuges which are less vulnerable to climate change. Some of its benefits are highlighted below.

- The main benefits would be the provision of a stable climate and habitat for biodiversity conservation in a changing climate to ensure its viability.
- Environmental benefits such as carbon sequestration, maintaining biodiversity, regulating the microclimate etc. which are associated with providing ecosystem services.
- Direct benefits to local communities from community conservation initiatives, REDD, payment for ecosystem services etc.
- Employment opportunities generated through the establishment and conservation & monitoring activities of the refuges.

## **5. Managing and monitoring invasive alien species (IAS)**

Focus will be on managing and monitoring invasive alien species as climate change exacerbate the spread of such non-native species, which include plants, animals, and pathogens. Enabling legislative and policy environment already exists in the country for management of IAS. Some of its benefits are highlighted below.

- The IAS being one of the leading causes of biodiversity loss, it will ensure sustainability of biodiversity and minimize degradation. Thus management of the IAS will be beneficial for overall biodiversity conservation.
- Controlling IAS will also be beneficial to the agricultural sector.
- Employment opportunities from the increasing personnel requirement for monitoring, enforcement and removal of IAS.
- Supplementary incomes from ecosystem services, community conservation, REDD etc.

## **6. Reducing other stresses on species and ecosystems**

This technology aims at reducing or removing other non-climatic stresses on species and ecosystems providing species the maximum flexibility to evolve responses to climate change. Some of its benefits are;

- Reducing stresses on biodiversity will ensure that ecosystem services are minimally impacted and will continue to provide food, watershed services, control erosion, regulate disease etc.
- A well conserved protected area or environment will attract more tourism and visitation thus benefiting local livelihoods.
- Create employment opportunities as increased conservation and monitoring activities will require additional manpower.
- Improved ecosystem services could provide income through the sustainable collection of NTFP and will be beneficial for agriculture through microclimatic improvements and pest control.
- This technology will maintain viability and resilience of biodiversity to enable adapting to impacts of climate change.
- Enhanced ecosystem services such as carbon sequestration and other environmental services.

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**7. Adaptive management and monitoring programs of species and ecosystems**

This technology focuses on adaptive management and monitoring programs of species and ecosystems. Monitoring is essential to observe climate change impacts and associated ecosystem responses and adjusts management strategies accordingly. Partnership based adaptive management is important as it will allow field managers help to test and refine ideas progressively in order to be effective during the uncertainties of climate change. Some of its benefits are highlighted below;

- Adaptive management will contribute to minimizing impacts of climate change so as to increase resilience which will be important for maintaining ecosystem services.
- Increased employment opportunities from conservation activities, while local communities could benefit from community conservation, payment for ecosystem services, ecotourism etc.
- Early action could minimize potential irreversible damages ahead of impacts becoming severe.
- Preventive and early action will cost less than intervening once considerable impact has occurred.

**8. Focusing on conservation of resources and carrying out special management for restricted range, highly threatened species and ecosystems**

This will focus on conservation of resources and carrying out special management practices for restricted range, highly threatened species and ecosystems vulnerable to climate change to minimize species loss and extinction. This mechanism will ensure that biodiversity is conserved in a sustainable manner, preventing threats of extinction. Some of its benefits are;

- It will ensure that ecosystem services are maintained.
- Income generation from ecotourism and visitation to conservation facilities/areas for observing targeted programs for threatened species.

**9. Improving management of existing protected areas, increasing extent, creating buffer zones and new areas in vulnerable zones**

These efforts will provide for improved management of existing Protected Areas, expansion, creating buffer zones and new areas in vulnerable zones. Some of its benefits are highlighted below.

- Direct benefits to local communities from ecotourism related activities and community conservation programs, REDD, payments for ecosystem services etc.
- Benefits from ecosystem services such as micro-climate regulation, watershed services, erosion and flood control, carbon sequestration etc.

**10. Reviewing and modifying existing laws, regulations, and policies relating to biodiversity and natural resources and incorporating climate change adaptation considerations.**

This technology will involve reviewing and reforms as required to the existing laws, regulations, and policies relating to biodiversity conservation and natural resources management in order to incorporate climate change adaptation considerations. Some of the benefits of the technology are;

- Ensures sustainability ecosystem services and increase of resilience of biodiversity.
- Although the review and amendment process itself will not generate income, but subsequent implementation of such reformed instruments could contribute to providing additional income generating opportunities such as payments for ecosystem services, community conservation, REDD etc.
- Enabling legislation and policies will ensure effective implementation of climate change adaptation strategies.
- Generate donor interest as the fundamentals are in place for adaptation.

**11. Ex-situ conservation for highly threatened species and possible reintroduction**

This will entail carrying out ex-situ conservation for highly threatened species and reintroducing into the natural habitats. The main environmental benefit would be its contribution to the viability of threatened biodiversity, and sustainability of genetic diversity. Other benefits will be;

- Certain ex-situ conservation programs, particularly those associated with zoological gardens, botanical gardens and aquaria can generate significant income from foreign tourists and local visitors.
- Zoological Gardens, botanical gardens and aquaria provide excellent learning platforms for students and adults as well.
- Provide access to information on threatened species and awareness on the importance of conservation and will contribute to garner wider support for biodiversity conservation.

## 8.3 Criteria and Process of Technology Prioritization

### 8.3.1 Multi Criteria Decision Analysis (MCDA)

The methodology used to prioritize the technologies was Multi Criteria Decision Analysis (MCDA) Approach. The criteria and the weightings for selected criteria were determined through stakeholder consultations.

#### 8.3.1.1 Determination of Criteria and Weightings

The criteria included cost of technologies, and economic, social, & environmental benefits.. Accordingly, seven (07) criteria were selected using the social, economic and environment importance and the respective weight factors for each criterion are given in the Table 8.4.

**Table 8.4: Criteria Adopted to Prioritize the Adaptation Technologies of the Biodiversity Sector**

Major Criteria	Sub divisions of criteria selected		Weight Factor
Costs 10%)	Annual investment in Rs Million (Government and Public)		10%
	Economic 10%)	Job creation/opportunities – Potential of the activity to create employment opportunities.	10%
	Social (30%)	Ecotourism and Conservation benefits (payments for ecosystem services, REDD etc) - The contribution of the strategy for ecotourism development (benefits accrued by the local communities and the State).	20%
		Improve awareness, research opportunities	10%
	Environmental (50%)	Overall contribution to saving biodiversity (effectiveness/impact) – Degree of contribution to biodiversity conservation in the medium to long term (eg: protecting one species vs a larger group; small impact to survival vs major impact)	15%
		Addresses conservation urgency, including threatened species – Potential benefits of an urgent/essential conservation issue is being addressed (E.g.: a highly threatened ecosystem or Red List species)	15%
		Enhancing ecosystem services (general) - Contribution to enhancing ecosystem services (E.g.: Contribution of restoration to ecosystem services vs ex-situ conservation)	20%

**8.3.2 Scoring Matrix:** The Scoring Matrix constructed based on the above criteria and respective weight factors to evaluate the comparative effectiveness of different technologies appear in Annex VII which include weighted scores, costs and benefits of technologies.

## 8.4 Results of Technology Prioritization for the Bioiversity Sector

It is noted that for a natural resource based sector like biodiversity, benefits are relatively more important when compared with other sectors. Hence, environmental and ecotourism & conservation benefits are given relatively high weight factor in the MCDA process (Table 8.4). In prioritizing technologies those options that had the highest level of benefits per unit cost have been considered as



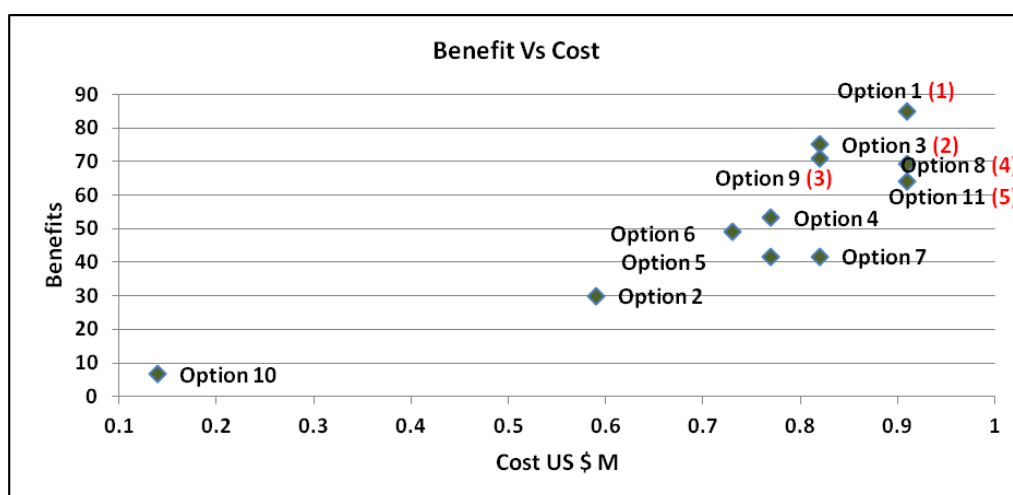
of highest priority. Those options shown to have the highest benefit/cost ratios received the high priority and the top five technologies selected had the highest B/C ratios, indicating the highest returns per unit cost. The costs and benefits of selected technologies based on the MCDA and performance matrix are given in Table 8.5 and Figure 8.1.

Since it is considered important to include inter alia species level interventions as well, the total number of technologies prioritized for the sector has become five. These five technologies are recognized the most important adaptation strategies for the biodiversity sector to counter climate change challenges.

As shown in Table 8.5 and Figure 8.1, technological options 1,3,8,9 and 11 have the potential to provide high level of benefits as well as highest C/B ratios which primarily dictated the final selection. The sensitivity analysis has not show a significant deviation from these results.

**Table 8.5: Costs and benefits of the selected technologies of the Biodiversity Sector and the order of priority**

No.	Technology	Benefits	Annual Costs (US \$ mill/year)	Priority
1.	Restoration of degraded areas inside and outside the protected area network to enhance resilience	85.00	0.91	(1)
2.	Modeling the impact of climate change on biodiversity to predict changes for conservation and management	30.00	0.59	10
3.	Increasing connectivity through corridors, landscape/matrix improvement and management	75.00	0.82	(2)
4.	Protect refuges which are less vulnerable to climatic changes	53.33	0.77	6
5.	Manage and monitor invasive alien species (IAS)	41.67	0.77	8
6.	Reduce other stresses on species and ecosystems	49.17	0.73	7
7.	Adaptive management and monitoring programs of species and ecosystems	41.67	0.82	9
8.	Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems	69.17	0.91	(4)
9.	Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones	70.83	0.82	(3)
10.	Review and modify existing laws, regulations, and policies relating to biodiversity and natural resources and incorporate climate change adaptation considerations	6.67	0.14	11
11.	Ex-situ conservation for highly threatened species and possible reintroduction	64.17	0.91	(5)



**Figure 8.1: Benefit vs. cost plot for selected technologies for Biodiversity Sector**

The five (5) technologies thus selected for the sector are given below in their order of priority.

1. **Option 1:** Restoration of degraded areas inside and outside the protected area network to enhance resilience.
2. **Option 3:** Increasing connectivity through corridors, landscape/matrix improvement and management
3. **Option 9:** Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones
4. **Option 8:** Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems
5. **Option 11:** Ex-situ conservation for highly threatened species and possible reintroduction.

**Table 8.6: Summary table for Prioritized Technologies for the Biodiversity Sector**

No.	Technology	Scale of Application (small, medium or large scale)	Time Scale (short, medium or long term)	Benefits (outputs from the MCDA)	Estimated total annual cost (US \$ million)
1.	Restoration of degraded areas inside and outside the protected area network to enhance resilience	Medium-large scale	Long-term	85.00	0.91
2.	Increasing connectivity through corridors, landscape/matrix improvement and management	Medium-large scale	Long-term	75.00	0.82
3.	Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones	Medium-large scale	Long-term	70.83	0.82
4.	Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems	Medium-large scale	Long-term	69.17	0.91
5.	Ex-situ conservation for highly threatened species and possible reintroduction	Medium-large scale	Long-term	64.17	0.91

### 8.4.1 Categories of the Prioritized Technologies

To facilitate the barrier analysis, it is useful to categorize technologies according to the types of goods and services they belong or contribute to, as the different types of goods and services have distinct market characteristics. The transfer and diffusion of technologies within each category are influenced either by market or political decisions. The diffusion of consumer goods and to some extent capital goods are generally dominated by market decisions, whereas publicly provided goods and non-market goods are primarily implemented through political decisions. Government institutions therefore have a direct influence on the diffusion of publicly provided and non-market goods.

**Table 8.7: Prioritized Technologies for the Biodiversity Sector**

No	List of Prioritized Technologies	Category of the Technology
1.	Restoration of degraded areas inside and outside the protected area network to enhance resilience.	Publicly provided goods/ Nonmarket goods
2.	Increasing connectivity through corridors, landscape/ matrix improvement and management	Publicly provided goods/ Nonmarket goods
3.	Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones	Publicly provided goods/ Nonmarket goods
4.	Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems	Publicly provided goods/ Non - market goods
5.	Ex-situ conservation for highly threatened species and possible reintroduction.	Publicly provided goods/ Nonmarket goods

### 8.5 Preliminary targets for technology transfer and diffusion

Presently there are no specific targets identified for biodiversity related technology transfer and diffusion for climate change adaptation. However the Sector Vulnerability Profile for Biodiversity and Ecosystem Services<sup>73</sup>, an addendum to Sri Lanka's Climate Change Strategy has addressed at priorities for biodiversity and ecosystem services. Targets for the prioritized technologies are provided in table 8.8.

**Table 8.8: Preliminary Targets for the Prioritized Technologies in the Biodiversity Sector**

Technology	Targets
<b><i>Technology 1 - Restoration of degraded areas inside and outside the protected area network to enhance resilience.</i></b>	<ul style="list-style-type: none"> <li>• Restoration of at least 10,000 hectares of terrestrial and marine ecosystems, over 5 years.</li> <li>• Introduce a minimum of one incentive scheme for restoration.</li> <li>• Set aside at least 2% from the annual budgets of the Forest and Wildlife Department for restoration.</li> <li>• Prioritization of restoration interventions .</li> <li>• Publish ecosystem specific best practices.</li> <li>• Complete a minimum of 10 pilot interventions.</li> <li>• One campaign for political awareness completed.</li> <li>• Document evidence of implementing policies/legislation.</li> </ul>

<p><b><u>Technology 2 -</u></b>  <b><u>Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement).</u></b></p>	<ul style="list-style-type: none"> <li>• Introduce a minimum of one incentive scheme for private landowners to set aside or maintain areas required for connectivity.</li> <li>• Introduce provisions in current policies to ensure that medium to large development projects include areas that allow connectivity.</li> <li>• Prioritization of areas for connectivity completed.</li> <li>• One campaign for political awareness completed.</li> <li>• Climate change modeling for a minimum of two regions.</li> <li>• Document evidence of implementing policies/legislation.</li> <li>• Include a minimum of 4 critical areas into protected area network.</li> </ul>
<p><b><u>Technology 3 -</u></b>  <b><u>Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones.</u></b></p>	<ul style="list-style-type: none"> <li>• Set aside at least 2% from the annual budgets of the Forest and Wildlife Department for improving management, increasing extent of protected areas/buffer zones, and creating new areas.</li> <li>• Prepare and implement a minimum of 20 management plans for prioritized areas.</li> <li>• Introduce an incentive scheme for using brown field/degraded areas.</li> <li>• Introduce a system for ensuring staff accountability.</li> <li>• Physical demarcation/re-demarcation of boundaries according to legal/gazette boundaries in at least 10 key protected areas.</li> </ul>
<p><b><u>Technology 4 -</u></b>  <b><u>Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems.</u></b></p>	<ul style="list-style-type: none"> <li>• Develop and implement a minimum of 15 species action plans based on priority.</li> <li>• Set aside at least 2% from the annual budgets of the Forest and Wildlife Department to implement above action plans based on priority.</li> <li>• A minimum of one comprehensive climate modeling study to assess the climate change impact on species and ecosystems.</li> <li>• Provide legal protection for 2-5 sites where point endemics are found.</li> <li>• Introduce an incentive scheme for protection of important areas outside protected areas.</li> <li>• Establish a minimum of 5 effective partnerships for species conservation between Ministry/Departments and universities, NGOs, species specialists etc.</li> <li>• Awareness and capacity building program for 25% of staff in Forest and Wildlife Departments.</li> <li>• Implement a minimum of five research studies on critical species.</li> </ul>
<p><b><u>Technology 5 -</u></b>  <b><u>Ex-situ conservation for highly threatened species and possible reintroduction</u></b></p>	<ul style="list-style-type: none"> <li>• Establish two conservation facilities based on requirements and priority.</li> <li>• Set aside at least 2% from the annual budgets of the Forest and Wildlife Department for setting up ex-situ facilities that may be required in the near future.</li> <li>• Introduce a framework/protocol for reintroduction and monitoring.</li> <li>• Establish a minimum of 20 partnerships built with species specialists.</li> <li>• Capacity building on ex-situ conservation</li> <li>• Introduce standard protocols for ex-situ conservation including maintenance of facilities, disease control, quarantine etc.</li> <li>• Undertake a study to identify and prioritize species for ex-situ conservation.</li> <li>• Introduce a regulated system to allow ex-situ breeding by other parties under the supervision of respective government stakeholders.</li> </ul>

## 8.6 General Description, Barrier analysis and Possible Enabling Measures for the Biodiversity Sector

### 8.6.1 General Description of the "Restoration of degraded areas inside and outside the protected area network to enhance" resilience

Restoration of degraded areas inside and outside the protected area network to enhance resilience will allow biodiversity to better withstand the impact of climate change. Resilience can be defined as the capacity of a system to absorb disturbance and reorganize, while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks<sup>126</sup>. Some legally protected areas have been subjected to degradation due to illegal activities such as illegal clearing for settlement and cultivations, logging and fire damage. On the other hand there are areas existing outside the legally protected area system which are important for conservation at present and also in the event of species shift their range as a result of climate change. Restoration will require selecting suitable native species and recreating the former conditions of the ecosystem. Some ecosystems that can be restored include forests, wetlands, coastal areas, coral reefs etc. Restoration is not a new technology in Sri Lanka where forests<sup>6</sup>, aquatic ecosystems<sup>64</sup>, reefs and coastal areas in number of locations have been restored during the last several decades. Some of these technologies are currently in place, and has been so for several decades.

Several Policies, Action Plans and Strategies of the country has already identified this option as an essential technology for biodiversity conservation<sup>89</sup>.

Following are some potential elements of this technological intervention.

- a) Mapping and modeling to identify ecosystems and species (aquatic and terrestrial) that are highly vulnerable to climate change.
- b) Device appropriate technologies for natural/aided restoration within protected areas in highly vulnerable areas as identified in the mapping and modeling.
- c) Facilitate regeneration in areas outside protected areas as identified in mapping and modeling.
- d) Monitoring restoration inside and outside the protected area network.
- e) Aided natural restoration within protected areas.
- f) Identify suitable scientific methods of restoration.
- g) Creation of analogous ecosystems outside protected areas.

#### 8.6.1.1 Identification of barriers and measures for the Technology

The barriers and enabling measures for the technology are given in Table 8.9 .

**Table8.9: Key Barriers and Measures Identified for Restoration of degraded areas inside and outside the protected area network to enhance resilience**

No	Key Barriers Identified		
	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers</b>			

1.	Low funding allocation for restoration (nationally):	Set aside adequate funds from the annual budgets of Forest and Wildlife Departments for restoration activities based on agreed action plan.	US\$ 750,000.00 annually
2.	No immediate returns from restoration and lack of incentives for undertaking restoration by the communities and the private sector.	Provide incentives by government and the donors for restoration by communities and private sector and introduce a biodiversity-offset mechanism.	US\$ 1.1 million (2-3 years)
<b>Non Financial Barriers</b>			
<b>Information &amp; awareness, Human Skills and other barriers</b>			
3.	Poor understanding of the true value of ecosystem services and absence of local ecosystem specific information on their ecosystem services potential.	Ecosystem specific studies to assess ecosystems services potential and dissemination of information thus generated.	US\$ 0.46 million (3 years)
4.	Lack of national level prioritization of areas for restoration.	Study to identify and prioritize critical areas for restoration, Climate change modeling to identify critical areas and an Action Plan.	US\$ 2.0 million (3 years)
5.	Conflict of interests in terms of development versus restoration.	Creation of political awareness and location specific environmental valuation for prioritized areas.	US\$ 0.275 million (2 years)
6.	Capacity constraints related to ecosystem specific technically proven restoration technologies.	(i): Dissemination of information related to ecosystem specific best practices in local languages. (ii) Promote research on technologies (iii): Demonstration areas and pilot studies.	US\$ 2.21 million (8 years)
<b>Policy, Legal and Regulatory Barriers</b>			
7.	Inadequate working modalities to exchange and access restoration related best practices from other countries.	Facilitate exchange and sharing of knowledge. Conduct Joint programs.	US\$ 0.5 million (1 year)
<b>Network failure and Social, cultural &amp; behavioral barriers</b>			
8.	Land tenure issues before and after restoration (ownership of a restored land).	Implementation of existing policies and legislation relating to land tenure in such areas.	US\$ 0.875 million (1 year)
9.	Lack of partnerships for restoration and management of lands outside protected areas.	Partnership arrangements between government institutions and private sector agencies..	US\$ 0.035 million Over the project period

## 8.6.2 General Description of the "Increasing connectivity through corridors, landscape/matrix improvement and management including altitudinal and other movements"

Increasing connectivity in the broader landscape is vital for conserving biodiversity during climate change<sup>63</sup>. It is an important mechanism to connect fragmented areas, as many protected areas are isolated from each other. With climate change, corridors become important as they will allow migration of species, whose range will change to the changing climate<sup>63,31</sup>.

This strategy involves the protection of areas and regions that would be essential for climate-induced wildlife movements<sup>4</sup>. Technologies that can be used include movement corridors for terrestrial species, while unblocked streams and rivers are important movement corridors for aquatic species<sup>63</sup>. In the case of forests, a system of corridors could be designed utilizing existing patches or augmenting with restoration and other restoration mechanisms, creating an opportunity for short or long term migration. There are provisions for such corridors in wildlife legislation (Fauna and Flora Protection Ordinance No. 2 of 1937) and are referred to as 'jungle corridors'<sup>117</sup>. Several Policies, Action Plans and Strategies in the country have already identified this approach as essential for biodiversity conservation<sup>89</sup>. Following are some potential actions that would facilitate this technological approach.

- a) Mapping of existing corridor network using existing knowledge and identification of proposed corridors through climate modeling and mapping.
- b) Establish a corridor network (existing and new corridors).
- c) Strengthen management of existing corridors.
- d) Design and map a system of corridors to allow gene flow.
- e) Management plans for corridors (especially in watershed areas).
- f) Promoting organic agriculture to support livelihoods among local communities.
- g) Reduce pressures and threats to corridors.
- h) Establish special corridors in selected areas while protecting existing corridors.

### 8.6.2.1 Identification of barriers and measures for the Technology

The barriers and respective enabling measures are given in Table 8.10.

**Table 8.10: Key Barriers and Measures for increasing connectivity through corridors, landscape/matrix improvement and management including altitudinal and other movements**

No	Key Barriers Identified			
	Barriers		Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers</b>				
1.	Low funding allocation for conservation related activities		Set aside adequate funds from the annual budgets of Forest and Wildlife Departments for increasing connectivity based on an agreed action plan.	US\$ 675,000 per annum

2.	Non availability of incentives to protect isolated ecosystems found in private lands (plantations/home gardens etc).		<p>i) Develop an incentive scheme for private landowners to encourage managing areas identified as important for connectivity.</p> <p>ii) Create and enabling legal and policy environment to ensure that medium to large development projects include areas that allow for connectivity.</p> <p>iii) Political awareness; site specific environmental services evaluation for areas prioritized for maintaining connectivity.</p>	US\$ 1.02 million. (2 years)
<b>Information &amp; awareness, Technical and market failure barriers</b>				
3.	No national level prioritization of areas for ensuring connectivity.		Identify critical areas to be connected and prioritize required corridors and apply climate change modeling to identify critical areas.	US\$ 1.85 million. (3 years)
4.	Lack of adequate knowledge on true value and potential benefits of maintaining connectivity.		Undertake environmental services valuation and assess benefits of maintaining connectivity followed by information dissemination and awareness creation.	US\$ 0.5 million. (4 years)
<b>Information &amp; awareness, social, cultural &amp; behavioral and policy legal and regulatory barriers</b>				
5.	Lack of community awareness on sharing habitats with biodiversity vis a vis need for protecting critical species and lack of policy and legal framework for benefit sharing.		Create awareness, build capacity and provide assistance to promote coexistence with biodiversity	US\$ 0.275 million. (9 years)
<b>Policy, Legal and Regulatory Barriers</b>				
6.	High altitudinal (montane) areas are poorly protected due to nonenforcement of relevant laws and implementation of management plans.		<p>i) Ensure effective enforcement and management of protected areas and actions to increase the level of protection.</p> <p>ii) Include critical areas into protected area network.</p>	US\$ 1.5 million. (9 years)
7.	Absence of Matrix/landscape level planning of conservation efforts and lack of enable policies and legislation for mandatory matrix level planning and conservation.		Integrate landscape level planning into management planning processes of the Forest and Wildlife Departments.	US\$ 0.25 million. (9 years)



	Ambiguity in defining the lands as 'unutilized' areas for development purposes.		Policy harmonization to enable protecting isolated ecosystem patches critical for conservation.	US\$ 0.02 million. (1 year)
	Procedural delays in land acquisition (e.g. LRC and private sector).		Amend the respective legal instruments to enable expediting land acquisition process.	US\$ 0.03 million. (9 years)
<b>Social, cultural &amp; behavioral, market failures and 'Other' barriers</b>				
	Conflicting land use practices in private lands.		i). Provide Incentives for private landowners to set aside or maintain areas identified as critical for facilitating connectivity. ii) Make enabling legal and policy environment to ensure that medium to large development projects to provide for areas that maintain connectivity.  Political awareness creation and site specific environmental services valuation for areas prioritized for maintaining connectivity.	US\$ 0.295 million (2 years)

### 8.6.3 General Description of the "Improve management, and explore increasing the extent of protected areas, buffer zones and create new areas in vulnerable zones"

Protected areas are a conservation tool to conserve biodiversity by protecting species and ecosystems. This strategy will focus on effectively managing established protected areas and will also entail increasing the extent of terrestrial and aquatic habitats, which have been identified as a climate change adaptation strategy<sup>63</sup>. Conservationists often favor protected areas as they aim to provide a safe haven and minimize impacts from humans and other threats. Protected areas have various purposes and levels of protection<sup>53</sup>. In Sri Lanka these vary from Strict Natural Reserves where access is strictly limited to Sanctuaries, which may contain even private lands<sup>117</sup>. It is vital to ensure that in these areas provide the maximum representation of biodiversity in the country. Effective management of existing protected areas is important as creating new areas is challenging due to ever increasing demand for land for economic development in the country. However there are numerous areas that are earmarked as proposed reserves based on their conservation values, which can be included into the protected area network. Creating new protected areas or expanding existing areas does not require any advanced technologies.

This strategy has been globally accepted as an essential climate change adaptation strategy for biodiversity<sup>63</sup>. Further, this strategy has already been included in national Policies, Strategies and Action Plans for climate change adaptation related to biodiversity conservation (see Fact Sheet 9 for more details). Some mechanisms/sub technologies suggested in this regard include the following:

- a) Enhance the capacities of the relevant authorities to enable efficiently manage highly vulnerable protected areas/corridor network.
- b) Promote individuals and private sector organizations to acquire and manage habitats for conservation.
- c) Increase extent of protected areas and buffer zones.
- d) Identify the species or ecosystems that can be accommodated within anthropogenic ecosystems.
- e) Identify and research the forms of adaptive management for native species.
- f) Promote the purchase of forests for its conservation.

### 8.6.3.1 Identification of barriers and measures for the Technology

The barriers and enabling measures for successful transfer and dissemination of the Technology are given in the Table 8.11.

**Table 8.11: Key Barriers and Measures for the Technology Improve management, and explore increasing the extent of protected areas, buffer zones and create new areas in vulnerable zones**

No	Key Barriers Identified		
	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers</b>			
1.	a) Low funding allocation for conservation related activities.	Set aside adequate funds from the annual budgets of Forest and Wildlife Departments for implementation of the technology based on an agreed action plan.	
2.	b). Under-implementation of existing management plans due to lack of resources.	Allocate required resources and undertake effective implementation of management plans.	US\$ 1.6 million. (10 years)
3.	c). Lack of management plans for some protected areas.	Prepare and implement management plans for such areas.	US\$0.0025 million.(9 years)
4.	d). Capacity constraints in terms of number of personnel, knowledge, vehicles for adequate management and monitoring.	Recruiting competent personnel as required by the job descriptions.	US\$0.0025 million.(9 years)
<b>Non Financial Barriers</b>			
<b>Information &amp; organizational capacity and information &amp; awareness Barriers</b>			

5.	e). Demand for land for medium/ large development projects from areas earmarked and already set aside for conservation.	i) Incentives for using brown field/ degraded areas for economic development initiatives. ii) Policies to discourage conversion of natural ecosystems for development projects. iii) Upgrade proposed reserves/parks to a higher level of protection.	US\$ 1.01 million. (3 years)
4.	f). Lack of effectiveness of relevant departments and staff (mainly field staff) in protected area management.	Ensure accountability and performance based staff evaluations together with incentives (financial and non-financial) to recognize good performance.	US\$ 0.02 million. (9 years)
<b>Policy legal &amp; regulatory, information &amp; awareness, social, cultural and behavioral barriers</b>			
5.	g). Lack of community awareness on sharing habitats with biodiversity/critical species and lack of enabling policy and legal framework for benefit sharing.	Create awareness, build capacity and introduce enabling environment to promote coexisting technologies.	US\$ 0.02 million. (9 years)
<b>Policy, Legal and Regulatory Barriers</b>			
6.	h). Conflicting land use practices in buffer zones.	Encouraging non-conflicting land use through incentives. ii) Enforcement of buffer zone legislation.	US\$ 0.02 million. (2 years)
7.	i). Absence of legally defined buffer zone for protected areas	Amend and implement buffer zone legislation.	US\$ 0.5 million. (9 years)
8.	j). Insufficient physical demarcation of some protected area boundaries and all buffer zones. Lack of enforcement of and awareness on boundaries	Physical demarcation of protected area boundaries and buffer zones, ii) Effective law enforcement on boundaries and removing encroachments etc, iii) Create awareness on boundaries.	US\$ 1.85 million. (9 years)
9.	k). No provisions for community or privately owned protected areas (outside the current protected area system).	Introduce enabling provisions for community owned protected areas and provide incentives for such activities.	US\$ 0.28 million
<b>Network failures</b>			
10.	l). Lack of inter agency coordination in managing adjacent protected areas.	Enabling policies and initiatives to encourage Forest, Wildlife and other relevant departments to work together.	
11.	m). Lack of ecological information in protected areas.	Identify priority areas and carry out biodiversity assessments.	US\$ 0.225 million. (9 years)

#### 8.6.4 General Description of the

This technology involves investing resources in the maintenance and continued survival of species that are likely to become extinct as a result of global climate change<sup>63</sup>. Thus it would target species that need special attention, with high vulnerability to climatic changes.

Recent studies have shown that the ecological changes in the phenology and distribution of plants and animals are already occurring, and have been linked to local and regional climate change. Range-restricted species show severe range contractions and certain such species have become extinct. Tropical coral reefs and amphibians have been most negatively affected<sup>100</sup>. The Sri Lanka Red List<sup>51</sup> which identifies threatened species and their locations can be used to identify and target specific species that may require additional conservation intervention. Globally the IUCN Red List is already being used to identify species at risk with climate change<sup>52</sup>. Several National Policies, Action Plans and Strategies in Sri Lanka also have identified this as essential for biodiversity conservation. Some potential actions related to implementation of this technology include the following.

- a) Device specific species management plans for vulnerable species.
- b) Implement a regular monitoring program for identified vulnerable species.
- c) Establish a database incorporating details of identified vulnerable species.
- d) Develop a tropical register for all remnant patches
- e) Conduct translation from ecosystems cited for destruction.
- f) Build a database of people in particular taxa and encourage research in such restricted ranges.

##### 8.6.4.1 Identification of barriers and measures for the Technology

The barriers and enabling measures for diffusion and dissemination of technology are given in Table 8.12.

**Table 8.12: Key Barriers and Measures Identified for Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems"**

No	Key Barriers Identified		
	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers</b>			
1.	a) Inadequate funding available for protecting highly threatened species.	Allocate sufficient funds from annual budgets based on priority action plans.	US\$ 750,000 per annum.
2.	b) Absence national biodiversity action plans for highly threatened species.	Develop and implement species action plans based on priorities.	US\$ 1.6 million. (10 years)
<b>Non Financial Barriers</b>			

<b>Information &amp; awareness and technical Barriers</b>			
3.	a) Lack of information including climate change modeling to determine climate change impact on species/ ecosystems.	Generation of necessary information and climate change modeling on potential climate change impacts on species and ecosystems.	
4.	b) Inadequate information on threatened species (distribution data, ecological information including population size and genetics - (in-situ research)	Carry out extensive surveys/ research; obtain expertise on the subject/ capacity building.	US\$ 0.8 million (2 years)
	c) Poor awareness by general public and policy-makers on point endemics and other threatened species. Lack of recognition for voluntary conservation actions.	i) Awareness programs on point endemics and critically endangered species and the importance of their conservation ii) Introduce appropriate mechanisms to reinforce voluntary conservation actions	US\$ 0.8 million. (8 years)
	d) Insufficient in-house knowledge on species management strategies.	Build capacity and equip staff within departments to enable effectively conserve and monitor threatened species/ecosystems.	US\$ 0.8 million. (2 years)
<b>Technical Barriers</b>			
5.	h) Lack of focused research on habitats for species migration.	Research on habitats for species migration, identification and conservation of such habitats.	US\$ 0.5 million. (4 years)
<b>Policy, Legal and Regulatory Barriers</b>			
6.	All of the sites that harbor threatened point endemic species are not protected.	i) Provide legal protection for all sites where point endemics are found. (ii) Integrate climate change and species related considerations into respective legislation. iii) Provide incentives and alternatives for protection of important areas outside the protected area network. iv) Introduce mechanisms for effective Inter-agency coordination for protection of point endemics.	US\$ 2.865 million (8 years)
<b>Network failures</b>			
7.	h). Lack of inter agency coordination in managing adjacent protected areas.	Create effective partnerships between Ministries/Departments and Universities, NGOs, species Specialists etc for species conservation.	million.(5 years)
<b>Institutional &amp; organizational capacity and 'Other' Barriers</b>			
7.	a) Delay in obtaining permission for conducting research by individuals and non-state sector institutions.	Review and reform the current process with a view to expedite securing permission for conducting research by individuals and non- state institutions.	US\$ 0.025 million.(1 year)

### 8.6.5 General description of the "Ex-situ conservation for highly threatened species and possible reintroduction"

Ex-situ conservation refers to conservation activities that occur outside the usual habitat of a species. Often this approach focuses on captive maintenance programs for species that would otherwise become extinct due to various extreme factors. Such an approach would generally be a last resort for species<sup>63</sup>. Zoological Gardens, captive breeding centers, seed banks etc are some example of ex-situ conservation activities, and therefore not a new technology in the country. However some advanced facilities would be required for certain species. Zoological Gardens and breeding centers have long been carrying out captive breeding, especially for keystone mammals. Sperm and egg banks would be rather extreme forms of this strategy, but may be necessary<sup>63</sup>. Often such activities are carried out as insurance against future or unexpected threats that will make in-situ conservation difficult. Ex-situ conservation is usually not favored where in-situ conservation is possible, but its importance as an insurance mechanism is recognized. In some situations, ex-situ conservation would become the only chance of survival for some species. Ex-situ collections should have sufficient diversity to allow adaptation<sup>92</sup>. Several national Policies, Action Plans and Strategies also have identified this as essential for biodiversity conservation. Some potential mechanisms involved in the implementation of this technology could include the following:

- a) Establishing a program for captive breeding/propagation of the species selected for ex-situ conservation.
- b) Implement a reintroduction program to facilitate establishing wild populations which would ensure their long-term survival.
- c) Monitoring of captive breeding/propagation and the reintroduction programs for optimizing the utility of the technology.
- d) Introduce enable legislation and policies in the wildlife sector.
- e) Identify species' survival potential fin new habitats.
- f) Establish seed-banks and in-vitro gene banks for flora.

#### 8.6.5.1 Identification of barriers and measures for the Technology

The barriers and enabling measures for successful implementation and dissemination of the technology are given in Table 8.13.

**Table 8.13: Key Barriers and Measures Identified for Ex-situ conservation for highly threatened species and possible reintroduction**

Key Barriers Identified			
No	Barriers	Measures	Cost of Implementation for the Target Years
<b>Economic and Financial Barriers</b>			
1.	Lack of proper planning and funding for ex-situ conservation and absence of a protocol for species reintroduction and monitoring.	i) Identify and prioritize ex-situ conservation facilities that are required with costing and set a side a portion of the annual budgets of respective agencies for setting up such facilities as required. ii) Introduce a protocol for species reintroduction and monitoring.	US\$ 2.25 million. (2 years)

2.	Lack of expertise, enabling facilities and resources to carry out ex-situ conservation.	Capacity building on ex-situ conservation, partnerships with species specialists, facilitate knowledge sharing and provide capital resources.	US\$ 1.825 million. (5 years)
<b>Non Financial Barriers</b>			
<b>Policy, legal &amp; regulatory, information &amp; awareness and market failure measures</b>			
3.	Ex-situ conservation of wild fauna has not received the due recognition in conservation related policies	Awareness creation on the concept of exsitu conservation and review and reform relevant policies with a view to accord due priority.	US\$ 0.35 million. (2 years)
4.	Weak law enforcement against sub-standard ex-situ conservation activities	Efficient enforcement of existing laws to regulate such ex-situ conservation initiatives.	US\$ 0.15 million. (5 years)
5.	Existing legal environment enables ex-situ conservation by some specified government agencies only.	parties to undertake ex-situ breeding under the overall supervision of respective government authorities.	(2 years)
6.	Poor understanding on species that would require ex-situ conservation.		US\$ 2.0 million. (3 years)

## 8.7 Linkages of the barriers identified

Although some of the barriers are technology specific, there exist some common barriers for all or more than technology and these barriers are discussed below.

### 8.7.1 Lack of incentives

The lack of incentives is one of the major barriers for Technology 1 - Restoration of degraded areas inside and outside the protected area network to enhance resilience and Technology 2 - Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movements, Currently there are no incentives given to protect isolated forest patches/ecosystems present in private lands.

### 8.7.2 Funding constraints

Inadequate financial provisions is a barrier common to all the technologies. The non-availability of adequate financial resources under the current scenario reflects the low priority accorded to those technologies that are deemed essential for biodiversity adaptation to climate change.

### 8.7.3 Lack of understanding, awareness and appreciation of value of biodiversity and ecosystems.

Poor understanding and lack of awareness and appreciation of value of biodiversity and the ecosystem service is a significant barrier for all the technologies. Such awareness amongst political leadership, general public and decision makers are vital for the success of proposed technological interventions. As for the Technology 1 - Restoration of degraded areas inside and outside the protected area network to

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enhance resilience, the true value of restoration and its contribution to ecosystem services is less understood. Other areas where awareness creation is essential are, the value and benefits of maintenance of connectivity (Technology 2 -Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement), value of point endemics and other threatened species, & lack of recognition for voluntary conservation action (Technology 4 - Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems), and species requiring ex-situ conservation (Technology 5 - Ex-situ conservation for highly threatened species and possible reintroduction).

#### **8.7.4 Capacity constraints**

Lack of capacity, which includes expertise/skills and other resources, is also a major barrier for all the technologies. As for Technology 1 - Restoration of degraded areas inside and outside the protected area network to enhance resilience, there is inadequate technical skills related to the available technologies. The capacity constraints of the Technology 3 -Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones are insufficient number of skilled personnel, and inadequate capital resources such as vehicles for management and monitoring. The main capacity related barrier for the Technology 4 -Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems, is insufficient institutional capacities on species management strategies. With regard to Technology 5 -Ex-situ conservation for highly threatened species and possible reintroduction, lack of expertise and capital resources is considered a capacity constraint.

#### **8.7.5 Lack of information, research, climate modeling**

This is a common barrier for Technology 3-Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones and Technology 4 -Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems. Inadequate ecological information in protected areas, potential climate change impacts on species/ecosystems, inadequate information on threatened species and lack of focused research on habitats for species migration are seen as significant barriers for the two barriers respectively.

#### **8.7.6 Need for prioritization of areas for interventions and use of climate change modeling for information generation.**

Research, studies, and comprehensive analyses are necessary to identify conservation priorities. Climate change modeling is an essential tool in this regard. In the case of Technology 1 – Restoration of degraded areas inside and outside the protected area network to enhance resilience, currently there is no national level prioritization scheme to identify the most important areas requiring restoration. As for Technology 2 - Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement), information on critical areas requiring connectivity based on national priorities is lacking. Since ex-situ conservation of wild fauna has not been accorded the due priority in conservation related policies, there exists a potential risk of successfully implementing the Technology 5 - Ex-situ conservation for highly threatened species and possible reintroduction.



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### **8.7.7 Pressure from development and impact of competing land use**

Pressure for land for other economic development activities is a major constraint for Technology 1 – Restoration of degraded areas inside and outside the protected area network to enhance resilience. This is also an issue for Technology 2 - Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement). The demand for land from within the existing Protected Area Network for medium/large projects, despite the availability of already cleared and degraded lands from outside the protected area system for such economic activities, is a major barrier for Technology 3 - Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones.

### **8.7.8 Weak law enforcement and policy implementation**

This is a major barrier for Technology 2-increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement), as high altitudinal (montane) areas are poorly protected due to non-enforcement of the respective protected area management plans and relevant laws. Ineffective implementation of existing management plans for want of adequate resources is a major barrier for Technology 3 -Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones. The success of this technology also will be constrained with the insufficient physical demarcation of some protected area boundaries and all buffer zones combined with lack of enforcement of and awareness on boundaries. As for the Technology 5 -Ex-situ conservation for highly threatened species and possible reintroduction, existence of unregulated ex-situ conservation initiatives will be a major constraint.

### **8.7.9 Lack of partnerships**

Lack of partnerships is a common barrier for Technology 1 – Restoration of degraded areas inside and outside the protected area network to enhance resilience, Technology 3 - Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones, and Technology 4 - Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems. The Technology 1 will also be affected by the lack of inter-agency coordination In managing adjacent protected areas.

## **8.8 Proposed Action Plan for the Bio Diversity Sector**

### **8.8.1 Rehabilitation and Restoration of degraded areas inside and outside the protected area network to enhance resilience**

#### **Target for technology transfer and diffusion**

- o Rehabilitation and restoration of 10,000 hectares of terrestrial and marine ecosystems, over 5 years.
- o Introduce a minimum of one incentive scheme for rehabilitation and restoration.
- o Set aside a minimum of 2-5% of Forest and Wildlife Department budgets for rehabilitation and restoration.
- o Prioritization of rehabilitation and restoration interventions.
- o Document ecosystem specific best practices.
- o Complete a minimum of 10 pilot sites.

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- o Awareness creation for political leadership through awareness campaign.
  - o Document evidence of implementing policies/legislation.

### **8.8.2 Increasing connectivity through corridors, landscape/matrix improvement and management**

#### **Target for technology transfer and diffusion**

- Introduce an effective and sustainable incentive scheme for private landowners to set aside or manage areas necessary for maintaining connectivity.
- Allocate 2-5% of the annual budgets of Department of Wildlife Conservation and Forest Department for improved management and to increase the extent under conservation.
- Integrate provisions into the policies to make it mandatory for medium and large development projects to reserve areas to maintain connectivity.
- Complete study for prioritization.
- Undertake one awareness program for the political leadership.
- Complete climate change modeling for at least two regions.
- Document evidence of implementing policies/legislation.
- Include 4 critical areas into the Protected Area Network.

### **8.8.3 Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones**

#### **Target for technology transfer and diffusion**

- Allocation of at least 2-5% of annual budgets of Department of Wildlife Conservation and Forest Department for improving management, increasing extent of protected areas/buffer zones, and creating new areas.
- Prepare and implement at least 20 management plans for prioritized areas.
- Introduce an incentive scheme for using brown fields/degraded areas for economic development ventures.
- Establish a system to ensure staff accountability.
- Demarcate legal boundaries of 10 key protected areas declared through gazette notifications.
- Upgrade the legal status of 5-10 declared protected areas.

### **8.8.4 Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems**

#### **Target for technology transfer and diffusion**

- Develop and implement a minimum of 15 species/habitat action plans based on priority.
- Allocation 2-5% of annual budgets of the respective agencies to implement the action plans.
- Undertake a minimum of one comprehensive climate modeling studies to assess climate change impact on species and ecosystems.
- Provide legal protection for 2-5 sites where point endemics are found.
- Introduce an incentive scheme to ensure protection for areas of interest situated outside the

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existing PA network.

- Develop up to 5 effective partnerships between Ministry/Departments and universities, NGOs, species specialists etc for species conservation.
- Provide awareness and capacity building opportunities for 25% of staff in Forest and Wildlife Departments.
- Implement at least five research studies on critical species.

Proposed Action plans for identified technologies are in Annex XII

# CHAPTER 9

## Summary/Conclusions

Although Sri Lanka is a relatively low net GHG emitter, it is highly vulnerable to climate change in relation to physical as well as socio-economic impacts. There is convincing evidence that Sri Lanka is affected by the global climate change impacts. The analyses of climate data over the four decades from 1960 to 1990 indicate a significant trend in increasing air temperature. At the same time, the future scenarios predict higher levels of emissions and greater potential for adverse climate changes impacts unless timely mitigatory and adaptive actions are undertaken.

Sri Lanka being a developing country party to the UNFCCC, it is required to undertake a Technology Needs Assessment (TNA) with respect to climate change to explore country needs for the reduction of greenhouse gas emissions and adaptation technologies for the vulnerable sectors. The TNA carried out from June to December 2011 has recognized the **Food, Health, Water Coastal and Biodiversity** sectors as the most vulnerable sectors to climate change in Sri Lanka. Accordingly, the following technological interventions have been recommended as priority adaptation options for the respective sectors;

### **Food Sector:**

- (1) Culture-based fisheries.
- (2) Sustainable land management.
- (3) Crop diversification and precision farming.

### **Health Sector:**

- (1) Early Warning Systems and Net-working for information exchange on extreme events and other Climate Change related events
- (2) Transfer of knowledge and skills to health personnel
- (3) Management of Health Care waste

### **Water Sector:**

- (1) Restoration of minor tank net works.
- (2) Rainwater harvesting from rooftops.
- (3) Boreholes/tube wells as a drought intervention for domestic water supply.

### **Coastal Sector:**

- (1) Sand dune rehabilitation.
- (2) Restoration of Mangroves
- (3) Restoration of coral reefs by transplanting corals.

### **Biodiversity Sector:**

- (1) Restoration of degraded areas inside and outside the Protected Area network to enhance resilience.
- (2) Increasing connectivity through corridors, landscape/matrix improvement and

- 
- management
- (3) Improve management, and consider increasing the extent of protected areas, buffer zones and create new areas in vulnerable zones
  - (4) Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems
  - (5) Ex-situ conservation for highly threatened species and possible re-introduction.

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16. Mr. G. Ranjith, Assistant Director, Ministry of Local Government and Provincial Council
17. Mr. M.J.M. Ifham, Asst. Secretary, Ministry of Economic Development
18. Mr. W.R.K Fonseka, Research Officer, Industrial Technology Institute

**SECTORAL STAKEHOLDER WORKING  
GROUPS****Food Sector**

1. Ministry of Agriculture
2. Ministry of Export Crop Promotion
3. Ministry of Livestock and Rural Development
4. Ministry of Fisheries and Aquatic Development
5. Department of Agrarian Development
6. Department of Export Agriculture
7. Natural Resource Management Centre, Department of Agriculture
8. Oil Crops Research & Development Institute , Department of Agriculture
9. Field Crops Research and Development Institute (FCRDI), Department of Agriculture
10. Horticultural Crop Research & Development Institute
11. Sri Lanka Council for Agricultural Research Policy(SLCARP)
12. Tea Research Institute
13. Coconut Research Institute
14. Coconut Development Board
15. Practical Action of Sri Lanka
16. Hadabima Authority of Sri Lanka
17. National Aquatic Resources Research & Development Agency
18. Hector Kobbekaduwa Agrarian Research and Training Institute
19. Department of Crop Science, Faculty of Agriculture, University of Peradeniya
20. Department of Animal Science, Faculty of Agriculture, University of Peradeniya
21. Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka.

**Health Sector**

1. Ministry of Health
2. Centre for Environment Justice
3. Urban Development Authority
4. National Science & Technology Commission
5. Central Environmental Authority
6. Waste Management Authority -Western Province
7. National Waste Management Supporting Centre
8. Sri Lanka Anthropological Association
9. WHO – WHO Representative
10. Faculty of Medicine, Defense University of Sri Lanka
11. Faculty of Medicine, University of Peradeniya
12. National Science Foundation

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### **Water Sector**

1. Ministry of Irrigation and Water Supply
2. Ministry of Water Supply and Drainage
3. Department of Irrigation
4. Dept. of Meteorology
5. National Water Supply and Drainage Board
6. Water Resources Board
7. Mahaweli Authority of Sri Lanka
8. Hector Kobbekaduwa Agrarian Research & Training Institute
9. National Aquatic Resources Research and Development Agency
10. Sarvodaya, Sri Lanka (NGO)
11. Practical Action of Sri Lanka
12. Water Care Engineering (pvt) Ltd
13. International Water Management Institute (IWMI)
14. DSWRPP project (Dam safety & water resources planning project)
15. Dept. of Chemistry, Faculty of Science, University of Colombo,
16. Dept. of Civil Engineering, University of Moratuwa.
17. Dept. of Limnology, Faculty of Fisheries, Aquaculture & Marine Sciences, University of Ruhuna.
18. Faculty of Agriculture, University of Ruhuna.
19. Lanka Rain Water Harvesting Forum, Kirilepona, Colombo 5
20. National Water Supply & Drainage Board

### **Coastal Sector**

1. Ministry of Fisheries and Aquatic Development
2. Department of Coast Conservation
3. Disaster Management Center
4. National Building Research Organization
5. Department of Meteorology
6. National Aquatic Resources Research and Development Agency
7. Practical Action
8. Faculty of Fisheries & Marine Sciences & Technology, University of Ruhuna.
9. Dept. of Limnology, University of Ruhuna
10. Dept. of Botany, University of Kelaniya
11. Department of Wildlife Conservation

### **Biodiversity Sector**

1. Ministry of Environment, Battaramulla
2. Ministry of Land and Land Development
3. Ministry of Fisheries and Aquatic Resources
4. Forest Department
5. Department of Land Use Policy Planning
6. Department of Coastal Conservation
7. National Aquaculture Development Authority of Sri Lanka
8. Department of Fisheries & Aquatic Resources

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9. Central Environmental Authority
  10. Department of Crop Science, Faculty of Agriculture, University of Peradeniya
  11. IUCN, Sri Lanka
  12. Wildlife and Nature Protection Society
  13. Young Zoologist Association
  14. Green Movement of Sri Lanka
  15. National Science Foundation
  16. Environmental Foundation
  17. Rainforest Rescue International
  18. Galle Wildlife Conservation Society
  19. Centre for Environmental Justice
  20. Munasinghe Institute for Development (MIND)
  21. Practical Action Sri Lanka
  22. Department of Zoology, University of Colombo
  23. Department of Botanical Gardens
  24. South Asia Co-operative Environment Programme
  25. Total Management solutions company

Matrix of Weighted Scores, Costs and Benefits – Food Sector

Technology Options	Cost US \$ M	Weighted Scores												GHG Emissions										
		Environmental						Economic																
		Weighted Cost	Ground Water Quality/ Quantity	Surface Water Quality/ Quantity	Soil Erosion /Runoff & Sedimentation	Soil Quality /Health	Biodiversity Conservation	Watershed Functions	Air Pollution	Household labour involvement	Rural Dev	Livelihood improvement	Health benefits		Community participation	Food Security	Employment generation	Farmers income /Poverty reduction	Energy use	New markets/ enterprises /Industries	Total Score	Benefits		
1. Appropriate Varieties	0.82	26.00	2.00	2.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Appropriate Breeds	2.95	14.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Sustainable Land Management	0.27	29.00	2.00	3.00	5.00	5.00	2.00	2.00	1.00	1.00	0.00	0.00	1.00	2.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	2.00
4. Drip Irrigation	0.32	29.00	2.00	2.00	5.00	5.00	2.00	1.00	1.00	1.00	0.00	0.00	1.00	2.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	2.00
5. Rain Water Harvesting	5.45	0.00	3.00	3.00	5.00	5.00	2.00	2.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.70
6. Crop Diversification & Precision Farming	0.68	27.00	2.00	2.00	3.00	3.00	2.00	1.00	1.00	1.00	2.00	0.00	0.00	1.00	2.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00	1.00	2.00
7. Ecological Pest & Disease Management	0.25	29.00	3.00	2.00	3.00	3.00	2.00	2.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.70
8. Responsive Agricultural Extension	0.55	28.00	2.00	2.00	3.00	3.00	2.00	2.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.70
9. Sustainable culture - based fisheries	0.15	30.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Technology Options (As above)	Weighted Scores																							
	Social						Economic						Benefits											
	Household labour involvement	Rural Dev	Livelihood improvement	Health benefits	Community participation	Food Security	Employment generation	Farmers income /Poverty reduction	Energy use	New markets/ enterprises /Industries	Total Score	Benefits												
1.	0.70	0.00	0.00	0.50	0.00	10.00	2.50	10.00	10.00	10.00	2.50	10.00	0.00	2.50	62.20	36.20								
2.	1.00	0.50	4.00	0.50	1.50	10.00	5.00	10.00	10.00	10.00	5.00	10.00	0.00	2.50	56.10	42.00								
3.	1.00	0.50	0.00	0.00	1.50	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	65.00	36.00								
4.	0.00	0.50	0.00	0.00	0.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	5.00	2.50	60.00	31.00								
5.	0.70	0.50	4.00	1.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	32.40	32.40								
6.	0.70	0.50	0.00	0.50	0.00	10.00	2.50	10.00	10.00	10.00	2.50	10.00	0.00	2.50	73.70	46.70								
7.	0.70	0.50	0.00	1.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	48.40	19.40								
8.	0.30	0.50	0.00	0.50	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.00	16.00								
9.	0.70	1.00	4.00	0.50	3.00	10.00	5.00	10.00	10.00	10.00	5.00	10.00	0.000	5.00	80.90	50.90								



Matrix of Weighted Scores, Costs and Benefits - Health Sector

Option No	Cost \$ US	Weighted Scores										Total Score	Benefits
		Environmental			Social			Economic					
		Minimize Eco-system Degradation	Impact on Pollution	Access to Services	Long- term health benefits	Local & Multi-sector involvement	Employment Generation	Energy use for Technology					
1	50,000	7.20	9.00	12.00	25.00	9.00	1.80	5.00	94.00	69.00			
2	50,000	1.20	2.50	6.00	12.50	3.60	0.90	2.50	45.20	29.20			
3	112,500	3.20	4.00	4.80	12.50	4.50	0.90	2.00	31.90	31.90			
4	75,000	7.20	9.00	12.00	25.00	9.00	4.20	4.50	80.90	70.90			
5	55,000	3.20	3.00	3.00	15.00	6.30	2.40	2.50	50.40	35.40			
6	50,000	3.20	4.00	7.20	10.00	4.50	0.90	2.00	47.80	31.80			
7	15,750	3.20	4.00	4.80	10.00	3.60	0.60	1.50	52.70	27.70			
8	43,750	3.20	4.00	6.00	10.00	3.60	0.90	2.00	47.70	29.70			
9	62,500	5.60	7.00	7.20	17.50	3.60	1.50	1.50	56.90	43.90			

1. Transfer of knowledge and skills to Health Personnel; 2. Diagnostic facilities to detect water borne diseases; 3. Technology to Detect, Prevent and Control water borne diseases; 4. Technology for Early Warning Systems and Net-working for information exchange on Extreme events and other Climate Change related events; 5. Research to identify the magnitude of diseases other aspects affecting human health due to climate change; 6. Drinking water quality improvement through continued surveillance during and after extreme weather events; 8. Technology to improve urban health inputs to adapt for climate change and extreme weather events related adverse health impacts; 8. Technology to enhance adaptability of the people on Psychological effects due to climate change; 9. Technology for management of health care waste

Matrix of Weighted Scores, Costs and Benefits - Water Sector

Option	Cost/ m <sup>3</sup> US\$	Weighted Score											Benefits Total Score					
		Environmental			Social				Economic									
		Impacts on Under ground water	Impacts on surface water	Minimi zing flooding	Continuous Water Supply	Health	Aware ness	Schools/ University	Research	Income	Employ ment	Invest ment		Low GHG release				
1	1.88	17.64	4.50	4.50	6.00	15.00	10.00	5.00	5.00	0.00	2.67	2.00	2.00	1.00	2.00	2.00	75.31	57.67
2	1.50	18.14	6.00	4.50	6.00	7.50	0.00	3.34	0.00	2.50	2.67	2.00	2.00	1.00	1.00	1.00	54.65	36.51
3	15.03	0.00	3.00	3.00	3.00	15.00	20.00	3.34	2.50	2.50	0.00	2.00	2.00	0.00	1.00	1.00	55.34	55.34
4	1.16	18.60	0.00	3.00	3.00	15.00	10.00	3.34	2.50	2.50	4.00	2.00	2.00	1.00	1.00	1.00	65.94	47.34
5	3.22	15.68	1.50	1.50	3.00	0.00	20.00	1.65	2.50	2.50	1.32	2.00	2.00	1.00	2.00	2.00	54.65	38.97
6	0.12	20.00	6.00	6.00	6.00	7.50	10.00	3.34	2.50	2.50	4.00	2.00	2.00	2.00	1.00	1.00	72.84	52.84
7	4.00	15.87	0.00	0.00	3.00	15.00	20.00	1.65	2.50	2.50	1.32	0.00	2.00	2.00	0.00	0.00	63.84	47.97

1. Rainwater harvesting from rooftops for drinking and household uses; 2. Surface runoff rainwater harvesting; 3. Household drinking water treatment and safe storage; 4. Boreholes/tube wells as a drought intervention for domestic water supply; 5. Solar distillation; 6. Restoration of minor tank networks; 7. Desalination of brackish water by reverse osmosis

## Matrix of Weighted Scores, Costs and Benefits - Coastal Sector

1-Coral reef rehabilitation; 2-Beach nourishment and establish new seagrass beds; 3-Sand dune restoration without beach nourishment;  
4-Mangrove restoration; 5-Beach nourishment; 6-Dike construction; 7-Floating mariculture- seaweed farming; 8-Floating mariculture- fish farming; 9-Groins & Sea walls

Option No.	Cost/ m <sup>2</sup> US\$	Weighted Score													Total score	Benefits	
		Economic						Social				Environmental					
		Employment opportunities	Increase Foreign Exchange	Protect infrastructure	Income	Awareness	Research-based Education	Environ Sensitivity	Improve Health	Reduction GHG	Reduce land loss due to SLR	Reduce Inundation	Land Reclamation				
1	14.3	18.72	1.63	3.35	3.35	10.00	5.00	3.00	5.00	3.50	7.00	5.34	1.67	5.33	72.89	54.17	
2	22.94	14.26	1.63	0.00	3.35	3.33	5.00	3.00	5.00	0.00	7.00	5.34	1.67	1.67	51.25	36.99	
3	2.13	25.00	3.33	3.35	3.35	6.67	5.00	3.00	5.00	3.50	7.00	8.00	3.34	5.00	81.54	56.54	
4	10.5	20.68	3.35	3.35	3.35	6.67	5.00	3.00	5.00	3.50	7.00	5.34	3.34	3.34	72.90	52.22	
5	25.56	12.90	1.63	5.00	3.35	6.67	0.00	0.00	7.00	3.50	3.50	8.00	5.00	5.00	52.06	39.16	
6	37.5	6.75	1.63	3.35	0.00	6.67	0.00	3.00	0.00	3.50	3.50	8.00	5.00	5.00	46.40	39.65	
7	31	10.11	3.35	3.35	0.00	10.00	5.00	0.00	0.00	3.50	7.00	0.00	0.00	0.00	42.31	32.20	
8	50.59	0.00	3.35	5.00	0.00	10.00	5.00	3.00	0.00	3.50	0.00	0.00	0.00	0.00	29.85	29.85	
9	22.5	13.39	1.63	3.35	5.00	6.67	0.00	3.00	0.00	3.50	3.50	8.00	5.00	5.00	58.04	44.65	

Matrix of Weighted Scores, Costs and Benefits - Biodiversity Sector

Option No	Weighted Scores										Benefit
	Annual cost Us \$ million	Weighted Cost	Environmental			Economic		Social		Total Score	
			Overall contribution to saving biodiversity (impact)	Addresses conservation urgency, incl threatened species	Enhancing ecosystem services (general)	Job creation/ opportunities	Ecotourism and conservation benefits	Improve awareness, research opportunities			
1.	0.91	0.00	15.00	15.00	20.00	10.00	20.00	5.00	5.00	85.00	85.00
2.	0.59	4.12	7.50	7.50	0.00	5.00	5.00	5.00	5.00	34.12	30.00
3.	0.82	1.18	15.00	15.00	20.00	5.00	15.00	5.00	5.00	76.18	75.00
4.	0.77	1.76	7.50	7.50	13.33	5.00	15.00	5.00	5.00	25.00	53.33
5.	0.77	1.76	7.50	7.50	6.67	10.00	5.00	5.00	5.00	43.43	41.67
6.	0.73	2.35	15.00	7.50	6.67	5.00	10.00	5.00	5.00	51.52	49.17
7.	0.82	1.18	7.50	7.50	6.67	5.00	10.00	5.00	5.00	42.85	41.67
8.	0.91	0.00	7.50	7.50	6.67	10.00	20.00	10.00	10.00	69.17	69.17
9.	0.82	1.18	15.00	15.00	13.33	10.00	20.00	5.00	5.00	72.01	70.83
10.	0.14	10.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00	16.67	6.67
11.	0.91	0.00	15.00	15.00	6.67	5.00	20.00	10.00	10.00	64.17	64.17

1. Restoration of degraded areas inside and outside the protected area network; 2. Modeling the impact of climate change on biodiversity to predict changes for conservation and management; 3. Increasing connectivity through corridors landscape/matrix improvement and management; 4. Protecting refugia which are less vulnerable to climatic changes; 5. Managing and monitoring invasive alien species (IAS); 6. Reducing other stresses on species and ecosystems; 7. Adaptive management and monitoring programs of species and ecosystems; 8. Focusing on conservation of resources and carrying out special management for restricted range, highly threatened species and ecosystems; 9. Improving management of existing protected areas, increasing extent, creating buffer zones and new areas in vulnerable zones; 10. Reviewing and modifying existing laws, regulations, and policies relating to biodiversity and natural resources and incorporating climate change adaptation considerations; 11. Ex-situ conservation for highly threatened species and possible reintroduction

**Proposed Action Plan for the Sustainable Inland Culture Based Fisheries**

<b>Measure/Action 2: Assuring adequate availability of financial resources.</b>						
<b>Justification for the action:</b> To encourage potential investors and assist investment fund providers.						
Action/Sub Action No.	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I Develop model investment packages for different production systems.	V. High	NAQDA	0-5 years	0.05 M Domestic	No. of model investment packages introduced annually.	
ii. Introduce financial incentives on concessionary terms and provide longer grace period for repayment.	V. High	M/ Finance and Planning, Central Bank	2-10 years	Interest subsidy to banks – 5 M Domestic	% of producers/ organizations availing of the credit facilities annually.	
<b>Measure/Action 3: Assuring adequate R&amp;D and Training Facilities.</b>						
<b>Justification for the action:</b> To develop adequate R & D required for the industry and to expand Training Facilities.						
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
Improve R& D Infrastructure.	V. High	NARA	0 - 5 years	10 M	No. of research institute improved,	
<b>Measure/Action 2: Assuring adequate availability of financial resources.</b>						
<b>Justification for the action:</b> To encourage potential investors and assist investment fund providers.						

Action/Sub Action No.	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I Develop model investment packages for different production systems.	V. High	NAQDA	0-5 years	0.05 M Domestic	No. of model investment packages introduced annually.
ii. Introduce financial incentives on concessionary terms and provide longer grace period for repayment.	V. High	M/ Finance and Planning, Central Bank	2-10 years	Interest subsidy to banks – 5 M Domestic	% of producers/ organizations availing of the credit facilities annually.
<b>Measure/Action 3: Assuring adequate R&amp;D and Training Facilities.</b>					
<b>Justification for the action:</b> To develop adequate R & D required for the industry and to expand Training Facilities.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Improve R & D Infrastructure.	V. High	NARA	0 - 5 years	10 M	No. of research institute improved,
i. Assist financial institutes to offer insurance system for CBF.	V. High	NAQDA Central Bank Commercial Banks and Financial Institutes	0- 10 years	5 M Domestic & International	No. of insurance packages introduced by banks. Percentage of producer organizations obtaining insurance annually.
ii. Introduce subsidy scheme for fingerlings supplied to farmers.	V. High	NAQDA Central Bank MF& ARD	0-10 years	5 M Domestic	Subsidy funds disbursed annually. No. of beneficiaries.
<b>Measure/Action 5: Improving marketing infrastructure and price.</b>					
<b>Justification for the action:</b> Promote the marketing avenues for inland fishery products.					

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Identify new markets and value addition.	V. High	NAQDA, M/Tec&Res Universities M/TI&SED	0-10 years	1 M Domestic & International	No. of new value added products introduced within the project period. Quantity processed per year.
ii. Facilitate and promote marketing of 'standardized' fish grades.	V. High	NAQDA	0 - 5 years	0.5 M Domestic	% of 'standard' size/weight marketed per year..
iii. Support development of producer associations involving all stakeholder groups.	High	NAQDA MF&ARD	0-10 years	0.05 M Domestic	No. of producer associations established per year.
iv. Introduction of a marketing information system.	High	NAQDA Universities	0-2 years	0.5 M Domestic	MIS established within two years. No. of subscribers from the time of establishment.
v. Introduction of a marketing information system.	Medium	NAQDA, MF&ARD M/Tech&Res, SLSI	0 -5 years	0.5 M Domestic	National Quality standards introduced within two years. % reduction in fish discarded.
<b>Measure/Action 6:</b> Improving institutional arrangements for stakeholder participation in policy making.					
<b>Justification for the action:</b> To improve coordination among stakeholder groups and policy making process for strengthening the industry.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Timeframe	Cost (US \$) & Funding Source	Indicators
i. Improve a consultation mechanism involving industry and policy makers.	High	NAQDA MF&ARD	In the first year	No cost	Stakeholder Group established in the Ministry.
ii Liberalization of the industry operations to enhance fingerling production.	Medium	M F&ARD	0-10 years	0.05 M Domestic	No. of private breeding farms approved/established per year.

<b>Measure/Action 7: Preventing degradation of Water quality.</b>						
<b>Justification for the action:</b> To ensure meeting water quality levels as required for CBF.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I Regular monitoring of fresh water quality.	High	NAQDA CEA	0-10 years	1 M Domestic	No. of water quality reports produced annually. % water bodies assessed.	
ii. Create awareness among general public on water pollution.	Medium	NAQDA CEA	0-5 years	0.1 M Domestic	Number of awareness campaigns conducted per year.	
iii. Monitoring of effluent discharge into reservoirs.	Medium	CEA	0-10 years	1 M Domestic	Number of reservoirs reporting improved water quality parameters annually.	
<b>Measure/Action 8: Introducing product standards, codes and certification.</b>						
<b>Justification for the action:</b> To ensure product safety and quality.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I Establish quality control measures and good management practices.	High	NAQDA SLSI	0-5 years	0.05 M Domestic	No. of best management practices introduced within the project period. No. of national quality standards established within two years.	
ii. Establish a regular monitoring scheme for fingerling production	High	NAQDA	0-2 years	0.05 Domestic	Inspection scheme established assess fingerling size and quality within two years. Monitoring schedule developed within a year.	



iii. Introduce and implement product standards, codes and certification and licensing system for marketable fish.	Medium	NAQDA, SLSI M/F&ARD DoARD	0-2 years	0.05 Domestic	No. of licenses issued per year.
<b>Measure/Action 9: Improving Policy Coordination.</b>					
Justification for the action: To delegate powers among aquaculture developers at the local level.					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
i. Establish a mechanism for consultation of all stakeholders and create stronger partnerships with local authorities.	High	NAQDA MF&AR	0-2 years	No cost	Federations of Provincial CBF Producer Associations formed within two years.
ii. Establish a policy coordination mechanism.	Medium	NAQDA MF&AR	0-2 years	No cost	National Federation of CBF Producers Organization established within two years.
iii. Improve community based Management systems.	Medium	NAQDA MF&ARD	0-2 years	No cost	Community Based Management Systems are improved within 2 years.
<b>Measure/Action 10: Improving consumer preferences and overcoming social inhibitions.</b>					
Justification for the action: To increase consumer acceptance of CBF products.					

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I Raise awareness on product quality and health benefits.	High	NAQDA M/F&ARD	0 – 5 years	1 M Domestic & International	Number of campaigns carried out annually.
ii. Introduce new value-added products and improve quality of dry fish.	High	NARA Universities M/TI&SED NAQDA	0 – 5 years	1 M Domestic	Number of recipes developed. Number of products introduced to the market annually. Number of processed CBF products marketed.
iii. Carry out promotional activities.	Medium	NAQDA	0 – 5 years	0.5 M Domestic & International	Number of campaigns conducted per year. Number of publicity material distributed per year.
iv. Develop marketing facilities with superior hygienic standards.	Medium	M F&AR CBO	0 – 5 years	0.5 M Domestic	Types of marketing facilities introduced annually.
<b>Total Cost of the Technology 1</b>					
<b>Approx: US \$ 53.75million</b>					

V. High - Very High; NAQDA - National Aquaculture Development Authority; M/TI&SED- Ministry of Traditional Industry & Small Enterprise Development; MF&ARD - Ministry of Fisheries and Aquatic Resources Development; M/Tec&Res - Ministry of Technology and Research; SLSI - Sri Lanka Standard Institute; CEA - Central Environmental Authority; DoARD - Department of Agriculture Research and Development; NARA - National Aquatic Research & Development Agency; CBO -Community Based Organization; M F&ARD - Ministry of Fisheries and Aquatic Resources Development

## Proposed Action Plan for the Sustainable Land Management

<b>Measure/Action 1: Increasing affordability of improved land management.</b>						
<b>Justification for the action:</b> To encourage adoption of land management and for creating an enabling financing environment.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I Introduce & implement subsidy schemes for inputs and outputs.	V. High	M/A M/I & WRMgt.	0-10 years	10 M Domestic	Introduction of land development subsidies/incentives within two years.  Amounts disbursed under land development subsidies.	
ii. Awareness Creation on long term benefits of SLM.	V. High	M/L & LD M/A	0-10 Years	1 M Domestic & International	15% of the planned sessions held annually.  Over 20% of the planned posters/leaflets distributed annually.  Over 15% of the planned TV programs telecasted annually.	
<b>Measure/Action 2: Securing Land Ownership rights.</b>						
<b>Justification for the action:</b> To ensure land ownership rights for responsible land management.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
i Enhance clarity of ownership rights of land.	V. High	M/L & LD M/A, M/I & WRMgt.	0-5 years	0.05 M Domestic	Over 20% of the planned land titles issued annually.  Amendments to land law to permit long termleases within three years.	

<b>Measure/Action 3: Increasing affordability of conservation practices and reducing social constraints in small land holdings.</b>						
<b>Justification for the action:</b> To Overcome barriers to adopt SLM practices in small land parcels.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
i Set up incentive schemes for small land parcels.	V. High	M/A M/Plantation Inds. M/D M/I & WRMgt. M/De &UD, M/ED M/DM	0-10 years	2.5 M Domestic	Over 90% of incentive schemes launched for small land parcels.  10% of funds disbursed annually under each scheme.	
ii. Introduce water-shed level conservation methods.	V. High	M/A M/I & WRMgt. M/Plantation Inds.	years	1 M Domestic & International	Over 90% of planned conservation techniques introduced.	
<b>Measure/Action 4: Introducing and enforcing land management policies, laws and regulations.</b>						
<b>Justification for the action:</b> To strengthen legal structures for responsible land management.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
i Reform and enforce the relevant policies, laws and regulations.	V. High	M/L & LD M/A	0-5 years	No cost	90% of planned legislative amendments and revisions effected within five years.	
ii. Independently monitor enforcement.	V. High	M/A M/L&LD	5-10 years	0.5 M Domestic	Legal actions against all offenders.	
<b>Measure/Action 5: Raising Knowledge on appropriate land management techniques and new challengers.</b>						
<b>Justification for the action:</b> To promote SLM technology and improve land productivity.						

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Develop and maintain long term benchmark sites with appropriate land management techniques in different agro-ecological zones.	V. High	M/A M/Plantation Inds. M/I & WRMgt.	0 – 10 years	2 M Domestic & International	Over 90% of planned benchmark sites established in each agro-ecological zone. Benchmark data on fertility status of land compiled within ten years. Data on land productivity improvement within ten year.
ii. Awareness creation on best practices available.	V. High	M/A. M/L & LD M/Plantation Inds. M/I & WRMgt.	0-5 years	0.5 M Domestic	25% of beneficiaries participated per year. Over 20% of programs conducted per year. Over 20% of people/ community adopted proper land management practices per year.
iii. Capacity strengthening of community/local agents for sustainable land management.	High	M/A	0-10 years	0.5 M Domestic	Percentage of target groups subjected to capacity building annually.
<b>Measure/Action 6: Ensuring proper attention to conservation in non-agricultural land uses.</b>					
<b>Justification for the action:</b> To promote sustainable development and safeguard the potential agricultural lands in the country.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Identify land conservation as a national priority in all land uses.	V. High	M/Economic Dev M/H M/Posts & Telecom. M/Env.	0-5 years	1.5 M Domestic	EIA Procedures expanded to include land related issues within two years.

ii. Identify potential prime agricultural lands and reserve for agricultural purposes.	High	M/L & LD M/A M/I & WRMgt. M/Plantation Inds.	0-5 years	2 M Domestic	80% of planned land use zonation maps prepared based on potentials and limitations.
iii. Revise land use policy and legislation.	High	M/L & LD M/A, M/Env.	0-2 years	No Cost	Revisions undertaken within two years.
<b>Measure/Action 7: Improving coordination among stakeholder organizations.</b>					
<b>Justification for the action:</b> To Improve results from investments on land management.					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
i Strengthen inter agency coordinating mechanisms.	V. High	M/A M/L & LD	0-2 years	No Cost	Activate an Inter-Ministerial Committee on Land Management and meetings conducted twice a year.
ii. Set up land use planning and monitoring system.	V. High	M/A M/L & LD	0-10 years	0.5 M Domestic	Land use planning and monitoring system established and reviewed annually.
<b>Measure/Action 8: Raising public and private investment on research and development.</b>					
<b>Justification for the action:</b> To increase investments on land management related R&D..					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
i. Increase public investment on R & D for generating scientific data and collecting technical information.	High	M/A. M/L & LD M/I & WRMgt. M/Plantation Inds.	0-10 years	5 M International	Over 80% of planned research grant schemes awarded for land use studies. Amount of funds disbursed for land use related R&D.

ii. Facilitate private investment on land use research.	Medium	M/A M/L & LD	0-10 years	4 M International	Tax credit and no of matching grants for land use research.
<b>Measure/Action 9: Promoting collective land management measures.</b>					
<b>Justification for the action:</b> To enhance effectiveness of land management measures through collective planning and implementation.					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
i. Develop and promote collective conservation measures.	High	M/A M/L & LD NGO,s	0-10 years	1.5 M Domestic & International	Extent of land area under collective conservation schemes within two years.
ii. Introduce catchment and watershed management.	High	M/A, M/L & LD M/I & WRMgt.	0-10 years	1.5 M Domestic	Extent of land area under common catchment management within two years.
iii. Promote social responsibility through remedial measures.	Medium	M/A M/L & LD	0 – 5 years	0.5 M	Over 20% of the planned remedial measures introduced by the stakeholder groups annually.
<b>Measure/Action 10: Improving relevance of land management techniques under diverse land, weather, soil, terrain, size and land formations.</b>					
<b>Justification for the action:</b> To increase reliability of land management recommendations.					

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
I Develop and implement site-specific technologies for different land classes and environments.	High	M/A M/L & LD M/Plantation Inds.	0-10 years	4 M Domestic & International	Over 50% of planned technologies developed & introduced within five years. 90% of land groups covered by new recommendations. Over 80% of planned pilot sites established for demonstration/study.
<b>Measure/Action 11: Reducing dependency on land for livelihoods to lower pressure on land.</b>					
<b>Justification for the action:</b> To Promote off-farm income earning opportunities.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Promote diversification of land-based livelihood activities.	High	M/A M/Plantation Inds.	0-10 years	1.5 M Domestic	Over 20% of farmers adopting alternative off-farm livelihoods annually. 80% of planned innovative solutions introduced.
<b>Total Cost of the Technology</b>				<b>Approx: US \$ 40.05 million</b>	

V. High = Very High; M/A - Ministry of Agriculture; M/I & WRMgt. - Ministry of Irrigation and Water Resource Management; M/L & LD - Ministry of Land and Land Development; M/De & UD - Ministry of Defence and Urban Development; M/ED - Ministry of Education; M/DM - Ministry of Disaster Management; M/H - Ministry of Health; M/Env - Ministry of Environment; NGOs - Non-Governmental Organizations



## Proposed Action Plan for the Crop Diversification & Precision Farming

<b>Measure/Action 1: Lowering marketing risk arising from seasonal production.</b>						
<b>Justification for the action:</b> To enhance resilience and ensure food security.						
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
i. Develop and implement crop forecasting and marketing advisory service.	V. High	M/A DC&S M/Co-Op & IT	0-10 years	1.5 M Domestic	Crop Forecasts and Price Reporting systems in place for all major crops within two years.	
ii. Develop value addition techniques to preserve perishables commodities.	V. High	M/A M/T&R	0-10 years	2.5 M Domestic & International	Over 10% of planned new processed products introduced and marketed annually.	
iii. Develop and implement technologies for off season cultivation.	V. High	M/A M/I & WRMgt. M/Plantation Inds.	0-5 years	1.5 M Domestic	80% of planned technologies introduced within five years.	
<b>Measure/Action 2: Contain price fluctuations due to volatile import policy.</b>						
<b>Justification for the action:</b> To prevent frequent price fluctuation due to volatile import policy.						
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
i. Adopt transparent and stable tariff policy framework.	V. High	M/A M/F&P M/Co-Op & IT	0-15 years	No Cost	Long-term tariff bounds introduced.	

<b>Measure/Action 3: Making irrigation network designs favorable for diversification.</b>						
Justification for the action: To promote crop diversification.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I. Modify irrigation network design for greater flexibility.	V. High	M/I & WRMgt. M/A	0-15 years	10 M International	Extents of land area covered by the modified canal system and tanks at the end of the project period. At least 70% irrigation systems adopts modified schedules.	
<b>Measure/Action 4: Developing varieties/Breeds and management packages suitable for diversification.</b>						
Justification for the action: To ensure food security and enhance resilience to Climate Change vulnerability.						
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I. Develop and introduce suitable crops/pastures /varieties/Breeds and technologies.	V. High	M/A M/LD M/I & WRMgt. M/Plantation Inds	0-10 years	10 M Domestic & International	Over 80% of planned new crops/pastures/varieties/Breeds released at the end of the project period. Over 50% of planned technology packages developed and introduced within 5 years.	
<b>Measure/Action 5: Improving marketing system– Increase penetration of rural markets and providing timely and accurate market information.</b>						
Justification for the action: To increase farmers’ income and food accessibility.						

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Improve the road connectivity and marketing network.	High	M/ED	0-15 years	0 M Domestic & International	80% of planned road length Improved at the end of the project period. Road density in farming areas increased.
ii. Develop marketing information and price reporting system.	High	M/A M/Co-Op & IT	0-10 years	1 M Domestic	Marketing information system introduced and operated within the project period.
iii. Encourage appropriate public and private institutional arrangements.	High	M/A M/Co-Op & IT	0-2 years	1 M Domestic	80% of planned supply chains developed in 2 years. Over 80% of planned markets developed in 2 years.
<b>Measure/Action 6: Improving post harvest technologies and processing infrastructure.</b>					
<b>Justification for the action:</b> To Stabilize price fluctuation and ensure food security.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
i. Develop appropriate post harvest technologies including cold chain and cold storage facilities.	High	M/A M/Co-Op & IT	0-15 years	5 M Domestic & International	Over 80% of planned cold chains introduced and operated at the end of the project period. Volume of produce handled by cold chain network annually after 3rd year.
ii. Develop food processing and support product promotion.	High	M/A M/T&R	0-10 years	2 M domestic	Volume of processed food marketed annually after 3rd year. Varieties of processed food available in the market.

iv. Establish storage facilities for Onion/Grains.	High	M/A M/ED	0-3 years	1 M Domestic	90% of planned of storage facilities established within 3 years.
<b>asure/Action 7: Lowering cost of production including labor cost.</b>					
<b>Justification for the action:</b> To increase farmers' income.					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
i. Introduce and implement agricultural credit and insurance scheme.	High	M/F&P M/A	0-15 years	3 M Domestic	Integrated agricultural credit and crop insurance system introduced within two years. No of beneficiaries per year.
ii. Introduce appropriate mechanization practices.	High	M/A	5-10 years	5 M Domestic & International	60% of planned mechanized farms after 8th year. Over 70% of planned machinery units in operation after 8th year.
<b>Measure/Action 8: Reducing fragmentation of land holdings.</b>					
<b>Justification for the action:</b> To encourage mechanization with a view to reduce cost of production.					
<b>Action/Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I Modify the legal framework to favor land consolidation.	Medium	M/A M/L& LD	0-5 years	0.05 M Domestic	New land titling and tenancy law introduced within 5 years.
<b>Measure/Action 9: Making Land tenancy arrangements diversification friendly.</b>					
Justification for the action: To increase land productivity.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I Amend tenurial arrangements.	Medium	M/L M/A& LD	5-10 years	0	Modified land tenure system introduced within 10 years.
<b>Measure/Action 10: Raising technical knowledge on the cultivation of new crops and precision farming methods.</b>					
Justification for the action: To withstand CC vulnerability and increase input use efficiency and secure food quality and safety.					
Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators

I Expand use of information technology and electronic mass media for agricultural extension.	Medium	M/A	0-10 years	4 M Domestic & International	Cyber extension systems in operation for all key crops within five years.
ii. Training and awareness creation on precision farming methods and food quality & safety.	Medium	M/A	0-10 years	0.5 M	15% of planned of training sessions conducted annually.
iii. Develop/Improve integrated plant nutrient management packages.	High	M/A M/Plantation Inds	0-10 years	1 M Domestic & International	Over 50% of planned crops covered by IPNS within five years. % of farms adopting IPNS per year.
iv. Develop/Improve integrated pest and disease management technologies.	High	M/A M/Plantation Inds	0-10 years	2 M Domestic & International	60% of planned crops covered by IPM practices within five years. % of farms adopting IPM per year.
<b>Total Cost of the Technology 3</b>					
				<b>Approx: US \$ 61.05 million</b>	

V. High = Very High; M/A - Ministry of Agriculture; M/I & WRMgt. - Ministry of Irrigation and Water Resource Management; M/L & LD - Ministry of Land and Land Development; M/ED - Ministry of Education; DC&S - Department of Census and Statistics; M/Co-Op & IT - Ministry of Cooperatives & Internal Trade; M/F&P - Ministry of Finance & Planning; M/T&R - Ministry of Technology and Research

**Proposed Action Plan for Technology for Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events**

<b>Measure/Action 1: Allocation of adequate funds by the government and Exploring alternative funding sources and mechanisms.</b>					
<b>Justification for the action:</b> To ensure adequate finances for technology implementation.					
<b>Action /Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility of Implementation</b>	<b>Time frame</b>	<b>Cost &amp; Funding Source (US \$)</b>	<b>Indicators</b>
I. Advocacy for Legislators, Policy Planners, NGOs, UN and Donors.	V. High	Ministry of Health/ Ministry of Disaster Management/ Ministry of Finance	0-1 year	10,000 IF	Number of programs conducted within one year.
II. Explore alternative funding sources and mechanisms.	V. High	Ministry of Health/ Ministry of Disaster Management/ Ministry of Finance	0-3 year	3,000 IF	60% increase of annual financial allocation by the end of 3 years.
<b>Measure/Action 2: Align with existing government structures and establishment of an inter and intra-agency network.</b>					
<b>Justification for the action:</b> To address issues related to inter and intra agency information sharing.					
<b>Action /Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility of Implementation</b>	<b>Time frame</b>	<b>Cost &amp; Funding Source (US \$)</b>	<b>Indicators</b>
I. Assess suitable and sustainable networking methods.	V. High	Ministry of Health	0-1 year	3,000 \$ US IF	Number of methods selected annually.
II. Establish focal units and focal points at all administrative levels (National/ Provincial, and District) down to the grass roots.	V. High	Ministry of Health/National Disaster Management Centre	0-1 year	5,000 \$ US DF	Number of administrative levels covered annually.

III. Establish a network up to the grass roots level by identifying focal points at different levels.	V. High	Ministry of Health/National Disaster Management Centre	0-3 years	10,000 \$ US IF	Networking system in place by end of 3years.
<b>Measure/Action 3: Rectify the issue of administrative gaps.</b>					
<b>Justification for the action:</b> To increase awareness on climate change and its impacts.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Advocacy to all administrators at different levels.	V. High	Ministry of Health/ National Disaster Management Centre	0-1 year	3,000 \$ US DF	Number of administrative units covered annually.
II. Provide required training to all focal points to discharge respective duties and responsibilities.	V. High	Ministry of Health	0-2 year	5,000 \$ US DF	Number of focal points trained% of focal units regularly reporting by the end of two years..
<b>Measure/Action 4: Improve utilization of modern and innovative for EWS; Networking, training and related research and development.</b>					
<b>Justification for the action:</b> To introduce new, affordable and appropriate technologies.					



Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Identify appropriate and affordable technologies.	High	Ministry of Health/ Ministry of Science and Technology Research	0-1 year	7,500 \$ US DF	Number of technologies identified for implementation annually.
II. a) Train personnel for the technologies to be used, including Training needs assessment. b) Preparation of training modules, pre-testing, identification of health personnel to be trained and trainers.	High	Ministry of Health	0-1 year	15,000 \$ US IF	Number of assessments completed by the end of first year. Availability of training modules by the end of first year. Categories of health workers identified for
III. Provide training to adequate number of personnel selected from different levels.	High	Ministry of Health/ Ministry of Disaster Management	0-8 years	15,000 \$ US IF	Number of training programmes conducted annually.
IV. Promote R & D in new innovations for EWS.	High	Ministry of Health/ Ministry of Technology and Technology Research	0-3 years	25,000 \$ US	Number of new innovations for EWS developed at the end of three years.
<b>Measure/Action 5: Streamlining and regular monitoring of policy , stakeholder awareness creation on existing policies and stakeholder engagement in policy reviews.</b>					
<b>Justification for the action:</b> To enable regular policy reviews, updating as appropriate and increase policy awareness.					

Action /Sub Action	Priority Rank	Responsibility	Time frame	Cost & Funding (US \$)	Indicators
I. Review all related policies every three years.	Medium	Ministry of Health	0-3 years	3,500 \$ US DF	Review policies by the end of three years.
II. All health personnel provided with information on policy measures through awareness, training activities.	Medium	Ministry of Health	0-3 years	2,500 \$ US	% of health personnel made aware of the policy measures at the end of three years.
<b>Measure/Action 6: Improve and enhance the use of available trained persons.</b>					
<b>Justification for the action:</b> To enhance training capacities of health institutions and improve skills of trainers.					
Action /Sub Action	Priority Rank	Responsibility	Time frame	Cost & Funding (US \$)	Indicators
I. Incorporate EWS in the HRH Policy.	Medium	Ministry of Health	0-1 year	1,500 \$ USDF	EWS category included in the National HRH Policy by the end of one year.

II. Address the issues related retention of personnel at the peripheries.	Medium	Ministries of Health/Finance & Planning/ Public Administration	0-1 year	1,500 \$ US DF	Number of measures implemented to ensure retention of personnel annually.
III. Take positive measures to retain personnel already in the service.	Medium	Ministry of Health/ Ministry of Economic Development/ Ministry of Public Administration	0-2 years	2,500 \$ US	Number of financial and non-financial measures implemented to retain personnel in the service by the end of two years.
<b>Total Cost of Technology 1</b>					<b>Approx: US \$ 113,000</b>

DF – Domestic Funds, IF – International Funds; V: High = Very High

## Proposed Action Plan for Transfer of knowledge and skills to Health Personnel

<b>Measure/Action 1: Provide sufficient funds (government and other avenues) and facilities for training and human resource development.</b>					
<b>Justification for the action:</b> To improve financial inputs from different sources and to reform the unfavorable policy issues as appropriate.					
Action /Sub Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Advocacy and awareness programs for legislators, policy makers and donor community including Private sector.	V. High	Ministry of Health	0-2 year	4,500 \$ US IF	Number of programs conducted by the end of two years. Number of policy issues addressed by the end of two years.
<b>Measure/Action 2: Establish a coordination unit and strengthen coordination mechanism. Preparation and sharing of an annual training calendar, and to solicit technical assistance from other agencies.</b>					
<b>Justification for the action:</b> To overcome issues related to training through regularizing training activities and by making training more diverse.					

Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Establishment of a training coordination unit for training coordination.	V. High	Ministry of Health	0-11.5 year	10,000 \$ US DF	Training coordination unit established within one and half years.
II Develop an annual training calendar (training plan).	V. High	Ministry of Health/ Ministry of Disaster Management	0-1 year	2,500 \$ US DF	Training calendar prepared by the end of the previous year.
<b>Measure/Action 3: Conduct training needs assessments and design training programs accordingly.</b>					
<b>J:ustification for the action</b> To enable undertaking regular training needs assessment of the Health Ministry staff and to develop training curricula accordingly.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost &Funding Source (US \$)	Indicators
I. Conduct sector wide training needs assessments.	V. High	Ministry of Health	0-1 years	2,500 \$ US DF	Training needs assessment completed by the end of 1st year.
II. Development of appropriate curricula for training.	V. High	Ministry of Health /Ministry of Education	0-1 year	5,000 \$ US IF	New curricula for training completed by the end of 1st year.
III. Training of health personnel.	V. High	Ministry of Health/Provincial and District Health Authorities	0-5 years	15,000 \$ US IF	Number of districts covered by the end of three years. Number of programs completed by the end of first three years

IV. Conduction of drills and simulations.	High	Ministry of Health/ NDMC/ Ministry of Public Administration/ Ministry of Defense	0-8 years	200,000 \$ US IF	Number of drills conducted by end of first three years. Number of institutions involved as a percentage by the end of first three years.
<b>Measure/Action 4: Explore and provide opportunities to use modern educational methodologies and technologies.</b>					
<b>Justification for the action:</b> To enable replacing student centered, class room activities with outdoor activity based technology transfer and skills development.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility of Implementation</b>	<b>Time frame</b>	<b>Cost &amp; Funding Source (US \$)</b>	<b>Indicators</b>
I. Identification of appropriate training methodologies to use in training programs.	High	Ministry of Health/ Ministry of Education	0-1 year	5,000 \$ US DF	Number of new educational methodologies identified by end of the 1st year.
<b>Measure/Action 5: Development and inclusion of a M &amp; E mechanism into an existing system to monitor and evaluate transfer and diffusion of knowledge, and recording lessons learnt for incorporation into future M &amp; E purposes.</b>					
<b>Justification for the action:</b> To introduce regular monitoring and evaluation system and to assess impact of transfer and diffusion of knowledge.					

Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Recruitment and training of monitoring teams, establishment of a monitoring mechanism, and implementation of regular monitoring activities island wide.	High	Ministry of Health	0-8 years	15,000 \$ US IF	Number of monitoring events conducted annually. Number of different methodologies used for monitoring. Annual coverage as a percentage.
<b>Measure/ Action 6: Provide financial and non-financial benefits, pooling of trainers from other sectors, due recognition to trainers.</b>					
<b>Justification for action:</b> To address issues related to shortage of competent trainers.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Establishment and implementation of measures to address the issue of shortage competent trainers.	Medium	Ministry of Health/ Ministry of Environment	0-2 years	5,000 \$ US IF	Number of trainers in the roster at the end of two years. Number of financial and non-financial measures adopted to retain them at the end of two years.
<b>Total Cost of Technology 2</b>					<b>Approx: US \$ 284,500</b>

DF – Domestic Funds, IF – International Funds; V. High = Very High

Proposed Action Plan Technology for management of Health Care Waste

<b>Measure/Action 1: Exploring additional funding sources, Public-private partnerships and Identification of appropriate and low-cost technologies for implementation.</b>					
<b>Justification for the action:</b> Explore partnerships to secure additional funding sources, and identify low-cost technologies to address issues related to high costs of implementation.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Identification of financial sources, low-cost technologies, and establishment of a national information centre to facilitate public-private and other partnerships.	V. High	Ministry of Health/ Ministry of Environment	0-2 years	25,000 \$ US IF	Number of parties providing resources by the end of two years. Availability of partnership information reports by the end of two years. Number of technologies implemented by the end of two years.
<b>Measure/Action 2: Feasibility studies on different technologies and implementation of sustainable technologies.</b>					
<b>Justification for the action:</b> To identify appropriate technologies for ensuring sustainability of the programs.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Study to identify appropriate, sustainable, and affordable technologies and implement the identified technologies.	V. High	Academic/Research institutions Ministry of Health	0-3 year	30,000 \$ US IF	Number of technologies identified and implemented by end of three years; Availability of study reports by the end of the three years.



<b>Measure/Action 3: Awareness creation among health personnel.</b>						
<b>Justification for the action:</b> To create awareness in order to generate interest for healthcare waste management and to prevent ill effects on the environment.						
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators	
I. Preparation of educational material, leaflets, booklets, posters.	V. High	Ministry of Health / Ministry of Environment	0-1 year	10,000 \$ US DF	Number of different educational materials prepared annually.	
II. Awareness creation among health personnel at national and sub-national levels.	V. High	Ministry of Health/Ministry of Environment/ Ministry of Education	0-1 year	7500 \$ US IF	Number of awareness programmes conducted annually.	
<b>Measure/Action 4: Train interested and qualified persons already in service, open avenues for carrier development and take measures to retain personnel for a predefined period.</b>						
<b>Justification for the action:</b> To overcome the barrier related to shortage of technical staff by providing required skills and opportunities for carrier development.						
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators	
I Select and provide training and skills to sector wide health personnel.	High	Ministry of Health/ Provincial Ministries of Health	0-3 years	15,000 \$ US IF	Number of institutes with proper waste management skills at the end of three years.	
<b>Measure/Action 5: Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other agencies.</b>						
<b>Justification for the action:</b> To overcome the obstacles due to lack of commitment by the policy planners and administrators.						

Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Advocacy to administrators at national and sub-national levels.	High	Ministry of Health/ Ministry of Environment	0-1 years	3,000 \$ US DF	Number of Provinces covered annually.
<b>Measure/Action 6: Improve the inter sectoral coordination</b>					
<b>Justification for the action:</b> To address inter-sectoral coordination weaknesses.					
Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US \$)	Indicators
I. Strengthen the existing network to include the healthcare waste management.	High	Ministry of Health	0-2 years	20,000 \$ US IF	Over 70 % of institutions networked by the end of two years.
<b>Total Cost of Technology 3</b>					
<b>Approx: US \$ 111,000</b>					

DF – Domestic Funds, IF – International Funds; V. High = Very High

## WATER SECTOR

## Proposed Action Plan for Restoration of Minor Tank net works

<b>Action 1: Provide sufficient funds and mobilize farmer contributions in terms of labor</b>						
<b>Justification for the action:</b> The barrier related to this action is <i>'high capital cost and inadequate allocation of funds in the annual national budget for restoration work'</i> . Minor tank network system is a water conservation method to meet the challenges of water scarcity and for retention of flood waters during heavy rains, which are considered as serious negative impacts of climate change. However, at present climate change and its effects do not appear to be priorities for certain relevant policy makers and legislators.						
Action/Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I. Advocacy of policy makers and legislators for implementation of adaptive measures with respect to climate change.	V. High	M/ Finance and Planning • M/Agrarian Development and Wildlife • M/Local Government and Provincial Councils	0-1 years	600 Domestic	(i) Awareness creation on potential socioeconomic benefits of the technology. (ii) Policy makers and legislators render due recognition and priority for implementation of climate change adaptation measures.	
II. Allocate sufficient funds from annual budget for diffusion of the technology.	V. High	• M/Agrarian Development and Wildlife • M/Local Government and Provincial Councils	1-2 years		(i) 50% increase of funding in the annual budget within the second year for diffusion of the technology.	
III. Explore additional funding from donor agencies.	V. High	• M/Finance and Planning	0-1 years	5,000 International	(i) Completion of three stakeholder meetings. (ii) Completion of a strong proposal for securing grants/loans by end of year -1.	

**Action 2 : Provide alternative income sources to farmers during extended dry seasons.**

Justification for the action: There is no return from the investments during extended dry seasons and therefore alternative livelihoods need to be provided.

Action/Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Provide compensation to farmers in the event of extended dry seasons.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• Dept. of Agrarian Development</li> </ul>	2-9 years	6 M International	(i) Compensation paid to eligible farmers from year 2 until end of the project.
II. Encourage involvement of farmers in restoration/rehabilitation work through incentives.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• Dept. of Agrarian Development</li> </ul>	2-9 years	0.02 M Domestic	(i) Incentives from year 2 until end of the project for (dry ration, drinking water etc.) all (100%) villagers involved.
III. Awareness creation on alternative employments during extended dry seasons.	V. High	<ul style="list-style-type: none"> <li>• Dept. of Agrarian Development</li> <li>• Dept. of Irrigation and Water Management</li> </ul>	2-9 years	12 M Domestic and international	(i) Completion of ten training and awareness programs in year-2 (ii) Repeating the above program annually.
IV. Build capacity of Department of Agrarian Development and Provincial Councils in terms of recruitments & availability of machines/equipment.	V. High	<ul style="list-style-type: none"> <li>• M/Agrarian Services and Wildlife</li> </ul>	2-9 years	0.05 M Domestic	(i) 30% Increased capacity of Agrarian Service Department (in terms of recruitment & availability of equipment by end of year 2.

<b>Action 3: Improve operation and maintenance practices for sustainability of minor tank systems</b>					
<b>Justification for the action:</b> <i>The related barrier is 'Lack of sustainability of minor tank systems due to poor tank/catchment management practices' . In order to overcome this barrier tank /catchment management should be improved through Farmer Organizations.</i>					
<b>Action/Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
I. Promote Farmer Organizations based mechanism for sustainability of minor tank systems.	V. High	<ul style="list-style-type: none"> <li>Dept. of Agrarian Development</li> <li>Provincial Councils</li> <li>Farmer organizations</li> </ul>	2-9 years	2000 Domestic	(i) Active involvement of Dept of Agrarian Development and Provincial Councils to promote involving Farmer Organizations in operation and maintenance of minor tanks (from year 2 to year 9).
<b>Action 4: Improve the knowledge on importance of good tank/catchment/canal management practices.</b>					
<b>Justification for the action:</b> <i>The barrier is 'Lack of knowledge on importance of good tank/catchment management practices' . This is due to inadequate training/knowledge and guidance given to farmer communities on such aspects.</i>					
<b>Action/Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
I. Develop and implement an annual calendar to provide necessary awareness to farmers. This will be included under Action 2-III.	V. High	<ul style="list-style-type: none"> <li>Dept. of Agrarian Services</li> <li>Provincial Councils</li> </ul>	2-9 years	Already included under Action 2-III.	(i) Conducting regular awareness programs on operation and management from year 2 to year 9.

<b>Action 5 : Increase involvement of farmers in planning and decision making on restoration/rehabilitation of minor tank networks Strength en Farmer Organizations.</b>						
<b>Justification for the action: Barrier is 'Lack of involvement of farmer community in planning and decision making processes related to restoration/rehabilitation of minor tank network.'. This is mainly due to, weak Farmer Organizations.</b>						
<b>Action/Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I. Address the issue of weak Farmer Organizations and identify measures to strengthen them.	High	<ul style="list-style-type: none"> <li>• Dept. of Agrarian Services</li> <li>• Provincial Councils</li> </ul>	1.0-2.0 years	3000 Domestic	(i) Active involvement of Dept. of Agrarian Services and Provincial Councils to strengthen Farmer Organizations.	
II. Implement measures to improve involvement of farmer community through Farmer Organizations in planning and decision making processes related to restoration work. This will be included under Action 2-III.		<ul style="list-style-type: none"> <li>• Dept. of Agrarian Services</li> <li>• Provincial Councils</li> </ul>	1-2 years	Already included under Action 2-III.	See indicators under Action 4-I.	
<b>Action 6 : Development of a policy/protocol/strategy for selection and prioritization of cascade systems/minor tanks for restoration/rehabilitation and preparation of a priority list</b>						
<b>Justification for the action: Barrier related to this action is 'Lack of prioritized areas for selecting the most suitable cascade systems/minor tanks for restoration/rehabilitation'. In most of the previous restoration processes, selection of cascade systems/minor tanks has been ad hoc without proper consideration of hydrology of the cascade system and needs, leading such restorations/rehabilitations efforts to be failures.</b>						

Action/Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Formulate a clear policy/strategy/protocol for selection and prioritization of cascade systems/minor tanks for restoration/rehabilitation.	High	<ul style="list-style-type: none"> <li>M/ Agrarian Services and Wildlife</li> <li>M/ Local Government and Provincial Councils</li> </ul>	0-1 years		(i) Availability of a policy for prioritization of cascade systems and their minor tanks for restoration/rehabilitation by end of year 1.
II. Collect data on major restoration/rehabilitation work needed, number of beneficiaries from each tank, relocation needs and amounts of funds available etc. and prepare a priority list for restoration.	High	<ul style="list-style-type: none"> <li>Dept. of Agrarian Services</li> <li>Provincial Councils</li> </ul>	1-2 years	0.05 M International	(i) Availability of data on cascade systems in the dry zone requiring restoration / rehabilitation, major rehabilitation , number of beneficiaries from each tank, relocation needs and amounts of funds available etc. and availability of a priority list for restoration work by end of year 2:
<b>Action 7: Demarcation of responsibilities of Agrarian Service Department and Provincial Councils with respect to restoration/rehabilitation of minor tank network systems and allocation of funds accordingly.</b>					
<p><b>Justification for the action: Barrier - Lack of policy/legal mandate for distribution of funds among different government agencies involved in restoration/rehabilitation of minor tank network systems.</b> There is no demarcation of responsibilities between the Agrarian Services Department and the Provincial Councils with respect to restoration/rehabilitation of minor tank net work systems and their level of support to FOs. Due to this reason, there is no proper mechanism to determine the amount of funds that should be made available for these agencies for restoration/rehabilitation work. As a result, these agencies have failed to undertake a proper planning of such work in the country for optimizing financial returns from the investments.</p>					
Action/Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators

I. Review the mandates of Agrarian Services Department and Provincial Councils for clear definition of their respective responsibilities with regard to restoration/rehabilitation work.	High	• M/Finance and Planning	0-1 years		(i) Respective responsibilities defined by the end of year 1.
II. Allocate funds based on respective responsibilities.	High	• M/Finance and Planning	2-9 years		(i) Allocation of funds based on the work assigned, from year 2.
<b>Action 8 : Build capacity of relevant institutes/Departments to collect and update hydrological data</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Poor understanding on cascade hydrology due to lack of hydrological data and limited institutional and organizational capacity'. Due to lack of capacity of relevant institutions/Departments, updated data on hydrology of most of the cascade systems are not available. Failure to consider cascade hydrology had been detrimental to small tank restoration/rehabilitation projects in the recent past.					
<b>Action/Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
I. Build capacity of relevant institutes and organizations and promote collection of hydrological data of selected cascade systems.	Medium	• Dept. of Agrarian Services	0-2 years	0.2 M international	By end of year-1 Appointment of research assistants/scientific officers and access other facilities such as equipment, improved mobility etc.
<b>Action 9: R &amp; D on tank water pollution and strict enforcement of relevant environmental laws/policies/regulations.</b>					
<b>Justification for the action:</b> Limitations of the technology-1 due to water pollution' is the barrier related to this action. Dental fluorensis and kidney diseases are reported in Anuradhapura, Polonnaruwa etc. The suspected reason is poor water quality due to pollution.					



Action/Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Monitor water quality of the tanks selected for restoration/rehabilitation work and health conditions of people consuming water from these tanks to establish the relationship between health issues and tank water pollution.	Medium	<ul style="list-style-type: none"> <li>Universities</li> <li>Dept. of Health</li> </ul>	3-9 years 0.5	0.5 M International	(i) Hiring of three research students for M.Phil Degrees and publish results by end of year 9. (ii) Availability of data collected in a regular basis (annually). (iii) Publish results of the statistical analysis by year 9.
II. Strengthen the efficiency of relevant agencies to implement existing environmental policies and legal instruments.	Medium	<ul style="list-style-type: none"> <li>M/Environment</li> </ul>	0-9 years		Number of offences detected per year
<b>Total Cost of Technology 1</b>					<b>Approx: US \$ 18.83 million</b>

V. High = Very High

### Proposed Action Plan for Rainwater Harvesting from Rooftops for Drinking and Household uses

Action 1: Obtain additional funds and Reduce high capital cost.						
Justification for the action: The barrier related to this action is 'High capital cost'. The Government has not identified this technology as a priority area, although this technology helps to solve certain negative effects of climate change. i.e. water conservation to overcome water scarcity , minimize erosion and flooding during heavy rains by diverting reasonable volumes of rainwater into storage tanks.						
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I. Advocacy of policy makers and legislators for implementation of adaptive measures with respect to climate change.	V. High	<ul style="list-style-type: none"> <li>M/ Water Supply &amp; Drainage</li> </ul>	0-1 years	0.01 M Domestic	(i) Awareness programs on potential socioeconomic benefits through implementation of the technology. (ii) Policy makers and legislators recognize the impacts of climate change and take need based policy decisions.	
II. Allocate sufficient funds from annual budget for diffusion of the technology.	V. High	<ul style="list-style-type: none"> <li>M/ Water Supply &amp; Drainage</li> <li>M/Environment and Natural Resources</li> </ul>	1-2 years		(i) 50% increase of funding in the annual budget by the second year for technology implementation.	
III. Explore mechanism for securing additional funding from donor agencies.	V. High	<ul style="list-style-type: none"> <li>NWSDB</li> </ul>	0-1 years	5000 International	(i) Completion of three stakeholder meetings. (ii) Compilation of a strong proposal for securing grants/loans by end of year -1.	
IV. Promote R & D on low cost, high quality roof top rainwater harvesting systems.	V. High	<ul style="list-style-type: none"> <li>Universities</li> <li>Research Institutes</li> </ul>	0 - 2 years	0.01 M International	(i) Low cost high quality roof top rainwater harvesting systems developed by end of year 2.	
V. Subsidy scheme for storage tanks to those registered with the NWSDB.	V. High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>INGOs, NGOs</li> </ul>	3-9 years	1 M International	(i) Provide storage tanks at a subsidized rate (50 % price reduction) from year-3 to year 9.	

<b>Action 2: Provide potable water during extended dry seasons at subsidized rates.</b>					
<b>Justification for the action:</b> The barrier related to this action is 'no return on investment during extended dry seasons'. Roof top rainwater harvesting system requires considerable financial commitment by the household. As the water collected during the rainy season would not meet the domestic needs of extended dry seasons, they need to be provided with potable water during such period at subsidized rates.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Provide water during extended dry seasons at concessionary rates.	V. High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>INGOs, NGOs</li> </ul>	3-9 years	10000 International	(i) Provide water during extended dry seasons at subsidized rates (50 % price reduction) from year-3 to year 9.
<b>Action 3: Raising knowledge on operation and management practices of rooftop rainwater harvesting systems.</b>					
<b>Justification for the action:</b> The related barrier is 'Lack of sustainability of roof top rain water harvesting systems due to poor management practices'. The importance of good operation and maintenance practices is poorly understood by the community due to lack of training/guidance/ information.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Awareness creation on good operation and management practices.	High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>Lanka Rain water Harvesting Forum</li> <li>Dept. of Health</li> </ul>	2-9 years	3.5 M International	(i) Conduct awareness programmes annually from year-2 until end of the project.

III. Establish demonstration models and prepare audio-visuals on proper operation and maintenance of roof top rainwater harvesting systems.	V. High	NWSDB • Lanka Rain water Harvesting Forum	0 -2 years	1M Domestic and International	Availability of demonstration models in the three districts and audio-visuals on proper operation and maintenance of roof top rainwater harvesting systems by end of year 2.
<b>Action 4: Formulate standards, codes &amp; certification and also annual license for roof top rainwater harvesting systems in Sri Lanka.</b>					
<b>Justification for the action:</b> This action is aimed at addressing the barrier on 'Lack of standards, codes and certification for roof top rainwater harvesting systems'. Many consumers use contaminated water and certain storage tanks have become mosquito breeding sites and there would be a tendency to use substandard roof materials by technology users.					
<b>Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
I. Develop or formulate standards/ codes/ certificates for roof top rainwater harvesting systems and an annual licensing scheme.	High	<ul style="list-style-type: none"> <li>• Urban Development Authority</li> <li>• NWSDB</li> </ul>	0-1 years		Availability of national standards for roof top rainwater harvesting systems, by end of year-1.
<b>Action 5 : Awareness creation on roof top rain water harvesting technology as a method for water conservation and minimizing flash flood s.</b>					
<b>Justification for the action:</b> Barrier is 'Poor understanding of importance of rain water harvesting as a water conservation method against potential water scarcity due to climate change'. It is necessary to address the issue of lack of/inadequate programs for dissemination of knowledge on benefit of this technology as a water conservation and flood minimizing method for climate change.					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Create awareness on the technology as a means of water conservation and a flood mitigation technology. Include this activity under Action 3-1.	High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>Urban Development Authority</li> <li>Lanka Rain water Harvesting Forum</li> </ul>	2-9 years	Included under Action 3-1	See indicators under Action 3-1.
II. Include "rooftop rainwater harvesting technology" into G.C.E (O/L) school curriculum	High	<ul style="list-style-type: none"> <li>Dept of Education</li> <li>National Institute of Education (NIE)</li> </ul>	0-1 years		(i) By end of year 1, introduction of this technology in the GCE (O/L) school curriculum.
<b>Action 6 : Develop a protocol to facilitate the Meteorological Department to provide free access to rainfall data.</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Poor accessibility for information on rainfall data'. Therefore, free access for rainfall data for previous years does not exist.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Review and revise as appropriate the data dissemination policies of Meteorology department.	High	Met department	0-1 year		Rainfall data for previous years freely available at no cost from end of year-1.
<b>Action 7: Formulate a clear mechanism/strategy /protocol for prioritization of areas for diffusion of this technology and prepare a priority list.</b>					
<b>Justification for the action:</b> Barrier – 'Lack of prioritized areas for installation of roof top rainwater harvesting systems'.					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Formulate a mechanism/strategy/protocol to prepare a priority list.	High	<ul style="list-style-type: none"> <li>M/ Water Supply &amp; Drainage</li> </ul>	0-1years		Policy/strategy available by end of Year 1 for identification and prioritization of areas for intervention.
II. Collect information of level of needs and data on rainfall, quality of rain water, urgency and results of Climate change modeling etc. and prepare a priority list for intervention.	High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>CEA</li> </ul>	0-2 years	0.02 M Domestic	Data and information on needs, rainfall, quality of rain water, urgency and results of Climate change modeling etc. available by end of Year 2.
<b>Action 8 : Increase the confidence in roof top harvested rain water as a potable water source.</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Lack of confidence in roof top rainwater harvesting technology'. It is necessary to implement suitable steps for community confidence building on use of harvested rain water as a potable water source.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Provide water quality analytical services for harvested rain water at a regular basis and at a nominal rate.	High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>Lanka rainwater harvesting forum</li> </ul>	3-9 Years	1 M Domestic and International	Availability of biannual analytical reports on water quality of harvested rain water.
II. Free monitoring service on health conditions of harvested rain water consumers.	High	<ul style="list-style-type: none"> <li>Dept. of Health</li> </ul>	2-9Years	0.5 M Domestic and International	Availability of annual reports on health conditions of persons consuming harvested rain water.

<b>Action 9: Increase the demand for roof top harvested rain water.</b>					
<b>Justification for the action:</b> 'Due to aesthetic considerations, roof top harvested rainwater has no demand' is the barrier related to this action and awareness creation is necessary.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I Create awareness through guide books, TV programs, leaflets and posters on roof top rainwater harvesting systems and experiences of other countries.	High	<ul style="list-style-type: none"> <li>NWSDB</li> <li>Lanka rainwater harvesting forum</li> </ul>	0-9 years	1 M Domestic and International	From end of year 1, availability of guide books, TV programs, leaflets and posters on roof top rainwater harvesting systems and information on use of rain water harvesting systems in other countries.
<b>Action 10: Strict enforcement of national rainwater harvesting policy.</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Inefficient enforcement of national rainwater harvesting policy'. The reason being the apathy of the Urban Development Authority, Municipal Councils, and NWSDB in implementation of the Policy.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Effective enforcement of national rainwater harvesting policy.	Medium	UDA <ul style="list-style-type: none"> <li>Municipal councils</li> <li>NWSDB</li> </ul>	0-9 years		Number of certificates issued for new buildings annually commencing from year 1.

<b>Action 1.1: Good operation and management of rainwater harvesting systems to minimize possible contamination of rain water.</b>						
<b>Justification for the action:</b> Barrier related to this action is 'Limitations of the technology due to potential for contamination of water'. There are instances where harvested rain water found to be contaminated with E. Coli due to lack of institutional capacity for treatment of harvested water.						
<b>Sub Action No</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
I. Build capacity of Health Department and NWSDB	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• M/Health</li> </ul>	0-1 years	5000 Domestic	Capacity at NWSDB and Health Department built for implementation of the technology by end of Year 1.	
II. Provide Technical assistance for good operation and maintenance and for water treatment.	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• Dept. of Health</li> <li>• Lanka rainwater harvesting forum</li> </ul>	2-9 years	5000 Domestic Domestic	Technical assistance provided by NWSDB and Health Department by Year 2.	
<b>Total Cost of Technology 2</b>					<b>Approx: US \$ 8.07 M</b>	

V. High = Very High



## Proposed Action Plan for Boreholes/Tube wells as a drought intervention for domestic water supply

<b>Action 1: Reduce high capital cost.</b>						
<b>Justification for the action:</b> The barrier related to this action is 'High capital cost ' 50% of the cost of construction of borehole is for drilling of the well and the drilling cost increases with increase in the depth.						
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I. Select sites having suitable hydro-geological conditions.	V. High	<ul style="list-style-type: none"> <li>Dept. of Irrigation</li> <li>NWSDB</li> </ul>	2-3 years		Reduced drilling cost.	
<b>Action 2: Adequate funding allocation for diffusion of the technology- in prioritized areas (e.g. rural areas).</b>						
<b>Justification for the action:</b> The barrier related to this action is 'Inadequate funding allocation for diffusion of the technology in prioritized areas (e.g. rural areas) '. The government has not given priority in the annual budget, for the diffusion of the technology in prioritized areas.						
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I. Advocacy of policy makers and legislators for implementation of appropriate climate change adaptive measures.		<ul style="list-style-type: none"> <li>M/ Finance and Planning</li> <li>M/ Irrigation and Water Resources Management</li> <li>M/ Water Supply &amp; Drainage</li> </ul>	0-1 years	0.01 M Domestic	Awareness programs on potential socioeconomic benefits of the technology. Policy makers and legislators recognize the importance of climate change adaptation measures as a priority.	
II. Allocate sufficient funds from annual budget.	V. High	<ul style="list-style-type: none"> <li>M/ Irrigation and Water Resources Management</li> <li>M/ Water Supply &amp; Drainage</li> </ul>	0-1 years		50% increase of annual funding within the second year.	

III. Mechanism for additional funding from donor agencies.		<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	0-1 years	0.01 M	Complete three stake holder meetings and a strong proposal for obtaining grants/loans by end of year1.
<b>Action 3: Build capacity of relevant institutes to offer a certificate course to disseminate necessary knowledge and technical skills on construction of successful boreholes.</b>					
<b>Justification for the action:</b> The barrier related to this action is ' <i>Lack of assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing</i> '. Poor hydro-geological conditions of the site can affect the sustainability of the borehole/tube well. Persons having necessary knowledge and technical skills for construction of successful boreholes is lacking due to inadequate capacity of relevant institutes to offer skill development training programmes.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Build capacity of NWSDB/WRB to offer a certificate course on construction of successful boreholes.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	0-1 years	0.5 M Domestic and International	Adequate capacity of WRB and NWSDB for successful implementation of the technology built by end of Year 1..
II. Develop a methodology to register organizations having at least one person who has successfully completed the above certificate course as tube well contractors at WRB/NWSDB.		<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	1-2 years		A list of qualified borehole constructing organizations registered at WRB/ NWSDB is available by end of the year-2.
<b>Action 4: Improve the knowledge on negative impacts of over extraction of ground water.</b>					
<b>Justification for the action:</b> The related barrier is ' <i>Lack of understanding on negative impacts of over extraction of ground water</i> '. In certain areas in the country, rate of groundwater abstraction has exceeded the rate of recharge primarily due to lack of knowledge of consumers on negative impacts of over extraction of ground water.					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Build capacity of NWSDB and WRB to enable creating awareness on negative impacts of over extraction of ground water. Include this under 3-I.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	0-1 years	Included under 3-I.	Indicators given under 3-I.
II. Awareness creation at national and sub national level.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	2-6 years	2 M Domestic and International	From year 3, conduct awareness programmes annually on negative impacts of over extraction of ground water.
III. Publish guide books (in Sinhala/English/Tamil), leaflets, posters etc.	V. High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	0-1 years	0.05 M Domestic and International	By end of year-1, availability of 1000 guide books (60 % in Sinhala/10% in English/30% in Tamil media) by end of the third quarter of year-0.
<b>Action 5: Diffusion of the technology by giving special attention to sustainability of boreholes.</b>					
<p><b>Justification for the action:</b> Barrier is 'Lack of Policies/ laws/ by-laws/ guidelines for safe and sustainable use of groundwater'. At present, ground water is over-extracted by certain consumers due to lack of policy/strategy in the country to control over extraction. As a result, such boreholes have dried-out and brackish water intrusion has 169 taken place in such boreholes in coastal areas.</p>					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Construct 25 boreholes based on the priority list and ensure good Operation & Management practices.	High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> <li>• Registered organisations</li> </ul>	3-5 years	6 M International	25 boreholes successfully established in the dry zone by end of the fifth year.
II. Construct the next successful 25 boreholes.	High	<ul style="list-style-type: none"> <li>• M/ Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	5-6 years	6 M International	25 additional boreholes successfully established by end of the sixth year.
III. Establish an annual licensing system coupled with regular inspections for boreholes to prevent over extraction.	High	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	3-6 years	5000 International	Annual licensing system in place by the year-3 and Inspection reports available from the year-3.
<b>Action 6 : Revise existing guidelines for safe and sustainable use of groundwater.</b>					
<b>Justification for the action:</b> Barrier is 'Lack of Policies/ laws/ by-laws/ guidelines for safe and sustainable use of groundwater'. At present, ground water is over-extracted by certain consumers due to lack of policy/strategy in the country to control over extraction. As a result, such boreholes have dried-out and brackish water intrusion has 169 taken place in such boreholes in coastal areas.					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Review and reform the existing guidelines for safe and sustainable use of groundwater.	High	<ul style="list-style-type: none"> <li>• M/Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	0-1 years		Revised guidelines available for sustainable use of ground water.
II. Dissemination of above guidelines through awareness programs. This will be included under Action 4-II.	High	<ul style="list-style-type: none"> <li>• M/ Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	2-6 years	Included under 4-II	See indicators given under 4-II.
<b>Action 7 : Revise existing policies/ laws related to ground water in order to regulate drilling of boreholes affecting vulnerable aquifers</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers'. Depending on the site conditions drilling of boreholes can affect vulnerable aquifers.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Review and reform existing policies/laws.	High	<ul style="list-style-type: none"> <li>• M/Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	0-1 years		Revised policies/laws available by end of year 1.

<b>Action 8 : Establish a mechanism for adequate availability of financial resources through a concessionary credit scheme.</b>					
<b>Justification for the action:</b> Barrier – ‘High interest on loans for importers/producers of tube wells. Currently there is no mechanism in the country to establish low-interest credit system for purchasing of necessary equipment.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Formulate financial incentives through loan schemes.	V. High	<ul style="list-style-type: none"> <li>• Central Bank</li> <li>• Treasury</li> <li>• Private sector</li> </ul>	0-1 years		Financial incentives such as loans on concessionary interest with longer grace periods available by end of Year 1.
<b>Action 9: Establish a mechanism for adequate availability of financial resources through import duty concessions.</b>					
<b>Justification for the action:</b> Barrier related to this action is ‘High import tax for importers/producers of tube wells due to lack of mechanism/strategy to establish import taxrelief’. Currently there is no mechanism available to provide import duty relief to promote importing necessary equipment.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Formulate financial incentives through import tax relief; Combine this to Action 8- I.	High	M/Finance and Planning	0-1 years		Provide import tax relief by the end of Year 1.

<b>Action 10: Update information on status of aquifers in the dry zone of Sri Lanka by WRB/NWSDB.</b>					
<b>Justification for the action:</b> <i>'Lack of information on ground water resources'</i> is the barrier related to this action. There is no regular monitoring program to update the status of ground water resources in the country.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Implement an annual monitoring program by WRB/NWSDB.	High	<ul style="list-style-type: none"> <li>• WRB</li> <li>• NWSDB</li> </ul>	2-6 years	0.01 M International	Availability of annual updates on the status of ground water resources.
<b>Action 11: Develop a mechanism for prioritization of areas/sites for installation of boreholes and preparation of a priority list.</b>					
<b>Justification for the action:</b> Barrier related to this action is <i>'Lack of prioritization of areas to implement this technology'</i> . At present, prioritized locations for introduction of the technology is not available.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
1. Formulate a protocol/mechanism for prioritization of locations for the interventions.	High	<ul style="list-style-type: none"> <li>• M/Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	0- 1 years		A protocol for prioritizing areas available by end of year 1.
I. Collect data on highly vulnerable areas for climate change, need and urgency.	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	0-2 years	5000 Domestic	Availability of data on highly vulnerable areas for climate change, need and urgency by end of year 2.

III. Preparation of a priority list.	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	2-3 year	Prioritized areas by year3. Action 12:	
<b>Action 12: Awareness campaigns on special facilities provided for tube well constructors.</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Lack of information on prices of equipment, loan schemes etc.' Certain tube well constructors/producers are not aware of special facilities provided to borehole constructors registered at WRB/NWSDB.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(I). Create awareness on special facilities provided for construction of boreholes particularly in rural areas.	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	2-6 years	5000 International	Publicity on special facilities provided to constructors/producers through media.
<b>Action 13: Promote R &amp;D on ground water availability/quality and hydrogeology of various sites.</b>					
<b>Justification for the action:</b> Barrier related to this action is 'Lack of R & D on ground water availability and hydrogeology'. Above information should be monitored and updated by WRB/NWSDB.					
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
I. Monitor ground water availability, quality and hydro-geological data in a systematic basis.	Medium	<ul style="list-style-type: none"> <li>• NWSDB</li> <li>• WRB</li> </ul>	2-6 years		Regular monitoring mechanism in place.



<b>Action 14: Prevent degradation of Ground water quality</b>						
<b>Justification for the action: Barrier – ‘imitation of the technology due to poor quality of ground water’</b> Quality of the bore hole/ tube well depends on ground water quality. Tube well water samples contaminated with Escherichia coli, Fluoride and nitrate ions, agrochemicals etc, have been reported. Therefore, it is necessary to ensure ground water is maintained at standard quality levels.						
Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators	
I. Regular monitoring of water quality of boreholes This can be incorporated with present water quality surveying program	Medium	<ul style="list-style-type: none"> <li>• M/ Irrigation and Water Resources Management</li> <li>• M/Water Supply &amp; Drainage</li> </ul>	3-7 years	0.02 M International	Regular water quality monitoring data available.	
II. Monitor health conditions of people consuming water from the boreholes and study any relationship between health status and water quality.	Medium	<ul style="list-style-type: none"> <li>• Dept. of Health</li> </ul>	3-7 years	0.02 M International	Regular information on health status available together with Statistical analyses.	
<b>Total Cost of Technology 3</b>						
						<b>Approx: US \$ 14.67 million</b>

V. High = Very High

## Proposed Action plans for Rehabilitation of sand dunes

Measure/Action 1: Provide adequate funding from the Government sources based on suitably justified proposals submitted by relevant line Ministries/ Departments and by NGOs & INGOs who are actively involved in adaptation procedures for climate change and on conservation of ecosystems & biodiversity.					
Justification for the action: Inadequate funds for rehabilitation of sand dunes through beach nourishment and restoration of dune vegetation and for awareness creation.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Provide adequate funding for sand dune rehabilitation activities.	High	CoastConservation Department (CCD)	0-7 year	Domestic US \$ 50,000	Availability of funding with effect from end of year 1 to year 7
Measure/Action 2: Conduct stakeholder awareness programmes on existing policies, rules & regulations, socioeconomic importance of sand dune ecosystems and their non-extractive uses.					
Justification for the action: General lack of awareness at all levels of the society on the socioeconomic importance of sand dunes and associated vegetation and the nonextractive uses of sand dune resources.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Conduct awareness workshops.					
a) Stakeholder awareness programmes to all stakeholders on socio-economic benefits of sand dune ecosystems and the associated vegetation and on technologies for propagation and maintenance of dune plantations.	V. High	Coast Conservation Department (CCD)	0-2 years	Domestic & International US \$ 21,000	Improved awareness among all stakeholders on sand dunes within 2 years.
b) Awareness workshops to members of the Police department, Navy and Coast Guard on the importance of protecting sand dune ecosystems from illegal and destructive activities.	V. High	Coast Conservation Department (CCD)	0-2 years	Domestic & International US \$ 6,000	At least 50% reduction of reported sand dune ecosystem destructive activities by the end of 2 years.

c) Training workshops on ecotourism to unemployed youth.	High	CCD/ Tourist Board/ Coast Guard	1 to 3 years	Domestic & International US \$ 12,000	100- 200 Trained tour guides are engaged in eco-tourism from 2-4 years.
d) Awareness workshops to coastal tourist hotel owners on conservation & management of sand dunes, establishment of nature trails in dune vegetation.	High	CCD/ Tourist Board/ Tourist hotel owners	1.5-3.0 Years	D & I US \$ 6,000	Over 60-80% of coastal tourist hotels involved in conservation of sand dunes & establishment of nature trails by end of year 3.
e) Training workshops on identification of suitable dune plants of economic & medicinal importance for replanting, tissue culture techniques to produce propagules.	High	M/Agricultural Development, M/Indigenous medicine, CCD,	1 to 3 years	US \$ 120,000	100- 200 persons trained for identification of suitable dune plants and tissue culture techniques by 2 to 4 years.
f) Awareness/training programmes on use of alternatives for dune sand in construction industry.	High	ICTAD & CCD	0.5-1.5 Years	D & I US\$ 6,000	25%to 90% reduction in usage of dune sand for construction work (from 2- 7 years).
Measure/Action 3:I. Encourage plantations of dune vegetations of economic and medicinal importance; II. Establish SMEs and provide incentives to trained persons to establish SMEs;III. Conduct feasibility studies for introduction of exotic species of Pandanus of economic importance.					
Justification for the action: General lack of awareness on the non extractive uses, ecological functions of coastal sand dunes and knowledge on sustainable utilisation of dune vegetation.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Establish Tissue culture laboratories and nurseries for propagation of plants for dune re-habilitation & herbal gardens.	High	Universities, Agrarian research institutes,	1-3 years	D & I US \$ 600,000	Two tissue culture laboratories established at research/higher educational institutes by the end of 2nd year. Ten nurseries and 10 Dune plantations/herbal gardens of economic/ medicinal importance established within 2-4 years.
II. Establish SMEs and provision of incentives to trained persons to establish SMEs	High	Indigenous medicine, M/Industrial Development,	1.5 -4.0 year	D & I\$ 200,000	Ten dune vegetation related SMEs established within 2 - 5 years.

III. Conduct feasibility studies for introduction of exotic Pandanus spp. of economic importance.	High	Universities/ Agrarian research institute	1.5-2.5 years	D & I US \$ 50,000	Suitable exotic Pandanus spp of economic importance identified within 2 years.
<b>Measure/Action 4:</b> (I) Development of multidisciplinary projects in collaboration with research/academic institutions to address the issues related to sand dunes by identifying strategies to develop and improve effective collaborations and problems in dune ecosystems					
<b>Justification for the action:</b> Inadequate inter agency coordination.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time Frame</b>	<b>Cost (US\$) &amp;Funding</b>	<b>Indicators</b>
I. Prepare R & D projects/plans in collaboration with government agencies responsible for activities in the coastal areas.	Medium	National Science Foundation (NSF)	Every 3- 5 years	D US \$ 35000 (Funding for projects are not included)	Funds secured for at least 3 project proposals once in every 3 years.
II. Regular consultations with relevant institutions to identify and take appropriate actions through collaborative arrangements to address such issues related to conservation and sustainable management of dune ecosystems.	Medium	Provincial councils. M/Environment	02	D US \$ 24,000	Effective collaborative arrangements among relevant institutions developed within 2 years.
<b>Measure/Action 5:</b> Train and retain adequate number of staff and prepare a directory of such trained personnel.					
<b>Justification for the action:</b> Inadequate trained personnel/experts to conduct awareness programmes and to provide knowledge on technologies used for dune rehabilitation and related activities.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Allocation of funds for training by line ministries.	Medium	- M/Environment - Ministry/Science & Technology - M/Higher education	0-5 Years	D & I 500,000* (*This has not been included in the initial budget)	5 to 10 personnel trained from each of the institutions falling under the respective line ministries to serve as trainers within 2-5 years .
II. Develop strategies to retain trained Persons (e.g. Medium obligatory service based on bond agreements).	Medium	M/Environment; M/Agricultural dev, M/Higher ed;	No time limits		A minimum of 5 trainers in each institutions retained after 7 years.
III. Preparation of a directory of trained personnel based on respective field of expertise.	Medium	NSF/ Centre for Agrarian Research policy(CARP)	0-0.1 Years	D US \$ 5,000	Database and a Directory of experts and their research out puts prepared at within 1 year.
<p><b>Measure/Action 6:</b> Form a core group of catalysts selected from among the coastal communities, provide alternative sources of income or employment within the region to those involved in destructive activities and the government agencies to develop suitable strategies for better understanding and appreciation of NGOs involved in community participatory programmes.</p>					
<p><b>Justification for the action:</b> Lack of commitment by the coastal communities and industries to protect existing sand dunes and to rehabilitate disturbed sand dunes from destructive coastal livelihood activities.</p>					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Form community based organisations to be involved in sand dune rehabilitation programmes.	Medium	Communities within the area/ CCD/NGOs	0-2 Years	D & I US \$ 5,000	Effective conservation and management systems established for dune ecosystems through community participation after 1.5 years.
II. Provide employment to those involved in destructive livelihood activities (Tourism, SMEs, etc.)	Medium	CCD/M/ Environment/ NGOs	1 -6 Years	D & I US \$ 150,000	Destructive activities reduced by 50% and 90% after 3 and 7 years respectively.
III. Development of community participatory programmes by government institutions in collaboration with NGOs.	Medium	CCD/NGOs	0-7 years	D & I US \$ 450,000	A minimum of 10 community participatory socioeconomic programmes established by the end of 7 years.
Measure/Action 6: Encourage off-shore sand extraction for building construction together with popularization of construction technologies which do not utilize coastal sand					
Justification for the action: Heavy use of dune sand for construction work and need for actions to minimize the use of dune sand for construction work.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Encourage extraction of off shore sand for construction purposes.	High	NBRO/Land Reclamation & Development Corporation (SLLRDC)	0-3.0 Years	US \$ 5,000 D & I	Removal of sand from dunes and other coastal areas reduced by 25% and 90% by 0.5 7 years respectively.
Measure/Action 9: Build capacity at R & D institutions to enable handling research activities related to environmental protection, conservation & management through incorporation of such aspects in the respective Corporate Plans.					
<b>Justification for the action:</b> Inadequate research opportunities available for dune rehabilitation activities.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US\$) &Funding	Indicators
I. Improve infrastructure facilities at R & D institutions and Higher Educational Institutions and develop R&D plans incorporating respective research activities.	Medium	- M/Technology & Research - M/Higher Education	0.5-5.0 years	D & I \$ 150,000/ year to each institution	Required infrastructure facilities available at R & D and Higher Educational Institutions within 5 years.
<b>Total Cost of Technology 1:</b>					<b>US \$ 2.395 million</b>

V. High - Very High; D – Domestic; I – International; CCD – Coast Conservation Department; ICTAD - Institute of Construction Training and Development; SLLRDC - Land Reclamation & Development Corporation; NSF – National Science Foundation; CARP - Centre for Agrarian Research Policy; NBRO – National Building Research Organization; NGOs – Non-governmental Organizations.

## COASTAL SECTOR

### Proposed Action plans for Mangrove Rehabilitation

Measure/Action 1: Explore funding opportunities through properly formulated proposals and promotion of self sustaining economic activities using mangrove products.						
Justification for the action: Inadequate financial assistance and government patronage for mangrove restoration programmes.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
I. Conduct awareness programs to facilitate fund raising etc.						
a) Two workshops for preparation of suitable project proposals and to explore financing opportunities.	Medium	Coast Conservation Department(CCD)	0 -1 years	D & I US \$ 6,000	Two project proposals developed with ensured funding by end of year 1 and availability of funds by the end of year 2.	
b) Awareness programmes to officials from the Ministry of Finance & Planning on socioeconomic significance of mangrove restoration.	Medium	CCD	0-1.0 years	D & I US \$ 3,000	Incremental increased of annual budgetary allocations to relevant institutions from year 1 through year 7.	
II: Encourage community-based organisations to introduce mangrove based activities yielding financial gains (eco-tourism, SMEs, etc.).	Medium	CCD/NGOs	1-7 year onwards	D & I 100,000 initially	Community based self sustaining SMEs and. Ecotourism activities established by the end of year 2 and continue up to 7 years.	
Measure/Action 2 : Improve awareness and provide assistance to respective government agencies to prepare suitable management plans for rehabilitation.						
Justification for the action: General lack of appreciation/awareness on the non-extractive uses, ecological functions & services provided by mangroves and unsustainable practices in mangrove areas. Lack of management plans or strategies to protect and manage mangroves ecosystems.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
I. Awareness creation on mangrove related activities.						
a) Three stakeholder participatory workshops for Preparation of a management plan for protection, rehabilitation and sustainable utilisation of mangroves.	V. High	CCD	0-1 years	D & I US \$ 9,000	Successful management plan available after 1.0 year.	



b) Awareness workshops for different stakeholder groups on mangrove rehabilitation and sustainable management of mangrove ecosystems.	Very High	CCD/ Forest Dept NGOs	0-2.0 years	D & I 25,000	Awareness improved by 80% among all stakeholder groups after 2 years. Cooperation among stakeholder groups improved by 60% after 2.0 year.
c) Awareness programmes through electronic & print media, using resource persons with international and local experience in the field of integrated coastal zone management & mangrove restoration.	High	CCD & Local media organisations	0-3 years	D US \$ 100,000 up to 3 years	Series of awareness programmes conducted on popular television channels and news papers over a period of 3 years. Awareness among all stakeholder improved by 70% at the end of 3 years.
d) Training programmes for members of the coastal communities on tissue culture techniques for production of propagules, maintenance of nurseries, replanting etc.	High	CCD	0.5 – 2 years 5 – 2 years	D & I US \$ 20,000	Adequate trained personnel for all aspects of mangrove rehabilitation programmes available within 2 years.
<b>Measure/Action 3</b> : Encourage non-extractive and sustainable utilisation of mangroves and other associated resources and reduce pollution & sedimentation.					
<b>Justification for the action:</b> The need for developing strategies to protect and manage mangroves in view of the absence of a proper legal machinery and strategies to ensure sustainable management.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US\$) &amp;Funding</b>	<b>Indicators</b>
I. Encourage formation of community organisations to manage, produce propagules through tissue culture, rehabilitation of mangroves and develop eco-friendly socioeconomic activities in mangrove areas.	Medium	CCD/NGOs	0.5 onwards	D & I US \$ 150,000	Sufficient numbers of propagules produced for replanting from end of year 1 through year 3 and onwards. Community organisations actively involved in related activities. from year 1 onwards.
II. Strict enforcement of law/regulations to protect mangrove ecosystems from all coastal and land based destructive activities.	High	CCD/CEA Coast guard Police department.	At all times	US \$ 25,000	Harmful anthropogenic activities reduced by 50% and 90% at the end of Year 2 and Year 5 respectively.

Measure/Action 4. Establish regulatory mechanisms to ensure replanting of mangroves based on zonal plans developed using GIS and remote sensing techniques.						
Justification for the action: Currently systematic approach which includes zonal plans and species selection procedure for replanting of mangroves is lacking.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
I. Develop zonal plans to streamline mangrove replanting programmes.	Medium	CCD/Forest Department (FD)		D & I US \$ 40,000	Zonal plans prepared for mangrove areas by end of 1.5 years.	
II. Use aerial photographs and past information to identify most suitable species for mangrove rehabilitation.	Medium	Forest Department (FD).	0.5 -2	D & I US\$ 20,000	A list of location specific plant species suitable for mangrove rehabilitation available by the end of Year 2.	
<b>Measure/Action 5:</b> Conduct research projects related to rehabilitation, sustainable management and value added products of mangroves.						
Justification for the action: Currently suitability of mangrove plant species are not tested prior to undertaking rehabilitation programs.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
1. Conduct research on rehabilitation & sustainable management of mangroves and value addition to mangrove products.	High	CCD/FD/Higher Education,	0-5 years and onwards	D & I US\$ 200,000	Research findings for sustainable utilisation of mangroves available after 1.5 years	
<b>Total Cost of Technology 2:</b>					<b>US \$ 0.698 million</b>	

High - Very High; D – Domestic; I – International; CCD - Coast Conservation Department; SD – Forest Department; NGOs – Non Governmental Organizations; CEA – Central Environmental Authority

### Proposed Action Plans for restoration of coral reefs

<b>Measure/Action 1:(i).</b> Explore project specific funding from local & foreign sources, NGOs etc. and introduce eco-friendly activities with adequate financial returns.						
<b>Justification for the action:</b> Inadequate financial assistance for restoration programmes and program monitoring.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
I. Prepare project proposals for reef restoration through stakeholder participatory workshops.	Medium	CCD). M/ Technology & Research.	0.5-1.0 years	US \$ 6,000 D	A minimum of 2 successful major collaborative project proposals completed within 1.5 years.	
II. Introduce eco-friendly socio-economic activities to enable generating revenue from foreign from visitors to reef sites.	Medium	CCD &Ministry of Tourism	1.0 onwards	D & I US \$ 100,000	Four eco-friendly socioeconomic activities established at the end of 5 years.25% to 80% increase in the Income from local &foreign visitors increased by 20% to 80% fromyear 2 through year 7.	
III. Awareness creation among respective government officials to facilitate access to incremental annualfinancial allocations for reef restoration activities.	Medium	CCD & M/Finance & Planning	0.5-1.0 years	D & I US \$ 10,000	Incremental increased of required funds from annual budget for coral restoration after year 1.	
<b>Measure/Action 2:</b> Establish community participatory organizations in the vicinity of coral reefs to monitor the development programmes ensure sustainability of coral reefs and help mitigation practices; (ii). Appoint competent committees as deemed appropriate to review the IEE &EIA.						
<b>Justification for the action:</b> Poor enforcement of coastal regulations and lack or poor IEEs & EIAs when establishing large tour ist resorts cum facilities in the vicinity of coral reefs.						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	

I. Formation of community participatory organisations comprised of personnel with swimming, snorkelling and diving skills committed to protect, conserve and restore coral reefs.	High	CCD/NGOs/ Community	0.5-1.0 years	D & I US \$ 1,600,000	A minimum of two community participatory organisations established within 2 years for each reef site included in the programme.
II. Ensure conduct of IEEs & EIAs to all major development and economic activities in the coastal zone and be reviewed by committees possessed with required knowledge, skills & experience.	High	M/environment/ CEA/CCD	0-0.5 years	D US \$ 50,000	All coastal developmental activities are reviewed by the IEE/EIA committee from 0.5 year through to 7 years and onwards.
<p><b>Measure/Action 2:</b> Establish community participatory organizations in the vicinity of coral reefs to monitor the development programmes ensure sustainability of coral reefs and help mitigation practices; (ii). Appoint competent committees as deemed appropriate to review the IEE &amp; EIA.</p> <p>Justification for the action: Poor enforcement of coastal regulations and lack of poor IEEs &amp; EIAs when establishing large tour ist resorts cum facilities in the vicinity of coral reefs.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators
I. Formation of community participatory organisations comprised of personnel with swimming, snorkelling and diving skills committed to protect, conserve and restore coral reefs.	High	CCD/NGOs/ Community	0.5-1.0 years	D & I US \$ 1,600,000	A minimum of two community participatory organisations established within 2 years for each reef site included in the programme.
II. Ensure conduct of IEEs & EIAs to all major development and economic activities in the coastal zone and be reviewed by committees possessed with required knowledge, skills & experience.	High	M/environment/ CEA/CCD	0-0.5 years	D US \$ 50,000	All coastal developmental activities are reviewed by the IEE/EIA committee from 0.5 year through to 7 years and onwards.

<p><b>Measure/Action 3:(i).</b> Improve stakeholder awareness on the impacts of unsustainable reef based socio economic activities and non-extractive uses of coral reefs and initiate actions to promote eco friendly activities.</p> <p><b>Justification for the action:</b> Availability of unsustainable development plans and ongoing resource utilisation practices (e.g. corals for lime industry, collection of ornamental fish, use of explosives for fishing) within reef sites.</p>						
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators	
I. Improve awareness on significance of coral reef ecosystems.						
a) Conduct awareness programmes to all stake holder groups within and in close proximity to reef ecosystems.	V. High	CCD & MEPA	0.5- 2.0 years	D & I US \$ 25,000	Awareness created within Year 1 among government officials on importance of collaborative approaches for conducting development programmes.	
b) Conduct awareness programmes on the non extractive uses/importance, roles and functions of corals and on the need for controlling pollution and sedimentation.	Medium	CCD	1.0-2.0	D & I US \$ 15,000	Impacts of pollution and sedimentation in the coral reef ecosystems reduced by 25% within 2.0 years.	
c) Involve those engaged in coral destructive activities in coral transplanting programmes and provide training on eco-friendly income generating activities.	V. High	CCD & MEPA	0.5-3.0 years	D & I US \$ 50,000	50% to 90 % of persons engaged in coral destructive activities involved in coral transplanting and eco-friendly economic activities from Year 2 through Year respectively.	
<p><b>Measure/Action 4:(i).</b> Implementation of river basin management programmes and control of land use patterns to reduce sedimentation from agriculture, mining and erosion through the involvement of National Physical Planning Department, effective law enforcement against illegal coastal practices and undertake reef cleaning programmes.</p> <p><b>Justification for the action:</b> Sedimentation and pollution due to unplanned land based and coastal socioeconomic activities.</p>						

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators
I. Monitoring programmes to determine the sedimentation rates and influx of nutrients into reef ecosystems.	High	CCD	0.5-1.5 years	D & I US \$ 200,000 (30,000 annually)	Baseline information available within 1.5 years for each reef site for future reference related to development programmes and IEE/EIAs.
II. Regulate land use practices in the river basin catchment areas which releases water into sensitive reef ecosystems.	High	National Physical Planning Department/CEA	Start at year 1 and continue	US \$ 10,000	Land use patterns within the relevant catchment areas controlled by 90% within 7 years.
III. Organise community participatory reef cleaning programmes with the assistance of nature lovers NGOs.	High	MEPA & CCD	Annual	D & I US \$ 80,000	Evidence of growth of healthy coral reefs, sans any exotic materials monitored and established during year 1 to 7.
IV. Severe punitive actions against those involved in activities harmful to coral reefs (e.g. release of untreated sewage, effluents, illegal fishing, removal of corals etc.)	High	MEPA/CCD Coast Guard	No time limit	No financial involvement	Severe punishments imposed from the initial stages to those persons/organisations responsible for coral reef destructive activities.
<b>Measure/Action 5:(i).</b> Provide adequate training to members selected from among the stakeholder groups and line ministries to be involved as leaders for implementation of the respective restoration programmes and trainers.					
<b>Justification for the action:</b> Inadequate trained personnel to be involved in coral rehabilitation programmes.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators
I. Provide adequate training in all reef restoration and conservation related activities to groups selected from among the communities and related institutions.	High	CCD/MEPA /NGOs	0.5 years onwards	D & I US \$ 200,000	Ten trained individuals available for each reef site at the end of Year 1. Sustainably managed healthy coral reefs after 1.5 years.
Measure/Action 6:(i).Formulate development plans in consultation and through cooperation of important stakeholders; (ii).Conduct seasonal monitoring programmes with the cooperation of trained stakeholders to be on alert for natural extreme events. Justification for the action: Inadequate stakeholder awareness on naturally occurring extreme events that contribute for coral bleaching.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US\$) &Funding	Indicators
I. Develop a sustainable management plan for reef eco systems through consultation of stakeholders and experts.	Medium	CCD/NGOs	Year 1 onwards	D & I US \$ 9,000	A long-term management plan acceptable to all stakeholders available after 2 year.
II. Conduct seasonal monitoring programmes to monitor resilience of coral reefs and to identify early signs of bleaching.	Medium	CCD/MEPA/ R & D Institutions/ Univer sities	0.5 onwards	D & I US \$ 80,000 (At least 10,000 annually)	A data bitions to help Identifyingany changes in the rease available on coral biodiversity and physicochemical confed ecosystems
III. Use GIS & remote sensing techniques to forecast damage to reef ecosystems due to natural extremeevents to be on alert for such potential hazards					
<b>Total Cost of Technology 3: US \$ 2.435 million</b>					

High - Very High; D – Domestic; I – International; CCD - Coast Conservation Department; FD – Forest Department; NGOs – Non Governmental Organizations; CEA – Central Environmental Authority; R & D – Research & Development; MEPA - Marine Environment Protection Authority

**Action Plan for rehabilitation and restoration of degraded areas inside and outside the protected area network to enhance resilience**

<p><b>Measure/Action 1:</b> Provide incentives and remove perverse incentives for restoration by communities &amp; private sector and introduce a biodiversity-offset mechanism.</p> <p><b>Justification for the action:</b> Returns from rehabilitation and restoration are not immediate and no incentives are available for restoration work done by communities and the private sector. In addition to numerous benefits from ecosystem services, rehabilitation and restoration also has both mitigation and adaptation benefits. Long gestation period and lack of incentives are considered as major hindrances for community and private sector involvement in the interventions.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Provide incentives by government/ donors for rehabilitation and restoration by communities & private sector and introduce a biodiversity-offset mechanism.	V. High	Forest Dept/ Wildlife Dept/ M/Environment & CEA Ministry of Fisheries & Coast Conservation Department	2-3 years	Domestic & International Cost of incentives approx US\$ 1,100,000 (including monitoring)	- Incentive mechanism established during year 1. - At least 10,000 hectares of ecosystems restored & incentive paid in 2years. .
<p><b>Measure/Action 2:</b> Apportion part of annual budgets of Forest and Wildlife Departments for rehabilitation and restoration based on an agreed action plan*</p> <p><b>Justification for the action:</b> Funding is a constraint for need based rehabilitation and restoration. The Department of Wildlife Conservation and Forest Department being the main departments dealing with environment and biodiversity, do not receive adequate funds for restoration from the respective nationally allocated budgets.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators



(i) Apportion part of annual budgets of Forest, Wildlife Departments and other relevant agencies for rehabilitation and restoration based on an agreed action plan* (ii). Explore external funding sources*	V. High	Forest/Wildlife Dept/ M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD	0.5-1 year annually thereafter	Domestic from the budget No cost (5%, approx. US\$ 750,000 annually).	Aet aside a minimum of 2-5% of the annual budget for rehabilitation and restoration within 3 years.
<b>Measure/Action 3:</b> Ecosystem specific studies on values of ecosystems services and dissemination of study findings.*					
<b>Justification for the action:</b> The true value of ecosystem services is little understood and information based on local ecosystem services valuations for key local ecosystems is lacking. The contribution by the ecosystem services to the national economy and day-to-day activities of the public at large is poorly understood. Hence, the true value of rehabilitation and restoration and its returns is undervalued and often being unrecognized. It is vital that land managers, policy makers and politicians are made aware of such values.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Ecosystem specific studies to determine ecosystem service values and dissemination.* of study results.	High	Forest/Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities/ Research institutions/ Environmental organizations/)	0.5 – 3 years	Domestic & international US\$ 460,000	- Annually 2-5 studies completed. - Effective information dissemination channels established and relevant information made available to at least 500 key stakeholders and 1000 members of the public within 2-5 years.
<b>Measure/Action 4:</b> Undertake studies including climate change modeling to identify and prioritize critical areas for rehabilitation and restoration and prepare an Action Plan based on study results*					

**Justification for the action:** Prioritization of areas for rehabilitation and restoration is lacking at a national scale. At present no areas or key ecosystems have been prioritized or identified for rehabilitation and restoration. Therefore, identification of the most vital ecosystems on a priority basis for restoration is required to avoid haphazard restoration interventions for optimizing the benefits and returns on the investments.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Undertake studies coupled with climate change modeling to identify and prioritize critical areas for rehabilitation and restoration and prepare an action plan based on study*.	V: High	Forest/Wildlife Dept/ Climate Change Secretariat of M/E M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental organizations	Phased study : 1 – 3 years	Domestic & international US\$ 2,000,000	- One comprehensive study completed in 3 years. - One set of modeling data produced and maps prepared within 3 years.
<b>Measure/Action 5:</b> Publish in local languages the best practices for ecosystem specific rehabilitation and restoration methods, promote research on technologies and disseminate research findings.					
<b>Justification for the action:</b> Capacity constraint to implement ecosystem specific and technically sound rehabilitation and restoration methods/ technologies is another major hindrance to rehabilitation and restoration. Access to technical information and best practices is limited.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i) Publish in local languages and disseminate the best practices for ecosystem specific rehabilitation and restoration methods.	High	Forest/Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental org)	1- 4 years	Domestic & international US\$ 250,000	- A minimum of 1 publication produced in 2 years. - A minimum of 10 best practices adopted within 5 years.
(ii) Undertake research studies on ecosystem specific technologies* .	Medium	Forest/Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental org)	1- 4 years	Domestic & international US\$ 760,000	- 2-3 research grants awarded annually and studies successfully completed
(iii). Demonstration plots/pilot studies.*	High	High Universities Environmental organizations Local communities	1 – 8 years	Domestic & international US\$ 1,200,000	- A minimum of 10 Pilot studies undertaken over a 5 year period.
<b>Measure/Action 6:</b> Facilitate knowledge exchange and sharing including local knowledge and from other countries through joint programs.					
<b>Justification for the action:</b> Inadequate working modalities for knowledge sharing on best practices from other countries. Other tropical countries have various innovative rehabilitation and restoration practices that can be adapted to the Sri Lankan context and learning on these practices will be important for biodiversity related climate change adaptation in the country.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Facilitate knowledge sharing through joint programs.	Medium	Forest/ Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental organizations Foreign collaboration)	0.5 – 1 year Annual exchange programmes (10 years)	Domestic and international US\$ 500,000	- A minimum of 1 exchange visit undertaken per year over a 10 year period. - A minimum of 5 personnel trained a year over a 10 year period.
<b>Measure/Action 7:</b> Create awareness of all stakeholders including the political leadership, administrator etc. on specific sites prioritized for rehabilitation and restoration.					
<b>Justification for the action:</b> Competing interests, pressure for lands for development and other non-conservation uses is a barrier for effective rehabilitation and restoration, as hard development activities often take a priority over “soft” development approaches. Often decision and policy makers lack adequate awareness on the importance of protecting ecosystem and services provided by them.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Implement site specific awareness programs for the political leadership and other relevant stakeholders on the areas prioritized for rehabilitation and restoration* .	High	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD	0.5 – 2 years Annually thereafter	Domestic and international US\$ 275,000	- Annually a minimum of 50 decision makers exposed to awareness creation events.

<b>Measure/Action 8:</b> Effective implementation of existing policies and legislation relating to land tenure in areas earmarked for restoration*					
<b>Justification for the action:</b> There is no clarity regarding land tenural rights of restored state land, if carried out by a private party. Therefore a clear policy on the 'ownership', benefits and rights need to be established to encourage those private parties having interest in undertaking restoration interventions.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i). Implementation of existing policies and legislation relating to land tenure rights*.	High	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD Police Department	0.5-1year on wards	Domestic and international US\$ 875,000	- One Strategy prepared within 6 months Number of issues addressed annually.
(ii). Gap analysis on existing legislation, and legal reforms as required.					
<b>Measure/Action 9:</b> Building partnerships between government and non-state institutions.					
<b>Justification for the action:</b> Partnership arrangements for rehabilitation and restoration and management of lands outside protected areas are non-existent. Often state agencies lack adequate resources to carry out rehabilitation and restoration effectively. Therefore working with non-state parties would be beneficial and could result in successful restoration programs.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(1). Build partnerships between government institutions/private sector.	Medium	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD Private sector (implementation) Environmental organizations	0.5 year – continuous	Domestic and international US\$ 35,000	- At least 10 successful and sustainable partnership arrangements established over a five year period.
<b>Total cost for Technology 1</b>				<b>.#Approx. US \$ 7.5 million for 10 years</b>	

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department

**Proposed Action Plan for Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)**

<p><b>Measure/Action 1:</b> Apportion part of annual budgets of Forest and Wildlife Departments for connectivity based on an action plan. *</p> <p><b>Justification for the action:</b> The key government departments mandated with the responsibility of managing the environment and biodiversity in the country do not have sufficient financing for this activity provided through their nationally allocated budgets. Improving connectivity being a high priority intervention for biodiversity adaptation to climate change, unavailability of funds on a prioritized basis will be a major hindrance for the success of the Technology.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i) Allocate sufficient funds from annual budgets to implement the action plans prepared on priority needs* (ii) Seek external funds*	V. High	Forest/Wildlife Dept M/ Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0.5 – 1 year and thereafter annually	Domestic No additional cost (4.5%, approx. US\$ 675,000 annually).	- A minimum of 2-5% of the annual budgets allocated for this activity within 3 years
<p><b>Measure/Action 2:</b> Provide incentives for private landowners to reserve or maintain areas required for improving connectivity*.</p> <p><b>Justification for the action:</b> No incentives are available for protecting isolated forest patches/ecosystems found in private lands and it is considered a major constraint for the success of this activity. The landscape/ecosystem approach to conservation plays a major role in improving connectivity. There are considerable extents of private land/leased land situated adjacent to protected areas which could serve as corridor for ensuring connectivity. In the absence of any incentive scheme to promote conservation of such private forests and other ecosystems, these lands remain vulnerable to conversion into other land uses.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Provide incentives for private landowners to reserve or maintain areas required for connectivity*	V. High	Forest/Wildlife Dept M/ Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	0.5 – 2 year on wards	Domestic & international US\$ 1,020,000	- A minimum of 500 beneficiaries a year and up to US\$ 100,000 worth of incentives disbursed annually.

<p><b>Measure/Action 3:</b> Integrate provisions into the policies and legal instruments to make it mandatory for medium and large development projects to reserve areas to maintain connectivity.</p> <p><b>Justification for the action:</b> At present no provisions exist to ensure that large development projects reserve areas to allow for connectivity. The landscape/ecosystem approach to conservation places a major importance on connectivity including areas outside protected areas.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Policy and legislative revisions to provide for the medium to large development projects reserve areas that allow for connectivity.	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 – 2 years thereafter continuous	Domestic & international US\$ 20,000	- New provisions incorporated in 6-12 months.
<p><b>Measure/Action 4:</b> Create awareness among the political leadership on site specific environmental valuations for those areas prioritized for interventions.</p> <p><b>Justification for the action:</b> In order to encourage the private landowners get involved in connectivity related activities, an enabling policy environment need to be created with political patronage. Further, site-specific evaluation and prioritization is essential to ensure that the most important sites are connected first, and it would also help when prioritizing conservation vis a vis development.</p>					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Awareness creation for the political leadership on specific areas prioritized for interventions*.	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 – 2 years annual	Domestic & international US\$ 275,000	- Participation of up to 50 decision makers annually in awareness programs.
<p><b>Measure/Action 5:</b> Identify using climate change modeling the critical areas to be connected and prioritize the areas for intervention* .</p> <p><b>Justification for the action:</b> Identification and prioritization of critical areas for connectivity has not taken place at national scale and it remains a major barrier for biodiversity adaptation. Although, some attempts have been made towards conservation, rehabilitation and restoration of small patches of forests, these actions often takes without a holistic approach towards conservation..</p>					



Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Identify and prioritize using climate change modeling the critical areas to be connected*.	V. High	Forest/Wildlife Dept, Climate Change Secretariat of M/E M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 3 years Implementation continuous	Domestic & international US \$ 1,850,000	- One comprehensive study completed in 3 years and up to 4 critical areas included into protected area network.
<b>Measure/Action 6:</b> Effective management of protected areas including law enforcement together with increasing the level of protection where appropriate.					
<b>Justification for the action:</b> High altitudinal areas are considered critically important for migration and dispersal of biodiversity during climatic changes. Currently there are adequate policies and laws that provide protection to critical areas including montane areas. However the lack of effective enforcement has led to degradation due to inappropriate land use practices. Integration of the critical montane areas within the national protected area system and upgrading the protected area category where appropriate to ensure high degree of legal protection and more effective management will be vital for the conservation of these areas.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Actions to prevent illegal activities and management of the critical areas based on management plan prescriptions including raising protection level as appropriate.	V. High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	Domestic & international US\$ 1.5 million	- Number of illicit activities detected and legal actions taken annually and percentage of management prescriptions implemented.
<b>Measure/Action 7:</b> Integrate the concept of Landscape level planning for protected area management.					
<b>Justification for the action:</b> Matrix/landscape level planning of conservation is not properly carried out and enabling policies and legislation for mandatory matrix level planning/conservation is lacking. Therefore landscape level planning for conservation, special management and implementation need to be integrated into Forest and Wildlife Department management planning process. It is also important to explore integration of Forest and Wildlife Department management plans of adjacent protected areas.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). integrate landscape level planning for conservation and special management into Forest and Wildlife Department management plans.	Medium	Forest/Wildlife Dept, CEA, M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	Domestic & international US\$ 250,000	Number of protected areas included in landscape planning annually. .
(ii). Include elements of climate change consideration in the EIA process and draft the TOR accordingly					
<b>Measure/Action 8:</b> Carry out environmental valuation and identify benefits of connectivity, publicize results including awareness creation and communication.					
<b>Justification for the action:</b> No scientific studies have been undertaken to assess the values and benefits of connectivity. Effective and innovative communication and awareness of results of such assessments will be crucial for decision making at all levels.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Carry out area specific valuation and identify benefits of connectivity, publicize results including awareness creation and communication.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	2 – 5 years	Domestic & international US\$ 500,000	- Up to 10 studies carried out within 3 years - Up to 1000 information dossiers based on the valuations published by year 4.
<b>Measure/Action 9:</b> Policy harmonization					
<b>Justification for the action:</b> There is ambiguity in the definition of the term “Unutilized” when such “unutilized land” are taken over for government purposes as the legal definition includes patches of natural ecosystems vital for connectivity as well. In order to address this ambiguity, policy harmonization including re-defining the term needs to be undertaken.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Review of relevant policies and re-defining the term 'unutilized'.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD Environmental organizations	0 – 1 year	Domestic & international US\$ 20,000	- Policy gap analysis completed within 6 months followed by policy harmonization exercise including re-definition of the term "Unutilized". .
<b>Measure/Action 10:</b> Amend procedures to expedite land acquisition process.					
<b>Justification for the action:</b> Currently unprecedented procedural delays take place when acquiring lands for public purposes including conservation. Therefore, the existing procedure needs to be reviewed to identify the causes for such delays and introduce required amendments to expedite the process to avoid continued degradation of the areas requiring urgent attention.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Undertake a comprehensive review of the existing land acquisition process and amend the procedure to enable expediting land acquisitions.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	Domestic US\$ 30,000		Amend the relevant legislation in 2 years.
<b>Measure/Action 11:</b> Create awareness and build capacity to promote co-existence with biodiversity.					
<b>Justification for the action:</b> Often communities lack awareness on sharing habitats with biodiversity including critical species and an enabling policy & legal environment for benefit sharing is non-existent. In many areas where communities living adjacent to the protected areas have conflicts with certain species of biodiversity such as elephants, wild boar etc. which ultimately contribute to negative public attitudes towards conservation.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Create awareness, build capacity and provide material to promote coexisting with biodiversity.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	2 – 10 years	Domestic & international US \$ 275,000	- Annually ten awareness/capacity building programs conducted with at least 50 participants in each event. - Up to 5 successful case studies conducted annually.
<b>Total Cost for Technology 2</b>					<b>#Approx. US \$ 6.75 million for 10 years</b>

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; CEA – Central Environmental Authority

**Proposed Action Plan for Improving management, and increasing the extent of protected areas, buffer zones and creating new areas in vulnerable zones.**

<b>Measure/Action 1:</b> Apportion part of the annual budgets of Forest and Wildlife Departments for the technology implementation based on an agreed action plan*					
<b>Justification for the action:</b> Currently the main departments involved with management of the environment and biodiversity in the country do not have adequate financial provisions for this activity in their nationally allocated budgets.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Apportion part of the annual budgets of Forest and Wildlife Departments for this technology based on agreed action plans and also explore external funds*.	V. High	Forest/Wildlife Dept,	1 – 10 years	Domestic No additional cost.	2-5% of the annual budget allocated within 3 years.
<b>Measure/Action 2 and 3:</b> Allocation of resources for implementation of existing management plans and prepare and implement management plans for those areas not covered by such plans.					
<b>Justification for the action:</b> The non-implementation of management plans due to lack of resources, finances in particular, is a major constraint to effective protected area management. Further, some protected areas are not covered by management plans.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Implement existing management plans with on-course revisions as appropriate. (ii) Prepare and implement new management plans for other areas.	V. High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	Domestic & international US\$ 1,600,000	Management Plans implemented as per the management prescriptions, Up to five management plans produced annually.
<b>Measure/Action 4:</b> Introduce enabling policies to discourage conversion of natural ecosystems for development projects and provide incentives for using brown field/degraded areas* for such economic ventures.					
<b>Justification for the action:</b> Lands from the protected areas are in demand for medium/large economic development projects, instead of utilizing lands outside the PA network which are already degraded.. Utilizing already cleared lands may require rehabilitation and therefore investors should be offered these lands by providing them with incentives such as tax concessions, cash payments, subsidies etc.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Introduce Incentive programs for using brownfield/degraded areas for economic development ventures*.  (ii). Identify and map brownfield degraded areas that can be used for development.	V. High	Forest/Wildlife Dept, M/Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 -3 year	Domestic & international US\$ 1,000,000	- One incentive mechanism introduced within one year with 500 beneficiaries a year - Annually 2-5 brownfields/degraded areas put into utilization.
(iii). Develop enabling policies to discourage conversion of natural ecosystems for non-conservation activities.	V. High	Forest/Wildlife Dept, M/Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 -3 year	Domestic & international US\$ 10,000	- Policy reviews completed within 6 months and enabling provisions incorporated within 2 years.
<b>Measure/Action 5:</b> Upgrade the protection status of proposed and declared protected areas to higher levels as appropriate and include new areas into the PA network.					
<b>Justification for the action:</b> Continued demand for lands for development purposes is a major hindrance to protected area expansion. Often forested areas, which have been earmarked for declaring as protected areas are utilized for development purposes whereas already degraded areas suitable for such purposes exist outside the PA network. Therefore areas earmarked for protection need to be upgraded to higher levels of protection as soon as possible to ensure such areas no longer be used for development.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Upgrade the Proposed Reserves and already declared protected areas as deemed appropriate to a higher level of protection.	V. High	Forest Department, Wildlife Department, M/Environment; CEA	0 – 4 years	Domestic US\$ 10,000	Conservation status of up to 2-5 protected areas upgraded annually through gazette notifications.
<b>Measure/Action 6:</b> Encouraging non-conflicting land use practices through incentives* and enforcement of buffer zone legislation*					

<b>Justification for the action:</b> Conflicting land use practices in buffer zone sometimes result in damages to the protected area, defeating its sole purpose of buffering the protected area from threats. There are several land uses that can be compatible with protected areas, and provide a shield from threats. Sometimes it's not the land use per se, but the methods and manner in which the land is used causes the impacts on the protected area (eg: intensive farming vs organic farming). Therefore encouraging non-conflicting/non-degrading land use practices through appropriate incentives would be effective in ensuring that the buffer zone provides a shield for the protected area.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Encourage non-conflicting land use practices through incentives*.	High	Relevant Ministry Department Private sector	3 - 4 years	Domestic & international Cost based on the incentive mechanism.	An incentive mechanism developed and institutionalized within 12 months.
(ii). Effective enforcement of buffer zone legislation*.		Forest/Wildlife Dept, CCD		Domestic & international US\$ 610,000	An inventory of priority areas prepared in 6 months followed by boundary demarcation of 2 Pas annually and records of legal actions.
<b>Measure/Action 7:</b> Recruiting personnel with biodiversity and climate change adaptation competence and capacity building programs for existing staff					
<b>Justification for the action:</b> Inadequacy of technical capacity of the respective departments and their staff, especially field staff is a major constraint for effective protected area management. Performance based evaluations which appears to be lacking in State institutions, combined with rewarding the outstanding performers would be an incentive for effective performance of assigned tasks.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(I). Recruit personnel having competency in biodiversity conservation and climate change adaptation and provide appropriate capacity building opportunities for existing staff.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1-10 years	Domestic & international US\$ 2,500	Appropriate recruitment policy/criteria developed within 6 months.
<b>Measure 8</b> - Institutionalize a mechanism to ensure staff accountability.					
<b>Justification for the action:</b> Sub-optimal performance of respective departments and their staff, the field staff in particular, is a major constraint for effective protected area management. However, by developing mechanisms to ensure staff accountability together with a program for rewarding the outstanding performers through performance based evaluations would lead to effective PA management.					



Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Develop a mechanism to ensure accountability by incorporating elements of performance based evaluations with incentives . .	Medium	Forest/Wildlife Dept, M/Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	1-10 years	Domestic US\$ 20,000	Number of annual evaluations conducted.
<b>Measure/Action 9:</b> Develop enabling policies and institutional arrangements for effective inter-agency co-ordinations.					
<b>Justification for the action:</b> Inadequate inter agency coordination in managing adjacent protected areas by different authorities renders inefficient conservation. Often the legally declared protected boundaries do not follow the natural boundaries of such ecosystems, thus bisecting the an ecosystem by the administrative boundaries of the respective management authority (ie. Forest and Wildlife Department manage). Hence collaborative management of such areas will ensure more effective management and monitoring.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Institutionalize enabling policies and mechanisms to ensure Forest, Wildlife and other relevant departments work in collaboration.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	No cost involved	- Policy/strategy to promote partnerships formulated within 6 months and 2-5 collaborative projects undertaken annually.
<b>Measure/Action 10:</b> Prioritize areas and undertake biodiversity assessments accordingly* .					
<b>Justification for the action:</b> Unavailability of adequate ecological information for the protected areas is a major hindrance for effective conservation. Ecological information such as species inventories, status of threat, populations, niches, ecosystems, threats etc are critical parameters for designing appropriate management interventions.					



Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Identify and prioritize areas for biodiversity assessments* and undertake studies based on the priorities.	High	Forest/Wildlife Dept, M/Fisheries and Aquatic Resources Dev, NARA and CCD Universities Environmental org.	1 – 10 years	Domestic & international US\$ 255,000	An inventory prepared in 3 months and undertake 2-3 studies/assessments annually.
<b>Measure/Action 11:</b> Amend and implement buffer zone legislation*					
<b>Justification for the action:</b> Protected Area buffer zones are not legally defined and demarcated. Even though the National Environmental Act refers to buffer zones within a certain distance from the PA boundary, such buffer zones lack physical demarcations and most activities are permissible in such areas with or without EIAs. Further, not all protected areas have such a buffer zone. Therefore a review and reforms to the existing legislature is imperative for effective buffer zone management.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Amend and implement buffer zone legislation*	High	Forest/Wildlife Dept, CCD	1 – 10 years	Domestic & international US\$500,000	Legal review report produced in 6 months and legal amendments introduced within 2 years.
<b>Measure/Action 12:</b> Physical demarcation of protected area boundaries and buffer zones* and effective enforcement of boundary regulations including removing encroachments etc.* & create awareness on boundaries*					
<b>Justification for the action:</b> Inadequate physical demarcation of protected area and buffer zone boundaries has contributed to multifaceted management issues such as encroachment, clearing and other violations. Therefore, it is important to physically demarcate these boundaries by fixing boundary markers to avoid boundary disputes together with effective law enforcement.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i) Physical demarcation of protected area boundaries and buffer zones*	High	Forest/Wildlife Dept, CCD	2-10 years	Domestic & international US\$ 1,000,000	An inventory of prioritized areas for boundary demarcation prepared within 3 months and boundary demarcation of 50% of the prioritized PAs completed within 3 years.
(ii) Effective law enforcement on boundaries including removal of encroachments etc. *	V. High	Forest/Wildlife Dept, CCD Police Department	1-10 years	Domestic & international US\$ 750,000	An inventory of encroachments completed within 3 months and 75% of detected encroachments removed.
(iii) Create awareness on boundaries*	Medium	Forest/Wildlife Dept, CCD Local/Provincial level Authorities Environmental org	2-10 years	Domestic & international US\$ 100,000 US\$ 750,000	Up to 2-5 awareness programs conducted annually with 25-50 participants.
<b>Measure/Action 13:</b> Awareness creation, capacity building and promote coexistence with biodiversity through facilitation*.					
<b>Justification for the action:</b> As the communities living adjacent to the PAs often have conflicts with animal species such as elephants, wild boar etc sometimes contributing to negative attitudes towards conservation, there is a need to create community awareness to promote coexistence with biodiversity in such areas. adjacent to high value ecosystems and protected areas. Community involvement in conservation is imperative for its success. Pockets of important habitats, key tree species etc, and home gardens are critical for ensuring connectivity. Therefore, capacity building and providing support to facilitate the co-existence will also be equally important.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Awareness creation, capacity building and facilitation of coexistence with biodiversity.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD, Environmental org.	1-10 years	Domestic & international US\$275,000	An Action Plan prepared within 6 months, over 80% of the awareness programs completed annually and up to 2 – 5 case studies completed annually.

<b>Measure/Action 14:</b> Introduce enabling legislation to promote community owned protected areas and provide incentives for such activities*					
<b>Justification for the action:</b> No legal provisions are currently available for communities to own and manage 'protected areas' outside the declared PA system. Therefore, introduction of enabling legal environment for managing such areas while ensuring usufruct rights will be beneficial, especially where there are intact or good quality ecosystems outside the PA network..					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Introduce enabling legal provisions for community owned protected areas and provide incentives to endure effective management of such properties*.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, CCD Environmental organizations.	Year 1 Continuous implementation	Domestic & international	Legal analysis report prepared within 3 months and relevant legal provisions introduced within 6 – 12
<b>Total cost for Technology 3</b>				<b>.#Approx. US\$ 6.75 million for 10 years</b>	

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; CEA – Central Environmental Authority

**Proposed Action Plan for Focus conservation resources and special management for restricted range, highly threatened species and ecosystems**

<b>Measure/Action 1:</b> Apportion part of the annual budgets of Forest and Wildlife Departments for the technology implementation based on an agreed action plan*.					
<b>Justification for the action:</b> Currently the main departments involved with management of the environment and biodiversity in the country do not have adequate financial provisions for this activity in their nationally allocated budgets.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i). Apportion part of the annual budgets of Forest and Wildlife Departments for this technology based on the action plans and explore external support as appropriate.	V. High	Forest/Wildlife Dept, M/Environment	Year 3 Annually	Domestic No additional funding involved (5%, approx. US\$ 750,000 annually)	Up to 2-5% of budget allocated for the technology after 1 year.
<b>Measure/Action 2:</b> Develop and implement species/habitat action plans based on priorities.					
<b>Justification for the action:</b> There is a dearth of conservation action plans for highly threatened species and habitats. Although certain landscapes and ecosystems are protected, it appears to be insufficient to conserve certain highly threatened species and habitats. Therefore, based on the information provided in the IUCN Red List, a comprehensive study is necessary to understand the existing and potential future threats, and prepare Action Plans accordingly.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i). Develop and implement species and habitat action plans based on priority.	V. High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD, Disaster Management Center	2-5 years	Domestic and international 1,750,000	Comprehensive species and habitat Action Plans prepared within 2 years. Species population and extent & quality of critical habitats increased by 10% in 5 years. A minimum of one strategy for disaster response prepared annually.
(ii) Introduce mechanism to incorporate disaster response such as rescue & relocation strategies and establishment of a Contingent Fund for biodiversity conservation.					
<b>Measure/Action 3:</b> Information generation through climate modeling for determining potential climate change impacts on species and ecosystems.*					

<b>Justification for the action:</b> Information available on potential climate change impacts on species/ecosystems is inadequate. A preliminary GIS mapping exercise carried out based on available species data and broad climate predictions has only drawn broad conclusions. Detailed and localized information at a fine scale is required to get accurate predictions on how species will be impacted by climate change. This information would be useful for modeling to enable developing climate change adaptation strategies for the specific species and ecosystems.						
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
(i). Undertake actions to generate essential information and climate modeling for determining potential climate change impacts on species and ecosystems.*	V. High	Forest/Wildlife Dept, M/Environment NARA and CCD Universities Environmental organizations	1 – 3 years	Domestic and international US\$ 500,000	Comprehensive study completed and modeling data, such as maps etc available within 3 years.	
<b>Measure/Action 4:</b> Provide legal protection to sites where point endemics are found and introduce incentives and alternative lands as appropriate for protecting critical areas found outside the already protected areas*. Take actions to ensure inter-agency coordination for protection of point endemics and make recommendation to incorporate climate change and species related considerations into legislation.						
<b>Justification for the action:</b> - Not all sites of point endemic species are protected. Currently there are certain point endemic species that do not fall within the existing PA Network. Although the species are provided with adequate protection, some critical ecosystems and sites are not protected thereby exposing to high level of threat through non conservation related activities.						
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>	
(i). Introduce enabling legislations to accord adequate protection to the sites where point endemics are found.	Medium	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Dev, CCD	1-4 years	Domestic and international US\$ 760,000	Gap analysis and prioritization of locations completed within 6 months. Appropriate legal protection provided for at least 1 area annually.	
(ii). Integrate climate change and species related considerations into legislation.						
(iii). Provide incentives and alternative livelihoods for protecting sites outside the PA Network*.	High	Forest Dept, Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Dev, CCD	1-4 years	Domestic and international US\$ 1,500,000	Annually 2-5 alternative livelihoods introduced and up to 500 beneficiaries annually.	

(iv). Ensure effective inter-agency coordination for protection of point endemics.	High	Forest Dept, Wildlife Dept CCD	3-10 years	Domestic and international US \$ 600,000	Enabling policy and strategies formulated within 6 months. And 5-10 coordination meetings held annually.
(v). Identify and take actions to integrate appropriate climate change and species related considerations into the existing policy and legal instruments.		Individual experts, Conservation oriented NGOs M/Environment	years	Domestic US\$ 5,000	
<b>Measure/Action 5:</b> Establish effective partnerships between government line agencies, Universities, NGOs and species specialists etc for species conservation.					
<b>Justification for the action:</b> The Department of Wildlife Conservation being the prime government agency legally mandated for conservation of species has hitherto established limited partnerships for species conservation despite the availability of numerous researchers and institutions working on biodiversity conservation, and species focused research. Forming formal partnerships with these specialists will facilitate carrying out appropriate conservation related research and preparation of action plans & strategies for species requiring urgent attention.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Establish effective partnerships between respective government agencies, Universities, NGOs, species specialists etc for species conservation.	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD Environmental organizations Species specialists	3 years & Continuous		Up to 10 partnerships established within 2-5 years with proven sustainability of such partnerships.
<b>Measure/Action 6:</b> Carry out ecological surveys, research studies and capacity building through co-opting external expertise as appropriate.					
<b>Justification for the action:</b> Availability of information on threatened species in terms of distribution, population size and genetics which is vital for preparing management plans and strategies for their long-term conservation is inadequate. This information will also be essential for climate change modeling as it provides an indication of possible migration/dispersal and other potential changes.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators

(i). Undertake extensive ecological surveys and research through soliciting external expertise.	Medium	Universities Environmental org Species specialists Forest/Wildlife Dept, NARA and CCD	Year 2	Domestic and international US\$ 800,000	Up to 2-5 studies and capacity building workshops with 5- 50 stakeholders participating completed annually.
<b>Measure/Action 7:</b> Awareness creation on point endemics, critically endangered species, importance of their conservation and introduce mechanisms for voluntary conservation actions.					
<b>Justification for the action:</b> The level of awareness by both the general public and policy-makers on the importance of point endemics, and other threatened species, their ecological & biological significance, and potential threats to their survival is poor.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i) Conduct general public awareness programs on point endemics and critically endangered species, and the importance of their conservation.	Medium	Forest/Wildlife Dept, ,NARA and CCD Universities Environmental org	Annual from year 3	Domestic and international US \$250,000	2-5 awareness workshops conducted annually with 25- 50 stakeholders
(ii).Conduct awareness for specific target groups such as the government sector for policy makers, school children etc.*	High	Forest/Wildlife Dept, , NARA and CCD Universities Environmental org	Annual from year 4	Domestic and international US\$250,000	2-5 awareness workshops conducted annually with 25-50 stakeholders.
(iii) Introduce appropriate mechanisms to reinforce voluntary conservation initiatives*.	Medium	Environmental org Local communities Forest Dept, Wildlife DeptCCD Private sector	Year 2	Domestic and international US\$300,000	Develop and institutionalize appropriate Incentive mechanism in 1 year.
<b>Measure/Action 8:</b> Review and reform the existing administrative process for granting approvals for research work by individuals and non-state sector institutions*					
<b>Justification for the action:</b> The existing administrative process for granting approvals for conducting research by individuals and non-state sector institutions is unjustifiably long and discouraging. Such undue delays often adversely impact upon seasonal research activities. Therefore, reviewing the procedure for expeditious decision making while ensuring that the essential administrative requirements are complied with is essential to encourage research activities.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators



(i). Review and reform appropriately the process for granting approval for research by individuals and non-state sector institutions* (ii) Create adequate awareness on the reformulated process.	High	Forest/Wildlife Dept, NARA and CCD	Year 1	Domestic and international US\$ 25,000	Reformulated mechanism introduced within a year to reduce the time period by 25% .
<b>Measure/Action 9:</b> Research to identify habitats for species migration and initiate conservation measures for such habitats*					
<b>Justification for the action:</b> Focused research on habitats for species migration is inadequate. With the effects of climate change, the species will tend to migrate into more favorable ecosystems and there will also be a tendency for altitudinal migration. Climate change modeling would enable identifying such potential sites of future migration. Information thus generated would be useful to identify potential sites of migration and their suitability for species migration/dispersal.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i). Undertake research to identify habitats for species migration and actions for conservation of such habitats*	V. High	Universities Environmental org. Forest/Wildlife Dept, NARA and CCD	Year 4	Domestic and international US\$500,000	An inventory of research priorities developed within 3 months and annually 2-5 research studies completed based on the priorities and initiate interventions.
<b>Measure/Action 10:</b> Institutional capacity building through providing specialized knowledge for conservation and monitoring of threatened species/ ecosystems.*					
<b>Justification for the action:</b> Knowledge and skills within the relevant authorities for species management is poor. Insufficient knowledge is a major hindrance for appreciating the need for species conservation and for species focused conservation.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i). Institutional capacity building and specialized training for staff of respective government agencies . *	V. High	Forest/Wildlife Dept, NARA and CCD (Environmental org.)	Year 2	Domestic and international US\$275,000	2-5 Capacity building training sessions conducted annually with 25-50 stakeholders participating.
<b>Total cost for the Technology 4</b>				<b>.#Approx. US\$ 7.5 million for 10 years</b>	

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; NGOs – Non-governmental Organizations



### Proposed Action Plan for Ex-situ conservation for highly threatened species and possible reintroduction

<b>Measure/Action 1:</b> Apportion a part of annual budgets of the relevant agencies for setting up ex-situ conservation facilities.					
<b>Justification for the action:</b> The main State sector agencies dealing with environment management and biodiversity conservation do not receive adequate financial provisions through their nationally allocated budgets for this activity. It is a major hindrance for ex-situ conservation, which is considered a high priority for biodiversity adaptation to climate change.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Set aside a portion of annual budgets of Forest and Wildlife Departments for this technology based on agreed action plans and explore external assistance as appropriate.	V. High	Wildlife Dept, Dept of National Zoological Gardens, PlantGenetic Resource Centre, National Botanic Gardens , NARA	Year 2	Domestic No additional funds required	Up to 2-5% of annual budgets allocated for the technology within 3 years.
<b>Measure/Action 2:</b> Identify and prioritize ex-situ conservation facilities including financing requirements..					
<b>Justification for the action:</b> Proper planning and funding for ex-situ conservation is lacking. A framework and a protocol for reintroduction and monitoring is absent. Ex-situ conservation is usually considered a last resort for conservation.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i).Identify and prioritize ex-situ conservation facilities that are required including required finances. .	V. High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	2 – 3 years	Domestic and international 2,000,000	An inventory of priorities prepared in in 6 months and 2-5 facilities established annually for 3 years based on the requirements.
<b>Measure/Action 3:</b> Introduce a framework/protocol for reintroduction/translocation and monitoring of species.					
<b>Justification for the action:</b> A framework or protocol for captive breeding, reintroduction, monitoring etc, is absent.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Develop and institutionalize a framework/protocol for reintroduction/translocation and monitoring of species.	High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	2 – 3 years	Domestic and international US \$ 250,000	Protocol developed and institutionalize within years.
<b>Measure/Action 4:</b> Capacity building for ex-situ conservation* including partnerships with species specialists, exchanges and knowledge and resources sharing.					
<b>Justification for the action:</b> Required expertise and resources such as suitable land, specialized locations, standard protocols etc to carry out ex-situ conservation is lacking. Additionally it is vital to have standard protocols and procedures to carry out ex-situ conservation in the country.					
Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US \$) & Funding Source	Indicators
(i). Institutional capacity building for ex-situ conservation*	High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA (Universities Environmental org)	Year 3, thereafter annually	Domestic and international US\$ 500,000	Up to 2-5 Capacity building workshops conducted annually attending 25-50 stakeholders in each session.
(ii). Establish partnerships with species specialists and facilitate exchange and knowledge sharing.	High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA, (Universities Environmental org. Species specialists)	Years 1-2	Domestic and international US\$ 150,000	Up to 10 partnerships formed within 2-5 years with 50% long term sustainability.
(iii). Identification of required resources.	V. High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 3	Domestic and international US\$ 1,000,000	Prioritized inventory of resources required compiled within 6 months.

(iv). Formulate standard protocols for ex-situ conservation including maintenance of facilities, disease control, quarantine etc.	High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA, (Universities Environmental org)	Year 3-4	Domestic and international US\$ 175,000	Standard protocols prepared within 12 months and annual monitoring of implementation.
<b>Measure/Action 5:</b> Accord the due priority for ex-situ conservation through awareness creation.					
<b>Justification for the action:</b> Ex-situ conservation of wild fauna is not considered a high priority in the existing conservation related policies due to the complexity and high costs associated with it. However, in view of the impending threats of climate change, due attention needs to be given for ex situ conservation as survival of some species could be entirely dependent on this activity. Adequate awareness creation on the importance of ex-situ conservation will be essential to enable catching the attention of the decision makers so that it is given due priority when allocating annual budgets and setting related national agendas.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>
(i) Create enabling environment to accord due priority for ex-situ conservation.	High	Wildlife Dept, Forest dept M/ Environment, Dept of National Zoological Gardens PGRC	Year 1-2	Domestic and international US\$ 200,000	Existing policies reformed within 6 months and 2 awareness workshops conducted annually with 25-50 participating in each session.
(ii) Awareness creation on significance of ex-situ conservation.	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 1-2	Domestic and international US\$ 150,000	Two awareness workshops conducted annually with 25-50 stakeholders participating in each.
<b>Measure/Action 6:</b> Studies including climate change modeling to identify and prioritize species for ex-situ conservation* .					
<b>Justification for the action:</b> Understanding, capacities and information available on species that may require ex-situ conservation is weak. However, under the impending climate change scenario it would be necessary to have some predictions made to identify species requiring such interventions. This will enable setting up required facilities in advance to enable interventions as and when required. Understanding on species that need ex-situ conservation will require a comprehensive analysis on current threat levels and potential climate change impacts on species already under threat.					
<b>Action /Sub Action</b>	<b>Priority Rank</b>	<b>Responsibility for Implementation</b>	<b>Time frame</b>	<b>Cost (US \$) &amp; Funding Source</b>	<b>Indicators</b>

(i). Undertake studies to identify and prioritize species for ex-situ conservation*.	V. High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA, CCS of M/E (Universities Environmental org)	Year 1-3	Domestic and international US\$ 2,000,000	A comprehensive study completed in 3 years. One set of modeling data, maps etc available within 3 years.
A comprehensive study completed in 3 years. One set of modeling data, mapsetc available within 3 years.	<b>Measure/Action 7:</b> Introduce a regulated system under the mandatory supervision by government stakeholders to allow ex-situ breeding by non state sector parties...				
<b>Justification for the action:</b> - The existing laws permit only designated government institutions to implement ex-situ conservation debaring non state and the private sector under the strict and mandatory supervision of the relevant government department may create opportunities for accessing funds, skills etc which is critical for effective ex-situ conservation.					
(i). Introduce a regulated system to allow ex-situ breeding by other parties, under the supervision of the respective government agencies.	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 2-3	Domestic and international US\$ 1,040,000	Breeding guidelines, regulations, monitoring parameters developed within 12 months and implemented under regular State monitoring and evaluation.
<b>Measure/Action 8:</b> Strict regularization of ex-situ conservation activities through effective law enforcement*					
<b>Justification for the action:</b> Although, ex-situ conservation initiatives by non state parties are rare, there are instances where small scale private zoos, parks etc have been set up by violating or with non-compliance to relevant legislation. Further, conditions of these facilities are found to be substandard. Therefore, existing laws need to be reviewed and amended and enforced as required to enable ensuring appropriate safeguards.					
(i). Enforce existing laws for improper ex-situ conservation activities*.	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 1	Domestic and international US\$ 150,000	Strategy prepared for strict law enforcement within 6 months.
<b>Total cost for Technology 5</b> <span style="float: right;"><b>#Approx. US\$ 7.5 million for 10 years</b></span>					

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; FD – Forest Department; DWLC – Department of Wildlife Conservation; PGRC – Plant Genetic Resource Centre; CCS – Climate Change Secretariat