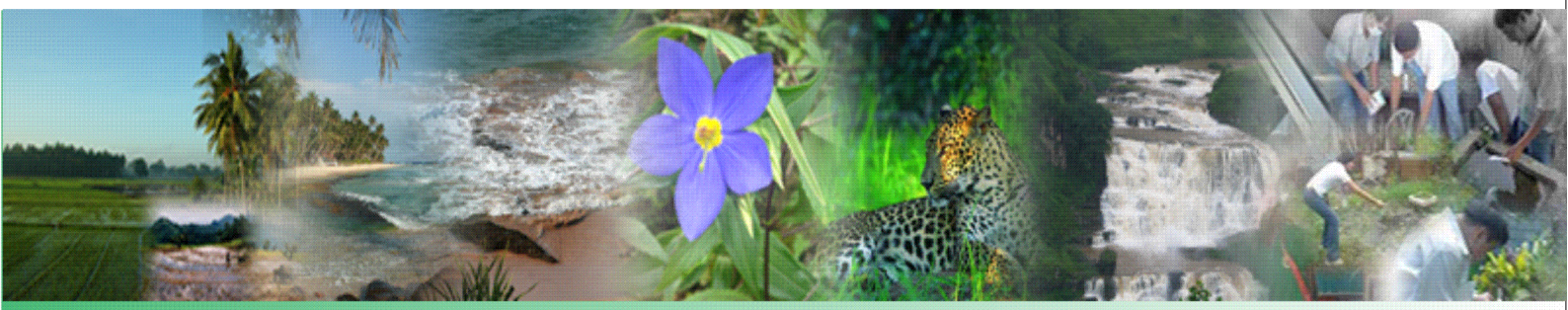
Ministry of Environment and
Renewable Energy
Sri Lanka



Technology Needs Assessment And Technology Action Plans For Climate Change Adaptation

Technology Action Plan

2012

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CLIMATE CHANGE SECRETARIAT

FORWARD

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 ˙ 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.

"*Mahinda Chinthana* – 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.

Susil Premajayantha, MP

Minster of Environment and Renewable Energy

Government of Sri Lanka

PREFACE

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 extent 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.

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

ACKNOWLEDGMENT

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 Division 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.

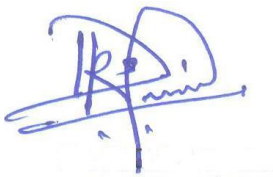
I wish to take this opportunity to express my sincere gratitude to Hon. Susil Premajayantha, Minister of Environment and Renewable Energy, Hon. Anura Priyadarshana Yapa, Former Minister of Environment, Mr. B.M.U.D. Basnayake, Secretary, Ministry of Environment and Renewable Energy and Mr. Gamini Gamage, 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. Bandaratillake, 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. Cumaranatunga (Coastal Sector), and Mr. Shamen Vidanage 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 Division 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.



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Workshop Participants	– Annex A2

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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ABBREVIATIONS

ADB	Asian Development Bank
AMCs	Aquaculture management committees
ARPAs	Agricultural Research and Production Assistants
CBF	Culture Based Fishery
CBO	Community Based Organization
CBSL	Central Bank of Sri Lanka
CCD	Coast Conservation Department
CD & PF	Crop Diversification and Precision Farming
CEA	Central Environmental Authority
CIDA	Canadian International Development Agency
CWSSP	Community Water Supply and Sanitation Project
CZMP	Coastal Zone Management Plan
DAD	Department of Agrarian Development
DC&S	Department of Census and Statistics
DOA	Department of Agriculture
DOF&ARD	Department of Fisheries & Aquatic Resource Development
DWLC	Department of Wildlife Conservation
EIA	Environmental Impact Assessment
EWS	Early Warning Systems
GCE (O.L.)	General Certificate of Examinations (Ordinary Level)
GDP	Gross domestic production
Gg	Giga gramme
GHG	Green House Gases
GIS	Geographic Information System
HFC	Hexa Fluoro Carbons
HMP	Health Master Plan
HPS	Health Policy Statement
HRH	Human Resources for Health
ICTAD	Institute of Construction Training
IFAD	International Fund for Agricultural Development
INGO	International Non-governmental Organisation
IPCC	Intergovernmental Panel for Climate Change
IRCSA	International Rainwater Catchment Systems Association
ISDR	International Strategy for Disaster Reduction
IUCN	International Union for Conservation of Nature
LRWHF	Lanka Rainwater Harvesting Forum
M&E	Monitoring and Evaluation
M/A	Ministry of Agriculture

M/De&UD	Ministry of Defense and Urban Development
M/DM	Ministry of Disaster Management
M/Env.	Ministry of Environment
M/I & WRM	Ministry of Irrigation and Water Resource Management
M/L & LD	Ministry of Land and Land Development
M/LD	Ministry of Livestock Development
M/Plantation Inds	Ministry of Plantation Industries
M/Tech&Res	Ministry of Technology and Research
M/TI&SE	Ministry of Traditional Industry & Small Enterprise Development
MCDA	Multi Criteria Decision Analysis
MEPA	Marine Environment Protection Authority
MF&ARD	Ministry of Fisheries and Aquatic Resources Development
MIS	Marketing Information System
MoH	Ministry of Health
MSL	Mean Sea Level
NAQDA	National Aquaculture Development Authority
NARA	National Aquatic Research & Development Agency
NBRO	National Building Research Organisation
NGO	Non-Governmental Organization
NRMC	Natural Resource Management Centre
NSF	National Science Foundation
NWSDB	National Water Supply & Drainage Board
O & M	Operation and Maintenance
^{o}C	Celsius
PCs	Provincial Councils
R&D	Research and Development
RH	Relative Humidity
RWH	Rooftop rainwater harvesting
SCBF	Sustainable Culture Based Fishery
SHF	Sulphur Hexa Fluorides
SLLRDC	Sri Lanka Land Reclamation and Development Corporation
SLR	Sea Level Rise
SLSI	Sri Lanka Standard Institute
SME	Small and Medium scale Enterprise
SVP	Sector Vulnerability Profile
TAP	Technology Action Plan
TNA	Technology Needs Assessment
TT & D	Technology Transfer and Diffusion
UN	United Nations
UNEP	United Nations Environmental Programme

UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WMO	World Meteorological Organization
WRB	Water Resources Board

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EXECUTIVE SUMMARY

The Technology Needs Assessment (TNA) for Climate Change in Sri Lanka was carried out from June to December 2011. The priority sectors identified for adaptation are Food, Health, Water, Coastal and Biodiversity. A list of potential technologies for each sector were identified through stakeholder consultations and prioritized by using the Multi Criteria Decision Analysis (MCDA) process. Three technologies were prioritized for each sector except for the Biodiversity sector. For the Biodiversity sector, five technologies were prioritized based on stakeholder consensus. The barrier analysis was carried out through stakeholder consultations during March to July 2012, and enabling framework was developed for each technology, in order to overcome the potential barriers to ensure success of technology transfer and diffusion. Subsequently, the Technology Action Plans (TAP) was developed for each technology.

The Technology Action Plan (TAP) report presents Action Plans for the prioritized technologies. For each technology, a description of the technology, targets, identified barriers to technology transfer and diffusion, and measures/actions recommended by detailed action plans are presented. The action plan is a concise proposal for an enabling framework for the technology, along with identification of implementing agencies, priority of the proposed measure/action, the time frame for implementation, estimated costs, potential sources of funding and indicators for the measurement of success.

Technology Action Plans for the Food Sector: Food sector which includes agriculture (Rice, Fruits & Vegetables, Other Field Crops, Sugar Cane, Tea, Coconut, Export Agricultural Crops), Livestock (Dairy, Poultry) and Fishery is considered to be one of the most vulnerable sectors to climate change impacts in Sri Lanka[1]. Changing climate and weather patterns suggest potentially severe negative impacts on food production, food security and natural resources in the country. The food sector is still the sector with the highest employment although its contribution to the national production has progressively declined during the recent years. The sector provides nearly all of the rice production which is the staple food in Sri Lanka and significant quantities of other food crops, milk and fishery produce locally consumed. The impending vagaries of climate change such as high intense, uncertain, highly variable rainfall pattern and temperature, sea level rise, combined with deterioration and dwindling of natural resources emphasize the necessity of sustainable adaptation technologies to increase the productivity, stability and resilience of production of the food sector.

The Technology Action Plan report presents a quick overview of the existing laws and policies relating to agriculture and food sector. There are a many Acts and Regulations covering many traditional aspects of the food sector such as laws pertaining to land, water, crop and animal protection, and agrarian services dating back to 1840s and updated from time to time. Food sector policies and programs in Sri Lanka were

[1] ME, 2010, Sector Vulnerability Profile: Health, Supplementary Document to: The National Climate Change Adaptation
Strategy for Sri Lanka, 2011 to 2016, Ministry of Environment, Sri Lanka.

observed to have changed with the change of the administrative regime of the country. Four existing national policies and 10 laws are presented in the report. The main focus of the policies have been on increasing food production and setting up and improving the infrastructure requirements to support that goal.

The prioritized climate change adaptation technologies for the food sector are *(1) Sustainable Inland Culture-based fisheries, (2) Sustainable land management and (3) Crop diversification and Precision Farming.* These Technologies in the food sector have been selected by giving a high weight to sustain the current levels of food supply from CC impacts, in the short to medium term. The other important consideration was the cost of the technology. Some of these technologies have been around for long periods and are less expensive to implement, but have not been fully utilized due to various operational and institutional constraints.

There are five general/common barriers having a significant potential for impacting achieving the targets in the food sector. They are: (i) Inadequate R&D Investments, (ii) Short-term and inconsistent policy outlook, (iii) Inadequate finances, (iv). Poor risk management tools, and (v) Ineffective monitoring and evaluation. Measures to overcome these general barriers are also identified and briefly described in the report.

The measures recommended to address these general/common barriers are; Set up R&D expenditures target at a level comparable to sector GDP; secure international funding for R&D; facilitate increased private sector R&D undertakings; Develop a long-term, stable, nationally-committed and realistic policy framework; Make finances available at concessional terms for long-term investments; Set up financing mechanisms for specific technology packages; Introduce incentive packages; Introduce an effective insurance scheme for high cost technologies; Extend subsidy schemes for specific technology components; Strengthen public-sector M&E institutions; Facilitate and strengthen community participation in M&E.

The enabling framework proposes 10, 11 and 10 measures/actions for diffusion of the technologies 1, 2 and 3 respectively, and sets targets and the estimated time frame for technology transfer and diffusion.

Technology Action Plans for the Health Sector: The Climate Change has both direct and indirect impacts on health of the humans. The common direct health effects are, vector, including rodent and water borne diseases, conditions associated with extremes of temperatures such as heat waves and cold spells. The effect of natural disasters and extreme weather events causes many health effects on humans of which some are immediate and effects of others become evident over time. The immediate health effects are death and injury. Late ones are disability, communicable diseases, psycho-social problems etc. On the other hand, protracted or sudden weather events indirectly affect human health through crop failure, loss of live stock, livelihoods etc.

The role of the health sector in Sri Lanka depends on the ability and capacity of the health sector personnel, aspirations and demands of the people and the vision of the government. There should be a balance between the supply and demand as the major health provider is the public sector though the private sector is rapidly growing. One other factor is the existence of other systems providing healthcare services to population other than the Allopathic Medicine. Moreover, currently the country is going through a transition period of economic growth and every sector is expanding and growing. Currently the country enjoys a better health status in the South Asian countries. But due to various known and unknown factors it is not an epoch to be complacent of the state of the health services.

The Technology Action Plan (TAP) report briefly describes the three prioritized technologies, barriers identified for the transfer and diffusion of technologies and the enabling framework recommended to overcome the barriers. The prioritized technologies for the health sector are*; (1) early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events, (2) ransfer of knowledge and skills to Health Personnel,* and *(3) technology for management of Health Care Waste.*

Five (05) general/common barriers have been identified for transfer and diffusion of all three technologies in the health sector. These are: (i) economic and financial aspects, (ii) institutional and organizational capacity, (iii) network failures, (iv) human skills, and (v) information and awareness barriers.

Measures identified to overcome general barriers are; Allocation of sufficient funds from government sources, exploration of alternative and additional funding sources; Mechanisms and development of policies conducive to successful transfer & diffusion of technologies; Assign focal points where necessary and align with existing national government structures through the focal points; Identify the administrative gaps and rectify the deficiencies with appropriate measures; Make amendments to the HRH policy facilitating utilization; Appoint a training coordinator in the Ministry of Health and establish a coordination mechanism; Develop and share an annual training plan; Training of identified and interested personnel already in the staff and pooling of staff from other sections; Identify a set of master trainers from other sectors as well; Extend information mechanisms available for disease forecasting and outbreak control to other health issues; Awareness creation for policy makers and top administrators; Strengthen the available coordination mechanisms; Identify affordable and appropriate new technologies for implementation; Make the service a closed-service and establish carrier development pathways in the service; Provide necessary financial and non-financial incentives; Create awareness using existing forums; Utilization of and mass media as much as possible.

The proposed enabling framework for the health sector identifies 6 measures/actions for diffusion of each technology, the targets and the estimated time needed for island wide diffusion of the the technologies.

Technology Action Plans for the Water Sector: During the 40 year period from 1961 to 2000, an increasing trend in annual maximum temperatures with rates up to 0.046 ^{o}C per year has been recorded at all

weather stations except at Nuwara-Eliya and Ratnapura which showed decreasing trends[2]. The potential climate change impacts on the water sector are severe droughts, floods, sea level rise etc. It has been predicted that the dry zone districts are more vulnerable to droughts and the wet zone districts to floods and landslides. Prominent change due to low rainfall will be expansion of the dry zone. Due to such droughts, surface water availability and per capita water availability will decrease. The floods due to increase in rainfall intensity will reduce ground water recharge and also would affect quality of surface water and generation and transport of sediments. Studies on the sea level rise have shown an increasing trend of sea water intrusion in certain coastal areas. As a result salinity of surface water and ground water in such areas will increase.

The prioritized technologies for the water sector are; *(1) restoration 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.*

Seven (07) general/common barriers for transfer and diffusion of all three technologies in the water sector has been identified. They are: (i). high capital cost, (ii). lack of sustainability, (iii) poor enforcement of policies/laws, (iv). lack of information and awareness, (v) no prioritized areas to implement the technology, (vi) limitations of the technology due to water pollution, (vii) lack of Research & Development.

The measures identified to address these general/common barriers are ; Obtain sufficient funds from the government and donor agencies while taking actions to solicit farmer and household contributions in terms of labor to minimize the cost; Implement and monitor operation and maintenance practices to improve sustainability; Capacity building of relevant departments/ institutes/boards; Prepare a clear policy on selection and prioritization of cascade systems/minor tanks for restoration; Formulate a National Water Policy; Strengthen involvement of agencies to implement existing policies/legal frame work; Improve operation and maintenance practices through effective awareness programs and by publishing guide lines; Capacity building of relevant departments/institutes/boards to conduct training and awareness programs; Climate change modeling for prioritizing areas; Strict enforcement of environmental laws to protect surface/ground water from pollution; Good operation and management practice; R & D to collect required data for sustainability of the technology; Availability of adequate funds for necessary R & D; Incentives for research students carrying out research projects in this field.

Proposed enabling framework identifies 9, 11 and 14 measures/actions for diffusion of the technologies 1, 2 and 3 respectively. Furthermore, proposed targets and the estimated time frame for technology transfer and diffusion for the technologies have been presented in the action plan report.

Technology Action Plans for the Coastal Sector: 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 contains a variety of terrestrial habitats, such as sandy beaches,

[2] Sri Lanka Second National Communication on Climate Change, 2012, Ministry of Environnent

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[3]. 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 issues as salt water intrusion[4]. Apart from the high 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[4]. The coastal zone accounts for about 43% of the nations GDP, so impacts on coastal settlements translate into substantial impacts on the nation's economy[5].

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.

The prioritized technologies identified for the coastal sector are: *(i) sand dune rehabilitation, (ii) restoration of mangroves and (iii) restoration of coral reefs.*

Seven (07) general/common barriers for transfer and diffusion of the technologies have been identified and they are: (i) inadequate financial assistance; (ii) inadequate government patronage; (iii) poor enforcement or lack of resource management plans; (iv) unsustainable practices /resource utilisation; (v) inadequate coordination & among different Institutions; (vi) inadequate awareness and (vii) inadequate knowledge on the technologies.

The measures proposed to overcome these general barriers are: Request for annual funding from the government; Encourage self sustaining economic activities using mangrove products; Introduce eco-friendly activities with financial gains; Conduct awareness programmes to all relevant stakeholders on importance of sustainable management of mangroves, proper enforcement of coastal zone management regulations and existing rules and regulations on coastal resources; Prepare suitable management plans for rehabilitation of mangroves; Establish community participatory organizations; Identify strategies to develop and improve fruitful collaborations; Form a committed group of catalysts selected from the coastal communities; Provide alternative sources of income or employment within the same region to those involved in destructive activities; Enforcement of strict regulations and appropriate punitive actions for violators; Develop zonal plans to identify areas requiring rehabilitation; Identify most suitable species for replanting.

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[3] Gazette extraordinary of the Democratic, Socialist Republic of Sri Lanka, 2006

[4] Jayatilake, 2008

[5] Ministry of Environment, Climate Change Vulnerability in Sri Lanka –b, 2010

The enabling framework identifies 8, 5 and 6 measures/actions for diffusion of the technologies 1, 2 and 3 respectively and the Action Plan proposes targets and the estimated time frame for technology transfer and diffusion for the technologies.

Technology Action Plans for the Biodiversity Sector: Sri Lanka is one of the most biologically diverse countries in Asia, with its biodiversity considered to be the richest per unit area in the region with regard to mammals, reptiles, amphibians, fish and flowering plants. However, the country's biodiversity is under threats due to external reasons. These threats will be no doubt is compounded with climate change impacts.

Although it is unlikely that all impacts of climate change on biodiversity are preventable, 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, therefore, be one of the most practical climate change adaptation strategies that Sri Lanka can adopt to conserve the country's natural heritage.

The Sector Vulnerability Profile (SVP) for the biodiversity sector predicts 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. 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.

The prioritized technologies for the biodiversity sector are: *(1) rehabilitation and 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 conservation resources and carryout special management for restricted range, highly threatened species and ecosystems and (5) ex-situ conservation for highly threatened species and possible reintroduction.* The action plan report presents a brief account of existing key national policies and laws with an outline of 3 existing national policies and 2 laws related to the biodiversity sector.

Nine (09) general/common barriers for diffusion and transfer of technologies have been identified and they are: (i) lack of incentives; (ii) low funding availability; (iii) lack of understanding, awareness and appreciation of value of biodiversity and ecosystems; (iv) insufficient capacity; (v) lack of information, research, climate modeling; (vi) no prioritization and use of climate models for this purpose; (vii) pressure from development/competing land use; (viii) weak law enforcement and implementation of policies; and (ix) lack of partnerships.

Measures proposed to address these general/common barriers as presented in the enabling framework are: Create incentives and remove perverse incentives for biodiversity adaptation; Recognize the need for funding at the National Planning process and allocate funds from annual budgets for adaptation; Create

understanding through effective awareness programs and innovative communication; Capacity building and resource allocation; Carry out studies, research and climate modeling to generate information; Prioritization based on needs, urgency with the use of climate models; Use planning tools such as Strategic Environmental Assessments development and conservation programs; Reduce pressure from development/competing land use by providing alternatives and encourage compatible land use activities and provide incentives to utilize abandoned/brownfield sites; Institutional strengthening for agencies responsible for implementing legal framework and policies; Recognize partnerships as effective means for implementing technologies and create effective partnerships with other government institutions, NGOs, universities and private sector to implement adaptation technologies.

Technology Action Plans for the technologies include approximately 12-20 measures/actions of which some are related or similar. Since these activities are crosscutting they can be combined with similar activities (both within this technology and under other technologies). Common activities within the sector include incentives, budget allocation, climate modeling and prioritization, research and studies, capacity building, awareness creation, and enforcement and implementation. In addition, proposed targets and the estimated timeframe required for technology transfer and diffusion for the technologies are presented in the Action Plan.

Crosscutting Issues: There are some common/crosscutting barriers and measures among those identified for the transfer and diffusion of technologies in different sectors. As such measures are advantageous for technological development, a brief discussion on cross-cutting measures are included in the Action Plan in order to explore possibilities of combining measures/actions to overcome such common and cross-cutting barriers of all five sectors. The major groups of common barriers across sectors are; (i) Inadequacy of finances, (ii) inadequate policies/laws and enforcement, (iii) lack of sustainability, (iv) inadequate information and awareness, (v) inadequacy of Research & Development and (vi) poor coordination.

The common measures thus proposed to overcome these cross cutting barriers are; (i) provide adequate funds from government & explore donor funding, (ii) review and revise existing policies and legislation and effective enforcement and develop new policies and laws as appropriate (iii) take appropriate action such as feasibility studies, operation and maintenance, encourage non-extractive uses etc. to ensure sustainability (iv) awareness creation among all relevant stakeholders, (v) carry out R & D on relevant aspects in all sectors and (vi) improve inter agency coordination .

Since these are common measures, they will have impacts on transfer and diffusion of technologies in all five sectors. Therefore, such measures/actions should be given due priority in implementation of the technology action plans.

CHAPTER 1

Technology Action Plan for the Food Sector

1.1 Actions at sectoral level

1.1.1 Short sector description:

Food sector is one of the most important sectors of the economy. Food sector in Sri Lanka comprises of 3 key sub-sectors: **(1)** agriculture (rice, fruits & vegetables, other field crops, sugar cane, tea, coconut, export agricultural crops)**, (2)** livestock (dairy, poultry), and **(3)** fishery – coastal, marine and inland.

Agriculture together with fishery and livestock sectors have a multifunctional role to play in the economy of the country. Apart from providing food, fodder and fiber, food sector significantly contributes to the Sri Lanka's socio-economic growth as well. The importance of food sector in the economy is primarily identified as a 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. Rapid growth of the food sector, particularly the domestic food production, export crop sectors, floriculture, livestock and fishery are necessary to achieve self reliance at national level and to ensure food security. It also leads to equity in the income distribution and wealth 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[6]. In Sri Lanka, among food sector's 11.2% contribution to national GDP in 2011, 79% came from crop production. In comparison, the respective contributions from livestock, and fisheries sectors were 14% and 7% respectively. The livestock and fishery sub-sectors play a vital role in the Sri Lankan economy and 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 is 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 half of the Sri Lankan population. Hence, the significant contribution made by the food sector to the economy as a determinant of economic growth and source of employment to the

[6] CBSL, 2011

nation's work force drives its climate change adaptability as critical for continued economic growth and for food security.

GHG Emissions 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 emits 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 into the atmosphere. Summary of the GHG emission contribution from the food sector for 2000 is given in Table 1.1.

Table 1.1: Summary of GHG emissions from Food Sector in Sri Lanka

Source	Emissions (Gg)					Emission Removals (Gg)
	CH_4	N_2O	CO	NO_2	CO_2	CO_2
Enteric fermentation	59.68					
Manure management	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, 2011

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.

Vulnerability to Climate Change:

Food sector productivity depends on soils, availability of water and required nutrients, climate, and energy combined with the genetic characteristics of crops, fishery and livestock. Various elements of the entire 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, pest and disease outbreaks. The food sector in Sri Lanka depends heavily on climate, and it is sensitive to climate change 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 change their population dynamics. Climate change is also contributory for lower yields from dairy cattle and 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 of mean air temperature is in the order of 0.016^{o}C per year during the period 1961 – 1990 (Premalal, 2009). The nighttime annual average temperature increase (up to a maximum of 0.02^{o}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 exposure while 139,000 ha are highly or moderately vulnerable for flood exposure due to the effects of climate change[7]. 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 since 2008 Yala to 2010/2011 Maha that 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 when compared with Yala 2008 due to delay in onset of rains in many districts and prolonged dry period.

In 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 production.

[7] Weerakoon, W.M.W., Maruyama A. & Ohba K. (2008), Impact of humidity on temperature-induced grain sterility in rice (*Oryza sativa L*), *Journal Agronomy and Crop Science* 194: 135-140.

Fishery sector is also highly vulnerable to the variability of the rain fall. It was 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. Losses of fish production and sometimes fish deaths due to pollutants and sediment accumulation resulting from floods have been observed.

It is clear that the changes in the rainfall pattern would likely 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 must endeavour to address all these concerns in an integrated manner.

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

In the absence of efforts for institutionalizing fixed-term national plans, the food sector policies and programs have often changed with the change of governments. A culture of translating policies into action programs supported by enabling legislative and other enactments is nonexistent.

Table 1.2 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 1.2: 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 Sri Lanka	2007	Agricultural land use
The National Fisheries and Aquatic Resources Policy	2006	Inland and marine fishery development
The National Livestock 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 in1977 are shown in the Table 1.3. 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 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 1.3: Agricultural Policy and Program Changes - Major Events after 1977

Year	Description
1977	Liberal market economic policies of the Government encouraged private sector participation in agricultural production, storage, marketing and processing.
1977-84	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.
1990	The Marketing Department, which involved in domestic agricultural product marketing and processing, ceased its operations.
1991	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.
1995	Shares of Regional Plantation Companies were sold to private sector and plantations were leased to the private sector for 50 years.
1996	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.
1997	Seed and planting material import restrictions were relaxed.
1998	A Private extension service was initiated as a pilot project.
1999	Privatization of Government Seed Production Centers.
1999	Private insurance companies are allowed to engage in agricultural insurance.
2000	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.
2000	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.
2003	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.
2006	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.

2007	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 and setting up and improving the infrastructure requirements to support that goal. Many Acts and Ordinances have been enacted to create an enabling operational environment (Table 1.4).

Table 1.4: 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 upon state lands
State Land Ordinance	1947	1949	Make provision for grant and disposition of state lands in Sri Lanka.; 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, 1973	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 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	1979		Matters relating to landlords and tenant

Agrarian Development Act		2000	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 repel 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.

However, 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. Some impacts that are well accepted to be affecting agriculture have not been factored in the drafting of policies. Therefore, a comprehensive assessment of existing and likely future agricultural policies is imperative to enable addressing climate change impacts effectively.

1.1.2 An overview of the prioritized technologies in the Food Sector

The food sector comprised of crop, livestock and fishery sub-sectors face a multitude of climate-change related challenges. Therefore, following technologies were identified through an extensive consultative process and prioritized using the Multi-Criteria Decision Analysis in order to introduce climate change adaptation measures into the sector.

a) Sustainable Inland Culture Based Fisheries
b) Sustainable Land Management
c) Crop Diversification & Precision Farming

These selected technology components which are less costly to implement have been in existent for long periods but have not been fully utilized due to various constraints in the operational and institutional spheres. Proven and reliable short term technologies suitable for a similar environment are available.

a) Sustainable Inland Culture-based fisheries (SCBF): The potential for Sustainable Culture-based fisheries (SCBF) lies in the extensive network of perennial and seasonal reservoirs developed in the dry zone for irrigation purposes. Sustainable Culture based fisheries is a non-competitive, complimentary resource use that permits maximization of benefits from freshwater resources and enhances food security for the practitioners and the nation as a whole. The small-sized (<100 ha) minor irrigation reservoirs that dry up for 2–3 months (July – September) of the year can be utilized for the development of sustainable culture-based fisheries which is essentially a fisheries enhancement strategy through the stocking of individuals of selected fish species. As the preferred fish species for CBF do not naturally spawn under local conditions, the reservoirs have to be stocked regularly to sustain fisheries.

b) Sustainable Land Management (SLM): Need for Sustainable Land Management (SLM) is the resultant of the intensive land use practices adopted due to high land pressure. Land degradation is one of the most serious environmental problems in the country and occurs in all agro-ecological regions at different intensities. As the land is interconnected with other natural resources such as the air, water, fauna and flora, in addition to guaranteeing food supplies, proper land management will help protecting environment and natural resources that facilitates sustainability of ecological functions and services. Although, SLM is a CC adaptation technology, it also helps in reducing GHG emission through efficient use of fertilizer, better management of farm yard manure (manure produced in farms from animal dung) combined with integrated plant nutrient management , and by increasing organic carbon content in soil.

c) Crop Diversification and Precision Farming (CD&PF): 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 serves as a buffer to increase the ability of agricultural systems to tolerate effects of rising climate variability and extreme events. Rice farming will face a severe challenge due to increased vulnerability of cultivations resulting from reduced crop diversity, threatening the food security. Climate change impacts can negate economic benefits exploited by transformation to mono-crop systems. Precision farming can complement crop diversification in securing a sustainable agricultural system. Precision farming would facilitate matching agricultural inputs and practices based on the specific requirements of crops grown in a given eco system to enable optimizing input usage while improving efficiency.

Future Targets for the Food Sector

The central theme of all plans for food sector development has been 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 produced 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 contribute to remain the policy objective.

Policy support towards achieving these targets is extended 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. Also, 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.

1.1.3 General Barriers and Proposed Measures in the Food Sector

At the aggregate level, rapid development of the food sector is confronted with several common barriers. These barriers have industry-wide impacts by failing to harness resources required for infrastructure upgrading for appropriate technological advancement or by adversely impacting the incentive structure that governs investments within the sector. Distortions introduced through such shortcomings can lead to developments that weaken climate resilience in the sector. The key general barriers to progress in agriculture sector are briefly outlined below:

(a) Barrier: Inadequate R&D Investments

Proposed Measures:

- *Set up R&D expenditures target at a level comparable to sector GDP*
- *Secure international funding for R&D*
- *Facilitate increased private R&D undertakings*

Strategic investments in the R&D infrastructure and operation are critical determinants of technological advancement in any sector. The food sector has been severely constrained by chronically inadequate investments for the R&D activities. The research infrastructure has failed to receive required finances for upgrading from the national budget with the allocations being just sufficient to meet the recurrent expenses. Historically much of the investment capital for R&D infrastructure development has been secured through development aid, either grant or loan financed projects and public-sector driven. However, for nearly two decades there have not been major infusions of donor funds into the food sector due to various reasons, thereby preventing the necessary advancements in R&D capacity and technological know-how. The overall R&D expenditure shows a declining trend and thereby low output. As a result, the capacities of the system to develop appropriate technologies that are at the same time climate-resistant remain severely constrained.

The critical importance of R&D in the promotion of selected technologies featured strongly in the Culture Based Fisheries (CBF) and Crop Diversification and Precision Farming (CD&PF). Continuous improvements in the technology components are essential for selected adaptation technologies to remain viable.

(b) Barrier: Short-Term and Inconsistent Policy Outlook

Proposed Measures: Develop a long-term, stable, nationally-committed and realistic policy framework

The policy framework that governs the food sector has failed to maintain a medium- to long-term outlook that is necessary for sustainable development. While the structural changes in the food sector tend to be disruptive in the short-term, decisions aimed at effecting profound changes in the food sector have to be maintained over a period before any significant improvements can be observed. Short-term measures have to be put in place to cushion disruptions resulting from such policies. However, given the politically determined short-term nature of the planning horizon, instead of pushing ahead with such structural policies Governments have resorted temporary policies that cushion impacts in the near term. Naturally, policies that strengthen climate resilience have been neglected in the process.

Policies affect implementation of measures in the all three technologies in the food sector. Policy failure in the SLM relate to institutional type policies whereas in CD&PF it relates more to trade policies. But, insufficient overall policy is identified as a barrier to promoting selected technologies.

(c) Barrier: Inadequate finances

Proposed Measures:

- *Make finances available at concessionary terms for long-term investments*
- *Set up financing mechanisms for specific technology packages*
- *Introduce incentive packages*

In the area of economic and financial constraints the most commonly cited barrier is the high cost of implementing the identified interventions and sources of finance. The absence of a system of long-term financing such as concessionary credit facilities through the formal sector impedes investments. While formal financing mechanisms are poorly developed in such areas informal mechanisms do not simply address it. Due to the high cost of implementation of some of the technology components and the long payback period, the access to finances becomes a critical determinant of determining adoption.

The absence of a system of financing such as credit facilities was directly identified in the case of culture-based fisheries. The availability of finances from formal and informal sources of credit is the principal mechanism for securing funds for any investment, and in some activities relating to Sustainable Land Management (SLM) and Crop Diversification & Precision Farming (CD&PF), formal financing mechanisms are poorly developed. Due to the high cost of implementation of some of the technology components and the long payback period, the accesses to finances become a critical determinant of determining adoption.

(d) Barrier: Poor risk management tools

Proposed Measures:

- *Introduce an effective insurance scheme for high cost technology introduction*
- *Extend subsidy schemes for specific technology components*

The risk management measures should be examined as a common approach to promoting any new development. Measures to manage risks are a major requirement in any new enterprise. Risks can arise from many causes including the lack of technology awareness. This is particularly important with new technologies or those with high investments. Such risk management measures require an approach led by social consciousness, a matter where governments have assume leadership.

(e) Barrier: Ineffective monitoring and evaluation (M& E)

Proposed Measure:

- *Strengthen public-sector M&E institutions*
- *Facilitate and strengthen community participation in M&E*

Continuous assessment of the relevance, effectiveness, efficiency of programs launched and undertaking necessary on-course corrections for improvement is an essential requirement in managing for results. Majority of the present day programs and projects have grown in complexity and become ambitious in targeting. Thus, the monitoring and evaluation needs have extended beyond the usual capacity of the public sector institutions. Either the institutions have to be strengthened or new structures formed to address this situation. The experience has suggested that the neither approach has been utilized affectively.

1.1.4 Specific Measures Proposed for the Selected Technologies:

The specific measures proposed for prioritized technologies in the Food Sector are given below.

Table 1.5: Technology 1: Sustainable Culture-based fisheries (SCBF)

No.	Recommended Measures
1.	Assuring adequate availability of financial resources
2.	Lowering the risk of investment
3.	Strengthening adequate supply of fingerlings
4.	Improving marketing infrastructure and price
5.	Assuring adequate R&D and Training Facilities
6.	Improving consumer preferences and overcoming social biases
7.	Improving Policy Coordination
8.	Improving institutional arrangements for stakeholder participation in policy making
9.	Introducing product standards, codes and certification
10.	Preventing degradation of Water quality

Table 1.6: Technology 2: Sustainable Land Management (SLM)

No.	Recommended Measures
1.	Increasing affordability of improved land management
2.	Increasing affordability of conservation practices and reducing social constraints in small land holdings
3.	Raising public and private investment on research and development
4.	Lessening dependency on land for livelihoods to reduce pressure on land
5.	Securing Land Ownership rights
6.	Introducing and enforcing land management policies, laws and regulations
7.	Raising knowledge on appropriate land management techniques and new challenges
8.	Ensuring proper attention to conservation in non-agricultural land uses
9.	Improving relevance land management techniques under diverse land, weather, soil, terrain, size and land formation
10.	Improving coordination among stakeholder organizations
11.	Promoting collective land management measures

Table 1.7: Technology 3: Crop Diversification & Precision Farming (CD&PF)

No.	Recommended Measures
1.	Contain price fluctuations due to unstable import policy
2.	Lowering cost of production including labor cost
3.	Reducing fragmentation of land holdings
4.	Making Land tenancy arrangements diversification friendly
5.	Developing varieties/Breeds and management packages suitable for diversification
6.	Improving post harvest technologies and processing infrastructure
7.	Lowering marketing risk arising from seasonal production
8.	Improving marketing system, Increase penetration of rural markets and providing timely and accurate market information
9.	Raising technical knowledge on the cultivation of new crops & precision farming methods
10.	Making irrigation network designs favorable for diversification

1.2 Action Plan for Technology 1: Sustainable Inland Culture Based Fishery

1.2.1 Description of the technology

Growing demand for fishery products with rising incomes and natural & manmade inland water resources provide ample prospects for development of environmental friendly, less capital and less 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. The small-sized (<100 ha) minor irrigation reservoirs that dry up for 2–3 months (July – September) of the year can be utilized for the development of sustainable culture-based fisheries which is essentially a fisheries enhancement strategy through the stocking of individuals of selected fish species. As the preferred fish species for SCBF do not naturally spawn under local conditions, the reservoirs have to be stocked regularly to sustain fisheries.

Since it uses the natural environment itself, unlike aquaculture, culture-based fisheries are not limited by land or population pressures and do not have to modify or manage the culture system to approximate the natural environment. Therefore, 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.

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

Ref. Annex D1: Technology Fact Sheet for Sustainable Culture Based Fisheries, Technology Needs Assessment Report (Part I).

1.2.2 Target for technology transfer and diffusion

To increase the production of culture-based fishery from the current level of about 5,400 mt to 9,000 mt in 10 years (by 2023), involving seasonal and minor perennial reservoirs with a cumulative surface area of 30,000 ha supported by the production of 75 million fingerlings.

1.2.3 Barriers to the technology's diffusion

There are many constraints, as identified through stakeholder consultations, to SCBF development starting from the inadequate supply of fingerlings, which is dominated by the public sector, i.e. NAQDA, to the absence of finances to invest in the stocking of fingerlings that affect the supply. The coordination of fingerling production as well as the information on the supply arrangements is preventing smooth production operations. Technology development and R&D support is undersupplied. A variety of shortcomings exist in the marketing area including the absence of any information, coordination activities. The list of key barriers and hierarchy classification identified is given in table 1.8.

Table 1.8: List of Key barriers and hierarchy classification for sustainable inland culture based Fisheries

Technology Name: Sustainable Inland Culture Based Fisheries			
No.	**Key Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	Insufficient and weak supply arrangements for fingerlings	1	Market failure
2.	Inadequate availability of financial resources	1	Economic and financial
3.	Inadequate R&D and Training Facilities	1	Institutional and Organizational Capacity
4.	High risk of investment	1	Economic and financial
5.	Poor marketing infrastructure and low price	2	Market failure/Imperfection
6.	Poor institutional arrangements for stakeholder participation in policy making	2	Network failure
7.	Water quality degradation	2	Other
8.	Inadequate product standards, codes and certification	2	Technical
9.	Inadequacy of Government Policy	2	Policy, legal and regulatory

10.	Not-favorable consumer preferences and social biases	2	Social, cultural, behavioral

1.2.4 Proposed action plans for the Technology

The Proposed Action Plan for Sustainable Inland Culture Based Fishery is provided in table 1.9.

The Action Plan proposed to overcome barriers to the development of SCBF for the development of Sustainable Inland Culture Based Fishery (SCBF) (Table 1.9.) contains 31 Sub actions categorized under 10 Actions (enabling measures). For each action the agency responsible, the timeframe, required finances and the indicators for monitoring of implementation are presented.

In view of the need for increasing the supply of fingerlings for stocking, the two highest ranked actions required in this regard are (a) to open up the fish breeding and hatchery operations for private sector and (b) ensuring availability of financial resources to undertake these activities. These actions have to be supplemented by appropriate R&D activities which is lacking at the moment and actions to improve risk management by developing and introducing appropriate products.
On the product side, a number of actions are identified to improve marketing by introducing innovation in the product standards, range of uses and quality improvement. Facilitation of greater producer participation in marketing by promoting value addition and the development of price information systems is also recommended. Specific actions leading to development of product quality parameters and specifications, product standards and certification processes and to promote popularity of CBF produce to increase consumer acceptance thereby strengthening demand.

Efforts to increase policy coordination and expanding opportunities for producer participation in the policy process are also identified. Institutional arrangements to support stakeholder input into the key decision making processes are suggested. Towards ensuring sustainability of the CBF, actions to ensure responsible environmental management and adoption of Best Management Practices are suggested.

Implementation responsibility for much of the actions rests with the Ministry of Fisheries and Aquatic Resources and its line agencies primarily NAQDA and NARA. However, participation of the other state sector agencies to facilitate much of the actions is required. Non-state actors involved in implementation comprises of Universities and private investors.

FOOD SECTOR

Technology Action Plan for Technology 1

Table 1.9: Proposed Action Plan for the Sustainable Inland Culture Based Fisheries

Measure/Action 1: **Strengthening adequate supply of fingerlings**					
Justification for the Action: To expand capacity of fingerling rearing operations to improve availability of fingerlings regionally and awareness creation					
Action/Sub Action No.	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Facilitate private sector participation in fish breeding	V. High	NAQDA	0-10 years	3 M Domestic & International	- No of private hatcheries established within the project period - Percentage (%) of fingerlings produced by private agencies per year
ii. Increase community based nurseries	V. High	NAQDA	0-5 years	2 M Domestic & International	- No of nurseries established within the first five years
iii. Introduction of loan scheme for fingerling produces	V. High	M/ Finance and Planning, Central Bank	0-10 years	1 M Domestic	- No of beneficiaries per year
iv. Improve awareness on sources and availability of fingerlings	V. High	NAQDA	0-10 years	0.5 M Domestic	- No. of forward contracts placed for fingerlings supply per year - Percentage (%) of on time supplied of fingerlings annually
Measure/Action 2: **Assuring adequate availability of financial resources**					
Justification for the action: To guide potential investors and assist suppliers of investment funds					

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 - concessionary interest and longer grace period for loans	V. High	M/ Finance and Planning, Central Bank	2-10 years	Interest subsidy to banks – 5 M Domestic	- % producers/ organizations obtaining loans annually
Measure/Action 3: Assuring adequate R&D and Training Facilities					
Justification for the action: 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 Universities NAQDA	0 - 5 years	10 M Domestic & International	- No. of research institute improved, equipped and staffed in first five years
ii. Encourage collaborative R&D activities between the state and private sector	V. High	NARA NAQDA Universities	0-10 years	10 M Domestic & International	- No. of research grants awarded during the project period
iii. Establish new training facilities accessible to farmers	High	NAQDA MF&ARD	0-10 years	3 M Domestic & International	- 90% of the planned training centers established within the project period - 90% of the planned

					training modules prepared per year - 90% of the planned programs conducted per year - 90% of beneficiaries participated
Measure/Action 4: **Lowering the risk of investment**					
Justification for the action: To reduce the risk of investment					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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 supply for farmers	V. High	NAQDA Central Bank MF& ARD	0-10 years	5 M Domestic	- Subsidy funds disbursed annually - No. of beneficiaries
Measure/Action 5: **Improving marketing infrastructure and price**					
Justification for the action: Promote the market 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 &	V. High	NAQDA	0 - 5 years	0.5 M	- % of produce

Promote marketing of 'Standard' size fish.				Domestic	marketed at 'standard' size/weight 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. Facilitate staggered harvesting and good management system	Medium	NAQDA, MF&ARD M/Tech&Res, SLSI	0 -5 years	0.5 M Domestic	- Introduced National Quality standards within two years - % reduction in fish spoilage
Measure/Action 6: Improving institutional arrangements for stakeholder participation in policy making					
Justification for the action: 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 consultative 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

Measure/Action 7: **Preventing degradation of Water quality**					
Justification for the action: To ensure water quality requirements for CBF					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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 covered
ii. Create awareness among general public on water pollution	Medium	NAQDA CEA	0-5 years	0.1 M Domestic	- Awareness campaigns conducted per year
iii. Monitoring of effluent discharge	Medium	CEA	0-10 years	1 M Domestic	- No. of reservoirs reporting improved water quality parameters annually
Measure/Action 8: **Introducing product standards, codes and certification**					
Justification for the action: To ensure product safety and quality					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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	High	NAQDA	0-2 years	0.05 Domestic	- Inspection scheme established for fingerling size and

fingerling production					quality within two years - Monitoring schedule developed within a year
iii. Introduce and implement product standards, codes and certification and license system for marketable fish	Medium	NAQDA, SLSI M/F&ARD DoARD	0-2 years	0.05 Domestic	- No. of license issued per year
Measure/Action 9: **Improving Policy Coordination**					
Justification for the action: To delegate powers among aquaculture development at the local level.					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Establish a mechanism for consultation of all stakeholders & creates stronger partnership 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 system	Medium	NAQDA MF&ARD	0-2 years	No cost	- Community Based Management Systems are improved within 2 years
Measure/Action 10: **Improving consumer preferences and overcoming social biases**					

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	- No. of campaigns carried out annually
ii. Introduce new value-added products and improve dry fish quality	High	NARA Universities M/TI&SED NAQDA	0 – 5 years	1 M Domestic	- No. of recipes developed - No. of products introduced to the market annually - No. of processed CBF products marketed
iii. Carry out promotion activities	Medium	NAQDA	0 – 5 years	0.5 M Domestic & International	- No. of campaigns launched per year - No. of publicity materials distributed per year
iv. Develop hygienic marketing facilities	Medium	M F&AR CBO	0 – 5 years	0.5 M Domestic	- Types of hygienic marketing facilities introduced annually
Total Cost of the Technology 1				**Approx: US $ 53.75million**	

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

1.3. Action Plan for Technology 2: Sustainable Land Management (SLM)

1.3.1. Description of the Technology:

Sri Lanka experiences a variety of land degradation problems of different intensities across the 48 agro-ecological zones due to the combination of many factors. These factors are high population density (21 million people in an area of 65,500 km^2), low per capita land availability and 17% of the land being hilly and mountainous terrain with steep slopes and narrow valleys. The latter is the area highly susceptible to land degradation with 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 shifting cultivation[8].

In 2002, the number of farmers with landholding of less than one acre (0.4 ha) has increased to 63% from 42% in 1982. Intensive land use practiced on such small farmlands due to high land pressure contribute to increased land degradation and limit the income from agriculture and thereby hindering adoption of SLM practices. However, the land is interconnected with other natural resources such as the air, water, fauna and flora, which are essential for survival and adaptation of sustainable land management technology. These factors together guarantee food supplies and help to protect environment and natural resources in the country.

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.

1.3.2 Target for technology transfer and diffusion

Target identified in the Technology Action Plan for SLM is restoration of the fertility status of 240,000 ha of lowland paddy and 100,000 ha under other highland food crops and 75,000 ha of plantation crop lands within 10 years (by 2023) and maintaining the present fertility status of the remaining non-degraded land allocated to food production.

1.3.3 Barriers to the technology's diffusion

Eleven key barriers to technology transfer and diffusion of SLM in the context of climate change have been identified through a stakeholder consultation and expert inputs. Seven of them ranked as highly significant while the following economic and financial barriers were found to be the most critical.

- High cost of Implementation and slow return from SLM practices.
- High economic cost of conservation practices and social constraints in small land holdings.

[8] Upper watershed Management Project, Final Report, 1997

Following barriers were identified as having some importance;

- Low public and private investment on research and development
- High dependency on land for livelihoods resulting in high land pressure

The identified key barriers were ranked and classified to several main groups as shown in the Table 1.10 by nature of their occurrence.

Table 1.10: List of key barriers and hierarchy classification for Sustainable Land Management

Technology Name: Sustainable Land Management			
No.	**Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	High cost of Implementation and slow return from SLM practices	1	Economic and Financial
2.	Insecure Land Ownership	1	Policy, Legal and Regulatory
3.	High economic cost of conservation practices and social constraints in small land holdings	1	Economic and Financial
4.	Inadequacy and poor enforcement of Policies, laws and regulations	1	Policy, Legal and Regulatory
5.	Inadequate knowledge on appropriate land management techniques and new challenges to sustainable management	1	Human Skills
6.	Low priority to conservation in non-agricultural land uses	1	Institutional and organizational capacity
7.	Poor coordination among stakeholder organizations	1	Network Failures
8.	Low public and private investment on research and development	2	Economic and Financial
9.	Single or individual efforts are not effective	2	Social cultural and behavioral
10.	Poor relevance of broad-spectrum techniques due to diversity of land, weather, soil, terrain, size, land formation and land use	2	Institutional and organizational capacity
11.	High dependency on land for livelihoods resulting in high land pressure	3	Economic and Financial

1.3.4. Proposed Action Plan for the Technology

The priority actions to assure Sustainable Land Management (SLM) are categorized under 11 key measures and comprise of 22 sub actions (Table 1.11). Some of the land management measures are actions that take a long time to implement with long payback period. This long-term nature causes some constraints requiring support over an extended period when compared with production activities. Ensuring adoption of various SLM practices by cultivators require raising awareness on the importance of the practices, supporting actions with low-cost funds or grants, as well as assuring returns to investments by granting ownership rights.

Nature of SLM practices are such that it calls for interventions in a complete or a large part of the respective watersheds thus requiring spatial planning units that comprise of multiple holdings. Planning and designing SLM practices in a manner that facilitates coordination and participation of multiple operators are suggested.

Recognizing shortcomings in the area of enforcement of laws and regulations pertaining to land management, actions to strengthen legal remedies are suggested. Other supporting actions comprise of strengthening R&D in the SLM technologies and improving coordination among key stakeholder groups concerned with implementation. Recognizing the need to lessen the pressure from intensive utilization of land as a source of livelihood by sacrificing its long-term sustainability, remedial actions are suggested.

The Proposed Action Plan for Sustainable Land Management is provided in table 1.11.

FOOD SECTOR

Technology Action Plan for Technology 2

Table 1.11: Proposed Action Plan for the Sustainable Land Management

Measure/Action 1: **Increasing affordability of improved land management**					
Justification for the action: To encourage adoption of land management and support affordability					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Introduce & implement subsidies (input & output subsidies)	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 per year - Over 20% of the planned posters/ leaflets distributed/year - Over 15% of the planned TV programs/year

Measure/Action 2: Securing Land Ownership rights					
Justification for the action: To ensure land ownership rights for responsible land management					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Enhance the clear 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 titles to land issued annually - Amendments to land law to permit long-term leases within three years
Measure/Action 3: Increasing affordability of conservation practices and reducing social constraints in small land holdings					
Justification for the action: To Overcome barriers to SLM adoption in small land parcels					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Set up incentives targeted to 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 targeting small land parcels - 10% of funds per year disbursed 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 appropriate conservation techniques introduced

Measure/Action 4: Introducing and enforcing land management policies, laws and regulations					
Justification for the action: To strengthen legal structures for responsible land management					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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 amended/revised legislations introduced within five years
ii. Independently monitor enforcement	V. High	M/A M/L&LD	5-10 years	0.5 M Domestic	- 100% of offenders taken legal action
Measure/Action 5: Raising Knowledge on appropriate land management techniques and new challengers					
Justification for the action: To promote SLM technology & improve land productivity					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Develop & 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	0-5 years	0.5 M Domestic	- 25% of beneficiaries participated per year

		M/Plantation Inds. M/I & WRMgt.			- 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 group capacity developed annually
Measure/Action 6: Ensuring proper attention to conservation in non-agricultural land uses					
Justification for the action: 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 amplified 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	- Revise within two years

Measure/Action 7: Improving coordination among stakeholder organizations					
Justification for the action: To Improve results from investments on land management					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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 arrange meetings 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 set up and upgrade annually
Measure/Action 8: Raising public and private investment on research and development					
Justification for the action: To increase investments for R&D on land management					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Increase public investment for R & D aimed at 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 for land use studies - Funds disbursed for land use 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
Measure/Action 9: Promoting collective land management measures					
Justification for the action: To enhance effectiveness of land management measures through collective planning and implementation					

Action/Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
i. Develop and promote collective conservation efforts	High	M/A M/L & LD NGO,s	0-10 years	1.5 M Domestic & International	- 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	- 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 of remedial measures introduced by the stakeholder groups per year
Measure/Action 10: **Improving relevance of land management techniques under diverse land, weather, soil, terrain, size and land Formation**					
Justification for the action: 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 of technologies developed & introduced within five years - 90% of land groups covered by new recommendations - Over 80% of planned pilot sites set up for demonstration/study

Measure/Action 11: Lessening dependency on land for livelihoods to reduce pressure on land					
Justification for the action: To Promote off-farm income earning opportunities					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Timeframe**	**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 per year - 80% of planned innovative solutions introduced
Total Cost of the Technology 2				**Approx: US $ 40.05 million**	

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

1.4. Action Plan for Technology 3: Crop Diversification and Precision Farming

1.4.1. Description of the Technology

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. This can be achieved by matching inputs and practices based on precise needs of crops and eco systems and reduced use of water, fertilizer, pesticide, and labor while assuring quality of produce, productivity of natural resources and safeguarding environment. In livestock, precision techniques increases productivity through regulation of micro-environment, improving feed and fodder production, and timely veterinary care.

In the context of CC 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 serves as a buffer to increase the ability of agricultural systems to tolerate effects of rising climate variability and extreme events. The predominant position of rice cultivation could have negative impacts on food security in view of increased vulnerability due to inadequate crop diversity. Climate change impacts can influence crop growing conditions in a manner that reverses economic benefits of mass transformation to mono-crop systems thereby making diversification more attractive. Precision farming can complement crop diversification in securing a sustainable agricultural system. Precision farming could match agricultural inputs and practices based on crop specific needs in a specific eco system to optimize accuracy and efficiency of inputs. Precise application of inputs ensures avoiding overuse or under use of inputs protecting soil health and environment.

1.4.2. Target for the Technology Transfer and Diffusion

Target identified in the Technology Action Plan for Crop Diversification and Precision Farming is diversification of 80,000 ha of marginal lands presently cultivated with rice under major irrigation schemes, 100,000 ha of rice lands (from over 200,000 ha of rice lands) not cultivated due to water shortage in the minor (Yala) season and 75,000 ha of marginal lands under Plantation crops to other food crops and pasture cultivation over a 15-year period.

1.4.3. Barriers to the Technology's Diffusion

Ten (10) barriers having the potential for negatively impacting upon the success of technology transfer and diffusion of CD&PF have been identified. These barriers comprised of two from the economic/financial category and others mostly from policy, legal & regulatory, institutional, organizational capacity and network failures. Lack of attention for the development of the non-rice crop sector appears to be the root cause for many problems in this sector. List of key barriers and hierarchy classification for Crop Diversification and Precision Farming is given in table 1.12.

Table 1.12: List of key barriers and hierarchy classification for Crop Diversification and Precision Farming

Technology Name: Crop Diversification & Precision Farming (CD & PF)			
No.	**Key Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	High risk of marketing due to seasonal production	1	Market failure/Imperfection
2.	Price fluctuation due to unstable import policy	1	Economic and financial
3.	Irrigation network designs not conducive for diversification	1	Other
4.	Lack of varieties and management packages suitable for diversification	1	Institutional and organizational capacity
5.	Under-developed marketing system– No penetration of rural markets and lack of timely and accurate market information	1	Network failures Information and awareness
6.	Inadequate post harvest technologies and processing infrastructure	1	Institutional and organizational capacity
7.	High cost of cultivation including labor cost	2	Economic and financial
8.	Fragmentation of land holdings	2	Policy, legal, and regulatory
9.	Unfavorable land tenancy arrangements for diversification from rice	2	Policy, legal, and regulatory
10.	Poor technical knowledge on the cultivation of new crops & precision farming	3	Information and awareness

1.4.4 Proposed action plans for Technology 3: Crop Diversification & Precision Farming (CD&PF)

Suggested actions under Crop Diversification and Precision Farming are categorized under 10 key measures and comprise of 20 sub actions (Table1.13). CD&PF technology includes measures aimed at harnessing a range of technology components to enhance food production and improve efficient resource use.

The priority actions relating to the technology category addresses deficiencies in product marketing by removing price uncertainty and policy failures. These actions are based on the recognition of an available market for diversified crop products. However, access to the market would be handicapped by poor planning and coordination.

On the production side, actions are designed so as to improve technology supply by strengthening R&D and create a favorable environment for crop diversification under irrigation systems which are designed only for rice production. Need for improvements in the food technology and product development to increase demand for produce is also recognized. It is also proposed to remove structural constraints caused by poor tenancy arrangements and land fragmentation. Improving competitiveness of the produce by addressing cost escalation and by increasing productivity are also identified as areas requiring action.

The Proposed Action Plan for Crop Diversification and Precision Farming is provided in table 1.13.

FOOD SECTOR

Technology Action Plan for Technology 3

Table 1.13: Proposed Action Plan for the Crop Diversification & Precision Farming

Measure/Action 1: **Lowering marketing risk arising from seasonal production**					
Justification for the action: To enhance resilience & assure 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 added techniques to preserve perishables	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 & 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
Measure/Action 2: **Contain price fluctuations due to volatile import policy**					
Justification for the action: 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
Measure/Action 3: Making irrigation network designs favorable for diversification					
Justification for the action: To persuade to adopt crop diversification					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Modify irrigation network design for greater flexibility	V. High	M/I & WRMgt. M/A	0-15 years	10 M International	- Area covered by the modified canal system and tanks at the end of the project period - At least 70% irrigation systems with modified schedules
Measure/Action 4: Developing varieties/Breeds and management packages suitable for diversification					
Justification for the action: To ensure food security and enhance resilience to Climate Chang vulnerability					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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 & introduced within 5 years.
Measure/Action 5: Improving marketing system– Increase penetration of rural markets and providing timely and accurate market information					
Justification for the action: To increase farmers' income & 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	10 M Domestic & International	- 80% of planned KM Improved at the end of the project period - Road density in farming areas
ii. Develop marketing information and price reporting system	High	M/A M/Co-Op & IT	0-10 years	1 M Domestic	- Price 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
Measure/Action 6: Improving post harvest technologies and processing infrastructure					
Justification for the action: To Stabilize price fluctuation and ensure food security					
Action/Sub Action No	**Priority**	**Responsibility for**	**Time**	**Cost (US $) &**	**Indicators**

	Rank	Implementation	frame	Funding Source	
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 food marketed as processed products 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
Measure/Action 7: Lowering cost of production including labour cost					
Justification for the action: To increase farmers' income					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Introduce and implement agricultural credit and insurance scheme	High	M/F&P M/A	0-15 years	3 M Domestic	- Integrated ag. credit and crop insurance system introduced within two years - No of beneficiaries annually
ii. Introduce appropriate mechanization	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.

Measure/Action 8: Reducing fragmentation of land holdings					
Justification for the action: To encourage mechanization to reduce cost of production					
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
Measure/Action 9: Making Land tenancy arrangements diversification friendly					
Justification for the action: To increase land productivity and there by 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.
Measure/Action 10: Raising technical knowledge on the cultivation of new crops & precision farming methods					
Justification for the action: To resist CC vulnerability and increase input use efficiency and secure food quality & safety					
Action/Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
i. Wide use of information technology and electronic mass media for agricultural	Medium	M/A	0-10 years	4 M Domestic &	- Cyber extension systems in operation for all key crops within five years

extension				International	
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 classes per year
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
Total Cost of the Technology 3				**Approx: US $ 61.05 million**	

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

CHAPTER 2

Technology Action Plan for the Health Sector

2.1 Actions at sectoral level

2.1.1 Short sector description:

Climate change affects the health of the humans directly as well as indirectly. The common direct health effects are, vector, including rodent and water borne diseases (Malaria, Dengue, Yellow fever, leptospirosis, viral hemorrhagic diseases and diarrheal diseases including Cholera). Conditions associated with extremes of temperature such as heat waves and cold spells also exist. The effect of natural disasters and extreme weather events causes many health effects on humans; some are immediate and others late. The immediate health effects are death and injury. Late ones are disability, communicable diseases, psycho-social problems etc. On the other hand, protracted or sudden weather events indirectly affect human health through crop failure, loss of live stock, livelihoods etc. Poor and underdeveloped countries and nations will be affected more compared to developed nations as they are capable of implementation of mitigation and adaptation mechanism to minimize human suffering[9]. Therefore, it is imperative to identify strategies and methods to reduce human suffering. As health sector produces negligible amount of green house gases (GHGs) and no actions are envisaged in reducing the GHGs already in the atmosphere, the sector can design and implement technologies related to climate change adaptation only.

The status and development of the health sector in Sri Lanka depends on the ability and capacity of the 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 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

[9] Climate Change and Human Health, Risks and Responses, Summar
y: WHO, WMO, UNEP; 2007. (ISBN 92 4 159081 5)

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. To achieve these objectives the health sector has to play different roles at different levels and during different phases of development (web. MoH) These commitments have been repeatedly emphasized in many plans, including health master plan (HMP) sub-sector policies and health sector policy statement (HPS). 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 total aggregate emission of GHGs in Sri Lanka estimated for 2000 amounts to 18,842 $GgCO_2$ equivalents from all sectors. With the uptake of 6,254 $GgCO_2$ equivalents from the land use change and forestry sector, the total net emission for the country is 12,589 $GgCO_2$ equivalents from all sectors[10]. This amount is negligible compare to the amounts emitted by the industrialized countries[11]. Though the health sector produces GHGs, mainly CO_2, directly and indirectly, the amount of GHGs emitted by the health sector is negligible compared to that of Industry, Transport and Energy sectors.

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[12]. 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.

[10] ME,2011, Sri Lanka's Second National Communication on Climate Change

[11] UNEP/WB, 2011

[12] ME, 2010, National Climate Change Adaptation Strategy for Sri Lanka- 2011 to 2016

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

A) Existing Policies related to Health Sector

The Existing Policies and Laws related to Health Sector are given in table 2.1 & 2.2.

Table 2.1: 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, 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: ○ 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

Table 2.2: 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 eco-systems
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	1980	Production of Cosmetics, devises and drugs, Importation of the same, distribution and trade regulation 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

2.1.2 An overview of the prioritized technologies

The Technology Needs Assessment process nine potent technologies have been selected and following three were prioritized utilizing the Multi-Criteria Decision Analysis (MCDA) approach.

a) Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events
b) Transfer of knowledge and skills to Health Personnel
c) Technology for management of Health Care Waste

a) Technology 1: Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events.

The importance of EWS is emphasized in its definition as “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.”

This technology is not novel in the local context as there is some progress already taken place in this regard. The objective of selecting this technology is to sustain and to strengthen the ongoing activities and to fill the major gaps identified. Moreover, the economic, social, health and other benefits to populations override the resources incurred to develop and improve EWS and related systems.

Target for technology transfer and diffusion and employment targets

The preliminary target group is comprised of the health personnel actively working 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 approximate number of personnel to be benefited during the project period is 1250-1400. Nationwide diffusion of the technology will take eight to ten years. The current level of employment is restricted to the less than 100 personnel who marginally involved in EWS related activities and the future target for employment is 1500 personnel.

b) Technology 2: Transfer of knowledge and skills to health personnel.

Activities and projects under this technology are already taking place in the island. For example, presently an awareness program is being conducted by the Environmental and Occupational Health Directorate of the Ministry of Health for health workers at district level. Many other organizations are also conducting, school programs, public awareness activities, exhibitions etc. The primary goal of the technology is to go beyond the awareness creation and to provide the health workers with necessary knowledge, skills and attitudes to enhance adaptation measures in the society through health sector activities. Training of some master trainers to upscale the training activities is another objective. However, there are certain inherent problems that need to be rectified in order to make these programs successful. Firstly, the emphasis on climate change and its potential effects on human health have not received the due recognition in any of the ongoing training programs. Instead, disaster or emergency management is given the priority or the focus as the island is subject to many natural disasters like, floods, flash floods, thunderstorms, droughts, landslides and disease outbreaks over the potential risks of global warming and climate change. Secondly, almost all training activities are confined to class room teaching, basically lecture-demonstrations. Evaluation of the training and testing of knowledge and skills gained through trainings in the forms of drills and simulations are not done except in few occasions and even these are also not repeated over time. In addition, there are no follow-up actions to improve capacity and diffusion across the sector. Thirdly, the amount of time spent and the number of health personnel trained are very limited due to many constraints, including finances, shortage of trainers, absence of a training schedule, unavailability of training modules, and low priority given to climate change related health training by the training institutions.

The technology is less costly compared to the other interventions but the economic, social, health and educational benefits are immense. Diffusion of the technology is easy as the health personnel are already engaged in health activities. Any negative impacts on the environment are absent or minimal.

Target for technology transfer and diffusion and employment targets

The preliminary target of beneficiaries of this technology is 2000-2500 health personnel during the project period. This number is comprised of 50 health personnel from each of the 25 districts, 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. The new employment opportunities will be minimal except for replacements for attrition due to retirement, leaving etc.

c) Technology 3: Technology for management of health care waste.

The World Health Organization identifies health waste care management as a measure to reduce the burden of disease, including alternatives to incineration.[13] 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. Waste and by-products cover a diverse range of materials, such as infectious waste, pathological waste, sharps, chemicals, pharmaceuticals, radioactive substances, genotoxins, and heavy metals. 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, and nursing homes for the elderly.

Improvements in health-care waste management rely on few key elements such as building a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements, raising awareness of the risks related to health-care waste, and of safe and sound practices,and selecting safe and environmentally-friendly management options, to protect people from hazards when collecting, handling, storing, transporting, treating or disposing of waste[14]. Government commitment and support is needed for universal, long-term improvement, although immediate action can be taken locally.

Target for technology transfer and diffusion and employment targets

The preliminary target for technology transfer and diffusion is 25 selected major health institutions in the island. In implementing the planned projects, the implementers will be targeting institutions in underserved areas. The number of health workers subjected to the training component will be 300-350 @ 5 or 6 persons from each institution. It will take approximately 12 –15 years for transfer and diffusion of the technology

[13] WHO, 2011

[14] WHO, 2011

island wide. The current employment status cannot be defined clearly as the sector specific policy is still at draft stage. The future employment target will be around 500.

2.1.3 General Barriers and Proposed Measures

Although the nature of the barriers will vary depending on the type of technology, yet there are some general or common barriers for all three technologies selected. Five general barriers identified for transfer and diffusion of the technologies are as follows;

- Economic and Financial aspects
- Institutional and organizational capacity
- Network failures
- Human Skills
- Information and awareness

a) ***Barrier: Economic and Financial*** - *Inadequacy of financial resources to sustain the ongoing activities and to introduce new technologies.* This barrier has relevance to all the three technologies. The expensive treatment technologies and lack of sustainability over time also reflects funding requirements. Further, there is a hidden component of economic and financial aspects in many other barriers identified

Proposed Measures: *Allocation of sufficient funds from government sources, exploration of alternative and additional funding sources and mechanisms and development of policies conducive to successful transfer & diffusion of technologies* are the measures recommended for overcoming this barrier.

b) ***Barrier: Institutional and organizational capacity*** - Seven key barriers of this category were identified for all three prioritized technologies. These have been considered as main barriers specifically for technology 1 and 2. Absence of an established structure in the sector, administrative gaps, underutilization of available trained personnel, poor coordination of training activities, unavailability of training plans, unavailability of monitoring mechanisms and shortage of technical staff to manage regular activities are the common barriers related to three technologies.

Proposed Measures: The proposed enabling measures are; a) assign focal points where necessary and align with existing national government structures through the focal points b) identify the administrative gaps and rectify the shortcomings with appropriate measures, c) make amendments to the HRH Policy facilitating utilization, d) design financial and non-financial incentive measures, e) appoint a training coordinator in the Ministry of Health, f) establish a coordination mechanism by the Ministry of Health with all training institutions, g) develop and share an annual training plan, h) provide authority to the directorate responsible

for monitoring, i) develop monitoring mechanism with suitable methods and implement on a regular basis, j) training of identified and interested personnel already in the staff, and k) pooling of staff from other sections.

c) ***Barrier: Network failures*** - Two key barriers of this category has been identified for technology 1 and 3. Networking for inter and intra agency information sharing at national and sub-national levels is the network failure related barrier for Technology 1. This is due to shortcomings in sharing EWS information between sectors as well as issues related to diffusion of information in a timely and regular manner. A similar issue has been identified for Technology 3 as *inadequate inter-sectoral coordination* for Healthcare Waste Management due to network failures between sectors.

Proposed Measures: The proposed enabling measures to eliminate network failure barriers are; a) Regularize the available information sharing mechanisms, b) extend information sharing mechanisms available for disease forecasting and outbreak control to other health issues, e) awareness creation for policy makers and top administrators, and f) strengthen the available coordination mechanisms.

d) ***Barrier: Human Skills -*** These barriers identified are P*oor utilization of novel technologies* for technology 1, *shortage of competent trainers* for technology 2 and *shortage of technical staff to manage regular activities* for technology 3.

Proposed Measures: The proposed enabling measures are, a) training of identified and interested personnel already in service, b) pooling of staff from other sections, c) identify and implement affordable and appropriate new technologies, d) develop policies for maintenance (including preventive), repair and replacement of equipment used in such technologies, e) train adequate number of staff to implement the technologies, f) make the service a closed-service g) identify a set of master trainers from other sectors as well, h) establish in-service carrier development opportunities , and j) provide necessary financial and non-financial incentives.

e) ***Barrier: Information and awareness –*** The general barriers under this category are *poor utilization of novel technologies for the purposes of EWS* for technology 1 and poor *awareness among health personnel including administrators* for Technology 3.

Proposed Measures: The proposed enabling measures are, a) create awareness using existing forums, and b) utilization of mass media to the extent possible.

2.1.4 Specific Measures Proposed for the Selected Technologies

The specific measures proposed for prioritized technologies in the health sector are given below.

Table 2.3: Measures proposed for technology 1: Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events

No	Recommended Measures
1.	Allocation of adequate funds by the government and explore alternative funding sources and mechanisms
2.	Align with the existing Government structure (National Disaster Management Centre of the Ministry of Disaster Management)
3.	Rectify the issues related to administrative gaps
4.	Improve utilization of novel technologies for the purposes of EWS
5.	Regular review and monitoring of policy; Stakeholder awareness creation on existing policies and stakeholder involvement in policy reviews
6.	Improve and enhance the use of available trained persons

Table 2.4: Measures proposed for technology 2: Transfer of knowledge and skills to Health Personnel

No	Recommended Measures
1.	Provide sufficient funds and facilities for training and human resource development
2.	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.
3.	Explore and provide opportunities to use modern educational methodologies and technologies
4.	Conduct training needs assessments and design trainings accordingly
5.	Development and inclusion of an M &E mechanism into an existing system to monitor and evaluate transfer and diffusion of knowledge.
6.	Provide financial and non-financial benefits, pooling of trainers from other sectors, provide due recognition to trainers

Table 2.5: Measures proposed for technology 3: Technology for management of Health Care Waste

No	Recommended Measures
1.	Explore funding sources, public-private partnerships and identification of low-cost technologies
2.	Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other agencies
3.	Awareness creation among health personnel
4.	A combination of conducting feasibility studies on different technologies and implementation of sustainable technologies
5.	Train interested and qualified in-service persons, open avenues for carrier development and take measures to retain personnel for a stipulated period
6.	To improve inter agency coordination

2.2 Action Plan for Technology 1: Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events

2.2.1 Description of the technology

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 following four main elements[15].

- *Risk Knowledge*: Risk assessment provides essential information to set priorities for mitigation and prevention strategies and designing early warning systems.
- *Monitoring and Predicting*: Systems with monitoring and predicting capabilities provide timely estimates of the potential risk faced by communities, economies and the environment.
- *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.
- *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.

[15] United Nations (UN), 2006, International Strategy for Disaster Reduction (ISDR)

The basic rationale behind early warning is that the earlier and more accurately we are able to predict short and long-term potential risks associated with natural and human-induced hazards, the more likely we will be able to manage and mitigate disasters' impact on society, economies, and environment.

Early warning systems help to reduce economic losses and mitigate the number of injuries or deaths from a disaster, by providing information that allows individuals and communities to protect their lives and property. Effective early warning systems embrace all aspects of emergency management, such as: risk assessment analysis, which is one of early warning system's design requirements; monitoring and predicting location and intensity of the natural disaster waiting to happen; communicating alerts to authorities and to potentially affect; and responding to the disaster.

EWS is not a new technology to Sri Lanka. It has come into existence as a response to the impact of the tsunami disaster in 2004. Basically, the issue in Sri Lanka is not establishment of a EWS as a new technology, but to transform the existing EWS to be effective. The objective of selecting this technology is to sustain and to strengthen the ongoing activities and to fill the major gaps identified. Moreover, the economic, environmental, social, health and other benefits to populations override the resources incurred to develop and improve EWS and related systems.

2.2.2 Target for technology transfer and diffusion

The preliminary target group is 'selected health personnel' actively working 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 approximate number to be benefited during the project period is 1250-1400 health personnel. Island wide diffusion of the technology will take eight to ten years.

2.2.3 Barriers to the technology's diffusion

Six (06) key potential barriers have been identified for technology transfer and diffusion of 'Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events'. Of the key barriers, one belonged to the category of economic and financial barriers and the other five are non-financial related. The non-financial barriers are related to institutional and organizational capacity, policy, legal and regulatory and human skills.

The list of key barriers and hierarchy classification for Technology 1 is given in table 2.6.

Table 2.6: List of key barriers and hierarchy classification for Technology 1

Technology Name: Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events			
No.	**Key Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	Inadequacy of financial resources	4	Economic and financial
2.	Absence of an established structure for EWS and networking for inter agency information sharing	1	Institutional and organizational capacity
3.	Administrative gaps in relevant sectors	2	Institutional and organizational capacity
4.	Poor utilization of novel technologies for the purposes of EWS	3	Institutional and organizational capacity
5.	Feeble policies and policy reviews	5	Policy, legal and regulatory
6.	Underutilization of available trained people	6	Human skills

2.2.4 Proposed Action Plans for the Technology

The Proposed Action Plan for 'Early Warning Systems and networking for information exchange on extreme weather events and other climate change related events' is provided in table 2.7.

HEALTH SECTOR

Action Plan for Technology 1

Table 2.7: Proposed Action Plan for the technology 1: Technology for Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events

Measure/Action 1: **Allocation of sufficient amount of funds by the government; Exploration for alternative funding sources and mechanisms**					
Justification for the action: To ensure adequate finances for technology implementation					
Action /Sub Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source (US $)**	**Indicators**
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
Measure/Action 2: **Align with existing government structures and establishment of a inter and intra agency network**					
Justification for the action: To address issues related to inter and intra agency information sharing					

Action /Sub Action	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source (US $)	Indicators
I. Assess suitable and sustainable networking methods	V. High	Ministry of Health	0-1 year	3,000 $ US IF	- Number of methods selected In one year
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 by the end of one year
III. Establish a network down 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 3 years
Measure/Action 3: Rectify the issue of administrative gaps					
Justification for the action: 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 by the end of one year
II. Provide training to all focal points on carrying out their duties and responsibilities	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

Measure/Action 4: **Improve utilization of novel technologies for the purposes of EWS; Networking, training and related research and development**					
Justification for the action: 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 within the year
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 done by the end of first year - Availability of modules by the end of first year - Categories of health workers identified for training by the end of the first year
III. A second line of trained personnel to be on call, including Training of selected health personnel at different levels	High	Ministry of Health/ Ministry of Disaster Management	0-8 years	15,000 $ US IF	- Number of training programmes conducted per year
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

Measure/Action 5: Regular streamlining and monitoring of policy; Make all involved aware of existing policies and involvement in policy reviews					
Justification for the action: 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. All related policy revive 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 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
Measure/Action 6: Improve and enhance the use of available trained persons					
Justification for the action: 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. Include a category in the HRH Policy from the existing cadre	Medium	Ministry of Health	0-1 year	1,500 $ US DF	- EWS category included in the National HRH Policy by the end of one year
II. Address the issues related to rural (peripheral) retention	Medium	Ministries of Health/Finance & Planning/ Public Administration	0-1 year	1,500 $ US DF	- Number of measures implemented to rural retention by the end of one year

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
Total Cost of Technology 1				**Approx: US $ 113,000**	

DF – Domestic Funds, IF – International Funds; V. High = Very High

2.3 Action plans for Technology 2: Transfer of knowledge and skills to Health Personnel

2.3.1 Description of the Technology

Activities and projects under this technology are already taking place in the island. For example, presently an awareness program is being conducted by the Environmental and Occupational Health Directorate of the Ministry of Health for health workers at district level. Many other organizations are also involved with awareness programs in the form of 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 attitudes to enhance adaptation measures among the public through health sector initiatives. One other objective is to train some master trainers for the benefit of trainers while rectifying inherent problems associated with these programs.

The emphasis on climate change and its effects on human health are not highlighted in any of the ongoing training programs. Instead, disaster or emergency management is given the priority as the island is subjected to many natural disasters such as floods, flash floods, thunderstorms, droughts, earth slips and disease outbreaks without appreciating the fact that most natural disasters are global warming and climate change induced. Almost all training activities are confined to class room activities such as lecture-demonstrations. Evaluation of the training, testing of knowledge and skills acquired through trainings in the forms of drills and simulations are not undertaken except in few occasions. Even such actions are not repeated over time. In addition, there are no follow-up actions to improve capacity and diffusion across the sector. The amount of time spent and the number of health personnel trained is limited due to many constraints, including finances, shortage of trainers, absence of a training calendar, unavailability of training modules, and low priority given to climate change related health training by training institutions.

The technology is less costly compared to the other interventions but the economic, social, health, educational benefits are immense. It is easy to diffuse the technology as the health personnel are already in place and Negative impacts on the environment is minimal.

2.3.2 Target for technology transfer and diffusion

The preliminary target of beneficiaries for this technology is 2000-2500 health personnel during the project period. This includes fifty (50) from health institutions in each of the 25 districts, 750 from different institutions of the line Ministry of Health, and 50 from Municipality health workers. The estimated duration of country wide diffusion of the technology is 5-8 years.

2.3.3 Barriers to the technology's diffusion

One economic and financial barrier and five non-financial barriers have been identified being impediments for the success of this technology. The first barrier is 'Unavailability of sufficient funds' and the proposed enabling measures are to increase the allocation of funds for the climate change related activities from the government. The authorities should pursue other options such as public-private partnerships, exploring funds from international agencies interested in climate change adaptation activities.

The non-financial barriers identified include one network failure, three institutional and organizational capacity and one human skill related. Poor coordination of training activities, under utilization of modern educational technologies, unavailability of a training calendar, unavailability of a mechanisms to monitor diffusion of knowledge and skills and shortage of competent trainers are the non-financial barriers identified for the technology 'transfer of knowledge and skills to Health Personnel'.

The list of key barriers and hierarchy classification for technology 2 is given in table 2.8.

Table 2.8: List of key barriers and hierarchy classification for the technology 2

Technology Name: Transfer of Knowledge and Skills to Health Personnel			
No.	**Key Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	Unavailability of sufficient funds	2	Economic and financial
2.	Poor coordination of training activities	1	Network failure
3.	Modern educational technologies are not utilized	3	Institutional and organizational capacity
4.	Unavailability of a training calendar	4	Institutional and organizational capacity
5.	Unavailability of a mechanism/s to monitor diffusion of knowledge and skills, including to the general public	5	Institutional and organizational capacity
6.	Shortage of competent trainers	6	Human skills

2.3.4 Proposed Action Plans for Technology 2: Transfer of Knowledge and Skills to Health Personnel

The Proposed Action Plan for Transfer of Knowledge and Skills to Health Personnel is provided in table 2.9.

HEALTH SECTOR

Action Plan for Technology 2

Table 2.9: Proposed Action Plan for the technology 2: Transfer of knowledge and skills to Health Personnel

Measure/Action 1: Provide sufficient funds (government and other avenues) and facilities for training and human resource development					
Justification for the action: 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 rectified by the end of two years
Measure/Action 2: 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					
Justification for the action: 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 at the end of one and half years
II Develop an annual training calendar (training	V. High	Ministry of Health/	0-1 year	2,500 $ US DF	

plan)		Ministry of Disaster Management			- Training calendar made available at the end of one year
Measure/Action 3: Conduct training needs assessments and design trainings accordingly					
Justification for the action: To enable undertaking regular training needs assessment of the Health Ministry staff and develop training curricula accordingly.					
Action /Sub Action	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source (US $)**	**Indicators**
I. Conduct training needs assessments **across the sector**	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 made available 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 out of 25 by the end of three years - Number of programmes 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 Defence	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

Measure/Action 4: Explore and provide opportunities to use modern educational methodologies and technologies					
Justification for the action: To enable replacing student entered, class room activities with outdoor activity based technology transfer and skills development					
Action /Sub Action	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source (US $)**	**Indicators**
I. Identification of appropriate training methodologies to use in training programs (Under 3. III)	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.
Measure/Action 5: Development and inclusion of a M &E mechanism into an existing system to monitor and evaluate transfer and diffusion of knowledge, and recording lessons learned for incorporation into future M &E purposes					
Justification for the action: 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 across the country	High	Ministry of Health	0-8 years	15,000 $ US IF	- Number of monitoring events conducted annually - Number of different means used for monitoring - Annual percentage of coverage
Measure/ Action 6: Provide financial and non-financial benefits, pooling of trainers from other sectors, provision of a due recognition to trainers					
Justification for action: 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 pooled 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
Total Cost of Technology 2				**Approx: US $ 284,500**	

DF – Domestic Funds, IF – International Funds; V. High = Very High

2.4 Action plans for Technology 3: Technology for management of Health Care Waste

2.4.1 Description of the technology

The World Health Organization identifies health care waste management as a measure to reduce the burden of disease, including alternatives to incineration[16]. Of the total amount of waste generated by health-care activities, about 80% is general waste comparable to domestic waste. The remaining 20% is considered hazardous material that may be infectious, toxic or radioactive. Waste and by-products cover a diverse range of materials, such as infectious waste, pathological waste, sharps, chemicals, pharmaceuticals, radioactive substances, genotoxins, and heavy metals. The major sources of health-care waste are: hospitals and other health-care establishments, laboratories and research centres, mortuary and autopsy centres, animal research and testing laboratories, blood banks and collection services, and nursing homes for the elderly.

High-income countries generate on average up to 0.5 kg of hazardous waste per bed per day while low-income countries generate on average 0.2 kg. However, health-care waste is often not separated into hazardous or non-hazardous wastes in low-income countries making the real quantity of hazardous waste much higher.

Health-care waste contains potentially harmful micro-organisms which can infect hospital patients, health-care workers and the general public. Other potential infectious risks may include the spread of drug-resistant micro-organisms from health-care establishments into the environment. Waste and by-products can also cause injuries such as radiation burns, sharps-inflicted injuries etc. Poisoning and pollution due to improper disposal of health care waste could occur through the release of pharmaceutical products, in particular, antibiotics and cytotoxic drugs, waste water; and toxic elements or compounds, such as mercury or dioxins that are released during incineration. The Risks associated with waste disposal are indirect health risks that may occur by the release of toxic pollutants into the environment through treatment or disposal.

Incineration of waste has been widely practiced but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants and ash residues into the air. Incinerated materials containing chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (in particular lead, mercury and cadmium) can lead to the spread of toxic metals in the environment. Dioxins, furans and metals are persistent and bio-accumulate in the environment. Materials containing chlorine or

[16] WHO, 2011

metal should therefore not be incinerated. Only modern incinerators operating at 850-1100 °C and fitted with special gas-cleaning equipment are able to comply with the international emission standards for dioxins and furans. Alternatives to incineration are now available, such as autoclaving, microwaving, steam treatment integrated with internal mixing, and chemical treatment.

Improvements in health-care waste management rely on building a comprehensive system, addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements, raising awareness of the risks related to health-care waste, and of safe and sound practices;,and selecting safe and environmentally-friendly management options, to protect people from hazards when collecting, handling, storing, transporting, treating or disposing of waste[17]. Government commitment and support is needed for universal, long-term improvement, although immediate action can be taken locally.

2.4.2 Target for technology transfer and diffusion

The preliminary target for technology transfer and diffusion is 25 selected major health institutions in the island. In implementing the planned projects, the main emphasis will be for targeting institutions in underserved areas. The number of health workers to be will be 300-350 (5 or 6 persons from each institution). It will take approximately twelve to fifteen years for transfer and diffusion of the technology island wide.

2.4.3 Barriers to the technology's diffusion

Two economic and financial barriers and four non-financial barriers have been identified and the economic and financial barriers included '*Treatment technologies of health care waste are expensive'* and '*Lack of sustainability of ongoing implemented activities due to financial constraints'.* Non-financial barriers included one each from Information and awareness, Institutional and organizational capacity, Social, cultural and behavioral and Network failure categories.

The list of key barriers and hierarchy classification for technology 3 is given in table 2.10.

[17] WHO, 2011

Table 2.10: List of key barriers and hierarchy classification for the technology 3

Technology Name: Technology for management of Health Care Waste			
No.	**Key Barriers Identified**	**Priority Rank (1 – 5)**	**Category of Barriers**
1.	Treatment technologies of health care waste are expensive	1	Economic and financial
2.	Lack of sustainability of ongoing activities due to financial constraints	3	Economic and financial
3.	Poor awareness among health personnel including administrators	2	Information and awareness
4.	Shortage of technical staff to manage regular healthcare waste activities	4	Institutional and organizational capacity
5.	Uncommitted attitude of policy planners and administrators	5	Social, cultural and behavioral
6.	Inadequate inter-sectoral coordination	6	Network failures

2.4.4 Proposed Action Plans for Technology 3: Technology for management of Health Care Waste

The Proposed Action Plan for Technology for Management of Health Care Waste is provided in table 2.11.

HEALTH SECTOR

Action Plan for Technology 3

Table 2.11: Proposed Action Plan for the technology 3: Technology for management of Health Care Waste

Measure/Action 1: Exploration for additional funding sources, Public-private partnerships and Identification of appropriate and low-cost technologies for implementation					
Justification for the action: To secure additional funding, explore partnerships 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
Measure/Action 2: A combination of conducting feasibility studies on different technologies and implementation of sustainable technologies					

Justification for the action: 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 year - Availability of study reports by the end of the three year
Measure/Action 3: Awareness creation among health personnel					
Justification for the action: To create awareness in order to generate interest for healthcare waste management and to prevent ill effects on the environment soil and water.					
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 by the end of one year
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 by the end of one year

Measure/Action 4: Train interested and qualified persons already in service, open avenues for carrier development and take measures to retain personnel for a stipulated period					
Justification for the action: 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 Selection and provision of training and skills to health personnel across the sector	High	Ministry of Health/ Provincial Ministries of Health	0-3 years	15,000 $ US IF	- Number of established institutes with proper waste management skills at the end of three years
Measure/Action 5: Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other agencies					
Justification for the action: 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 by the end of one year
Measure/Action 6: To improve the coordination between sectors					
Justification for the action: 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 connected with the network by the end of two years - Number of sectors connected by the end of two years
Total Cost of Technology 3				**Approx: US $ 111,000**	

DF – Domestic Funds, IF – International Funds; V. High = Very High

CHAPTER 3

Technology Action Plan for the Water Sector

3.1 Actions at sectoral level

Major action identified as adaptations to climate change under the water sector are to take measures to reduce water stress during droughts, reduce dependency on surface & ground water, storm water control & capture and ground water recharge. These measures are primarily targeted on rain water, surface run-off and ground water.

3.1.1 Short Sector description:

Based on the average annual rainfall, Sri Lanka 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 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.

There are 103 distinct natural river basins that cover 90% of the island. Most of the cultivation of crops in the dry and intermediate zones is carried out using water from irrigated schemes comprising both ancient systems and modern systems[18]. More than 90% of the minor 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. 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.

[18] ME,2011, Sri Lanka's Second National Communication on Climate Change

Water is mainly used for domestic, irrigation, hydropower and industrial processes in the country. Economic status of the dry zone mainly depends on agriculture. Nationally, 37% of the population receives pipe borne water, which comprises 95% of the urban population. Over half of the piped water connections are in the Western province. Rural populations are supplied by small scale piped water schemes, hand pump operated tube wells, protected dug wells and harvested rainwater. Water stressed populations are periodically supplied water by bowsers by the National Water Supply and Drainage Board (NWSDB) in cooperation with local authorities, NGOs and International NGOs (INGOs)[19]. The Water Resources Board Act No.29 of 1994 provides access for integrated planning and conservation of water resources, co-ordination of river basin surveys and studies and other measures to control economic uses of water.

GHG emissions level and trends: CH_4 emissions from domestic and commercial waste water management are 0.59 and 13.14 Gg respectively[6].

Vulnerability to climate change: Climate change is likely to result in rapid temperature increases in Sri Lanka, faster than the average global rate of warming. Between 1961 and 1990, the temperature increase in Sri Lanka has been 0.016ºC per year. Night time annual average temperatures have increased faster than daytime, up to a maximum of 0.02 ºC per year. National level modeling undertaken by the Sri Lankan Centre for Climate Change Studies has reported that, by 2100 the temperature increase (2.9ºC) during the northeast monsoon season (December to February) is more prominent than that of (2.5ºC) 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.

The projections of IPCC 4th Assessment report (2007)[20] the possible impacts of climate change due to changes in extreme weather and climate events, shows an increase in the frequency of heavy precipitation events over most areas. Adverse effects on quality of surface and groundwater is anticipated, contamination of water supply and water scarcity may be relieved. The area affected by drought increases and more widespread water stress is expected.

Based on the projections of the IPCC 3rd 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. Sea level rise can cause salt water intrusion and decrease in fresh water

[19] M/F&E, 2000, Initial National Communication under the United Nations Framework Convention on Climate Change

[20] IPCC, 2007, Climate Change, Synthesis Report, Intergovernmental Panel on Climate Change, 2007

availability. The IPCC has categorized water sector in the South Asian region as one of the highly vulnerable sectors[21]. 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[22].

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 are given below.

Table 3.1: Existing Key Policies Involved:

Name of the Policy	Year		Responsible Authority	Main contents
	Enacted	Revised		
1. Participatory Irrigation Management (PIM) Policy	1988	-	Department of Agrarian Development	- Full responsibility for O&M of small or minor irrigation schemes were given to farmers. - Responsibility of managing the head works and the main canal system were given to the irrigation agency. - Medium and major irrigation works were brought under joint management with FO
2. The national policy on water supply and sanitation	2000	2011	Ministry of Water Supply and Drainage / NWSDB	- Recognize water as a basic human need -Identified that water has an economic value - User should bear the operational costs of drinking water provision and sewage and sanitation services
3. National policy for Rural Water Supply & Sanitation Sector	2001	-	Ministry of Water Supply and Drainage /	The government will assist the promotion of the hygiene education as an integral part of the Rural

[21] Practical Action, 2011

[22] ME, 2010, National Climate Change Adaptation Strategy for Sri Lanka- 2011 to 2016

				Water Supply Sector (RWSS) Sector 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.
5. National Rainwater Policy and Strategies	2005		Ministry of Urban Development and Water Supply	Rainwater harvesting has been 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.
6. National Policy on Drinking Water	2009			- 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
7. *Mahinda Chinthanaya*	2006		Natinal Planing Department	- Strategies to provide safe drinking water to 90% of people by the year 2016 - Complete rehabilitation of 10,000 tanks by 2020.

Table 3.2: Existing Key Laws Involved:

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,

3.1.2 An overview of prioritized technologies

The most appropirate adaptation technologies for the water sector were identified through a process of Multi-Criteria Decision Analysis (MCDA) in consultation with stakeholders. The prioritized technologies are given below in order of priority.

a) Restoration of minor tank net works
b) Rainwater harvesting from rooftops for drinking and household uses

c) Boreholes/tube wells as a drought intervention for domestic water supply

a) Restoration of minor tank net works:

Restoration of minor tank net works contributes to adaptation for climate change by diversification of water supply, storm water control and capture and groundwater recharge. The irrigation water demand in the Yala (minor) season is greater than that of the Maha (major) season in the dry zone. Further, due to climate change, dry zone will be vulnerable to droughts. Due to above reasons minor tanks can play a major role in suppling irrigation water to the dry zone and at present there are a considerable number of abandoned/ damaged/silted minor tanks. Restoration of abandoned minor tanks is costly whereas restoration of silted or damaged cascade minor tank systems is affordable. The preliminary target for Restoration of minor tank net works is restoration of 10 minor tank net works (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. Expensive modern technologies such as GPS and remote sensing will be required for quick identification and mapping the problems in the catchment and command areas of minor tank systems.

b) Rainwater harvesting from rooftops for drinking and household uses:

Rainwater harvesting means collection, preservation and obtaining maximum use of rain. Many parts of the 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. A study on the rainfall for the period from 1960 to 2001 has shown that the length of dry spells is increasing all over Sri Lanka. The above study (Ratnayake U.R., *etal* 2005) has also shown that the daily rainfall intensities increases and therefore rain water from roof tops could be harvested within a short period during the rainy season and the stored rainwater can provide short term security against such dry periods. At present, in certain areas the rain water harvesting is not being carried out in a proper manner and it is necessary to provide necessary guidance through awareness programs. The preliminary target for rainwater harvesting from rooftops is introduction of 400 roof top rain water harvesting systems for households/schools/hospitals/suitable buildings in the dry zone, within a period of ten years. Priority will be given to areas where surface water is scarce and quality of ground water is poor.

c) Boreholes/Tube wells as a drought intervention for domestic water supply:

Ground water can be extracted using boreholes and ground water is used as a drinking water source and also for back-garden agriculture and aquaculture in the dry zone. The borehole efficiency (high efficiency means both high yield and high success rates) changes with the bedrock geology. Farmers abstract groundwater at rates typically ranging between 27 m^3/hour and 45 m^3/hour (Premanath *et al* 1994) 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 the community in small villages in the dry zone and also to individual houses. Preliminary target for Boreholes/Tube wells is introduction of 50 hand pump operated boreholes/tube wells in the dry zone where suitable hydro geological conditions are available. The project will be completed within a period of seven years. Ref. Technology Fact Sheet, TNA report Report (PartI) for more information on this technology.

3.1.3 General barriers and proposed measures for the water sector

Following general barriers have been identified for implementation of the three technologies;

- High capital cost
- Lack of sustainability
- Poor enforcement of policies/laws
- Lack of information and awareness
- No prioritized areas to implement the technology
- Limitations of the technology due to water pollution
- Lack of Research & Development.

(a) Barrier: *High capital cost*

Proposed Measure: *Obtain sufficient funds from the government and donor agencies; whenever necessary, farmer/ household contributions in terms of labor inputs should be obtained to minimize the cost.*

High capital cost is identified as the major barrier for all three technologies. Financial requirements for implementation of these technologies should be identified at the national planning process and provide from the national budget to the respective agencies. As development funds of the government are limited, additional project specific funds need to be mobilized from external sources in the form of grants/loans from the donor community. It is recommended to edevor securing farmers and household contributions in terms of labor to minimize the costs.

(b) Barrier: *Lack of sustainability*

Proposed Measure: *Regular operation and maintenance practices to improve sustainability and institutional capacity building*

Lack of sustainability is another major general barrier likely to affect all three technologies. For the Technology 1 (*Restoration of minor tank networks*), sustainability could be improved by implementing effective operation and management practices such as de-siltation, rehabilitation of damaged bunds, reducing high evaporation of tank water by planting trees in the *Gasgommana,* oiling and greasing of sluice

structure on a regular basis etc. For the Technology 2 (*Rainwater harvesting from rooftops*), sustainability could be improved by management practices such as minimizing contamination possibilities within the rainwater harvesting system, treatment of harvested rainwater and minimization of possible leakages. It is also recommended to publish a simple guide book on rain water harvesting from roof tops. For the Technology 3 (*Boreholes/Tube wells as a drought intervention for domestic water supply*), sustainability could be increased by installing tube wells only in areas with suitable hydro-geological conditions and good quality ground water. Good operation and maintenance practices should be implemented while preventing over extraction. Necessary training/guidance is recommended for registered contractors for tube well construction.

(c) Barrier: *Poor enforcement/Lack of policies/laws*

Proposed Measure: *(i) Prepare a clear policy on selection and prioritization of cascade systems/minor tanks for restoration; (ii) Formulate a National Water Policy and new policies as required; (iii) Strengthen involvement of agencies to implement existing policies/legal framework.*

Poor enforcement of policies/laws is also a common barrier for all three technologies. For the Technology 1, it is necessary to formulate a clear policy/strategy for selection and prioritization of cascade systems/minor tanks by considering the demand for water, number of potential beneficiaries, amounts of funds available and type of restoration/rehabilitation work required and hydrology of the tank system etc. For the Technology 2, it is necessary to strengthen involvement of Municipal councils, Urban Development Authority (UDA), National Water Supply and Drainage Board (NWSDB) for strict enforcement of existing national rainwater harvesting policy. It is also recommended to issue licenses to roof top rainwater harvesting systems, in an annual basis. For the Technology 3, policies/laws should be formulated to register and issue licenses to tube well constructors in order to control large scale abstractions and also to limit drilling of boreholes affecting vulnerable aquifers. It is also recommended to formulate policy/strategy to establish a low-interest loan scheme facility and import tax relief to the registered tube well constructors to import/locally purchase necessary equipment for tube well industry at affordable prices.

(d) Barrier: *Lack of information and awareness*

Proposed Measure: *Improve operation and maintenance practices through effective awareness programs and by Publishing guide books; Capacity building of relevant departments/institutes/boards to conduct training and awareness programs*

Lack of information and awareness is a common barrier for all three technologies. For the Technology 1, it is recommended to promote R & D to collect data on cascade hydrology and make them available to

interested parties. In relation to the Technology 2, it is necessary to improve operation and management practices of rooftop rainwater harvesting systems through improved awareness and by providing necessary guide books on operation and maintenance of roof top rainwater harvesting systems. For the Technology 3, it is recommended to provide information related to benefits provided, prices of necessary equipment and information on aquifers in Sri Lanka etc. to constructors from rural areas and other contractors registered for installation of boreholes. In addition to above, it is recommended to publish guide books on operation and maintenance of tube wells as well.

(e) ***Barrier:*** *Lack of prioritized areas to implement the technology*

Proposed Measure: *Develop a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration, needs, urgency and climate change modeling should be considered.*

Lack of prioritized lists of locations for interventions is a common barrier for all three technologies. For the Technology 1, it is recommended to develop a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration. For both Technology 2 and 3, first it is necessary to identify areas vulnerable to climate change by applying climate change modeling followed by prioritization of locations based on the needs, quality of rain water/ ground water etc**.** Hydrogeology of the sites also should be considered for the implementation of the Technology 3.

(f) ***Barrier:*** *Limitations of the technology due to water pollution*

Proposed Measure: *Select suitable alternative sites; strict enforcement of environmenalt laws to protect surface/ground water from pollution; good operation and management practices, R & D.*

Risks related to water pollution is another general barrier which is likely to restrict application of the technologies. For all three technologies, strict enforcement of environment laws and research & development are recommended to reduce water pollution. For the Technology 2 and 3, Good operation and management practices are recommended. Selecting suitable alternative sites is also recommended for the technology 3.

(g) ***Barrier:*** *Lack of Research & Development*

Proposed Measure: *R & D to collect required data for ensuring sustainability of the technology; funds for necessary R & D should be provided to universities, research institutions etc., 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, Incentives should be given to research students carrying out research projects in this field.*

Lack of R & D is also a common barrier for all three technologies and it is necessary to give priority for R & D activities when allocating funds in the annual budgets. For the technology 3, it is extremely necessary to collect required data on aquifers in Sri Lanka and incentives should be considered to attract students for undertaking related research projects.

3.1.4 Specific Measures Proposed for the Selected Technologies:

The specific measures proposed for prioritized technologies in the water sector are given below.

Table 3.3: Proposed measures for Restoration of minor tank net works

No	Recommended Measures
1.	Provide sufficient funds and farmer contributions in terms of labor
2.	Provide alternative income sources to farmers during extended dry seasons
3.	Improve operation and maintenance practices to increase sustainability of minor tank systems
4.	Improve the knowledge on importance of good tank / catchment management practices
5.	Increase involvement of farmers in planning and decision making on restoration of minor tank networks; Strengthen Farmer Organizations
6.	Development of a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration
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
8.	Build capacity of relevant institutes/departments to collect and update hydrological data
9.	R & D on tank water pollution and strict enforcement of environmental laws/ policies/regulations

Table 3.4: Proposed measures for Rainwater harvesting from rooftops for drinking and household uses

No	Recommended Measures
1.	Obtain additional funds and Reduce high capital cost
2.	Provide potable water during extended dry seasons at subsidized rates
3.	Formulate standards, codes & certification and also annual licenses for roof top rainwater harvesting systems
4.	Raising knowledge on operation and management practices of rooftop rainwater harvesting systems

5.	Awareness creation on importance of the technology as a water conservation method and means for minimizing flash flood s
6.	Review and revise data dissemination policies of Meteorology Department in order to provide free access to rainfall data
7.	Formulate a clear mechanism/strategy/protocol for prioritization of areas for diffusion of this technology and prepare a list of priority sites
8.	Increase the public confidence in roof top harvested rain water as a potable water source
9.	Increase the demand for roof top harvested rain water
10.	Strict enforcement of national rainwater harvesting policy
11.	Good operation and management practices to minimize possible contamination of rain water.

Table 3.5: Proposed measures for Boreholes/Tube wells as a drought intervention for domestic water supply

No	Recommended Measures
1.	Tke appropriate measures to reduce high capital cost
2.	Adequate funding allocation for diffusion of the technology in prioritized areas
3.	Build capacity of relevant institutes to offer a certificate course to disseminate necessary knowledge and technical skills on construction of successful boreholes
4.	Improve the awareness on ramifications of over extraction of ground water
5.	Diffusion of the technology by giving special attention to sustainability of boreholes
6.	Revise existing guidelines for safe and sustainable use of groundwater
7.	Revise existing policies/ laws related to ground water in order to control drilling of boreholes affecting vulnerable aquifers
8.	Establish an environment to enable easy access to financial resources through a low-interest loan scheme
9.	Establish a mechanism for adequate availability of financial resources through an import tax relief for importers/producers of tube wells
10.	Update information on status of aquifers in the dry zone of Sri Lanka by WRB/NWSDB
11.	Develop a mechanism for prioritization of areas/sites for installation of boreholes and preparation of a priority list
12.	Awareness campaigns on special facilities provided for tube well constructors
13.	Promote R &D on ground water availability and hydrogeology of various sites
14.	Prevent degradation of Ground water quality

3.2 Action Plan for Technology 1: Restoration of minor tank net works

3.2.1 Description of the Technology

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 its surrounding area served as a resource-base for many other activities such as making bricks, pots, baskets, etc, with women often providing assistance in these 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.

At present 12,120 of minor tanks are in working order out of which most of them are not able to provide the maximum benefits due lack of regular maintenance and such minor tanks have to be restored and protected to enable facing the predicted water scarcity in the dry zone due to climate change and also to sustain their contribution to the social development, economic wellbeing and environmental benifits. Restoration of minor tanks involves work such as breach closing, tank bund strengthening, aquatic weeds control and repairing or reconstruction of sluices and weirs. Considering the importance of rural development in the Dry Zone, there have been numerous minor tank rehabilitation efforts in the past, but most of them have achieved poor results as such work has been focused on individual tanks without considering the cascade hydrology. Therefore, the proposed technology is focused on restoration of minor tank networks in the dry and intermediate zones of the country. This technology contributes to adaptation for climate change through diversification of water supply, storm water control and capture and groundwater recharge. It also enhance access to groundwater and hence the expansion in irrigable area. Another reason to select this technology is that it has the potential to contribute to enhance employment opportunities and farm income through increased crop yields by altering crops and crop diversification.

3.2.2 Target for technology transfer and diffusion

The target for Restoration of minor tank net works is 10 minor tank networks (50 minor tanks) in the Dry Zone which are in working condition but need rehabilitation within a period of ten years. Detailed targets for transfer and diffusion includes; (i) conducting awareness programs to decision/policy makers to enable securing required funds (ii) formulation of a clear policy/strategy for selection and prioritization of cascade systems/minor tanks for interventions, (iii) collect necessary information such as priority cascade systems and minor tanks in them, (iv) capacity improvements of Department of Agrarian Development and Provincial Councils, (v) strengthen farmer organizations in restoration work and operation and management of minor tank systems, and improve engagement of farmer community in planning and decision making, (vi) conduct awareness programs to disseminate knowledge on importance of good tank/catchment/canal management practices and also on potential alternative employments opportunities during extended dry seasons., (v) incentives and compensations to encourage involvement of farmers in restoration/rehabilitation work and for extended dry seasons respectively, (vi) R & D on tank water pollution .

3.2.3 Barriers to the technology's diffusion

Existing overall enabling framework: Importance of conservation of water has been recognized even at the time of king Parakramabahu the Great (1153-1186). Sri Lanka is working on formulation of a water policy since 1990 and still it is in progress. Department of Agrarian development is responsible for minor irrigation systems, establishment of Farmer organizations and management of irrigation water within the area of authority of the Farmer Organizations.

During the past, there have been numerous minor tank rehabilitation projects and efforts, but most of them have achieved poor results due to lack of focus. 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.

Under the ongoing *"Dahasak Maha Wevu"* water resources management program, which has planned to rehabilitate 10,000 tanks will be expedited with the participation of farmer community in order to complete rehabilitation by 2020. It is scheduled to complete 1000 tanks every year from 2010 at an annual estimated cost of Rs. 500 mn. It is also noted that, farmers are expected to make a meaningful contribution in the form of labor for minor schemes, with the major proportion of the finances being provided by the government or other agencies such as NGOs and the private sector. The benefits of this program include increased production, ground water recharge and enhancing water supply for domestic purposes, livestock, fisheries

and recreation. Another aspect reported is that, the private sector investors will be encouraged to invest in fields such as eco-tourism and agri-business, where return on investment is attractive[23].

Identified Barriers: A total of nine barriers have been identified and they are classified under the categories of Economic & financial and Non-financial. The economic & financial barriers include high capital cost**,** no return/benefit from the investment during extended dry seasons and lack of payments for communities involved in restoration activities and inadequate allocation of funding for restoration work. The non-financial barriers are; lack of sustainability of minor tank systems due to poor tank/catchment management practices, lack of understanding on importance of good tank/catchment management, lack of farmer community involvement in planning and decision making on restoration of minor tank network, weak farmer organizations, absence of prioritized locations for selecting the most suitable cascade systems/minor tanks for restoration, lack of policy for distribution of funds among different government agencies involved in restoration of minor tank network systems, poor understanding on cascade hydrology due to lack of R & D and limited institutional and organizational capacity and limitations of the technology due to water pollution

The list of key barriers and hierarchy classification for technology 1 is given in table 3.6.

Table 3.6: List of key barriers and hierarchy classification for the technology

Technology Name: Restoration of minor tank net works			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital cost and inadequate allocation of funds in the annual national budget	1	Economic and financial
2.	No returns/benefits from the investments during extended dry seasons and lack of payments for communities involved in restoration activities	8	Economic and financial
3.	Lack of sustainability of minor tank systems due to poor tank management practices	2	Technical and network failure
4.	Lack of understanding on importance of good tank / catchment management practices	6	Institutional and organizational capacity/ Network failure
5.	Lack of involvement of farmer community in planning and decision making on restoration of minor tank network: weak farmer organizations	3	Institutional and organizational capacity/ Network failure

[23] *Mahinda Chinthana*, 2010; The Department of National Planning.

6.	Lack of priority list for selecting the most suitable cascade systems/minor tanks for restoration	5	Policy, legal and regulatory
7.	Lack of policy for distribution of funds among different government agencies involved in restoration of minor tank network systems	4	Policy, legal and regulatory
8.	Poor understanding on cascade hydrology due to lack of R & D and limited institutional and organizational capacity	8	Information and awareness
9.	Limitations due to water pollution	9	Other barriers

3.2.4 Proposed Action Plans for Technology 1: Restoration of minor tank net works

The Proposed Action Plan for Restoration of minor tank net works is provided in table 3.7.

WATER SECTOR

Technology Action Plan for Technology 1

Table 3.7: Proposed Action Plan for Restoration of Minor Tank net works

Action 1: Provide sufficient funds and farmer contributions in terms of labor					
Justification for the action: The barrier related to this action is *'high capital cost and inadequate allocation of funds in the annual national budget for restoration work'.* Minor tank network system is a water conservation method for water scarcity and for reduction of floods during heavy rains, which are the negative impacts expected due to climate change. However, climate change and its effects are not priority areas 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 programs on possible socioeconomic benefits through the technology-1. (ii) Policy makers and legislators consider implementation of adaptive measures with respect to climate change as a priority area when taking policy decisions

II. Allocate sufficient funds from annual budget for diffusion of this 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 technology 1
III. Mechanism for additional funding from donor agencies	V. High	• M/Finance and Planning	0-1 years	5,000 *International*	(i) Completion of three stake holder meetings. (ii) Completion of a strong proposal for obtaining 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/benefit during extended dry seasons with respect to the investment 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	• NWSDB • Dept. of Agrarian Development	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	• NWSDB • Dept. of Agrarian Development	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 for extended dry seasons	V. High	• Dept. of Agrarian Development • Dept. of Irrigation and Water Management	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	• M/Agrarian Services and Wildlife	0-2 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.
Action 3: Improve operation and maintenance practices for sustainability of minor tank systems					
Justification for the action: 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.					
Action/Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Promote Farmer Organizations based mechanism for sustainability of minor tank systems	V. High	• Dept. of Agrarian Development • Provincial Councils • Farmer organizations	2-9 years	2000 Domestic	(i) Active involvement of Dept of Agrarian Development and Provincial Councils to promote Farmer Organizations based mechanism for operation and maintenance of minor tanks (from year 2 to year 9)

Action 4: Improve the knowledge on importance of good tank/catchment/canal management practices					
Justification for the action: 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 this subject.					
Action/Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Develop an annual calendar to provide necessary awareness to farmers and act accordingly. This will be included under Action 2-III.	High	• Dept. of Agrarian Services • Provincial Councils	2-9 years	Already included under Action 2-III.	(i) Conducting awareness programs according to a schedule, on operation and management from year 2 to year 9.
Action 5 : Increase involvement of farmers in planning and decision making on restoration/rehabilitation of minor tank networks Strengthen Farmer Organizations					
Justification for the action: Barrier is *'Lack of involvement of farmer community in planning and decision making on restoration of minor tank network: weak Farmer Organizations'.* This is mainly due to, weak Farmer Organizations.					
Action/Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Address the issue of weak Farmer Organizations and identify measures to strengthen them	High	• Dept. of Agrarian Services • Provincial Councils	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	High	• Dept. of Agrarian	1-2	Already	See indicators under Action 4-I.

farmer community through Farmer Organizations in planning and decision making in restoration work. This will be included under Action 2-III.		Services • Provincial Councils	years	included under Action 2-III.	
Action 6 : Development of a policy/protocol/strategy for selection and prioritisation of cascade systems/minor tanks for restoration/rehabilitation and preparation of a priority list					
Justification for the action: Barrier related to this action is '*Lack of priority list when selecting the most suitable cascade systems/minor tanks for restoration'.* In most of the previous restoration processes, selection of cascade systems/minor tanks has been carried out without properly considering hydrology of the cascade system and needs and as a result such restorations have failed to maximize benefits/returns.					
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	• M/ Agrarian Services and Wildlife • M/ Local Government and Provincial Councils	0-1 years	---	(i) Availability of a policy for prioritization of cascade systems and their minor tanks for restoration by end of year 1.
II. Collect data on major rehabilitation work needed, number of beneficiaries from each tank, relocation needs and amounts of funds available etc. and prepare a priority list	High	• Dept. of Agrarian Services • Provincial Councils	1-2 years	0.05 M International	By end of year 2: (i) Availability of data on cascade systems in the dry zone which need rehabilitation, major rehabilitation work needed, number of beneficiaries from each tank in them,

					relocation needs and amounts of funds available etc. (ii) Availability of a priority list for restoration work.
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.					
Justification for the action: Barrier - *Lack of policy/legal mandate for distribution of funds among different government agencies involved in restoration of minor tank network systems.* There is no demarcation of responsibilities of Agrarian Service Department from Provincial councils pertaining to restoration/rehabilitation work of minor tank net work systems and their support to FOs. Due to this reason, there is no proper mechanism to determine the amount of funds that should be allocated to each of the above two agencies for restoration/rehabilitation work. As a result, they have failed to prepare a proper planning of restoration work in the country targeting a considerable financial benefit.					
Action/Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Review the mandates of Agrarian Service Department and Provincial councils and demarcate their responsibilities pertaining to restoration work.	High	• M/Finance and Planning	0-1 years	---	(i) Type of involvement in restoration work by each department is clearly defined by the end of year 1.
II. According to the assigned responsibilities allocate the required percentages of total funds to above two agencies	High	• M/Finance and Planning	2-9 years	---	(i) Allocation of funds based on the work assigned, from year 2.

Action 8 : Build capacity of relevant institutes/Departments to collect and update hydrological data					
Justification for the action: 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 instates/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 rehabilitation projects, during the past.					
Action/Sub Action	**Priority Rank Action/Sub Action**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
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, availability of necessary equipment, transport facility
Action 9: R & D on tank water pollution and strict enforcement of relevant environmental laws/policies/regulations					
Justification for the action: *Limitations of the technology-1 due to water pollution'* is the barrier related to this action. Dental fluoresis and kidney diseases are reported in Anuradhapura, Polonnaruwa etc. The suspected reason is poor water quality due to pollution.					
Action/Sub Action	**Priority Rank Action/Sub Action**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Monitor water quality of the tanks selected for restoration/rehabilitation work, Monitor Health conditions of people consuming water from above tanks and study any relationship between health issues and tank water pollution	Medium	• Universities • Dept. of Health	3-9 years	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 involvement of relevant agencies to implement existing environmental policies/legal frame work	Medium	• M/Environment	0-9 years	----	Number of penalties per year
Total Cost of Technology 1					**Approx: US $ 18.83 million**

V. High = Very High

3.3 Action Plan for Technology 2: Rainwater harvesting from rooftops for drinking and household uses (RWH)

3.3.1 Description of the Technology

Rainwater harvesting from rooftops is a simple, inexpensive technology that promotes sustainable water management. This technology can be adopted as a household project or in hospitals, schools, housing complexes etc. 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. 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 as described below. 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 family members have full control of their own system. The RWH technology facilitates women by providing water which is otherwise brought from distanced water sources. It reduces their physical hardship and mental stress as well as time required to fetch water from other water sources. The saved time can thus 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 water supply costs and also provides significant savings as a storm water management tool. Appropriately designed rainwater harvesting systems will have minimal maintenance costs associated with its upkeep and therefore will show the best long-term relationship between cost and financial benefit. Rainwater is soft, which means less detergent is used and released into the environment. Also, rainwater harvesting systems with a connected vaporization system can raise site humidity and create a healthier microclimate. This is ideal for city areas dealing with air pollution[24]. Considering all the above facts, this technology was identified as an adaptation method for water sector for climate change.

A roof top rainwater harvesting system consists of three basic elements: Roof top - the catchment area, gutters - conveyance system, and storage tank. The effective roof area and the roof material affect the water

[24] LaBranche-Tucker *et al*, 2009

quality and efficiency of collection. Drain pipes, roof surfaces and the storage tank should be constructed by chemically inert, non toxic materials in order to avoid adverse effects on water quality.

3.3.2 Target for technology transfer and diffusion

The target for the technology is installation of 400 roof top rain water harvesting systems for households/schools/hospitals/suitable buildings in the dry zone, within a period of ten years. Priority will be given to areas where surface water is scarce/ polluted and ground water quality is poor. Detailed targets for technology transfer and diffusion are; Program for decision/policy makers to enable securing required funds and preparation of a strong proposal with the assistance of stake holders, to obtain additional funds from donor agencies; Improve capacities of Department of Health and NWSDB; Formulate standards/ codes/certificates for roof top rainwater harvesting systems and a scheme for annual license; Formulate a clear mechanism to prioritize sites for interventions and collect necessary data (needs, rainfall data, quality of rain water, urgency and results of climate change modeling etc); Prepare a priority list based on above data; Awareness creation on the technology as means for water conservation and a flood minimizing; Awareness creation on good operation and management practices; Technical assistance for good operation, management, and for water treatment; Installation of 300 RWH systems based on priorities identified; Based on the results of monitoring and evaluation, next 100 RWH systems will be installed from year 8 to 9, Evaluation of success in years 2,3,5,6,7,9

Overall target will be achieved by end of 2023 if the project will be commenced in 2013.

3.3.3 Barriers to the technology's diffusion

Existing overall enabling framework: Since time immemorial Sri Lanka has been using rain water for both domestic and agricultural purposes for many centuries. According to the Act No. 13 of 1992, NWSDB is vested with the responsibility of providing various services related to water supply schemes. Institutionalized rainwater harvesting became a practice in Sri Lanka in 1995, under the World Bank funded Community Water Supply and Sanitation Project (CWSSP). This project initiated the emergence of the Lanka Rainwater Harvesting Forum (LRWHF), the 1st NGO directly working towards the promotion of rainwater harvesting in the country. Later, the Southern Development Authority (SDA), Dry Zone Development Project funded by IFAD and 3rd and 4th ADB water and sanitation project also contributed in rainwater harvesting for domestic use. LRWHF has conducted demonstration projects, awareness programs and training in all districts in order to promote this technology. The National rainwater rain water policy and strategies was enacted in 2005. A

bill was gazetted in 2007, to amend the UDAL Law No 41 of 1998, to facilitate rainwater harvesting in new buildings[25].

Identified barriers for meeting the targets transfer and diffusion:

Eleven barriers are identified and they are classified as Economic & financial and non-financial. The barriers identified are given below. Due to aesthetic considerations, roof top harvested rainwater has no demand. Inefficient enforcement of national rainwater harvesting policy has lead to contamination of water due to no water quality monitoring.

The list of key barriers and hierarchy classification for technology 2 is given in table 3.8.

Table 3.8: List of key barriers and hierarchy classification for the technology 2

Technology Name: Rainwater harvesting from rooftops for drinking and household uses			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital cost	1	Economic and financial
2.	No benefit during extended dry seasons with respect to the investment	9	Economic and financial
3.	Lack of sustainability of roof top rain water harvesting systems due to poor management practices	2	Technical/Institutional & organizational capacity
4.	Lack of standards, codes and certification for roof top rainwater harvesting systems	3	Technical/Policy and legal
5.	Poor understanding of importance of rain water harvesting from roof tops as a water conservation method for water scarcity due to climate change	5	Information and awareness
6.	Poor dissemination of information on rainfall data	11	Information and awareness
7.	Lack of prioritized areas for installation of roof top rainwater harvesting systems	4	Information and awareness
8.	Lack of confidence in roof top rainwater harvesting technology	7	Social, cultural, behavioral/Information and awareness

[25] Rainwater harvesting, Practioners Guide for Sri Lanka, 2009

9.	Due to aesthetic considerations, roof top harvested rainwater has no demand	8	Social, cultural, behavioral/Information and awareness
10.	Inefficient enforcement of national rainwater harvesting policy	6	Policy, legal and regulatory
11.	Possibility of water contamination	10	Institutional and organizational capacity/ Technical

3.3.4 Proposed Action Plans for the Technology

The Proposed Action Plan for Rainwater harvesting from rooftops for drinking and household uses is provided in table 3.9.

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Technology Action Plan for Technology 2

Table 3.9: Proposed Action Plan for the Technology 2: 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'.* 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	• M/ Water Supply & Drainage	0-1 years	0.01 M Domestic	(i) Awareness programs on possible socioeconomic benefits through the technology-2. (ii) Policy makers and legislators consider implementation of adaptive measures with respect to climate change as a priority area when taking policy decisions
II. Allocate sufficient funds from annual budget for diffusion of this technology	V. High	• M/ Water Supply & Drainage • M/Environment	1-2 years	----	(ii) 50% increase of funding in the annual budget within the second year for diffusion of technology 2.

		and Natural Resources			
III. Mechanism for additional funding from donor agencies	V. High	• NWSDB	0-1 years	5000 International	(i) Completion of three stake holder meetings. (ii) Completion of a strong proposal for obtaining grants/loans by end of year -1.
IV. Promote research on development of low cost, better quality roof top rainwater harvesting systems	V. High	• Universities • Research Institutes	0 - 2 years	0.01 M International	**(i)** Availability of methodology for low cost, better quality roof top rainwater harvesting systems by end of year 2.
V. Subsidy scheme for storage tanks to those registered with the NWSDB.	V. High	• NWSDB • INGOs, NGOs	3-9 years	1 M International	(i) Provide storage tanks at a subsidized rate (50 % price reduction) from year-3 to year 9.

Action 2 : Provide potable water during extended dry seasons at subsidized rates

Justification for the action: The barrier related to this action is '*no benefit during extended dry seasons with respect to the investment'.*
Roof top rainwater harvesting system requires considerable financial commitment by the household, but the rain water collected during the rainy season may not be sufficient for extended dry seasons. Therefore it is needed to provide them potable water 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 subsidised rates	V. High	•NWSDB •INGOs, NGOs	3-9 years	10000 International	(i) Provide water during extended dry seasons at subsidized rates (50 % price reduction) from year-3 to year 9.

Action 3: Raising knowledge on operation and management practices of rooftop rainwater harvesting systems					
Justification for the action: 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	• NWSDB • Lanka Rain water Harvesting Forum • Dept. of Health	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 operation and maintenance of roof top rainwater harvesting systems	V. High	• NWSDB • Lanka Rain water Harvesting Forum	0 -2 years	1 M Domestic and International	By end of year 2: (i) Availability of demonstration models in the three districts selected (ii) Availability of audio-visuals on operation and maintenance of roof top rainwater harvesting systems
Action 4: Formulate standards, codes & certification and also annual license for roof top rainwater harvesting systems in Sri Lanka					
Justification for the action: The barrier is '*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. There is also a possibility of using inappropriate roof materials by technology users.					

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
I. Develop or formulate standards/ codes/certificates for roof top rainwater harvesting systems and a scheme for annual license.	High	• Urban Development Authority • NWSDB	0-1 years	---	(i) Availability of accepted standards for Sri Lanka for roof top rainwater harvesting systems, by end of year-1.
Action 5 : Awareness creation on roof top rain water harvesting technology as a method for water conservation and minimizing flash flood s					
Justification for the action: Barrier is *'Poor understanding of importance of rain water harvesting from roof tops as a water conservation method for 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 this technology as water conservation and a flood minimizing technology. Include this activity under Action 3-1.	High	• NWSDB • Urban Development Authority • Lanka Rain water Harvesting Forum	2- 9 years	Included under Action 3-1 .	(i) See indicators under Action 3-I.
II. Include "rooftop rainwater harvesting technology" into G.C.E (O/L) school curriculum	High	• Dept of Education • National Institute	0-1 years	---	(i) By end of year 1, introduction of this technology in the GCE (O/L) school

		of Education (NIE)			curriculum as a method for water conservation and minimization of flash floods.
Action 6 : Revise data dissemination policies of Met department in order to provide free access to rainfall data					
Justification for the action: Barrier related to this action is '*Poor accessibility for information on rainfall data'.* There is no free access for rainfall data for previous years.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Revise the data dissemination policies of Meteorology department	High	Met department	0-1 year	---	(i) Availability of rainfall data for previous years, free of charge from end of year-1.
Action 7: Formulate a clear mechanism/strategy /protocol for prioritization of areas for diffusion of this technology and prepare a priority list					
Justification for the action: 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	• M/ Water Supply & Drainage	0-1years	---	By the end of year-1: (i) Availability of a policy/strategy to prepare a priority list.
II. Collect data on needs, rainfall data, quality of rain water, urgency and results of Climate change modeling etc. and prepare a priority list	High	• NWSDB • CEA	0-2 years	0.02 M Domestic	(i) By end of year-2, availability of data on: needs, rainfall data, quality of rain water, urgency and results of Climate change

					modeling etc. (ii) Availability of a priority list by end of year-1
III. Provide the priority list to relevant authorities	High	• NWSDB	Year 2	---	Availability of a priority list at authorities handling this technology by end of year 2.
Action 8 : Increase the confidence in roof top harvested rain water as a potable water source					
Justification for the action: Barrier related to this action is '*Lack of confidence in roof top rainwater harvesting technology'.* It is necessary to implement suitable steps to convince the community that the harvested rain water can be used as potable water.					
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	• NWSDB • Lanka rainwater harvesting forum	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 for persons consuming harvested rain water.	High	• Dept. of Health	2-9Years	0.5 M Domestic and International	Availability of annual reports on health conditions of persons consuming harvested rain water.
Action 9: Increase the demand for roof top harvested rain water					
Justification for the action: '*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 information on use of rain water harvesting systems in other countries.	High	• NWSDB • Lanka rainwater harvesting forum	0-9 years	1 M Domestic and International	(i) 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.
Action 10: Strict enforcement of national rainwater harvesting policy					
Justification for the action: Barrier related to this action is '*Inefficient enforcement of national rainwater harvesting policy'*. The reason is poor involvement of Urban Development Authority, Municipal councils, and NWSDB in this regard.					
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 • Municipal councils • NWSDB	0-9 years	---	(i) Number of certificates issued per year for new buildings from year 1.

Action 11: Good operation and management of rainwater harvesting systems to minimize possible contamination of rain water.					
Justification for the action: Barrier related to this action is '*Limitations of the technology-2 due to contamination of water'.* Harvested rain water contaminated with *E. Coli* is reported at certain occasions. Lack of capacity for treatment of harvested water is a barrier.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Build capacity of Health Department and NWSDB	Medium	• NWSDB • M/Health	0-1 years	5000 Domestic	(i) By end of year 1, sufficient capacity at NWSDB and Health Department pertaining to Technology 2.
II. Provide Technical assistance for good operation and management, and for water treatment.	Medium	• NWSDB • Dept. of Health • Lanka rainwater harvesting forum	2-9 years	5000 Domestic Domestic	(ii) By year 2, technical assistance by NESDB and Health Department
Total Cost of Technology 2					**Approx: US $ 8.07 M**

V. High = Very High

3.4 Action Plan for Technology 3: Boreholes/tube wells as a drought intervention for domestic water supply

3.4.1 Description of the Technology

Ground water is used as a drinking water source and also for back-garden agriculture and aquaculture primarily in the dry zone. Boreholes/Tube wells consist of a narrow, screened tube (casing) driven into a water bearing zone of the subsurface. The borehole efficiency (high efficiency means both high yield and high success rates) changes with the bedrock geology. One of the main reasons for selecting this technology is that, under surface water stress situation the ground water can be substituted for domestic purposes as it free of pollutants. The total cost of construction of a hand pump tube well (HPTW) and a production borehole are Rs. 193,920 – Rs. 210,080 and Rs. 198,550 – Rs. 219,450 respectively[26] out of which 50% is for drilling of the well, 20% is for screening, 15% is for testing of water quality and yield, 5% is for cleaning, communication and the balance is for demobilization[27].The total cost changes with the depth and the size of the borehole and investment cost is very high.

When the bed rock is igneous or metamorphic in formation and with no weathered zones and fractures, it would result in low yielding and less sustainable bore holes. Issues related to ground water quality are connected with natural geochemistry of the area and also with industrial or agricultural pollution of aquifers.
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 saved time 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.

3.4.2 Targets for technology transfer and diffusion

Target for the technology 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

[26] US $ = SLRs. 135.00

[27] Personal communications – NWSDB, 2012

years. The overall target will be achieved by 2021 if the project is commenced in 2013. Main steps proposed to be adopted for technology transfer and diffusion is as follows;

Conduct an awareness program for decision/policy makers to facilitate securing funds on a priority basis; Preparation of a strong proposal with the assistance of stake holders to obtain additional funds from donor agencies; Financial incentives through loan schemes and import tax relief, build capacity of NWSDB/WRB; Amend the existing guidelines/laws for safe and sustainable use of groundwater: Formulate a protocol for prioritization of areas/sites; Collect data on highly vulnerable areas for climate change; Implement a method to register organizations having at least one person who has successfully completed the certificate course as tube well contractors at WRB/NWSDB, Create awareness; R&D on ground water availability/quality; Construct the first successful 25 boreholes from year–3 to year-5) and next successful 25 boreholes during year-5 to year-6; Introduce an annual license system for boreholes to prevent over extraction; Steps to prevent degradation of Ground water quality; Evaluation of success (year-3 to year-7).

3.4.3 Barriers to the technology's diffusion

Existing overall enabling framework: Water Supplies for towns such as Nuwara Eliya, Tangalle, Batticalo, Dambulla, Wennappuwa, Ahangama, Kataragama, Vavuniya, Puttalam, Chilaw, Anamaduwa, Nikaweratiya, Kuliyapitiya and Mihintale are being fully or partly operated by using groundwater from deep bore holes. At present, about 8% of the total population is benefited by this technology. Usage of ground water in the country is rapidly increasing leading to intensified smallholder cultivation thereby improving the standards of living of poor farmers in the dry zone.

Water Resources Board (WRB) is responsible for ground water resources (Act No. 42 of 1999). WRB, collects data and information on Water Resources for advisory purposes, and undertakes Hydro-geological investigation and Groundwater development projects.

In Sri Lanka, a land owner is regarded as owning the unreserved rights to water underneath his land and tend to extract all accessible water. Such unregulated activities results in drying up the aquifers by the end of the dry season and some communities are left without drinking water.

Identified barriers for transfer and diffusion of the technology:

Fourteen (14) key barriers have been and are comprised of two (2) economic & financial, three (03) institutional & organizational, four (04) policy, legal & regulatory, three (03) information & awareness and market failure, one (01) technical and one (01) "Other" barriers.

The list of key barriers and hierarchy classification for technology 3 is given in table 3.10.

Table 3.10: List of Key Barriers and Hierarchy Classification for the Technology 3

Technology Name: Boreholes/Tube wells as a drought intervention for domestic water supply			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital cost	1	Economic and financial
2.	Inadequate funding allocation for this technology	11	Economic and financial
3.	Lack of technical assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing	4	Institutional and organizational capacity
4.	Lack of understanding on negative impacts of over extraction of ground water	10	Institutional and organizational capacity
5.	Lack of sustainability	3	Institutional and organizational capacity
6.	Lack of policies/laws/ by laws/ guidelines for safe and sustainable use of groundwater	5	Policy, legal and regulatory
7.	Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers	6	Policy, legal and regulatory
8.	High interest on loans for importers/producers of tube wells due to lack of policies/strategies to establish low-interest loan scheme	14	Policy, legal and regulatory
9.	High import taxes due to lack of policies/strategies to provide tariff relief	12	Policy, legal and regulatory
10.	Lack of information on ground water resources	7	Information and awareness/Market failures
11.	Lack of prioritization of areas to implement this technology	2	Information and awareness, market failures
12.	Lack of information on prices of equipment, loan schemes etc.	13	Informationand awareness, market failures
13.	Lack of R & D on ground water availability and hydrogeology	8	Technical
14.	Limitations of the technology due to poor quality of ground water	9	Other

3.4.4 Proposed Action Plans for the Technology

The Proposed Action Plan for Boreholes/Tube wells as a drought intervention for domestic water supply is provided in table 3.11.

WATER SECTOR

Action Plan for Technology 3

Table 3.11: Proposed Action Plan for the Technology 3: Boreholes/Tube wells as a drought intervention for domestic water supply

Action 1: Reduce high capital cost					
Justification for the action: 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	• Dept. of Irrigation • NWSDB	2-3 years	----	(i) Reduced drilling cost
Action 2: Adequate funding allocation for diffusion of the technology-3 in prioritized areas (e.g. rural areas)					
Justification for the action: 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-3 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 adaptive measures with respect to climate change	V. High	• M/ Finance and Planning • M/ Irrigation and	0-1 years	0.01 M Domestic	(i) Awareness programs on possible socioeconomic benefits through the technology-3.

		Water Resources Management • M/ Water Supply & Drainage			(ii) Policy makers and legislators consider implementation of adaptive measures with respect to climate change as a priority area when taking policy decisions
II. Allocate sufficient funds from annual budget	V. High	• M/ Irrigation and Water Resources Management • M/ Water Supply & Drainage	0-1 years	----	(iii) 50% increase of funding in the annual budget within the second year for diffusion of technology 2.
III. Mechanism for additional funding from donor agencies		• NWSDB • WRB	0-1 years	0.01 M	(i) Completion of three stake holder meetings. (ii) Completion of a strong proposal for obtaining grants/loans by end of year -1.
Action 3 : Build capacity of relevant institutes to offer a certificate course to disseminate necessary knowledge and technical skills on construction of successful boreholes					
Justification for the action: The barrier related to this action is '*Lack of assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing'.* 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	V. High	• NWSDB	0- 1	0.5 M	(i) By end of year-1, adequate capacity of WRB

certificate course on construction of successful boreholes.		• WRB	years	Domestic and International	and NWSDB for successful implementation of technology-3.
II. Implement a method to register organizations having at least one person who has successfully completed the above certificate course as tube well contractors at WRB/NWSDB.	V. High	• NWSDB • WRB	1-2years	---	(i) Availability of a list of qualified borehole constructing organizations registered at WRB/NWSDB, by end of the year-2.
Action 4: Improve the knowledge on negative impacts of over extraction of ground water					
Justification for the action: The related barrier is *'Lack of understanding on negative impacts of over extraction of ground water'*. In certain areas in the country, rate of groundwater abstraction has exceeded the rate of recharge. One of the main reasons is 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 create awareness on negative impacts due to over extraction of ground water. Include this under 3-I.	V. High	• NWSDB • WRB	0-1 years	Included under 3-I.	(i) Indicators given under 3-I.
II. Raise awareness at national and sub national level	V. High	• NWSDB • WRB	2-6 years	2 M Domestic and International	(i) 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	• NWSDB • WRB	0-1 years	0.05 M Domestic and	(i) By end of year-1, availability of 1000 guide books (60 % in Sinhala/10% in English/30%

				International	in Tamil media) by end of the third quarter of year-0.
Action 5: Diffusion of the technology by giving special attention to sustainability of boreholes					
Justification for the action: The barrier is '*Lack of sustainability'.* Many boreholes constructed in Sri Lanka have become failures due to poor hydrogeological conditions of the site, over extraction and poor water quality etc. Therefore special attention should be given to sustainability of boreholes.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Construct the first successful 25 boreholes according to the priority list. After installation, implement good Operation & Management practices.	High	• NWSDB • WRB • Registered organisations	3-5 years	6 M International	(i) Availability of 25 Successful boreholes in the dry zone by end of the fifth year.
II. Construct the next successful 25 boreholes.	High	• NWSDB • WRB • Registered organisations	5-6 years	6 M International	(i) Availability of another 25 successful boreholes by end of the sixth year.
III. Establish a periodic inspection scheme/Introduce an annual license system for boreholes to prevent over extraction.	High	• NWSDB • WRB	3-6 years	5000 International	(i) Annual license system from the year-3 (ii) Inspection reports available from the year-3
Action 6 : Revise existing guidelines for safe and sustainable use of groundwater					
Justification for the action: 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 in Sri Lanka due to lack of policy/strategy in the country to control over extraction. As a result, such					

boreholes have dried-out. In coastal areas, brackish water has entered in to such boreholes.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Amend the existing guidelines for safe and sustainable use of groundwater, developed for the regolith aquifer.	High	• M/Irrigation and Water Resources Management • M/Water Supply & Drainage	0-1 years	---	(i) Availability of revised guidelines for sustainable use of ground water
II. Dissemination of above guidelines through awareness programs. This will be included under Action 4-II.	High	• M/ Irrigation and Water Resources Management • M/Water Supply & Drainage	2-6 years	Included under 4-II	(i) See indicators given under 4-II.
Action 7 : Revise existing policies/ laws related to ground water in order to control drilling of boreholes affecting vulnerable aquifers					
Justification for the action: Barrier related to this action is ' *Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers'.* Depending on the site, drilling of boreholes can affect vulnerable aquifers.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
I. Revise existing policies/laws.	High	• M/Irrigation and Water Resources Management • M/Water Supply & Drainage	0-1 years	---	(i) Availability of revised policies/laws by end of year 1.

Action 8 : Establish a mechanism for adequate availability of financial resources through a low-interest loan scheme					
Justification for the action: Barrier – '*High interest on loans for importers/producers of tube wells.* Currently there is no mechanism in the country to establish low-interest loan 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	• Central Bank • Treasury • Private sector	0-1 years	---	i) With effect from end of year-1, availability of financial incentives such as concessionary interest and longer grace periods for loans.
Action 9: Establish a mechanism for adequate availability of financial resources through an import tax relief					
Justification for the action: Barrier related to this action is '*High import tax for importers/producers of tube wells due to lack of mechanism/strategy to establish import tax relief'.* Currently there is no mechanism in the country to establish an import tax relief for 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	---	By end of year-1, implementation of import tax relief.
Action 10: Update information on status of aquifers in the dry zone of Sri Lanka by WRB/NWSDB					
Justification for the action: '*Lack of information on ground water resources'* 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	• WRB • NWSDB	2-6 years	0.01 M International	Availability of annual data on ground water resources
Action 11: Develop a mechanism for prioritization of areas/sites for installation of boreholes and preparation of a priority list					
Justification for the action: Barrier related to this action is '*Lack of prioritisation of areas to implement this technology'* At present a prioritized list for the country for introduction of the technology 3 is not available.					
Sub Action No	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
1. Formulate a protocol/mechanism	High	• M/Irrigation and Water Resources Management • M/Water Supply & Drainage	0- 1 years	--	(i) Availability of a protocol for preparation of a priority list by end of year 1.
I. Collect data on highly vulnerable areas for climate change, need and urgency	Medium	• NWSDB • WRB	0-2 years	5000 Domestic	(i) 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	• NWSDB • WRB	2-3 year	---	(i) Availability of a priority list by year 3.

Action 12: Awareness campaigns on special facilities provided for tube well constructors

Justification for the action: 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 to constructors/producers especially in rural areas.	Medium	• NWSDB • WRB	2-6 years	5000 International	(i) Publicity on special facilities provided to constructors/producers through media.

Action 13: Promote R &D on ground water availability/quality and hydrogeology of various sites

Justification for the action: 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-geolological data in a systematic basis.	Medium	• NWSDB • WRB	2-6 years	--	

Action 14: Prevent degradation of Ground water quality

Justification for the action: *Barrier – 'Limitation of the technology due to poor quality of ground water'*

If the quality of ground water is poor, quality of borehole/tube well water will also be poor. 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 quality required.

Sub Action No	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
I. Regular monitoring of quality of borehole water. This can be incorporated with present water quality surveying program.	Medium	• M/ Irrigation and Water Resources Management • M/Water Supply & Drainage	3-7 years	0.02 M International	(i) Availability of data on quality of borehole water.
II. Monitor health conditions of people consuming water from above boreholes and study whether there is a relationship between health issues and borehole water quality.	Medium	• Dept. of Health	3-7 years	0.05 M International	(i) Availability of data on health conditions of people consuming water from above boreholes. (ii) Results of statistical analysis
Total Cost of Technology 3					**Approx: US $ 14.67 million**

V. High = Very High

CHAPTER 4

Technology Action Plan for the Coastal Sector

4.1 Actions at sectoral level

Major action to be taken as adaptations to climate change under the coastal sector are to take precautionary measures to reduce the impacts of Sea Level Rise (SLR), coastal inundation and erosion that may occur in the coastal belt. These actions are mainly focused on the sand dunes, mangroves and coral reefs which are sensitive coastal ecosystems that act as natural barriers against waves, tides, storm surges, tsunami, etc. that cause damage to coastal environment.

4.1.1 Short sector description:

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 issues as salt water intrusion[28]. 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[29]. 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[30].

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[31]. It includes several sensitive ecosystems such as, coral reefs, sea grass beds, sand dunes, mangroves, salt marshes and sandy, pebble and rocky beaches.

Role of the sector: Coastal belt of Sri Lanka is very important for many socioeconomic activities, some of which are playing a major role in attracting foreign exchange (e.g. tourism, ornamental & food fish trade,

[28] Jayatilake, 2008

[29] Ministry of Environment, Climate Change Vulnerability in Sri Lanka -a, 2010

[30] Ministry of Environment, Climate Change Vulnerability in Sri Lanka –b, 2010

[31] CZMP of Coast Conservation Department, Olsen et.al, 1992

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.

GHG emissions level and trends: 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 also includes growth of corals which removes carbon dioxide from the aquatic environment.

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 tsunami 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 coast. 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[32]. 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[33].

Existing Policies and Laws related to the Sector and Technology Deployment

a) Existing Policies Involved:

There are four 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

[32] Practical Action, 2011

[33] ME, 2010, National Climate Change Adaptation Strategy for Sri Lanka- 2011 to 2016

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 below (Table 4.1 and 4.2).

Table 4.1: Existing policy framework related the 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	• 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. • Policy target is to achieve a healthy and pleasant environment sustaining nature for the well-being of the people and the economy. • 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 sharing of benefits and costs.
2.National Forestry Policy (NFP)	Enacted in 1995.	Ministry of Environment and Natural resources/Forest Department	• 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. • 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
3.National Policy on Wild Life Conservation	June 2000	Department of Wildlife Conservation (DWLC)	• Objective is to conserve wildlife resources, through protection, research, education, sustainable use and benefit sharing, for the benefit of present and future generation. • To maintain ecological processes and life-sustaining systems. • To manage all components of genetic diversity, as resources to improve crop plant and farm animal, and to develop in a fair and equitable manner. • To ensure sustainable use and equitable sharing of benefits. • To conserve native and endemic species and their habitats, so as to maintain the overall species richness and ecological integrity of the country. • To encourage the development of biological repositories, for the purposes of conservation education and science. • To encourage the private sector and communities to join as a full partners in all aspects of the wildlife-conservation process
4. National Policy on Wetlands	Enacted in 2005	Ministry of Environment	• 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.
5. Mahinda Chinthena & Mahinda Chinthena way forward	2005 Amended in 2010	Ministry of Finance & Planning	• 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. • 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

			• Direct employment generation through development of coastal resources. • 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. • 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. • 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. • 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.

b) Existing Laws Involved:

Table 4.2: Existing laws related the sector and technology deployment

Existing laws	When Enacted and Revised	Responsible Authority	Main Contents
- Coast Conservation Act No. 57 - Coast Conservation Act No. 64 - Coastal zone	Enacted In 1981, Amended in 1988	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

management plan (CZMP) Conservation Act. 1990 - Revised CZMP	1990 1997 & implemented in 2004		certain written lows; 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.

4.1.2 An overview of prioritized technologies

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, as an initial adaptation measures against climate change, the following three technologies have been prioritised as soft barriers that would help socioeconomic development in the coastal region while acting as barriers against SLR, coastal inundation and erosion.

- Sand dune Rehabilitation
- Restoration of Mangroves
- Restoration of Coral Reefs

A) Sand dune Rehabilitation

Aimed at facilitating the growth of the sand dunes by replanting dune vegetation, especially in areas affected by anthropogenic activities and in areas vulnerable to SLR, coastal inundation & erosion. In addition to providing a protection from SLR and coastal erosion, it will also act as a wind belt in areas where strong winds persist. It is recommended to identify dune plants most suitable for replanting taking in to account their economical and medicinal importance during this process. Further, the plants of economic and medicinal value will provide an alternative income source for coastal communities. With the improvement of soil conditions due to rehabilitation, many other natural plant communities also will get established improving their biodiversity. Statistics on the status of employment in the activities within sand dune areas has not been recorded and it is negligible when compared with employment opportunities in other sectors.

B) Restoration of Mangroves

One of the most commonly restored wetland ecosystems for coastal protection in Sri Lanka is mangroves. Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. In addition to the provision of ecosystem functions, the mangroves are instrumental in supporting the livelihoods of the local coastal communities. These mangrove systems also perform vital hydrological functions and serve as breeding grounds for fish & other marine species.

Mangrove rehabilitation is an activity currently being practiced although it is not done according to a properly formulated zonal plan. Therefore, this program recommends preparing a zonal plan, to identify the mangrove areas severely affected due to anthropogenic activities, the levels of restoration needed and the natural mangrove plant diversity as a prerequisite for the rehabilitation programme.

Replanting of mangroves will not only provide protection from sea level rise but it will also provide other socio economic benefits to local communities, opportunities for the development of tourism industry and SMEs based on mangrove products as an income source for local communities. Improvement of mangroves will also improve the lagoon fish production.

C) Restoration of Coral Reefs

Coral reef restoration has been given priority only during the past two decades but transplanting corals and that too is conducted only at experimental level in the Southern Coastal belt. Since these experiments have has shown promising results, it is recommended to transplant corals in areas where the reefs have been subjected to destruction by the anthropogenic activities. Thus far there has been no involvement of the responsible authorities for coral reef restoration activities and most research initiatives are by the researchers, conservationists and other scientists studying coastal marine biodiversity.

4.1.3 General Barriers and proposed measures

There are seven general barriers for the implementation of the proposed adaptation technologies in the coastal sector and they are as follows;

(i) Inadequate financial assistance
(ii) Inadequate government patronage
(iii) Poor enforcement or lack of resource management plans
(iv) Unsustainable practices /resource utilisation
(v) Inadequate inter agency coordination

(vi) Inadequate awareness
(vii) Inadequate knowledge on the technologies

Out of the above, barriers (i), (ii), (iii), (v) and (vii) are common for all the three technologies and the barriers (iv) and (vii) have relevance to Rehabilitation of sand dunes and Restoration of coral reefs only.

Proposed measures for general barriers

(h) Inadequate financial assistance

Following three measures are proposed to overcome this barrier;

a) Seek annual government funding and also from other sources such as donors, NGOs & INGOs for project specific activities.
b) Encourage self sustaining economic activities using mangrove products.
c) Introduce eco-friendly activities with financial gains.

(ii) Inadequate government patronage

a) Justify government financing by highlighting the socioeconomic spin offs due to restoration of sand dunes and their vegetation and also the potential economic losses in the absence of investments for dune rehabilitation.
b) Encourage the government to increase the budgetary allocations for sustainable socioeconomic programmes.
c) Awareness creation on the importance of sustainable management of mangroves to enable the relevant government officials to allocate required funds.
d) Conduct awareness programs to policy makers, highlighting the potential socioeconomic gains of reef restoration

(iii) Poor enforcement or lack of resource management plans

a) Conduct awareness programmes to law enforcement officers, on the importance of proper enforcement of coastal zone management regulations.
b) Conduct awareness programmes to all stakeholders, on the existing rules and regulations and on the necessity of abiding by the existing laws for sustainability of the sand dune ecosystems & their resources.
c) Provide assistance to relevant government agencies to prepare suitable management plans for rehabilitation of mangroves

d) Organise awareness creation meetings/workshops for the senior officials of the line agencies to highlight the importance of rehabilitation of mangroves for socioeconomic benefits
e) Establish community participatory organizations in the vicinity of coral reefs to ensure sustainability of coral reefs and to monitor the development programmes
f) Appoint properly constituted competent committees to review the IEE/EIA reports related to development and economic activities in the coastal zone as deemed appropriate.

(iv) Unsustainable practices/resource utilisation

a) Development of multidisciplinary projects in collaboration with research/academic institutions.
b) Identify strategies to develop and improve fruitful collaborations, to

- Identify location specific problems in sand dune conservation.
- Prepare activity plans to overcome the problems to achieve desired development goals

c) Conduct awareness programmes to key officials from different line ministries indicating the need for effective inter agency coordination for successful coral restoration programmes.
d) Engage trained personnel from respective line agencies for coral transplanting, reef cleaning and reef restoration programmes.

(v) Inadequate coordination & among different Institutions

a) Form a core group of actors selected from the coastal communities
b) Provide alternative sources of income or employment, within the same region, to those involved in destructive activities
c) Government agencies should develop suitable strategies to better appreciate and understand the role of NGOs involved in community participatory programs related to sand dune conservation and restoration activities.
d) Conduct awareness programs to those involved in unsustainable practices within mangrove areas
e) Enforcement of strict regulations and appropriate punitive actions against culprits.
f) Conduct awareness programs on the impacts of unsustainable socio economic activities related to reefs
g) Offer alternative livelihood opportunities or training for those involved in coral destructive self employment.

(vi) Inadequate awareness

a) Conduct awareness programmes to all stakeholder coastal communities on the importance of restoring sand dune ecosystems for their own wellbeing for securing their assistance for restoration of sand dunes.
b) Involve unemployed coastal youth in eco-tourism and the coastal tourist hoteliers for sand dune restoration and coastal eco-tourism.
c) Establish nature trails among dune vegetations and turtle nesting sites with the involvement of local tourism authorities.
d) Establish herbal gardens, by planting dune vegetation having medicinal importance.
e) Encourage floating hotels in the vicinity of coastal sand dunes.
f) Conduct awareness programs to different stakeholders separately and collectively highlighting the non extractive uses/importance, role and functions of corals.
g) Formulate development plans with stakeholder participation.
h) Conduct awareness programs on the importance of controlling potential pollution and sedimentation due to land-based and costal activities.

(vii) Inadequate knowledge on the technologies

a) Encourage rehabilitation of dune vegetations with plants of economic and medicinal importance.
b) Conduct awareness/training programs to disseminate knowledge on

- Plants suitable for sand dune rehabilitation.
- Tissue culture & other propagation methods to produce sufficient numbers of plants/ propagules for replanting.

c) Encourage the government to introduce proven economically important exotic dune plants (*Pandanus spp.*) based on feasibility studies.
d) Sustainable utilisation of dune vegetation for SMEs
e) Establish regulatory mechanisms for mangrove replanting programs.
f) Develop zonal plans to identify priority mangrove areas requiring rehabilitation using GIS & remote sensing techniques.
g) Identify most suitable species for replanting.
h) Provide adequate training to members selected from the stakeholder groups and use them as catalysts for implementing the respective programs and also as trainers for the rest of the community.

4.1.4 Specific Measures Proposed for the Selected Technologies

The specific measures proposed for prioritized technologies in the coastal sector are given in Table 4.3 below.

Table 4.3: Proposed measures for Sand dune Rehabilitation

No	Recommended Measures
1.	Request project specific annual funding from the government sources.
2.	Conduct awareness programs to all stakeholders of the coastal regions on existing policies, rules & regulations, socioeconomic importance of sand dune ecosystems and their non-extractive uses.
3.	Encourage planting of dune species of economic and medicinal importance; Establish SMEs and provision of incentives to trained persons to manage SMEs; Conduct feasibility studies for introduction of exotic species of *Pandanus* spp. of economic importance.
4.	Develop multidisciplinary projects with stakeholder collaboration and identify strategies to develop and improve fruitful collaborations for sand dune rehabilitation.
5.	Build capacity at R & D institutions for undertaking research related to environmental protection, conservation & management.
6.	Form a committed group of actors selected from the coastal communities; Provide alternative sources of income or employment within the same region to those involved in destructive activities; Government departments and their line ministries to develop suitable strategies to better appreciate and understand the role of NGOs in community participatory programs.
7.	Train and retain adequate number of staff and prepare a bibliography of available trained personnel
8.	(i) Encourage off-shore sand extraction for building construction (ii) Popularise construction technologies not involved with coastal sand.

Table 4.4: Proposed measures for Restoration of Mangroves

No	Recommended Measures
1.	Attract funds through properly formulated proposals and self sustaining economic activities using mangrove products
2.	Improve awareness and provide assistance to relevant government agencies to prepare suitable management plans for rehabilitation
3.	Encourage non-extractive and/or sustainable utilisation of mangroves and its resources and reduce pollution & sedimentation
4.	Establish regulatory mechanisms for replanting mangroves based on properly formulated zonal plans using GIS & remote sensing techniques
5.	Conduct research projects related to rehabilitation, sustainability and value added products related to mangroves.

Table 4.5: Proposed measures for Restoration of coral reefs

No	Recommended Measures
1.	(i) Attract project soecific funding from local & foreign sources, NGOs etc., (ii) Introduce eco-friendly activities having potential for financial gains.
2.	(i) Establish community participatory organizations in the vicinity of coral reefs to monitor the development programmes, ensure sustainability of coral reefs and to help mitigation practices; **(ii)** Appoint competent committees to review the IEE & EIA
3.	Improve stakeholder awareness on the impacts of unsustainable economic activities related to reefs and non-extractive uses of coral reefs and promote eco friendly activities.
4.	Implementation of river basin management programs and regulate land use practices to reduce sedimentation due to agriculture, mining and other modes of erosion.
5.	Provide adequate training to members of stakeholder groups and line ministries and use them as leaders for implementation of the respective restoration programs and as trainers to train others
6.	(i) Formulate development plans with stakeholder consultations; **(ii)** Conduct regular monitoring programmes by involving stakeholders trained to be alert about natural phenomena,

4.2 Action Plan for Technology 1: Rehabilitation of Sand Dunes

4.2.1 Description of the Technology

Natural sand barriers with their vegetation could be used as soft barriers as an adaptation against coastal erosion and inundation due to climate change induced sea level rise. Wherever they have been removed for anthropogenic activities, their rehabilitation need to be done by replanting dune vegetation. Propagation of plants could be done by using seeds or tissue culture techniques.

Facilities to collect seeds of *Pandanus* and other dune plants with economic or medicinal value and to establish nurseries to raise the required number of propagules should be provided at academic or research institutes or at community centres established for this purpose. In areas where dune sand has been removed for anthropogenic activities, such as construction work, replanting could be carried out after beach nourishment to improve the quality of the substratum to speed up the establishment of dune vegetation. In addition to replanting of *Pandanus* spp., other dune plant species should be introduced to the same area or allow natural regeneration over time with the improvement of environmental conditions upon replanting *Pandanus* sp. Terraced plantations should be introduced.

Pandanus plantations are widely practiced in Pacific islands and it has been accepted by the local communities due to its economic value. The successful post tsunami rehabilitation programs appear to suffer due to the lack of maintenance in view of inadequate government patronage to promote such projects. If the funding is made available, this project will be a feasible one and would provide opportunities for cottage industries based on *Pandanus* leaves.

Plant species that grow on dune sand are abundant in Sri Lanka and scientifically organised terraced plantations would not only provide protection to the coastal sand dunes against coastal erosion, storm surge, tsunami and other harmful coastal activities, but it will also provide alternative income sources for coastal communities and will improve the aesthety of the sandy beaches. 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 would be the potential beneficiaries of this technology.

It will provide a protection from coastal erosion and also will act as a wind belt in areas where strong winds persist. In addition, *Pandanus* plant and other plants of economic and medicinal value will provide an alternative income source for coastal communities. Improved soil conditions due to rehabilitation would facilitate natural regeneration of plant communities while improving their biodiversity.

4.2.2 Target for Technology Transfer

The initial target for the technology is 20 ha within a period of 7 years. The activity schedule for rehabilitation of sand dunes is summarised below.

- Identification and demarcation of 10 suitable sites each having approximately 2 ha
- Conduct awareness programs
- Train 100 persons selected from 10 sites
- Establish dune plant nurseries
- Re-planting of dunes and select best sites for maintaining plantations
- Commence establishment of Small and Medium Industries (SMEs) in successful sites
- Select the most suitable sites to re-establish dune vegetation and expand the area up to 50 ha by 3rd quarter of the sixth year. The total period involved will be 7 years.

4.2.3 Barriers to Technologies diffusion

Ten (10) key barriers comprised of one (01) economic & financial, two (02) policy, legal & regulatory, one (01) network failures, one (01) institutional & organizational capacity, one (01) human skills, one (01) social, cultural & behavioural, one (01) information & awareness and, one (01) technical and one (01) "Other" have been identified.

The list of key barriers and hierarchy classification is given in table 4.6.

Table 4.6: List of key barriers and hierarchy classification for the technology 1

Technology Name: Rehabilitation of Sand Dunes			
No.	**Key Barriers Identified**	**Priority Rank (1-5)**	**Category of Barriers**
1.	Inadequate funds for restoration of sand dunes through natural beach nourishment and planting of dune vegetation and to conduct awareness programs	2	Economic and financial
2.	Poor enforcement of coastal zone management regulations	1	Policy, legal & regulatory
3.	Low priority given for funding for environmental protection and R&D under the existing financial policy	3	Policy, legal & regulatory
4.	Inadequate inter agency coordination among relevant government agencies	3	Network failures
5.	Inadequate opportunities for research	5	Institutional & organisational capacity
6.	Inadequate trained personnel / experts to provide knowledge on technologies used	4	Human Skills
7.	Lack of commitment by the coastal communities & industries to protect existing sand dunes and rehabilitation due to difficulty in giving up destructive coastal resources based livelihood activities	5	Social, cultural & behavioural
8.	General lack of awareness on the non extractive uses/importance, role and functions of coastal	2	Information and Awareness

	sand dunes for national development and protection of the environment, at all levels of the society		
9.	Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation	3	Technical
10.	Negative impacts of extracting sand for construction industries	5	Other barriers

4.2.4 Proposed Action Plans for Rehabilitation of Sand Dunes

The Proposed Action Plan for Rehabilitation of Sand Dunes is provided in table 4.7.

COASTAL SECTOR

Action plans for Rehabilitation of Sand Dunes

Table 4.7: Proposed Action plans for Rehabilitation of sand dunes

Measure/Action 1: Provide annual funding from the Government, 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 by beach nourishment and planting of dune vegetation and to conduct awareness programs					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time Frame**	**Cost (US$) & Funding**	**Indicators**
I. Provide funding for implementation of sand dune rehabilitation activities.	High	Coast Conservation 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 awareness programmes to all stakeholders of the coastal regions on existing policies, rules & regulations, socioeconomic importance of sand dune ecosystems and their non-extractive uses					
Justification for the action: General lack of awareness on the socioeconomic importance of sand dunes and its vegetation and the non-extractive uses of sand dune resources at all levels of the society					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time Frame**	**Cost (US$) & Funding**	**Indicators**
I. Conduct awareness workshops					

a) Awareness programmes to all stake holders on socio-economic benefits of sand dune ecosystems and its vegetation and on technologies involved in 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 to be involved 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 involve 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 trained persons for identification of suitable dune plants and on 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 provision of incentives to trained					

persons to establish SMEs; **III.** Conduct feasibility studies for introduction of exotic species of *Pandanus* spp. of economic importance.					
Justification for the action: General lack of awareness on the non extractive uses/importance role and functions of coastal sand dunes; Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time Frame**	**Cost (US$) & Funding**	**Indicators**
I. Establishment of Tissue culture laboratories & nurseries for propagation of plants for dune re-plantatings & herbal gardens.	High	Universities, Agrarian research institutes,	1-3 years	D & I US $ 600,000	- Establishment of 2 tissue culture laboratories at research/higher educational institutes by 2nd year. - Establishment of 10 nurseries and 10 Dune plantations/herbal gardens of economic/medicinal importance by 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 years	D & I $200,000	- Establishment of 10 dune vegetation related SMEs by 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 are identified by the end of 2 years
Measure/Action 4: (I) Development of multidisciplinary projects in collaboration with research/academic institutions, identify strategies to develop and improve fruitful collaborations, identify problems within the locations with sand dunes and prepare activity plans to overcome the problems to reach development goals					
Justification for the action: Inadequate inter agency coordination					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time Frame	Cost (US$) & Funding	Indicators
I. Preparation of R & D projects/plans in collaboration with government agencies having responsibilities for activities in the coastal areas.	Medium	National Science Foundation (NSF)	Every 3- 5 years	D US $ 35000 (Funding for projects are not included)	- Approval of funding for at least 3 project proposals once in every 3 years.
II. Conduct regular consultations with relevant institutions for identification of specific and important problems for implementation of collaborative activities related to conservation & sustainable management of dune ecosystems.	Medium	Provincial councils. M/Environment	0-2	D US $ 24,000	- Development of fruitful collaborations among relevant institutions from 2 years
Measure/Action 5: Train and retain adequate number of staff and prepare a bibliography of available trained personnel					
Justification for the action: 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	- 5 to 10 trained personnel in each of the institutions under three line ministries to serve as trainers within 2-5 years .

II. Develop strategies to retain trained Persons (e.g. obligatory service based on bond agreements)	Medium	M/Environment; M/Agricultural dev; M/Higher ed;	No time limits	the initial budget)	- Retention of at least 5 trainers in each of the relevant institutions after 7 years.
III. Preparation of a bibliography of trained persons in relevant fields,	Medium	NSF/ Centre for Agrarian Research policy(CARP)	0-0.1 Years	D US $ 5,000	- Database & a bibliography of experts and their research out puts prepared after 1 year
Measure/Action 6: Form a committed group of catalysts selected from the coastal communities, provide alternative sources of income or employment within the same region to those involved in destructive activities; Government agencies to develop suitable strategies for better understanding and appreciation of NGOs involved in community participatory programmes.					
Justification for the action: Lack of commitment by the coastal communities and industries to protect existing sand dunes and to rehabilitate disturbed sand dunes due to difficulty in giving up livelihood activities based on destructive coastal activities.					
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 of dune ecosystems through community participation after 1.5 years.
II. Provide employment to persons involved in destructive activities (Tourism, SMEs, etc.)	Medium	CCD/M/Environment/NGOs	1 -6 Years	D & I US $ 150,000	- 50% reduction of dune destructive activities after 3 years and 90% reduction by 7th year
III. Development of community participatory programmes by government institutions in collaboration with NGOs	Medium	CCD/NGOs	0-7 years	D & I US $ 450,000	- Establishment of at least 10 community participatory socioeconomic programmes by the end of 7 years.

Measure/Action 6: Encourage off-shore sand extraction for building construction**; II.** Popularise construction technologies, not involving coastal sand					
Justification for the action: Use of dune sand for construction work. Action is 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	- 25% reduction of removal of sand from dunes and coastal belt close to sand dunes after 0.5 years and 90% reduction by 7 years.
Measure/Action 9: Build capacity at R & D institutions to handle research related to environmental protection, conservation & management, by incorporating this need in the corporate plan					
Justification for the action: Inadequate opportunities for research activities related to sand dune rehabilitation					
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 to including required 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.
Total Cost of Technology 1:				**US $ 2.395 million**	

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; NBR0 – National Building Research Organization; NGOs – Non-governmental Organizations.

4.3 Action Plan for Technology 2: Rehabilitation of Mangroves

4.3.1 Description of the Technology

Mangroves is one of the most commonly restored wetland ecosystems in the country for coastal protection. Twelve Indian Ocean countries affected by the tsunami waves on 26th of December 2004 revealed that coastal areas with dense and healthy mangrove forests played a vital role in buffering the force and such areas suffered fewer losses and less damage to property than those areas in which mangroves had been degraded or converted to other land use[34]. Costs of sea defences are less when they are located behind large areas of mangroves[35]. Even before the Tsunami, Sri Lanka has been experiencing rapid loss of mangrove ecosystems mainly due to anthropogenic factors including unprecedented growth of the tourism sector. In addition to the provision of ecosystem functions, the mangroves are instrumental in supporting the livelihoods of the local coastal communities and the vital hydrological functions and serve as breeding grounds for fish & other marine species.

In Sri Lanka, mangrove systems cover an area of 6000-7000 ha along the coastline of Puttalam, Baticoloa and Tricomalee districts and the largest is the Puttalam Lagoon – Dutch Bay – Portugal Bay complex (3385 ha). This unique ecosystem is home to over 20 true mangrove species. The major genera that represent these species are *Avicennia, Rhizophora*, *Bruguiera*, and *Sonneratia*. The mangrove forests in Bentota are highly threatened due to expanding tourism. The legal jurisdiction of the mangrove ecosystem falls under the Forest Department, Department of Wildlife Conservation, and the Coast Conservation Department. However, there appears to be inadequate legal protection for these pristine ecosystems.

Any disadvantages of wetland restoration are minimal and it also requires a degree of expertise, especially in locations where wetland re-colonisation has to be encouraged by transplanting wetland plants. Replanting mangroves is a widely accepted technology for restoration of degraded mangrove ecosystems worldwide, but some wetland habitats will be more difficult to recreate than others and will require greater expertise. The very common and widely distributed 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 they are the most appropriate species for mangrove reforestation. The common category of mangrove species represent *Aegiceras corniculatum, Avicennia officinalis, Bruguiera cylindrica, Bruguiera sexangula, Ceriops tagal, Heretiera littoralis, Pemphis acidula, Sonneratia alba, Nypa fruticans* are also suitable for replanting purposes due to their wide distribution although found in few numbers[36]. Replanting of mangroves will not

[34] Kathiresan & Rajendran, 2005

[35] Barbier, 2008

[36] Information brief on mangroves of Sri Lanka, IUCN

only provide protection from climate change induced sea level rise , but also will provide other socio economic benefits to local communities and also development of tourism industry and Small and Medium Enterprises (SMEs) based on mangrove products will provide an income source for local communities. Improvement of mangroves will also improve the lagoon fish production as well.

4.3.2 Target for Technology Transfer and Diffusion

The target for the technology transfer is 20 ha within a period of 5 years. This includes 10 mangrove sites each with an area of approximately 2 ha. The schedule of activities for rehabilitation of mangroves are summarised below.

- Selection of 10 mangrove sites each with an area of approximately 2 ha.
- Conduct awareness and training programmes.
- Collection and preparation of propagules for replanting.
- Establishment of 20 nurseries for production of propagules.
- Preparation of sites and planting of propagules.
- Evaluate the success of replanting programme by monitoring the growth and survival of propagules. The total period involved will be 5 years.

4.3.3 Barriers to the technology's diffusion

Eight key barriers comprised of one (01) economic & financial, two (02) policy, legal & regulatory, two (02) social cultural & behavioral, one (01) each of technical, institutional & organizational capacity and "Other" have been identified.

The list of key barriers and hierarchy classification for the technology is given in table 4.8.

Table 4.8: List of key barriers and hierarchy classification for the technology 2

Technology Name: Rehabilitation of Mangroves			
No.	**Key Barriers Identified**	**Priority Rank (1-5)**	**Category of Barriers**
1.	Inadequate financial assistance for restoration programmes.	3	Economic & Financial
2.	Inadequate Government patronage & commitment.	5	Policy, legal & regulatory

3.	No proper legal authority for protection and management of mangroves and therefore lack of management plans or strategies to protect and manage this resource.	1	Policy, legal & regulatory
4.	Unsustainable practices (unplanned developments and projects) in areas with mangroves. i.e. removal of mangrove vegetation for development projects, waste disposal etc.	2	Social cultural & behavioural
5.	Destructive lagoon fishing techniques.	5	Social cultural & behavioural
6.	Replanting mangroves without establishing proper zonal plans and use of unsuitable species.	5	Technical
7.	General lack of appreciation/ awareness on the non extractive uses/importance, role and functions of mangroves at all levels of the society.	4	Institutional and organizational capacity
8.	Illegal & unsustainable land use practices in the hinterland, which cause heavy sedimentation in lagoons and estuaries.	4	Other barriers

4.3.4 Proposed Action Plans for the Technology 2

The Proposed Action Plan for Rehabilitation of Mangroves is provided in table 4.9.

COASTAL SECTOR

Action plans for Mangrove Rehabilitation

Table 4.9: Proposed Action plans for Mangrove Rehabilitation

Measure/Action 1: Attract funds through properly formulated proposals and through encouragement 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 workshops to attract funds, etc.					
a) Two workshops for preparation of suitable project proposals and to attract funding	Medium	Coast Conservation Department (CCD)	0 -1 years	D & I US $ 6,000	- Two successful project proposals which ensure funding by end of year 1. - Availability of funds by the end of year 2.
b) Awareness programmes to officials from the Ministry of Finance & Planning on socioeconomic importance of allocating funds for restoration of mangroves	Medium	CCD	0-1.0 years	D & I US $ 3,000	- Increased annual budgetary allocations to relevant institutions from 1.0 year up to 7 years
II. Encourage community-based organisations to launch mangrove based programmes yielding financial gains (eco-tourism, SMEs, etc.)	Medium	CCD/NGOs	1-7 year onwards	D & I 100,000 initially	- Establishment of Community based self sustaining SMEs and. Ecotourism by the end of year 2 and continuation up to 7 years.
Measure/Action 2 : Improve awareness and provide assistance to line ministries or institutions under them to prepare suitable management plans for rehabilitation					

Justification for the action: General lack of appreciation/awareness on the non-extractive uses/importance, role and functions of mangroves, unsustainable practices in mangrove areas, lack of management plans or strategies to protect and manage mangroves					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US$) & Funding**	**Indicators**
I. Conduct workshops for 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 is 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 on popular television channels and news papers for 3 year. - 70% Improved Awareness among all stakeholder after 3 years
d) Training programmes to the community on tissue culture techniques for production of propagules, maintenance of nurseries, replanting etc	High	CCD	0.5 – 2 years	D & I US $ 20,000	- Availability of trained personnel for all aspects of mangrove rehabilitation programmes within 2 years.
Measure/Action 3 : Encourage non-extractive and/or sustainable utilisation of mangroves and its resources and reduce pollution & sedimentation					

Justification for the action: To develop strategies to protect and manage mangroves due to absence of a proper legal authority to protect from destructive activities and for sustainable management					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US$) & Funding**	**Indicators**
I. Encourage formation of community organisations to conserve, manage, produce propagules through tissue culture, replant mangroves and develop eco-friendly socioeconomic activities in mangrove areas.	Medium	CCD/NGOs	0.5 onwards	D & I US $ 150,000	- Production of sufficient numbers of propagules for replanting from end of year 1 to year3 and onwards. - Community organisations actively involved in related activities. from year 1 onwards
II. Strict enforcement 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	- 50% reduction of harmful anthropogenic activities within 2 years and 90% reduction after 5years.
Measure/Action 4. Establish regulatory mechanisms for replanting mangroves using zonal plans developed by means of GIS & remote sensing techniques					
Justification for the action: Currently replanting of mangroves is carried out without proper zonal plans and by using unsuitable species of mangrove plants					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US$) & Funding**	**Indicators**
I. Develop a zonal plans to streamline mangrove replanting programmes	Medium	CCD/Forest Department (FD)	0.5-1.5	D & I US $ 40,000	- Zonal plans prepared for mangrove areas by end of 1.5 years.
II. Use of aerial photographs and past information to identify most suitable species to be used in mangrove replanting programmes,	Medium	Forest Department (FD).	0.5 -2	D & I US$ 20,000	- Availability of information on suitable mangrove plant species to be used for different sites for planting after 2 year.

Measure/Action 5: Conduct research projects related to rehabilitation, sustainability and value added products related to mangroves.					
Justification for the action: Currently replanting of mangroves is carried out by using unsuitable species of mangrove plants					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US$) & Funding**	**Indicators**
1. Conduct research programs on rehabilitation, sustainability and value added mangrove products.	High	CCD/FD/Higher Education,	0-5 years and onwards	D & I US$ 200,000	- Availability of research findings for sustainable utilisation of mangroves after 1.5 years
Total Cost of Technology 2:				**US $ 0.698 million**	

High = Very High; D – Domestic; I – International; CCD - Coast Conservation Department; SD – Forest Department; NGOs – Non Governmental Organizations; CEA – Central Environmental Authority

4.4 Action Plan for Technology 3: Restoration of Coral Reefs

4.4.1 Description of the Technology

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[37].

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) 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 $US375 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[38].

As an adaptation to climate change induced sea level rise, this natural reef building mechanism continued during the evolutionary process, should 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 have been successfully implemented on pilot scale in Sri Lanka.

[37] Garison, 1995; http://en.wikipedia.org/wiki/

[38] http://en.wikipedia.org/wiki/Coral_reef; Kumara 2008

4.4.2 Target for Technology Transfer and Diffusion

The anticipated time line to achieve the results is 7 years. The scheduled activities with respect to successful transfer and diffusion of the technology Restoration of Coral Reefs are summarised below:

(i) Selection of suitable reef sites for transplanting of corals/establishment of artificial reefs, (ii) Conduct awareness/training workshops to different stakeholder groups, (iii) Preparation of material needed for transplanting programme, (iv) Conduct transplanting and monitoring programs with the possibility of expanding the program a wider area once proven success, (v) Evaluation of the program during the final quarter of the third year with appropriate recommendations on suitability of the technology as an climate change adaptation measure.

The total period involved will be 7 years.

4.4.3 Barriers to the technology's diffusion

Ten (10) key barriers comprised of one (01) economic & financial, two (02) policy, legal & regulatory, three (03) social cultural & behavioral, one (01) each of network failure, information & awareness, technical and "Other" have been identified.

The list of key barriers and hierarchy classification for technology 3 is given in table 4.10.

Table 4.10: List of key barriers and hierarchy classification for the technology 3

Technology Name: Restoration of Coral Reefs			
No.	**Key Barriers Identified**	**Priority Rank (1-5)**	**Category of Barriers**
1.	Inadequate financial assistance for monitoring & restoration programmes	5	Economic and financial
2.	Inadequate government patronage & financial assistance at central &/or provincial level for coral reef conservation and rehabilitation programmes	3	Policy, legal & regulatory
3.	Poor enforcement of coastal regulations and lack or poor EIAs when establishing large tourist resorts in the vicinity of coral reefs	2	Policy, legal & regulatory

4.	Unsustainable resource utilisation (e.g. corals for lime industry, collection of ornamental fish, use of explosives for fishing)	1	Social cultural & behavioural
5.	Sedimentation and pollution due to unplanned socioeconomic activities in the coastal belt and hinterland	2	Social cultural & behavioural
6.	Destructive activities against conservation /rehabilitation programmes, transplanting, etc	5	Social cultural & behavioural
7.	Inadequate inter agency coordination	4	Network failure
8.	Inadequate stakeholder awareness	3	Information and awareness
9.	Inadequate trained personnel to involve in coral rehabilitation programmes	2	Technical
10.	Natural phenomena that bleach corals	3	Other barriers

4.4.4 Proposed Action Plans for Restoration of Coral Reefs

The Proposed Action Plan for Restoration of Coral Reefs is provided in table 4.11.

COASTAL SECTOR

Action plans for Restoration of Coral reefs

Table 4.11: Proposed Action plans for Restoration of coral reefs

Measure/Action 1: **(i).** Attract project specific funding from local & foreign sources, NGOs etc. and introduce eco-friendly activities with financial gains.					
Justification for the action: 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	- At least 2 successful major collaborative project proposals completed within 1.5 years.
II. Introduce eco-friendly socio-economic activities to attract foreign exchange from visitors to reef sites.	Medium	CCD &Ministry of Tourism	1.0 onwards	D & I US $ 100,000	- Establishment of 4 eco-friendly socioeconomic activities after 5 years. - 25% to 80% increase in the income from local & foreign visitors 2-7 years.
III. Conduct 2 awareness programmes to government officials who allocate funds from the annual budget, in order to improve government patronage & funding for restoration	Medium	CCD & M/Finance & Planning	0.5-1.0 years	D & I US $ 10,000	- Increased allocation of funds from annual budget for coral restoration after 1 year.

Measure/Action 2: Establish community participatory organizations in the vicinity of coral reefs to monitor the development programmes, ensure sustainability of coral reefs and to help mitigation practices; **(ii).** Appoint competent committees as deemed appropriate to review the IEE & EIA.					
Justification for the action: Poor enforcement of coastal regulations and lack or poor IEEs & EIAs when establishing large tourist resorts 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 consisting of persons committed to protect, conserve and restore coral reefs with swimming, snorkelling and diving skills.	High	CCD/NGOs/ Community	0.5-1.0 years	D & I US $ 1,600,000	- At least two responsible community participatory organisations for each reef site included in the programme within 2 years.
II. IEEs & EIAs should be conducted to all major development and economic activities in the coastal zonet and be reviewed by committees with required knowledge & 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 after 0.5 years to 7 years. and onwards.
Measure/Action 3: **(i).** Improve stakeholder awareness on the impacts of unsustainable socio economic activities related to reefs and non-extractive uses of coral reefs and promotion of eco friendly activities.					
Justification for the action: Unsustainable development plans and resource utilisation (e.g. corals for lime industry, collection of ornamental fish, use of explosives for fishing) within reef sites					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US$) & Funding**	**Indicators**
I. Improve awareness on coral reef ecosystems					
a) Conduct awareness programmes to all groups of stakeholders within and in close proximity to reef	V. High	CCD & MEPA	0.5- 2.0 years	D & I US $ 25,000	- Awareness among government officials on importance of collaborative approach on

ecosystems.					development programmes after 1 year
b) Conduct awareness programmes on the non extractive uses/importance, role and functions of corals and on the importance of controlling pollution and sedimentation.	Medium	CCD	1.0-2.0	D & I US $ 15,000	- 25% reduction of impacts from pollutants and sedimentation to the coral reef ecosystems after 2.0 years
c) Involve persons engaged in coral destructive activities in coral transplanting programmes and/or train them for eco-friendly income generating activities.	V. High	CCD & MEPA	0.5-3.0 years	D & I US $ 50,000	- 50% to 90 % of persons involved in coral destructive activities assist in coral transplanting and eco-friendly economic activities from 2 to 7 years.
Measure/Action 4: **(i).** Implementation of river basin management programmes and control of land use patterns to reduce sedimentation through agriculture, mining and erosion through involvement of National Physical Planning Department, law enforcement to illegal coastal practices and reef cleaning programmes					
Justification for the action: Sedimentation and pollution due to unplanned Socioeconomic activities in the coastal belt and hinterland					
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 to reef sites	High	CCD	0.5-1.5 years	D & I US $ 200,000 (30,000 annually)	- Availability of baseline information, on each reef site to be used for future development programmes and IEE/EIAs after 1.5 years.
II. Regulate land use practices in the catchment areas of river basins which releases water into sensitive reef ecosystems	High	National Physical Planning Department/CEA	Start at year 1 and continue	US $ 10,000	- 90% control over the land used patterns within the relevant catchment areas 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	- Healthy coral reefs, growing satisfactorily without any exotic materials from year1 to year7.
IV. Severe punitive actions against persons and organisations 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 to persons/organisations involved in coral reef destructive activities from the beginning.
Measure/Action 5: **(i).** Provide adequate training to suitable members selected from the stakeholder groups and line ministries and uses them as leaders for implementation of the respective restoration programmes and as trainers to train others					
Justification for the action: Inadequate trained personnel to involve 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 of persons selected from the community and related institutions	High	CCD/MEPA /NGOs	0.5 years onwards	D & I US $ 200,000	- Availability of 10 trained persons in each reef sites for all responsibilities after 1.0 year. - Sustainably managed healthy coral reefs after 1.5 years.
Measure/Action 6: **(i).**Formulate development plans in consultation and through cooperation with important stakeholders; **(ii).** Conduct seasonal monitoring programmes with the cooperation of trained stakeholders to be alert about natural phenomena,					
Justification for the action: Inadequate stakeholder awareness on natural phenomena that bleach corals					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US$) & Funding	Indicators
I. Develop a sustainable management plan for reef ecosystems, through consultation of stakeholders and experts.	Medium	CCD/NGOs	Year 1 onwards	D & I US $ 9,000	- Availability of a long-term management plan acceptable to all stakeholders 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/Universities	0.5 onwards	D & I US $ 80,000 (At least 10,000 annually)	- Existence of a data base on coral biodiversity and physicochemical conditions, that would help to Identify any changes in the reef ecosystems
III. Use of GIS & remote sensing techniques to forecast damage to reef ecosystems by natural phenomena and to be alert on such hazards					
Total Cost of Technology 3: US $ 2.435 million					

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

CHAPTER 5

Technology Action Plan for the Biodiversity Sector

5.1 Actions at sectoral level

5.1.1 Short sector description:

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. 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[39]. 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[40]. Biodiversity provides a multitude of ecosystem goods and services to people of Sri Lanka, including watershed services, regulation of climate, carbon sequestration, supply of non-timber forest products such as rattan, wild foods, fruits, and medicinal plants, among many others. It is estimated that about 15% of the island's forests and scrublands lie within the country's Protected Area (PA) system[41], while some marine protected areas have also been set up in addition to these terrestrial areas. Additionally there are several policies, legislations and programs set up to protect the country's biodiversity. The value of conserving the country's biodiversity is recognized in national planning, and is highlighted in the *MahindaChintana*, national policy framework for Sri Lanka, *Haritha*(Green) Lanka Action Plan and the National Physical Planning Policy and Plan[42].

Despite all these efforts, Sri Lanka's biodiversity remain threatened. While some critical localities 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 and conversion to other land uses, illegal extraction of natural resources, shifting cultivation, forest fires, haphazard development projects, poaching, pollution, siltation and sedimentation, sewage and solid waste

[39]NARESA 1991, Natural Resources of Sri Lanka: Conditions and Trends. Natural Resources, Energy and Science Authority of Sri Lanka, Sri Lanka

[40] Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. & Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature*403, 853–858

[41] Ministry of Environment (1999). *Biodiversity conservation in Sri Lanka: a framework for action*. Colombo, Sri Lanka.

[42]Ministry of Environment. 2010. Sector Vulnerability Profile: Biodiversity and Ecosystem Services.

disposal in coastal and marine ecosystems, development of aquaculture and due to illegal sand/coral and gem mining, among others. According to the latest IUCN Red List in 2007 for Sri Lanka, of the 677 vertebrate species 233 (33%) have been classified as Nationally Threatened. Of this, 138 (62%) are endemic to the country. Many plant species in the country are also facing threat. The Red List assessed about 35% (1,099) of indigenous angiosperm flora and found that 61% of these species are threatened, of this 412 (61%) are endemic[43].

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, therefore, be one of the most practical climate change adaptation strategies that Sri Lanka can adopt to conserve the country's natural heritage[44].

Vulnerability to climate change: 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. 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 the SVP, the impact of climate change on biodiversity and possible areas for adaptation are still speculative.

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.

[43]IUCN Sri Lanka & the Ministry of Environment and Natural Resources. (2007). The Red List of threatened fauna and flora of Sri Lanka. Colombo, Sri Lanka, xiii+148pp.

[44]Ministry of Environment. 2010. Op. Cit.

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 below.

Existing Key Policies and Laws in the Biodiversity sector are given in tables 5.1 and 5.2 below.

Table 5.1: 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	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. Goal of the policy is Adaptation to and mitigation of climate change impacts within the framework of sustainable development 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

Table 5.2: 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.

5.1.2 An overview of prioritized technologies:

Through stakeholder consultations and by using the Multi Criteria Decision Analysis (MCDA) approach, the Technology Needs Assessment process has identified five prioritized technologies for the sector. The prioritized technologies are listed below in order of priority.

1. Rehabilitation and 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 will be necessary to enhance resilience that will allow biodiversity to better withstand the impact of climate change.

Rehabilitation and 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.

2. *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)*

Increasing connectivity in the broader landscape is vital for conserving biodiversity during climate change[45]. 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[46,47]. Rehabilitation and restoration, linking fragmented areas etc is already being carried out it Sri Lanka. Further, enabling legal provisions are available for such corridors in wildlife legislation and are referred to as 'jungle corridors'[48].

3. *Improve management, and possibly increase 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[49]. The technology is currently in place and has been so for several decades. In Sri Lanka, the protected area categories vary from Strict Natural Reserves where access is strictly limited to Sanctuaries, which may contain private land[50]. It is vital to ensure that these areas contain a good representation of the country's biodiversity. Effective management of existing protected areas is important as creating new areas is challenging in view of the demand for lands for other economic development purposes in a developing country. However there are numerous areas that are earmarked as proposed reserves, which can be included into the protected area network.

4. *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*

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[51]. Thus it would target species that need special

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[45]Mawdsley, et al. 2009. Op. Cit.

[46]Mawdsley, et al. 2009. Op. Cit.

[47]Hannah, L and Hansen, L. 2005. Chapter 20 – Designing Landscapes and Seascapes for Change. In: Lovejoy T, Hannah L, eds. 2005. In Climate Change and Biodiversity. New Haven, CT: Yale Univ. Press

[48]The Fauna and Flora Protection Ordinance No. 2 of 1937 and Amendment Act No. 49 of 1993.

[49]Mawdsley, et al. 2009. Op. Cit.

[50] The Fauna and Flora Protection Ordinance No. 2 of 1937 and Amendment Act No. 49 of 1993.

[51]Mawdsley, et al. 2009. Op. Cit.

attention, with high vulnerability to climatic changes. The Sri Lanka Red List[52] identifies threatened species, and their locations. Thus the Red List can be used to identify and target specific species that may require additional conservation intervention. Some conservation programs have already been targeted at threatened species, but much remains to be done.

5. 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 climate change. Such an approach would generally be a last resort for species[53]. Zoological Gardens and seed banks are some example of such conservation activities, which are in place in Sri Lanka and therefore not to be considered a new technology. However some advanced facilities for captive breeding, sperm and egg banks will be necessary for certain species.

These prioritized technologies are applicable to both terrestrial and marine biodiversity. It can include any species or ecosystem vulnerable to climate change including sub-sets of biodiversity such as agro biodiversity.

5.1.3 General Barriers and Proposed Measures:

The general barriers identified for the biodiversity sector can be broadly categorized into the following:

(a) ***Barrier***: *Lack of incentives for adopting various technologies.*

Proposed measure: *Create incentives for facilitating the diffusion of appropriate technologies and remove perverse incentives for biodiversity adaptation.*

The lack of incentives for adopting various technologies is one of the major barriers identified and it is particularly critical for Technology 1 and 2. Currently there are no incentives for protecting isolated forest patches/ecosystems in private lands. As technologies for biodiversity adaptation are costly, incentives are required to encourage other institutions to invest in such programs. Incentives could include tax concessions, subsidies and cash payments etc. for carrying out technologies for biodiversity adaptation.

[52]IUCN Sri Lanka and the Ministry of Environment and Natural Resources (2007) The 2007 Red List of Threatened Fauna and Flora of Sri Lanka, Colombo, Sri Lanka. xiii+148pp.

[53]Mawdsley, et al. 2009. Op. Cit.

(b) ***Barrier***: *Inadequate funding*

Proposed measure: National planning level *recognition for the need of providing adequate funding. Incorporate such requirements when planning for external fund raising.*

Low funding allocation is a barrier for all technologies and there is also lack of proper planning for ex-situ conservation. Securing funds will be cruicial to implement these technologies as these are costly, but yet critical for biodiversity adaptation. Thus, financial requirements need to be recognized at the National Planning level. Such needs should be incorporated in External Resource Department planning for securing external funds in order to supplement government financing through the annual budgets.

(c) ***Barrier***: *Lack of understanding, awareness and appreciation of value of biodiversity / ecosystems.*

Proposed measure: *Create understanding through effective awareness programs and innovative communication.*

Poor understanding, lack of adequate awareness and appreciation of value of biodiversity and ecosystem conservation is a significant barrier. Such understanding is vital amongst political authority, the general public and decision-makers. The true value of restoration and its contribution to ecosystem services is not well established while the value and benefits of connectivity is unknown and there is also a lack of communication and awareness. Poor awareness by the general public and policy-makers on point endemics and other threatened species and lack of recognition to reinforce voluntary conservation action are considered barriers for Technology 4. AS for the Technology 5, there is poor understanding on species requiring ex-situ conservation. The lack of understanding awareness and appreciation of economic and environmental values is a major constraint for several technologies, and therefore it is vital to create understanding through effective awareness programs and innovative communication methodologies.

(d) ***Barrier***: *Insufficient capacity*

Proposed measure: *Capacity building and resource allocation*

Insufficient capacity, which includes expertise, skills and other resources is a major barrier for most of the technologies. Capacity building and resources allocation will be essential to address this barrier. Capacity building, especially on specialist knowledge as required by the respective technologies, climate modeling etc is necessary for successful implementation of the interventions. Resource allocation is critical to ensure timely availability of equipments and other requirements. This is especially considered a priority for technologies 1, 3, 4, & 5.

(e) Barrier: *Lack of information, research, climate modeling*

Proposed measure: *Carry out studies, research and climate modeling*

Lack of information, research and climate modeling is a major barrier for certain technologies in the biodiversity sector. Therefore it is essential to carry out studies, research and climate modeling to generate adequate information. In the absence of such research studies, there is a dearth of information on potential climate change impacts on species and ecosystems. The information available on threatened species including distribution data, ecological information, population size and genetics is inadequate. Absence of focused research on habitats for species migration is yet another significant barrier. These actions are necessary for Technology 3 and 4.

(f) ***Barrier***: *No prioritization and use of climate models for this purpose*

Proposed measure: *Carry out prioritization based on needs, urgency in the use of climate models for prioritization.*

Currently attempts for prioritization of sites and species for technology implementation is lacking, thus preventing the most urgent issues from being addressed. Therefore, prioritization of interventions using climate models is essential in order to identify the needs and urgency of actions. Research studies and a comprehensive analysis of information are necessary to identify conservation priorities. Climate modeling is considered an essential component as this prioritization is focused on climate change adaptation. These actions have particular reference to implementation of Technology 1, 2 and 5.

(g) ***Barrier***: *Pressure from development/competing land use*

Proposed measure(s): *Use tools such as Strategic Environmental Assessments for planning and implementation of both development and conservation programs. Reduce pressure from development/competing land use by providing alternatives, encouraging compatible land use activities and provide incentives to utilize abandoned/ brown field sites.*

Demand for lands for development activities and other competing uses is a major constraint to implement several technologies. Such pressures could be reduced by providing alternatives, encouraging compatible land use activities and by providing incentives to utilize abandoned/brown field sites. Additionally, use of planning tools such as Strategic Environmental Assessments (SEA) when planning and implementation of both development and conservation programs needs to be recognized as a pre-requisite.

This is required for Technology 1, 2 and 3.

(h) ***Barrier***: *Weak law enforcement and implementation of policies.*

Proposed measure: *Strengthen agencies implementing existing legal framework and policies.*

The inadequate enforcement of the existing legal framework and policies is a major constraint for implementing is a major barrier for Technology 2 while, non-implementation of existing management plans due to lack of resources is a major barrier for technology 3. Inadequacy of physical boundary demarcation of some protected areas and all buffer zones together with the poor enforcement of boundaries and lack of awareness on the boundaries is a very critical barrier. Implementation of the Technology 5 is likely to be hampered by weak enforcement of law against improper ex-situ conservation efforts. Therefore it is vital to implement existing legal framework and policies for the success of Technologies 2, 3 and 5.

(i) ***Barrier***: *Lack of partnerships*

Proposed measure(s): *Policy level recognition of partnerships as effective means for implementing technologies is required. Create effective partnerships with other government institutions, NGOs, universities and private sector to implement adaptation technologies.*

Currently there is near absence of partnerships to implement technologies related to biodiversity conservation. Therefore, it is essential to establish an enabling environment conducive for effective partnerships with other government institutions, NGOs, universities and private sector to implement biodiversity conservation related adaptation technologies. Policy level recognition of the partnerships as an effective means for implementing technologies is also vital. This is particularly necessary for Technology 1, 3 and 4.

5.1.4 Specific Measures Proposed for the Selected Technologies:

The specific measures proposed for prioritized technologies for the sector are given below.

Table 5.3: Proposed measures for Rehabilitation and Restoration of degraded areas inside and outside the protected area network to enhance resilience

No	Recommended Measures
1.	Apportion part of the annual budgets of Forest, Wildlife Departments and other relevant agencies for rehabilitation and restoration based on above action plan.
2.	Provide incentives and remove perverse incentives for rehabilitation and restoration by communities and private sector; introduce a biodiversity-offset mechanism.
3.	Ecosystem specific studies (for Sri Lanka) on values of ecosystems services and dissemination of

	information generated.
4.	Undertake studies to identify and prioritize areas critical for rehabilitation and restoration. Climate change modeling to identify critical areas. Program planning and budgeting based on study out puts.
5.	(i) Publish in local language and disseminate best practices for ecosystem specific rehabilitation and restoration methods; Promote research on technologies and information dissemination.
6.	Awareness for political authority, administrators at all levels; Site specific evaluation for areas prioritized for rehabilitation and restoration (over development).
7.	Facilitate knowledge exchange and sharing. Conduct Joint programs.
8.	Implementation of existing policies and legislation relating to land tenure in such areas.
9.	Build partnerships (between government institutions/private sector).

Table 5.4: Proposed measures for increasing connectivity through corridors, landscape/matrix improvement and management

No	Recommended Measures
1.	Apportion part of the annual budgets of Forest and Wildlife Departments for enhancing connectivity based on above action plan; Incentives for private landowners to set aside or maintain areas necessary for connectivity.
2.	(i) Create enabling legal and policy environment to ensure maintaining areas for connectivity in medium to large development projects. (ii) Political awareness; site specific evaluation for areas prioritized for restoration (over development).
3.	Identify critical areas to be connected and prioritize required corridors. Climate change modeling to identify critical areas. Implement activities to enhance connectivity.
4.	Carry out valuation and identify benefits of connectivity, publicize results including awareness creation and communication.
5.	Awareness creation and capacity building and promotion of coexistence with biodiversity (eg: Kandyian home gardens; native plants seeds, materials etc)
6.	Enforcement and management of montane protected areas, increasing protection level and effectiveness of conservation/ management. Include critical areas into protected area network
7.	Integrate landscape level planning for conservation, special management and implementation into Forest and Wildlife Department management plans.
8.	Policy harmonization (definition of ‘unutilized’ should not include areas vital for biodiversity conservation).
9.	Amend procedures to expedite land acquisition process.

Table 5.5: Proposed measures for improving management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones

No	Recommended Measures
1.	Apportion part of annual budgets of Forest and Wildlife Departments for this technology based on above action plan. Allocation of resources and implementation.
2.	Allocation of resources and implementation of existing management plans.
3.	Prepare management plans where necessary and implementation.
4.	(i) Incentives for using brown field/degraded areas (ii) Policies to discourage conversion of natural ecosystems for development purposes. (iii) Upgrade proposed reserves /parks to a higher level of protection.
5.	(i) Encourage non-conflicting and complimentary land use through incentives (ii) Enforcement of buffer zone legislation
6.	Recruit competent personnel for biodiversity related climate change adaptation activities and provide capacity building training for existing staff
7.	Create accountability of responsible people. eg: performance based evaluations; incentives (financial and non-financial) for good performance.
8.	Policies and initiatives that encourage Forest, Wildlife and other relevant departments to work together - bring DWLC and FD under one ministry.
9.	Amend and implement buffer zone legislation
10.	(i) Physical demarcation of protected area boundaries and buffer zones (ii) Effective law enforcement on boundaries/removing encroachments etc. (iii) Create awareness on boundaries
11.	Introduce legal provisions for community owned protected areas and provide incentives for such activities
12.	Identify areas to carry out studies, undertake biodiversity assessments
13.	Awareness creation , capacity building and promote coexistence with biodiversity (eg: Kandyan home gardens, native plants seeds, materials etc)

Table 5.6: Proposed measures for Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems

No	Recommended Measures
1.	Allocate sufficient funds from annual budgets to implement priority based action plans.
2.	Develop and implement species action plans based on priority.
3.	Generation of necessary information and climate modeling for assessing climate change impacts on species and ecosystems.

4.	(i) Legalizing the protection of sites where point endemics are found. (ii) Incentives and alternatives for protection in areas outside protected areas. (iii) Inter-departmental coordination for protection of point endemics.
5.	Make recommendation on climate change and species related considerations into legislation – and publicize amendments.
6.	Create effective partnerships for species conservation between Ministry/Departments and universities, NGOs, species specialists etc.
7.	Carry out extensive surveys/research; obtain expertise on the subject/capacity building.
8.	(i) Awareness programs on point endemics and critically endangered species and the importance of their conservation. (ii) Awareness and introduction of mechanism for voluntary conservation actions.
9.	Expedite the existing administrative process for obtaining research permission for individuals and non-state institutions.
10.	Research on habitats for species migration and identification/conservation of such habitats.
11.	Build capacity and equip staff within departments to conserve and monitor threatened species/ecosystems (specialized knowledge).

Table 5.7: Proposed measures for Ex-situ conservation for highly threatened species and possible reintroduction

No	Recommended Measures
1.	Apportion part of the annual budgets for setting up ex-situ facilities that would be required in the near future
2.	(i) Identification of required ex-situ conservation facilities, prioritization and costing (ii) Introduce framework/protocol for reintroduction/translocation and monitoring.
3.	(i) Carry out capacity building on ex-situ conservation. (ii) Establish partnerships with species specialists; facilitate knowledge exchange and sharing. (iii) Provide suitable resources (eg: land etc). (iv) Standard protocols for ex-situ conservation (maintenance of facilities, disease control, quarantine etc).
4.	(i) Give ex-situ conservation high priority. (ii) Create awareness on its importance
5.	(i) Studies to identify and prioritize species for ex-situ conservation (ii) Climate change modeling to identify vulnerable species.
6.	Introduce a regulated system to permit ex-situ breeding by other parties under the government supervision.
7.	Enforcement of existing laws for improper ex-situ conservation activities.

5.2 Action Plan for Technology 1: Rehabilitation and Restoration of degraded areas inside and outside the protected area network to enhance resilience

5.2.1 Description of the Technology

Rehabilitation and 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[54]. Although legally declared, some protected areas are degraded due to illegal activities such as encroachments for settlement, clearing logging etc. There are other areas outside existing protected area system that would be important for conservation now, or when species shift their range as a result of climate change. Rehabilitation and 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.

Rehabilitation and Restoration is not a new technology, in Sri Lanka forest[55], aquatic[56], reef and coastal areas have been restored. Some of these technologies are currently in place, and has been so for several decades.

There are several international experts who endorse this strategy as an essential climate change adaptation strategy for biodiversity in papers published in peer-reviewed journals[57,58]. Additionally several Policies, Action Plans and Strategies in Sri Lanka have identified this essential for biodiversity conservation.

Some of its benefits are highlighted below:

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[54] Walker BH, Holling CS, Carpenter SR, Kinzig AS. 2004. Resilience, adaptability and trans-formability. *Ecology and Society* 9(2):

[55] Ashton, M.S., Gunatilleke, C.V.S., Singhakumara, B.M.P. and Gunatilleke, I.A.U.N. 2001. Restoration pathways for rainforest in south west Sri Lanka: a review of concepts and models, *Forest Ecol. Manage.* 154 (2001), pp. 409–430

[56] MDG SriLanka. 2009. *Ensure environmental sustainability.* Available online from: http://www.mdg.lk/images/flash/learningzone.swf

[57] Mawdsley, et al. 2009. Op. Cit.

[58] Heller, N.E. & Zavaleta, E.S. (2009) Biodiversity management in the face of climate change: a review of 22 years of recommendations. *Biological Conservation*, 142, 14.

- Environment - The main benefit of restoration would be from carbon sequestration and thus a mechanism from which climate change can be mitigated. It will also ensure that other ecosystem services are restored.
- Employment – Opportunities for employment generation, as rehabilitation and restoration will require manpower. Local communities can easily be involved with some training for this purpose; once restored there could be other job opportunities associated with ecotourism and sustainable utilization of natural resources.
- Investment – Capital investment required, especially if the restoration requires hard technologies (eg: groynes to restore beach, artificial reefs).
- Income - Accrued social benefits from jobs created due to rehabilitation and restoration related work; Further potential for income generation from the harvest of non-timber forest products and ecotourism related activities once restoration is completed.
- Education - An opportunity for students to learn about rehabilitation and restoration techniques; University students can learn and contribute to solutions.
- Health – Enhanced ecosystem services in the form of watershed services, providing sufficient water for drinking and sanitation will contribute to improve quality of life of communities.

5.2.2 Target for technology transfer and diffusion

- Rehabilitation and restoration of at least 10,000 hectares of terrestrial and marine ecosystems, over 5 years.
- At least one incentive scheme for rehabilitation and restoration introduced.
- At least 2-5% of Forest and Wildlife Department budgets allocated for rehabilitation and restoration.
- Rehabilitation and restoration prioritization study completed.
- Best practices for specific ecosystems published.
- At least 10 pilot sites completed.
- One campaign for political awareness completed.
- Evidence of implementing policies/legislation documented.

5.2.3 Barriers to the technology's diffusion

For the technology ***Rehabilitation and restoration of degraded areas inside and outside the protected area network to enhance resilience,*** total number of nine (09) barriers including two (02) economic & financial, four (04) information & awareness, two (02) network failures and one (01) policy, legal & regulatory have been identified.

The list of key barriers and hierarchy classification for technology 1 is given in table 5.8.

Table 5.8: List of Key Barriers and hierarchy classification for the Technology 1

Technology Name: Rehabilitation and restoration of degraded areas inside and outside the protected area network to enhance resilience			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	No immediate returns from restoration and lack of incentives for restoration (for communities/private sector)	1	Economic and financial
2.	Low funding allocation for restoration (nationally).	2	Economic and financial
3.	Poor understanding of the true value of ecosystem services and no information on local value for key ecosystems and their services	7	Information and awareness & human skills
4.	Lack of prioritization of areas for restoration at a national scale	3	Information and awareness & human skills
5.	Insufficient capacity on ecosystem specific and technically sound restoration methods/technologies	5	Information and awareness & human skills
6.	Conflicting interests/pressure from development (development versus restoration)	6	Information and awareness & human skills
7.	Inadequate working modalities to exchange and learn about restoration best practices from other countries	9	Network failures, human skills and technical
8.	Land tenure issues before and after restoration (ownership of a restored land).	4	Policy, legal and regulatory
9.	Lack of partnerships for restoration and management of lands outside protected areas.	8	Network failure, Social, cultural and behavioral

5.2.4 Proposed Action Plans for the Technology

The Proposed Action Plan for Technology 1 is provided in table 5.9.

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Action Plan for Technology 1

Table 5.9: Proposed Action Plan for the technology 1: Rehabilitation and restoration of degraded areas inside and outside the protected area network to enhance resilience

Measure/Action 1: Provide **incentives** and remove perverse incentives for restoration by communities and private sector; introduce a biodiversity-offset mechanism.					
Justification for the action: Currently there are no immediate returns from rehabilitation and restoration and also lacks incentives for restoration work (for communities/private sector). Rehabilitation and restoration has both mitigation and adaptation benefits, in addition to numerous benefits from ecosystem services. One of the major hindrances for community and private sector involvement in rehabilitation and restoration is no immediate returns or incentives for their investment.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
(i). Provide incentives by government/donors for rehabilitation and restoration by communities and private sector; introduce a biodiversity-offset mechanism.	V. High	Forest Dept/ Wildlife Dept/ M/Environment & CEA Ministry of Fisheries & Coast Conservation Department	2-3 years	Domestic & International Cost of incentives approx US$ 1,100,000 (including monitoring)	- Incentive mechanism set in place/legalized in 1 year. - At least 10,000 hectares of ecosystems are restored & incentive paid by 2years. .
Measure/Action 2: Apportion part of **annual budgets** of Forest and Wildlife Departments for rehabilitation and restoration based on above action plan*					
Justification for the action: Low funding allocation for rehabilitation and restoration (nationally) is a major barrier to conservation. Currently the Department of Wildlife Conservation and Forest Department being the main departments dealing with environment and biodiversity, do not have sufficient funds for restoration in their					

nationally allocated budgets. This is a major hindrance for rehabilitation and restoration, which is considered a priority for biodiversity adaptation to climate change.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i) Apportion part of annual budgets of Forest, Wildlife Departments and other relevant agencies for rehabilitation and restoration based on above action plan* **(ii).** Seek external funds*	V. High	Forest/Wildlife Dept/ M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD	0.5-1 year annually thereafter	Domestic from the budget No cost (5%, approx. US$ 750,000 annually).	- Decision made on budget allocation within 1 year. - At least 2-5% of budget allocated for rehabilitation and restoration within 3 years.

Measure/Action 3: **Ecosystem specific studies** (for Sri Lanka) on values of ecosystems services and its dissemination.*

Justification for the action: There is poor understanding of the true value of ecosystem services and no information available based on valuations for key local ecosystems and their services. Currently the concept of ecosystem services and its value to the national economy and day-to-day function of people and the country is poorly understood. This has led to rehabilitation and restoration and its returns being 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 $) & Funding Source	Indicators
(i). Ecosystem specific studies (for Sri Lanka) to determine ecosystem service values and dissemination.* of study results	High	Forest/Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities/ Research institutions/ Environmental organizations/)	0.5 – 3 years	Domestic & international US$ 460,000	- At least 2-5 studies completed annually. - Materials reach at least 500 key stakeholders and 1000 members of the public within 2-5 years.

Measure/Action 4: Studies to identify and **prioritize critical areas** for rehabilitation and restoration. **Climate change modeling** to identify critical areas. Action

planning and budgeting based on study results*

Justification for the action: There is a lack of prioritization of areas for rehabilitation and restoration at a national scale. At present no areas or key ecosystems have been prioritized or identified for rehabilitation and restoration. Therefore, a prioritization mechanism is essential to restore the most vital ecosystems on a priority basis. Lack of such a system will lead to haphazard restoration, which will not maximize the investment and its subsequent benefits/returns.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Undertake studies coupled with climate change modeling to identify and prioritize critical areas for rehabilitation and restoration. Budget and action plan based on study to implement*	V. High	Forest/Wildlife Dept/ Climate Change Secretariat of M/E M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental organizations	Phased study : 1 – 3 years	Domestic & international US$ 2,000,000	- One comprehensive study completed in 3 years. - One set of modeling data, maps etc within 3 years.

Measure/Action 5: Publish in local languages the **best practices for ecosystem specific rehabilitation and restoration** methods, promote research on technologies and its dissemination

Justification for the action: Insufficient capacity on ecosystem specific and technically sound rehabilitation and restoration methods/technologies is another major hindrance to rehabilitation and restoration. This information is often not disseminated widely and there is no proper access to technical information and best practices . Therefore the lack of dissemination of technical information and lack of human skills and capacities to engage in such restoration activities is a significant hindrance to rehabilitation and restoration in Sri Lanka.

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	High	Forest/Wildlife Dept M/Fisheries and Aquatic	1- 4 years	Domestic & international	- At least 1 publication produced in 2 years..

and restoration methods.		Resources Development, NARA and CCD (Universities Environmental org)		US$ 250,000	- At least 10 examples of best practices being used within 5 years.
(ii). Promote research on technologies (if ecosystem specific rehabilitation and restoration methods are not available)*	Medium	Forest/Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities Environmental org)	1- 4 years	Domestic & international US$ 760,000	- At least 2-3 grants given a year. - 2-3 studies successfully completed annually.
(iii). Demonstration plots/pilot studies.*	High	Universities Environmental organizations Local communities	1 – 8 years	Domestic & international US$ 1,200,000	- At least 10 Pilot studies carried out over 5 years.
Measure/Action 6: Facilitate knowledge **exchange and sharing** including local knowledge and from other countries through joint programs.					
Justification for the action: Inadequate working modalities to exchange and learn about rehabilitation and restoration 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 $) & Funding Source**	**Indicators**
(i). Facilitate exchange and sharing of knowledge through joint programs. (Including information gathering and identifying possible partnerships to facilitate this).	Medium	Forest/ Wildlife Dept M/Fisheries and Aquatic Resources Development, NARA and CCD (Universities	0.5 – 1 year Annual exchange programmes (10 years)	Domestic and international US$ 500,000	- At least 1 exchange visit per year (10 years) - At least 5 people trained a year (10 years)

		Environmental organizations Foreign collaboration)			
Measure/Action 7: **Political awareness** site specific evaluation where some areas are prioritized for rehabilitation and restoration (over development). [Awareness to include all levels of administrators, decision and policy makers].					
Justification for the action: Competing interests, pressure for lands for development and other uses is a barrier to rehabilitation and restoration, as conservation activities often take a backseat in the development agenda. Often decision and policy makers are unaware of the importance of rehabilitation and restoration and ecosystem services – and the fact that it is vital for development. Thus innovative communication programs is vital to create political awareness so that correct decisions are made.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
(i). Political awareness; site specific evaluation for areas prioritized for rehabilitation and restoration (over development)* [Awareness to include all levels of decision makers]	High	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD	0.5 – 2 years Annually thereafter	Domestic and international US$ 275,000	- At least 50 decision makers participate in annual events. .
Measure/Action 8: **Implementation of existing policies and legislation** relating to land tenure in areas ear marked for restoration*					
Justification for the action: Land tenure issues before and after restoration (ownership of a restored land) is another barrier. 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 should be available to those who maybe interest in restoration. It is of utmost importance to consider granting rights and benefits to those carrying out restoration activities in state land. Such a mechanism					

could boost restoration activities considerably.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Implementation of existing policies and legislation relating to land tenure in such areas* **(ii).** Gap analysis on existing legislation, and legal reforms as required.	High	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD Police Department	0.5-1year on wards	Domestic and international US$ 875,000	- One Strategy prepared within 6 months - At least 10-20 issues addressed annually.
Measure/Action 9: Build **partnerships** (between government institutions/private sector)					
Justification for the action: There is near absence of partnerships for rehabilitation and restoration and management of lands outside protected areas. Often state departments may not have adequate resources in terms finances and skills to carry out rehabilitation and restoration. Therefore working with non-state parties would be beneficial and could result in successful restoration programs. However currently there is no arrangement for such partnerships and this is seen as a barrier for restoration.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
(i). Build partnerships (between government institutions/private sector)	Medium	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Development, NARA and CCD Private sector (implementation) Environmental organizations	0.5 year – continuous	Domestic and international US$ 35,000	- At least 10 partnerships formed in 2-5 years. - At least 5 partnerships have lasted more than 1 or 2 years.

Total cost for Technology 1	**#Approx. US $ 7.5 million for 10 years**

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department

5.3 Action Plan for Technology 2: Increasing connectivity through corridors, landscape/matrix improvement and management

5.3.1 Description of the Technology

Increasing connectivity in the broader landscape is vital for conserving biodiversity during climate change[59]. 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.[60,61]

This strategy involves the protection of areas and regions that would be essential for climate-induced wildlife movements[62]. Technologies that can be used include movement corridors for terrestrial species, while unblocked streams and rivers are important movement corridors for aquatic species[63]. In the case of forests, a system of corridors could be designed utilizing existing patches or augmenting with rehabilitation and restoration and other restoration mechanisms, creating an opportunity for short or long term migration. There are provisions for such corridors in wildlife legislation and are referred to as 'jungle corridors'[64].

Several Policies, Action Plans and Strategies in Sri Lanka have identified this technology as an essential strategy for biodiversity conservation.

Some of its benefits are highlighted below:

- Environment - Environmental benefits include maintaining genetic diversity, allowing migration of species within large home ranges, seed dispersal, carbon sequestration and other ecosystem services. It will also allow ecosystems to be resilient to the changing climate as they are better conserved.

[59] Mawdsley, et al. 2009. Op. Cit.

[60] Mawdsley, et al. 2009. Op. Cit.

[61] Hannah, L and Hansen, L. 2005. Chapter 20 – Designing Landscapes and Seascapes for Change. In: Lovejoy T, Hannah L, eds. 2005. In Climate Change and Biodiversity. New Haven, CT: Yale Univ. Press

[62] Allan, J. D., M. Palmer, and N. L. Poff. 2005. Climate change and fresh- water ecosystems. Pages 274–290 in T. E. Lovejoy and L. Hannah, editors. Climate change and biodiversity. Yale University Press, New Haven, Connecticut.

[63] Mawdsley et al., 2009. Op. Cit.

[64] The Fauna and Flora Protection Ordinance No. 2 of 1937 and Amendment Act No. 49 of 1993.

- Employment – Employment opportunities will be created locally through the implementation of rehabilitation, restoration, monitoring and conservation related activities. There also would be opportunities for ecotourism, community conservation and sustainable utilization of NTFP
- Investment - No major capital investments will br required. However, some investment will be required if rehabilitation and restoration or any construction (eg: fish ladders) related activities are found to be required. Investment will need to be made in order to secure land in the case of corridors. In some cases payment of compensation to legitimate owners would be required.
- Income - Income could be generated through activities associated with corridors and matrix management and ecotourism related activities. Possible benefits from community conservation, payments for ecosystems services, REDD, NTFPs etc.
- Education - Educational benefits will include the opportunities available for students to learn about the technology; University students can learn and contribute to this technology.
- Health - It will help sustain biodiversity and ecosystem services, contributing to good environmental quality, which in turn will improve well-being and health of people.

5.3.2 Target for technology transfer and diffusion

- At least one incentive scheme introduced for private landowners to set aside or maintain areas necessary for connectivity.
- Allocation of at least 2-5% from the annual budgets of Department of Wildlife Conservation and Forest Department for improving management, increasing the extent under conservation.
- Integrate provisions into the policies to ensure that medium to large development projects set aside areas to maintain connectivity.
- Complete study for prioritization.
- One campaign for political awareness completed.
- Climate change modeling for at least two regions completed.
- Evidence of implementing policies/legislation documented.
- At least 4 critical areas included into protected area network.

5.3.3 Barriers to the technology's diffusion

Eleven (11) key barriers which comprised of four (04) economic & financial, four (04) policy, legal & regulatory and three (03) information & awareness have been identified.

The list of key barriers and hierarchy classification for this technology is given in table 5.10.

Table 5.10: List of key barriers and hierarchy classification for the technology 2

Technology Name: Increasing connectivity through corridors, landscape/matrix improvement and management			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Low funding allocation for connectivity.	1	Economic and financial
2.	No incentives for protecting isolated forest patches/ecosystems in private lands.	3	Economic and financial
3.	No provisions exist to ensure that large development projects set aside areas to allow connectivity.	5	Economic and financial
4.	Insufficient incentives and policies to involve private landowners in enhancing connectivity.	6	Economic and financial
5.	Critical areas for connectivity and priorities not identified at a national scale.	2	Information and awareness, technical
6.	High altitudinal (montane) areas are poorly protected due to non-enforcement of laws and management plans.	4	Policy, legal and regulatory
7.	Matrix/landscape level planning of conservation not carried out; lack of enabling policies and legislation to ensure matrix level planning/conservation.	8	Policy, legal and regulatory
8.	Lack of awareness on value and benefits of connectivity due to poor communication.	7	Information and awareness
9.	Ambiguity in government policies on 'taking over unutilized land' – as the term 'unutilized' is ill defined hence include patches of natural ecosystems vital for connectivity.	9	Policy, legal and regulatory
10.	Procedural delays in land acquisition.	10	Policy, legal and regulatory
11.	Lack of community awareness on cohabitation with biodiversity/critical species and lack of policy and legal framework for benefit sharing	11	Information and awareness, social, cultural and behavioral

5.3.4 Proposed Action Plans for the Technology

The Proposed Action Plan for Technology 2 is provided in table 5.11.

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Action Plan for Technology 2

Table 5.11: Proposed Action Plan for the Technology 2: Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)

Measure/Action 1: Apportion part of **annual budgets** of Forest and Wildlife Departments for connectivity based on an action plan. *					
Justification for the action: Currently the main departments dealing with environment and biodiversity in the country do not have sufficient allocation for this activity through their nationally allocated budgets. This is seen as a major barrier, as activities related to improving connectivity cannot be implemented without funds being made available. Improving connectivity being a high priority for biodiversity adaptation to climate change, not prioritizing improving connectivity and unavailability of funds is is a major hindrance in this regard.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
(i) Allocate sufficient funds from annual budgets to implement the action plans based on priority* (ii) Seek external funds*	V. High	Forest/Wildlife Dept M/ Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0.5 – 1 year and thereafter annually	Domestic No additional cost (4.5%, approx. US$ 675,000 annually).	- At least 2-5% of budget allocated for this activity within 3 years
Measure/Action 2: **Incentives** for private landowners to set aside or maintain areas necessary for improving connectivity*					
Justification for the action: No incentives are available for protecting isolated forest patches/ecosystems in private lands (plantations/home gardens etc) and it is considered a major constraint for the success of this activity. The landscape/ecosystem approach to conservation places 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.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Incentives for private landowners to set aside or maintain areas necessary for connectivity*	V. High	Forest/Wildlife Dept M/ Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	0.5 – 2 year on wards	Domestic & international US$ 1,020,000	- A minimum of 500 beneficiaries a year - At least US$ 100,000 worth of incentives disbursed annually.
Measure/Action 3: Make enable legal and policy environment to ensure that medium to large development projects set aside areas that allow for connectivity.					
Justification for the action: Currently there are no provisions available to ensure that large development projects set aside areas that allow for connectivity. The landscape/ecosystem approach to conservation places a major importance on connectivity including areas outside protected areas. There is a considerable amount of private land/state land adjacent to protected areas which are likely to be used for state sponsored and private sector development activities. Hence, this is considered a major barrier for improving connectivity.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) & Funding Source**	**Indicators**
(i). Make provisions (legal/policy) to ensure that medium to large development projects set aside areas that allow for connectivity.	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 – 2 years thereafter continuous	Domestic & international US$ 20,000	- New provisions incorporated in 6-12 months.
Measure/Action 4: Political **awareness**; site specific environmental valuations for areas prioritized for rehabilitation and restoration (over development)*					
Justification for the action: In order to provide incentives to involve private landowners in connectivity related activities, an enabling policy environment need to be created					

with political patronage through awareness. Additionally 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.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Political awareness; site specific evaluation for areas prioritized for rehabilitation and restoration (over development)* [Awareness to all levels of decision makers]	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	0 – 2 years annual	Domestic & international US$ 275,000	- At least 50 decision makers participate in annual events. - At least 10 decision makers advocate for environmental issues in 2 years.

Measure/Action 5: **Identify critical areas** to be connected and prioritize required corridors. **Climate change modeling** to identify critical areas*

Justification for the action: Identification and prioritization of critical areas for connectivity has not taken place at national scale. A lack of prioritization of sites to be conserved for connectivity remains a major barrier for biodiversity adaptation. Connectivity is vitally important for climate change adaptation as it facilitates migration and dispersal of species. Although, some attempts exists towards conservation, rehabilitation and restoration of small patches of forests, these actions often takes palcehappens haphazardly and not based on priorities. Therefore critical areas for connectivity and its prioritization still remain to be carried out through a national level study. Additionally, climate change modeling should accompany the study to make it accurate and select the most vital areas for connectivity.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Identify critical areas to be connected and prioritize required corridors. Climate change modeling to identify critical areas*	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. - At least 4 critical areas included into protected area network.

Measure/Action 6: **Enforcement and management** of protected areas; increasing protection level and effectiveness of conservation/ management*; Include critical areas into protected area network

Justification for the action: 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 enforcement has led to degradation due to through conversion into other land uses and encroachment. Inclution of the critical montane areas within the national protected area system and upgrading the protected area category to ensure high degree of legal protection and more effective management will be vital for the conservation of these montane areas.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Enforcement and management of protected areas, increasing its protection level and effectiveness of conservation/ management*	V. High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	Domestic & international US$ 1.5 million	- One Strategy prepared within 6 months - At least 10-20 issues addressed annually.

Measure/Action 7: Integrate the concept of Landscape level **planning for conservation** and special management into Forest and Wildlife Department management plans

Justification for the action: Matrix/landscape level planning of conservation is not properly carried out while the focus is only on isolated areas; Enabling policies and legislation for mandatory matrix level planning/conservation is lacking. Therefore landscape level planning for conservation, special management and implementation should be integrated into Forest and Wildlife Department management planning process. It is also vital to integrate Forest and Wildlife Department management plans, and these institutions need to work closely together. Such a mechanism needs to be formalized by two institutions.

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	- One Strategy prepared within 3 months - At least 2-5 instances where landscape planning has been used and implemented every year.
(ii). Include elements of climate change consideration in the EIA process and draft the the TOR accordingly					
Measure/Action 8: Carry out environmental valuation and identify **benefits of connectivity**, publicize results including awareness creation and communication.					
Justification for the action: Value and benefits of connectivity is generally unknown while there is a lack of communication and awareness as well. Effective and innovative communication and awareness programs must be launched to enable the decision makers to recognize the true value and benefits of connectivity. Where information on values are not available, research and studies need to be carried out. However the most important aspect is dissemination and the information reaching the most important stakeholders in a convincing manner.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost (US $) &Funding Source**	**Indicators**
(i). Carry out valuation and identify benefits of connectivity, publicize results including awareness creation and communication.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	2 – 5 years	Domestic & international US$ 500,000	- At least 10 studies carried out successfully within 3 years - At least 1000 documents of published results disseminated by year 4.

Measure/Action 9: **Policy harmonization**

Justification for the action: There is ambiguity in the definition of the term "Unutilized" when 'taking over unutilized land' for government purposes. At present the legal definition of the term 'Unutilized' includes patches of natural ecosystems vital for connectivity. In order to address this ambiguity, land – policy harmonization has to be carried out to address any misconceptions. Additionally, an amendment to the policy will be necessary to ensure that the definition of "unutilized" shall not include valuable ecosystems requiring strict protection.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost (US $) & Funding Source	Indicators
(i). Policy harmonization (eg: definition of 'unutilized' should not include areas vital for biodiversity).	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD Environmental organizations	0 – 1 year	Domestic & international US$ 20,000	- One document analyzing policy gaps produced within 6 months. - At least 2-5 instances where harmonized policy is used annually.

Measure/Action 10: Amend procedures to **expedite land acquisition** process.

Justification for the action: Currently there are procedural delays in land acquisition. In order to address this issue, the current procedures that cause delay should be amended. It should include a comprehensive analysis of the existing procedure and identify where delays occur and introduce amendments in order to expedite the procedure. Such amendments would be beneficial as delays in acquisition can result in further degradation of the areas requiring urgent attention.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Amend procedures to expedite land acquisition process.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and	1 – 10 years	Domestic US$ 30,000	- Amend the relevant legislation in 2 years.

		Aquatic Resources Dev, NARA and CCD			
Measure/Action 11: Create **awareness and build capacity** to promote coexistence with biodiversity. (eg: Kandyian home gardens; native plants seeds, materials etc)*					
Justification for the action: Often communities lack awareness on sharing habitats with biodiversity/critical species and a policy and legal framework is not available for benefit sharing in such instances. In order to address this barrier, awareness creation on coexistence with biodiversity should be carried out in areas where people inhabitate adjacent to high value ecosystems and protected areas. In many areas communities have conflicts with certain species of biodiversity such as elephants, wild boar etc. Sometimes such incidents contribute to negative attitudes towards conservation.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & 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	- Ten awareness/capacity building programmes annually, each attended by at least 50 participants - At least 2-5 successful case studies a year.
Total Cost for Technology 2				**#Approx. US $ 6.75 million for 10 years**	

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; CEA – Central Environmental Authority

5.4 Action Plan for Technology 3: Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones

5.4.1 Description of the Technology

Protected areas are a conservation tool to conserve biodiversity by protecting species and ecosystems. The proposed technology 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[65]. 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[66]. In Sri Lanka the protected area categories vary from Strict Natural Reserves where access is strictly limited to Sanctuaries, which may contain private land[67]. It is vital to ensure that these areas contain a good representation of biodiversity of the country. Effective management of existing protected areas is important as creating new areas is challenging in view of increasing demand for land in a developing country. However there are number of areas earmarked as proposed reserves, which can be included into the protected area network. Creating new protected areas or expanding existing areas does not require advance technologies.

Several Policies, Action Plans and Strategies existing in Sri Lanka have identified this technology as an essential strategy for biodiversity conservation.

Some of its benefits are highlighted below:

- Environment - Carbon sequestration, microclimate regulation, flood control, conservation of ecosystems and other associated services.
- Employment - Increased employment opportunities due to work associated with conservation activities and management of the protected area. More employment avenues associated with ecotourism would be available. There could be future opportunities from community conservation and ecotourism.
- Investment - Investment will be required to acquire land, purchase, and pay compensation where necessary.

[65] Mawdsley, et al. 2009. Op. Cit.

[66] IUCN. 2011.IUCN Protected Area Management Categories http://www.iucn.org/about/work/programmes/pa/pa_products/wcpa_categories/

[67] The Fauna and Flora Protection Ordinance No. 2 of 1937 and Amendment Act No. 49 of 1993.

- Income – Income generation due to tourism, community conservation, REDD and payments for ecosystem services.
- Education - Educational benefits will include a 'living laboratory' for students to learn about science and nature.
- Health - Good environmental quality and ecosystem services play a role in creating good health.

5.4.2 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.
- An incentive scheme introduced for using brownfield/degraded areas.
- A system to ensure staff accountability established.
- Physical demarcation/re-demarcation of boundaries to be in par with the legal/gazetted boundaries in at least 10 key protected areas.
- At least 5-10 protected areas are upgraded and declared.

5.4.3 Barriers to the technology's diffusion

Thirteen (13) key barriers which comprised of four (04) economic & financial, two (02) institutional & organizational capacity, four (04) policy legal & regulatory, two (02) policy legal & regulatory, two (02) information & awareness and one (01) network failure have been identified.

The list of key barriers and hierarchy classification for technology 3 is given in table 5.12.

Table 5.12: List of key barriers and hierarchy classification for the technology 3

Technology Name:			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Low funding allocation for this technology (nationally).	1	Economic and financial
2.	Non-implementation of existing management plans due to lack of resources.	5	Economic and financial
3.	Lack of management plans for some protected	4	Economic and financial

	areas		
4.	Insufficient capacity in terms of number of personnel, knowledge, vehicles for adequate management and monitoring.	10	Economic and financial
5.	Demand for land (for medium/large projects) from proposed reserves/parks without utilizing land already cleared/degraded.	2	Institutional and organizational capacity
6.	Lack of effectiveness of relevant departments and staff (mainly field staff) in protected area management.	11	Institutional and organizational capacity
7.	Conflicting land use practices in buffer zones.	7	Policy, legal and regulatory
8.	No legally defined buffer zone for protected areas	12	Policy, legal and regulatory
9.	Insufficient physical boundary demarcation of some protected areas and in all buffer zones. Lack of enforcement of boundaries and awareness on boundaries	3	Policy, legal and regulatory
10.	No provisions for community or privately owned protected areas (outside the current protected area system).	13	Policy, legal and regulatory
11.	Lack of community awareness on sharing habitats with biodiversity/critical species and absence of policy and legal framework for benefit sharing.	12	Policy legal and regulatory, information and awareness
12.	Lack of ecological information in protected areas	9	Policy legal and regulatory, information and awareness
13.	Inadequate inter agency coordination for managing adjacent protected areas.	8	Network failures

5.4.4 Proposed Action Plans for the Technology

The Proposed Action Plan for Technology 3 is provided in table 5.13.

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Action Plan for Technology 3

Table 5.13: Proposed Action Plan for the Technology 3: Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones.

Measure/Action 1: Apportion part of the **annual budgets** of Forest and Wildlife Departments for this technology based on the action plan*					
Justification for the action: 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. This is seen as a major barrier.					
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 action plans **(ii).** Seek external funds*	V. High	Forest/Wildlife Dept,	1 – 10 years	Domestic No additional cost.	- At least 2-5% of budget allocated for this activity within 3 years
Measure/Action 2 and 3: Allocation of resources for implementation of existing **management plans**; Prepare and implement management plans for those areas already not covered by such plans.					
Justification for the action: The non-implementation of management plans is a major constraint to effective protected area management, and is mainly caused by the lack of resources, finances being one of the biggest. Lack of management plans for some protected areas is also major barrier as management plans are necessary for the effective management of protected areas. Therefore producing management plans for such protected areas is also a necessity.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Implement existing management plans (revise if necessary) (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	- At least 5 good quality management plans annually produced. - Implementation according to action plan of management plan – monitored annually.
Measure/Action 4: Incentives for using brownfield/degraded areas* and policies to discourage conversion of natural ecosystems for development projects					
Justification for the action: There is a demand for land from proposed reserves/parks for medium/large projects, instead of utilizing land already cleared/degraded. Demand for land is a major hindrance to protected area expansion. Often forested areas, which are proposed protected areas are cleared for development activities while already degraded/cleared areas are not utilized for such purposes. Utilizing already cleared lands may require rehabilitation and therefore investors should be offered these lands by providing them with incentives such as tax breaks, cash payments, subsidies etc.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Incentives for using brownfield/degraded areas* **(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 set in place/legalized in 12 months - A minimum of 500 beneficiaries a year - Annually 2-5 brownfields/degraded areas used.
(iii). Policies to discourage conversion of natural ecosystems for development	V. High	Forest/Wildlife Dept, M/Environment, CEA	0 – 3 years	Domestic & international	- One legal analysis document produced in 6 months. - Provisions incorporated in 2 years.

projects.		M/Fisheries and Aquatic Resources Dev, NARA and CCD		US$ 10,000	

Measure/Action 5: Upgrade proposed reserves /parks to a higher level of protection; create new protected areas.

Justification for the action: Continued demand for lands for development purposes is a major hindrance to protected area expansion. Often forested areas, which are have been earmarked for declaring as protected areas are utilized for development purposes while already degraded/cleared areas are not made use of. Therefore proposed areas should 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 & Funding Source	Indicators
(i). Upgrade proposed reserves /parks to a higher level of protection; create new protected areas.	High	Forest Department, Wildlife Department, M/Environment; CEA	0 – 4 years	Domestic US$ 10,000	- At least 2-5 upgraded protected areas/gazettes annually.

Measure/Action 6: Encouraging non-conflicting land use through **incentives*** and enforcement of buffer zone legislation*

Justification for the action: Conflicting land uses in buffer zone sometimes cause more damage to the protected area, defeating its 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 is either beneficial or harmful (eg: intensive farming vs organic farming). Therefore encouraging non-conflicting/non-degrading land use through incentives will probably be the most effective way of ensuring that the buffer zone creates a shield for the protected area..

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Encouraging non-conflicting land use through incentives*	High	Relevant Ministry Department Private sector	3 - 4 years	Domestic & international Cost based on the incentive	- An incentive mechanism set in place/legalized in 12 months - Annually 2-5 brownfields/degraded areas used.

				mechanism.	
(ii). Enforcement of buffer zone legislation*	High	Forest/Wildlife Dept, CCD		Domestic & international US$ 610,000	- List of priority areas produced in 6 months - Physical markers in at least 2 areas annually. - Annually 10 instances/evidence of enforcement
Measure/Action 7: Recruiting personnel with biodiversity and climate change adaptation competence and provide capacity building programs for existing staff					
Justification for the action: Inadequacy of technical capacity of the respective departments and their staff, especially field staff is a major constraint for effective protected area management. However this constraint can be overcome by creating accountability of responsible people. Often in the government sector there are no rewards for those who are effective. Performance based evaluations would be an incentive for effective performance of assigned tasks. This will encourage more staff to perform well, while those who perform best should be given financial or non-financial incentives					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(I). Recruit personnel having competency in biodiversity conservation and climate change adaptation and provide capacity building programs 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	- Amended recruitment policy/criteria within 6 months.
Measure 8 - Create a mechanism to ensure **accountability** of responsible people. eg: promotions based on performance evaluations; incentives (financial and non-financial) for good performance.					
Justification for the action: Lack of effectiveness of departments and their staff, especially field staff is a major constraint for effective protected area management. However this constraint can be overcome by creating accountability of responsible people. Often in the government sector there are no rewards for those who are effective. . Performance based evaluations would be an incentive for effective performance of assigned tasks. This will encourage more staff to perform well, while those who perform best should be given financial or non-financial incentives.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Create a mechanism to ensure accountability of responsible people. eg: performance based evaluations for promotions; incentives for good performance.	Medium	Forest/Wildlife Dept, M/Environment, CEA M/Fisheries and Aquatic Resources Dev, NARA and CCD	1-10 years	Domestic US$ 20,000	- Evaluations carried out once a year.
Measure/Action 9: Enabling policies and initiatives to ensure Forest, Wildlife and other relevant departments to **work together-** bring DWLC and FD under one ministry.					
Justification for the action: Inadequate inter agency coordination when adjacent protected areas are managed by different authorities impacts conservation. Even though ecosystems have natural boundaries, legally protected areas rarely follow such boundaries. Additionally there are many instances in Sri Lanka where the Forest and Wildlife Department manage two or more adjacent protected areas independently. Collaborative management of such areas will ensure more effective management and monitoring.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Enabling policies/strategies and initiatives to ensure Forest, Wildlife and other relevant departments to work together - bring DWLC and FD under one ministry.	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD	1 – 10 years	No cost involved	- Policy/strategy promoting partnerships formulated within 6 months. - 2-5 projects and issues are jointly addressed annually.
Measure/Action 10: Identify areas to carry out **studies**, carry out **biodiversity assessments***					
Justification for the action: Lack of ecological information in protected areas is a major hindrance for effective conservation. Often there is limited or absence information on the ecology of protected areas. Ecological information such as species inventories, their status of threat, populations, niches, ecosystems; threats etc					

are are critical parameters for scientific management as such information are essential for appropriate management interventions. Therefore it is vital to identify areas where such information is lacking and carry out studies depending on priorities.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Timef rame	Cost & Funding Source	Indicators
(i). Identify areas to carry out studies, carry out biodiversity assessments*	High	Forest/Wildlife Dept, M/Fisheries and Aquatic Resources Dev, NARA and CCD Universities Environmental org.	1 – 10 years	Domestic & international US$ 255,000	- Priority list prepared in 3 months - 2-3 Studies/assessments successfully completed/reports annually.

Measure/Action 11: Amend and **implement buffer zone legislation***

Justification for the action: There is no (proper) legally defined buffer zone for protected areas. Even though the National Environmental Act refers to buffer zones within a certain radius, many in the environmental sector are of the view that these are not buffer zones in the typical sense, especially as 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 of the existing legislature is imperative for effective buffer zone management.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Amend and implement buffer zone legislation*	High	Forest/Wildlife Dept, CCD	1 – 10 years	Domestic & international US$500,000	- Review document produced in 6 months - Commencement of the implementation plan within 2 years.

Measure/Action 12: Physical **demarcation of protected area boundaries and buffer zones***; effective law **enforcement** on boundaries/removing encroachments etc.*; and create awareness on boundaries*

Justification for the action: Inadequate physical demarcation of protected area and buffer zone boundaries has contributed to many management issues such as encroachment, clearing and other violations. Therefore, it is important to physically demarcate these boundaries by fixing boundary markers, leaving no room for speculation of boundaries and disputes. Additionally it is equally important to enforce existing laws relating to protected areas and buffer zone boundaries.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & 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	- List of areas that require demarcation in 3 months - Boundary demarcation completed at least 50% of the areas by year 3.
(ii) Effective law enforcement on boundaries/removing encroachments etc.*	V. High	Forest/Wildlife Dept, CCD Police Department	1-10 years	Domestic & international US$ 750,000	- List of priority areas in 3 months - At least 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	- At least 2-5 programmes annually with 25-50 participants

Measure/Action 13: **Create awareness**, **build capacity** and provide material to promote coexistence with biodiversity. (eg: Kandyan home gardens; native plants seeds, materials etc)*

Justification for the action: There is a need to create community awareness to promote coexistence with biodiversity in areas adjacent to high value ecosystems and protected areas. In many areas communities have conflicts with certain species of biodiversity such as elephants, wild boar etc. Sometimes such incidents cause negative attitudes towards conservation. If conservation is to be carried out successfully community involvement in conservation is important as most areas outside

protected areas have significant human habitations. Patches of important habitats, key trees species etc, and home gardens are all vital patches important for connectivity. Building capacity and providing material to facilitate the process is also important.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & 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, Environmental org.	1-10 years	Domestic & international US$275,000	- Action Plan prepared within 6 months - Over 80% of awareness programmes identified are successfully completed annually. - At least 2-5 successful case studies a year.

Measure/Action 14: Introduce enabling legislation to promote community owned protected areas and provide **incentives** for such activities*

Justification for the action: Currently there are no legal provisions for communities to own and manage 'protected areas' outside the traditional protected area system. Introducing such a system will be beneficial, especially where there are intact or good quality ecosystems outside protected areas. It will not only serve as a buffer but also a habitat for biodiversity. Sustainable utilization such as the collection of non-timber forest products could be allowed as benefits.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Timeframe	Cost & Funding Source	Indicators
(i). Introduce a legal provision for community owned protected areas and provide incentives for such activities*	Medium	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, CCD Environmental org	Year 1 Continuous implementation	Domestic & international US$ 280,000	- Legal analysis document in 3 months - Provisions added within 6-12 months.

Total cost for Technology 3	**#Approx. US$ 6.75 million for 10 years**

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; CEA – Central Environmental Authority

5.5 Action Plan for Technology 4: - Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems

5.5.1 Description of the Technology

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[68]. Thus it would target species with high vulnerability to climatic changes that need special attention.

Recent studies have shown 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 some of such species have already become extinct. Tropical coral reefs and amphibians have been most negatively affected[69]. The Sri Lanka Red List[70] identifies threatened species, and their locations. Thus this can be used as a resource 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[71].

Some of its benefits are highlighted below:

- Environment - This will facilitate long-term conservation and viability of species and ecosystems while ensuring that ecosystem services will continue unhindered.
- Employment - Employment opportunities through the implementation of the program and also from ecotourism related ventures.
- Investment - There could be medium to high capital investment requirements in the event of any need for providing special facilities or conservation areas established.
- Income - Income generation from ecotourism and visitation to conservation facilities/areas where technology related programs are implemented. The local communities and other stakeholders will

[68] Mawdsley, et al. 2009. Op. Cit.

[69] Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution and Systematics 37:637–669.

[70] IUCN Sri Lanka and the Ministry of Environment and Natural Resources (2007) The 2007 Red List of Threatened Fauna and Flora of Sri Lanka, Colombo, Sri Lanka. xiii+148pp.

[71] IUCN. 2009. Climate change and species.
http://www.iucn.org/about/work/Programs/species/our_work/climate_change_and_species/

also be benefited by getting involved in ecotourism activities. There also could be benefits from payments for ecosystem services, community conservation and from conservation-related jobs.

- Education - Students will get an opportunity to study threatened species and understand is importance; Ability to study how such species can be protected from threats such as climate change.
- Health – Management interventions of this nature will contribute to ecosystem services such as provision of water, micro-climate regulation etc that will benefit the well-being and health of communities.

5.5.2 Target for technology transfer and diffusion

- Develop and implement at least 15 species/habitat action plans based on priority.
- Allocation at least 2-5% of annual budgets to implement above action plans.
- At least one comprehensive climate modeling to study climate change impact on species and ecosystems.
- Legal protection of 2-5 sites where point endemics are found.
- Incentive scheme introduced for protection in areas outside protected areas.
- At least 5 effective partnerships between Ministry/Departments and universities, NGOs, species specialists etc for species conservation.
- Awareness and capacity building programs targeting at least 25% of staff in Forest and Wildlife Departments.
- Implement at least five research studies on critical species.

5.5.3 Barriers to the technology's diffusion

Ten key barriers comprised of one (01) economic & financial, four (04) information & awareness, two (02) technical, one (010 each of policy, legal & regulatory, network failure, and institutional & organizational capacity have been identified.

The list of key barriers and hierarchy classification is given in table 5.14.

Table 5.14: List of key barriers and hierarchy classification for the technology 4

Technology Name:			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Minimal funding allocated for protecting highly threatened species/habitats.	1	Economic and financial
2.	Lack of national biodiversity action plans for highly threatened species/habitats	3	Technical barriers
3.	Lack of focused research on habitats for species migration.	5	Technical barriers
4.	Lack of information (including modeling) on potential climate change impacts on species/ecosystems.	2	Information, awareness
5.	Inadequate information on threatened species (distribution data, ecological information including population size and genetics - (in-situ research)	7	Information, awareness
6.	Poor awareness by general public and policy-makers on point endemics and other threatened species. Lack of recognition to reinforce voluntary (suasive) conservation action	9	Information, awareness
7.	Insufficient knowledge within the relevant authorities on species management strategies	4	Information, awareness
8.	Not all sites that harbor threatened point endemic species are protected.	10	Policy, legal and regulatory
9.	Insufficient partnerships for species conservation.	8	Network failure
10.	Delay in obtaining permission for conducting research by individuals and non-state sector institutions.	6	Institutional and organizational capacity

5.5.4 Proposed Action Plans for Technology 4:

The Proposed Action Plan for Technology 4 is provided in table 5.15.

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Action Plan for Technology 4

Table 5.15: Proposed Action Plan for the technology 4: Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems

Measure/Action 1: Allocate sufficient **funds from annual budgets** to implement action plans based on priority.*					
Justification for the action: There is a low financial allocation for implementation of this technology (nationally). Currently the main departments dealing with environment and biodiversity in the country do not have financial provisons for this activity in their nationally allocated budgets and it is considered a major constraint for conserving restricted and threatened species which is a high priority for biodiversity adaptation to climate change.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Apportion part of the annual budgets of Forest and Wildlife Departments for this technology based on the action plans (ii). Seek external funds*	V. High	Forest/Wildlife Dept, M/Environment	Year 3 Annually	Domestic No additional funding involved (5%, approx. US$ 750,000 annually)	- At least 2-5% of budget allocated for the technology after 1 year.
Measure/Action 2: Develop and implement **species/habitat action plans** based on priority.					
Justification for the action: There is a dearth of conservation action plans for highly threatened species/habitats. The main reason is being the insufficient funds and other resources being made available for preparation and implementation of such plans. Even though certain landscapes and ecosystems are protected, it appears to be insufficient to conserve certain highly threatened species/habitats. These species may be highly threatened due to a range of reasons. Therefore a comprehensive study is necessary to understand the existing and potential future threats, and prepare an action plan accordingly. It is of vital importance to take actions to implement the action					

plans once prepared. The level of threat to species/habitats as highlighted in the IUCN Red List can be utilized for planning purposes.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Develop and implement species/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	- Completed comprehensive species/habitat action plans within 2 years. - 10% increase in species population/habitat area/quality in 5 years.
(ii) Mechanism to incorporate disaster response for biodiversity (including rescue/relocation strategies and contingent fund)					- At least one strategy for disaster response prepared in one year.

Measure/Action 3: Generation of necessary **information** and **climate modeling** for determining potential climate change impacts on species and ecosystems.*

Justification for the action: There is a lack of information (including modeling) on potential climate change impacts on species/ecosystems.

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.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Generation of necessary information and climate modeling for determining potential climate change impacts on species and ecosystems.*	V. High	Forest/Wildlife Dept, M/Environment NARA and CCD	1 – 3 years	Domestic and international US$ 500,000	- Comprehensive study completed in 3 years. - Set of modeling data, maps etc within 3 years.

		Universities Environmental organizations			
Measure/Action 4: Legalizing the protection of sites where point endemics are found; **incentives** and alternatives for protection in areas outside protected areas*; **inter-departmental coordination** for protection of point endemics and make recommendation to incorporate climate change and species related considerations into legislation and publicize amendments.					
Justification for the action: - Not all sites of point endemic species are protected. Currently there are certain point endemic species that do not fall within the protected area system. Even though the species are protected, some ecosystems/sites are not protected and therefore non conservation related activities in such sites cause high threat to these point endemics. If the sites of these species are not protected, they will disappear permanently, and climate change will only compound the threats. Therefore protecting such sites will increase their adaptability to climate change.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Enabling legislations to protect the sites where point endemics are found. (ii). Integrate climate change and species related considerations into legislation – make recommendations and publicize amendments.	Medium	Forest/Wildlife Dept M/Environment M/Fisheries and Aquatic Resources Dev, CCD	1-4 years	Domestic and international US$ 760,000	- Document with gaps and priorities identified within 6 months. - At least 1 area successfully legalized (and implemented) annually.
(iii). Incentives and alternatives for protecting sites outside protected areas*	High	Forest Dept, Wildlife Dept M/Environment M/Fisheries and Aquatic Resources	1-4 years	Domestic and international US$ 1,500,000	- 2-5 alternative livelihoods introduced and carried out annually. - At least 500 beneficiaries annually.

		Dev, CCD			
(iv). Inter-departmental coordination for protection of point endemics.	High	Forest Dept, Wildlife Dept CCD	3-10 years -	Domestic and international US $ 600,000	- Internal policy/strategy promoting partnership formulated in 6 months. - 5-10 meetings between departments annually.
(v). Make recommendations on climate change and species related considerations	High	Individual experts, Conservation oriented NGOs M/Environment	Year 3	Domestic US$ 5,000	

Measure/Action 5: Create effective **partnerships** between Ministry/Departments and universities, NGOs, species specialists etc for species conservation.

Justification for the action: The Department of Wildlife Conservation being the legally mandated organization to conserve species has established limited partnerships for species conservation. Currently there are numerous researchers and institutions working on biodiversity conservation, and species focused research. Forming formal partnerships with these specialists will facilitate carrying out appropriate species-specific conservation. Their assistance can also be sought for carrying out specialist research and preparation of action plans & strategies for conserving such species etc.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Establish effective partnerships between Ministry/Departments and universities, NGOs, species specialists etc for species conservation.	High	Forest/Wildlife Dept, M/Environment M/Fisheries and Aquatic Resources Dev, NARA and CCD Environmental	3 years & Continuous	Domestic and international US$ 115,000	- At least 10 partnerships formed in 2-5 years. - At least 5 partnerships have lasted more than 1 or 2 years.

		organizations Species specialists			
Measure/Action 6: Carry out extensive **surveys/research**; obtain expertise on the subject/**capacity building***					
Justification for the action: There is inadequate information on threatened species in terms of distribution, population size and genetics. This information is vital when preparing management plans and strategies for their long-term conservation. It is proposed undertake such research in-situ in view of the vulnerability of these species. This information will also be essential for climate change modeling as it will give an idea of possible migration/dispersal and other changes. Therefore, availability of this information is a prerequisite for climate adaptive strategies for biodiversity conservation.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Carry out extensive surveys/research; obtain expertise on the subject/capacity building*	Medium	Universities Environmental org Species specialists Forest/Wildlife Dept, NARA and CCD	Year 2	Domestic and international US$ 800,000	- 2-5 of studies/research successfully completed (incl. reports) annually - 2-5 Capacity building – workshops annually with 25-50 stakeholders participating.
Measure/Action 7: **Awareness programs** on point endemics and critically endangered species, and the importance of their conservation; awareness and mechanisms for voluntary conservation action					
Justification for the action: Currently there is poor awareness by both the general public and policy-makers regarding the importance of point endemics and other threatened species. Many do not have any awareness on the importance, the role-played in terms of ecosystem services and the threats to their survival. It is often the lack of awareness on its importance that leads to threats and destruction of such species. Awareness creation should be carried out in a manner that is easily understood and captivates the interest of those whose priorities are often not conservation.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Timeframe**	**Cost & Funding Source**	**Indicators**
(i) Awareness programs on point	Medium	Forest/Wildlife	Annual from	Domestic and	-2-5 awareness workshops annually with 25-50

endemics and critically endangered species, and the importance of their conservation.		Dept, , NARA and CCD Universities Environmental org	year 3	international US $250,000	stakeholders
(ii). Awareness (in an innovative manner) with the support of 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 annually with 25-50 stakeholders.
(iii) Introduce relevant mechanisms to reinforce voluntary conservation action*	Medium	Environmental org Local communities Forest Dept, Wildlife Dept CCD Private sector	Year 2	Domestic and international US$300,000	- Incentive mechanism set in place/legalized in 1 year.
Measure/Action 8: Expedite the current administrative process available for obtaining **permission** for research work by individuals and non-state institutions*					
Justification for the action: There are experiences of undue delays in obtaining permission for conducting research by individuals and non-state sector institutions. The current existing administrative procedure to obtain such permission is unjustifiably long and discouraging. In some instances delays mean there is a lack of time for researches to carry out the research at the correct season or time period making research ineffective. Expediting the procedure is essential to encourage research activities, while ensuring that the essential administrative requirements are complied with.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Expedite process for obtaining permission for research by individuals and non-state institutions* (ii) Create awareness on process	High	Forest/Wildlife Dept, NARA and CCD	Year 1	Domestic and international US$ 25,000	- Mechanisms introduced to expedite selection. - 25% reduction in time to grant permission for research activities within a year.
Measure/Action 9: **Research** on habitats for species migration and identification/conservation of such habitats*					
Justification for the action: There is a lack of focused research on habitats for species migration. With the effects of climate change is felt, the species will tend to migrate into more favorable ecosystems and sites, while there will also be altitudinal migration. Often research is carried out in the present habitats of species. However with climate change, potential migration/dispersal sites of species also become important. Climate change modeling would enable identifying such potential sites. This information should be used as a guide and potential sites need to be researched to identify their suitability for species migration/dispersal.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Research on habitats for species migration and identification/conservation of such habitats*	V. High	Universities Environmental org. Forest/Wildlife Dept, NARA and CCD	Year 4	Domestic and international US$500,000	- List of research priorities identified in 3 months. - 2-5 successful studies completed and activities implemented annually.
Measure/Action 10: **Build capacity** and equip staff within departments for conservation and monitoring of threatened species/ecosystems (specialized knowledge).*					
Justification for the action: There is insufficient knowledge on species management strategies within the relevant authorities. Sri Lanka has a high diversity of species and it is not feasible for one department to be equipped with all the expertise on the country's biodiversity. Yet insufficient knowledge is a major hindrance for appreciating the need for species conservation. For species focused conservation, it is vital that ecological and other information relevant to the threatened or endemic species is known.					

Capacity building, and knowledge acquired from researchers and external experts will be essential when planning and carrying our conservation of species.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Build capacity and equip staff within departments to conserve and monitor threatened species/ecosystems (specialized knowledge).*	V. High	Forest/Wildlife Dept, NARA and CCD (Environmental org.)	Year 2	Domestic and international US$275,000	- 2-5 Capacity building – workshops annually with 25-50 stakeholders participating.
Total cost for the Technology 4				**#Approx. US$ 7.5 million for 10 years**	

V. High = Very High; NARA – National Aquatic Resources Research and Development Agency; CCD – Coast Conservation Department; NGOs – Non-governmental Organizations

5.6 Action Plan for Technology 5: Ex-situ conservation for highly threatened species and possible reintroduction

5.6.1 Description of the Technology

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 climate change. Such an approach would generally be a last resort for species[72]. Zoological Gardens, captive breeding centers, seed banks etc are some example of such conservation activities, and therefore not a new technology. However some advanced facilities may be necessary for certain species. Zoos 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[73]. 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 will need to be carried out until global warming is reversed as the only chance of survival for some species. Ex-situ collections should have sufficient diversity to allow adaptation[74].

Several Policies, Action Plans and Strategies in Sri Lanka have identified this technology as essential for biodiversity conservation.

Some of its benefits are highlighted below:

- Environment - The main environmental benefit would be that this mechanism would contribute to the viability of threatened biodiversity, and genetic diversity.
- Employment – Expansion and up gradation of existing ex-situ conservation facilities, and creation of new facilities will provide employment opportunities during the planning and construction phase and for day to day activities. It will require support staff and also scientists and veterinarians.
- Investment - There will be medium to high capital investment requirements to upgrade existing facilities, and to establish new facilities.

[72] Mawdsley, et al. 2009. Op. Cit.

[73] Mawdsley et al. 2009. Op. Cit.

[74] Noss, R. F. 2001. Beyond Kyoto: forest management in a time of rapid climate change. Conservation Biology 15:578–590.

- Income - Certain ex-situ conservation programs, especially those associated with zoos, botanical gardens and aquaria can generate significant income from tourists and local visitors. In fact they can accommodate larger number of visitors depending on the location and ease of visitation as carrying capacity will not be a limiting factor.
- Education - Zoos, botanical gardens and aquaria are excellent learning platforms for students of all ages and adults. It gives an opportunity to learn about both native and exotic species, and the ability to see a wide variety of species and obtain information, and usually have excellent interpretation centers. They also provide information on threatened species and importance of conservation, and play an important role in harnessing public support of biodiversity conservation in general.
- Health - There are no obvious health benefits from ex-situ conservation, but can contribute to good mental health and relaxation, as it is a recreational activity.

5.6.2 Target for technology transfer and diffusion

- Create at least two conservation facilities based on requirements and prioritization.
- Allocation at least 2-5% of annual budgets of the respective agencies for setting up ex-situ facilities that may be required in the near future.
- Introduce a framework/protocol for reintroduction and monitoring.
- At least 20 partnerships built with species specialists.
- Carry out capacity building on ex-situ conservation
- Standard protocols for ex-situ conservation (maintenance of facilities, disease control, quarantine etc) introduced.
- A study to identify and prioritize species for ex-situ conservation.
- Introduction of a regulated system to allow ex-situ breeding by non state parties under the close supervision of the government stakeholders.

5.6.3 Barriers to the technology's diffusion

Seven (07) key barriers comprised of three (03) economic & financial and four policy, legal & regulatory have been identified.

The list of key barriers and hierarchy classification for technology 5 is given in table 5.16.

Table 5.16: List of key barriers and hierarchy classification for the technology 5

Technology Name: Ex-situ conservation for highly threatened species and possible reintroduction			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Low funding allocation for this technology (nationally).	1	Economic and financial
2.	Lack of proper planning and funding for ex-situ conservation, No framework/protocol for reintroduction and monitoring	2	Economic and financial
3.	Lack of expertise and resources (suitable land/specialized locations, standard protocols) to carry out ex-situ conservation	4	Economic and financial
4.	Ex-situ conservation of wild fauna not a high priority in conservation policies.	5	Policy, legal and regulatory, information & awareness
5.	Weak law enforcement for improper ex-situ conservation	7	Policy, legal and regulatory, information & awareness
6.	Existing legal framework permits ex-situ conservation by only few government agencies.	6	Policy, legal and regulatory, information & awareness
7.	Poor understanding on species that may require ex-situ conservation (at present or in the future).	3	Policy, legal and regulatory, information & awareness

5.6.4 Proposed Action Plans for Technology 5: Ex-situ conservation for highly threatened species and possible reintroduction

The Proposed Action Plan for Technology 5 is provided in table 5.17.

BIODIVERSITY SECTOR

Action Plan for Technology 5

Table 5.17: Proposed Action Plan for the Technology 5: Ex-situ conservation for highly threatened species and possible reintroduction

Measure/Action 1: Apportion a part of **annual budgets** of the relevant agencies for setting up ex-situ facilities that may be required in the near future*					
Justification for the action: There is a low funding allocation for this technology (nationally). Currently the main departments dealing with management of environment and biodiversity conservation in the country do not have financial provisions for this activity in their nationally allocated budgets. Non prioritization of this activity and insufficient finances from annual budgets 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 & Funding Source**	**Indicators**
(i). Set aside a portion of annual budgets of Forest and Wildlife Departments for this technology based on action plans **(ii).** Seek external funds*	V. High	Wildlife Dept, Dept of National Zoological Gardens, Plant Genetic Resource Centre, National Botanic Gardens , NARA	Year 2	Domestic No additional funds required	- least 2-5% of budget allocated for the technology within 3 years
Measure/Action 2: **Identify** ex-situ conservation facilities required and **prioritization** and **estimating costs**.					
Justification for the action: There is a lack of proper planning and funding for ex-situ conservation. No framework/protocol for reintroduction and monitoring. Ex-situ conservation is usually considered a last resort for conservation, and thus it is an important technology for biodiversity adaptation. Ex-situ conservation requires proper advance planning to seek budgetary allocations.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Identify ex-situ conservation facilities that are required , prioritize and estimate the cost.	V. High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	2 – 3 years	Domestic and international 2,000,000	- Priority list in 6 months - 2-5 Built facilities annually for 3 years.
Measure/Action 3: **Introduce framework/protocol** for reintroduction/translocation and monitoring.					
Justification for the action: Currently there is no framework or protocol for captive breeding, reintroduction, monitoring etc,.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Introduce framework/protocol for reintroduction/translocation and monitoring.	High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	2 – 3 years	Domestic and international US $ 250,000	- At least 1 publication of best practices produced in 2 years. - At least 2-5 examples of best practices being used within 5 years.
Measure/Action 4: Carry out **capacity building** on ex-situ conservation*; **partnerships** with species specialists and facilitate exchange and **sharing of knowledge**; suitable resources and standard protocols					
Justification for the action: There is a lack of required expertise and resources (suitable land/specialized locations, standard protocols) to carry out ex-situ conservation. The resource requirements include suitable land and specialized location for certain species. Additionally it is vital to have standard protocols and procedures to carry out ex-situ conservation in the country. Without a combination of these skills, expertise and resources it would be difficult to carry out ex-situ conservation successfully.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). Carry out capacity building on ex-situ conservation*	High	DWLC, FD, National Zoological	Year 3,	Domestic and	- 2-5 Capacity building –

		Gardens, PGRC, National Botanic Gardens & NARA (Universities Environmental org)	thereafter annually	international US$ 500,000	workshops annually with 25-50 stakeholders.
(ii). Partnerships with species specialists and facilitate exchange and sharing of knowledge	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	- At least 10 partnerships formed in 2-5 years. - At least 5 partnerships have lasted more than 1 or 2 years.
(iii). Provision of suitable resources (eg: land etc).	V. High	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 3	Domestic and international US$ 1,000,000	- List of requirements needed and priorities in 6 months
(iv). Standard protocols for ex-situ conservation (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 in 12 months - Monitoring annually.
Measure/Action 5: Give ex-situ conservation **high priority** and **create awareness** on its importance.					
Justification for the action: Ex-situ conservation of wild fauna is not a high priority in the existing conservation related policies. Due to the complexity and high costs involved ex-situ conservation is not considered a high priority in conservation efforts. However, in view of the impending threats due to climate change, due attention needs to be given for ex situ conservation as survival of some species may entirely be dependent on this activity. The importance of ex-situ conservation should be clearly convinced to decision makers so that it is given due priority when allocating annual budgets, drafting strategies and policies.					

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i) Give ex-situ conservation high priority.	High	Wildlife Dept, Forest dept M/ Environment, Dept of National Zoological Gardens PGRC	Year 1-2	Domestic and international US$ 200,000	- Changes made to current policy and priorities in 6 months - Two awareness workshops annually with 25-50 stakeholders.
(ii) Create awareness on its importance* *(can combine with above activity)*	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 1-2	Domestic and international US$ 150,000	- Two awareness workshops annually with 25-50 stakeholders.
Measure/Action 6: **Studies** to identify and **prioritize species** for ex-situ conservation* and **climate change modeling** to also identify species vulnerable to climate change*					
Justification for the action: Currently there is poor understanding and dearth of information available on species that may require ex-situ conservation (at present or in the future). Perhaps under the present context ex situ conservation is not deemed a priority, but under the impending climate change scenario it would be necessary to have some predictions made to identify species requiring such interventions. This will enable certain facilities to be set up 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. Capacity building, technology transfer etc will be required in this regard.					
Action /Sub Action	**Priority Rank**	**Responsibility for Implementation**	**Time frame**	**Cost & Funding Source**	**Indicators**
(i). 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	Year 1-3	Domestic and international US$ 2,000,000	- A comprehensive study completed in 3 years. - One set of modeling data,

(ii). Climate change modeling to also identify species vulnerable to climate change* *(can combine with above activity)*		(Universities Environmental org)			maps etc within 3 years.

Masure/Action 7: Introduction of a regualted system to allow **ex-situ breeding** by non state sector parties, under the mandatory supervision by government stakeholders (In accordance to the legal system).

Justification for the action: - The existing the laws permit only some government sector institutions to carry out ex-situ conservation debarring non state sector participation. Ex-situ conservation certainly needs government involvement, however not having a mechanism to work with other institutions and the private sector may prevent funds, skills etc that will be essential for effective ex-situ conservation. It is however vital that even if ex-situ conservation is allowed by external parties, it should be under the strict and mandatory supervision of the relevant government department.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Introduction of a regulated system to allow ex-situ breeding by other parties, under the supervision of the government stakeholders.	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic Gardens & NARA	Year 2-3	Domestic and international US$ 1,040,000	- Breeding guidelines, regulations in 12 months. - Monitoring and evaluation

Measure/Action 8: **Enforcement** of existing laws for improper ex-situ conservation activities*

Justification for the action: Although, ex-situ conservation initiatives by non state parties are rare, there have been instances where small scale private zoos, parks etc have been set up violating or non-adherence to certain legislation. Further, conditions of these facilities were found to be substandard.Therefore enforcement of the respective legal instruments is essential. Therefore, existing laws need to be reviewed and amended as required to enable ensuring appropriate safeguards.

Action /Sub Action	Priority Rank	Responsibility for Implementation	Time frame	Cost & Funding Source	Indicators
(i). Enforcement of existing laws for improper ex-situ conservation activities*	Medium	DWLC, FD, National Zoological Gardens, PGRC, National Botanic	Year 1	Domestic and international	- Prepared strategy in 6 months.

		Gardens & NARA		US$ 150,000	- Execution of strategy
Total cost for Technology 5				**#Approx. US$ 7.5 million for 10 years**	

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

Chapter 6

Cross-cutting Issues

Barriers to transfer and diffusion of climate change adaptation technologies are unlikely to occur independently of one other. The barrier analyses in different sectors show linkages between different barriers or existence of general/common barriers faced by the prioritized technologies. Although specific barriers are different from technology to technology, some general or common barriers and appropriate measures can be identified for some technologies in all the sectors. Therefore, it is useful to analyze such linkages and measures in order to maximize synergies and optimize the effects of recommended measures.

The action plans proposed for adaptation technologies in different sectors as provided in Chapters 1-5, listed measures and actions to overcome the barriers in each sector. Amongst them there are some common measures in different sectors. Such measures and actions may not only have impacts on development of these technologies, but also may influence in resolving barriers of other technologies in the same sector or in other sectors. In general, such measures are advantageous for technological development.

The aim of this section is to identify common or general barriers to technology transfer and diffusion, that cut across the five prioritized sectors namely food, health, water, coastal and biodiversity, and to analyze possible cross-sectoral development actions.

6.1 Identification of common barriers across the sectors

The general/common barriers and proposed measures for all five sectors are described in the Report II, 'Report on Barrier Analysis and Enabling Framework' and in Technology Action Plan (TAP) report. The major groups of common barriers across sectors are as follows;

1) Inadequacy of finances
2) Inadequate enabling policies/laws and enforcement
3) Lack of sustainability
4) Inadequate information and awareness
5) Inadequacy of Research & Development
6) Poor inter agency coordination

These common barriers across the sectors are provided in table 6.1.

Table 6.1: The common barriers across the sectors

Barrier Group	Sectors / Barriers				
	Food	Health	Water	Coastal	Biodiversity
1. Finances	Inadequate finances	Inadequate finances	Inadequate finances	Inadequate finances	Low funding availability
2. Policies/laws	Inadequacy of enabling Policies/Poor enforcement of laws	Feeble policies and policy reviews	Poor enforcement of policies/laws	Poor enforcement	Weak law enforcement and implementation of policies
3.Sustainability	Not applicable	Lack of sustainability over time	Lack of sustainability	Unsustainable practices	Not applicable
4. Information and awareness	Poor technical knowledge	Poor awareness among health personnel	Inadequate information and awareness	Inadequate awareness	Lack of understanding, awareness and appreciation of value of biodiversity
5. Research & Development	Inadequate R&D and Training Facilities	Not applicable	Inadequate R & D	Not applicable	Lack of information, research, climate modeling
6. Coordination	Poor inter agency coordination	Poor coordination of training activities/.	Not applicable	Inadequate inter agency coordination	Not applicable

As shown in Table 6.1 above, inadequate finances, policies & laws, and information & awareness are the most critical barriers that cut across all five prioritized sectors. It can be concluded that inadequate finances appear to be the most critical issue for all the sectors. Similarly, inadequacies in information & awareness and policies, laws and poor enforcement are also critical barriers for most of the technology

developments in all the sectors. Lack of sustainability, poor inter agency coordination, and inadequate research & development are the next most significant barriers affecting the transfer and diffusion of technologies in most of the sectors.

Furthermore, research & development and information & awareness barriers as a matter of fact, are interrelated and linked with inadequate finances. For example, due to inadequate finances for R&D, many climate change adaptation related important research works cannot be sustained. Similarly, without adequate finances, the information including recent developments in sciences and climate change adaptation technologies cannot be disseminated to relevant stakeholders including general public. Issues related to inadequate of finances can be easily resolved by informed decision by the concerned parties.

6.2 The measures to overcome common barriers in sectors

The proposed actions and measures to overcome the cross-sectoral barriers are summarized in table 6.2.

As shown in table 6.2 following are the common measures to overcome cross cutting barriers for the technologies in food, health, water, coastal and biodiversity sectors.

- Provide adequate government financing and seek donor support
- Review and revise existing policies and legislation, effective enforcement and develop new policies and legislation as appropriate
- Take appropriate action such as, feasibility studies, adequate operation & maintenance and encourage non-extractive uses etc to ensure sustainability
- Awareness creation among all relevant stakeholders
- Carry out R & D as required for all sectors.
- Improve inter agency coordination among stakeholder organizations

Since these measures are common, they have the potential for making significant impacts on success of transfer and diffusion of technologies in all five prioritized sectors. Therefore, such measures and actions should be given due priority when implementing the technology action plans.

Table 6.2: Proposed actions/measures to overcome the cross-sectoral barriers

Group of Measures	Sectors / Measures					Common measures to overcome barriers
	Food	Health	Water	Coastal	Biodiversity	
1. Finances	Assuring availability of financial resources; Introduce subsidies and Agricultural credit	Provide sufficient government funds and explore alternative funding sources; Public-private partnerships and identification of low-cost technologies	Provide adequate funds and secure farmer contributions; Take steps to reduce the investment (capital) cost	Provide funding from the government and explore project specific external financing	Allocate a portion of annual budgets of Forest and Wildlife Departments for restoration	Provide adequate funds from government & donors
2. Policies/laws	Introduce and enforce policies, laws and regulations	Regular policy reviews and reforms	Develop a policy & strategy for selecting and prioritizing cascade systems; Review and revise information dissemination policies of Meteorology department; Review	Law enforcement to control illegal coastal practices and reef cleaning	Implement existing policies and legislation relating to land tenure; Policy harmonization; Enabling policies to discourage conversion of natural ecosystems for development projects; Enforcement of legislation	Review and revise existing policies and laws and ensure enforcement; Develop new policies and legislation as appropriate

			and revise existing policies & laws related to use of ground water			
3.Sustainability	-	Conduct feasibility studies on different technologies and implement only sustainable technologies	Improve operation and maintenance to increase sustainability of minor tanks; Pay special attention to sustainability of boreholes	Encourage non-extractive and/or sustainable utilisation of mangroves; Improve awareness on the impacts of unsustainable socio economic activities	Identify critical areas to be connected and prioritize required corridors	Take appropriate action to ensure sustainability (feasibility studies/ operation and maintenance / encourage non-extractive uses)
4. Information and awareness	Raise knowledge on cultivation of new crops and precision farming; Appropriate land management techniques	Awareness creation among health personnel	Improve the knowledge on importance of good tank & catchment management; Operation and management practices of rooftop rainwater harvesting systems; importance of the roof top RW	Raising awareness of all stakeholders including law enforcement officers; Improve awareness and provide assistance for preparation of management plans for rehabilitation	Awareness for decision makers; Create awareness and build capacity to promote coexistence with biodiversity; Awareness programs on point endemics and critically endangered species	Awareness creation among all relevant stakeholders

			harvesting as a water conservation method			
5. Research & Development	Assuring adequate R&D and training facilities; Encourage public and private partnerships for investments on R&D	-	R & D on tank water pollution; Promote R &D on ground water availability and hydrogeology; Formulate standards, codes & certification	Capacity building at R & D institutions to handle research; Conduct research on rehabilitation, sustainability and value added products of mangroves.	Climate change modeling; Ecosystem specific studies for valuation of ecosystem services; Research on habitats for species migration	Carry out R & D on relevant aspects in all sectors.
6. Coordination	Improve policy coordination & inter agency coordination	Establish and strengthen a coordination unit and a mechanism; Improve intra agency coordination	-	-	Inter-departmental coordination for protection of point endemics	Improve inter agency coordination

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Annex I

List of Stakeholders Involved and their Contacts

FOOD SECTOR

List of Stakeholders

No	Name	Institution	Address
1.	Dr.(Mrs.) A.P Bentota, Additional Director	Oil Crops Research & Development Institute	Department of Agriculture, Angunukolapelassa
2.	K.N. Kannangara, Senior Research Officer	Field Crop Research & Development Centre	Department of Agriculture, Aralaganwila
3.	Dr. W.M.A.D.B. Wickramasinghe, Director	Natural Resource Management Centre	Department of Agriculture, Sarasavi Mawatha, Peradeniya.
4.	Mr. K.M.A. Kendaragama, Research Officer	Natural Resource Management Centre	Department of Agriculture, Sarasavi Mawatha, Peradeniya.
5.	W.R.R.T. Wickramarachchi, Research Officer	Horticultural Crop Research & Development Institute	Gannoruwa, Peradeniya
6.	Dr. S.P. Nissanka, Head, Department of Agricultural Crop Science	Faculty of Agriculture University of Peradeniya	University of Peradeniya, Sarasawi Mawatha Peradeniya
7.	Mr. S.A.M. Azmy	Head, Environmental Studies Division	NARA, Crow Island, Col. 15
8.	Mr. M.M.m. Aheeyer, Research Officer	HARTI	114 Wijerama Mawatha, Colombo 7
9.	Dr. R.M. Herath, Ag. Economist	Socio Economic & Planning Centre	Department of Agriculture, Peradeniya
10.	Mrs. Nirushs Ayoni, Ag. Economist	Socio Economic & Planning Centre	Department of Agriculture, Peradeniya
11.	S. N. Jayawardana, Agronomist	DZLISPP	303, Gattuwana Rd, Kurunagala
12.	W.M.P.K. Walisinghe, Asst. Director	Hadabima Authority	PO Box 09, Gannoruwa Rd, Peradeniya
13.	Dr. Damayanthi Galanina, Entamologist	Horticultural Crop Research & Development Institute	Gannoruwa, Peradeniya
14.	Yasantha Munasinghe	Asst. Director	NPD

15.	K.G.R.G.R. Wickramawardane	Asst. Director	NPD
16.	Asitha Senevirathna	Addl. Secretary	Ministry of Industry & Commerce
17.	Mr. H.M. Bandaratillake	Team Leader/ TNA Project	Ministry of Environment
18.	Dr. R.D.S. Jayathunga	Director/ Climate Change,	Ministry of Environment
19.	Ms. Anoja Herath	TNA Coordinator	Ministry of Environment
20.	Ms. Kema Kasthuriarachchi	Environment Management Officer	Ministry of Environment
21.	Ms. Surani Pathirana	Environment Management Officer	Ministry of Environment

HEALTH SECTOR

List of Stakeholders

No	Name	Institution	Contact Address
1.	Dr. M.S.D. Wijesinghe	Environmental & Occupational Health, Ministry of Health	P.O. Box 385, Ven. Baddegama Wimalawansa Thero Mw, Colombo-10
2.	Dr. Thushara Ranasinghe	Consultant Community Physician, Ministry of Health	P.O. Box 385, Ven. Baddegama Wimalawansa Thero Mw, Colombo-10
3.	Ms. Nilusha Kariyawasam,	Env. Planning Officer Urban Development Authority (UDA)	'Sethsiripaya' 6th & 7th floors Battaramulla
4.	Ms. Padma Wijesinghe	Planning Officer UDA	'Sethsiripaya' 6th & 7th floors Battaramulla
5.	Ms. G.D. Dayani	Env. Planning Assistant UDA	'Sethsiripaya' 6th & 7th floors Battaramulla.
6.	Ms. Sarojini Jayasekara	Deputy Director Central Environmental Authority	104, Hector Kobbekaduwa Mw, Battaramulla
7.	Ms. Christine Dasanayake	Scientific Officer National Science Foundation	47/5, Maitland Place, Colombo-7

8.	Dr. A. Balasuriya	Senior Lecturer in Community Medicine, Faculty of Medicine	Defence University of Sri Lanka Kandawela Estate, Ratmalana,
9.	Ms. Kanchana Weerakoon	Founder/ President Eco Friendly Volunteers (ECO-V)	42/3/I, Nadee Uyana, Gangarama Road, Boralasgomuwa
10.	Dr. Mahesh Gunasekara	International Federation of Red Cross	Dharmapala Mawatha, Colombo-7
11.	Dr. E.C. Salvador	Technical Officer/ EHA WHO	226, Bauddhaloka Mawatha, Colombo-7
12.	Ms. A. Kavitha	Asst. Director, NPD	
13.	Dr. Inoka Suraweera	Consultant Community Physician, MOH	Ministry of Health

WATER SECTOR

List of Stakeholders

No	Name	Institution	Contact Address
1.	Eng. P.M. Jayadeera	Deputy Director (Irrigation) Department of Irrigation	P.O.Box 1138 Bauddhaloka Mawatha Colombo
2.	Mr. R.S.C. George	Deputy General Manager	National Water Supply and Drainage Board
3.	A.N.D.S. Waidyarathne,	Asst. Director (D)	National Water Supply and Drainage Board
4.	Mr. Asoka Ajantha	Project Manager Practical Action of Sri Lanka	5, Lionel Edirisinghe Mawatha Kirulapone, Colombo 5
5.	Ms. M.L. Nimanthi Manjula	Civil Engineer	Mahaweli Authority of Sri Lanka
6.	Mr. T. Samarathunga	Director	Mahaweli Authority of Sri Lanka
7.	Mr. I.G. Madduma Bandara,	DSWRPP project (Dam safety & water resources planning project)	2nd floor, MASL building,No. 500, T.B. Jaya Mawatha,Colombo 10.
8.	Dr. H. Manthitillake	International Water Management Institute (IWMI)	Head, 127, Sunil Mawatha, Pelawatta, Battaramulla

9.	Mr.M.M. Aheeyar	Head (EWRM) Hector Kobbekaduwa Agrarian Research & Training Institute	114, Wijerama Mawatha, Colombo 7
10.	Mr. S.A.M. Azmy	Head/ Environmental Studies Division NARA	NARA, Crow Island, Col. 15
11.	Dr. P.D. Ranasinghe	Assistant Medical Officer of Health (AMOH)	MOH Office Homagama
12.	Mr. W.D. Dharmasiri	Director, Ministry of Agriculture	Ministry of Agriculture Battaramulla
13.	Dr. S.M. Wijesundara	Food Sector Expert/ TNA Project	TNA Project Ministry of Environment
14.	Mr. H.M. Bandaratillake	Team Leader/ TNA Project	TNA Project Ministry of Environment
15.	Ms. Anoja Herath	TNA Coordinator	TNA Project Ministry of Environment
16.	Ms. Surani Pathirana	Environment Management Officer (EMO), TNA Project	TNA Project Ministry of Environment
17.	Ms. Nilmini Ranasinghe	Environment Management Officer	Ministry of Environment

COASTAL SECTOR

List of Stakeholders

No	Name	Institution	Contact Address
1.	Mr. R.A.S. Ranawaka	Senior Engineer (R &D) , Department of Coast Conservation	4 th Floor, New Secretariat Building, Maligawatta, Colombo 10
2.	Mr. K. Sugathapala,	Head, Human Settlement Division, National Building Research Organization	National Building Research Organization 99/1 Jawatta Road Colombo 05
3.	Mr. S.A.M. Azmy	Head/ Environmental Studies Division NARA	NARA, Crow Island, Col. 15.
4.	Ms. Vishaka	Regional Director, Practical	5, Lionel Edirisinghe Mawatha

	Hidellage,	Action	Kirulapone Colombo 5
5.	Dr. Terney Predeep Kumara	Head, Dept of Oceanography & Marine Geology	Faculty of Fisheries & Marine Sciences & Technology University of Ruhuna
6.	Asitha K. Senevirathne	Addl. Secretary Ministry of Industry & Commerce	Ministry of Industry & Commerce, Colombo
7.	Mr. H.M. Bandaratillake	Team Leader/ TNA Project	TNA Project Ministry of Environment
8.	Ms. Anoja Herath	TNA Coordinator	TNA Project Ministry of Environment
9.	Ms. Surani Pathirana	Environment Management Officer (EMO), TNA Project	TNA Project Ministry of Environment
10.	Ms. Nilmini Ranasinghe	Environment Management Officer	Ministry of Environment

BIODIVERSITY SECTOR

List of Stakeholders

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2.	Mr. B.M. Sooryabandara	Development Assistant	Forest Department Sampathpaya, Battaramulla
3.	Mr. R.A.S. Ranawaka,	Senior Engineer (R&D) Department of Coast Conservation	Department of Coast Conservation New Secretariat Building, Maligawatta, Colombo 10.
4.	Mr. S.A.M. Azmy	Head/Environmental Studies Division, NARA	NARA Crow Island, Colombo. 15
5.	Ms. D.M.T.K. Dissanayake	SEO, Central Environment Authority (CEA)	104. Denzil Kobbekaduwa Mw, Battaramulla
6.	Mr. Sunil Maithripala	Asst. Director, CEA	104. Denzil Kobbekaduwa Mw, Battaramulla
7.	Mr. Pradeep Rajadewa	CEA	104. Denzil Kobbekaduwa Mw, Battaramulla

8.	Mr. Ravi Deraniyagala	President, Wildlife and Nature Protection Society of Sri Lanka	No. 86, Rajamalwatte Road, Battaramulla
9.	Mr. Dinal Samarasinghe	Young Zoologist Association	Anagarika Dharmapala Mawatha, Dehiwala.
10.	Mr. Sameera Karunarathne	Young Zoologist Association	Anagarika Dharmapala Mawatha, Dehiwala.
11.	Mr. Gayan Pradeep,	Asst. Programme Manager Green Movement of SL	Green Movement of SL No. 09, 1st Lane, Wanatha Rd, Gangodawila, Nugegoda
12.	Ms. Christine Dasanayake	Scientific Officer National Science Foundation	National Science Foundation 47/5, Vidya Mawatha, Colombo 7
13.	Mr. Vimukthi Weerathunga	Environmental Foundation	Environmental Foundation Havelock Road, Colombo 5
14.	Ms. I.C. Vandabona	Environmental Officer Centre for Environmental Justice	Centre for Environmental Justice 20A, Kuruppu Road Colombo 08.
15.	Mr. W.K. Rathnadeera	South Asia Co-operative Environment Programme (SACEP)	SACEP, Anderson Road, Colombo - 5
16.	Dr. Mayuri Wijesinghe	University of Colombo	Department of Zoology, Faculty of Science, Uni. Colombo, Colombo. 03.
17.	Ms. Mayuri Malawarachchi ,	PA, Department of National Botanic Gardens,	Department of National Botanic Gardens, P O Box 14, Peradeniya
18.	Mr. Kanchana Weerakoon	Eco Friendly Volunteers	
19.	Mr. Hasula Wickramasinghe	Biodiversity Secretariat Ministry of Environment	Ministry of Environment Battaramulla.
20.	Dakshini Perera	Biodiversity Secretariat	Ministry of Environment
21.	Leel Randeni	Biodiversity Secretariat	Ministry of Environment