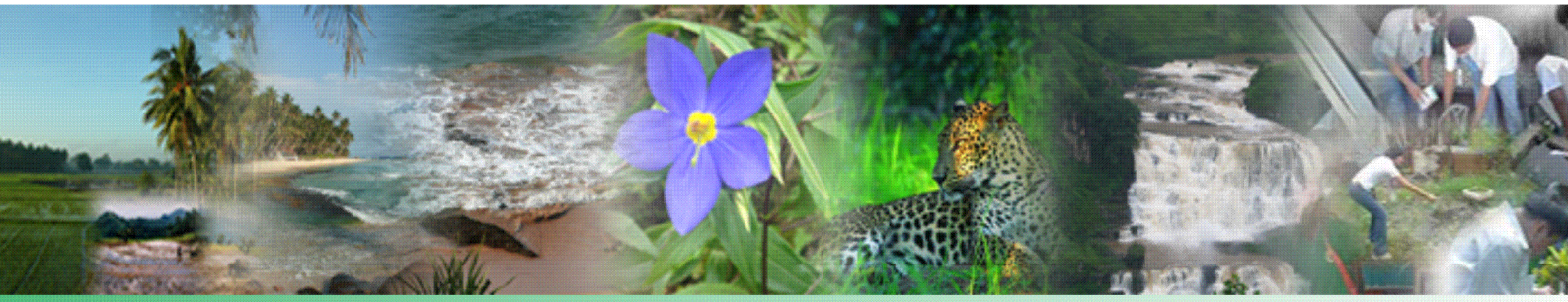
Ministry of Environment and
Renewable Energy
Sri Lanka



Technology Needs Assessment And Technology Action Plans For Climate Change Adaptation

Barrier Analysis and Enabling Framework

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 in rainfall patterns and extreme climatic events such as heavy rainstorms, flash floods, and extended droughts and weather related natural disasters in various forms and severity. These extreme and sometimes unseasonal events affect not only the human lives and properties but also have long term impacts on the ecosystems as well.

"*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

ACKNOWLEDGMENTS

This report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation was the outcome of the project on Technology Needs Assessment (TNA) on Climate Change Adaptation and Mitigation for Sri Lanka conducted by the Climate Change 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.

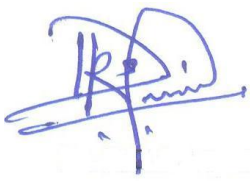
I wish to take this opportunity to express my sincere gratitude to Hon. Susil Premajayantha, Minister of Environment and Renewable Energy, Hon. Anura Priyadarshana Yapa, Former Minister of Environment, Mr. B.M.U.D. Basnayake, Secretary, Ministry of Environment and Renewable Energy and Mr. Gamini Gamage, 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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Stakeholder Participation

TNA Committee	– Annex A1
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

CARP	- Council for Agrarian Research Policy
CBF	- Culture Based Fishery
CBSL	- Central Bank of Sri Lanka
CC	- Climate change
CCD	- Coastal Conservation Department
CCS	- Climate Change Secretariat
CD & PF	- Crop Diversification and Precision Farming
CEA	- Central Environmental Authority
CIDA	- Canadian International Development Agency- ACDI
CZM	- Coastal Zone Management
DAD	- Department of Agrarian Development
DC&S	- Department of Census and Statistics
DGHS	- Director General of Health Services
DO	- Divisional Officers
DOA	- Department of Agriculture
DWLC	- Department of Wildlife Conservation
DZ	- Dry Zone
EIA	- Environmental Impact Assessment
EWS	- Early Warning System
FD	- Forest Department
FO	- Farmer Organization
FYM	- Farm Yard Manure
GDP	- Gross domestic production
GEF	- Global Environmental Facility
GHG	- Green House Gases
GIS	- Geographic Information System
Ha	- Hectare
HRH	- Human Resources for Health
INGO	- International Non Governmental Organizations
IPCC	- Inter-Governmental Panel on Climate Change
IUCN	- International Union for Conservation of Nature
LRC	- Land Reform Commission
M	- Meter
MCDA	- Multi Criteria Decision Analysis
MEPA	- Marine Environmental Protection Authority
MF&AR	- Ministry of Fisheries and Aquatic Resources
MoDM	- Ministry of Disaster Management
MOE	- Ministry of Environment

MOH	- Medical Officer of Health
MOH	- Ministry of Health
MSL	- Mean Sea Level
NAQDA	- National Aquaculture Development Authority
NARA	- National Aquatic Resources Research and Development Agency
NDMC	- National Disaster Management Centre
NGO	- Non-Governmental Organization
NSF	- National Science Foundation
NWSDB	- National Water Supply & Drainage Board
PAs	- Protected Areas
PCs	- Provincial Councils
PDHS	- Provincial Director of Health Services
PHI	- Public Health Inspector
PHM	- Public Health Midwife
R&D	- Research and Development
RDHS	- Regional Director of Health Services
RE	- Regional Epidemiologist
RH	- Relative Humidity
SCBF	- Sustainable Culture Based Fishery
SIDA	- Swedish International Development Cooperation Agency
SLR	- Sea Level Rise
SME	- Small and Medium scale Enterprise
TNA	- Technology Needs Assessment
TT & D	- Technology Transfer and Diffusion
UNDP	- United Nations Development Program
UNEP	- United Nations Environmental Program
WHO	- World Health Organization
WZ	- Wet Zone

LIST OF TABLES

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 and Coastal and Biodiversity**. Through an extensive stakeholder consultative process a potential list of technologies for each sector were identified, and prioritized by using the Multi Criteria Decision Analysis (MCDA) process. Although the TNA process was resulted in identifying potential technologies based on priority needs, there are some critical barriers that need to be overcome for achieving the desired objectives of technology transfer and diffusion. Therefore, the barrier analysis was carried out and enabling framework was developed for each technology through a stakeholder consultation process which also involved literature review and other investigations as well.

Food Sector:

The prioritized technologies for climate change adaptation in the food sector are; **(1) Sustainable inland culture-based fisheries**, **(2) Sustainable land management** and **(3) Crop diversification and precision farming**. These technologies were selected as the most promising adaptation options for the food sector. The first technology is categorized as a consumer good while the remaining are as other non-market goods.

Sustainable inland culture-based fisheries (SCBF) will rely on the extensive network of perennial and seasonal reservoirs developed for irrigation purposes. SCBF is a non-competitive but complimentary resource use that would permit maximization of benefits from freshwater resources and enhances food security for the participants and the nation as a whole.

Ten key barriers for the development of SCBF have been identified. Financial and economic constraints involved with committing increased investments are two most critical barriers for the expansion of SCBF. Inadequacy of financial resources available for investment and the high risks related with such investments are the potential financial barriers. Amongst the non-financial barriers identified, (i) Insufficient and weak supply arrangements for fingerlings and (ii) Inadequate R&D and Training Facilities have been recognized as the most critical barriers for the success of SCBF. It is noted that the key steps pertaining to R&D aspects of the fingerlings production remains a state monopoly held by National Aquaculture Development Authority (NAQDA). Capacity limitations and inadequate coordination arrangements being the results of state domination contributes to the other non-financial barriers viz; (i) Poor marketing infrastructure and low price; (ii) Non-favorable consumer preferences and social biases; (iii) Water quality degradation; (iv) Inadequacy of Government policy; (v) Poor institutional arrangements for stakeholder participation in policy making; and (vi) Inadequate product standards, codes and certification.

Need for **Sustainable land management (SLM)** is the manifestation of unregulated intensive land use practices due to high land pressure. Sri Lanka is recognized as one of the 19 countries with high population densities with land degradation being one of the most serious environmental problems. Land degradation is widespread in the country and occurs in all agro-ecological regions at different intensities. Land as a resource interconnected with other natural resources such as air, water, fauna and flora, which are essential for human survival, proper land management will help protecting the environment and conservation of natural resources while augmenting the food supply.

A were identified as barriers having some significant importance. Insecure land ownership and inadequacy of and poor enforcement of policies, laws & regulations were identified as barriers in policy/legal/regulatory category Lack of attention for conservation of non-agricultural lands and poor relevance of techniques due to diversity were identified as barriers in relation to institutional and organizational capacity. Inadequate knowledge, lack of stakeholder coordination and individual efforts were considered as significant barriers with respect to the categories of human skills, network failures and social cultural & behavior respectively.

Given the long gestation period required to yield the benefits of adopting SLM technologies, it is seen that measures that enhances affordability of investments to implement SLM technologies such as subsidies and other financial assistance and strengthening of security of land ownership could play a major role in ensuring success of adopting the technologies. Assigning the appropriate priority to SLM through the strengthening of coordination mechanisms, monitoring of enforcement, adopting a broader community approach to SLM are seen as essential measures.

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. Prominence given to rice cultivation in order ensure increased supply of the staple food is likely to impact food security due to increased vulnerability resulting from reduced crop diversity.

Barrier analysis in the CD&PF technology identified ten key barriers with two from the economic/financial category and others being non-financial barriers mostly from policy/legal/regulatory, institutional/organizational capacity, market failures and Information and awareness categories. The economic & financial barriers are Price fluctuation due unstable import policy and High cost of cultivation including labor cost. The non-financial barriers include Fragmentation of land holdings and Land tenancy arrangements obstructive to diversification away from rice (Policy, Legal, Regulatory); Lack of varieties and management packages suitable for diversification and Inadequate post harvest technologies and processing infrastructure (Institutional and Organizational capacity); High risk of marketing due to seasonal production and Under-developed marketing system, no penetration of rural markets & lack of timely accurate market information (Market failure); Poor technical knowledge on the cultivation of new

crops & precision farming (Information & awareness) and Irrigation network designs not practical for diversification (Other).

The measures identified to overcome economic/financial barriers include; Contain price fluctuations due to unstable import policy and Increasing affordability of cost of cultivation including labor cost. The measures identified to overcome non-financial barriers are Reducing fragmentation of land holdings and Revising land tenancy arrangements (Policy, Legal, Regulatory); Providing crop varieties and management packages suitable for diversification and Improving post harvest technologies and processing (Institutional and organizational capacity); Lowering marketing risk arising from seasonal production, Improving marketing systems and Raising technical knowledge on the cultivation of new crops & precision farming (Market failure) and Making irrigation network designs favorable for diversification (Other).

Health Sector:

The prioritized technologies for climate change adaptation in the health sector are **(1) Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events, (2) Transfer of knowledge and skills to Health Personnel and (3) Technology for management of Health Care Waste**. The first two technologies were categorized as other non-market goods and the third technology categorized as publicly provided goods.

Climate change could cause both direct and indirect impacts on human health. The threat of climate change poses to health is evident and if current global warming trends remain uncontrolled, humanity will face more injury, disease and death related to natural disasters, higher rates of food borne, waterborne, and vector-borne disease and more premature deaths and disease related to air pollution (WHO, 2008). Poor and underdeveloped countries and nations will be affected more compared to developed nations as they are capable of implementing mitigation and adaptation mechanism to minimize human suffering.

The first technology option for the health sector, **Early Warning Systems and Networking for Information Exchange on Extreme Weather events and other Climate Change related events (EWS)** was recognized as a very important technology because it helps to reduce economic losses and mitigate the number of injuries or deaths from health disasters, by providing information that allows individuals and communities to prevent health hazards. If well integrated with risk assessment studies and communication and action plans, early warning systems can lead to substantive benefits for preventing health hazards. Effective early warning systems embrace all aspects of emergency management, such as: risk assessment analysis, monitoring and predicting location and intensity of the disaster waiting to happen; communicating alerts to authorities and general public in order to take necessary precautionary measures in advance.

Six (06) key barriers for successful technology transfer and diffusion related to Early Warning Systems and Networking (EWS) were identified. Of the key barriers, one falls under the economic and financial category and the other five are non-financial barriers. Inadequacy of finances and unfavorable financial regulations being an economic and financial barrier is considered as crucial for implementing EWS successfully. Amongst the non-financial barriers, absence of an established structure for EWS & networking; administrative gaps; and poor utilization of novel technologies falls under category of institutional and organizational capacity. Feeble policies and policy reviews and underutilization of available trained people were identified as barriers under the categories of policy/legal/regulatory and human skills respectively.

Allocation of adequate funds by the government; and exploration for alternative funding sources & mechanisms are suggested as measures to overcome the economic and financial barrier. The measures recommended for non-financial barriers included (a) align with the existing government structure; (b) assign a focal point to deal in EWS matters with relevant sectors; (c) improve and enhance the use of available trained persons; (d) identify appropriate and affordable novel technologies; (e) train and assign a second line of personnel and (f) regular streamlining and monitoring of policy including policy reviews.
Sri Lanka's health sector is facing a number of human resource challenges that are influencing effective delivery of services. There is a continuous mismatch of demand and supply of human resources over the years, which has resulted in mal distribution and shortages. These are further complicated by the disease burden and demographic changes. Accordingly, the human resource issues it faces need to be resolved quickly, if it were to show any further improvement in its service delivery. Therefore, **Transfer of Knowledge and Skills to Health Personnel** is of paramount importance not only for climate change related issues but also for the general betterment of the health sector service delivery.

Barrier analysis related to **Transfer of Knowledge and Skills to Health Personnel** has identified six (06) key barriers including Inadequate Financial resources under the economic/financial category, non-utilization of modern educational technologies; lack of training needs assessment; unavailability of a training calendar and unavailability of a mechanisms to monitor diffusion of knowledge and skills falling under the category of institutional/organizational capacity, poor coordination of training activities under network failure, and shortage of competent trainers under human skills.

One economic and financial measure and five non-financial measures were identified to overcome these barriers. The economic and financial measure thus identified is to "provide sufficient funds". The non-financial measures identified includes (a) Establish and strengthen a coordination unit and a mechanism; (b) Conduct training needs assessments and design trainings accordingly; (c) Explore and provide opportunities to use modern educational methodologies and technologies; (d) develop an appropriate monitoring system and regularly carryout monitoring and evaluation of the diffusion of knowledge countrywide; (e) prepare and implement an annual training calendar and (f) provide a suitable benefit scheme and opportunities to trainers for their carrier development.

The barrier analysis in relation to **Technology for Management of Health Care Waste** has identified six (06) key barriers affecting technology transfer and diffusion under this technology. This includes two economic and financial barriers (i.e. treatment technologies of health care waste are expensive and lack of sustainability due to financial constraints) and four non- financial barriers. The non-financial barriers include poor awareness among health personnel, shortage of technical staff, inadequate commitment of policy planners & administrators and inadequate inter-sectoral coordination falling under the categories of information & awareness, institutional & organizational capacity, social, cultural & behavioral and network failures respectively.

The economic and financial measures identified to overcome the barriers are; Exploration of funding sources; Public-private partnerships, and Identification of low-cost technologies; feasibility studies on different technologies and implementation of sustainable technologies. The non-financial measures are (a) Awareness creation among health personnel and policy makers; (b) Train interested and qualified persons already in staff, open avenues for carrier development and take measures to retain personnel for a stipulated period; (c) Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other donors; (d) Establish a mechanism to improve the inter-sectoral coordination

Water Sector:

The prioritized technologies for climate change adaptation in the water sector are; **(1) Restoration of minor tank net works, (2) Rainwater harvesting from rooftops for drinking and household uses and (3) Boreholes/Tube wells as a drought intervention for domestic water supply.** These are classified under the categories of publicly provided goods, other non-market goods, and the capital goods respectively.

Restoration of minor tank net works is considered as a viable option to augment water supply in the dry zone which is already in a water stress due to inherent climatic conditions in the region. This situation is likely to be further aggravated by the climate change. Therefore, it is imperative to develop technologies to supply irrigation water to the dry zone of the country.

Nine (09) barriers likely to affect the success of this technology have been identified and they are; i. High capital cost and inadequate allocation of funds, ii. No return/benefit during extended dry seasons, iii. Lack of payments for communities (economic and financial barriers), iv. Lack of understanding on importance of good tank management, v. Lack of involvement of farmer community in planning and decision making (institutional and organizational capacity barriers), vi. Lack of prioritization procedure when selecting the most suitable cascade systems/minor tanks for restoration, vii. Lack of policy for distribution of funds among different government agencies (policy, legal and regulatory barriers), viii. Lack of sustainability of minor tank systems due to poor tank management (technical and network failure) and ix. Poor understanding on cascade hydrology due to lack of R & D (information and awareness and other barriers such as limitations due to water pollution. Of these, high capital cost is considered the most critical.

Three economic and financial measures and seven non-financial measures were identified to enable overcome these barriers. The economic and financial measures are; (a) obtain additional funds from donor agencies and as farmer contributions; (b) introduction of alternative employments during extended dry seasons and payments for communities involved in restoration activities. The non-financial measures are; (a) improve operation and maintenance practices; (b) improve the understanding on importance of good tank management practices; (c) strengthen farmer organizations and increase involvement of farmers in planning and decision making; (d) development of a policy/strategy on selection and prioritization of cascade systems/minor tanks; (e) Review and revise the mandate of Agrarian Service Department and Provincial Councils with respect to restoration of minor tank network systems as appropriate; (f) improve understanding on cascade hydrology by promoting R & D; (g) R & D on tank water pollution and strict enforcement of environmental laws.

Rainwater Harvesting (RHW) from Rooftops for Drinking and Household Uses is aimed at harnessing rain water due to intense rain storms and supplement domestic water supply during prolonged droughts both caused by climate change impacts.

Eleven (11) barriers were identified and they are i. High capital cost, ii. No benefit during extended dry seasons (economic and financial barriers), iii. Lack of sustainability of roof top rain water harvesting systems due to poor management, iv. Lack of standards, codes and certification for roof top rainwater harvesting (technical barriers), v. Poor understanding of importance of rain water harvesting from roof tops as a water conservation method, vi. Poor accessibility for information on rainfall data, vii. Lack of prioritized areas for installation of roof top rainwater harvesting systems (information and awareness), viii. Lack of confidence in roof top rainwater harvesting technology, ix. No demand for roof top harvested rainwater due to aesthetic considerations (social, cultural and behavioral), x. Inefficient enforcement of national rainwater harvesting policy (policy, legal and regulatory) and xi. Limitations due to contamination of water (institutional and organizational capacity). The high capital cost is considered as the most critical barrier.

The identified measures to overcome the barriers include two economic and financial measures and nine non-financial measures. The economic and financial measures are (a) obtain additional funds from donor agencies, and promote research on development of low cost, better quality roof top rainwater harvesting systems; (b) provide incentives for households/communities using rainwater harvesting systems. The non-financial measures are (a) Formulate a mechanism for standards, codes and certification for roof top rainwater harvesting systems; (b) Improve operation and management practices of rooftop rainwater harvesting systems through awareness programs, and demonstration of a roof top rainwater harvesting model system and dissemination of knowledge through audio-visuals; (c) Conduct awareness programs on importance of the technology as a water conservation method; (d) Provide free access to rainfall data; (e) Identify and prioritize suitable areas in the country for installation of roof top rainwater harvesting systems; (f) Build confidence in roof top rainwater harvesting technology; (g) Increase the demand for

roof top harvested rain water; (h) Strict enforcement of national rainwater harvesting policy, and (h) Good operation and management practices to minimize possible contamination of water.

Boreholes/Tube Wells can be used as alternative domestic water supplies especially during drought periods. Ground water is used as a drinking water source and also for back-garden agriculture and aquaculture in the dry zone.

The barriers identified with respect to promoting boreholes and tube wells are i. High capital cost, ii. Inadequate funding allocation (economic and financial), iii. Lack of assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing, iv. Lack of understanding on negative impacts of over extraction of ground water, v. Lack of information on ground water resources, vi. Lack of sustainability (institutional/organizational capacity and information and awareness), vii. Lack of policies/laws/guidelines for safe and sustainable use of groundwater, viii. Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers, ix. Lack of policies/strategies to establish low-interest loan scheme, x. Lack of policies/strategies to establish import tax relief (policy, legal and regulatory barriers), xi. Lack of prioritization of areas to implement the technology, xii. Lack of information on prices of equipment, loan schemes etc (Information and awareness, market failure barriers), xiii. Lack of R & D on ground water availability and hydrogeology (technical) and xiv. Limitations of the technology due to poor quality of ground water (other barriers).

The measures identified to overcome barriers are (a) Take appropriate steps to reduce the investment (capital) cost which includes measures to reduce cost of equipment and cost of construction; (b) Provide adequate funding for the technology (economic and financial measures) and (a) Provide assistance for physical investigations through registered contractors; (b) Improve the understanding on negative impacts of over extraction of ground water; (c) Providing suitable conditions for sustainability; (d) Formulate laws/guidelines for safe and sustainable use of groundwater; (e) Formulate laws/ bylaws/ guidelines to control drilling of boreholes affecting vulnerable aquifers; (f) Establish a low-interest loan scheme for importers/producers of tube wells; (g) Establish an import tax relief for importers/producers of tube wells; (h) Availability of information on aquifers in Sri Lanka; (i) Identify vulnerable areas for climate change and study hydrogeology of such areas etc and prepare a prioritized list; (j) Awareness campaigns on special facilities provided for tube well constructors; (k) Promote R &D on ground water availability and hydrogeology of various sites; (l) Select sites having good quality ground water (non-financial measures).

Coastal Sector:

The prioritized technologies for the coastal sector are; **(1) Sand dune rehabilitation, (2) Restoration of Mangroves and (3) Restoration of coral reefs** and are categorized as other non-market goods.
Sand dune rehabilitation is a measure to combat coastal erosion and inundation, which could be expected to occur due to sea level rise, as sand dunes create natural barriers together with their

vegetation. In areas where dune sand has been affected by anthropogenic activities such as construction work, rehabilitation should be done by planting suitable tree species such as *Pandanus* and other dune plants with economic or medicinal value with community participation after beach nourishment.

Barriers identified include both economic & financial and non-financial barriers. Lack of funds for restoration of sand dunes through natural beach nourishment and establishment of dune vegetation and to conduct awareness programs is recognized as the key economic & financial barrier. The non-financial barriers include two policy, legal and regulatory barriers (viz. poor enforcement of coastal zone management regulations; low priority of providing funds for environmental protection and R&D) and one each from network failure, institutional & organisational capacity, human skills, social, cultural & behavioural, information & awareness, technical and other barriers (i.e. lack of coordination among different institutions, lack of opportunities for research, inadequate trained personnel/experts to provide knowledge on technologies used, lack of commitment by the coastal communities & industries, 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 and negative impact due to extraction of sand for construction industries respectively).

The measures identified to overcome these barriers include one economic and financial measure and nine non-financial measures. The economic and financial measures are (a) Explore funding opportunities from the government and suitable donor agencies for implementing specific project proposals. The non-financial measures are (a) Conduct awareness programs to law enforcement officers and other stakeholders; (b) Increase the annual budgetary allocations; (c) Development of multidisciplinary projects and identify strategies to improve collaborations with stakeholders; (d) Build capacity of R & D institutions and incorporate capacity building needs in respective cooperate plans of the R & D institutions; (e) Provide annual budgetary allocations for the relevant institutions to train adequate number of staff in required fields and develop mechanisms to retain trained personnel; (f) Form a committed group of actors selected from the coastal communities, provide alternative sources of income or employment opportunities for those who are involved in destructive activities, and develop suitable strategies to enable active community participation in conservation and restoration programmes; (g) Conduct awareness programmes to involve all stakeholders coastal communities in sand dune conservation programmes; (h) Encourage plantations of dune vegetations with economic and medicinal importance through awareness/training programmes; (i) Encourage off-shore sand extraction for building construction and discourage construction involving coastal sand.

At present, the most commonly practiced wetland ecosystem for coastal protection is **Rehabilitation of Mangroves**. Wetland habitats perform essential functions in terms of coastal flood and erosion control. In addition, mangroves are instrumental in providing socio-economic benefits by 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.

Eight (08) barriers including one economic & financial and seven non-financial barriers have been identified. Lack/inadequate financial assistance for mangrove rehabilitation is conceived as the main financial barrier and non financial barriers include two policy, legal & regulatory barriers (viz. inadequate government patronage & commitment; lack of proper legal authority), two social, cultural & behavioural barriers (viz; unsustainable practices; destructive lagoon fishing techniques) and one each of technical, institutional and organizational capacity and other barriers (viz; replanting mangroves without establishing proper zonal plans and inappropriate species selection, general lack of appreciation/awareness on the non extractive uses/importance, and functions of mangroves and illegal & unsustainable land use practices in the hinterland respectively).

The measures identified to overcome the barriers include one economic & financial measure and nine non-financial measures. The economic and financial measure is aimed at exploring funds for targeted programs and encouraging self sustaining economic activities using mangrove products. The recommended non-financial measures are (a) Encourage the government to increase budgetary allocations for sustainable socio-economic programmes; Conduct awareness programmes on importance of sustainable management of mangroves; (b) Provide assistance to relevant authorities to prepare suitable management plans for rehabilitation of mangroves; Highlight the importance of rehabilitation of mangroves for socio-economic benefits; (c) Conduct awareness programmes for all stakeholders including those involved in unsustainable practices within mangrove areas; Strict enforcement of laws ; (d) Ensure strict compliance with of fishery regulations and regulatory mechanisms; Introduce Co-management procedures; Conduct awareness programmes and establish regulatory mechanisms; (e) Establish regulatory mechanisms for mangrove replanting programmes; Develop zonal plans to identify the mangrove areas required rehabilitation; Identify most suitable species for replanting; (f) Encourage projects that support mangrove rehabilitation; (g) River basin management; Conduct IEE/EIAs for all development programmes in the hinterland; Control land use patterns to reduce erosion.

Ten (10) barriers are identified including one under economic & financial category and nine barriers under non-financial category have been identified in relation to **Restoration of Coral Reefs**. Inadequate financial assistance for monitoring and restoration of coral reefs is considered the only economic and financial barrier while the non-financial sector include two barriers under policy, legal & regulatory category,(viz; inadequate government patronage & financial assistance; poor enforcement of coastal regulations), three social cultural & behavioral barriers (viz; unsustainable resource utilisation; sedimentation and pollution due to unplanned socio-economic activities; destructive activities against conservation/rehabilitation programmes), one each under network failures, information and awareness, technical and other (viz; insufficient coordination among different ministries, inadequate awareness among stakeholders, inadequate trained personnel to involve in coral rehabilitation programmes and natural phenomena that bleach corals respectively.

The measures identified to overcome these barriers are comprised of one economic and financial measure and nine non-financial measures. The economic and financial measure is aimed at attracting

funds from local & foreign sources for specific programs and also to introduce eco-friendly activities with financial gains. The non-financial measures include (a) Conducting awareness programs for policy makers and government officials involved with decision making processes when allocating funds; (b) Establishment of community participatory organizations in the vicinity of coral reefs; Appointment of properly constituted committees to review the EIA reports related to development and economic activities in the coastal belt; (c) Conducting awareness programmes on the impacts of unsustainable socio-economic activities; Offer alternative livelihoods or training for those who engaged in livelihood activities leading to destruction of coral reef habitats; (d) River basin management to prevent sedimentation; Conduct proper EIAs for all specified development programmes in the hinterland; Regulated land use practices to reduce erosion; Carry out reef cleaning programs with stakeholder participation; Enforcement of laws for all coastal development activities; (e) Awareness programmes to highlight the importance of coral transplanting; (f) Conduct awareness programs to key officials of different line ministries; Provide training for persons from relevant line ministries on coral transplanting and reef cleaning; (g) Conduct awareness programs on the importance of non extractive uses, role and functions of corals and importance of controlling pollution and sedimentation; Formulate development plans in consultation with important stakeholders; (h) Provision of training to stakeholder groups and use them as leaders for implementation of respective programmes and also as trainers for the rest of the community; (i) Conduct seasonal monitoring programs with the co-operation of trained stakeholders to be vigilant during natural phenomena.

Biodiversity Sector:

The adaptation technologies prioritized for the biodiversity sector are; **(1) Restoration of degraded areas inside and outside the protected area network to enhance resilience, (2) Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement), (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, (5) Ex-situ conservation for highly threatened species and possible reintroduction.**

Restoration of degraded areas inside and outside the protected area network will enhance the resilience and allow biodiversity to better withstand the impact of climate change. Some protected areas, although legally declared, are degraded due to illegal activities such as encroachments for settlement and clearing, logging and fire damage etc. There appear to be other natural ecosystems existing outside the legally protected areas but having significant conservation status or required to be restored and protected in the event of species shift as a result of climate change. Restoration will require selecting suitable native species and restoring the original status of the ecosystem. Some ecosystems that can be restored include forests, wetlands, coastal areas, coral reefs etc.

The barrier analysis has been able to identify nine (09) barriers including two economic & financial and seven non-financial. The economic & financial barriers are low funding allocations for restoration work and no immediate returns from restoration and lack of incentives for undertaking restoration activities. The non-financial barriers include four information, awareness and human skills related barriers (viz; poor understanding of the true value of ecosystem services; lack of national level prioritization of areas for restoration; conflicting interests/pressure from development; insufficient ecosystem specific capacities and technically sound restoration methods) and one each related to network failures, human skills & technical, policy legal & regulatory and social, cultural & behavioral patterns viz; inadequate working modalities to exchange and learn about restoration best practices, land tenure issues before and after restoration and lack of partnerships for restoration and management of lands outside protected areas respectively.

The measures identified to overcome barriers fall under the categories of both economic & financial and non-financial measures. The economic and financial measures are (a) Provide annual budgetary allocations for the Forest and Wildlife Departments based on above restoration action plans. (b) Provision of incentives by government/donors for restoration by communities and private sector and introduce a biodiversity-offset mechanism. The non-financial measures are (a) Undertake ecosystem specific studies on ecosystems service values and dissemination of related information. (b) Study on identifying and prioritizing critical areas for restoration, Climate change modeling to identify critical areas and formulation of action plans and financial requirements thereupon. (c) Compile best practices for ecosystem specific restoration methods and its dissemination, Promote research on technologies, Demonstration plots/pilot studies, (d) Create political awareness, Site specific evaluation for prioritization restoration programs. (e) Facilitate information exchange and knowledge sharing. (f) Implementation of existing policies and legislation relating to land tenure. (g) Build partnerships between government institutions and the private sector.

Increasing connectivity through corridors, landscape/matrix improvement and management is vital for conserving biodiversity during climate change as it is seen as an important mechanism to connect fragmented areas, as many protected areas are isolated from each other. Corridors play an important role in facilitating migration of species, whose ranges are likely to be affected by climate change. This strategy involves the protection of areas and regions that would be essential for climate-induced movements of both terrestrial and aquatic species.

Low funding allocation for connectivity (nationally) and lack of incentives to protect isolated forest patches/ecosystems in private lands have been identified as the major economic & financial barriers for the success of this program. The non-financial barriers identified are comprised of four policy, legal, regulatory & technical barriers (viz; high altitudinal areas are poorly protected; absence of matrix/landscape level planning of conservation and lack of effective policies and legislation; conflicting government policies on taking over of unutilized lands; procedural delays in land acquisitions) three information, awareness & technical (viz; critical areas for connectivity and priorities not identified at a

national scale; value and benefits of connectivity unknown; communities not aware on how to share habitats with biodiversity/critical species and lack of policy and legal framework for benefit sharing) and one related to social, cultural & behavioral aspects (viz; Existence of private land and conflicting land uses that impede creation of corridors, Competing interests/pressure from development).

The measures identified to overcome barriers include two economic & financial measure and eight non-financial measures. The economic and financial measure are (a) Provision of annual budgetary allocations for Forest and Wildlife Departments based on above action plan (b) Incentives for private landowners to set aside or maintain reservations required to ensure connectivity; Make revisions (legal/policy) to ensure that medium to large development projects set aside areas to maintain connectivity; Political awareness.

The non-financial measures are; (a) Enforcement and management of montane protected areas while increasing their protection status and effectiveness of conservation/ management; Include critical areas into protected area network; (b) Landscape level planning for conservation, special management and implementation integrate into Forest and Wildlife Department management plans; (c) Harmonization of national policies on 'taking over of unutilized lands' by the State; (d) Amend procedures to expedite land acquisition process; (e) Identify critical areas to be connected and prioritize required corridors; (f) Carry out valuation, identify and publicize benefits of connectivity; (g) Create awareness and build capacity to promote co-existance with biodiversity.

The strategy to '**Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones**' will focus on effectively managing established protected areas and also entail increasing the extent of terrestrial and aquatic habitats. Protected areas are aimed at providing sanctuary to fauna and flora with minimal impacts from humans and other threats. It is vital to ensure that protected areas possess a good representation of biodiversity in the country.

The barrier analysis has resulted in identifying four economic & financial barriers and eight non-financial barriers. The economic and financial barriers are; inadequate financial provisions (nationally); non-implementation of existing management plans for want of resources; lack of management plans for some protected areas; insufficient capacity in terms of number of personnel, knowledge and other facilities for adequate management & monitoring. The non-financial barriers are; conflicting land use in buffer zones; no legally defined buffer zone for protected areas; insufficient physical boundary demarcation in some protected areas and all buffer zones, lack of enforcement and awareness on boundaries; no provisions for community or privately owned protected areas (policy, legal and regulatory barriers), demand for land from proposed reserves/parks for development purposes ignoring utilization of other lands already cleared/degraded; inefficient protected area management by the relevant departments and staff (institutional and organizational capacity), lack of community awareness on sharing habitats with biodiversity and lack of policy on shared utilization (information and awareness), lack of coordination

between different authorities managing adjacent protected areas and lack of ecological information in protected areas (network failures).

The measures identified to overcome these barriers include four economic and financial measures and eight non-financial measures. The economic and financial measures are; (a) Provision of annual budgetary allocations for Forest and Wildlife Departments based on above action plan; (b*)* Allocation of resources and implementation of management plans; (c) Preparation and implementation of management plans for PAs having no such plans and (d) Recruiting qualified personnel to enable performing specific job descriptions. Non-financial measures are; (a) Incentives for using brown field/degraded areas; Policies to discourage conversion of natural ecosystems for development projects; Upgrade proposed reserves/parks to a higher level of protection; (b) Create accountability of responsible people; (c) Encouraging non-conflicting land uses through incentives; Enforcement of buffer zone legislations; (d) Amend and implement buffer zone legislation; (e) Physical demarcation of protected area boundaries and buffer zones; Effective law enforcement on boundaries; Create awareness on boundaries; (f) Introduce a provision for community owned protected areas and provide incentives for such activities; (g) Create awareness and build capacity to promote coexistence with biodiversity; (h) Policies and initiatives that encourage Forest, Wildlife and other departments to work together.

Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems involves with investing resources in maintenance and continued survival of species likely to become extinct as a result of global climate change. Therefore it will be targeted for species that need special attention having high vulnerability to climatic changes.

The barriers identified consist of two economic & financial barriers and eight non-financial barriers. The economic and financial barriers are inadequate funding for protecting highly threatened species and lack of national biodiversity action plans for highly threatened species; The non-financial barriers are lack of information including modeling with regard to climate change impacts on species/ecosystems; inadequate information on threatened species; poor awareness by general public and policy-makers on point endemics and other threatened species; insufficient in-house knowledge on species management strategies (information & awareness), all sites of point endemic species are not protected (policy, legal & regulatory), insufficient partnerships for species conservation (network failure), difficulty in obtaining permission for conducting research by individuals and non-state sector institutions (institutional & organizational capacity) and lack of focused research on habitats for species migration (technical).

The measures identified to overcome these barriers include two economic & financial measures and eight non-financial measures. The economic and financial measures are (a) Allocate sufficient funds from annual budgets to implement species action plans; (b) Develop and implement species action plans based on priority. The non-financial measures comprise of (a) Generation of necessary information and climate modeling to address climate change impacts on species and ecosystems; (b) Carry out extensive surveys/research; Obtain expertise on the subject/capacity building; (c) Awareness programs on point

endemics, including the importance of their conservation and programs for policy makers and school children; Introduce relevant mechanisms to reinforce voluntary conservation actions (d) Build capacity and equip staff within departments to conserve and monitor threatened species/ecosystems; (e) Legalizing the protection of sites and establish inter-departmental coordination for protection of point endemics; Incentives and alternatives for protection in areas outside protected areas; (f) Create effective partnerships between Ministry/Departments and universities, NGOs, species specialists etc for species conservation; (g) Establish hassle free process for obtaining research permission for individuals and non-state institutions; (h) Research on habitats for species migration and identification/conservation such habitats.

Ex-situ conservation for highly threatened species and possible reintroduction refers to conservation activities undertaken 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. Zoo's, captive breeding centers, seed banks etc are some example of such conservation activities. Ex-situ collections should have sufficient diversity to allow adaptation.

The barriers identified include two economic & financial barriers (viz; Lack of proper planning and funding for ex-situ conservation and Lack of expertise and resources to carry out ex-situ conservation). The non-financial barriers are; ex-situ conservation of wild fauna is not considered a high priority in conservation related policies; weak legal instruments to act against improper ex-situ conservation; availability of restricted legal provisions to enable only few government sector institutions to carry out ex-situ conservation (policy, legal and regulatory/ information and awareness) and inadequate understanding on species that may require ex-situ conservation (technical).

The measures identified to overcome these barriers include two economic & financial measures (viz; Identify and prioritize required ex-situ conservation facilities, allocate funding for setting up of ex-situ facilities and introduce framework for reintroduction and monitoring: Carry out capacity building on ex-situ conservation, establish partnerships with species specialists, facilitate exchange and sharing of knowledge, provision of resources and standard protocols for ex-situ conservation) and four non-financial measures (viz; Create awareness and offer high priority for ex-situ conservation; (b) Enforcement of existing laws to prevent improper ex-situ conservation activities; (c) Introduction of a streamlined system to permit ex-situ breeding by other parties under the overall supervision of relevant government authorities; (d) Studies including climate change modeling to identify and prioritize species for ex-situ conservation)

Chapter 1

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 high potential of negative impacts on food production, food security and natural resources in the country. The impending vagaries of climate change such as intense, uncertain, 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 prioritization of technology options for climate change adaptation in the food sector in Sri Lanka was carried out through an extensive stakeholder consultative process utilizing the Multi-Criteria Decision Analysis (MCDA) approach (Ref. Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report) List of prioritized technologies appear on Table 1.1.

Table 1.1: Prioritized Technologies and Categories in the Food Sector

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

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

1.1 Preliminary targets for technology transfer and diffusion

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

[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.

1.1.1 Sustainable Inland Culture Based Fisheries (SCBF)

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

1.1.2 Sustainable Land Management (SLM)

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

1.1.3 Crop Diversification and Precision Farming (CD&PF)

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

1.2 Barrier analysis and possible enabling measures for Technology 1: Sustainable Inland Culture Based Fisheries (SCBF)

Inland Fisheries and Aquaculture has high potential for further development as the country has an abundance of inland water bodies almost island wide.

The National Aquaculture Development Authority (NAQDA) estimates fresh water bodies to be of around 260,000 ha in extent and is comprised of large, medium and minor irrigation reservoirs, seasonal village tanks, flood lakes, upland reservoirs/estate tanks and Mahaweli river basins[2].

There is a need to increase fish production in minor perennial reservoirs, seasonal tanks and brackish water bodies through culture-based fisheries. Reported production from the inland fisheries sector in 2010 was 47,000 mt (MF&AR). Inland fisheries and aquaculture has shown a sluggish growth over the last ten years, with a highest contribution to the total fish production about 20%, recorded in year 2005. However, the contribution of the sector has remained around 14% after 2005.

Reservoir fishery as the main aquaculture activity practiced currently provides significant contribution to food and nutritional security of the rural areas in the interior regions of Sri Lanka and has other benefits such as providing supplementary income for farmers by creating new job opportunities in the

[2] Ten Year Development Policy Framework, Ministry of Fisheries and Aquatic Resources, (2007)

communities, and making available animal protein at affordable prices. Statistics indicate that per-capita fish consumption in districts such as Anuradhapura, Polonnaruwa, where reservoir fisheries activities are successfully established is above the national per-capita fish consumption.

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

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

1.2.1 General description of Sustainable Inland Culture-Based Fisheries

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

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

Species stocked are either indigenous or exotic, and either, herbivorous, carnivorous, or omnivorous. In the tropics, high-yielding herbivores, detritivores and plankton feeders (like tilapia and carp), are commonly stocked in lakes and reservoirs. Sri Lanka's large perennial reservoirs and small seasonal tanks, which constitute the country's main freshwater resource, are regularly stocked with fingerlings of the different carp species (Indian, Chinese, and common), which are produced at Government-run hatcheries spread all over the country. Since the Indian and Chinese carps do not spawn in the

reservoirs/tanks, they have to be stocked regularly to sustain the fisheries. There is thus large pressure on the State to accelerate its seed production program to keep up with the large demand for fingerlings. In Sri Lanka, the National Aquaculture Development Authority under the Ministry of Fisheries is primarily responsible for the production of carp fingerlings for distribution among the various reservoirs and seasonal tanks.

Please see Annex I for the Market Map on technology 1- Sustainable Inland Culture Based Fisheries.

(For more information please refer to Technology Fact Sheet on Sustainable Culture-Based Fisheries in Annex D-1 of the report on Technology Needs Assessment and Technology Action Plans (Part I) for Climate Change Adaptation in Sri Lanka)

1.2.2 Identification of barriers for Sustainable Inland Culture-Based Fisheries

The process of identification of barriers included stakeholder consultations, literature reviews and interviews with sector specialists. These prioritized barriers with stakeholder consensus are described below;

1.2.2.1 Economic and financial barriers

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

a) Inadequate availability of financial resources

The stocking of reservoirs requires finances to procure fingerlings. Presently, much of these finances are met from a variety of sources such as NGOs, donor-funded projects, funds allocated from the public (treasury financed) projects, (i.e. *Gami Diriya, Gama Neguma* etc.) and Fishery Societies. Ideally, after initial assistance from various state and non-state sources, the reservoir based Fishery Societies should have accumulated savings to be used as investment capital for re-stocking. However, the Societies continue to depend on external sources to secure required finances. Financial institutions such as banks have not developed financing instruments to enable meeting the capital requirements for stocking the reservoirs. Although the reservoir based Fishery Societies are legally organizations, stocking operations have not been recognized as commercial investments. In view of these financing constraints, the Societies are not in a position to make advance payments for required fingerlings.

Fingerling production operations which require large investments are also faced with similar funding constraints. Hence, the construction and operation of hatcheries for induced breeding, post-larvae to fry rearing, fry to fingerling rearing are affected by lack of financing sources. Fry to fingerling rearing

operations are often out-sourced and undertaken as private investments. The capital investment required to supply the required quantities of fingerlings is very high and the unavailability of financing sources impedes adequate investments in this sector.

b) High risk of investment

The SCBF operations also present many risks at different stages of the production process requiring an approach to risk management. Cost recovery at the State owned breeding centers, and reasonable profit to fingerling rearers and fish farmers engaged in reservoir farming are prerequisites for the success of SCBF strategy. Induced breeding and rearing of post larvae to fry stage in State owned fish breeding centers is carried out under controlled conditions and are less susceptible to risks. Nonetheless, breeding operations could be disrupted due to changes in weather etc. Disruption to the fry supply, high-mortality of post-larvae & fingerlings and rising costs of feed are potential risks to be faced with during the process up to fingerling production. Post stocking incidences such as, high mortality due to water pollution, poaching, and predation and escaping of fish from culture systems caused by the institutional problems could result in financial losses to farmers.

The optimum rate of stocking for village reservoirs is estimated at 3,500 fingerlings per ha of inundation area and the total requirement of capital for fingerling stocking for a 10 ha tank is Rs. 70,000 (at the current price of Rs. 2/= per fingerling) (US $ = SL Rs. 130.2). The absence of a risk management scheme and non existence of a system to ensure the recovery of investment works as a disincentive for investments. As a result, many aquaculture communities depend on free or subsidized fingerlings supply by the State agencies under various ongoing livelihood enhancement programs such as *Divi Neguma, Gama Neguma* etc, donor and state-funded projects, NGOs.

1.2.2.2 Non-financial barriers

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

Market failure barriers:

a) Insufficient and weak supply arrangements for fingerlings

The supply arrangements for fingerlings are hampered by the state dominance in the fish breeding and fry production operations. The fish breeding centers operated by National Aquatic Development Authority (NAQDA) carry out brood stock maintenance, induced breeding and hatchery operations and post larvae to fry stage production. The level of supply is restricted due to capacity constraints of the fish breeding centers owned by the State and non participation of the private sector in the breeding operations. The

State monopoly in the fish breeding operations and non-commercial pricing schemes tend to discourage private entry participation fish breeding and hatchery operations. Enlisting participation of small private entrepreneurs under buy back arrangements has increased the capacity of the fingerling rearing operations to some extent. However, as this contract based rearing arrangements for fingerling supply restrict open market operations, potential growers have to rely on the state apparatus for fingerlings.

b) Poor marketing infrastructure and low price

The marketing infrastructure for SCBF products is at a rudimentary stage. The fish landing infrastructures facilities are nonexistent at most reservoirs inconveniencing both the sellers and buyers. Fish handling and cleaning facilities are not available and organized fish auctioning arrangements to induce price competitiveness is absent. There is no price reporting system for SCBF products.

In the absence of a regulated harvesting procedure, opportunities available for better prices for the producers are lacking. Proper post harvest methods and preservation techniques including value addition are not used widely. These result in offering of a low price for the produce.

Institutional & organizational capacity, information and awareness barriers:

c) Inadequate Research & Development and Training Facilities

SCBF gained momentum in most countries in Asia with technological developments such as artificial propagation of popularly cultured species that lessened constraints on seed-stock supplies. However, ensuring supply of adequate seed stocks within a short time span during which the water bodies begin to fill is a recurring constraint faced by SCBF. As SCBF is a new technology, effective extension and training services must be available and continued over several years until the SCBF practitioners become proficient in technology. In Sri Lanka, research relating to SCBF technology development and training for entrepreneurs interested in fingerling rearing and production remain the prerogative of the State, yet are underfunded and under developed.

Social, cultural, behavioral and information and awareness barriers:

d) Non favorable consumer preferences and social biases

Lack of consumer preferences and social biasness against freshwater fish further dampens the prospect of the SCBF as a major alternative to marine fishery products. As the fish species used for SCBF are exotic species introduced in the last few decades, consumer awareness and education is important in promoting consumption. The strong odor associated with fresh-water fish is not liked by some consumers.

Policy, legal and regulatory barriers

e) Inadequacy of Government Policy

Technology development, extension and training of SCBF is currently being carried out by NAQDA under the State patronage. However, many of the water bodies used for SCBF activities come under the jurisdiction of the Provincial Councils (PCs). Officials functioning under the Provincial authorities are responsible for decisions relating to water use from these reservoirs such as issuing water for irrigation. Therefore, a stronger collaboration with the PCs is essential for the development of SCBF. However, the tendency of the NAQDA to operate SCBF programs through its network of District Offices sans closer engagement of the provincial authorities appears to be a hindrance for the progress.

Network failure barriers:

f) Poor institutional arrangements for stakeholder participation in policy making

The policy decisions relating to SCBF development remain strictly a state affair with no arrangements for industry representation in the policy and strategy formulating processes. In the absence of such stakeholder consultation, decisions relating to future strategy are communicated only through pronouncements by State Agencies. This State Agency centered development approach in the SCBF sector has not catalyzed proper institutional arrangements for stakeholder participation in policy making. Therefore, much of the decision making relating to capacity expansion, product development, area selection etc are taken without stakeholder consultations. Scattered and unorganized nature of the producer groups as well as lack of direct linkages between key industry participants such as fingerling rearers and growers is not conducive for exchange of views. In the absence of focused efforts to strengthen coordination between these groups and the State actors opportunity for providing input to policy processes is nonexistent.

Technical barriers:

g) Inadequate product standards, codes and certification

Inadequate product standards, codes and certification were recognized as a technical barrier to SCBF development. The size of fish harvested varies widely due to the adoption of unregulated harvesting practices which has no standards on size/weight for fish to be eligible for harvesting. Good management practices in rearing fish needs to be followed by proper harvesting procedures to ensure sustainable industry development. The use of environmentally responsible management practices at all stages of production can be ensured by introducing appropriate codes of practice, product standards. Certification of product helps to establish consumer confidence that the SCBF products are produced and marketed following the best management practices sanctioned by the industry.

Information and awareness and other barriers:

h) Water quality degradation

The village reservoirs that host SCBF are multi-user, multi-purpose structures that service irrigation, domestic and recreational needs of the village residents as well as requirements of livestock. They suffer from the problems associated with the management of common resources and thus face threats from pollution, largely of non-point source type. However, the fresh water fish requires water that is free of pollution including suspended solids and other harmful substances. The pollution status of water bodies progressively worsens towards the tail-end of the dry period, during which time much of the fish growth takes place. Such a situation acts detrimental to CBF activities as fish are sensitive to water quality in which they habituate.

1.2.3 Identified Measures

The identification of appropriate measures to overcome the barriers was done through a stakeholder consultation process supplemented by literature reviews and expert inputs.

1.2.3.1 Economic and financial measures

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

a) Barrier: *Inadequate availability of financial resources*
Measures: *Assuring adequate availability of financial resources*

The 2 month long fingerling rearing nursery operation from fry stage up to stocking is carried through a public-private partnership arrangement of outsourcing to small and medium producers. The initial capital requirement for the construction of protected cages or ponds is substantial and the returns to investment are received over the life span of the structures which is 3 years for cages and 10-15 years for ponds. The cost of a 100 m^2 pond is about Rs. 80,000 and several of these ponds must be operated for economic viability. Therefore, the initial investment cost is substantial for an average farmer requiring some form of long-term credit facility.

Also, potential investors as well as financial institutions such as banks are unaware of potential returns on investments from SCBF activities. This makes it difficult to find investors and funding sources for fingerling nurseries as well as for tank-based culture operations. Also, as SCBF is being a community activity for which the consent and agreement of various user-right holders in a water body is required. Model investment plans or other easy communications methods become imperative for securing support

all stakeholder groups. A study carried out with fingerling cage culture showed a rate of return of 13% after taxes whereas studies from different countries have shown rates of return as high as 58%. Thus, producing model investment plans for operations of different scale would be useful to find more investor groups to enter into SCBF activities.

b) Barrier: *High risk of investment*
Measure: *Lowering the risk of investment*

An insurance scheme to cover risks in the cultured fishery, especially fingerlings nursery operations will encourage investments in the industry. Although, there are no serious disease related risks in SCBF as with other aquaculture operations, there is high probability of occurring problems related to substandard feed and water quality etc. Therefore, some risk bearing tool will be an encouragement to potential investor.

1.2.3.2 Non-financial measures

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

Market failure measures:

a) Barrier: *Insufficient and weak supply arrangements for fingerlings*
Measures: *Strengthening adequate supply of fingerlings*

The supply of fingerlings remained a State monopoly until it was recognized lately that the State agencies alone cannot meet the demand. This resulted in enlisting private nurserymen to operate fry to fingerling rearing operations thereby significantly enhancing the supply capacity. However, fish breeding and hatchery operations still remains with NAQDA and prices of fry and fingerlings are regulated by them. Fish breeding is an expensive and complex operation requiring importation and maintenance of brood stock, induced breeding through use of hormones etc. Private sector venturing into fish breeding requires the government adopting an incentive strategy to encourage investments and enabling stable policy environment over a sufficiently long period to ensure return on investments. Also, pricing of fry and fingerlings must be determined in a manner to make it profitable. In fact, the control of market for fry and fingerlings hinder open market opportunities which enable attracting private sector investments in hatchery and nursery operations.

Fingerling buy back and allocation by one agency act as a disincentive to develop an identity for quality. Instead a more market-oriented system that improve awareness on sources and availability of fingerlings and quality certification system would better serve the interests of the nurserymen and fish farmers.

b). Barrier: *Poor marketing infrastructure and low price*
Measures: *Improving marketing infrastructure and price*

Marketing of SCBF produce operates at a primitive state due to lack of attention to market and product development. Marketing services are often provided by fish vendors who have little relationship with the production system, particularly those engaged in non perennial SCBF operations. The seasonal nature of production does not encourage developing a long standing relationship between market agents and producers. However, supporting the development of producer associations involving all stakeholder groups including the marketing agents can be mutually beneficial thereby permitting development of a supply network and better coordinated harvesting schedule effectively extending the harvesting 'season'. The introduction of a marketing information system will facilitate closer collaboration and improved pricing for producers.

Staggered harvesting can be used to promote marketing fish of 'standard' size instead of a range of sizes as happening with one time harvesting. It will promote the consumer acceptance and market development. Given the range of sources from which inland fishery products are supplied, it is necessary to introduce a quality control system and a good SCBF reservoir management system to ensure consumer confidence on quality.

At present SCBF products are mostly consumed by inhabitants living in close proximity to the production sites. This has restricted the development of larger consumer base and price competitiveness. Presently, SCBF products are marketed at a significantly low price when compared with that of the marine fish. Promoting SCBF produce in areas where marine fish products are marketed should be undertaken as a market development strategy. Identifying new markets and value addition will enhance marketing options for producers. It will effectively extend the production season making fresh-water fish available over a longer period beyond the short harvesting period.

Institutional and organizational capacity, information and awareness measures:

c). Barrier: *Inadequate R&D and Training Facilities*
Measures: *Assuring adequate R&D and Training Facilities*

Adequate Research and Development including research on the best fish species for culture, improving fish breeding, hatchery and fingerling production operations are a prerequisite for SCBF industry development. Competing priorities inhibits sufficient state investment in R&D. Improving the R&D infrastructure through collaborative arrangements between the state and private sector and providing incentives for R&D activities by the private sector would help improve the situation.

The training capacity of the State sector is far too limited and such facilities are not accessible to a majority of farmers who are potential investors in culture operations. Therefore, it is necessary to

establish new training facilities in locations more accessible to stakeholders and also to expand the capacity of the existing facilities. Although, traditionally fishery is not considered as a farming activity, greater awareness on the SCBF as a supplementary source of income for the villagers engaged in agriculture would enhance farmer participation in SCBF.

Social, cultural, behavioral and information and awareness measures:

d). Barrier: *Non-favorable consumer preferences and social biases*
Measures: *Improving consumer preferences and overcoming social biases*

With the fish species utilized for SCBF being exotic species and not considered a worthy alternative to traditional freshwater fish, raising awareness and improving product quality can help overcome such inhibitions. Promotional activities highlighting benefits of freshwater fish as a source of safe food for consumers of all ages and introducing new value-added products are some measures to enhance its acceptability. Quality control and inspection system to ensure production and marketing under hygienic conditions will also bolster consumer confidence.

Policy, legal and regulatory measures:

e). Barrier: *Inadequacy of Government policy*
Measures: *Improving Policy Coordination*

A mechanism to engage the Provincial Authorities in the decision making process related to SCBF development in water bodies falling under the authority of the PCs is essential to overcome the existing communication gap between NAQDA, an agency functioning under the National Government and the Provincial Councils. An approach that creates stronger partnership with local authorities and improving coordination is required. This can be achieved by establishing a policy coordination mechanism with due assignment of responsibilities for the aquaculture development at the local level.

Network failure measures:

f). Barrier*: Poor institutional arrangements for stakeholder participation in policy making*
Measures: *Improving institutional arrangements for stakeholder participation in policy making*

A broad range of actors are involved with SCBF including fingerling suppliers, farmers, irrigation and reservoir management authorities, fish vendors and other market agents, consumers etc. Establishment of a consultative mechanism to engage industry and planners to enable strengthening policy making process is an important requirement for industry development. However, such a process should be accompanied by a greater liberalization of the industry operations, starting with enhanced private sector

participation in fingerling supply process as the present system of operation provides little opportunity and incentive for collaboration.

Technical measures:

g). Barrier*: Inadequate product standards, codes and certification*
Measures: *Introducing product standards, codes and certification*

Products standards, codes and inspections are neither recognized nor followed as much as that for marine products. Introducing quality control measures and good management practices will strengthen the product identity and competitiveness. Product safety and quality can be ensured through the establishment of a regular monitoring scheme for both fingerling production and marketable fish.

Information & awareness and other measures:

h). Barrier: *Water quality degradation*
Measures: *Preventing degradation of Water quality*

It is well known that inland fishery industry depends on seasonal and perennial reservoirs and water quality affects both fish productivity and quality. Therefore, water quality needs to be monitored regularly and analytical results must be assessed against a set of standards. Records of such analytical results should be publicly available. All water users of the reservoirs should be educated on ways of water quality deterioration by human activities and actions required to minimize such incidences.

1.3. Barrier analysis and possible enabling measures for Technology 2: Sustainable Land Management (SLM)

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

1.3.1 General description of Sustainable Land Management

Sri Lanka with a population of little over 20 million people in an area of 65,525 km^2 is one of the 19 countries with high population densities. Land degradation is among the most serious environmental problems in the country and badly affects the economic development. Land degradation is widespread and occurs in all agro-ecological regions at different intensities. Land is interconnected with other natural

resources such as the air, water, fauna and flora, which are essential for human survival. Well managed land help to protect environment and natural resources and facilitate continued accomplishment of ecological functions and services in a sustainable manner.

Land degradation in the country has manifested in several ways; heavy soil losses; high sediment yields; soil fertility decline; compaction, crusting and sealing; water logging; lowering of the soil surface; loss of productive functions; landslides; salinization; alkalinization; acidification including both desertification and formation of acid sulphate soils; iron toxicity development; nutrient and agro-chemical accumulation; indiscriminate disposal of waste and eutrophication. Out of those, soil erosion/sedimentation and soil fertility decline are the two most significant degradation processes taking place and heavy soil losses and high sediment yields caused by soil erosion are the most severe. At present, 44% of Sri Lankan agricultural lands are facing the problem of soil erosion.[3,4] This is evident in high rates of soil loss i.e; 100 tons/ha/yr in the hill country on sloping lands under intensive cultivation of vegetables and potatoes, poorly managed seedling tea and *chena* (shifting) cultivation.[5] Hence, human induced land degradation is more significant than that by natural forces in the country.

Synergetic and additive outcomes of sustainable land management (SLM) assure conservation of land associated natural resources and thereby increase agricultural and livestock productivity. All of these directly increase the nation's ability to withstand the negative impacts of climate change and benefits will be widespread. Socio-Economic benefits and Environmental benefits of SLM are shown in Table 1.2. Ref. Annex D-I - Technology Fact Sheet on Sustainable Land Management: Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report for further details.

Table 1.2: Benefits of Sustainable Land Management

Socio-Economic benefits	Environmental benefits
• Increased food security • Increased profitability from farming • Reduced food costs to consumers • Increased land and agricultural productivity • Creation of employment • Alleviate rural poverty • Improved livelihoods, human well-being and social sustainability	• Lowered reservoir de-silting and other off-site costs • Reduced downstream sedimentation and siltation • Reduced contamination of soil and surface and ground water • Reduced GHG emissions • Minimize non point source pollution • Improve ecosystem sustainability

[3] DOA, 2004.

[4] National Land Use Policy, 2007

[5] Upper watershed Management Project Final Report, 1997

	• Sustained ground water quality/quantity • Secured bio diversity • Improved health of mangrove ecosystems • Improved health of coral reefs • Reduced risks of natural disasters

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

1.3.2 Identification of barriers for sustainable land management (SLM)

The process of identification of barriers included stakeholder consultations, literature reviews and interviews with sector specialists. These prioritized barriers with stakeholder consensus[6] are described below

1.3.2.1. Economic and financial Barriers

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

a) High cost of Implementation and long term return on investments

Most of the organic methods used for improving soil fertility, such as application of manure and compost, are very labor-intensive and therefore not practicable for farmers managing relatively large extents of land or working on distant parcels. Furthermore, the benefits of such practices are long term and most importantly are dependent on ways in which the technologies are applied. For example, application of partially processed manure has limitations on its effectiveness due to the loss of nitrogen content and increased occurrence of weeds, pests and diseases. Land resource management technologies are knowledge-intensive. Therefore, inexpensive, technically and economically feasible best practices and alternatives resulting in “significant” erosion reduction needs to be explored for application.

[6] Overcoming Barriers to the Transfer and Diffusion of Climate Technologies, 2012

Absence of significant short term benefits and absence of immediately visible improvements in soil quality and health due to implementation of conservation practices is appear to be important factors that detract farmers from the sustainable use of soil conservation practices. Therefore, it is hard to expect farmer investment on expensive soil conservation structures such as stone terraces that have long-term pay off.

The soil conservation Act No. 24 of 1951 and as amended in 1996 has introduced provisions to promote conservation of land resources. However, such legal provisions have not yielded the desired results due to high implementation costs associated with the recommended measures.

b) High economic cost of conservation practices and social constraints in small land holdings

Sri Lankan agriculture is dominated by smallholders. Nearly 73% of all agricultural land is under smallholdings (except for about 740,800 ha plantations mainly tea, rubber, and coconut[7]). plantations mainly tea, rubber, and coconut). Over 85 percent of agriculture holdings are less than 0.5 ha in extent. The average holding size has been declining overtime due to fragmentation as pressures on land continue to rise with population increase.. The small size coupled with further fragmentation of existing holdings poses a challenge for applying sustainable land management techniques for obvious reasons such as further reduction in the cultivable land due to application of soil conservation methods. Therefore, small land holders are faced with difficulties in adopting even those SLM practices that provide short term benefits. Therefore, application of soil conservation practices that consume land are not favored in the smallholdings. Most of the mechanical soil conservation practices are often not feasible in small scattered, irregular holdings distributed over farm territories due to farmer apathy.

Land productivity decreases as a result of physical, chemical and biological degradation of soil as a consequence of continuous cultivation due to scarcity of land and continued practice of monoculture farming on such small land holdings without appropriate land management practices. In effect, soils have been mined of nutrients and farm yields and incomes declined.

C) Low public and private investment on research and development

Availability of economically feasible, environmentally friendly; scientifically sound options for a particular situation is lacking owing to the limited research on land management and soil conservation. National budget appear not to recognize land degradation and SLM as a priority issue. Thus public and private investments on research and technology development remain low and under funding of extension services and public institutions dealing with environment and natural resources management continues prevail. This presents a serious constraint to SLM adoption and mainstreaming. Under such

[7] Department of Census and Statistics, 2013

circumstances it is difficult to strengthen research-extension farmer/end user linkages that are critical for sustainable adoption of good husbandry practices.

Low funding for research and extension can be attributed to a lack of a proper assessment of environmental services in monetary terms and near absence of institutionalization of payments for environmental services. The benefits to soil conservation practices extend well beyond sustainable land management and the recognition of wider environmental benefits must be acknowledged. Identification and estimation of such benefits can strengthen the calls for greater funding for SLM.

d) High dependency on land for livelihoods resulting in high land pressure

A very large proportion of the labor force in the country is dependent on land to earn a living. The creation of employment and income opportunities outside agriculture sector does not take place at a significant rate to enable reduce dependency on land related enterprises as a primary income source. The majority of the farming population is identified as small scale subsistence farmers. Those farmers are mainly concerned with immediate benefits from their fields rather than future gains from land development programs. In general, over-exploitation and mismanagement of land lead to declining soil productivity. The over-exploitation is partly due to accelerated investment that seeks profit maximization with little or no effort at maintaining soil productivity. It is widely accepted that declining land productivity from land degradation and poverty are closely linked. Thus, this dependency operates as a vicious cycle that reinforces negative effects of land mismanagement.

1.3.2.2 Non-financial barriers

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

Policy, legal and regulatory barriers:

a) *Insecure Land Ownership*

In Sri Lanka the overall land-man ratio (Total land area of the country/Total population) is about 0.36 hectares, and net per capita land availability is only about 0.15 hectares. The remaining area of 0.21 hectares per person is not readily available due to it has been either designated for conservation or limited by topographical or ecological constraints[8]. Land balance sheet given in the Table 1.3 shows that nearly 35% of the total land area of the country is under agricultural uses and about 31% under forest, wild life conservation and catchment protection. This data reveal the nature of growing pressure on the land resources particularly on agricultural lands due to population increase.

[8] FAO, 1999

Table 1.3: Land balance sheet for Sri Lanka

	Land use	Area (Ha)
1	Utilized land (agricultural and urban)	2,635,000
2	Forests, wildlife conservation and catchment protection areas	2,000,000
3	Sparsely utilized land (under poor quality tea, patana grass, etc.)	728,800
4	Reserved land (reservoirs, stream banks, roads, etc.)	585,300
5	Steeply sloping land (sloping excessively for crop production)	380,000
6	Barren land (rock, sand, poor vegetation cover, etc.)	77,000
7	Land over 5000 feet/1500 meters altitude	76,400
8	Mangroves and marshes	70,000
9	Total	6,552,500

Somasekeram (1996)

In the country, land policies deal with five different forms of tenure categories. They are private lands, state lands, alienated state lands, Un-regularized encroached lands, and regularized encroachments of state lands. According to the most recent data available, approximately over 83%, or about 5,440,000 ha of the total land area of 6,552,500 ha of Sri Lanka are under some form of State control and 27 percent of rural farmers formally landless[9]. This apparent land shortage has been a significant contributory factor in the high level of encroachment onto State land thereby rapidly decreasing forest cover.

The difficulty in getting ownership of State lands encroached by farmers creates a very poor interest for the proper utilization of lands for higher agricultural productivity. Majority of the agricultural lands in the country belongs to the State and farmers have only usufruct rights. People who make use of land without proper title or title deeds often do not take any interest or motivation on conserving soil or increasing land productivity due to their uncertainty in ownership.

A large number of farmers in the country are used to cultivate the land not owned by them on the basis of a primitive tenancy system known as “Ande” (the tenant farmer and the land owner sharing harvest) and “Thattumaru” (alternating cultivation). Lack of clarity about land tenure presents a constraint to assessing land degradation problems and implementing sustainable land management practices.

b) Inadequacy and poor enforcement of Policies, laws and regulations

Some of the subsidies/taxes imposed by the government from time to time have contributed to accelerating land degradation, especially the soil erosion, e.g. Potato cultivation in Sri Lanka where farmers are given many concessions from seeds to fertilizer and at the same time high protection from

[9] Ridgway and Silva, 2001

taxes on imported potatoes. This has lead to increased potato cultivation especially in unsuitable land such as steep slopes of the upcountry intensifying soil erosion.

The high subsidies paid by the government for nitrogen, phosphorus and potassium fertilizer in recent years have resulted in soil fertility degradation from imbalances due to build up of high residual phosphorus and potassium levels in soils. Due to unrestrained applications of fertilizer results in the aggravation of pollution of water bodies leading to eutrophication. The availability of fertilizer at heavily subsidized prices caused the 'national program for soil-test based fertilizer recommendation' to become totally ineffective. Many other safeguards are provided in national legislation relating to environment and soil conservation which are undermined by such short sighted policies.

Human Skills barriers:

c) Inadequate knowledge on appropriate land management techniques and new challenges to sustainable management

Poor, inappropriate or non-use of land management and agricultural practices are the main causes of physical, chemical and biological degradation of cultivated land, thereby leading to overall loss of ecosystem productivity and health. At the local level, the stakeholders' knowledge of sustainable land management practices is often limited to traditional techniques and knowledge that has been transferred through generations. However, what might have been a sustainable land use practice in the past may not be viable anymore due to impending vagaries of CC. New technologies and information on how to adapt traditional technologies to the new challenges are key priorities. For example, many farmers live and work in isolation, without full access to data and information that are essential for choosing the right crop variety, estimating the right amount of irrigation water, precision farming techniques, application of soil test based fertilizer recommendations and preparing for a severe drought period or a potential natural disaster.

Greater awareness is a key factor in relation to soil quality resilience and the renewal of soil fertility. This can be achieved by raising farmer's knowledge on the magnitude of the problem and the resultant damage.

Among farmers, lack of basic knowledge of modern cultivation practices such as use of agricultural machinery, preparation of HYV seeds, timely and actual quantum of irrigation, proper use of pesticides and fertilizers etc, impedes the process of achieving higher productivity and efficient land management.

There is an urgent need for skills and experience to support land managers in moving toward more sustainable land use systems. Providing opportunities for land managers to up skill themselves on climate change and sustainability issues so they can increase resilience and profitability is essential as climate change technology transfer needs are ambitious and will not be achieved with current capability.

Institutional and organizational capacity barriers:

d) Low priority to conservation in non-agricultural land uses

According to the land use balance sheet only around 35% of the total land area of the country is used for agricultural activities. The share of non-agricultural land uses is rising rapidly with residential, economic infrastructure and recreational developments assuming greater importance with economic growth. Sustainable land management is not mainstreamed by incorporating conservation into these development policies, strategies, legislation and regulations. Results of actions that cause severe disturbance of land resources and irreparable damage are often visible where large, land-based infrastructure projects have been implemented. Thus, making conservation a requirement in development projects that disturb land must be undertaken as a priority.

e) Poor relevance of broad-spectrum techniques due to diversity of land, weather, soil, terrain, size, land formation and land use

The large diversity of climate is the most significant feature observed in the country despite its small size. Rainfall distribution in Sri Lanka has traditionally been generalized in to three climatic zones; Wet zone, Dry zone and Intermediate zone. However, availability of more spatial and temporal data, and advancement of GIS technology have led to 46 agro-eco-logical sub regions on an enhanced scale in 2003[10]. Considering based on process of formation and morphology characterized by relief, landform unit and their arrangement within the physiographic region, different land systems were identified for the major Agro Ecological Zones (AEZ) in Sri Lanka. Hence, type, intensity and the severity of land degradation demonstrate diverse pattern and magnitude.

Network failure barriers:

f) Poor coordination among stakeholder organization

In the present context a large number of Ministries, Departments and agencies are vested with responsibility of the implementation of environment protection related laws (Acts and Ordinances), statutes, regulations and rules. There are overlaps in responsibilities among the institutions on one hand and conflicts of interests on the other hand. Each agency plans development activities and executes programs in isolation without adequate coordination with other relevant stakeholder organizations. Therefore, mechanisms for improved inter-agency coordination becomes critical for achieving the set targets of given program.

[10] Punnayawardana, 2003

Social cultural and behavioral barriers:

g). Single or individual efforts are not effective

There can be no sustainable natural resource management unless it involves the participation of all inhabitants of the concerned environment/area in an active manner. Environmental regeneration is possible only when the concerned people realize a need for it and are empowered to have control over the process of resource utilization, management and conservation.

Given the diverse and heterogeneous nature of the land holdings of the different ecosystems in the country, piecemeal approaches such as contour bunding or terracing on individual holdings or a group of farms only marginally beneficial if done ignoring impacts on the neighboring area of which the hydrological characteristics are influenced. Such stand-alone actions generally fail to attract farmers as they do not acquire benefits proportional to the efforts and investment made and simultaneously create more degradation problems as well. Thus, to maximize advantages, all development activities should be carried out through a participatory, interdisciplinary and in a comprehensive manner.

1.3.3 Identified Measures

Measures to overcome barriers identified through a stakeholder consultation process and validated using results of analysis reported from national and international experiences with managing land degradation and promoting SLM are listed below.

1.3.3.1. Economic and financial Measures:

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

a) Barrier: *High cost of implementation and slow return to adoption of land management*
Measures: *Increasing affordability and returns to adoption of land*

In view of high implementation cost of soil conservation and other related practices for inputs such as labor, materials, equipment and technical know-how, farmers have reluctance towards adopting proper

land management measures. Economic incentives such as compensation mechanisms for environmental services is seen as a means promoting investments in capital and labor intensive SLM practices such as soil and water conservation technologies. Farmers with marginal land holdings are compelled to use the land intensively without due consideration for alternative options such as crop rotation, fallowing or even proper application of farm yard manure and other inputs.

Therefore, an attractive incentive program needs to be introduced to promote using organic fertilizer and other sustainable land management practices. Training on soil conservation practices and also availability of information on impacts of soil erosion, importance of soil conservation and modern low cost soil conservation techniques are also critical.

Several types of direct economic incentives have already been used to develop the ability and willingness of farmers to use soil conservation practices. The most widely used direct economic incentives have been compensation for labor and support with equipment. While the incentives have enabled the construction of massive soil conservation structures and the use of biological means for soil conservation, the continued use of the practices once interventions are phased out had been low.

The Government of Sri Lanka established a price subsidy for chemical fertilizer for the first time in 1962, at the onset of Green Revolution and is being continued for more than four decades. It is widely accepted that the fertilizer use has led to increased land productivity, and by presumption it increases the farmer ability to implement some conservation measures and also made it more beneficial to adopt SLM practices. However, the impacts have not been positive in this regard, as farmers have turned exclusively to the use of chemical fertilizers ignoring the use of farm yard manure and other organics. Also, the increased productivity due to green revolution technologies hassled to the cultivation of fragile lands previously not used for any cultivation.

The granting of the fertilizer subsidy has become a delicate political issue with successive governments using it to garner farmer support. Presently, a fifty kilogram bag of fertilizer is provided at Rs. 350 under the subsidy scheme for paddy. For other crops, a 50 kilogram bag of single nutrient fertilizer is supplied at Rs. 1,200 and a mixed fertilizer bag at Rs. 1,300. The actual cost in the open market is between Rs. 3,500-5,000. The government has allocated Rs. 54 billion this year (2012) for the fertilizer subsidy. The allocation for the implementation of soil conservation practices is a paltry Rs. 10 million. On the average, a smallholder farmer has to spend at the least Rs. 60,000 to establish contour drains in an acre of land. But, only a fraction of that will be covered under the soil conservation subsidy.

One of the key lessons learnt in promoting preventive measures to combat land degradation is to put in place SLM packages that link economic and financial incentives for the majority of smallholders. In order to encourage soil conservation at the farm level, future programs should incorporate an appropriate mix of direct and indirect incentives. Compensation for installing soil conservation structures, subsidizing seed supply and planting materials and application costs of organic manure can be used as direct

incentives, whereas training, technical support and extension services are common indirect measures. Promotional activities such as recognition of the best adopters through competitions and award schemes can be introduced.

The cost of implementation over a 10 year period is US$ 11.0 million.

b) Barrier: *High economic cost of conservation practices and social constraints in small land holdings*
Measures: *Increasing affordability of conservation practices and reducing social constraints in small land holdings*

Current practice of designing and implementing soil conservation and similar land management practices are based on individual holdings. The quantum of payment is generally linked with size of the holding subject to a maximum. However, in small farm situations where small holding are involved,, in some instances such as those lands on steep slopes the actual economic cost per holding could be prohibitive. Planning and implementing SLM practices on a watershed basis would permit minimizing impacts on smaller holdings and lowering the overall cost of adopting SLM. But, the current practice of determining appropriate measures and payments at the farm/farmer level does not permit such innovations. The net effect of this is that the actual quantity of conservation implemented is sub-optimal. Therefore, economic incentives such as subsidies should be designed and implemented for the total watershed, with variable payment schemes based on the nature of SLM practices adopted. This provides an opportunity to small scale resource poor farmers for acquiring suitable technologies and adopting sustainable practices.

The cost of implementation over a 10 year period is US$ 3.5 million

c) Barrier: *Low public and private investment on research and development*
Measure: *Raising public and private investment on research and development*

SLM related R&D expenditures are grossly inadequate to enable study and recommend site specific solutions to diversity of situations. The use of modern technology such as GIS mapping, satellite imaging etc can be used to provide rapid solutions to users. As the availability of budgetary provisions from the domestic sources is not sufficient hence harnessing donor support should be explored.

The cost of implementation over a 10 year period is US$ 9.0 million.

d) Barrier: *High dependency on land for livelihoods resulting in high land pressure*
Measure: *Lessening dependency on land for livelihoods to reduce pressure on land*

In an expanding economy where agriculture sector is dominated by smallholdings it fails to raise incomes to match the non agricultural incomes. Therefore, livelihood development needs to be considered as a combination of both on-farm works and off-farm activities in order to generate a sufficient income for rural

inhabitants. However, given the limited opportunities for alternative income generation, the rural people are forced to dependent on land for a livelihood and incomes. Therefore, in an effort to maximize incomes from the lands the farmers resort to intensive cultivation practices with less regard to conservation needs, which either reduces the extent available for SLM or any capital that would be available for investing in SLM, is ploughed back into cultivations.

Generation of off-farm opportunities that can be availed by farmers is required to enable moving farmers away from heavy dependence on intensive exploitation of land with less regard to conservation needs. This approach will be challenging as it is an essential aspect of an economy-wide solution. Short-term solutions such as hydro-phonic cultivation of high value crops which is favored from a conservation point of view can be considered initially.

Livelihood improvement projects such as agro-processing, Bee keeping, Mushroom production and Culture Based Fisheries that are basically not dependent on the land can be set up for long term employment generation.

The cost of implementation over a 10 year period is US$ 1.5 million.

1.3.3.2. Non-financial measures

Policy, legal and regulatory measures:

a). Barrier: *Insecure Land Ownership*
Measure: *Securing Land Ownership*

Secure land rights is a key determinant in the context of increasing land productivity and enhancing agricultural development. Ensuring land ownership rights encourage land owner to invest in appropriate land management practices. Therefore, it is required to safeguard the ownership rights to land through the provisions of legal instruments such as long-term leases or transfer of ownership.

Sri Lanka has been attempting to establish a suitable policy and legislative framework particularly since the colonial period to settle the clouded land tenure structure towards greater equity and freedom to utilize it as an economic non-renewable natural resource. Ensuring the ownership of the process is not a simple task. To resolve the issue, the "*Bim Saviya*" program is implemented under the provisions of Registration of Title Act No. 21 of 1998 as a national program from year 2007. Under this program, lands are surveyed, demarcated and a Title Certificate is issued free of charge to ensure the ownership. Four government Departments viz; Land Settlement Department, Survey Department, Land Commissioner General's Department (under the Ministry of Land & Land Development) and Registrar General's Department (under the Ministry of Public Administration) are jointly involved in this Program. However, the pace at which the project moves forward is considered too slow to make a significant impact.

The cost of implementation over a 5 year period is US$ 0.05 million.

b). Barrier: *Inadequacy and poor enforcement of Policies, laws and regulations*
Measures: *Introducing and enforcing land management policies, laws and regulations*

Legislation on land conservation is based on top-down, command and control regulations that rely on compliance and enforcement. In practice, the government's inability to enforce the laws effectively often leads to perverse behavior by local land users. In such cases, laws and regulations are often poorly understood, ineffectively enforced, and subject to varying interpretations.

It is also necessary to raise the skills of field agricultural advisory officers to make them effective change agents by enhancing their skills to provide adaptive solutions that suit the physical conditions and socio-economic background of the farmers. It is not possible to practice a standardized methodology with a diverse group of small farmers whose economic capacity and the level of knowledge spread over a wide range. The capacity of the field extension officers to interact effectively with farmers needs to be enhanced for them to be able to work with farmers with diverse backgrounds and resource capacities. Awareness and education through well placed, on-farm demonstrations and other methods of farmer education and capacity building will be necessary to underpin such efforts.

Furthermore, forthright enforcement of legislation is necessary to protect credibility of the regulatory system as it remains an integral instrument in ensuring compliance. However, such efforts should be supported by sincere efforts to raise awareness and education on the importance of the purpose of the legislation.

The cost of implementation over a 10 year period is US$ 0.5 million

Human skills measures:

c). Barrier: *Inadequate knowledge on appropriate land management techniques and new challenges to sustainable management*
Measures: *Raising knowledge on appropriate land management techniques and new challenges*

Sri Lanka needs to develop an evidence based policy for managing land degradation in the areas prone to be severely affected. Such an evidence based approach requires that policies are based on scientific data and analysis and validated by prior experiences where such evidence exists. While the relationship between extreme weather events, poor land management and land degradation has been well recognized, formulating and implementing a strong land management policy is prevented by the absence of scientific evidence that can customize it to specific situations. Mainstreaming of land degradation and SLM issues into national development frameworks and processes, including government budgetary process, would

involve the development of a policy paper on highlighting the benefits of mainstreaming SLM aiming at convincing the key line ministries including decision makers at the political hierarchy.

Human resources are the most crucial resources that are very weak. There is an urgent need to train a critical number of government officials, and other stakeholders such as NGOs, farmers, forest communities, civil society bodies and resource users by imparting knowledge and developing skills through training and other means. Institutions dealing with land management are also weak. Capacity needs include developing mandates, tools, guidelines and information management systems in order for appropriate institutions to function effectively. Creation of an "enabling environment" to implement SLM policies, programs and projects is crucial at the system level, This would require developing policy, economic, regulatory, and accountability frameworks (monitoring and evaluation) in the context of land degradation and SLM.

The cost of implementation over a 10 year period is US$ 3.0 million.

Institutional and organizational capacity measures:

d). Barrier: ***Low priority to conservation in non-agricultural land uses***
Measures: ***Ensuring proper attention to conservation in non-agricultural land uses***

Increased allocation of land for non-agricultural purposes, a trend associated with economic development driven by the non-farm sector leads to neglect of land management objectives because such provisions have been historically associated with agriculture, as it was the heaviest user of land. In order to ensure practice of SLM as a national responsibility requires bring these non-agricultural sectors under some discipline. This may be achieved by identifying SLM as a social responsibility not limited to agriculture sector and giving it necessary consideration as a priority area. Land conservation should be identified as a national priority in all land uses.
The cost of implementation over a 5 year period is US$ 3.5 million.

e) Barrier: ***Poor relevance of broad spectrum techniques due to diversity of land, weather, soil, terrain, size, land formation and land use***
Measure: ***Improving relevance land management techniques under diverse land, weather, soil, terrain, size and land formation***

New technologies such as Geographic Information Systems (GIS), geo-spatial mapping and remote sensing technologies are central to achieving a successful transition from traditional environmental and resource management practices to sustainable development because of their integrative quality (linking social, economic, and environmental data) and their place-based quality (addressing relationships among places at local and national levels). Hence, these technologies needs to be made use for developing site

specific best land management methods applicable in different land classes and environments to reduce land degradation.

The cost of implementation over a 10 year period is US$ 4.0 million.

Measures to prevent network failures:

f). Barrier: *Lack of coordination among stakeholder organization*
Measures: *Improving coordination among stakeholder organizations*

Given the nature of the interventions, inter-agency coordination will be critical for achieving the set targets. Involvement of numerous state and private sector agencies and actions by individuals and community organizations will be required for implementing soil conservation measures. The absence of an effective coordination mechanism impedes efficient utilization of resources for realizing anticipated outcomes of the interventions due to resource misuse and waste. The establishment of national and area-wide coordination structures to monitor and support conservation measures in order to bring all partners under one umbrella can be considered.

The cost of implementation over a 10 year period is US$ 0.5 million.

Social cultural and behavioral Measures:

g). Barrier: *Single or individual efforts are not effective*
Measures: *Promoting collective land management measures*

To be more effective, land management should be undertaken through a participatory, interdisciplinary and communitywide or watershed based approach. Soil conservation, land use planning, farming systems, forestry and water management are the fundamental elements of a community based land management system applicable over an entire watershed. In addition, social and economic aspects will also have a profound impact on land/watershed management. Nutrient management in different farming systems existing within the catchment is one of the primary sector issues that must be addressed. Nutrients have a catchment scale effect on all of the sub-sectors in a catchment such as perennials in the highland areas, seasonal crops and mixed-cropping in the middle and lower sections where each of the sub-sectors become interdependent.

The cost of implementation over a 10 year period is US$ 3.5 million.

1.4 Barrier analysis and possible enabling measures for Technology 3: Crop Diversification & Precision Farming (CD&PF)

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

1.4.1 General description of the technology - Crop Diversification & Precision Farming

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

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

1.4.2 Identification of barriers for CD&PF

Barriers for effective technology transfer and diffusion of CD&PF were identified through an extensive consultative process including literature reviews and expert inputs.

1.4.2.1 Economic and financial Barriers:

The economic and financial barriers identified are Price fluctuation due to unstable import policy and High cost of cultivation including labor.

a) Price fluctuation due to unstable import policy

Secondary food crops such as onion, chili, potato and pulses which have an insufficient domestic supply to meet the demand are being considered as potential choices for inclusion in crop diversification programs as they are an important import substitution having a ready market. However, Local cultivation of these crops has met with challenges due to availability of imports at competitive prices. In order to protect the local producers, the government from time to time has introduced import tariffs. However, with a view to safeguard interests of both farmers and the consumers these tariffs are adjusted frequently. In the absence of reliable harvest forecasts and likely market prices, even with frequent tariff adjustments it has been difficult to maintain prices at levels attractive to producers. Due to lack of information on production a level, market glut is a common occurrence during the peak harvest season resulting sharp fall of farm gate prices. The frequent import tariff adjustment often leads market uncertainty which allows manipulation by unscrupulous traders.

b) High cost of cultivation including labor costs

Relative to rice, the cost of cultivation of other food crops is significantly high[11]. The requirement of labor is high particularly because certain operations cannot be mechanized or requires to be carried out multiple times. Thus, crop diversification is more expensive to adopt. Unlike paddy cultivation, farmers are compelled to provide close attention to the management of these crops requiring allocation of more time for cultivation. Appropriate machinery to carry out field operations is not available. When the crops are grown in the lowland areas mechanization is difficult due to nature of the land. If the area cultivated or the prices are not sufficiently higher to guarantee a better income, cultivating highland crops will not be remunerative.

1.4.2.2 Non-financial Barriers:

Policy, Legal, Regulatory barriers

a). Fragmentation of land holdings

The small size of the agricultural holdings increases production costs. As diversification of crops requires farmers to spend more time in the farm, potential opportunities available to highland crop cultivators to earn other labor incomes are minimal. Therefore, the cultivation of small plots of land becomes unprofitable. Fragmentation of land holdings further aggravates the situation. Farmers do not have titles to much of the agricultural lands available under the colonization schemes and new irrigation projects making it difficult to transfer the ownership. Thus, even those farmers who have the interest and capacity

[11] DOA, Cost of Production, 2009/2010 Maha and 2010, Yala

to expand their farming operations cannot obtain land for cultivation. The inability to sell land leads to further fragmentation due to distribution of the holding among children.

b) Land tenancy arrangements obstructive to diversification away from rice

Tenure arrangements in the lowlands that hold most of the area suitable for diversification do not favor production of food crops over rice. Traditional harvest sharing arrangements are specified on the basis of apportioning the rice harvest between the landlord and tenant. In Sri Lanka the tenancy for rice lands is legally protected with the specified provisions for sharing the harvest between the owner and the tenant. The diversification of rice lands into other crops requires the consent of the owner, and crop shares have to be mutually determined. This acts as a deterrent to diversify rice lands to cultivate other crops.

Institutional and Organizational capacity barriers:

c). Lack of varieties and management packages suitable for diversification

Agricultural diversification simply implies increasing the range of agricultural commodities produced at the farm level. In the context of climate change, agricultural diversification entails more than merely growing other crops in place of paddy. Increasing diversity of cultivated crops by itself provides some resilience to climate change impacts. However, the varieties of crops chosen for cultivation must also provide greater resistance to climate impacts, and accompanied by management practices that reinforce this resistance.

To a great extent, availability of short-aged varieties having high yield potential has enabled farmers to overcome the vagaries of weather such as droughts and floods and escape pest and disease outbreaks. In the past farmers maintained a number of short-aged rice varieties that were able to assure some output during the seasons severely shortened by delayed rains etc. Long-aged varieties were able to produce bigger surpluses during periods of average or good weather. With the irrigation induced, two-season cultivation pattern and the market-dominated seed supply system, the age profile of the modern rice varieties has become standardized at the medium age category. With the synchronized irrigation schedules, planting takes place almost at the same time everywhere making all lands equally susceptible to any climate threat.

d). Inadequate post harvest technologies and processing infrastructure

Market-led food production and distribution systems have inadvertently restricted the range of crops and food products marketed and consumed. Standardization of crops produced, processed and marketed facilitates handling of large volumes while keeping the supermarket costs low. Therefore, post harvest technologies and processing infrastructure has developed quite extensively for a limited range of products, whereas many other products remain ignored.

Production and marketing of perishable food commodities demand expensive post-harvest handling technologies and infrastructure including cold chain development. Raising diversity of crop production systems and protecting sources of farm income requires inclusion of such products in the crop mix. Some horticultural and floricultural products have a potentially stronger export markets, yet require extensive and expensive handling and transportation infrastructure. In the absence of their development, producers are unable to cope up with such market demands.

Market failure barriers:

e). High risk of marketing due to seasonal production

Crop diversification necessitates engaging in the production of crops for which the marketing arrangements are not well developed or volumes handled are not large. Therefore, an even modest increase in output usually entering the market at the same time due to seasonal production quickly tends to overflow the markets. Where the volumes handled have been typically low, gluts can occur leading to waste of produce. This is particularly true with perishable produce such as fruits, vegetables and horticultural products that have limited handling capacity in place.

f). Under-developed marketing system, No penetration of rural markets and lack of timely and accurate market information

Lack of market information on the price, demand and supply status, or the absence of market outlets are adverse situations constraining farmers from producing large quantities. When farmers are not aware of the price and demand trends, they tend to sell at a price offered by the middlemen or traders. Marketing of produce from the rural areas could be completely at the mercy of limited number of market intermediaries who act as middlemen, assembling and delivering the marketed surplus to city-based wholesalers. The margins kept by such market intermediaries tend to be excessive. In the absence of timely available and reliable market information including price reporting, producers are compelled to carry out distress sales even at prices below cost of production.

Information and awareness barriers:

g). Poor technical knowledge on the cultivation of new crops & precision farming

Information on the cultural methods of new crops may not be widely accessible by the farmers as conventional agricultural extension systems may not be able to readily meet such demands. Even the information on the input supply networks could be restricted due to information gaps. With the cultivation of new crops, information needs of producers veer away from the normal comfort zones of rural

extension workers who are not regularly updated with the latest extension messages. This requires access to non-conventional information delivery mechanisms.

Precision farming techniques enhance the resilience of crop production systems by integrating and regulating nutrient management and plant protection systems employing new technology and use of expert systems and automation. They are also designed to optimize resource use by closely matching the supply of plant requirements and delivery systems. Some are designed as turn-key systems that require expertise on the management of complex instrument based operation systems as opposed to traditional farming expertise. Therefore, the knowledge and skills required to practice precision farming has to be acquired from other delivery systems than the regular extension systems familiar to farming community.

Other barriers:

h). Irrigation network designs not practical for diversification

Irrigation in Sri Lanka has been synonymous with paddy cultivation. Except for a handful of lift irrigation schemes, nearly all surface irrigation schemes have been designed to cultivate two seasons of rice. Land is leveled to irrigate by flooding. Therefore, even during the water scare minor crop season, preparing land for other food crops is not feasible. As paddy lands are ploughed to form a hard pan below the plough depth for the impounding of water, drainage after irrigation or rain is not rapid enough causing problems for highland crops.

The design of the irrigation schemes for flood irrigation which necessitates directing water flow from plot to plot is not conducive for highland crop irrigation. Highland crop cultivation thus requires re-design of the irrigated areas or at least those areas within the scheme, for example land in the upper catena for highland crop production. This requires cooperation of land owners and policy decisions at the highest levels.

1.4.3. Identified measures

Measures identified through stakeholder consultations and validated using recorded national and international experiences to overcome these barriers are discussed below under categories of economic & financial and non-financial measures.

1.4 3.1. Economic and financial measures:

a) Barrier: *Price fluctuation due to unstable import policy*
Measure: *Contain price fluctuations due to unstable import policy*

Unstable import policy characterized by frequent meddling with tariff structure has undermined the predictability of trade related policy regimes in the country. This has made it difficult for the market agents to undertake investments with a long-term perspective on the development of trade in a number of key commodities. A stable trade policy regime is essential for the private entrepreneurs to undertake investments to develop infrastructure related with warehousing, processing, transportation systems. Uncertainties arising from changing positions of the Government on the food commodity imports denied opportunity to adopt a long-term strategy towards developing post-harvest and marketing systems. Impacts of this have been felt in the marketing of produce, with the agents providing warehousing, stock-holding and processing services denying opportunities for large investments. Thus, it is necessary to adopt a stable and predictable policy regime for produce imports.

The implementation of this measure does not involve any additional costs as it requires only a policy decision to adopt transparent and stable policy framework.

b) Barrier: *High cost of cultivation including labor cost*
Measures: *Increasing affordability of cost of cultivation including labor cost*

Impacts of rising production costs can only be countered by raising productivity for which the most modern production technology must be utilized. This requires undertaking new investments as well as use of newer inputs. Like any other economic activity, financial markets should be able to fulfill increased capital requirements of agro-enterprises. Agricultural credit schemes need to move in to meet capital requirements of new crops and production systems. As agricultural pursuits are considered inherently risky, crop insurance schemes, often underwritten by the State are introduced until the farm sector achieves required maturity.

Increasing labor productivity, of which the costs are rising due to competition for wage labor in the economy, is the only means to promote viability of farming. Productivity improvement though higher crop yields and appropriate mechanization must be pushed through to prevent farming becoming unprofitable. In Sri Lanka, small size of the holding is often cited as a barrier to mechanization, but custom-hiring and other contract systems for providing mechanized services have evolved in a number of areas suggesting that farm size alone is not an impediment to appropriate mechanization, at least in some product sectors.

The cost of implementation is estimated to be around US$ 8.0 million over a period of 15 years.

1.4 3.2. Non-financial Measures:

Policy, Legal, Regulatory measures:

a) Barrier: *Fragmentation of land holdings*
Measure: *Reducing fragmentation of land holdings*

Increase of small holdings due to division of land among the siblings, which is the most common form of assets held, makes farming less attractive to the owner as a source of income. In the absence of a freely-traded market for land, opportunities available for those willing to exit from farming to dispose off their lands to raise capital and for those who wish to acquire new land to make their holdings bigger are lacking At present, in the major irrigation areas informal tenancy arrangements have emerged where some investors cultivate large farms by engaging in 'hidden tenancy'. Such arrangements are often very inefficient to operate. Therefore, it is necessary to liberalize agricultural land markets, with due safeguards to ensure that quality agricultural lands are not withdrawn from farming. Land consolidation can be promoted by setting up land exchanges and trading rules.

The cost of implementation is estimated to be around US$ 0.05 million over a period of 5 years.

b) Barrier: *Land tenancy arrangements obstructive to diversification away from rice*
Measure: *Making Land tenancy arrangements diversification friendly*

The customary rules for tenancy arrangements for paddy lands were described to discourage diversification in to non-rice crops even where it is technically feasible and economically profitable. The fear of loss of tenancy rights prevent the tenant farmers from engaging in non-rice cropping. The tenancy arrangements must be revised by specifying rental payments in monetary terms in reference to established production levels for the area and allowing the tenant to give the choice of deciding the crop to be cultivated.

The implementation of this measure does not involve any additional cost as it requires revising the legal framework to favor land consolidation.

Institutional and Organizational capacity measures:

c) Barrier: *Lack of varieties and management packages suitable for diversification*
Measure: *Provide varieties and management packages suitable for diversification*

Varietal development is important to protect the ability of current production systems to provide food supplies for everyone. In the event of stressed food supply situation, increase in prices is inevitable affecting food security of large segments of poor populations. Mixed-crop orchards and vegetable

gardens with high varietal diversity provide resilience against changing climate. Breeding high yielding and more stable genotypes of secondary food crops, vegetables and fruits and production and distribution through the commercial seed supply system must be encouraged to overcome the above limitation. Cultivars of crops other than rice, such as coarse grain, fruits, vegetables, other food crops suitable to the agro-climatic conditions have led to diversification and increased production.

The development of new varieties is a technology aimed at building resistance to diseases, pests and environmental stresses accentuated by climate change, thereby enhancing productivity of and quality, health and nutritional value of crops. The development of modern varieties is carried out by Plant Breeders in the Agricultural Research organizations. The active participation of farmers and private companies must be secured to help selecting, recommending and introducing varieties better adapted to local climatic conditions.

Although there are thousands of traditional and modern high-yielding varieties of crops in existence, only a small number of these are multiplied and distributed by the seed producing agencies, while farmers themselves continue to produce and exchange other preferred varieties due to their proven ability to adapt to climatic conditions, quality or other reasons. These lesser used varieties serve as a gene pool to develop new varieties with the characteristics that show better adaptation.

Breeding has tremendously expanded the scope of producing new varieties by facilitating to move beyond the existing genetic pool. Biotechnology and genetic engineering permits making even more dramatic and rapid changes in the breeding process. Varietal development reinforced by advances in biotechnology would be the most potent technology for strengthening adaptation to emerging climate change impacts. In general, breeding for such high levels of specificity and the management of such processes is complex and expensive process. But climate change has made it imperative to undertake breeding of varieties with higher abilities to tolerate extreme, hostile environments.

The cost of implementation is estimated to be around US$ 10.0 million over a period of 10 years.

d) Barrier: ***Inadequate post harvest technologies and processing infrastructure***
Measure: ***Improving post harvest technologies and processing infrastructure***

Post-harvest technology is used to improve the quality of foods processed and extend availability beyond the immediate period of production by marketing fully or partially processed products. Promotion of related technologies require assistance to buy/hire simple machines (for separation of seeds and drying with higher efficiency and minimization losses for crops such as maize and separation, grading and processing machines for cowpea, black gram, green gram etc.).

Value addition of high value products would fetch better prices in the market. Production of herbal teas, organic farming, medicinal soaps, canned vegetables & fruits etc. are other options which can be

explored in order to enable farmers to diversify their production base. Storage facilities and other post harvest infrastructure need to be set up initially at strategic locations so as to enable more farmers to use the facilities. Refrigerated vehicles for vegetable transportation are also required to maintain quality and freshness. Availability of such basic infrastructures would immensely boost and diversify production.

The cost of implementation is estimated to be around US$ 8.0 million over a period of 15 years.

Market failure measures:

e) Barrier: *High risk of marketing due to seasonal production*
Measure: *Lowering marketing risk arising from seasonal production*

Risks associated with seasonality in production also can be overcome through crop diversification related activities such as cultivation of high value crops under protected-housing (e.g. poly tunnels) in suitable areas, cultivation of new crops, staggered planting, developing storage facilities (e.g. onion) etc. Carrying out cultivation activities under Forward Sales Agreements with private/state institutions can be resorted to manage price risk. Development of crop forecasting services by the State can be undertaken as a long-term investment.

It has been found beneficial to encourage farmers to organize themselves into producer groups or farmer organizations in order to make production and marketing more efficient and cost effective. These associations could be instrumental in strengthening the farming communities by regular dissemination of information, facilitating increased competition by involving market agents, providing grading and sorting facilities, provision of group credit, arranging collective transport facilities etc.

The cost of implementation is estimated to be around US$ 5.5 million over a period of 10 years.

f) Barrier: *Under developed marketing system, No penetration of rural markets and lack of timely and accurate market information*
Measure: *Improving marketing system, Increase penetration of rural markets and providing timely and accurate market information*

Research studies have shown a direct correlation between farm income growth and improved access to market resulting from construction of feeder/farm roads. It has been observed that households living near the roads are generally better off than those residing in remote areas with poor accessibility.

Access to market, induces farmers to change over to cultivating high income yielding crops. Availability of roads facilitates reducing transport costs of both farm inputs and outputs, thereby increasing the profit margin of the farmers. Roads are seen as the main factor affecting agricultural diversification. Other

factors such as availability of resources, support facilities, markets etc. would play an active role only upon access facilities to market are developed.

It is evident from the above that assured markets and good road network could stimulate agricultural diversification in favor of high value crops as they help maximize profits and minimize price uncertainty for the produce. Inadequate marketing facilities could deprive farmers of taking the potential benefits of cultivating high-value crops. Facilitating establishment of appropriate institutional arrangements for better markets through cooperatives or contract farming would be highly useful in strengthening farm-firm linkages.

Better market and road network contribute to reduced marketing costs and easy and quick disposal of commodities. It also reduces the risk of post-harvest losses of perishable commodities.

The cost of implementation is estimated to be around US$ 12.0 million over a period of 15 years.

Information and awareness measures:

g) Barrier: *Poor technical knowledge on the cultivation of new crops & precision farming*
Measure: *Raising technical knowledge on the cultivation of new crops & precision farming methods*

Crop diversification and precision farming is knowledge intensive when compared with cultivation of traditional crops or mono-culture crops. The information delivery mechanisms on technology, production and marketing have to be dynamic, flexible and accessible. Realizing this will require stronger participation of the private sector and adoption of new production arrangements such as contract farming that integrate information delivery mechanisms as a part of the farmer service strategy. The electronic mass media could be effectively used for agricultural extension.

The cost of implementation is estimated to be around US$ 7.5 million over a period of 10 years.

Other measures:

h) Barrier: *Irrigation network designs not practical for diversification*
Measure: *Making irrigation distribution designs favorable for diversification*

The design of the irrigation schemes for flood irrigation for paddy cultivation does not support diversification due to difficulty in controlling both, the water flow and the wetness of the soil, current practice of irrigation scheduling etc. Not all areas within an irrigation scheme are suitable for highland crops. Generally, well drained areas in the upper catena are suitable for highland crop production. Thus, re-design of the irrigated land following a reclassification of lands under irrigated schemes is the only

feasible solution. This has to be undertaken with the cooperation of land owners and requires policy decisions at the highest levels.

The cost of implementation is estimated to be around US$ 10.0 million over a period of 15 years.

1.5 Linkages of the barriers identified

Barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independent of one another. Therefore, analyzing barriers in isolation is risky because such an approach tends to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies in the food sector are analyzed so as to ensure maximizing synergies and optimize the effects of recommended measures. The table below is an attempt to group together key barriers identified for the three technologies by economic & financial barriers and non-financial barriers.

Table 1.4: Key Barriers Identified for the Three Prioritized Technologies – Food Sector

No	Key Barriers Identified		
	Sustainable Culture Based Fisheries	Sustainable Land Management	Crop Diversification & Precision Farming
Economic and Financial Barriers			
1	Inadequate availability of financial resources	High cost of Implementation and slow return to adoption of land management	High cost of cultivation including labor cost
2	High risk of investment	High economic cost of conservation practices and social constraints in small land holdings	
3		Low public and private investment on research and development	
4		High dependency on land for livelihoods resulting in high land pressure	

Non Financial Barriers			
	Policy, Legal and Regulatory Barriers		
5	Inadequacy of Government Policies relating to aquaculture	Inadequacy and poor enforcement of laws and regulations relating to land use and soil conservation	Price fluctuations due to unstable import policy
6		Insecure Land Ownership	Fragmentation of land holdings
7			Land tenancy arrangements obstructive to diversification away from rice
Human Skills Barriers			
8		Inadequate knowledge on appropriate land management techniques and new challenges to sustainable management	
Institutional and Organizational Capacity Barriers			
9	Inadequate R&D and Training Facilities	Low priority to conservation in non-agricultural land uses	Lack of varieties and management packages suitable for diversification
10		Poor relevance of broad-spectrum techniques due to diversity of land, weather, soil, terrain, size, land formation and land use	Inadequate post harvest technologies and processing infrastructure
Market Failure/Imperfection Barriers			
11	Poor marketing infrastructure and low price		Under-developed marketing system– No penetration of rural markets and lack of timely and accurate market information
12	Insufficient and weak supply		High risk of marketing

	arrangements for fingerlings		due to seasonal production
Social, Cultural, Behavioral Barriers			
13	Not-favorable consumer preferences and social biases	Single or individual efforts are not effective	
Information and awareness Barriers			
14			Poor technical knowledge on the cultivation of new crops & precision farming
Network Failure Barriers			
15	Poor institutional arrangements for stakeholder participation in policy making	Poor coordination among stakeholder organization	
Technical Barriers			
16	Inadequate product standards, codes and certification		
Other Barriers			
17	Water quality degradation		Irrigation network designs not practical for diversification

Most of the barriers and measures to overcome barriers are technology specific and fall within broad categorization for barriers. However, close examination reveals some common elements among them. Some similar measures seem to occur in the case of quite a few barriers, though not so in the case of key barriers. This suggests the suitability of following a common approach to address barriers in some cases.

1.5.1. Inadequate Finances:

High cost of implementation is cited as the most common barrier under the Economic and Financial category. The absence of a financing system such as credit facilities appears to be an important barrier in the case of culture-based fisheries. Accessing finances from formal and informal sources of credit is the principal mechanism for securing funds for any investment. In some activities relating to Sustainable Land Management (SLM) and Crop Diversification & Precision Farming (CD&PF), formal financing mechanisms are poorly developed. High cost of implementation of some technology components and the long payback period are critical factors determining the adoption of a technology.

1.5.2. Poor Risk Management Tools:

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. Thus, risk management measures should be examined as a common approach in promoting any new development.

1.5.3. Poor Policy Framework:

Lack or inadequacy of policies is common to all the three categories of technologies affecting implementation of measures. Policy failure in the SLM is related to institutional-type policies whereas in CD&PF it relates more to trade policies. But, overall policy is identified as an area that presents a barrier to promoting the selected technologies.

1.5.4. Inadequate Research and Development:

The criticality of R&D in promoting the selected technologies appears to be very strong in relation to Sustainable Culture Based Fisheries (SCBF) and CD&PF. Continuous improvements in the technology components are essential for the selected adaptation technologies to remain viable.

1.6 Enabling framework for overcoming the barriers in the Food Sector

Four key barriers that are common to specific technologies were identified in the previous section. This section attempts to identify alternative sets of measures required to overcome the common barriers. Enabling measures can be non-specific to technologies at the higher level, but becomes more technology specific at a detailed level. The technology-specific enabling measures for the four common barriers as identified before are summarized in the Table 1.5.

Table 1.5 Key Measures Identified for the Three Prioritized Technologies – Food Sector

No	Key Measures Identified		
	Culture Based Fisheries	Sustainable Land Management	Crop Diversification & Precision Farming
Economic and Financial Measures			
1	Assuring adequate availability of financial resources	Increasing affordability and returns to adoption of land management	Price fluctuation due to unstable import policy
2	Lowering the risk of investment	Increasing affordability of conservation practices and reducing social constraints in small land holdings	Lowering cost of production including labor cost
3		Raising public and private investment on research and development	
4		Lessening dependency on land for livelihoods to reduce pressure on land	
Non financial Measures			
Policy, Legal and Regulatory Measures			
5	Improving Policy Coordination	Securing Land Ownership	Reducing fragmentation of land holdings
6		Introducing and enforcing land management policies, laws and regulations	Making Land tenancy arrangements diversification friendly
Human Skills Measures			
		Raising knowledge on appropriate land management techniques and new challenges	
Institutional and Organizational Capacity Measures			
7	Assuring adequate R&D and Training Facilities	Ensuring proper attention to conservation in non-agricultural land	Provide varieties and management packages

		uses	suitable for diversification
8		Improving relevance land management techniques under diverse land, weather, soil, terrain, size and land formation	Improving post harvest technologies and processing infrastructure
Market Failure/Imperfection Measures			
9	Improving marketing infrastructure and price		Lowering marketing risk arising from seasonal production
10	Strengthening adequate supply of fingerlings		Improving marketing system– Increase penetration of rural markets and providing timely and accurate market information
Social, Cultural, Behavioral Measures			
11	Improving consumer preferences and overcoming social biases	Promoting collective land management measures Single or individual efforts are not effective	
Information and Awareness Measures			
12			Raising technical knowledge on the cultivation of new crops & precision farming methods
Network Failure Measures			
13	Improving institutional arrangements for stakeholder participation in policy making	Improving coordination among stakeholder organizations	
Technical Measures			
14	Introducing product standards, codes and certification		

Other Measures			
15	Preventing degradation of Water quality		Upgrade the water distribution channel system for diversification

Based on the measures identified for each of the technologies, non-technology specific measures to overcome barriers are listed below in the table 1.6.

Table 1.6: Key Measures Identified for the Common Barriers to the three Prioritized Technologies – Food Sector

Common Barriers	Technologies Affected	Measures to overcome key barriers
Inadequate Finances	CBF,SLM, CD&PF	• Set up financing mechanisms for specific technology packages • Introduce incentive packages
Poor risk management tools	CBF, SLM	• Develop insurance schemes • Extend subsidy schemes for specific technology components
Poor policy framework	CBF,SLM, CD&PF	• Establish consultative mechanisms with the representation of all stakeholders • Support development of producer Associations
Inadequate R&D	CBF,SLM, CD&PF	• Increase support to public and private R&D institutions

Chapter 2

Health Sector

The 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 haemorrhagic diseases and diarrheal diseases including Cholera). Conditions associated with extremes of temperature in the form of heat waves and cold spells are also considered as direct effects. The effect of natural disasters and extreme weather events contribute to many health impacts on humans. Some of these impacts are immediate and others become evident over time. The immediate health effects are death and injury whereas impacts such as disability, communicable diseases, psycho-social problems etc. take time to surface. 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[12]. As health sector related activities produce negligible amount of Green House Gases (GHGs), climate change related interventions in the health sector will be confined to adaptation technologies only.

The prioritization of technology options for climate change adaptation in the health sector in Sri Lanka was carried out through an extensive stakeholder consultative process utilizing the Multi-Criteria Decision Analysis (MCDA) approach (Ref. Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report) List of prioritized technologies appear on Table 2.1.

Table 2.1: Prioritized Technologies and Categories in the Health Sector

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

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

2.1 Preliminary targets for technology transfer and diffusion

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

Technology-1: Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events

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

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

Technology-2: Transfer of knowledge and skills to Health Personnel

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

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

Technology-3: Technology for management of Health Care Waste

The preliminary target for technology transfer and diffusion is 25 selected major health institutions in the island. The number of health workers to be benefited from this component will be 300-350 (5 or 6

persons from each institution). The expected duration for transfer and diffusion of the technology island wide is 12 – 15 years. Institutions in underserved areas will be given priority during program implementation.

2.2 Barrier analysis and possible enabling measures for Technology 1: Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events

2.2.1 General 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 four main elements[13].

1 *Risk Knowledge*: Risk assessment provides essential information to set priorities for mitigation and prevention strategies and designing early warning systems.

2. *Monitoring and Predicting*: Systems with monitoring and predicting capabilities provide timely estimates of the potential risk faced by communities, economies and the environment.

3. *Disseminating Information*: Communication systems are needed for delivering warning messages to the potentially affected locations to alert local and regional governmental agencies. The messages need to be reliable, synthetic and simple to be understood by authorities and public.

4. *Response*: Coordination, good governance and appropriate action plans are a key point in effective early warning. Likewise, public awareness and education are critical aspects of disaster mitigation.

The basic idea 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 health disasters, by providing information that allows individuals and communities to prevent health hazards. If well integrated with risk assessment studies and communication and action plans, early warning systems can lead to substantive benefits for the health sector in preventing health hazards. It is essential to note that "predictions are not useful, however, unless they are translated into a warning and action plan the public can understand and unless the information reaches the public in a timely manner". Effective early warning systems for the health sector embrace all aspects of emergency management,

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

such as: risk assessment analysis, monitoring and predicting location and intensity of the disaster waiting to happen; communicating alerts to health sector authorities and general public in order to take necessary precautionary measures in advance.

The situation in Sri Lanka:

The responsibility for development of all hazards Early Warning System lies with the National Disaster Management Centre (NDMC) as per the provisions of the National Disaster Management Act of 2005[14]. Accordingly, the NDMC has developed a Road Map for Risk Management, which includes all hazards EWS.

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

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

It is also important to note that agencies in Sri Lanka are organized according to the specialized tasks for different hazards. For example, the Epidemiology Unit of the Ministry of Health deals with disease out breaks, the Meteorological Department is specialized in Hydro-meteorological Hazards and the Geological Survey and Mines Bureau is involved with Geological hazards etc., without much information sharing or partnership with other agencies. These gaps need to be addressed by bringing together all concerned agencies. Another key issue that warrants attention is the poor state of communication systems and specially their unavailability during times of emergencies[15].

Basically, what is required under the present context is to transform the existing EWS to an effective one. For this purpose the agencies responsible should follow the directions given in the definition of Early Warning System and fulfill the four components given under that to make the available EWS in the island

[14] National Disaster Management Act Sri Lanka, 2005

[15] Road Map for Disaster Risk Management, 2005

a reliable, timely, cost-effective, sustainable, user friendly tool for the country and the people[16] (Ref. Annex D-2) Technology Fact Sheet on 'Early Warning Systems (EWS) and networking for information exchange on Extreme Weather events and other Climate Change related events, Part 1 - Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka)

2.2.2 Identification of barriers for Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events

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

2.2.2.1 Economic and financial barriers

a) Inadequacy of financial resources and unfavorable financial regulations

The prime objective of an all hazard early warning system is to provide, timely, accurate, unambiguous, and credible information to a population at risk of an impending disaster. The health sector does not receive specific finances for this purpose. Required funds for the ongoing activities have been provided by the government, UN agencies, specifically UNDP and other international donors on project basis. The involvement of the private sector is minimal. Therefore, in order to make the available EWS more useful and sustainable, adequate funding on a regular basis is essential.

The economic policies such as heavy tariff for machinery and equipment, and other forms of restrictions, such as strict controls on International Experts etc. need to be reviewed to enable all partners to work together in sharing the experiences. The personnel involved in EWS related activities in all levels; National, Provincial, District and Divisional are neither provided with any financial incentives for their contributions in disaster situation nor given any training for want of funds.

2.2.2.2 Non-financial barriers

There are five non-financial barriers for this technology. These barriers include three institutional and organizational, one human skill, and one policy, legal and regulatory.

[16] National Early Warning System Sri Lanka, 2005

Institutional and organizational capacity barriers:

a) Absence of an established structure for EWS and networking for information sharing across the sectors

At the moment this responsibility lies with the National Disaster Management Centre (NDMC) of the Ministry of Disaster Management. However, regular and timely information sharing system between relevant agencies such as National Disaster Management Centre, Ministry of Health, Meteorological Department, Geological Survey and Mines Bureau etc. is lacking. Even though inter agency communications do take place in dire situations, establishment of a streamlined mechanism is essential for the purpose. The existing communication arrangements do not provide for lateral as well as down the line from national to sub-national level communications. Some sectors never receive early warnings, especially from the health sector as there is no proper network.

b) Administrative gaps in relevant sectors

There are many gaps in the administrative structures, mainly due to lack of awareness on the responsibilities of respective institution that is required to fulfill the sectoral obligations of a EWS system. Many of the sector administrators are of the view that all the disaster related responsibilities rest with the NDMC and not with the other line agencies. Many administrators either ignore or do not seem to recognize the importance of having a fully functional EWS system as a critical tool for mitigating adverse effects of disasters. Non-availability of professional institutions to provide technical inputs and continuous monitoring of the progress is another aspect of the same barrier. The capacity of the NDMC is limited. There is no interest in most of the sectors including the health sector in climate change related Research and Development and its effects on human health. There is no appreciation for the work done and being conducted by the administrative authorities.

c) Poor utilization of novel technologies for the purposes of EWS

The health sector has a well developed communicable diseases surveillance system. Information flow from the sub-national levels to the Centre and vice versa takes place regularly, in some instances such as dengue outbreaks on a daily basis and the update information is published in the health web (http://www.health.lk), however, such information is not officially shared with other sectors on a regular basis. Even other health related information which is also available in the public domain is not shared with other sectors as there is no inter-sectoral communication network. Often personal contacts are used to exchange information between health and other sectors.

Policy, legal and regulatory barriers:

d) Feeble policies and policy reviews

There is no streamlined information generation and sharing among different directorates of the Ministry of Health. Although Policy Analysis & Development and Legal & Regulatory bodies exist, tere is no core group of technical personnel dedicated to address climate change and health related policy, legal and regulatory issues. There appears to be no holistic approach when policy, legal and regulatory issues are addressed by respective directorates (e.g. Health Care Waste Management by the Directorate of Occupational and Environmental Health) rather work in isolation. There is no regular review and updating of policy, legal and regulatory needs unless in the event of a grave problem at hand. Moreover, inputs from countries in the region are not sought with regard to CC related issues.

Human skills barriers:

e) Underutilization of available trained people

The Ministry has only a handful of people who are trained and experienced in disaster management, emergency response, Health Care Waste Management and also lacks trainers. Often they are not given the required opportunities both locally and overseas to widen their horizons through improving knowledge and skills thus impacting upon carrier development as well. In trainings and representations related to Climate Change issues, totally unrelated personnel are given priority based on non-consequential merits. The net effect of all these is attrition of available trained people for climate change related work.

2.2.3 Identified measures

The measures to overcome the barriers were also identified through stakeholder consultations and measures thus identified are given below.

2.2.3.1 Economic and financial measures

a) Barrier: *Inadequacy of financial resources and unfavorable financial regulations*
Measures: *Allocation of required amount of funds by the government; exploration for alternative funding sources and mechanisms*

Since the 2004 tsunami disaster and implementation of the Disaster Management Act No. 13 of 2005 a Central Emergency Fund has been established for use during an emergency. However, at present there is no other dedicated financing arrangement available for any other activity related to disasters or emergencies. Therefore, it is imperative to explore avenues to seek government resources ear-marked

for country programs on sustainable development for the development and enhancement of Multi Hazard Early Warning Systems as an initial step to mitigate disaster and emergency situations. The details of such possibilities will be expressed in project ideas in the later reports to be developed.

In the absence of sufficient emergency funds available through the government sources, in an emergency the Government always tend to seek assistance from agencies of the UNITED NATIONS such as UNICEF, WHO, UNFPA and UNDP, and other funding agencies such as IDA,WB, JICA, ADB, EU, ECHO etc. Some existing economic policies also tend to hamper full implementation of the disaster and emergency management cycle. The existing financial regulations restrict advance procurement and pre-positioning of commonly needed items required to be used in any emergency as 80% of emergency needs are of generic in nature. Absence of tariff concessions items imported for disaster management related activities also impacts upon emergency procurements during a disaster. This situation is further compounded by existing policies which restricts collaborating with INGOO with proven track records and expertise. Procurement of modern equipment, employing international consultants for post emergency periods are permitted subjected to restrictions which at the end affect implementation of the full cycle of disaster and emergency related activities. The cost of implementation is estimated to be US$ 13,000 over a three year period.

2.2.3.2 Non-financial measures

Measures to Improve Institutional and organizational capacity:

a) Barrier: *Absence of an established structure for EWS and networking for information sharing across the sectors*

Measures: *Align with the existing Government structure (National Disaster Management Centre of the Ministry of Disaster Management); Establish a focal points to deal with relevant sectors at the Ministry and sub-national levels.*

The existing government structure for EWS and networking is the National Disaster Management Centre of the Ministry of Disaster Management. Health Ministry has identified focal points for disaster and emergency related activities in its Strategic Framework for Disaster management and response in all district and institutions. Similarly many other Departments also have their own focal points scattered all over the island. In addition the NDMC has set up Committees up to the village level as an activity of the risk management road map. The Preventive Care institutions has designated focal points up to the Divisional Administrative level whereas, the Curative Care institutions (hospitals) has focal points up to the Base Hospitals. Firstly, these already designated health sector focal points need to be assigned for Climate Change related health activities as well followed by establishment of an intra sector networking mechanism. The next step of this networking sequence would be to set up an inter sectoral structure through which the health sector is linked with other sectors such as Disaster Management, Meteorology,

Public Administration, Police, Armed forces, Telecommunication, water and Electricity etc. for the purposes of instant sharing of information to enable timely mitigatory and response interventions.
The cost of implementation is estimated to be US$ 18,000 over a three year period.

b) Barrier: *Administrative gaps in relevant sectors*
Measures: *Identify a focal point and a responsible unit for the purposes. Provide training with specific functions and responsibilities to be carried out.*

Appoint a trained focal point at national and sub-national levels (Provincial, District, and Divisional) with the responsibility of regular analysis on administrative pitfalls, and gaps and to report to the head /head of the decentralized units of all relevant sectors for timely rectification.

The cost of implementation is estimated to be US$ 8,000 over a two year period.

c) Barrier: *Poor utilization of novel technologies for the purposes of EWS*
Measure: *Identify appropriate and affordable novel technologies; train personnel on technologies to be introduced; assign a second line of personnel to take the place of regulars due to attrition*

Easy to use new technologies are already available outside the country. As these technologies are neither manufactured nor developed in Sri Lanka, need to be imported from developed and industrialized countries. However, cost of importation of these new equipment and technologies are exorbitant. Maintenance and replacements costs are prohibitive as newer products appear in the market regularly. In addition, trained personnel are required to operate such new equipment and adopt the technology and providing such training is very expensive. Further, a mechanism needs to be institutionalized so as to train the next generation of personnel to enable taking over as and when replacements are warranted. A proper training need assessment would address all such aspects of human resource development.

The cost of implementation is estimated to be US$ 62,500 over a three year period.

Policy, legal and regulatory measures:

d) Barrier: *Feeble policies and policy reviews*
Measures: *Regular streamlining and monitoring of policy; Make all involved aware of existing policies and involvement in policy reviews*

Most of the existing policies related to Climate Change, Disaster Management and Disaster Response, Emergencies are not regularly reviewed and updated by the principal stakeholders. Progress of implementation and enforcement of policies also should be regularly assessed and appropriate remedial actions need to be taken to rectify any short comings. Therefore, policies, objectives, strategies and

plans shall be reviewed regularly (may be once in three years) with relevant stakeholder participation and ensure publication in all three languages (Sinhala, Tamil and English).

The cost of implementation is estimated to be US$ 6,000 over a three year period.

Measures to Improve Human skills:

e) Barrier: *Underutilization of available trained people*
Measures: *Improve and enhance the use of available trained persons*

Human Resource Policy for Health (HRH) is a major component of the Policy of the Ministry of Health. However, many issues related to HRH remain unaddressed over a long period of time. One of such major issue is related to retaining health personnel in his or her field of specialization for a reasonably longer time. E.g. a health worker who has gained experience in preventive services may be transferred to a hospital which provides curative care either based on his preference or keeping with the transfer policy of the organization. Such frequent rotation adversely affects effective utilization of personnel who have acquired adequate knowledge and skills over time.

One other recurring issue is retention of health personnel in rural or underserved areas. Some of the main reasons being often cited is inadequate health facilities, poor health seeking behavior of the population, less opportunities for education, poor transportation, no accommodation facilities etc. Despite significant improvements of the situation in the recent past, the issue is yet to be properly addressed. The financial and non-financial incentives provided to health workers with the view to attract posting and retaining in such difficult areas for a substantial period of time has not yielded the desired results. Specific provisions need to be included in the human resources policy for health sector to enable recruiting and retain personnel for working in disaster management and climate change related activities. They need to be provided with necessary training as a short term measure and basic teaching should be included in the training curricula of, secondary and tertiary educational institutes and development of graduate, post graduate programs as long term measures.

The cost of implementation is estimated to be US$ 5,500 over a two year period.

2.3 Barrier analysis and possible enabling measures for Technology 2: Transfer of Knowledge and skills to Health Personnel

2.3.1 General description of the Technology

The theme of the World Health Day of 2008 was 'climate change and its impact on global health. It emphasized that the threat of climate change poses to health is evident and if current global warming trends remain uncontrolled, humanity will face more injury, disease and death related to natural disasters and heat waves; higher rates of food-borne, water-borne, and vector-borne illness; and more premature deaths and disease related to air pollution. Moreover, in many parts of the world, large populations will be displaced by rising sea level and affected by drought and famine. With this growing impact of climate change impact on health, the need for increased numbers of skilled, motivated and facilitated health workers is greater than ever. In the response to climate change, increasing the numbers, quality of training and working conditions of health workers must be seen as a priority to help reduce suffering and save lives[17].

Strengthening of the Human Resources for Health (HRH) in both public and private sector has been emphasized as one of major activities to be undertaken in the implementation of the Heath Master Plan, 2007[18]. Though developing a human resources strategic plan has received low priority in the past, lately the need for such a plan has been emphasized in many forums of the Ministry of Health.

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

Health Personnel' to be benefited from implementation of this technology includes personnel working in government as well as non-government and in the private sector. Further, personnel providing promotive, curative, preventive, and rehabilitative care will also be considered. The article 12 of the National Health Policy states; '**Human Resource Development'** will be supported and strengthened in keeping with contemporary needs' emphasizing the commitment of the government (National Health Policy, Sri Lanka,1996). Please refer to Annex D-2, Technology Fact Sheet on Transfer of Knowledge and skills to Health Personnel, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation Report (Part 1).

[17] World Health Organization, 2008

[18] Heath Master Plan, 2007

2.3.2 Identification of Barriers for Transfer of Knowledge and skills to Health Personnel

The barriers identified through stakeholders consultation and further ratified by the Experts are comprised of one economic and financial and five non financial barriers.

2.3.2.1 Economic and financial barriers

a) Inadequate Financial resources

Although, in comparison with other technologies training and skills development is less costly, it is observed that the lack of adequate financial resources remains a key barrier for the diffusion of the technology. Further, conducive education and training policy environment of the country also provide opportunities for successful implementation of this technology.

Certain aspects related to disaster management and climate change are included in the school curricula starting from grade 6 upwards. It is being introduced into curricula of higher educational institutes including universities and technical collages as well. The financial resources available are not sufficient to sustain ongoing programs and to implement new programs. It has also been found difficult to obtain funds or technical assistance for training and skills development programs from UN or similar organizations that support such activities. Hence, it is noted that inadequacy of funds as one of the key barriers for this technology.

Non-financial barriers

The non-financial barriers identified include one network failure, three institutional and organizational capacities and one human skill.

Network failure barriers:

a) Poor coordination of training activities

There appears to be overlaps in conducting similar training programs by different organizations causing difficulties in selecting the best suited participants and also the availability of trainers as well. This is found to be primarily due to shortcomings in coordination between and especially prioritizing the training programs by the respective organizations and also due to absence of an advance training calendar. Further, potential trainees stationed in distant places in provinces and districts are not adequately informed of available trainings locally as well as overseas.

Institutional and organizational capacity:

b) *Training needs are not identified*

There is no proper training needs assessment for the sector and standard training tools including manuals and curricula are also currently not available in the Ministry of Health.

c) Modern educational technologies are not utilized

At present mostly traditional student based teaching methods are used when providing education and training to personnel in the health sector. Currently, the modern educational technologies such as advanced audio-visuals, e-learning and distant learning opportunities are limited, and these educational technologies need to be promoted. Tested and appropriate curricula should be developed and approved to ensure uniformity in subject matter presented at training sessions. Concurrently, outdoor activities, problem based learning, result based learning, evidence based learning should be incorporated into the training methodologies.

d) Unavailability of a training calendar

There is no annual training calendar in the Ministry of Health at the moment. In view of lack of a coordination mechanism in existence, different trainings programs tend to overlap with each other most of the time. This results in losing opportunities for potential trainees working in distant places.

e) Unavailability of a mechanism/s to monitor diffusion of knowledge and skills, including to the general public

Currently there is no streamlined mechanism for monitoring diffusion of skills needed to provide assistance to adapt to climate change impacts of health. This is true for national as well as at sub-national levels. There is no policy, strategy and trained personnel to conduct monitoring activities of this nature. The R & D culture is very poor in the health sector. Except for few studies, mainly done on personal interest, detailed information in this regard is not available.

Human skills barriers:

f) Shortage of competent trainers

There is an acute shortage of competent as well as experienced trainers in the Ministry of health who are capable of providing required training to health workers on climate change and its effect on human health. The training facilities are also inadequate. The availability of experts in other institutions, universities and UN agencies are also appears to be limited.

2.3.3 Measures identified to overcome barriers

2.3.3.1 Economic and financial measures

a) Barrier: *Inadequate financial resources for human resource development*
Measures: *Provide sufficient funds (government and other avenues) and facilities for training and human resource development*

Increased government funding is essential for the climate change related training and human resource development activities in the health sector, as the benefits of such activities are substantial. The authorities also need to explore other avenues such as public-private partnerships, obtaining funds from international agencies interested in climate change adaptation activities directed to minimize effects of human health.

At the same time the government should establish an enabling policy environment conducive for the involvement of national and international agencies in activities related to this technology. Furthermore, the restrictions on government officers availing training opportunities abroad for set periods need to be relaxed and recognition of such training shall be considered as policy measures. Inclusion of foreign experts in the in-country training programs should be facilitated as another policy requirement.

The estimated cost of implementation over a period of 2 years is US$ 4,500.00.

2.3.2.2 Non-financial measures

Measures to prevent network failure:

a) Barrier: *Poor coordination of training activities*
Measures: *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*

An annual training calendar prepared in consultation with all training and academic institutions including Universities are imperative for conducting proper HRD activities. . The plan should be shared with all national and sub-national level institutions in advance. The donors, UN agencies, NGOO and other international agencies who provide financial and technical assistance need to be kept informed of training activities. A relevant section of the Ministry of Health shall be given authority to coordinate all trainings and this shall be conveyed to all health institutions in the country. The established coordination authority should coordinate with other Ministries and Departments, UN agencies, to provide the health personnel with avenues for foreign training.

The estimated cost of implementation over a period of 1.5 years is US$ 12,500.00.

Measures to improve institutional and organizational capacity:

b) Barrier: *Training needs assessments are not conducted*
Measures: *Conduct training needs assessments and design trainings accordingly*

Conducting regular training need assessments and designing of trainings based on such assessments is recommended as a measure to overcome this barrier.

The estimated cost of implementation over a period of 8 years is US$ 222,500.00.

c) Barrier: *Modern educational technologies are not utilized*
Measures: *Explore and provide opportunities to use modern educational methodologies and technologies*

Appropriate curricula will be developed and tested for training in order to ensure uniformity of information provided in training sessions. Modern educational technologies such as audio-visuals, e-learning and distant learning should be used in training of personnel. Furthermore, Video Conferencing, PBL, on-line and hands-on training and skills development opportunities need to be introduced. At the same time the age old student centered teaching to be avoided and problem, result and evidence based learning practices will be incorporated into the training methodologies.

The estimated cost of implementation over a period of 1 year is US$ 5,000.00.

d) Barrier: *Unavailability of a mechanism/s to monitor diffusion of knowledge and skills, including to the general public*
Measures: *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*

A monitoring system with appropriate tools shall be developed by the Ministry of Health and regularly applied to assess and evaluate the level of knowledge diffusion countrywide by adequately trained monitoring and evaluation teams. Regular monitoring of knowledge, skills and practices of the people who have undergone trainings and general public at large will be undertaken by such teams. Many avenues such as purpose school activities, training activities, quiz competitions; other competitions through electronic and print media can be used for this.

The estimated cost of implementation over a period of 8 years is US$ 15,000.00.

Measures to improve human skills:

e) Barrier: *Shortage of competent trainers*
Measures: *Provide financial and non-financial benefits, pooling of trainers from other sectors, provision of a due recognition to trainers*

Trainers are in short supply in this sphere of activities. This issue can be addressed through provision of financial and non-financial benefits and making their job category a closed-circuit one where if transferred to another place he/she will still function as a trainer and involved with development and regular updating of curricula, and preparation of a second tier of trainers. Another possibility is identification of master trainers from different sectors and pooling. It is imperative to establish carrier development schemes including promotional prospects for the trainers so as to retain them for continuance of trainings in the hitherto lesser appreciated subject of climate change mitigation and adaptation.

The estimated cost of implementation over a period of 2 years is US$ 5,000.00.

2.4 Barrier analysis and possible enabling measures for Technology 3: Management of Health Care Waste

2.4.1 General description of the Technology

The World Health Organization identifies health waste care management as a measure to reduce the burden of disease, including alternatives to incineration[19]. Of the total amount of waste generated by health-care related activities, about 80% is general waste comparable to domestic waste. The remaining 20% is considered hazardous material that may be infectious, toxic or radioactive.

The major sources of health-care waste are:

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

Although Sri Lanka has impressive health indicators, the health system has certain shortcomings. They include poor macro- and micro-health planning, unequal distribution of resources, lack of funds and no long term political and bureaucratic commitment towards health issues. Estimated total health care waste

[19] WHO, 2011

produced by listed government hospitals is estimated to be between 77, 000 and 171, 000 kg daily. This figure does not include health care waste generated by the private sector managed hospitals. Thus, it is incorrect to assume information of waste care generation from private hospitals in developed countries are comparable with the amount of waste generation by the private hospitals in Sri Lanka, as of now we do not have substantial information on that, as well as there is no streamlined mechanism to collect such information for that purpose. Using WHO estimates[20] the daily hazardous waste production in the listed government hospitals in Sri Lanka is between 7,662 and 42,697 kg daily. The health care waste generated by the State hospitals in Sri Lanka is currently disposed off by the following methods;

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

Sri Lanka at present is disposing general health care waste according to WHO recommendations. The point at which Sri Lanka departs from these recommendations is that we dispose hazardous waste along with the general waste into a common disposal system. Hazardous waste is not treated before releasing into the general waste stream to render it non-hazardous. Some major hospitals in the island are collecting waste using the internationally accepted color coded system.

The management of health care waste is being streamlined by the Ministry of Health by developing a policy on healthcare waste management which is now nearing completion. At the moment the Local Government Bodies are disposing the non-clinical waste. But, in most of the instances the stages of collection, separation, storage, transportation, and disposal is yet to be in par with the acceptable procedures. Some private sector agencies also provide services to dispose off expired drugs and devices by incineration under high temperature in cement factories. Still the diffusion of knowledge and practices to the periphery has not taken place and it is imperative to implement projects to begin with for the purpose of addressing the hazards. Ref. Annex D-2 - Technology Fact Sheet on Technology for management of Health Care Waste, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka - (Part I)

2.4.2 Identification of barriers for the technology

The barriers identified through stakeholder consultations comprised of two barriers under the economic and financial category and four under non-financial category.

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

2.4.2.1. Economic and financial barriers

The economic and financial barriers identified are; High costs of treatment technologies and Lack of sustainability over time.

a) *Treatment technologies of health care waste are expensive*

In most of the instances the health care waste is disposed without proper treatment which could result in health consequences in the event of ecological contamination due to toxic waste released into the environment. The government alone cannot afford to provide adequate resources for acquisition of the technology and its diffusion. As at present, the contributions from the other sectors are not sufficient to meet the demand.

b) Lack of sustainability of ongoing implemented activities over time

Sustainability of ongoing activities is questionable due to financial constraints. The low priority given for hazardous waste management in health institutions due to financial and administrative constraints is a major reason for inadequate diffusion of available technology across the sector.

2.4.2.2 Non-financial barriers

There were four non-financial barriers identified are; Poor awareness among health personnel including administrators (Information and awareness), Shortage of technical staff to manage regular activities (Institutional and organizational capacity), Uncommitted attitude of policy planners and administrators (Social, cultural and behavioral) and Inadequate inter-sectoral coordination (Network failures).

Information and awareness barriers:

a) Poor awareness among health personnel including administrators

The majority of administrators and the policy makers at all levels seem to be of the opinion that health care waste can be managed in the manner that the municipal waste is disposed. Although now there is a tendency towards improved health care waste management practices at the hospitals level, there is no scientific approach in addressing the systemic weaknesses such as lack of awareness among the policy makers and administrators. In general the health workers also do not have a clear vision on the need for proper health care waste management. In most of the medium and small institutions, the most common approach is to either bury or burn the clinical wastes. Many institutions still use incinerators, where the clinical waste is not sterilized before incineration. Their knowledge on environmental pollution due to improper disposal of health care waste including clinical waste is poor.

Institutional and organizational capacity barriers:

b) Shortage of technical staff for regular healthcare waste management *activities*

It is essential to employ personnel with adequate technical competency for healthcare waste management at all health institutions. There is a great dearth of such personnel in the health sector. Only in major hospitals one or two personnel having required knowledge and skills, have been posted to be in-charge of the activities. However, in all the institutions there is no dedicated staff category as such for waste management. In addition, the general health staff at all levels needs to be made aware of various aspects of waste care management which in turn will contribute to manage the system smoothly. One other reason for this barrier is low priority given for health care waste management and financial constraints.

Social, cultural and behavioral barriers:

c) Inadequate commitment of policy planners and administrators

There are many reasons for this behavior of the policy planners and the health administrators at different levels. First and the foremost reason is the official apathy due to the preconceived notion that the hospital waste management is in the domain of the local government and not with the health authorities. Secondly, they believe that there is more important and urgent work to be attended thus health care waste management is given a low priority. The administrators often have a compartmentalized approach against holistic vision with a sectoral approach. Lack of appreciation of the long term benefits of proper health care waste management due to poor knowledge and awareness among the policy makers and administrators also contribute for their apathy.

Network failures barriers:

d) Inadequate inter-sectoral coordination

This is one of the key non-financial barriers requiring priority attention. There is no proper network with the other sectors involved in health care waste management (local government authorities, private sector and representations of the general public). The connectivity between the stakeholders is poor. The coordination and cooperation between the relevant Ministries are insufficient.

Better awareness among the health personnel including the administrators on the importance of proper Health Care Waste management is essential. They should possess adequate knowledge on various aspects such as the composition of the hospital waste, general municipal waste, and clinical waste including hazardous waste. They also shall be made aware of the short, medium and long term dangers of haphazard disposal of clinical waste. Furthermore, action should be taken by the Ministry of Health

through its relevant Directorates to provide adequate and appropriate awareness, training and skills development programs in this regard. The attitudes of the policy makers and the administrators and inter-sectoral collaboration including the general public are essential aspects for the success in this endeavor. The public must be made aware of the benefits of proper disposal of hospital waste in order to solicit their support in various activities related to hospital waste management.

2.4.3 Identified measures

2.4.3.1 Economic and financial measures

a) Barrier: *Treatment technologies of health care waste are expensive*
Measures: *Exploration of funding sources, public-private partnerships and identification of low-cost technologies*

Following measures are recommended to explore towards overcoming these barriers.

i) Exploration of funding sources: Exploration of additional government funding sources as well as private sector engagement in activities related to this technology and seeking financial support from the donor agencies is recommended.

ii) Public-private partnerships: The Ministry of Health should take the leadership in inviting the interested private sector parties to be involved in all aspects of health care waste management. They shall be provided with information of potential benefits accruable by their involvement as the private sector ventures are usually profit oriented. Through an established national knowledge centre, they need to be provided with adequate opportunities to learn the experiences of other countries as well as that of the in country.

iii) Identification of low-cost technologies: The prime objective is to improve health care management using appropriate, applicable, and affordable technologies. Low-cost and appropriate technologies available elsewhere needs to be studied and applied in step-wise manner along with close monitoring. The task of identification of such technologies shall be entrusted to a national body comprised of all principal stakeholders.

The cost of implementation over a period of 2 years is estimated as US$ 25,000.00

b) Barrier: *Lack of sustainability of ongoing implemented activities over time*
Measures: *A combination of conducting feasibility studies on different technologies and implementation of sustainable technologies*

Many initiatives failed to sustain due to financial constraints, lack of support from administrators, protests from the general public etc. But the most important factor appears to be related to continue financing. Most of the Project funded initiatives suffer for wants of continued funding arrangements during the post project period. Therefore, the Ministry of Health and other principal stakeholders should look in to technically feasible and financially sustainable applications to improve health care waste management. The steps should be taken to internalize these activities without continued dependence on external funding. A feasibility study on different technologies and a needs assessment at different levels is recommended for this technology.

The cost of implementation over a period of 3 years is estimated as US$ 30,000.00

2.4.3.2 Non-financial measures

Measures to increase information and awareness:

a) Barrier: *Poor awareness among health personnel including administrators*
Measures: *Awareness creation among health personnel and policy makers*

Regular exchange of information and discussions for continued awareness creation and change of attitude of policy makers is recommended to be carried out at national and sub-national levels. It is imperative to make them aware of the related national laws and regulations and international conventions and other treaties the country has ratified.

The cost of implementation over a period of 1 year is estimated as US$ 17,500.00

Measures to improve institutional and organizational capacity:

b) Barrier: *Shortage of technical staff to manage regular healthcare waste activities*
Measures: *Train interested and qualified persons already in staff, open avenues for carrier development and take measures to retain personnel for a stipulated period*

Train identified and interested personnel already in service. The Ministry should identify the interested personnel from among the existing health staff at national and sub-national levels. Therefore, it will not entail recruiting new personnel for the purpose. It is also important to design a scheme for carrier development and further enhancement of their knowledge and skills through providing training opportunities locally and abroad as well. The Ministry of Health will be required to develop a data base of

personnel having appropriate skills to use as trainers and also identify resources from other sectors for pooling. Financial and non-financial incentives need to be explored for retaining the available trainers within the health sector. For the personnel working in underserved areas a minimal service period in such locations should be decided and implemented.

The cost of implementation over a period of 3 years is estimated as US$ 15,000.00

Social, cultural and behavioral measures:

c) Barrier: *Inadequate commitment of policy planners and administrators*
Measures: *Advocacy creation, illustrate evidence of ignorance and solicit technical assistance from UN and other donors*

It is recommended to establish mechanisms for continued commitment through *awareness creation* and *illustrating evidence of ignorance*. This has to begin at national level followed by expanding into sub-national levels. It is important to obtain the political blessing to make this activity at all levels. The available forums as well as special measures shall be taken for this purpose. Many policy makers in the Health sector, Hospital Directors and other Sector Leaders do not perceive that, proper Health Care Waste Management is conducive to future well being of the people, and improper Health Care Waste Management is a serious threat to Public Health. Firstly, they must be made aware and convinced a combined action is essential from all relevant sectors and secondly they must be shown the unpleasant and unhealthy effects of improper Hospital Waste Care Management with some examples; e.g.; water pollution with liquid Hospital Waste, air pollution due to burning of solid waste and contamination of soil due to improper Health Care Waste Management. The emphasis shall be on 'act now before' it is too late. The technical assistance for these activities should be sought from relevant UN agencies and the donor community as well. The awareness creation shall use all available print and electronic media to create awareness among the public as well.

The cost of implementation over a period of 1 year is estimated as US$ 3,000.00

Measures to prevent network failures:

d) Barrier: *Inadequate inter-sectoral coordination*
Measures: *Establish a mechanism to improve the inter-sectoral coordination*

Establishment of a Committee and a network to improve the inter-sectoral coordination is recommended. It is stakeholder view that the existing body in the Ministry needs to be given the administrative authority to coordinate with relevant sectors including the general public. The network proposed above to overcome non-financial barriers under the Technology-1 can be used for this purpose as such an

mechanism also could improve the inter-sectoral cooperation which will be required once the technology related projects are implemented.

The cost of implementation over a period of 2 years is estimated as US$ 20,000.00

2.5 Linkages of the barriers identified

Although the technologies suggested above are different from each other, yet some general or common areas can be identified for all three technologies discussed above. Barriers to technology transfer and diffusion on climate change adaptation are unlikely to function independentently. Therefore, analyzing barriers in isolation is risky because such an approach tends to overlook more holistic and potentially more efficient opportunities to address their combined effects. The linkages between different barriers of the three prioritized technologies in the health sector are analyzed so as to ensure maximizing synergies and optimize the effects of recommended measures. The Table below is an attempt to group together key barriers identified for the three technologies by economic & financial barriers and non-financial barriers.

2.5.1 Summary of Linkages of the barriers identified:

Table 2.2: Key Barriers Identified for the Three Prioritized Technologies – Health Sector

No	Key Barriers Identified		
	Early Warning Systems and networking for information exchange on Extreme Weather events and other climate change related events	**Transfer of knowledge and skills to health personnel**	**Technology for management of Health Care Waste**
Economic and Financial Barriers			
1	Inadequacy of financial resources and unfavorable financial regulations	Inadequate Financial resources	Treatment technologies of health care waste are expensive
2			Lack of sustainability of ongoing implemented activities over time

Non Financial Barriers			
	Policy, Legal and Regulatory Barriers		
1	Feeble policies and policy reviews		
Human Skills Barriers			
2	Underutilization of available trained people	Shortage of competent trainers	
Institutional and Organizational Capacity Barriers			
3	Absence of an established structure for EWS and networking for information sharing across the sectors	Training needs are not identified	Shortage of technical staff to manage regular healthcare waste activities
4	Administrative gaps in relevant sectors	Modern educational technologies are not utilized	
5	Poor utilization of novel technologies for the purposes of EWS	Unavailability of a training programme	
6		Unavailability of a mechanism/s to monitor diffusion of knowledge and skills, including to the general public	
Social, Cultural, Behavioral Barriers			
7			Inadequate commitment of policy planners and administrators
Information and awareness Barriers			
8			Poor awareness among health personnel including administrators
Network Failure Barriers			
9		Poor coordination of training activities	Inadequate inter-sectoral coordination

2.6 Enabling framework for overcoming barriers in the Health Sector

The section 2.5 identified the common barriers fall within the categories of Economic & financial, Institutional & organizational capacity, Network failures, Human skills and Information & awareness. The barriers under the categories of Technical, Policy, Legal and Regulatory and Social, Cultural & Behavioral were not linked common barriers, although there may be indirect interactions between the technologies of such barriers.

The enabling framework for the key linked barriers could be tabulated broadly as shown in table 2.2 below.

Table 2.2: Key linked barriers and the Enabling Framework in the Health Sector

No.	Broad/Common barriers	Enabling framework	Technologies
01	*Inadequacy of finances and unfavorable financial regulations*	Allocation of sufficient funds from government sources through routine measures and other possible avenues. Exploration of alternative and additional funding sources and mechanisms from government, private sector, national and international development partners and donors. Development of policies conducive to successful transfer & diffusion of technologies by relaxation of financial regulations and developing new policies through assessments.	Technology-1 Technology-2 Technology-3
02	*Expensive treatment policies*	Private- public partnerships should be explored to address the issue. Implementation of suitable, low-cost technologies identified by research	
03	*Lack of sustainability*	Implementation of feasible and sustainable processes with continued support	
04	*Absence of an established structures in the sector*	Assign focal points at all administrative levels where necessary Align with existing national government structures through the focal points	

05	*Administrative gaps in relevant sectors*	Identify the administrative gaps and rectify the faults with appropriate measures	
06	*Underutilization of available trained personnel related activities*	Make amendments to the HRH Policy facilitating utilization of currently available human resources in the sector. Design financial and non-financial incentive measures to attract and retain human resources for climate change related health activities.	Technology-1 Technology-2 Technology-3
07	*Poor coordination of training activities.*	Appoint a training coordinator in the Ministry of Health. Develop and share an annual training calendar across the sector and with all stakeholders. Establish a coordination mechanism by the Ministry of Health with all training institutions	
08	*Training needs assessments are not conducted*	Conduct training needs assessments and design trainings accordingly	
09	*Unavailability of a mechanism to monitor diffusion of knowledge and skills including the general public*	Provide authority to the directorate responsible for monitoring of diffusion of the related technologies. Develop monitoring mechanism with suitable methods and implement on a regular basis	
10	*Shortage of technical staff to manage regular activities*	Training of identified and interested personnel already in the staff personnel of the health sector. Pooling of technical personnel from other sectors.	
11	*Absence of networking for information sharing across the sectors and across the sector (Health) at national and sub-national levels*	Regularize the available information sharing mechanisms within the health sector and with other sectors. Extend information generation and sharing mechanisms available for disease forecasting and outbreak control to other health issues	Technology-1 Technology-3
12	*Inadequate inter-sectoral coordination*	Advocacy for policy makers and top administrators.	

		Strengthen the available coordination mechanisms	
13	*Poor utilization of novel technologies*	Identify affordable and appropriate new technologies (for HCWM) and implement Develop policies for maintenance (including preventive), repair and replacement of equipment used in such technologies Train adequate number of staff to implement the technologies	Technology-1
14	*Shortage of competent trainers*	Make the service HRH for HCWM a closed-service. Identify a set of master trainers from other sectors as well. Establish carrier development pathways in the service Provide necessary financial and Non-financial incentives to retain personnel.	Technology-2 Technology-3
15	*Poor awareness among health personnel including administrators.*	Create awareness among health personnel using existing forums and mass media.	Technology-1 Technology-3

Enabling framework for common barriers under different in detail:

Linked barriers of the category of **institutional and organizational capacity** have been identified in all three technologies. These have been considered as main barriers specifically for technology-1 and 2. The linked common barriers are; 1) *absence of an established structure in the sector, 2) administrative gaps in relevant sectors,* 3) *underutilization of available trained personnel for related activities, 4) poor coordination of training activities, 5) unavailability of training calendar, 6) unavailability of a mechanism to monitor diffusion of knowledge and skills including the general public, 7) shortage of technical staff to manage regular activities.* The proposed enabling measures are; a) Assign focal points where necessary, b) Align with existing national government structures through the focal points c) Identify the administrative gaps and rectify the faults with appropriate measures, d) Make amendments to the HRH Policy facilitating utilization, e) Design financial and non-financial incentive measures, f) Appoint a training coordinator in the Ministry of Health, g) Establish a coordination mechanism by the Ministry of Health with

all training institutions, h) Develop and share an annual training calendar, j) Provide authority to the directorate responsible for monitoring, k) Develop monitoring mechanism with suitable methods and implement on a regular basis, l) Training of identified and interested personnel already in the staff, and m) Pooling of staff from other sections.

The linked barriers belong to the category of **human skills** were common for technologies 1, 2 and 3. The key linked-barriers are; 1) *poor utilization of novel technologies*, 2) *shortage of competent trainers* and 3) *shortage of technical staff to manage regular activities*. The proposed enabling measures were, a) Training of identified and interested personnel already in the staff, b) Pooling of staff from other sections, c) Identify affordable and appropriate new technologies and implement, 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 carrier development pathways in the service, and j) Provide necessary financial and Non-financial incentives.

The linked barriers belong to the category of **Network Failure barriers** are; *1) Absence of networking for information sharing across the sectors and across the sector (Health) at national and sub-national levels,* and 2) *Inadequate inter-sectoral coordination.* The proposed enabling measures are; a) Regularize the available information sharing mechanisms, b) Extend information 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.

Liked barriers of the category of **Information and awareness** are; *1) poor utilization of novel technologies for the purposes of information,* and 2) *poor awareness among health personnel including administrators*. The proposed enabling barriers are, a) Create awareness using existing forums, and b) utilization of and mass media as much as possible.

Barriers of **Social, cultural and behavioral** were identified only for the technology 3. **Policy, legal and regulatory barriers** were identified only for technology 1.

It is important to note that, these technologies are already available in Sri Lanka particularly since devastating Asian tsunami of 2004. What is required is to identify the shortcomings and gaps and take remedial measures in order to ensure the sustainability of the technologies and less vulnerable due to barriers identified. It is also important to stress that; it will take fifteen to twenty years in general to have foolproof systems for technologies and island wide dissemination these technologies for adaptations related to climate change and the effects on human health. All is dependent upon the governments' policy, priority, forceful direction and active participation in actions related to adaptations to Climate Change and effects on Human Health. It is also important that sustained assistance of all sectors including, UN agencies, donors, and other international agencies, NGOO, Private Sector and General Public is secured to make the effort success.

Chapter 3

Water Sector

The rate of increase in the mean air temperature predicted for Sri Lanka, based on the data for the period from 1961 to 1990 is 1.6^0C per 100 years[21] and possible impacts predicted on the water sector due to climate change are severe droughts, floods, sea level rise etc. It has been predicted that by 2050, the amount of rainfall receive from the north-east monsoon (October – February) which is the major source of water for the dry zone of Sri Lanka at present, will be reduced by 34% while that received from the south-west monsoon (April – July) will be increased by 38%. This would make the dry zone districts more vulnerable to droughts and the wet zone districts to floods and landslides. Prominent change due to low rainfall will be the expansion of the dry zone. Due to such droughts, surface and per capita water availability will be decreased. The floods due to increase in rainfall intensity will reduce ground water recharge and also would affect quality of surface water, sediment generation and transport of sediments. Studies on the sea level rise have shown an increasing trend for sea water intrusion in certain coastal areas. As a result salinity of surface water and ground water in such areas will be increased.

The prioritized adaptation technologies identified through stakeholder consultations and the Multi-Criteria Decision Analysis (MCDA) process are given in Table 3.1 below in order of priority (Ref. Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report).

[21] Imbulana K.A.U.S *et al* 2010

Table 3.1: Prioritized Technologies and Categories in the Water Sector

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

3.1 Preliminary targets for technology transfer and diffusion

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

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

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

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

3.2 Barrier analysis and possible enabling measures for Technology 1: Restoration of minor tank net works

Barriers that are likely to impede success of this technology identified through stakeholder consultations supported by expert inputs 3.2.2.

3.2.1 General description of Restoration of minor tank net works

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

Dry zone receives around 1000 mm rainfall during the *Maha* season (North – East monsoonal rains during October – February) and 500 mm in the *Yala* season (South – West monsoonal rains during April – July) with a distinct dry season from May to September. The annual average evaporation in the dry zone is between 1,700 mm and 1,900 mm, which exceed the average annual rainfall, implying water stress in the dry zone[22]. The irrigation water demand in the *Yala* season is greater than that of the *Maha* season for the dry zone. The water stress in the dry zone will be further compounded by the impending vulnerability to droughts due to the climate change.

In view of the above it is necessary to develop technologies to augment the supply of irrigation water to the dry zone. North Western Province (NWP) and North Central Province (NCP) have the highest number as well as the highest density of small tanks in the country. There are abandoned minor tanks in the dry zone and their restoration would add additional water source but the capital cost will be very high. Ad hoc raising of bunds and spillways of minor tanks in recent development programs, have seriously disrupted the delicately balanced hydrology between the respective tanks within a cascade. It is necessary to study the total hydrological relationships between all the bigger tanks within a cascade before rehabilitating individual tanks. When restoring minor tanks it will be useful to follow the procedures/instructions given by Panabokke *et al*, 2002[23].

Restoration of silted or damaged cascade minor tank systems in vulnerable areas is important and it contributes to adaptation for climate change by diversification of water supply, storm water control and capture and groundwater recharge[24]. Ref. Annex D-3: Technology Fact Sheet on Restoration of minor tank net works, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I).)

3.2.2 Identification of barriers for Restoration of minor tank net works

The barriers identified through stakeholder consultations and expert inputs include three (03) economic & financial, one (01) technical, two (02) network failures, two (02) policy, legal & regulatory and one (01)

[22] Imbulana K.A.U.S. *etal* 2010

[23] Panabokke *et al*, 2002

[24] Bandara and Aheeyar, 2010

information & awareness and “other” barriers. These barriers were categorized into economic & financial barriers and non-financial barriers.

3.2.2.1 Economic and financial barriers

This is being flagged as the most important barrier category and two such economic & financial barriers exist and they are as follows:

a) High capital cost and inadequate allocation of funds in the annual national budget for restoration work

Depending on the rehabilitation processes, capital cost could vary between Rs. 0.5 m (Mahinda Chinthanaya – 2010) to 2.3 m (Adaptation Fund: Proposal for Sri Lanka, June 2011). Cost for heavy machinery and equipment, fuel etc. required for heavy rehabilitation processes are very high.

The main government agencies handling minor tank restoration work are Agrarian Service Department and the Provincial Councils and they do not get adequate funds for restoration work through the annual national budget. Even under the “Dahasak Maha Weu Programme” allocation of funds per tank is Rs. 0.5 m (Mahinda chinthanaya 2010) and it is insufficient if heavy rehabilitation work is deemed necessary. Estimated cost in the present study is $ 0.12 m^{-3}.

b) No return/benefit during extended dry seasons with respect to the investment and lack of payments for communities involve in restoration activities

Most of the minor tanks dry up for few months during *Yala* season, especially during extended dry seasons. While the restoration activities require a large financial inputs there is no return during long dry seasons for their investment. In addition, there is no payment for communities involved in restoration process.

3.2.2.1 Non-financial barriers:

Non financial barriers identified for the technology of restoration of minor tank networks, are related to information & awareness, technical, network failures, policy, legal & regulatory, institutional & organizational capacity and “other” barriers.

Technical and network failure barriers:

a) Lack of sustainability of minor tank systems due to *poor tank management practices*

This barrier falls into three categories and they are technical, institutional & organizational capacity and network failures. Poor operation and maintenance of cascade system, minor tanks and their catchments are technical barriers which can affect the sustainability of restored minor tank systems. Poor

tank/catchment management practices results in choking of canals, damages to the bund, high evaporation of tank water, leakages, erosion and water scarcity in downstream tanks etc.

Institutional & organizational capacity and Network failure barriers:

b) Lack of understanding on importance of good tank / catchment management practices

The importance of operation and maintenance is poorly understood by the community. This is due to inadequate training/knowledge and guidance given by the relevant technical officers (Technical officers of the Agrarian Service Department or Provincial Councils etc) to farmer communities on tank / catchment management and crop planning. Inadequacy of capacity in the above two agencies, lack of active involvement of farmer communities/beneficiaries and lack of motivation from the tank user group leaders etc. among the farmer community are vital aspects that need to be considered.

c) Lack of involvement of farmer community in planning and decision making on restoration of minor tank network: weak farmer organizations

In Sri Lanka, Minor tanks come under the jurisdiction of the Agrarian Development Act of 2000 and are managed by Farmer Organization (FO) established under its provisions. Those residents of the village who are involved in agriculture or agriculture related activities are entitled for membership of the Farmer Organizations. Involvement of the FO in tank management is poor due to their institutional weaknesses and lack of involvement in planning and decision making in restoration of minor tank networks. Most farmers do not think beyond their own tanks and they are not aware that augmenting water supplies is likely to affect downstream farmers. Different cropping patterns in the command area require different volumes of water and fish rearing in impounded water requires different conditions. Therefore, when the multiple benefits from the tanks are concerned, conflicts of interests among different classes of users are likely to occur with respect to releasing of water. In the absence of multi-village participatory planning due to weak farmer organizations leads to poor use planning within a cascade resulting in the above situation.

Farmer organizations have become weak, mainly because of the absence of involvement of different institutions and government departments falling under the jurisdiction of different Ministries with farmer organizations providing proper guidance and make them strong[25]. This is being noted as one of the major hindrances in restoration process.

[25] Umaheshwari M.S, 2009

Policy, legal and regulatory barriers:

d) Lack of priority list when selecting the most suitable cascade systems/minor tanks for restoration

There appears to be no national level prioritized program when determining restoration activities at the District/Provincial Council level thereby affecting implementation of a successful pilot restoration program. In the event of several cascade systems/minor tanks requiring restoration exist in a selected District/Provincial Council, there is no coherent policy to prioritize locations for interventions. In most of the previous restoration processes, selection of cascade systems/minor tanks has been carried out without properly identifying the needs and as a result such restorations have failed to maximize benefits/returns.

e) Lack of policy/ clear mandate for distribution of funds among different government agencies involved in restoration of minor tank network systems

While this barrier is categorized as policy, legal & regulatory it also manifest network failures as well. There is no policy or legal requirement for the involvement of Agrarian Service Department and Provincial Councils in restoration of minor tank net work systems. Hence a proper planning of restoration work in the country is absent. Therefore, the government is faced with difficulties when determining the amount of funds that should be allocated to relevant government agencies for restoration work.

Information and awareness barriers:

f) Poor understanding on cascade hydrology due to lack of R & D and limited institutional and organizational capacity

Lack of data on cascade hydrology is also considered a barrier for initiating rehabilitation projects. Many small tank rehabilitation projects have become failures during the past. The first step in planning of rehabilitation or improvements of minor tank networks is assessing and understanding the entire hydrology of the cascade. Except for a few cases data on physical and hydrological characteristics of tanks in cascades and their interactions within a cascade are not available. Failure to consider above facts, specially the cascade hydrology, had been detrimental to small tank rehabilitation projects. The government institutions or any other organization has not attempted to collect hydrological data on cascade systems in a systematic way. This is due to inadequate R & D capacity within relevant institutions.

Lack of data or inadequate information on rainfall, drainage return flow, spill water from upstream tanks, soil permeability and geomorphology affects decisions related to restoration of minor tank networks, and also distribution of tank water. Inadequacy of data on water quality and health related issues are barriers to address tank water quality related problems.

Other barriers

g) Limitations due to water pollution

Pollution of water bodies is due to lack of strict enforcement of environmental laws, inadequate capacity of the Health Department and other institutions engaged in water quality analysis to carry out such analytical work at a regular basis. As a result, reason for human health related problems such as diarrhea, dental fluoresis, and kidney diseases experienced by villages consuming water from minor tanks in Anuradhapura has not yet been revealed. But it is suspected that such diseases are caused due to poor water quality. Biological contamination (e.g. *E. Coli)* due to release of faecal matter into minor tanks can cause diarrhea. Prevailing kidney disease in specific areas in Anuradhapura area could be due to inappropriate release of water containing pesticides into tank water because of unavailability of a plan for strict enforcement of environmental laws and regulations. Dental fluoresis caused by high fluoride content in certain tanks could be due to leaching from the bedrock. Lack of R & D appears to be the main contributory factor for addressing the above health issues.

3.2.3 Identified measures

3.2.3.1 Economic and financial measures:

a) Barrier*: High capital cost and inadequate allocation of funds in the annual national budget for restoration work*
Measure*: Obtain additional funds from donor agencies and farmers contributions in terms of labor.*

Since development funds of the government is limited, it is necessary to explore funds in the form of loans/grants from those donor agencies that have shown interest in developing adaptation technologies for climate change or from any other potential donor agencies. Whenever necessary, farmers' contributions in terms of labor and other available local resources should be sourced through farmer organizations to minimize the cost of rehabilitation.

As the allocations provide in the annual budget is not sufficient for restoration work, it is necessary to give priority for restoration of minor tank network systems and allocate sufficient funds to line Ministries. Such a mechanism would boost restoration work considerably.

Estimated cost of implementation over the proposed period of 01 year is US$ 5,600.00.

b) Barrier: *No return/benefit during extended dry seasons with respect to the investment and lack of payments for communities involve in restoration activities*
Measure: *Introduction of alternative employments for extended dry seasons and payments for restoration communities*

In order to address the above issue, alternative employments should be introduced to farmers during extended dry seasons. The government or donor agencies should provide cash incentives for villager's involvement in restoration activities.

Estimated cost of implementation over the proposed period of 09 years is US$ 18.07 million.

3.2.3.2 Non-financial Measures:

Measures to address technical and network failure barriers:

a) Barrier*: Lack of sustainability of minor tank systems due* to *poor tank / catchment management practices*
Measure*: Improve operation and maintenance practices to increase sustainability of minor tank systems*

Tank / catchment operation and management practices can be improved by implementing steps for de-siltation, rehabilitation of damaged bunds, reducing high evaporation of tank water by planting trees in the *Gasgommana*[26], oiling and greasing of sluice structure on a regular basis etc. in an effective manner.

Estimated cost of implementation over the proposed period of 02 - 09 years is US$ 2,000.00.

b) Barrier*: Lack of understanding on importance of good tank / catchment management practices*
Measure: *Improve the understanding on importance of good tank / catchment management practices*

Involvement of farmer communities/beneficiaries and motivation of tank-user group leaders etc. in good tank / catchment management practices can be increased by providing them a sufficient understanding on importance of good tank / catchment management practices. For this purpose, it is necessary to provide knowledge, training and guidance on good tank / catchment management practices to them. Capacity of Agrarian Services Department and Provincial Councils should be increased to enable fulfilling this requirement

[26] It is the upstream of the land strip located above the tank bed where large tree species and some climbers are found. The *Gasgommana* helps to lower the temperature of water in the tank; it also acts as a wind barrier, and reduces evaporation of water from the tank.

Estimated cost of implementation over the proposed period of 02 - 09 years is US$ 2,000.00.

Measures to address network failures:

c) Barrier*: Lack of involvement of farmer community in planning and decision making on restoration of minor tank network: Weak farmer organizations*

Measure: *Strengthen Farmer Organizations and increase involvement of farmers in planning and decision making on restoration of minor tank networks*

Active involvement of the Divisional Secretary (DS), local technical officers, representatives of the Divisional Officers (DO) of the Department of Agrarian Development (DAD), Agricultural Research and Production Assistants (ARPAs) and National Aquaculture Development Authority (NAQDA) is necessary for strengthening the Farmer Organizations.

All decisions regarding allocation of water from the tanks should be made at the *Kanna* meeting (pre-seasonal meeting of farmers) in order to minimize disputes.

The cost of implementation of this measure is included under action (b) above and the additional cost would be around US$ 3,000.00 over the proposed period of 02 years.

Policy, legal and regulatory measures

d) Barrier: *Lack of priority list when selecting the most suitable cascade systems/minor tanks for restoration*

Measure: *Development of a policy/strategy on selection and prioritization of cascade systems/minor tanks for restoration*

Lack of policies/common strategy to select the most suitable districts/ provincial councils for restoration work to be implemented and to prepare a priority list of cascade systems/minor tanks for those areas can be addressed by preparing a clear policy/strategy for selection and prioritization of cascade systems/minor tanks. When formulating such a policy/strategy, it is necessary to consider need of water resources, number of beneficiaries, and amount of funds available, type of restoration/rehabilitation work required, hydrology of the tank system etc. This will formalize the restoration program and boost benefits/returns with respective to the investment.

Estimated cost of implementation over the proposed period of 02 years is US$ 0.05 million.

e) Barrier*: Lack of policy/clear mandate for distribution of funds among different government agencies involved in restoration of minor tank network systems*
Measure: *Development of a revised mandate for Agrarian Service Department and Provincial Councils with respect to restoration of minor tank network systems which would help when distributing funds for restoration work assigned to them*

The lack of mandate which demarcates responsibilities for the Agrarian Service Department and Provincial councils with respect to restoration work is a significant barrier and needs to be addressed to prevent distribution of funds among them in a baseless manner. Therefore it is necessary to revise the mandate of Agrarian Service Department and Provincial Councils with respect to restoration of minor tank network systems.

Once a revised mandate is available, it is possible to allocate the required percentages of total funds, to each line agency and it will ensure that the restoration process will successfully take place resulting a considerable financial benefit.

No additional cost is involved for implementation of this measure, as related activities are administrative functions of the relevant institutions.

Information and awareness, R & D measures:

f) Barrier: *Poor understanding on cascade hydrology due to lack of R & D and limited institutional and organizational capacity*
Measure: *Improve understanding on cascade hydrology by promoting R & D and increasing institutional and organizational capacity*

To address the above barrier, it is necessary to promote R & D to collect data on cascade hydrology and for this purpose, it is necessary to increase the capacity of relevant institutes and organizations. Results of the above study should be made available for interested parties.

Estimated cost of implementation over the proposed period of 02 years is US$ 0.2 million.

g) Barrier: *Limitations due to water pollution*
Measure(s): *R & D on tank water pollution and strict enforcement of relevant environmental laws/policies/regulations*

Diarrhea, dental fluoresis, and kidney diseases experienced by villagers consuming water from minor tanks should be monitored. Water quality should be monitored in a regular basis and data on health issues should be correlated. Comparison of the results can be used to identify the relationship between

health issues and pollution. The environmental laws related to pollution control should be strictly enforced.

Estimated cost of implementation over the proposed period of 03 - 09 years is US$ 0.5 million.

3.3 Barrier analysis and possible enabling measures for Technology 2: Rainwater harvesting (RWH) from rooftops for drinking and household uses

Barriers identified through stakeholder consultations are discussed under Section 3.3.2 below.

3.3.1 General description of the technology

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. In addition to serving as an adaptation technology for climate change, incorporation of RWH into household water use practices contributes to development by saving money and time.

A study on the rainfall for the period from 1960 to 2001 has shown that the lengths of dry spells are increasing all over Sri Lanka. This study[27] has also shown that the daily rainfall intensities increases and therefore rain water from roof tops could be harvested within a short period of time. Rainwater could be harvested during the rainy season and the stored rainwater can provide short term security against such dry periods. At present in certain areas, rain water harvesting is not carried out in a proper manner and it is necessary to provide necessary technical guidance for improvements through awareness programs. Refer Annex D-3: Technology Fact Sheet on Rainwater harvesting from rooftops for drinking and household uses, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

3.2.4 Identification of barriers for Rainwater harvesting (RHW) from rooftops for drinking and household uses

The prioritized barriers identified through stakeholder consultations, research literature reviews and expert inputs include two (02) economic & financial, two (02) technical, two (02) information & awareness, two (02) social, cultural & behavioral, one (01) policy, legal & regulatory and one “other” barriers. These barriers are also grouped into two categories, as economic & financial barriers and non-financial barriers.

[27] Ratnayake U.R., *etal*, 2005

3.3.2.1 Economic and financial barriers:

Two economic & financial barriers have been identified under this category and they are as follows:

a) High capital cost

While this barrier is identified as an economic & financial related, it also falls under the category of institutional & organizational as well. The entire cost of roof top rainwater harvesting systems is incurred during initial construction. Storage tanks are the most expensive component in any roof top rainwater harvesting systems and according to rain water harvesting Practioners' Guide for Sri Lanka, the cost of a storage tank is US $ 325/= (SL Rs. 50,400/=) per 5 m^3 tank[28]. In addition, cost of other required materials and labor during construction and maintenance is also high and it is estimated as US $ 1.88 m^{-3}. Under the existing financial policy, no priority has been given by the government to allocate funds for construction of roof top rainwater harvesting systems or provisions to promote this technology in the country. Research and Development related funding agencies also have not identified rooftop rainwater harvesting systems as a priority research area. Therefore Universities and research institutes have a limited capacity for R & D in this field and there appears to be no opportunities available to promote such R & D in the country. As the Government thus far has not identified this technology as a priority area requiring government assistance, this is considered as the most important barrier affecting promotion of this technology.

b) No benefit during extended dry seasons with respect to the investment

One of the hindrances for promoting this technology is that the rain water collected during the rainy season may not be sufficient for extended dry seasons which could compromise the likelihood of making a heavy financial commitment for the installation of roof top rainwater harvesting systems by the households. Incentives such as, provision of potable water during extended dry seasons at subsidized rates is likely to encourage investments of this nature for roof top rainwater harvesting systems.

3.3.2.2. Non-financial barriers:

Non financial barriers identified for the technology of roof top rain water harvesting systems, included technical, information & awareness, social, cultural & behavioral, and a barrier under the category of "others"

[28] Rain Water harvesting, Practioners guide for Sri Lanka; Lanka Rain Water Harvesting Forum; ISBN 978-955-1064-06-8, 2009

Technical failures, Institutional & organizational capacity, Information & awareness barriers:

a) Lack of sustainability of roof top rain water harvesting systems due to *poor management practices*

This barrier has technical, institutional & organizational capacity and information & awareness dimensions. Poor management practices affect sustainability of roof top rain water harvesting systems because lack of proper maintenance leads to degradation of water quality, health risks, growth of algae in the storage tank etc. The importance of good operation and maintenance practices is poorly understood by the community and they have poor/no knowledge in this regard. This is primarily due to lack of training, proper guidance and no effective information dissemination and inadequate awareness programs on this technology. In addition, inadequate capacity of the Health Department personnel restricts their involvement in monitoring health related issues of the communities using harvested rain water, testing the quality & treatment of the stored water and monitoring the standards of rain water harvesting system.

Technical failures, Policy and legal framework barriers:

b) Lack of standards, codes and certification for roof top rainwater harvesting systems

This is primarily a technical failure related barrier and it is a significant barrier for promoting rooftop rainwater harvesting systems. Currently, there are no standards, codes and certification system in the country for roof top rainwater harvesting systems. As a result many consumers use storage tanks sans a lid thereby water in the storage tank gets contaminated and become ideal sites for mosquito breeding. There is also a possibility of using inappropriate roof materials as well. Growth of algae is often seen when sun light penetrate into water.

Information & awareness barriers:

c) Poor understanding of importance of rain water harvesting as a means of water conservation for facing any water scarcity due to climate change

Currently most of the communities are unaware of the concept and importance of rain water harvesting from roof tops as a water conservation method for facing any potential water scarce situation due to climate change. This can be attributed to lack of information & awareness and community ignorance of the national rain water harvesting policy and strategies. This is a major hindrance for implementation of roof top rain water harvesting technology. Inadequate community based participatory programs by the relevant agencies such as the National Water Supply and Drainage Board (NWSDB), Municipal Councils, Urban Development Authority, National Rainwater Harvesting Forum etc. to disseminate information on the benefit of this technology is being considered as a major barrier for diffusion of this technology.

d) Poor accessibility for information on rainfall data

This barrier is categorized as information & awareness related and it has relevance to the previous barrier. Lack of free access to rainfall data is a barrier when designing a proper rainwater harvesting system.

e) Lack of prioritized areas for installation of roof top rainwater harvesting systems

There is no mechanism in place to prioritize areas for installation of roof top rainwater harvesting systems in the country.

Social, cultural, behavioral and information & awareness barriers:

f) Lack of confidence in roof top rainwater harvesting technology

Stakeholders identified this as another major hindrance for roof top rainwater harvesting technology. For many Sri Lankans, roof top rainwater harvesting is an unfamiliar technology for augmenting drinking water supplies and it is seen as alien with no utility. Therefore, they lack confidence and have negative attitude towards this technology.

g) Due to aesthetic considerations, roof top harvested rainwater has no demand

This barrier also can be categorized as social, cultural and behavioral related. Due to aesthetic considerations roof top harvested rainwater is not attractive to many people and have negative attitude towards this technology.

Policy, legal & regulatory barriers:

h) Inefficient enforcement of national rainwater harvesting policy

Although there is a National Rain Water Harvesting Policy, it is yet to be strictly practiced. Poor involvement of Municipal Councils, Urban Development Authority and National Water Supply and Drainage Board (NWSDB) in its implementation is a barrier. There is no mechanism to issue annual licenses for rain water harvesting systems.

Institutional and organizational capacity, technical and "Other" barriers:

i) Limitations due to contamination of water

This barrier can be categorized as "other" barrier relating to pollution and also as technical, and institutional & organizational barrier. Inadequate capacity of the Health Department to monitor health effects such as diarrhea experienced by villagers who consume rain water from roof top rainwater harvesting systems, and no capacity to provide facilities for treatment of harvested water are constraints affecting promoting this technology. Biological contamination (e.g. *E. Coli)* due to faecal matter of birds can cause diarrhea. Lack of standards, codes and licensing system for roof top rainwater harvesting systems and R & D are considered as major contributory factors for above health related issues.

3.3.3. Identified measures

3.3.3.1 Economic and financial measures

a) Barrier*: High capital cost*
Measures i): *Obtain additional funds from donor agencies*

Since development funds of the government are limited, it is required to explore donor support in the form of loans and grants from those agencies involved in developing adaptation technologies for climate change or from any other potential donor agencies. Whenever it is deemed necessary, household's contributions in terms of labor and other available local resources should be obtained to minimize the cost.

Measure (ii): *Promote research on development of low cost, better quality roof top rainwater harvesting systems*

Research activities on development of low cost, better quality roof top rainwater harvesting systems should be promoted. When allocating research funds, considering the importance, funding agencies should give priority for research in this area. Universities and research institutions can undertake such research projects. Lecturers, researchers and research students should identify and prioritize areas pertaining to this subject. Findings of these research programs should be made available to agencies/persons engaged in this technology or decision makers.

The estimated cost of implementation over the proposed period of 09 years is US$ 1.025 million.

b) Barrier: *No benefits from the investment during extended dry seasons*
Measure: *Provide incentives for households/communities using rainwater harvesting systems*

At present no annual budgetary allocations are provided for diffusion of this technology. Therefore, the government has to recognize this as a priority area and allocate funds from the annual budget, and provide incentives to households/communities for installation and maintenance of roof top rain water harvesting systems. Such incentives could be in the form of cash payment, tax deduction, subsidy for storage tank etc. Relevant NGOs also can be engaged in this process.

The estimated cost of implementation over the proposed period of 03 - 09 years is US$ 0.01 million.

3.3.3.2 Non-financial Measures

Technical failures, Institutional & organizational capacity barriers:

a) Barrier*: Lack of standards, codes and certification for roof top rainwater harvesting systems*
Measure: *Formulate a mechanism for standards, codes and certification for roof top rainwater harvesting systems*

Currently there are no standards, codes and mechanism for certification of roof top rainwater harvesting systems. This is a significant barrier and it is necessary to develop a mechanism to formulate standards, codes and certification for roof top rainwater harvesting systems and to issue license on annual basis. This could be handled by the NWSDB.

No additional cost is involved for implementation of this measure, as the related activities are routine functions of the relevant institutions.

Information and awareness measures:

b) Barrier*: Lack of sustainability of roof top rain water harvesting systems due* to *poor management practices*
Measure (i): *Improve operation and maintenance practices of rooftop rainwater harvesting systems through increased awareness*

In order to address the above barrier, it is recommended that awareness programs including training/guidance be conducted in an effective manner by NWSDB/NGO's or Health Department on operation and maintenance of rainwater harvesting systems. These awareness programs need to be designed so as to provide information to consumers, policy makers and decision makers on possible methods to minimize contamination of rain water within the rainwater harvesting system, treatment methods for harvested rainwater, how to minimize possible leakages, and the potential of RWH systems

becoming breeding sites for mosquitoes. Such information can be included into school curriculum as well. It is also recommended to publish a small guide book on rain water harvesting from roof tops.

Measure (ii): *Demonstration of model roof top rainwater harvesting system and dissemination of knowledge on good operation and management practices through audio-visuals.*

NGOs or NWSDB can set up a model roof top rainwater harvesting system for demonstration and disseminating good operation and management practices of the system through audio-visuals. Access to visit such places should be free and existence of such places should be publicized and encouraged through media.

The estimated cost of implementation over the proposed period of 09 years is US$ 4.5 million.

c) Barrier*: Poor understanding of importance of roof top rain water harvesting technology as a water conservation method for water scarcity due to climate change*
Measure: *Conduct awareness programs on importance of the technology as a water conservation method*

Awareness programs should be conducted by relevant NGOs, NWSDB, Municipal Councils, Urban Development Authority and media on importance of this technology as a water conservation method to face impending water scarcity due to clime change. Such awareness programs would also facilitate decisions by policy makers and decision makers on diffusion of this technology in the country.

The estimated cost of implementation over the proposed period of 09 years is US$ 4.5 million.

d) Barrier: *Poor accessibility to information on rainfall data*
Measure: *Revise the data dissemination policies of Meteorological Department and provide free access to rainfall data*

Lack of free access to rainfall data for previous years is a barrier and a procedure needs to be put in place for providing free access to rain fall data for past years when designing a proper rainwater harvesting system.

e) Barrier*: Lack of prioritized areas in the country for installation of roof top rainwater harvesting systems*
Measure*: Identify and prioritize suitable areas in the country for installation of roof top rainwater harvesting systems*

Lack of prioritization of areas is a major barrier which needs to be addressed immediately. Parameters such as quality of rain water, urgency and climate change modeling should be considered when prioritizing the areas. It is recommended that priority should be given to highly vulnerable areas where

surface water is scarce and quality of ground water is poor (e.g. Kalpitiya). The information on prioritized areas should be made available to general public.

Estimated cost of implementation over the proposed period of 02 years is US$ 0.02 million.

Social, cultural and behavioral and Information and awareness measures:

f) Barrier*: Lack of confidence in roof top rainwater harvesting technology*
Measure: *Build confidence in roof top rainwater harvesting technology*

Roof top rainwater harvesting technology is a new, unfamiliar technology for many Sri Lankans and hence it is not surprising to see lack of confidence in this technology. This barrier can be addressed by making them more familiar with it through demonstration models, awareness programs and audio-visual programs based on roof top rainwater harvesting practices in other countries. Government needs to consider providing incentives (e.g. rebate of 15 % from annual income tax) for households/communities maintaining roof top rainwater harvesting technology.

Estimated cost of implementation over the proposed period of 09 years is US$ 1.5 million.

g) Barrier: *Due to aesthetic considerations, roof top harvested rainwater has no demand*
Measure*: Increase the demand for roof top harvested rain water*

This barrier can be addressed by convincing that the quality of harvested rain water is good for consumption by performing water quality analyses. For this purpose, government or NGO's should provide water quality analyses service at a nominal fee for harvested rain water on a regular basis. In order to convince that consumption of harvested rainwater does not cause any negative health effects, Health Department should provide free monitoring services on health conditions. Certificate of conformity for new buildings should incorporate with rainwater harvesting facilities coupled with discounts in the rates. The requirement of ensuring the quality of harvested rainwater to be in par with other sources of domestic water should be strictly enforced by NWSDB.

Estimated cost of implementation over the proposed period of 09 years is US$ 1.0 million.

Policy, legal and regulatory

h) Barrier: *Inefficient enforcement of national rainwater harvesting policy*
Measure: *Strict enforcement of national rainwater harvesting policy*

In order to address the above barrier, action is required to strengthen the 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 for roof top rainwater harvesting systems, on an annual basis.

No additional cost is involved for implementation of this measure as the related activity is a routine function of the relevant institution.

"Other" measures:

i) Barrier: *Limitations of the technology-2 due to contamination of water*
Measure: *Good operation and management practices to minimize possible contamination of rain water within the roof top rain water harvesting system*

This barrier can be addressed by having good operation and management practices of rain water harvesting system. Technical assistance and assistance for quality control should be provided by the government or relevant NGOs.

Estimated cost of implementation over the proposed period of 09 years is US$ 0.01 million.

3.4 Barrier analysis and possible enabling measures for Technology 3: Boreholes/Tube wells as a drought intervention for domestic water supply

3.4.1 General description of the technology

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

Ground water is used as a drinking water source and also for back-garden agriculture and aquaculture in the dry zone. The borehole efficiency (high efficiency means both high yield and high success rates) changes with the bedrock geology. Boreholes in areas with hornblende biotite gneiss and charnockitic biotite gneiss have shown good efficiencies. Farmers usually tend to extract groundwater at rates ranging

between 27 m^3/hour and 45 m^3/hour[29] 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. Qualified organizations registered with NWSDB/WRB should be engaged in the construction of boreholes where the contractor providing all labor, transport, plant, tools, equipment and materials and appurtenances. The contractor has to ensure successful implementation of all stages of the construction including locating sites for drilling, construction of drilled boreholes including lowering of borehole assembly with PVC casing and screen and end cap, gravel packing at appropriate intervals and back filling, closing near surface water table aquifer, cleaning and development of boreholes, chlorination of borehole, installation of the pump with test pumping for 6 hours, construction of apron with drainage and soak away pit and chemical and biological water quality testing.

When installing a borehole for community, two or three locations that are acceptable to the community have to be selected and attention should be given on the road conditions for accessibility of the drilling rig and other heavy equipment. Then sites should be selected at each location by checking for Geophysical / Geological conditions or by confirming the technical feasibility of drilling a successful borehole(s) for hand pump installation. If there is a water committee it is better to get their consent for the selected site. The site should definitely not be in a place that gets flooded in the rainy season and should be away from the flood plain area of any streams or rivers in the locality. In addition to that, the sites chosen should be at least 30 meters away from toilet pits or any other sources of pollution such as grave yard, stagnant pools of dirty water.

Please see Annex I for the Market Map of the Technology and Annex D-3: Technology Fact Sheet on Boreholes/Tube wells, Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I).

3.4.2 Identification of barriers for *Boreholes/Tube wells as a drought intervention for domestic water supply)*

This technology is considered a capital good and the market map is given in the annex-1. The barriers identified through stakeholder consultations and expert inputs are comprised of two (02) economic & financial, three (03) institutional & organizational capacity, two (02) policy, legal & regulatory, one (01) information & awareness, one (01) technical, three (03) market failure barriers and one (01) under “other” category. They are also classified into two categories, as economic & financial and non-financial barriers.

[29] Premanath *et al* 1994

3.4.2.1 Economic and financial barriers

Two economic and financial barriers are identified under this category and they are as follows:

a) High cost of *capital*

Amongst the capital costs, cost of equipment and constructions are considered to be high cost investments. The estimated cost of equipment in the present study is $1.16 m^3. In order to construct bore holes it is necessary to purchase locally manufactured or imported drilling equipment, hand pumps, and motor pumps and they are relatively expensive.

Apart from the cost of equipment, construction of a borehole includes costs for physical investigation, construction and quality & quantity testing. The total cost of construction of a hand pump tube well (HPTW) and a production borehole are in the range of Rs. 1 93,920 – Rs. 210,080 and Rs. 198,550 – Rs. 219,450 respectively out of which 50% goes for drilling of the well, 20% for screening, 15% for testing of water quality and yield and 5% for cleaning, communication and demobilization. The total cost changes with the depth and the size of the borehole and investment cost is very high.

Because of the high cost, this barrier is identified as the most significant one under this technology.

b) Inadequate funding allocation for diffusion of the technology in prioritized areas (e.g. rural areas)

This barrier was identified as an economic and financial barrier. The priority given to this technology in the annual budget and allocation of funds is not sufficient.

3.4.2.2 Non- financial barriers

Non financial barriers are related to institutional & organizational capacity, policy, legal & regulatory, information & awareness and “other” category and these are discussed below.

Institutional & organizational capacity and information & awareness barriers:

a) Lack of assistance for physical investigations of sites, drilling of the well, screening, water quality and yield testing

Lack of assistance for physical investigations is primarily due to capacity constraints of the relevant institutes and therefore this barrier is considered as institutional and organizational related.

b) Lack of understanding on negative impacts of over extraction of ground water

This is mainly due to inadequate information and awareness. Over extraction of ground water seen in certain areas in the country is due to lack of understanding of the consumers on negative impacts of over extraction on water table and potential water quality problems etc. Relevant Ministries, Departments and Statutory Bodies have failed to disseminate this information to technology users through awareness programs.

c) Lack of information on ground water resources

This barrier is related to insufficient institutional and organizational capacity. At present, information available on groundwater resources of this country is not complete. There is no single publication available in the country that lists and summarizes the present state of knowledge of the different aquifers in the country. This is a significant barrier when selecting a site for a borehole/tube well. No effective strategy exists in the country to promote R and D to collect such data.

d) Lack of sustainability

Poor hydro geological conditions of the site and over extraction can affect the sustainability of the borehole/tube well. When the bed rock is igneous or metamorphic and if they do not have weathered zones and fractures, it would result in low yielding and less sustainable bore holes. For example Vijayan Complex in the country consist of orthogenesis and migmatites and it has the highest failure rate of both hand pump type and the production type bore holes[30]. Over extraction/high abstraction rate also can affect sustainability of the borehole.

Policy, legal and regulatory barriers:

e) Lack of policies/laws/guidelines for safe and sustainable use of groundwater

This barrier can be categorized as a policy, legal and regulatory related barrier. At present there is no policy and a strategy to control over extraction of ground water. This is a hindrance for the success of this technology as it could reduce the availability of groundwater by lowering the water table. As a result, the tube wells will dry out or in coastal areas, brackish water will enter in to the tube wells.

f) Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers

Depending on the site, drilling of boreholes can affect vulnerable aquifers. Lack of policies or laws to limit drilling of boreholes affecting vulnerable aquifers is a significant barrier for this technology.

[30] Shanuka Palamure *et al* , 2012

g) High interest on loans for importers/producers of tube wells due to lack of policies/strategy to establish low-interest loan scheme

In order to diffuse the technology of tube wells, the required equipment such as pups, drilling equipment etc. needs to be reasonably priced and the Government institutions and private constructors are unable to finance the high up-front costs to purchase pumps, drilling equipment etc,. Accessing bank loans is also practical as the interest rates for loans are high. Currently there is no supportive policy/strategy to enable providing low-interest loans for importers/producers of tube wells to purchase necessary equipment for tube well industry.

h) High import tax for importers/producers of tube wells due to lack of policies/strategy to establish import tax relief

High import taxes contribute to high cost of drilling equipment, pumps etc. This would be a constraint in promoting tube well. Currently there is no policy/strategy to grant incentives such as import tax relief for importation of necessary equipment for tube well industry.

Information and awareness, market failure barriers:

i) Lack of prioritization of areas to implement this technology

This barrier is related to inadequacy of information and awareness. At present a prioritized list of potential sites for introduction of this technology is not available. Once such information is compiled, a mechanism needs to be developed to make the information available to the general public.

j) Lack of information on prices of equipment, loan schemes etc

This barrier is categorized under market failures and lack of information & awareness. Tube well constructors/producers from rural areas have no access to information on prices of necessary equipment for construction/production of tube wells (e.g. drilling equipment, hand pumps, motor pumps) and low-interest loan schemes available for purchase of such equipment, other benefits provided etc, by the government and it is a significant hindrance for diffusion of this technology.

Technical barriers:

k) Lack of R & D on ground water availability and hydrogeology

R & D related initiatives to collect above information in an efficient and systematic manner is not promoted by the relevant agencies such as NWSDB and WRB.

"Other" barriers:

I) Limitations of the technology due to poor quality of ground water

Quality of tube well water entirely depends on the quality of ground water being tapped. Tube well water contaminated with *Escherichia coli* and other human-pathogenic bacteria can cause gastrointestinal diseases. Fluoride containing tube well water can cause Dental fluoresis. These situations are currently seen in certain locations in the country. Therefore, regular quality checking of water from tube wells is imperative to ensure avoiding health risks.

3.4.3 Identified measures

3.4.3.1 Economic and financial measures

a) Barrier: *High investment (capital) costs*
Measure: *Take appropriate steps to reduce the investment (capital) cost*

To address the above barrier it is necessary to reduce the high investment cost and it is described under the following two categories.

- *Measures to reduce cost of equipment*

High cost for equipment can be reduced in following ways;
Considering the importance of this technology, government should give import tax exemptions/relief and subsidiary on interest rates for loans for importers/local producers of drilling equipment, hand pumps and motor pumps. Technical support and quality assurance should be given by engineers to local producers. Arrangements should be made to provide trade standards and producer coordination. Publicity on availability of such equipment should be provided through information campaigns. Market information on above equipment should be provided to service providers such as NWSDB, Water Resource Board (WRB), and NGOs. Marketing support should be given to retailers and whole sellers of drilling equipment, hand pumps and motor pumps.

- *Measures to reduce cost for construction*

Construction costs can be reduced by installing boreholes at sites where hydrogeolology suitable. In addition to that, funds should be requested from donor agencies who are actively involved in adaptations for climate change, by submitting carefully prepared proposals through External Resource Department and the Department of National Planning. It is necessary to promote R & D to reduce cost of construction.

These measures do not involve any additional costs as the related activities are routine functions of the respective agencies.

b) Barrier*: Inadequate funding allocation for diffusion of the technology in prioritized areas (e.g. rural areas)*
Measure*: Provide adequate funding for diffusion of the technology in prioritized areas (e.g. rural areas)*

Government should identify this technology as a priority area at the national planning level and allocate sufficient funds from the annual budget to line ministries for diffusion of the technology in prioritized areas (e.g. rural areas).

Estimated cost of implementation over the proposed period of 01 year is US$ 0.02 million.

3.4.3.2 Non- financial measures

Institutional and organizational capacity measures:

a) Barrier: *Lack of assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing*
Measure: *Provide assistance for physical investigations of the site, drilling of the well, screening, water quality testing and yield testing through registered contractors*

Qualified organizations registered with NWSDB/WRB for construction of boreholes could be made involved for providing assistance for physical investigations of the potential sites, drilling of the well, screening, water quality testing and yield testing. These registered contractors could be from among the government sector or NGOs (e.g. NWSDB, WRB, NGOs). For this purpose, NWSDB/WRB should offer certificate courses to produce sufficient number of skilled persons having knowledge in hydrogeology. It is necessary to build capacity of relevant institutions and organizations to enable offering such courses.

Estimated cost of implementation over the proposed period of 02 years is US$ 0.5 million.

b) Barrier*: Lack of understanding on negative impacts of over extraction of ground water*
Measure: *Improve the understanding on negative impacts of over extraction of ground water*

To address the above issue, capacities of institutions/organizations need to be increased to enable effective dissemination of information on negative impacts of over extraction to consumers. This would help planning, development, protection and conservation of ground water resources in order to ensure sustainability of Boreholes/Tube wells as a drought intervention for domestic water supply.

Estimated cost of implementation over the proposed period of 06 years is US$ 2.05 million.

c) Barrier: *Lack of sustainability*
Measure: *Providing suitable conditions for sustainability*

Ground water availability, aquifer recharge potential, rate of abstraction and quality of ground water are governed by the type of basement rock. Therefore, for sustainability of the tube well, it is necessary to select suitable sites based on the hydro-geological conditions and quality of ground water. Lack of regular operation and maintenance also affect the sustainability. It is also recommended to publish guide books on operation and maintenance of tube wells.

Estimated cost of implementation over the proposed period of 03 - 06 years is US$ 12.005 million.

Policy, legal and regulatory measures:

d) Barrier*: Lack of Policies/laws/guidelines for safe and sustainable use of groundwater*
Measure: *Formulate laws/guidelines for safe and sustainable use of groundwater*

To address the above barrier, guidelines for safe and sustainable use of groundwater, developed for the regolith aquifer by the National Resources Management Centre of the Department of Agriculture in 1997 should be framed for the other aquifers in Sri Lanka as well. This information needs to be widely disseminated to both local and district provincial agencies and other end users. In order to control large scale extractions, policies/laws should be formulated to register and issue licenses by NWSDB/WRB to large scale users of ground water.

This measure does not involve any additional costs as the related activities are routine functions of the respective institutions and also parts of the cost is included under the measure (b) above.

e) Barrier: *Lack of policies/laws to control drilling of boreholes affecting vulnerable aquifers*
Measure: *Formulate laws/ guidelines to control drilling of boreholes affecting vulnerable aquifers*

To address the above barrier, policies and regulations should be formulated to prevent drilling of boreholes affecting vulnerable aquifers through licensing given by NWSDB/WRB.

This measure does not involve any additional costs as the related activities are routine functions of the respective institutions

f) Barrier*: High interest on loans for importers/producers of tube wells due to lack of policies/strategy to establish low-interest loan scheme*
Measure: *Establish a low-interest loan scheme for importers/producers of tube wells*

It is necessary to formulate policy/strategy towards establishing collaborative arrangement between local banks and the retailers selling equipment in order to develop a low interest scheme to assist purchasing necessary equipment by organizations registered with the NWSDB/WRB.

This measure does not involve any additional costs as the related activities are routine functions of the respective institutions

g) Barrier*: High import tax for importers/producers of tube wells due to lack of policies/strategy to establish import tax relief*
Measure: *Establish an import tax relief for importers/producers of tube wells*

An incentive program in the form of tax relief for the import of major equipment used for tube wells and also for accessories of tube wells to encourage local producers of boreholes/tube wells needs to be developed. Therefore, it is necessary to formulate an import tax relief policy/strategy in order to assist the organizations registered with the NWSDB/WRB.

This measure does not involve any additional costs as the activities related to policy revisions are by the respective institutions

Information and awareness measures and measures to address market failures:

h) Barrier*: Lack of information on ground water resources*
Measure*: Availability of information on aquifers in Sri Lanka*

In order to address this barrier, information on aquifers in Sri Lanka should be collected and made available to contractors registered for installation of boreholes/tube wells and also to decision makers by NWSDB and WRB. R & D on collection of such data should be promoted by providing necessary funding.

Estimated cost of implementation over the proposed period of 02 - 06 years is US$ 0.01 million.

i) Barrier: *Lack of prioritization of areas to implement this technology*
Measures*: Identify vulnerable areas for climate change and study hydrogeology of such areas, need and urgency etc, and based on those data, prepare a prioritized list*

Lack of a prioritized location specific list for installation of boreholes is a major barrier for promoting this technology. To address this issue, first it is necessary to identify vulnerable areas to climate change by

applying climate change modeling. Then suitability of the sites for setting up bore wells should be determined based on the hydrogeology, need and urgency.

Estimated cost of implementation over the proposed period of 02 years is US$ 0.005 million.

j) Barrier*: Lack of information on prices of equipment, loan schemes etc.*
Measure: *Awareness campaigns on special facilities provided for tube well constructors*

Awareness campaigns should be organized to provide above facilities to constructors/producers especially in rural areas.

Estimated cost of implementation over the proposed period of 02 - 06 years is US$ 0.005 million.

Technical measures:

k) Barrier*: Lack of R & D on ground water quality and hydrogeology of various sites*
Measure*: Promote R &D on ground water quality and hydrogeology of various sites to evaluate the suitability for boreholes and tube wells*

An incentive should be given to research students studying at NWSDB/WRB on the above subject to encourage them.

This measure does not involve any additional costs as the related activities are routine functions of the respective institutions

Other measures:

l) Barrier: *Limitations of the technology due to poor quality of ground water*
Measure: *Select sites having good quality ground water*

Boreholes/tube wells are not suitable for sites where ground water quality is not good. Therefore, poor quality ground water is a barrier for boreholes/tube wells. To address this issue, areas having bad quality ground water should be identified and published. This will make the programme effective and sustainable.

Estimated cost of implementation over the proposed period of 03 - 07 years is US$ 0.07 million.

3.5 Linkages of the barriers identified

The barriers common to different prioritized technologies in the water sector are given below.

The barriers which are common to all three technologies are;

3.5.1 High capital cost

High capital cost is found to be a barrier common to all three technologies ie. Restoration of minor tank networks, Rainwater harvesting from rooftops for drinking and household uses and Boreholes/Tube wells as a drought intervention for domestic water supply.

3.5.2 Lack of sustainability

Lack of sustainability is another common barrier for all three technologies.

- Restoration of minor tank networks - Lack of sustainability of minor tank systems is due to poor tank management practices.
- Rainwater harvesting from rooftops for drinking and household uses - Lack of sustainability of roof top rain water harvesting systems is due to poor management practices.
- Boreholes/Tube wells as a drought intervention for domestic water supply - Unsuitable hydro-geological conditions of the site and over extraction can affect the sustainability of the borehole/tube well.

3.5.3 Lack of/weak enforcement of relevant policies, legal and regulatory

This again is a common barrier for all the three technologies.

- Restoration of minor tank networks - policies/laws are lacking to facilitate prioritizing most suitable cascade systems/minor tanks for restoration and also for distribution of funds to different government agencies involved in restoration of minor tank network systems.
- Rainwater harvesting from rooftops for drinking and household - Enforcement of national rainwater harvesting policy is poor.
- Boreholes/Tube wells as a drought intervention for domestic water supply - Policies/laws/ by laws/ guidelines are not available for safe and sustainable use of groundwater and also to control drilling of boreholes affecting vulnerable aquifers, Import tax relief systems and low-interest loan schemes are not available to purchase the major equipment needed for the technology

3.5.4 Poor/lack of information and awareness

Lack of information and awareness is yet another common barrier for all three technologies.

- Restoration of minor tank networks - Lack of information on cascade hydrology is a barrier for planning of restoration work.

- Rainwater harvesting from rooftops for drinking and household - Households/communities lack awareness on the importance of rain water harvesting from roof tops as a water conservation method for climate change.
- Boreholes/Tube wells as a drought intervention for domestic water supply - Awareness on potential negative impacts of over extraction of ground water and incentive schemes are not available for constructors from rural areas

3.5.5 Lack of prioritized areas to implement the technology

Currently there is no national level prioritized scheme for implementation of climate change adaptation technologies for the water sector.

- Restoration of minor tank networks - Lack of priority list is a barrier when selecting the most suitable cascade systems/minor tanks for restoration.
- Rainwater harvesting from rooftops for drinking and household - Lack of prioritization of areas for installation of roof top rainwater harvesting systems.
- Boreholes/Tube wells as a drought intervention for domestic water supply - Lack of prioritization of areas for installation of boreholes.

3.5.6 Limitations of the technology due to water pollution

- Restoration of minor tank networks - Pollution of surface water
- Rainwater harvesting from rooftops for drinking and household - Contamination of rain water during harvesting and/or storing

Boreholes/Tube wells as a drought intervention for domestic water supply - Poor quality of ground water

3.5.7 Lack of research and development

- Restoration of minor tank networks - Lack of R & D on related health issues.
- Technology 2- R & D is necessary to develop a low cost system.
- Technology 3 - R & D by NWSDB/WRB is required for determination of ground water availability and hydrogeology.

3.6 Enabling framework for overcoming the barriers in the Water Sector

3.6.1 Common barriers and their enabling framework

The common barriers as listed under 3.5 above are thus as follows;

High capital cost, Lack of sustainability, Weak enforcement of policies/laws, Lack of information and awareness, Lack of prioritized areas to implement the technology, Limitations of the technology due to water pollution and Lack of research and development. Based on these common barriers, enabling framework was prepared. The enabling framework for these common barriers is given in Table 3.2.

Table 3.2: Enabling framework for the common barriers in the Water Sector

No.	Broad/Common barriers	Enabling framework	Technology
1	High capital cost	(i) Obtain additional funds from donor agencies through External Resource Department	1,2
		(ii) Promotion of research on development of low-cost rainwater harvesting systems	
		(iii) Import tax exemptions/reliefs and subsidiary on interest rates for loans for organizations registered at NWSDB/WRB	3
		(iv) Select suitable sites based on hydro-geological conditions	3
2	Lack of sustainability	(i) Improve operation and maintenance practices	1,2,3
		(ii) Select suitable sites based on hydro-geological conditions	3
		(iii) Recharge ground water	3
		(iv) Avoid over extraction	3
		(v) Avoid sites having poor ground water quality	
3	Poor enforcement of relevant policies/laws/regulations	(i) Prepare a clear policy on selection and prioritization of cascade systems/minor tanks for restoration	1
		(ii) Strengthen involvement of agencies to implement existing policies/legal frame work	2
		(iii) Introduce a system to issue license in an annual basis	2,3
		(iv) Import tax exemptions and subsidiary on interest rates	3
		(v) Prepare a policy/guidelines for ground water	3

		management	
4	Lack of information and awareness	(i) Promote R & D to collect data on cascade hydrology and made them available to interested parties (ii) Improve operation and management practices of rooftop rainwater harvesting systems through awareness programs (iii) Provide information on benefits provided and process etc. to constructors from rural areas (iv) Collect island wide information on aquifers in Sri Lanka in a systematic and efficient manner by NWSDB/WRB and made them available to contractors registered for installation of boreholes and also to decision makers	1 2 3 3
5	No prioritized areas to implement the technology	(i) Develop a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration (ii) Needs, urgency and Climate change modeling should be considered	1 2
6	limitations of the technology due to water pollution	(i) Strict enforcement of relevant environment lows/regulations (ii) Research & Development (iii) Good operation and management practices (iv) Select suitable alternative sites	1,2,3 1,2,3 2 3
7	Lack of R & D	(i) Funds for necessary R & D should be provided to universities, research institutions, NWSDB/WRB etc. (ii) As the annual budget does not allocate sufficient funds for R & D, it is necessary to give priority for R & D related to these fields (iii) Incentives should be given to research students at NWSDB/WRB carrying out research projects in this field	1,2,3 1,2,3 3

Enabling framework for common barriers in detail:

1. *Obtain additional funds from donor agencies through External Resource Department, Promotion of research on development of low-cost rainwater harvesting systems, Import tax exemptions/relief and subsidiary on interest rates for loans and Select suitable sites based on hydro-geological conditions*

High capital cost is a major barrier for all three technologies. Financial requirements for implementation of these technologies should be identified at the National Planning level. As development funds of the government are limited, project specific additional funds in the form of loans/grants should be sourced from donor agencies who have shown an interest in developing adaptation technologies for climate change or from other potential donor agencies, through External Resource department. The initial cost for technology-2 is high and it is necessary to carry out research to develop low-cost rainwater harvesting systems. High capital cost for boreholes is mainly due to high import tax and high interest rates for loans. Introduction of import tax relief and low-interest loan schemes for organizations registered with NWSDB/WRB for purchase of necessary equipment for boreholes would help to lower the high capital cost. If the hydro-geological conditions are not suitable, capital cost will be high due to high depth.

2. *Improve operation and maintenance practices, Select suitable sites based on hydro-geological conditions, Recharge of ground water, Avoid over extraction and Avoid sites having poor ground water quality*

Lack of sustainability is another major barrier for all three technologies. Sustainability of restoration of minor tank networks could be improved by the implementation of good operation and management practices such as desiltation, rehabilitation of damaged bunds, reducing high evaporation of tank water by planting trees in the Gasgommana, regular oiling and greasing of sluice structure etc. Sustainability of rainwater harvesting from rooftops could be improved by implementing good operation and management practices such as minimization of possible contamination of rain water within the rainwater harvesting system, treatment methods for harvested rainwater and to minimization of possible leakages. It is also recommended to publish a small guide book on rain water harvesting from roof tops. –Sustainability of boreholes/Tube wells as a drought intervention for domestic water supply could be ensured by installing tube wells at sites having suitable hydro-geological conditions and good quality ground water. Good operation and maintenance practices should be implemented. Over extraction should be avoided. Necessary training/guidance/certificate courses should be offered by NWSDB/WRB.

3. Prepare a clear policy on selection and prioritization of cascade systems/minor tanks for restoration, Strengthen involvement of agencies to implement existing policies/legal frame work, introduce a system to issue license in an annual basis, Import tax exemptions and subsidiary on interest rates for organizations registered at *NWSDB/WRB and Prepare policy/guidelines for ground water management*

Poor enforcement of policies/laws appears to be an inherent problem for the success of all the three technologies. It is necessary to formulate a clear policy/strategy for selection and prioritization of cascade systems/minor tanks on the basis demand for water, number of beneficiaries, availability of funds, type of restoration/rehabilitation work required, hydrology of the tank system etc to ensure success of restoration of minor tank networks. For Rainwater harvesting from rooftops, 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, on an annual basis. With regard to the construction of boreholes/tube wells as a drought intervention for domestic water supply, policies/laws should be formulated to register and issue license to tube well constructing organizations 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 registered tube well constructing organizations to import/locally purchase necessary equipment for tube well industry.

4. Promote R & D to collect data on cascade hydrology and make them available to interested parties, Improve operation and management practices of rooftop rainwater harvesting systems through awareness programs, Provide information on benefits provided, prices of necessary equipment etc. to constructors from rural areas, Collect information on aquifers in Sri Lanka and Publish guide books on operation and maintenance of roof top rainwater harvesting systems and tube wells

The R & D related issues of restoration of minor tank networks could be addressed by promoting collection of data on cascade hydrology and make them available to interested parties. For Rainwater harvesting from rooftops, it is necessary to improve operation and management practices of rooftop rainwater harvesting systems through awareness programs and to publish guide books on operation and maintenance of roof top rainwater harvesting systems. It is recommended to provide information on benefits provided, prices of necessary equipment etc. to constructors of boreholes/tube wells from rural areas, collect information by NWSDB/WRB on aquifers in Sri Lanka and make them available to decision makers. In addition to above, it is also recommended to publish guide books on operation and maintenance of tube wells.

5. 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 for implementation of these technologies is a common barrier for all three technologies. For restoration of minor tank networks, it is recommended to develop a policy/strategy for selection and prioritization of cascade systems/minor tanks for restoration. For rainwater harvesting from rooftops and for boreholes/tube wells as a drought intervention for domestic water supply, the foremost requirement is to identify vulnerable areas to climate change by applying climate change modeling. The attributes that also need to be considered thereafter include the needs, quality of rain water/ ground water etc. For the technology 3, hydrogeology of the site also should be considered.

6. Strict enforcement of relevant environment laws, R & D, Good operation and management practices, Select suitable alternative sites

Water pollution is another common barrier arising out of the limitations of the technology. Strict enforcement of environment laws and research & development are recommended for all three technologies. Good operation and management practices are critical; for the success of the technology on Rainwater harvesting from rooftops and construction of Boreholes/Tube wells as a drought intervention for domestic water supply. For the technology3, selecting suitable alternative sites is also recommended.

7. Funds for necessary R & D should be provided to universities, research institutions NWSDB/WRB 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 and 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 when allocating funds in the annual budget.. For the technology 3, (Boreholes/Tube wells as a drought intervention for domestic water supply) it is extremely vital to collect required data on aquifers in Sri Lanka and to attract research students by providing incentives for carrying out research projects in this field.

Chapter 4

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. Around 103 rivers radiating from the hill country flow down to the sea forming estuaries that are important features of the coastal landscape, which provide vital habitats for organsms of socioeconomic importance. They also carry sediments and pollutants that may degrade the quality of coastal waters and habitats. Coastal Zone contains a variety of terrestrial habitats, such as sandy beaches, barrier beaches, sand spits and dunes, rocky shores, mangrove stands & salt marshes and coastal wetlands such as coral reefs, lagoons, estuaries and sea grass beds. These systems help maintaining the vital physical processes, fulfill ecosystem services and functions and provide land, goods and services[31].

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[32]. 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[33]. 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[34].

Identification of suitable adaptations technologies for the coastal sector was carried out through an extensive stakeholder consultative process. A prioritization process utilizing the Multi-Criteria Decision Analysis (MCDA) approach was carried out to identify the preferred adaptation technologies for the sector. The prioritized technologies thus identified are **Sand dune rehabilitation, Restoration of mangroves** and **Restoration of coral reefs**. (Ref. Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report). The prioritized technologies and their categories are given in table 4.1.

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

[32] Jayatilake, A. 2008, Climate Change due to Global Warming: A Global Challenge in Sri Lanka Perspective. Economic
Review, 2008

[33] ME b, 2010, Climate Change Vulnerability in Sri Lanka - Sector Vulnerability Profile: Water.

[34] ME a, 2010, Climate Change Vulnerability in Sri Lanka - Sector Vulnerability Profile: Urban Development, Human Settlements and Economic Infrastructure

Table 4.1: Prioritized Technologies and Categories in the Coastal Sector

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

4.1 Preliminary targets for technology transfer and diffusion

Preliminary target of this programme is to develop stratergies to reduce damage to coastal ecosystems and infrastructure due to sea level rise, which may resulted due to global climate change. They should be implemented through community participatory socioeconomic activities and they are as follows.

(i) Establish plantations of *Pandannus sp* and other types of dune vegetation of economic & medicinal value, on 50 ha of existing sand dunes (in 25 selected sites with 2 ha each), within a period of 7 years, using tissue culture techniques to produce necessary number propagules of dune flora, for sustainable utilisation for socioeconomic development activities and to maintain ecosystem stability.

(ii) Establishment of 20 ha of mangrove plantations in degraded mangrove areas selected from 10 sites (each with an area of 2 ha) using proper zonal plans, within a period of 5 years, by raising required numbers of propagules from selected species of mangrove flora which would be collected from existing mangrove forests. They will be raised in nursaries, in order to allow the community to use them for sustainable socioeconomic activities and to ensure ecosystem stability.

(iii) Establish 10 ha of artificial coral reefs in degraded reefs selected from 10 sites with 1 ha, selected from different areas around Sri Lanka within 7 years, by transplanting high temperature tolerant species selected from the natural reefs found in the selected sites, in order to restore the degraded reefs and to allow the community and the tourist hotel industry to use them for sustainable socioeconomic activities such as eco-tyourism and research.

4.2 Barrier analysis and possible enabling measures for Technology 1: Sand dune Rehabilitation

Ten key barriers were identified through a stakeholder consultation process and the details are given under section 4.2.2

4.2.1 General description of the technology

Natural sand barriers along with their vegetation could function as soft barriers against coastal erosion and inundation, which could occur due to sea level rise as a result of climate change. Therefore, rehabilitation of degraded dune vegetation due to anthropogenic activities by replanting is considered an important adaptation technology. Propagation of plants could be done by using seeds or tissue culture techniques.

Facilities for collection of seeds of *Pandanus* and other dune plants with economic or medicinal value and to establish nurseries to raise the required propagules should be provided to academic or research institutes or to Centres especially established for this purpose with community participation. In areas where dune sand has been removed for anthropogenic activities such as construction work, these plantations could be carried after beach nourishment to improve the quality of the substratum. In addition to replanting, natural regeneration of dune plants should be allowed to take place under the improved environmental conditions due to replanting of *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 post-tsunami rehabilitation programme funded by the CIDA (Canada) has assisted the coastal communities in successfully re-establishing *Pandanus* sp,. This initiative has not yielded the desired results for want of government patronage to promote such projects. With adequate follow up funding, this project would have provided opportunities for cottage industries based on *Pandanus* leaves.

Plant species that grow on dune sand are abundant in Sri Lanka and scientifically designed terraced plantations would not only provide protection against coastal erosion, storm surge, tsunami and other harmful coastal activities, but also will provide alternative income sources for coastal communities and also improve the aesthetic conditions of the sandy beaches as well. It will also provide nesting sites to turtles and sea birds, which would attract nature lovers and local and foreign tourists. Coastal communities living in the vicinity of sand dunes in the North, North-western, South-eastern and Eastern coastal belts will benefit out of this technology.

It will provide a protection from coastal erosion and also will act as a wind belt in areas where strong winds persist. In addition, other plants of economic and medicinal value will provide an alternative income source for coastal communities. With the improvement of soil conditions, as a long term adaptation methodology, many other natural plant communities also will naturally establish in the areas where sand dunes exist, improving their biodiversity. Ref. Annex D-4: Technology Fact Sheet on '*Sand dune rehabilitation',* Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

4.2.2 Identification of barriers for the technology

Ten (10) barriers were identified through stakeholder consultations and expert inputs. These barriers consist of one (01) Economic and Financial barrier and nine (09) Non-financial barriers.

4.2.2.1 Economic and financial barriers:

The only economic & financial barrier identified for the technology is ***inadequate funds for restoration of sand dunes through natural beach nourishment and planting of dune vegetation and to conduct awareness programmes***

This is seen as a major barrier for restoration of disturbed sand dunes. Most of the government institutions such as Coast Conservation Department, Dept. of Wild Life, Department of Agriculture, Central Environmental Authority, National Science Foundation, Center of Agrarian Research Policy, Universities, Research Institutes, etc., involved with different aspects of coastal ecosystem management lack adequate funds for coastal ecosystem restoration related activities. This could be due to lack of understanding on the socioeconomic importance of conservation/management & restoration of sand dunes and the natural resources associated with them among the decision makers within the line Ministries and those involved in budgetary allocations. Furthermore, lack of commitment by the provincial government agencies to attract project specific funds to ensure social and economic security of the coastal communities through sustainable development and management of locally available natural resources also can be considered as another contributory factor for inadequate funding.

4.2.2.2 Non-financial barriers

The non financial barriers identified are categorised under eight key categories viz; Policy, legal & regulatory; Network failures; Institutional & organisational capacity; Human Skills; Social cultural & behavioural; Information & Awareness; Technical and Other barriers

Policy, legal & regulatory barriers:

Poor enforcement of coastal zone management regulations and Low priority given for funding for environmental protection & R&D under the existing financial policy are the barriers falling under this category.

a) Poor enforcement of coastal zone management regulations

This is considered as the most important barrier among all barriers identified under this technology. The reason for poor enforcement is the unavailability of a mechanism for enforcement of respective regulations due to inadequate political commitment, unavailability of sufficient human resources and lack

of intra agency cooperation among departments and institutions falling under the purview of different line Ministries. Some of the illegal activities taking place in the dune ecosystems are extraction of sand for construction work, use of dune flora are used for cottage industries, construction of human dwellings, tourist hotels & resorts and mechanised drawing of beach seine nets. Control of these activities requires a collaborative effort of all relevant agencies. Above all, political pressure is also seen as another reason for poor enforcement of coastal management regulations. However, serious commitment of policy makers and law enforcement and regulatory bodies is required to ensure conservation and management of sensitive coastal ecosystems such as the sand dunes.

b) Low priority given for funding for environmental protection and R&D under the existing financial policy

The underline reason for the low priority given when allocating finances for coastal zone resource management appears to be the inadequate knowledge of the decision makers on "the importance of protection and management of natural resources in the coastal zone for sustainable socioeconomic development", and on "the needs of R&D activities to develop technologies for protection, sustainable utilisation and management of sensitive coastal ecosystems and their resources". This is mainly due to the fact that when appointing persons to key positions in the policy making bodies, some times oppotunities are not given to qualified and experiance peopole due to various reasons. Such persons will either fail to get the assistance of experienced persons to obtain necessary information to frame necessary policies or will not possess the required knowledge to design respective policies. In addition to the above, activities related to protection of natural ecosystems do not lead to politically appealing quick short-term benefits but contribute to long-term results ensuring sustainable socio-economic developments.

Network failures barriers:

The only net work failure related barrier identified is inadequate coordination among different institutions and government departments under different Ministries.

c) *Inadequate coordination among different institutions and government Departments under different Ministries*

As mentioned in 4.2.2.1, activities related to coastal ecosystems management are carried out by several agencies (e.g. CCD, CEA, Dept. of Agriculture, District secretariats, Universities, Research institutions, etc.) falling under the jurisdiction of different line ministries whose functions are often overlapping. Each of these agencies has specific targets and goals expected to achieve individually. Such an approach invariably leads to competition and rivalry among institutions resulting in conflicts, slow progress and above all duplication of activities yielding sub-optimal benefits from scarce development funds spent. In view of overlapping functions, competition among different institutions is a strong barrier for restoration sand dune ecosystems and sustainability of socioeconomic activities in the coastal ecosystems.

Institutional & organisational capacity barriers:

Inadequate opportunities for research are a key institutional & organisational capacity related barrier.

d) Inadequate opportunities for research

Research is a prime need for development of new and low cost technologies needed for developing countries like Sri Lanka. Research needs identified for restoration of sand dunes are as follows;

- Identification of dune flora needed to restore sand dunes located in different coastal districts of Sri Lanka.
- Develop tissue culture techniques to produce required dune flora propagules.
- Development of soil conditions for re-establishment of dune vegetation.
- Develop marketable value added products using dune vegetation, in order to establish Small and medium scale enterprises (SMEs) for socioeconomic development of coastal communities.

Above research activities requires institutional capacity building for those institutions involved with coastal ecosystem restoration, resource development and utilisation related research.. Infrastructure facilities, skilled personnel and funds for training & field trials are essential ingredients for conduct of successful research activities. Infrastructure facilities include laboratories adequately equipped with facilities for chemical analyses, tissue culture and bio technology. In addition, equipment and facilities to conduct field research and facilities to visit field research stations and sites are also required.

Human Skills barriers:

"*Inadequate trained personnel/experts to provide knowledge on technologies used*" is identified as a barrier related to human skills.

e) Inadequate trained personnel / experts to provide knowledge on technologies used

Restoration of sand dunes and its vegetation has been a low priority until the destructive Asian tsunami in 2004. In certain areas where the natural sand dunes and vegetation existed, it provided natural protection to coastal infrastructure, human dwellings, etc. Although sand dunes are considered as natural soft barriers against coastal processes such as waves, storm surge, strong winds and tsunami, not much research has been carried out in Sri Lanka to develop technologies for restoration of sand dunes. At the time of 2004 tsunami, the only protective activity existed and practiced in the coastal belt was introduction of Cassuarina plantations, on sand dunes subjected to destructive anthropogenic activities. It was proved to be an unsuccessful programme as wherever tall mature *Cassuarina* plants were found, destruction from tsunami was severe due to lack of protective under growth among

Cassuarina trees. However, in certain instances small plants of *Cassuarina* with their branches touching the ground have provided some protection against the tsunami wave.

Therefore, to improve knowledge on different technologies adopted globally and to identify appropriate technologies to restore sand dunes and its vegetation in Sri Lanka, there should be well trained personnel with required experience and knowledge. Such expertise is essential to conduct advanced research and to disseminate useful research findings to coastal communities and other stakeholders for adoption so as to ensure coastal protection and socioeconomic development of communities dependent on coastal resources.

Social, cultural & behavioural barriers:

Lack of commitment by the coastal communities & industries to secure existing sand dunes and rehabilitate disturbed sand dunes due to difficulty in giving up destructive coastal activities, which have been a source of income" is being identified as an important barrier arising out of Social, cultural & behavioural patterns of the resource users.

f) Lack of commitment by the coastal communities & industries to secure existing sand dunes and rehabilitate disturbed sand dunes due to difficulty in giving up destructive coastal activities, which have been a source of income

Coastal communities dependent on resources of the sand dune ecosystems for their livelihoods are reluctant to give up such destructive activities due to lack of alternative income sources available in the area. Following are some of such major activities taking place in the coastal zone.

- Extraction of dune vegetation for cottage industries
- Removal of sand dunes and its vegetation to construct human dwellings and tourist resorts
- Clearing of coastal belt with sand dunes and dune vegetation to use it for human settlements and construction of tourist hotels resorts

In addition to the above sand dunes are damaged by destructive mechanisms used for other coastal industries such as beach seining, which is currently experienced in the North-western coast of Sri Lanka.

Absence of alternative income sources for coastal communities dependent on coastal resources, selfishness of persons involved in destructive activities, lack of understanding and cooperation among coastal communities involved in different socioeconomic activities and general lack of awareness on the natural protection provided by sand dunes for coastal infrastructure and communities & non-extractive uses of coastal resources etc has contributed to the above status of affairs.

Information and Awareness barriers:

Inadequate information & awareness has contributed to "General lack of awareness on the non extractive uses/importance, role and functions of coastal sand dunes for national development and protection of the environment, at all levels of the society".

g) General lack of awareness on the non extractive uses/importance, role and functions of coastal sand dunes for national development and protection of the environment, at all levels of the society

Sand dunes with its associated vegetation act as natural barriers against coastal erosion and inundation caused by wave action, storm surge, and strong winds and also against tsunami waves. These functions are considered as non-extractive uses of sand dunes and associated vegetation. Due to inadequate awareness within the community on such non-extractive uses, they engage in activities such as, removal of dune vegetation (e.g. *Pandanus* sp.) for small scale or cottage industries & sand for construction activities and construction of human dwellings and tourist hotels.

Those involved in above activities are unaware of the importance of the sand dunes as soft barriers for protection of their households, properties and other infrastructure against the coastal erosion and inundation that may occur due to sea level rise caused by climate change.

Technical barriers:

Only one barrier has been identified under the category of technical barriers it relates to *"*.Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation*"*.

h). Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation

Communities living in the vicinity of the sand dunes use very low technology when utilizing dune vegetation for cottage industries. The indigenous knowledge on such technologies is passed through generations without any improvements. New technologies with high economic returns needs to be adopted in these cottage industries in order to produce products of higher economic values for the sustainability of the socio economic gains accrued from dune vegetation, while ensuring the sustenance of non-extractive uses of the dune vegetation towards coastal protection,. Presently such technologies or facilities to conduct research to develop new technologies and a mechanism to transfer advanced technologies to improve cottage industries using dune flora are not available.

Other barriers:

Negative impact due to extraction of sand for construction industries is listed under the "Other" category of barriers. Although considered as a major barrier for restoration of sand dunes, it is given relatively low

priority as extraction of dune sand for construction purposes has been banned in recognizing the significance of sand dunes as a soft barrier against natural coastal processes.

i) Negative impact due to extraction of sand for construction industries

Dune sand is considered a useful resource for the construction industry as it has low salt content. Use of dune sand for construction work is becoming popular due to lack of alternative materials and knowledge on construction technologies which do not use beach sand. Further, easy access to dune sand and availability in abundance has attracted large scale suppliers to the constrcution industry.

4.2.3 Identified measures

Measures to overcome the barriers were also identified through a stakeholder consultation and are discussed below.

4.2.3.1 Economic & financial measures:

a) Barrier: *Inadequate funds for restoration of sand dunes, through beach nourishment and planting of dune vegetation & to conduct awareness programmes.*
Measures: *Request for project specific annual funding from the government by the relevant line ministries & departments, or from the suitable donor agencies by NGOs & INGOs actively involved in adaptation procedures for climate change and in conservation of ecosystems & biodiversity.*

Approximate funding requirement for a sand dune restoration programme would be around US $ 850,000. In order to overcome the above barrier, various potential funding sources need to be explored. Request for funds should be based on specific project proposals formulated in collaboration and cooperation with relevant agencies having mandate for coastal resources management to avoid duplication of work and wastage of funds.

Implementation of the project related activities also could be collaborative where different components of the project would be given to institutions involved in such activities within the ambit of sand dune restoration. Research and academic institutions could be involved in research activities. Funds should be allocated according to the quantum of work handled by each collaborative institution/department. Therefore project proposals should be prepared with clear identification of institutions/departments involved, responsibilities to be delegated to each department/institution and components of financial commitment by each of the collaborating institution/department.

Estimated cost of implementation over the proposed period of 7 years is US$ 0.05 million.

4.2.3.2 Non-financial measures

Policy, legal & regulatory measures:

a) Barrier: *Poor enforcement of coastal zone management regulations*
Measures:
(i) Conduct awareness programmes to law enforcement officers, on the importance of proper enforcement of coastal zone management regulations
(ii) 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.

These awareness programmes should be conducted by appropriately qualified resource persons drawn from different institutions. It will be added advantage to select resource persons from institutions located in the vicinity of the area to be rehabilitated as the community or personnel involved in rehabilitation programmes will have easy access to resource persons whenever their assistance is needed. Above all, resource persons selected from the concern area will feel more responsible and committed to the development programmes and law enforcement activities in the area and build a better rapport with the respective stakeholders in the community for successful implementation of activities. Above awareness programmes could be used as a platform to develop intra - institutional and inter - personnel linkages for better law enforcement in the area.

Estimated cost of implementation over the proposed period of 3 years is US$ 0.171 million.

b) Barrier: *Low priority given for funding for environmental protection and for R&D under the existing financial policy*
Measure(s): *Request should be made through the line ministries to increase the annual budgetary allocations for environmental protection projects highlighting the socioeconomic gains due to restoration of sand dunes and their vegetation and also about the economic losses if the Dunes are not rehabilitated.*

To overcome this barrier, suitable proposals should be forwarded through the line ministries to influence financial policy reforms to create an enabling environment for increasing the funds for protection of sensitive coastal ecosystems. Such proposals need to highlight socioeconomic gains resulting from restoration of sand dunes and also lost opportunities in the event of no interventions. If government budgetary allocation is not sufficient for successful restoration of sand dunes, funding opportunities need to be explored from other local and foreign sources who have already expressed interests in promoting research and awareness for climate change adaptations. In addition, the corporate plans of academic and research institutions under the relevant line Ministries shall be required recognise the need for promoting environmental research and education. Awareness programmes should be conducted for the

policy makers highlighting the importance of coastal & marine science education and research for socio-economic development of the country in order to facilitate securing increased funding for Science Education & research.

Estimated cost of implementation over the proposed period of 3 years is US$ 0.171 million.

Measures to prevent Network failures:

c) Barrier: *Inadequate coordination among different institutions government departments under different ministries*

Measures :(i) *Development of multidisciplinary projects in collaboration with research/academic institutions.*

(ii) Identify strategies to develop and improve fruitful collaborations, to

- *Identify, problems within the locations with sand dune*
- *Prepare activity plans to overcome the problems to reach development goals*

It is recommended to develop multi-disciplinary collaborative projects involving all relevant agencies for the restoration of sand dunes and socioeconomic development in order to ensure effective coordination among such institutions.

Estimated cost of implementation over the proposed period of 5 years is US$ 0.059 million.

Measures to increase institutional & organisational capacity:

d) Barrier: *Inadequate opportunities for research*

Measures: *(i) Build capacity of R & D institutions to handle research related to environmental protection, conservation & management*

(ii) In the corporate plans of respective R & D institutions, include need for capacity building for environmental protection, conservation & management research activities

Lack of opportunities for research is mainly due to unavailability of facilities such as infrastructure and equipment and also experienced personnel to design suitable research plans addressing the needs for conservation and restoration Sand dune ecosystems. Therefore, the need for undertaking research and institutional capacity building programs for improved environmental protection and conservation & management of coastal ecosystems should be given a adequate priority in the corporate plans of respective R & D institutions.

Estimated cost of implementation over the proposed period of 5 years is US$ 1.35 million.

Measures to improve Human Skills:

e) Barrier: *Inadequate trained personnel / experts to provide knowledge on technologies used*
Measures: *(i) Provide adequate budgetary allocation to all relevant agencies for staff training at local & foreign research/academic institutions.*

(ii) Develop mechanisms to retain trained personnel after giving appropriate training

(iii) Provide facilities to relevant institutions to enable gathering knowledge on required technology through training & research and also through electronic and print media

(iv) Use the experts/trained personnel available at research/ academic institutions to provide training to staff at relevant institutions prior to getting them involved in relevant projects.

v) Carry out the project work in collaboration with suitably qualified experts.

vi) Use of funds granted through donor agencies, should be focused on awareness and training activities related to conservation & restoration programmes,

While the Research and Higher Educational Institutes are faced with the problem of high turnover rate of foreign trained personnel due to lack of opportunities for carrier development, the government departments and institutions are constrained with lack of funds for training their staff at local or foreign institutions. Therefore there should be adequate annual budgetary allocations for training of personnel from the relevant government departments and research/academic institutions and institute mechanisms for carrier development in order to retain the trained staff. Persons available within the relevant institutions should be provided with facilities to gather knowledge on required technology through training & research and also through electronic and print media. As appropriate obtain the services of experts/trained personnel of the research/ academic institutions for providing training to respective staff at national level, prior to engage them in projects activities. Ensure that the project activities are entrusted with suitably qualified experts and with persons selected/identified through personnel contacts. Funds secured from donor sources should be spent on focused training and awareness activities related to conservation & restoration programmes, rather than on ad hoc events. Take suitable measures to improve a better understanding between the government & NGOs to obtain funds and training opportunities for suitable persons.

Estimated cost of implementation over the proposed period of 5 years is US$ 0.505 million.

Social cultural & behavioural measures:

f). Barrier: *Lack of commitment by the coastal communities & industries to secure existing sand dunes and rehabilitate disturbed sand dunes due to difficulty in giving up destructive coastal activities, which have been a source of income*

Measures: (i) *Form a committed group of actors selected from the coastal communities*

(ii) Provide alternative sources of income or employment, within the same region, to those who are involved in destructive activities

(iii) Government departments and their line ministries should develop suitable strategies to have a better understanding on NGOs, involved in community participatory programmes related to sand dune conservation and restoration programmes.

This problem could be solved by forming a committed group of actors selected from among the coastal communities, who have the capacity to form community based organizations to undertake conservation and restoration programmes. In addition to the above, action should be taken to provide alternative sources of income or employment within the same region to those who are involved in destructive activities and this should be done concurrently with the awareness programs conducted to all levels of the community. These awareness programs should highlight the social responsibilities with respect to conservation, management and sustainable utilisation of sand dunes and its resources. Since NGOs have ongoing projects which have successfully reached the local communities, government organisations should develop suitable strategies to have a better understanding on NGOs, for successful implementation of community participatory restoration programs.

Estimated cost of implementation over the proposed period of 7 years is US$ 0.605 million.

Measures to improve information and Awareness:

g) Barrier: *General Lack of awareness on the non extractive uses/importance, role and functions of coastal sand dunes for national development and protection of the environment, at all levels of the society*

Measures: *(i) Conduct awareness programmes to all stakeholders of the coastal regions on the importance of restoring sand dune ecosystems for the wellbeing of coastal communities, obtaining the assistance of all parties affected to restore sand dunes and planting sand dune vegetation.*

(ii) Involvement of unemployed coastal youth in eco-tourism, and involvement of coastal tourist hoteliers for sand dune restoration & encourage them to involve in eco-tourism.

(iii) Under the tourism industry in the area establishment of nature trails among dune vegetations and turtle nesting sites,

(iv) Establish herbal gardens, by planting dune vegetation having medicinal importance

(v) Encourage floating hotels in the vicinity of coastal sand dunes

The above five measures have been identified to overcome this barrier.

For successful implementation of project activities, prior awareness programmes should be held for different stakeholder groups highlighting the responsibilities of the respective organizations to ensure success of restoration activities. All stakeholder groups should be involved in common awareness programmes to ensure their collaboration and cooperation for successful outcomes of the restoration programmes. For example managers of tourist hotels should attend the awareness programmes on eco-tourism while all stakeholders including managers of tourist hotels also need to be involved in awareness programmes on replanting of dune vegetation and the significance of restoring sand dunes as protective mechanisms against sea level rise and coastal inundation.

Estimated cost of implementation over the proposed period of 7 years is US$ 0.605 million.

Measures to overcome technical barriers:

h) Barrier: *Lack of knowledge on technologies adopted for sustainable utilisation of dune vegetation*
Measures: *(i) Encourage plantations of dune vegetations of economic and medicinal importance.*
(ii) Conduct awareness/training programmes to disseminate knowledge on

- *Plants suitable to be grown on sand dunes*
- *Tissue culture & propagation methods to produce sufficient numbers of plants/propagules for plantation*
- *Sustainable utilisation of dune vegetation for SMEs*

(iii) Encourage the government to introduce economically important species of Pandanus, which are available in the Pacific region, after a well planned feasibility study.

Encourage plantations of dune vegetations of economic and medicinal importance and conduct awareness/training programmes to disseminate knowledge on plants suitable for sand dune restoration. Introduce Tissue culture & other propagation methods to produce sufficient numbers of plants/propagules for plantation and sustainable utilisation of dune vegetation for SMEs.

Estimated cost of implementation over the proposed period of 1 - 3 years is US$ 0.85 million.

Other measurers:

i) Barrier: *Use of Dune sand for construction work*
Measures: *(i) Encourage off-shore sand extraction for building construction*
(ii) Popularise construction technologies, not involving coastal sand

Off-shore sand extraction should be encouraged for building construction in place of dune sands. This sand should be used with least impacts on the marine ecosystems. Best areas for offshore sand extraction should be identified by suitable marine geological surveys. In addition to the above, construction technologies not involving dune sand should be popularized.

Estimated cost of implementation over the proposed period of 3 years is US$ 0.005 million.

4.3 Barrier analysis and possible enabling measures for Technology Rehabilitation of Mangroves

Barriers were identified through a stakeholder consultation are given under section 4.3.2

4.3.1 General description of technology 2 - Rehabilitation of Mangroves

One of the most commonly restored wetland ecosystems for coastal protection is mangroves. Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. They induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilize shore sediments, thus reducing erosion. Evidence from the 12 Indian Ocean countries affected by the 2004 tsunami disaster suggested that coastal areas with dense and healthy mangrove forests suffered fewer losses and less damage to property than those areas in which mangroves had been degraded or converted to other land use[35]. This was observed in the vicinity of Rekawa Lagoon after the 2004 tsunami incident.

In addition to the provision of ecosystem functions, the mangroves also support the livelihoods of the coastal communities. These mangrove systems also perform vital hydrological functions and serve as breeding grounds for fish & other marine species. Wetland restoration re-establishes these advantageous functions for the benefits of coastal flood and erosion protection. Restoration is required because mangroves have become increasingly degraded through both natural and human activities.

Sri Lanka has been experiencing rapid loss of mangrove ecosystems mainly due to anthropogenic factors including unprecedented growth of the tourism sector (i.e, Bentota area). In spite of the known ecological and economic values of mangroves there has been indiscriminate exploitation of mangroves for commercial, industrial, housing needs mainly due to the lack of knowledge of the ecological role of the mangroves amongst the decision-makers.

The mangrove systems covering an area of 6000-7000 ha are interspersed along the coastline of Sri Lanka. The largest mangrove system is located in Puttalam Lagoon – Dutch Bay – Portugal Bay complex and covers an area of 3,385 ha. The other large concentrations are in Batticaloa and Trincomalee districts. This unique ecosystem is home to over 20 true mangrove species of Sri Lanka. The major genera that represent these species are *Avicennia, Rhizophora*, *Bruguiera*, and *Sonneratia*.

[35] Kathiresan & Rajendran, 2005

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

Replanting mangroves is a widely accept technology for restoration of degraded mangrove ecosystems worldwide. The very common species of Sri Lankan mangroves are *Avicennia marina, Bruguiera gymnorrhiza, Excoecaria aggalocha, Lumnitzera racemosa, Rhizophora mucronata, Rhizophora apiculata, and Sonneratia caseolaris* which grow under a wide range of soil and hydrological conditions, and are widely distributed in Sri Lanka indicating that they are the most appropriate species for mangrove reforestation. The common category of mangrove species represent *Aegiceras corniculatum, Avicennia officinalis, Bruguiera cylindrica, Bruguiera sexangula, Ceriops tagal, Heretiera littoralis, Pemphis acidula, Sonneratia alba, Nypa fruticans* they are also suitable for replanting purposes due to their wide distribution although found in few numbers[36].

Replanting of mangroves will not only provide protection from sea level rise expected due to climate change, but it will also provide other socio economic benefits such as livelihood opportunities for local communities, development of tourism industry and SMEs based on mangrove products. Improvement of mangroves will also improve the lagoon fish production. Ref. Annex D-4: Technology Fact Sheet on 'Rehabilitation of Mangroves*'* - Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I).

4.3.2 Identification of barriers for the technology

Following eight barriers were identified based on stakeholder consultations and through specialist inputs.

4.3.2.1 Economic & Financial Barriers:

Inadequate financial assistance for rehabilitation of mangroves habitats is the only financial barrier identified and it is ranked as the third important barrier among the eight barriers identified for the technology.

a) Inadequate financial assistance for rehabilitation of mangroves

Common apprehension among certain stakeholders is that although funds are available for restoration programs they are not utilized in a productive manner. However considering the importance of rehabilitating mangrove ecosystems inadequacy of financial resources is considered a high priority among the barriers identified. One of the reasons for inadequate funding appears be inherent weaknesses of the project proposals seeking support from both government and external sources and

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

lack of evidence on self sustaining local community participatory approaches for socio-economically important activities such as Small and Medium Scale Enterprises (SMEs).
The cost of rehabilitation of mangroves is estimated as US $ 319,000 for 20 ha per year at the rate of US $ 1.60 per 1m^2.

4.3.2.2 Non-financial barriers

Policy, legal & regulatory barriers

a). Inadequate Government patronage & commitment

Insufficient budgetary allocations to restore and establish sustainable socioeconomic programs (e.g. eco-tourism, study centres to attract foreign researchers, nature trails, etc.) appears to be the manifestation of inadequate government patronage due to little or no awareness on the importance of sustainable management of mangroves among decision makers responsible for allocating funds for respective government agencies involved in rehabilitation of mangrove ecosystems.

a) No proper legal authority for protection and management of mangroves and therefore lack of management plans or strategies to protect and manage these resources.

Absence of a proper legal authority *vis a vis* lack of proper management approach for mangrove ecosystems is the second barrier identified under the policy, legal & regulatory barriers and it is considered the most important barrier among all barriers identified under this technology. There is no serious delegation of responsibilities to relevant agencies involved with coastal zone management activities in order to ensure sustainable utilisation of mangrove resources for socio economic development of local communities.

Social cultural & behavioral barriers

c) Unsustainable development practices in areas with mangroves.

This barrier is the result of lack of awareness on potential opportunities for sustainable utilisation of mangroves and punitive provisions to impose severe punishments for human induced destructive activities such as clearing of mangrove vegetation for development projects, garbage disposal etc.

d) Destructive lagoon fishing techniques

Destructive lagoon fishing is ranked as a very important barrier among all the barriers identified under this Technology. Destructive fishing is the result of inadequacies in lagoon fishery regulatory

mechanisms and lack of knowledge on responsible and sustainable fishery practices among lagoon fisher communities.

Technical barriers:

e) Replanting mangroves without proper zonal plans and using unsuitable species

Replanting of mangroves without proper zone planning and use of inappropriate species is the key barrier identified under the Technical barrier category. The reason for this barrier is the lack of properly designed regulatory mechanisms for mangrove restoration.

Institutional and organizational capacity barriers

f) General lack of appreciation/awareness on the non extractive uses and ecological functions of mangroves at all levels of the society

The underline reason for this barrier is related to inadequacies in dissemination of knowledge and information on the importance of mangrove ecosystems in terms of ecological functions and economic benefits to the general public through public communication systems.

Other barriers:

g) Illegal & unsustainable land use practices in the hinterland, which cause high sedimentation rates in lagoons and estuaries

This barrier is the result of poor river basin management and haphazard development programs in the hinterland which leads to release of large loads of sediments and pollutants to coastal lagoons. Lack of proper zonal plans appears to be main contributory factor for problems of this nature.

4.3.3 Identified measures

Measures to overcome the barriers were identified through a stakeholder consultation which included relevant government agencies and representation from the NGOs.

4.3.3.1 Economic & financial barriers

a) Barrier: *Inadequate financial assistance for restoration programmes*
Measures: *(i) Attract funds through properly formulated proposals*
(ii) Encourage self sustaining economic activities using mangrove products

To overcome the above barrier, it is suggested to explore project specific funds from local and foreign funding sources including NGOs etc. Introduce financially viable appropriate technologies to start small scale industries managed by the respective line ministries to utilise mangrove products in a sustainable manner (e.g. fruit drinks). Encourage self sustaining community participatory organisations to initiate economic activities using mangrove products in addition to their other responsibilities related to mangrove ecosystem management.

Estimated cost of implementation over a period of 07 years is US$ 0.109 million.

4.3.3.2 Non-financial barriers

Policy, legal & regulatory measures:

a). Barrier: *Inadequate Government patronage & commitment*
Measures: *(i) Encourage the government to increase the budgetary allocations for sustainable socioeconomic programmes*
(ii) Conduct awareness programmes on importance of sustainable management of mangroves, to government officials responsible for decisions on allocating funds for line ministries

In order to restore and establish sustainable socioeconomic programmes having the potential for financial returns such as eco-tourism, research study centres to attract foreign researchers, nature trails, etc in mangrove areas, government needs to consider providing assistance through increased budgetary provisions and other facilities such as capacity building in related institutions.

In order to facilitate such decisions, respective government officials responsible for policy decisions on allocating funds needs to be made aware of the importance of sustainable management of mangroves through awareness creation.

Estimated cost of implementation over a period of 03 years is US$ 0.134 million.

b) Barrier: *No proper legal authority for protection and management of mangroves and therefore lack of management plans or strategies to protect and manage these resources.*
Measures: *(i) Provide assistance to line ministries or institutions under them to prepare suitable management plans for rehabilitation of mangroves*
(ii) Organise meetings/workshops with the high ranking officers of the line ministries and institutions to highlight the importance of rehabilitation of mangroves for socioeconomic benefits

In order to overcome the above barrier Assistance needs to be provided to the respective agencies to define management approaches to be followed by management plans and strategies and also for their implementation to ensure effective rehabilitation and sustainable use of management of mangrove ecosystems. Furthermore, awareness creation among relevant offcials of the respective line agencies through meetings or workshops should be undertaken to disseminate information on the importance of and potential socio economic gains from mangrove ecosystems.

Estimated cost of implementation over a period of 03 years is US$ 0.134 million.

Social cultural & behavioral measures:

c) Barrier: *Unsustainable practices (unplanned developments and projects) within areas with mangrove*
Measures: *(i) Conduct awareness programmes to those who involve in unsustainable practices within mangrove areas*
(ii) Enforcement of strict regulations and punishments to those who violate them

Some of the major human induced unsustainable practices taking place in the mangrove ecosystems are clearing of mangrove vegetation for infrastructure development projects and disposal of municipal waste. Therefore, creating awareness on the ecological significance of fragile mangrove ecosystems and opportunities for sustainable use of mangroves is imperative. Such awareness programs needs to be conducted in collaboration with al the relevant agencies having some form of responsibility with regard to the management of mangrove areas. In addition, strict law enforcement with punitive actions such as spot fines, legal action, etc., should be imposed on the offenders.

Estimated cost of implementation over a period of 03 years is US$ 0.134 million.

d) Barrier: *Destructive lagoon fishing techniques*
Measures: *(i) Strict impose of fishery regulations and regulatory mechanisms*
(ii) Introduce Co-management procedures to all uses of resources in mangroves and associated lagoons
(iii) Conduct awareness programmes and establish regulatory mechanisms.

The destructive lagoon fishing practices directly impacts upon the sustainability of lagoon fishery. Therefore, strict law enforcement will be imperative for regulating lagoon fishery. A suitable regulatory

mechanism should be established in collaboration with the Ministry of Fisheries and Aquatic resource Development and Environmental Ministry to facilitate enforcement of relevant legal provisions. Lagoon fisher folks also should be given more responsibility for protection and sustainable management of lagoon and mangrove resources through co-management programs. Awareness programmes should be conducted to all lagoons and mangrove resource utilizes on the regulatory mechanisms and co-management practices in order to ensure sustainable utilisation of mangrove and associated resources.

Estimated cost of implementation for the project period is US$ 0.175 million.

Measures to address Technical barriers:

e) Barrier: *Replanting mangroves without establishing proper zonal plans and using unsuitable species*
Measures: *(i) Establish regulatory mechanisms for mangrove replanting programmes*
(ii) Develop zonal plans to identify the mangrove areas required rehabilitation using GIS & remote sensing techniques
(iii) Identify most suitable species for replanting

In order to address the issue related to haphazard mangrove replanting programmes carried out without any scientific approach, a regulatory mechanism should be developed in collaboration with CCD, Dept. of wildlife, Forest Dept, and CEA. Mangrove replanting without proper zonal plans and use of unsuitable mangrove plant species etc. are some of such unacceptable approaches. Through the collaboration of above departments, a zonal plan should be developed to identify potential mangrove areas requiring immediate attention. In addition, an intensive study on existing biodiversity should be carried out to identify most suitable species to be used for rehabilitation programs in mangrove areas located in different parts of the country.

Estimated cost of implementation over a period of 02 years is US$ 0.06 million.

Measures to improve institutional and organizational capacity:

f) Barrier: *General lack of appreciation/awareness on the non extractive uses/importance, role and functions of mangroves, at all levels of the society*
Measures: *(i)* Conduct *awareness programmes to both local community and other stakeholders*
(ii) Conduct *awareness programmes through electronic and print media using suitable resource persons/experts from relevant institutions*
(iii) Encourage projects that help rehabilitation of mangroves at research institutes, universities and schools.

Creating awareness will be a useful approach to overcome this barrier. Awareness programs need to be undertaken targeting all levels of the society including local communities and other stakeholders

depending on the resources of selected mangrove areas. Awareness and knowledge dissemination should be done through print & electronic media, using suitable persons with a wide experience and knowledge on mangrove eco-systems to ensure effective awareness creation. Furthermore, R& D projects related to rehabilitation of mangroves should be encouraged at schools, universities, research institutes etc. To successfully implement these activities, suitable resource persons need to be selected from among personnel of different institutions and organisations having the necessary expertise and educational backgrounds. In the event of lack of suitable individuals with required expertise, selected persons should be provided with necessary training to serve as resource persons.

Estimated cost of implementation over a period of 03 years is US$ 0.134 million.

Other measures:

g) Barrier: *Illegal & unsustainable land use practices in the hinterland, which cause high sedimentation rates in lagoons and estuaries*
Measures: *(i) River basin management*
(ii) Conduct IEE/EIAs for all development programmes in the hinterland
(iii) Control land use patterns to reduce erosion

Illegal and unsustainable land use practices in the hinterland contribute to cause high sedimentation in lagoons and estuaries. A holistic approach on the basis of river basin management should be adopted to address this issue. Conduct of proper IEE/EIAs for all development programs in the hinterland would also be a supplementary tool in this regard and those which are likely to cause soil degradation and sedimentation should not be permitted. National Physical Planning Department needs to be called upon to control the land use pattern in the hinterland to reduce erosion and sediment loading into the river basins.

Estimated cost of implementation over a period of 05 years is US$ 0.22 million.

4.4 Barrier analysis and possible enabling measures for Technology 3: Restoration of coral reefs

Barriers identified through a stakeholder consultation which involved agencies under several line Ministries, higher educational and research institutes and NGOs are discussed under section 1.4.2

4.4.1 General 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 for climate change induced sea level rise, this natural reef building mechanism needs to be artificially enhanced by providing hard substrata attached with relevant samples of temperature tolerant live corals to produce artificial coral reefs. Transplanting of corals on concrete blocks and tiles has been successfully experimented in the country. Ref. Annex D-4: Technology Fact Sheet on ‘Restoration of coral reefs’ - Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I).

4.4.2 Identification of barriers for the technology

Following ten barriers have been identified based on stakeholder consultations, through Expert inputs and literature reviews.

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

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

4.4.2.1 Economic and financial barriers

Inadequate financial assistance for monitoring & restoration of coral reefs is the only Economic and Financial barrier identified.

a) Inadequate financial assistance for monitoring & restoration programs

In view of the significance of coral reefs as a soft barrier for coastal protection against, wave action, storm surge and tsunami, and also due to its importance as a tourist attraction, the government has given high priority for protection and restoration of corals. However, since the responsibility of coral reef protection is shared by several government institutions such as Coast Conservation Department (CCD), Dept. of Wild Life Conservation and Marine Environmental Protection Authority (MEPA), which comes under the purview of different line Ministries, financing of this activity has become a tricky issue. Further, the Ministry of Tourism also has a legitimate interest on the protection of coral reefs as a unique tourist attraction. Therefore, Ministry of Tourism and tourist hotel owners have also shown an interest in helping reef restoration programs by indirectly funding certain activities related to reef restoration. Ministries involved in coral reef management related activities are Ministry of Environment & Natural Resources, Ministry of Defence & Urban Development, Ministry of Tourism, Ministry of Agriculture Development & Agrarian Services, Ministry of Local Government & Provincial Councils, Ministry of Technology & Research and Ministry of Higher Education. As such activities are often directed towards conservation and establishment of protected areas, funds allocated for regular monitoring of reef ecosystems is inadequate.

Funds provided to different Government agencies through the respective line Ministries need to be streamlined, so as to ensure sustainability of reef management related activities.

4.4.2.2. Non-financial barriers

Nine (09) non financial barriers likely to impact upon the success of implementation of this technology have been identified.

Policy, legal & regulatory barriers:

Two barriers have been identified under the Policy, legal & regulatory category.

a). Inadequate government patronage and financial assistance at central & Provincial level for coral reef conservation and rehabilitation programs

Inadequate government patronage and financial assistance at both central and provincial level has been identified as a major barrier for restoration of coral reefs. As mentioned under section 4.4.2.1, although

many government agencies have a legitimate interest in the management of coral reefs, often financing of activities such as coral transplanting and monitoring of reef ecosystems which are considered as requiring special attention is inadequate. Coral transplanting has to be carried out in all areas where coral reef have been destroyed due to extraction of corals for lime industry and areas affected by *El ninno* and marine pollution. Monitoring of reef ecosystems should be carried out regularly to identify the changes in coral colonies that are highly sensitive for environmental changes and those which are resistant to such changes. As at present the government patronage appears to be mostly on routine activities but serious attention should be given to investigations and monitoring programs and for transplanting which are critical activities for restoration of degraded reefs.

b) Poor enforcement of coastal regulations and lack or poor IEEs and EIAs when tourism related large infrastructure facilities are built in the vicinity of coral reefs

Poor enforcement of coastal regulations and lack or poor EIAs when establishing tourist hotel clusters in the vicinity of coral reefs has been a recurring issue requiring immediate attention as tourism being a rapidly growing industry under the “Mahinda Chinthana” policy frame work in which ttourism has been identified as capable of effectively driving the country’s socio-economic development.

The Government hopes to develop Sri Lanka as a regional hub in the tourism industry by developing the coastal areas such as Arugambay, Hambanthota and Kalpitiya in addition to the Dedduwa, Galle, Panama and Negombo. The resorts will host varied activities and offer concessions for both the international and local tourists. Most of the above tourism development areas are located close to coral reefs. The resorts development and improvement of accommodation facilities and other infrastructure is targeting a room capacity of 30,000 by the year 2015. Government support will be received to improve the existing hotel room quality and construct many small and large scale private sector led recreational and hotel room construction projects.

Therefore, these targeted improvements in the tourism industry needs to seriously address the potential impacts of such developments on the fragile coastal ecosystems. If proper EIAs are carried out as a prerequisite for establishing large tourist hotels, potential environmental impacts on the reef ecosystems due to coral reef related recreational activities, disposal of untreated or under treated sewage from hotels in to near shore areas, etc. could be identified and proper remedial measures could be instituted accordingly.

Social cultural & behavioral barriers:

Three barriers were identified under the Social, cultural & behavioral barrier category as follows;

c) Unsustainable resource utilisation (e.g. corals for lime industry, collection of ornamental fish, use of explosives for fishing)

Coral mining for lime industry, collection of ornamental fish, use of explosives for fishing etc. are some ongoing unsustainable resource utilisation practices and are as one of the most important barriers under this category and it also has been ranked as the most significant one among all of the barriers identified for this technology.

Mining of coral for lime industry from the existing reefs has been practiced over a long period of time and its impacts were clearly evident during the 2004 tsunami catastrophe. Loss of many human lives and damages to infrastructure in southern coastal areas such as Hikkaduwa and Ambalangoda could be attributed to extensive removal of corals for lime industry. Although coral mining for lime industry is under control at present, destructive fishing activities such as blast fishing, use of moxy nets, breaking the reef to catch ornamental fish and anchorage of fishing & glass bottom boats used for viewing corals still continues unabated. Unless these destructive activities are regulated, restoration of coral reefs will be challenging as the rate of coral destruction much greater than natural growth which is estimated to be less than 1 cm per year with respect to most coral forming organisms.

d) Sedimentation and pollution due to unplanned socioeconomic activities in the coastal belt and hinterland.

All pollutants generated due to the land based human activities and subsequently released to aquatic and terrestrial environments ends up in the coastal ecosystems due to surface run off during heavy rains and also through the river system. Therefore, sedimentation due to deforestation, mining, agriculture, etc. and pollutants from industrial and domestic sources would contribute to eutrophication, coral bleaching and pathogenic conditions in coral forming and associated organisms. Eutrophication, which is resulting algal blooms that reduce light penetration in coastal marine waters, will hinder the growth of corals. Construction of tourist hotels with large number of rooms may result in release of excessive volumes of sewage in to the reef sites, enhancing the coral reef degradation.

e) Destructive activities against conservation/rehabilitation programmes, transplanting, etc

Although the government has declared certain reef cites as protected areas and certain institutions, agencies and individuals are involved in reef restoration efforts by transplanting corals, the visitors to reef sites engaged in destructive acts which cause negative impacts on natural and transplanted corals. There have been instances where the visitors have disturbed the corals transplanted on cement blocks and removed the sediment traps fixed to monitor the sedimentation rate in reef sites. Such activities will discourage the persons voluntarily involved in reef restoration programs.

Network failure barriers:

f) Inadequate coordination among different Ministries

As mentioned in Section 4.4.2.1, coral reef conservation and protection has become the mandate of different institutions, i.e, CCD, MEPA, NARA, Universities which are under different line Ministries with their own visions and missions, some of which are drastically overlapping. They appear to have common targets and goals, which each agency endeavour to achieve independently. This invariably leads to competition and conflicts among institutions ultimately leading to slow progress of activities and under performance by the respective agencies. Duplication of activities results in wastage of scarce financial resources, time and efforts of those involved in reefs restoration programmes. Therefore, a well coordinated effort by all relevant agencies is required to ensure effectiveness of reef ecosystem rehabilitation programs.

Information and awareness barriers:

g) Inadequate awareness among stakeholders

Inadequate awareness among stakeholders has been identified as the only barrier under this category. As mentioned in previous sections there are numerous stakeholders majority of whom are those, dependent on reef ecosystems for their livelihoods such as coral miners, reef fish collectors, glass bottomed boat owners, tour guides, etc. and a few who are involved in reef restoration activities and others who directly or indirectly make some form of impacts on reef ecosystems (tourist hoteliers, coastal industry owners, SMEs holiday makers, etc.). Awareness among these stake holders on the ecological importance of coral reef ecosystems and their importance as a barrier against coastal erosion are at different levels. Therefore prior to commencement of reef restoration programs there should be a clear understanding on the levels of awareness among different stakeholder groups, in order to organize awareness programs for different stakeholder groups. Most of the persons who are involved in destructive activities may not be fully aware of the negative impacts resulting from their activities on the sustainability of reefs.

Technical barriers:

h) Inadequate trained personnel to involve in coral rehabilitation programs

Inadequate trained personnel to be engaged in coral rehabilitation programs is an important barrier identified under this category. Transplanting and establishment of artificial reefs is a technology which needs, proper scientific knowledge, education, skills and interest on coral reefs and reef forming and reef associated organisms. Persons who are involved in transplanting of corals should be able to biologically identify different coral species and their ecosystem affiliations, tolerance to different environmental

factors, etc., in addition to possession of diving skills. Although most coastal dwellers are good swimmers and divers, they do not possess scientific knowledge on reef forming organisms. Certain researchers and academics may have a good scientific background on coral biology, but they may not possess diving skills. Therefore, prior to commencement of the reef restoration programmes persons with necessary knowledge and skills should be identified and if there aren't sufficient numbers of persons, required knowledge should be imparted through intensive in situ training programs.

Other barriers

i) Natural phenomena that bleach corals

Natural phenomenon such as *El Ninno* which are warm water currents enter the Indian Ocean once in 5 years or so can cause bleaching of vast areas of corals. Although the impacts of such natural phenomena could not be controlled through human intervention, by using temperature and salinity sensors, such environmental changes could be monitored together with their effects on coral forming organisms. Careful monitoring of coral reefs at regular intervals will enable identifying temperature and salinity resistant coral varieties to be used in coral transplanting programs.

4.4.3 Identified measures

Measures to overcome the barriers were identified through a stakeholder consultation which included representatives from government agencies and NGOs dealing with activities in the coastal areas.

4.4.3.1 Economic and financial measures

a) Barrier*: Inadequate financial assistance for monitoring & restoration programmes*
Measures: *(i) Attract funding from local and foreign funding* sources, NGOs etc. through *properly formulated proposals with suitable justifications*
(ii) Introduce eco-friendly activities with financial gains.

Explore project specific financing opportunities from local and foreign funding sources including NGOs through properly formulated proposals with suitable justifications. These project proposals should include multidisciplinary programmes such as coral transplanting, monitoring, introduction of sustainable socioeconomic activities etc and designed to implement through collaborative and cooperative arrangements involving all relevant stakeholders and institutions. Introduction of eco-friendly activities with financial gains is an important element to ensure sustainability of the transplanting programmes. Uninterrupted financial inputs are essential for continuation of transplanting programmes. Therefore, self sustaining community participatory organisations which are capable of initiating sustainable economic activities need to be encouraged through project activities.

Estimated cost of implementation during the first year of the Project is US$ 0.116 million.

4.4.3.2 Non-financial measures

Policy, legal & regulatory measures:

a) Barrier: *Inadequate government patronage & financial assistance at central &/or provincial level for coral reef conservation and rehabilitation programmes*
Measures: *(i) Conduct awareness programs to policy makers, highlighting potential socioeconomic gains through reef restoration*

(ii) Conduct awareness programs to government officials who take decisions on allocating funds

To overcome this barrier caused by inadequate government patronage and financial assistance at central and provincial level, awareness programmes should be conducted to policy makers, highlighting the possible socioeconomic gains through reef restoration and *vis a vis* attaining the goals of Mahinda Chinthanaya. Conduct awareness programmes to government officials involved with allocating government funds to relevant agencies. Such awareness creation would facilitate accessing adequate funds for coral reef management and rehabilitation programmes. Activities such as eco-tourism and study centres to attract foreign researchers which are capable of generating funds for ploughing back to coral reef conservation, management and restoration programmes should be encouraged.

Estimated cost of implementation including measures (c), (e) and (f) over a project period of 3 years is US$ 0.09 million.

b) Barrier: *Poor enforcement of coastal regulations and lack or poor IEE & EIAs when establishing tourist resort complexes in the vicinity of coral reefs*
Measures: *(i) Establish community participatory organizations in the vicinity of coral reefs to ensure sustainability of coral reefs and to monitor the development programs.*
(ii) Appoint properly constituted credible committees to review the IEE & EIA reports related to development and economic activities in the coastal belt.

Establish community participatory organizations in the vicinity of coral reefs to ensure sustainability of coral reefs and to monitor the development programs and to overcome the barriers resulting from poor enforcement of coastal regulations and lack or poor EIAs when establishing tourist resorts in the vicinity of coral reefs. These organizations should be mandated to work in close association with institutions having relevant expertise and to seek training to ensure sustainability of the programs. Appoint properly constituted credible committees to review the IEE and EIA reports related to development and economic activities introduced in to the coastal belt prior to their commencement. Formulation of clear regulations,

enforcement and appropriate punitive actions for violating regulations is imperative for sustainability of the coastal resources.

Estimated cost of implementation during the first year of the Project is US$ 1.65 million.

Social, cultural & behavioral measures:

c) Barrier: *Unsustainable resource utilisation (e.g. coral mining for lime industry, collection of ornamental fish, use of explosives for fishing)*
Measure(s): *(i) Conduct awareness programmes on the impacts of unsustainable socio economic activities related to reefs*
(ii) Offer alternative livelihoods or training for such livelihoods for those who are involved in coral destructive self employment.

To overcome the impacts of mining corals for lime industry, it is recommended to implement soft solutions (close to nature) to prevent further degradation in areas which are not severely affected by erosion and to minimize coastal constructions in the vicinity of coral reefs. Awareness creation is essential to overcome the impacts of other unsustainable resource utilisation practices such as, coral mining for lime industry, collection of ornamental fish, use of explosives for fishing etc., Therefore, awareness programmes should be conducted to those who are involved in such activities. Furthermore, alternative livelihoods or training for activities such as, sea weed farming, ornamental fish rearing, tour-guide training, etc., should be offered to those who are involved in coral destructive self employment. Develop captive breeding techniques for marine ornamental fish through research and disseminate relevant fish breeding techniques to ornamental fish collectors. Spot fines and severe punishments should be imposed to those who are involved in reef destructive activities, such as blast fishing.

Estimated cost of implementation during the 3 years of the project is US$ 0.09 million.

d) Barrier: *Sedimentation and pollution due to unplanned socioeconomic activities in the coastal belt and hinterland*
Measures: *(i) River basin management to prevent sedimentation through agricultural or mining activities River basin management*
(ii) Conduct proper IEE and EIAs (wherever it is essential) for all development programmes in the hinterland, which may cause soil degradation and sedimentation in coastal areas
(iii) Control of land use pattern to reduce erosion through involvement of National Physical Planning Department.
(vi) Carry out reef cleaning programs through stakeholder participation
(vii) Enforcement of laws for all coastal development activities
Adoptions of proper river basin management practices enable reducing sedimentation and pollution related problems resulting from unplanned socioeconomic activities in the coastal belt and hinterland.

Furthermore proper IEE/EIAs need to be carried out for all development programmes in the hinterland to prevent soil degradation and sedimentation in coastal areas. National Physical Planning Department is called upon to take measures to control existing land use patterns in order to reduce erosion. Reef cleaning programs involving stakeholders, strict law enforcement for all coastal development activities & industrial waste release and introduction of alternative low cost technologies for managing wastes generated by large, medium & small scale industries are other activities to be implemented to reduce damage to coral reefs. Guidelines should be developed for all macro development projects and for resource management. Awareness creation programs to be implemented through print and electronic media.

Estimated cost of implementation during the Project period is US$ 0.29 million.

e) Barrier: *Destructive activities against conservation/rehabilitation programs, transplanting, etc.*
Measures: *(i) Awareness programmes should be carried out to highlight the importance of coral transplant programs.*
(ii) Employ/involve the communities engaged in destructive activities when conducting eco-friendly activities.

Conduct awareness programs to those who are disturbing coral transplant programs to highlight the importance of coral restoration programs. Engage or seek assistance of the communities involved in destructive activities when conducting coral transplant programs. Implementation of these conservation/restoration programs should be done through local societies/institutions having active and committed community leadership.

Estimated cost of implementation during the 3 years of the project is US$ 0.09 million.

Measures to prevent Network failures:

f) Barrier: *Inadequate coordination among different ministries*
Measures: *(i) Conduct awareness programs to key officials of relevant line Ministries in order to ensure inter agency coordination when implementing coral restoration programs.*
(ii) Train selected personnel from relevant line agencies on coral transplanting and reef cleaning and involve in reef restoration programs.

To improve the effective inter agency coordination and cooperation, awareness programs should be conducted to key officials from such agencies highlighting its need for a successful restoration program. Selected personnel from different line ministries should be trained on coral transplanting procedures and other eco-friendly activities such as reef cleaning and involve in reef restoration programs and also endeavor to use them as trainers for future programs.

Estimated cost of implementation during the 3 years of the project is US$ 0.09 million

Measures to improve information and awareness:

g) Barrier: *Inadequate awareness among stakeholders.*
Measures: *(i) Conduct awareness programs to different stakeholders separately and collectively highlighting the non extractive uses/importance, role and functions of corals*
(ii) Formulate development plans in consultation and through cooperation with important stakeholders
(iii) Conduct awareness programs on the importance of controlling pollution and sedimentation that may occur due to land-based and costal activities

To improve awareness among stakeholder groups, awareness programs should be organized to highlight the importance of controlling pollution and sedimentation caused by land-based & costal activities and also the non extractive uses/importance, role & functions of corals. Development plans for coastal belt should be formulate in consultation and cooperation with important stakeholders.

Estimated cost of implementation over a 5 year period is US$ 0.009 million.

Measures to address technical barriers:

h) Barrier: *Inadequate trained personnel to engage in coral rehabilitation programs*
Measures: *(i) Provide adequate training to members selected from the stakeholder groups and engage them to lead implementation of the respective programs and as trainers for the rest of the community.*

Provide adequate training to suitable members selected from among the stakeholder groups and use them as leaders for implementation of the respective programs and as trainers for the rest of the community.

Estimated cost of implementation during the Project period is US$ 0.2 million.

Other measures:

i) Barrier: *Coral bleaching*
Measures: *(i) Conduct seasonal monitoring programs with the cooperation of stakeholders trained to be alert about the natural phenomena.*

Conduct seasonal regular monitoring programs with the cooperation of trained stakeholders to equip them to be alert on natural phenomena, such as *El Ninno* and to make observations on resistant coral species. Identify the sensitive and temperature tolerant coral species to be used in transplanting

programs. Demarcate areas affected by natural phenomena and/or anthropogenic activities as sensitive areas and take necessary actions to protect them to facilitate natural recovery. Replant corals which can withstand high temperatures in affected areas without harming the natural diversity and density. Organise programs to get the respective stakeholders to initiate restoration and transplanting activities immediately upon onset of normal environmental conditions.

Estimated cost of implementation during the Project period is US$ 0.09 million.

4.5 Linkages of the barriers identified

Although the barriers involved are in relation to different sensitive ecosystems found in the coastal zone, there are few barriers common to all the technologies identified as suitable climate change adaptation options for the coastal sector.

4.5.1 Inadequate financial assistance

Inadequacy of funds is a common barrier for all the three technologies viz; *1) Rehabilitation of sand dunes, 2) Rehabilitation of Mangroves and 3) Restoration of Coral Reefs.* However, the financial requirements are for slightly different activities under each technology. In the case of Technologies 1 & 2 rehabilitation of the two ecosystems are involved with replanting of natural vegetation whereas, transplanting of corals is the major restoration activity in the case of coral reefs. In addition, all three activities are involved with conducting awareness programs for stakeholders and policy/decision makers. All these activities require adequate financing.

4.5.2 Inadequate government patronage

This barrier which falls under the policy, legal & regulatory barrier category is common to rehabilitation of mangroves & restoration of coral reefs. Under technology 1, Low priority given for funding environmental protection and R&D under the existing financial policy which has been identified as a barrier for rehabilitation of sand dunes also can be considered as lack of government patronage.

4.5.3 Poor enforcement or lack of resource management plans

Poor enforcement of resource management plans is a common barrier for technologies 1 and 3 and lack of proper management plan or strategy is a barrier for technology 2. Therefore these are quite related and cause a similar impact on the success of technologies identified.

4.5.4 Inadequate inter agency coordination

Inadequate inter agency coordination among different agencies has been identified as a common barrier for Technologies 1 & 3 resulting duplication of activities under several institutions and waste of scarce financial resources.

4.5.5 Unsustainable practices /resource utilisation

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

4.5.6 Inadequate awareness

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

4.5.7 Inadequate knowledge on the technologies

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

4.6 Enabling framework for overcoming the barriers in the Coastal Sector

Table 4.2: Common barriers and their enabling framework in the Coastal Sector

No.	Broad/ Common barriers	Enabling framework	Technology
1	Inadequate financial assistance	(i) Request for annual funding from the government of Sri Lanka, using suitably justified proposals forwarded through relevant line ministries & departments and by forwarding such proposals to NGOs & INGOs who are actively involved in adaptation procedures for climate change and on conservation of ecosystems & biodiversity,. (ii) Encourage self sustaining economic activities using mangrove products (iii) Introduce eco-friendly activities with financial gains.	1,2,3
2	Inadequate government patronage	(i) Request should be made through the line ministries to increase the annual budgetary allocations for environmental protection projects highlighting the socioeconomic gains due to restoration of sand dunes and their vegetation and also about the economic losses if the Dunes are not rehabilitated (ii) Encourage the government to increase the budgetary allocations for sustainable socioeconomic programmes (iii) Conduct awareness programmes on importance of sustainable management of mangroves, to government officials who take decisions on allocating funds for line ministries (iii) Conduct awareness programs to policy makers, highlighting the possible socioeconomic gains through reef restoration (iv) Conduct awareness programmes to government officials who take decisions on allocating funds.	1,2,3
3	Poor enforcement or lack of resource management	(i) Conduct awareness programmes to law enforcement officers, on the importance of proper enforcement of coastal zone management regulations (ii) Conduct awareness programmes to all stakeholders, on the	1,2,3

	plans	existing rules and regulations and on the necessity of abiding by the existing laws for sustainability of the sand dune ecosystems & their resources. (iv) Provide assistance to line ministries or institutions under them to prepare suitable management plans for rehabilitation of mangroves (iv) Organise meetings/workshops with the high ranking officers of the line ministries and institutions to highlight the importance of rehabilitation of mangroves for socioeconomic benefits (v) Establish community participatory organizations in the vicinity of coral reefs to ensure sustainability of coral reefs and to monitor the development programs (vi) Appoint properly constituted impartial committees to review the EIA reports related to development and economic activities in the coastal belt wherever it is essential.	
4	Inadequate coordination & among different Institutions	(i) Development of multidisciplinary projects in collaboration with research/academic institutions. (ii) Identify strategies to develop and improve fruitful collaborations, to • Identify, problems within the locations with sand dune • Prepare activity plans to overcome the problems to reach development goals (iii) Conduct awareness programs to key officials from different line ministries indicating the need for coordination among ministries to implement coral restoration programs (iv) Train a selected persons from different line ministries and train them for coral transplanting and reef cleaning and get them involved in reef restoration programs	1,3
5	Unsustainable practices /resource utilisation	(i) Form a committed group of actors selected from the coastal communities (ii) Provide alternative sources of income or employment, within the same region, to those who are involved in destructive activities (iii) Government departments and their line ministries should	1,2,3

		develop suitable strategies to have a better understanding on NGOs, involved in community participatory programmes related to sand dune conservation and restoration programmes (iv) Conduct awareness programmes to those who involve in unsustainable practices within mangrove areas (v) Enforcement of strict regulations and punishments to those who violate them (vi) Conduct awareness programmes on the impacts of unsustainable socio economic activities related to reefs (vii) Offer alternative livelihoods or training for such livelihoods for those who are involved in coral destructive self employment.	
6	Inadequate awareness	(i) Conduct awareness programmes to all stakeholders of the coastal regions on the importance of restoring sand dune ecosystems for the wellbeing of coastal communities, obtaining the assistance of all parties affected to restore sand dunes and planting sand dune vegetation. (ii) Involvement of unemployed coastal youth in eco-tourism, involvement of coastal tourist hoteliers for sand dune restoration & encourage them to involve in eco-tourism. (iii) Under the tourism industry in the area establishment of nature trails among dune vegetations and turtle nesting sites, (iv) Establish herbal gardens, by planting dune vegetation having medicinal importance (v) Encourage floating hotels in the vicinity of coastal sand dunes (vi) Conduct awareness programs to different stakeholders separately and collectively highlighting the non extractive uses/importance, role and functions of corals (vii) Formulate development plans in consultation and through cooperation with important stakeholders (viii) Conduct awareness programs on the importance of controlling of pollution and sedimentation that may occur due to land-based and costal activities	1,3

7	Inadequate knowledge on the technologies	(i) Encourage plantations of dune vegetations of economic and medicinal importance. (ii) Conduct awareness/training programmes to disseminate knowledge on • Plants suitable to be grown on sand dunes • Tissue culture & propagation methods to produce sufficient numbers of plants/ propagules for plantation (iii) Encourage the government to introduce economically important exotic dune plants (*Pandanus sp.*) after a carefully planned feasibility study (iv) Sustainable utilisation of dune vegetation for SMEs (v) Establish regulatory mechanisms for mangrove replanting programmes. (vi) Develop zonal plans to identify the mangrove areas required rehabilitation using GIS & remote sensing techniques (vii) Identify most suitable species for replanting. (viii) Provide adequate training to suitable members selected from the stakeholder groups and use them as leaders for implementation of the respective programmes and as trainers for the rest of the community	1,2,3

Chapter 5

Biodiversity Sector

Sri Lanka is one of the most biologically diverse countries in Asia. Despite its small size of 6,570,134 hectares Sri Lanka has a varied climate and topography, which has resulted in rich biodiversity, distributed within a wide range of ecosystems. 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[39]. 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 islands forests and scrublands lie within the country's Protected Area (PA) system[40].

Despite numerous efforts for conservation, Sri Lanka's biodiversity remain threatened. According to the latest IUCN Red List in 2007 for Sri Lanka[41], 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.

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.

The analysis of technology options for climate change adaptation in the biodiversity sector in Sri Lanka was carried out through an extensive consultative process The Multi-Criteria Decision Analysis (MCDA) approach was carried out to prioritize the technologies identified. In view of the significant importance of including species level interventions as well, five (05) prioritized technologies were chosen. (Ref. Technology Need Assessment and Technology Action Plans for Climate Change Adaptation: Part 1- Technology Need Assessment Report).

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[39] 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

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

[41] 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

Table 5.1: Prioritized Technologies and Categories in the Biodiversity Sector

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

5.1 Preliminary targets for technology transfer and diffusion

Currently there are no targets for technology transfer and diffusion specifically identified for biodiversity adaptation to climate change. However the Sector Vulnerability Profile for Biodiversity and Ecosystem Services[42], an addendum to Sri Lanka's Climate Change Strategy has looked at priorities for biodiversity and ecosystem services. Targets for the prioritized technologies are provided in table 5.2.

Table 5.2: Preliminary Targets for the Prioritized Technologies in the Biodiversity Sector

Technology	Targets
Technology 1 - Restoration of degraded areas inside and outside the protected area network to enhance resilience.	• Restoration of at least 10,000 hectares of terrestrial and marine ecosystems, over 5 years. • At least one incentive scheme for restoration introduced. • At least 2% of Forest and Wildlife Department budgets allocation for restoration. • Restoration prioritization study completed.

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

	• Best practices for specific ecosystems published. • At least 10 pilot sites completed. • One campaign for political awareness completed. • Evidence of implementing policies/legislation documented.
Technology 2 - Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement).	• At least one incentive scheme for introduced for private landowners to set aside or maintain areas necessary for connectivity. • Provision integrated to current policies to ensure that medium to large development projects include areas that allow connectivity. • Connectivity prioritization study completed. • One campaign for political awareness completed. • Climate change modeling of at least two regions completed. • Evidence of implementing policies/legislation documented. • At least 4 critical areas included into protected area network.
Technology 3 - Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones.	• Allocation of at least 2% 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. • Create at least 20 management plans for prioritized areas (and implement them). • An incentive scheme introduced for using brownfield/degraded areas. • A system of creating accountability of staff introduced. • Physical demarcation/re-demarcation of boundaries according to legal/gazette boundaries in at least 10 key protected areas.
Technology 4 - Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems.	• Develop and implement at least 15 species action plans based on priority. • Allocation at least 2% of annual budgets to implement above action plans based on priority. • At least one comprehensive climate modeling study on how climate change will impact 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 program targeting at least 25% of staff in Forest and Wildlife Departments. • Implement at least five research studies on critical species.
Technology 5 - Ex-situ conservation for highly threatened species and possible reintroduction	• Create at least two conservation facilities based on requirements and prioritization. • Allocation at least 2% of annual budgets 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 formalized system to allow ex-situ breeding by other parties, with supervision by government stakeholders.

5.2 Barrier analysis and possible enabling measures for Technology 1: Restoration of degraded areas inside and outside the protected area network to enhance resilience

5.2.1 General description of the technology

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[43]. Some protected areas, although legally declared, have been subjected to degradation due to illegal activities such as illegal clearing for settlement and cultivations, logging and fire damage. In the meantime there will be other areas existing outside protected areas that may not be legally protected, but yet be important for conservation now, or

[43]Walker BH, Holling CS, Carpenter SR, Kinzig AS. 2004. Resilience, adaptability and trans-formability. *Ecology and Society* 9(2): 5

in the event of species shift their range as a result of climate change. Restoration will require selecting suitable native species and recreating the former conditions of the ecosystem. Some ecosystems that can be restored include forests, wetlands, coastal areas, coral reefs etc. Restoration is not a new technology in Sri Lanka, forests[44], aquatic ecosystems[45], reefs and coastal areas in number of locations have been restored during the last 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[46,47]. Additionally, several Policies, Action Plans and Strategies in Sri Lanka have identified this option as an essential technology for biodiversity conservation[48].

Following are some mechanisms revealed at the stakeholder consultations (not in order of priority):

a) Mapping and modeling to identify ecosystems and species (aquatic and terrestrial) that are highly vulnerable to climate change.

b) Device appropriate technologies for natural/aided restoration within protected areas in highly vulnerable areas as identified in the mapping and modeling.

c) Facilitate regeneration in areas outside protected areas as identified in mapping and modeling.

d) Monitoring restoration inside and outside the protected area network.

e) Aided natural restoration within protected areas.

f) Identify suitable scientific methods of restoration.

g) Creation of analogous ecosystems outside protected areas.

Ref. Annex D-5: Technology Fact Sheet on 'Restoration of degraded areas inside and outside the protected area network', Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

[44]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

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

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

[47] 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.

[48] National Forest Policy of Sri Lanka (1995), National Policy on Wildlife Conservation (2000), Biodiversity Conservation in Sri Lanka, A Framework for Action (1999), National Action Plan for *Haritha* (Green) Lanka Programme (2009)

5.2.2 Identification of barriers for the technology

A total number of nine (09) barriers including three (03) information & awareness, two (02) economic & financial, two (02) network failures, two (02) policy, legal & regulatory, one (01) human skills and one (01) social, cultural & behavioral barriers were identified for Restoration of degraded areas inside and outside the protected area network to enhance resilience.

5.2.2.1 Economic and financial barriers

Following are the economic & financial barriers identified for this technology;

a) Low funding allocation for restoration (nationally):

Currently the main departments dealing with environment and biodiversity management in the country, namely the Department of Wildlife Conservation and Forest Department, do not have adequate financial provisions in their nationally allocated budgets for restoration of habitats. This was seen as a major barrier, as restoration cannot occur without the availability of funds. Yet, there are instances where several forest and coral restoration programs have been carried out successfully at a small scale. Therefore this technology is available in the country to a limited extent. In view of restoration is not considered a priority activity resulting inadequacy of finances available in the annual budgets for related activities is a major hindrance, despite the fact that restoration is one of the top priorities for biodiversity adaptation to climate change.

b) No immediate returns from restoration and lack of incentives for restoration (for communities/private sector)

Although this is identified as an economic & financial barrier, it also has policy, legal & regulatory and market failure elements as well. Restoration has both mitigation and adaptation benefits, in addition to numerous benefits from ecosystem services. Despite this, the amount of restoration taking place in various ecosystems in Sri Lanka is minimal. One of the major underline reasons could be that the conservation per say and parties involved in restoration do not yield immediate returns for their investment. Additionally, there are no incentives for both communities and the private sector to engage in restoration activities. Thus these two barriers are inter related and are considered a major hindrance for restoration and also is identified as the top priority for biodiversity adaptation to climate change.

5.2.2.2 Non-financial barriers

Majority of the barriers identified for the technology relating to restoration are of non financial nature. These barriers fall under the categories of Information & awareness, Policy legal & regulatory, Social cultural & behavioral, Network failures, Human skills, Technical and Others.

Information & awareness, human skills and other barriers

a). Poor understanding of the true value of ecosystem services and no information on local value for key ecosystems and their services

This is primarily information & awareness related barrier. Currently the concept of ecosystem services valuation, its significance to the economic & day-to-day functions of people and the country is poorly understood outside the environmental field. Further, there are no locally derived ecosystem service values for the major ecosystems of the country. This has led to 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. Often restoration is not encouraged as it's seen only as an expenditure and such sites requiring restoration are being used for other uses. Availability of information and awareness on the true value of ecosystems will allow decision makers to make the correct and informed decision. As the ecosystems in different areas and of various types have varying values, absence of locally derived values is a major hindrance for decision making.

b). Lack of prioritization of areas for restoration at a national scale

This barrier is also categorized as one relating to information & awareness. It is also considered to be falling under the 'Other' barrier category. Currently there is no system that has prioritized or identified specific areas and key ecosystems requiring restoration. Moreover, such information once generated should be publicly available. Such an approach is essential to restore the most vital ecosystems on a priority basis. Lack of such a system will obviously lead to haphazard restoration, which will not be helpful in maximizing the investment and its subsequent benefits/returns.

c). Conflict of interests (development versus restoration)

This barrier is information & awareness related and also falls under 'Other' barrier category as well. As lands that have the potential for restoration and providing good ecosystem services are in demand for development and other purposes, this can be considered as a very significant barrier with respect to ecosystem restoration. Often this is a result of ill informed decisions by policy-makers due to their lack of awareness on the benefits and returns of restoration. Hence there is the tendency of recognizing development and other uses as having much higher value than the restoration.

d). Insufficient capacity on ecosystem specific and technically sound restoration methods/technologies

This barrier falls into three categories namely, human skills, information & awareness and technical. It is considered as another major hindrance for restoration. As mentioned previously there have been successful pilot restoration programs carried out for ecosystems such as forests and corals, amongst others. This information is often not disseminated widely and there is no centralized source from where

any party interested in restoration can obtain technical information and best practice. Additionally ecosystem specific technologies and technologies suitable for certain geographic locations are not widely known. 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 restoration in Sri Lanka.

Network failures, human skills and technical barriers:

e). Inadequate working modalities to exchange and access restoration related best practices from other countries

This barrier can be considered as network failure, human skills and technical related. Currently there is no proper modality for exchange and learning through access of information on restoration related best practices from other countries. Other tropical countries have various innovative restoration practices that can be adapted to the Sri Lankan conditions and learning on these practices will be important for biodiversity adaptation in the country. The lack of this modality is currently seen as a significant barrier for restoration of ecosystems in Sri Lanka.

Policy, legal & regulatory barriers

f). Land tenure issues before and after restoration (ownership of a restored land)

Issues related to land tenure and clarity of ownership and rights are observed as another significant hindrance to restoration. In the event of a non-state actor is interested in carrying out restoration on state land requiring a significant investment, the investor could be discouraged due to the lack of clear information or a policy on the benefits/rights accruable to the investor from such a land.

Network failure and Social, cultural & behavioral barriers

g). Lack of partnerships for restoration and management of lands outside protected areas

Often state departments may not have adequate resources in terms finances and skills to carry out restoration. Therefore working with non-state parties may be beneficial and could result in successful restorations. However, currently there are no avenues or programs for such proactive partnerships and hence it is seen as a barrier for restoration. Such potential partnership opportunities for restoration would be available either in private or state lands and it could enhance connectivity which is yet another important measure for biodiversity adaptation.

5.2.3 Identified measures

5.2.3.1 Economic and financial measures

a). Barrier: *Low funding allocation for restoration (nationally).*
Measure: *Portion of annual budgets of Forest and Wildlife Departments allocated for restoration based on above action plan.*

Currently the annual budgets of the Forest and Wildlife Departments do not have an adequate budget for restoration activities. Introducing a mechanism by which certain specific amount or a percentage is allocated annually for restoration under a specific line item would ensure regular restoration activities. A prioritized list of sites and ecosystems for restoration would facilitate securing funds on annual basis for attending to restoration of critical areas. This will ensure that even a minimum area will be restored annually, and will prevent haphazard restoration activities that may not yield optimal benefits.
Implementation of this activity will not involve any additional costs. However, approximately 5% of the annual budget of the relevant Department should be provided for this purpose (Approx. US$ 750,000.00 annually).

b) Barrier: *No immediate returns from restoration and lack of incentives for restoration (for communities/private sector)*
Measure: *Provision of incentives by government/donors for restoration by communities and private sector; introduce a biodiversity-offset mechanism.*

In order to address the above barrier, it is recommended that government and donors consider providing incentives for restoration activities carried out by communities and the private sector. This could be treated as a biodiversity offset mechanism as well. Incentives could include cash payments; subsidies for planting materials, tax-breaks etc, and a package of incentives to suit different stakeholders might yield a more positive response.

Estimated cost of implementation over a period of 2-3 years is US$ 1.1 million.

5.2.3.2 Non-financial measures

Information & awareness, human skills and other measures

a) Barrier*: Poor understanding of the true value of ecosystem services and non availability of information on values for specific local key ecosystems and their services.*
Measure: *Ecosystem specific studies (for Sri Lanka) on values of ecosystems services and its dissemination.*

To address the above barrier related to poor understanding of ecosystem service values and lack of information, it is recommended the introduction of ecosystem specific studies as a key remedial measure. In addition, the results of the studies should be disseminated in a manner that it reaches a wide group of people and key stakeholders involved with decision and policy making. Additionally the studies should be localized in order to generate information on local values.

Estimated cost of implementation over a period of 3 years is US$ 0.46 million.

b) Barrier*: Lack of prioritization of areas for restoration at a national scale.*
Measure(s): *(i) Study on identifying and prioritizing critical areas for restoration; (ii) Climate change modeling to identify critical areas; (iii) Budget and action plan based on the study.*

The lack of prioritization of areas to be restored is a significant barrier which needs to be addressed as a matter of priority to prevent undertaking haphazard restoration programs. Therefore, comprehensive studies with the aim of identifying and prioritizing critical areas for restoration should be carried out immediately. Such studies should also include climate change modeling in order to identify the most critical areas requiring restoration for climate change adaptation. Further, such studies should be effectively carried out based on an action plan, and a budget to make it successful. These studies should be given priority in the research agenda of the relevant institution (ie, Forest Department and the Department of Wild Life Conservation).

Estimated cost of implementation over a period of 3 years is US$ 2.0 million.

c) Barrier*: Insufficient capacity on ecosystem specific and technically sound restoration methods/technologies.*
Measure (i): Dissemination of *best practices for ecosystem specific restoration methods in local languages*.

Currently there is insufficient capacity to carry out certain types of restoration activities based on proven methodologies. Therefore, best practices for various ecosystems such as for forest types, wetlands, and

marine etc should be documented and disseminated. This measure once again will minimize haphazard restoration activities and will yield more benefits at reduced costs.

Measure (ii): *Promote research on technologies (if ecosystem specific restoration methods are not available).*

If ecosystem specific restoration methods are not available or even if available are not suitable in the local context, research activities should be promoted in this regard. Universities are the best platform for this purpose. Universities should identify and prioritize research topics on technologies of restoration that can be undertaken by students, researchers and the academics. An incentive scheme or some funding support to students can be considered to encourage undertaking priority researches. Once research is carried out, the information must be made available to those who engage in restoration activities.

Measure (iii): *Demonstration plots/pilot studies.*

This is somewhat related to the above measure as well. Government departments and researchers can set up demonstration plots and carry out pilot studies. These studies should be part of the research agenda of the relevant department. Access to visit and information about the processes should be freely available, and the existence of such sites should be publicized and visits to these sites should be encouraged.

Estimated cost of implementation over a period of 8 years is US$ 2.21 million.

d) Barrier*: Conflicting of interests/pressure (development versus restoration)*
Measure: *Creation of political awareness and site specific environmental valuation for prioritized areas for restoration vs. development.*

Conflicting interests and pressure for lands for development and other uses is a barrier to restoration, as conservation activities often take a backseat in the development agenda. Often the decision and policy makers lack awareness on the importance of restoration and values of ecosystem services and the fact that it is vital for development. In fact development and environment are on the same side of the coin and should not be a choice between one or the other. Often information is disseminated to those who are already aware about the importance of conservation. Thus innovative communication programs are vital to create political awareness so that correct decisions are made. Site specific evaluation can play a critical role in decision making, as certain sites earmarked for purposes other than conservation may deemed vital for restoration in view of existing dependence on ecosystem services by the public at large.

Estimated cost of implementation over a period of 2 years is US$ 0.275 million.

Network failures, human skills and technical measures

e) Barrier: *Inadequate working modalities to exchange and learn about restoration best practices from other countries.*
Measure(s): *Facilitate exchange and sharing of knowledge. Conduct Joint programs.*

Inadequate working modalities to exchange and learn about restoration best practices are a considerable hindrance to restoration. Therefore, establishing modalities for facilitation of exchange and sharing of such knowledge is vital. Government Departments, Universities and even international NGOs can play an important role in this regard. Existing linkages with institutions abroad can be harnessed to facilitate exchange programs, study tours etc.. International donor agencies could also play an important role in such initiatives. However it is vital to ensure that the learning is diffused through subsequent training programs held locally for a larger group of people. Twining arrangements between Sri Lankan and foreign institutions would be useful for transfer of knowledge and technology. Such an approach would ensure the effectiveness and sustainability of information sharing arrangements.

Estimated cost of implementation over a period of 1 year is US$ 0.5 million.

Policy, legal & regulatory measures

f) Barrier*: Land tenure related issues (ownership of a restored land).*
Measure: *Implementation of existing policies and legislation relating to land tenure in such areas*

Land tenure status of restored state lands by a private party is ambiguous. Therefore a clear and unambiguous policy on the 'ownership', benefits and rights of such land should be set out to attract private sector entities interested in undertaking restoration initiatives. Many institutions are uncertain about the status of returns of the investment or its stability. If such a clear cut policy is nonexistent, it is of utmost importance to consider granting rights and benefits to those involved in restoration activities in State land. Such a mechanism could boost restoration activities considerably.

Estimated cost of implementation over a period of 1 year is US$ 0.875 million.

Network failure, Social, cultural and behavioral measures

g) Barrier*: Lack of partnerships for restoration and management of lands outside protected areas.*
Measure: *Build partnerships (between government institutions/private sectors).*

Absence of existing partnerships for restoration and management of lands outside protected areas can be addressed by building partnerships between government intuitions (amongst various departments) and also with private sector parties. Such a mechanism may ease the burden of financial and human

resource constraints and inadequacy of skills as well. However it is important to make such partnerships stable and a procedure must be set in place to ensure success of partnership arrangements.

Estimated cost of implementation over the project period is US$ 0.035 million.

5.3 Barrier analysis and possible enabling measures for Technology 2: Increasing connectivity through corridors, landscape/matrix improvement and management including altitudinal and other movements

5.3.1 General description of the technology

Increasing connectivity in the broader landscape is vital for conserving biodiversity during climate change[49]. 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[50,51].

This strategy involves the protection of areas and regions that would be essential for climate-induced wildlife movements[52]. Technologies that can be used include movement corridors for terrestrial species, while unblocked streams and rivers are important movement corridors for aquatic species[53]. In the case of forests, a system of corridors could be designed utilizing existing patches or augmenting with restoration and other restoration mechanisms, creating an opportunity for short or long term migration. There are provisions for such corridors in wildlife legislation (Fauna and Flora Protection Ordinance No. 2 of 1937) and are referred to as 'jungle corridors'[54].

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[55,56]. Additionally several Policies, Action Plans and Strategies in Sri Lanka have identified this essential for biodiversity

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

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

[51]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

[52]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.

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

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

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

[56]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

conservation[57]. Some mechanisms suggested at previous for a include the following (not in order of priority).

a) Mapping of existing corridor network using existing knowledge and identification of proposed corridors through climate modeling and mapping.

b) Establish a corridor network (existing and new corridors).

c) Strengthen management of existing corridors.

d) Design and map a system of corridors to allow gene flow.

e) Management plans for corridors (especially in watershed areas).

f) Promoting organic agriculture to support livelihoods among local communities.

g) Reduce pressures and threats to corridors.

h) Establish special corridors in selected areas while protecting existing corridors.

Ref. Annex D-5: Technology Fact Sheet on 'Increasing connectivity through corridors, landscape/matrix improvement and management', Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

5.3.2 Identification of barriers for the technology

5.3.2.1 Economic and financial barriers

One economic & financial barrier has been identified for this technology other barriers are all non financial.

a) Low funding allocation for connectivity (nationally)

This is primarily identified as an economic and financial barrier. Currently the main Government Departments dealing with environment and biodiversity conservation in the country are the Department of Wildlife Conservation and Forest Department. There are no financial provisions provided for enhancing connectivity in their nationally allocated budgets. This is seen as a major barrier, as activities related to enhancing connectivity cannot be implemented without funds at the disposal of the respective implementing agency. Although increasing connectivity needs to be treated as a top priority for biodiversity adaptation to climate change, due to non recognition of this technology as a priority and

[57] National Forest Policy of Sri Lanka (1995), National Policy on Wildlife Conservation (2000), Biodiversity Conservation in Sri Lanka, A Framework for Action (1999), National Action Plan for *Haritha* (Green) Lanka Programme (2009)

hence not allocating annual budgets is a major hindrance for successful implementation of this technology.

b) No incentives given to protect isolated forest patches/ecosystems in private lands (plantations/home gardens etc).

This barrier can be categorized as economic & financial. But it also has elements of policy, legal & regulatory and market failures aspects as well. Giving no incentives for isolated forest patches is considered a major constraint for maintaining connectivity. The landscape/ecosystem approach to conservation places a major importance on connectivity and ecosystems outside protected areas. However, there is a considerable amount of private lands / leased lands adjacent to protected areas. Currently there is no incentive scheme to reward those who conserve patches of private forests and other ecosystems. Therefore many such patches are cleared for other uses. Therefore, this is seen as a major barrier for connectivity which is vital for biodiversity adaptation to climate change.

5.3.2.2 Non-financial barriers

Most of the barriers relating to connectivity are non financial. These non financial barriers can be included under the categories of Information & awareness, Policy, legal & regulatory, Social, cultural & behavioral, Technical, Market failures, and 'Other'.

Information & awareness, technical and market failure barriers

a) Critical areas for connectivity and priorities not identified at a 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. Currently there are small scale conservation of patches of habitats and even such restorations often happens haphazardly and is not based on priorities. Therefore, critical areas for connectivity and its prioritization still remain to be carried out by a national level study.

b) Value and benefits of connectivity unknown.

The value and benefits of connectivity in relation to biodiversity, ecosystem services and its vital importance for biodiversity adaptation is largely unknown by the general public and decision makers. This is largely due to the fact that this information is not communicated in an effective and innovative manner that will capture the attention of these stakeholders. This is a major hindrance to biodiversity adaptation as investment for connectivity will not take place as long as those vested with mandates to conserve or convert these areas are not kept well informed.

Information & awareness, social, cultural & behavioral and policy legal and regulatory barriers

c). Lack of community awareness on sharing habitats with biodiversity vis a vis critical species and lack of policy and legal framework for benefit sharing.

One cannot exclude the importance of communities that occupy the matrix when considering connectivity. Therefore these communities must be included in matrix level planning. Many communities believe that habitats cannot be shared with biodiversity. Therefore, awareness on methods to avoid human-animal conflicts need to be created among those living in areas important for connectivity. Additionally, the lack of a benefit sharing system with the communities for living with biodiversity is not conducive for effective conservation.

Social, cultural &behavioral, market failures and 'Other' barriers

d). Existence of private lands and conflicting land uses.

The creation of corridors which link isolated ecosystems is vital for ensuring connectivity as it allows migration and dispersal of species. At present very few such corridors exists mainly due to the fact that areas outside protected areas are being owned by private or other state institutions. Additionally, lands outside protected areas have pressures for development and there are competing interests for such land for purposes such as settlement, agriculture, infrastructure etc. This poses a major barrier to connect isolated patches of ecosystems through corridors for providing enhanced ecosystem services.

Policy, legal & regulatory, technical and 'Other' barriers:

e). High altitudinal (montane) areas are poorly protected due to non-enforcement of laws and management plans.

This barrier can be categorized as largely a policy, legal and regulatory barrier. High altitudinal areas are vital as watersheds provide numerous ecosystem services. They are extremely important for altitudinal migration and dispersal of species as such movement occurs when lower altitude areas become warmer. In Sri Lanka these valuable montane ecosystems are degraded due to lack of enforcement of existing policies, laws and regulations. Although a good legal framework and policies exist in the country, poor enforcement has led to encroachment and clearing of these valuable areas both inside and outside the protected area system. Such degradation inside the protected are system is a serious issue as many assume these are 'protected' but some remain 'paper parks' which remain 'protected' in documents. Therefore enforcement of existing measures will be crucial to ensure connectivity, which is vital for biodiversity adaptation in this critical ecosystem.

f). Matrix/landscape level planning of conservation not carried out (focus only on isolated areas); lack of effective policies and legislation to push for matrix level planning/conservation.

Matrix and landscape level planning is vital for biodiversity conservation, and even more important in the context of climate change. However this approach in conservation planning is minimal in Sri Lanka. The areas outside protected areas are largely ignored in planning and innovative strategies to include these in planning and conserving biodiversity rarely occurs. Though such an approach is challenging it can be done, if planning and innovative strategies are used. This issue is compounded by the fact there is minimal policies and regulations to promote such planning and conservation activities. This is a major hindrance to biodiversity adaptation to climate change due to lack of connectivity.

g). Conflicting government policies on 'taking over unutilized land' as 'unutilized' areas include patches of natural ecosystems vital for connectivity.

This barrier can be considered to be policy, legal and regulatory, and market failures. Certain government policies can be sometimes contradictory, or can sometimes cause confusion as its implications may not be clear. Recent policies of taking over unutilized or underperforming assets including land could impact connectivity as these areas may include areas that are vital for connectivity. It is also possible that certain pockets classified under the category of "unutilized lands" for the purpose of taking over are important ecosystems that should remain at its natural status for conservation purposes. This can be especially true for plantation area such as tea, as some tea estates have considerable forest patches, some of which are montane area. Therefore it is vital to ensure that the term 'underutilized' should not include 'natural ecosystems' left for the betterment of the environment.

h). Procedural delays in land acquisition (e.g. LRC and private sector).

This can be considered to be a policy, legal and regulatory barrier. In order to maintain connectivity sometimes land acquisition is necessary. Such acquisition requirements may include both state and private land. The acquisition process has to follow a set government procedure. However, these procedures are such that acquisition is a long and time consuming exercise. Sometimes these delays act as a disincentive for conservation as the biological value of the particular land parcel may be lost over the long gestation period involved with the acquisition process. Therefore such procedural issues, especially with the acquisition of Land Reform Commission lands can be considered to be a significant barrier for enhancing connectivity and climate change adaptation.

5.3.3 Identified measures

5.3.3.1 Economic and financial measures

a). Barrier: Low funding allocation for connectivity (nationally).
Measure: Portion of annual budgets of Forest and Wildlife Departments allocated for connectivity based on above action plan.

Currently the annual budgets of the Forest and Wildlife Departments do not have a budget for connectivity. Introducing a mechanism by which certain fixed amount or percentage is allocated annually for this technology would ensure that connectivity and related activities will take place. A list of areas based on priorities to connect the most vital areas needs to be made so as to ensure effective utilization of funds allocated annually. This will ensure that even a minimum area will be connected annually, and will prevent haphazard activities that may not yield even minimal benefits.
No additional cost is involved for implementation of this measure. Approximately 4.5% of the annual budget of the relevant Department should be apportioned for this purpose (Approximately US$ 675,000 per annum).

b) Barrier: *No incentives for protecting isolated forest patches/ecosystems in private land (plantations/home gardens etc).*
Measure(s): i) *Incentives for private landowners to set aside or maintain areas necessary for connectivity.*
ii) Make Provisions (legal/policy) to ensure that medium to large development projects include areas that allow for connectivity.
iii) Political awareness; site specific evaluation where some areas are prioritized for restoration (over development).

Several measures can be used to address and overcome the above barrier. As previously mentioned it is vital to consider and include private lands and other areas outside the protected area system when considering connectivity for biodiversity adaptation. In such areas, the existence of natural ecosystems in the long-term cannot be assured. Therefore a scheme to provide various forms of incentives such as cash payments, subsidies and other benefits to private landowners who have important ecosystems in their lands should be formulated. An enabling policy and legal/regulatory framework should also be worked out to facilitate such an arrangement. This will provide assurance to landowners that commit themselves to such a program. Political awareness needs to be created to facilitate providing incentives and to develop enabling policies in order to involve private landowners in connectivity related activities. Additionally site-specific evaluation and prioritization is essential to ensure that the most important sites are connected first, and would also help when decisions are made between conservation and development.

Estimated cost of implementation over a period of 2 years is US$ 1.02 million.

5.3.3.2 Non-financial measures

Information & awareness, technical and market failure measures

a). Barrier: *Critical areas for connectivity and priorities not identified at a national scale.*
Measure(s): *Identify critical areas to be connected and prioritize required corridors and adopt climate change modeling to identify critical areas.*

In order to prevent implementation of ad hoc programs related to connectivity, a national level study to identify crucial areas and prioritizes such areas will be essential for the success of improving connectivity and to ensure biodiversity adaptation in areas of high value. Additionally, given that connectivity is being carried for the purpose of adapting to climate change, climate change modeling should accompany the study to make it accurate and select the most vital areas for connectivity.

Estimated cost of implementation over a period of 3 years is US$ 1.85 million.

b) Barrier: *Value and benefits of connectivity unknown; lack of communication and awareness.*
Measure: *Carry out valuation and identify benefits of connectivity, publicize results including awareness creation and communication*.

In order to create awareness among the public and decision makers to appreciate the true value and benefits of connectivity, effective and innovative communication and awareness programs must be launched. The relevant authorities should move away from traditional stereotype methods of awareness creation, which often do not appeal to those not interested in conservation. Where information on values is not available, research and studies would need to be carried out. However the most important aspect is the effective dissemination of information and ensuring that the information reaches to the most important segment of the stakeholders in a convincing manner.

Estimated cost of implementation over a period of 4 years is US$ 0.5 million.

Information & awareness, social, cultural and behavioral measures

c) Barrier: *Lack of community awareness on sharing habitats with biodiversity/critical species and lack of enabling policy and legal framework for benefit sharing.*
Measure: *Create awareness, build capacity and provide material to promote coexistence with biodiversity (eg: Kandyan home gardens; native plants seeds, materials etc).*

In order to address this barrier, awareness creation on how communities could co-exist with biodiversity

needs to be carried out to those people live adjacent to high value ecosystems and protected areas. In many areas communities have conflicts with certain species of biological importance such as elephants, wild boars etc. Sometimes such incidents cause negative attitudes towards conservation. If matrix conservation is to be carried out successfully, community involvement in conservation is important as most areas in the immediate environs of the protected areas have significantly high human populations. Despite this, these areas should also be considered in matrix conservation and mechanisms through which biodiversity can be conserved should be communicated. Patches of important habitats, key trees species etc, and home gardens are all equally important for connectivity. Capacity building will be important to facilitate this process.

Estimated cost of implementation over a period of 9 years is US$ 0.275 million.

Social, cultural & behavioral, market failures and 'Other' measures:

d) Barrier: *Existence of private lands and conflicting land uses that prevent creation of corridors. Competing interests/pressure from development (development versus restoration)*

Measures(s): *i). Incentives for private landowners to set aside or maintain areas necessary for connectivity.*

ii) Make enabling provisions (legal/policy) to ensure that medium to large development projects include areas that maintain connectivity.

iii) Political awareness; site specific evaluation for areas prioritized for restoration (over development).

Various inter-related measures are proposed to address this barrier. Areas outside protected areas, which are often under private ownership, are vital in matrix/landscape level conservation efforts. However, given that these areas are under private ownership there is no guarantee that important ecosystems will continue to be conserved. Therefore, incentives in the form of cash payments, tax concessions and subsidies can be provided to overcome such constraints. Additionally medium and large scale development projects, especially located adjacent to valuable ecosystems should set aside a certain minimum area to ensure connectivity. Such a mechanism will only be effective if enabling policies and enforceable regulations are set in place. This can be combined with the EIA process, and be included as an essential criteria for approving a development project. The decision makers and politicians need to be made aware of the need for such an approach to enable garner political support to formulate these mandatory requirements. An innovative awareness creation program will be vital in this regard. Site specific ecosystem valuations will generate localized values which will be important when deciding the best land use option for those lands located outside protected areas. Such information will also justify the conservation of isolated patches and its significance for enhancing connectivity.

Estimated cost of implementation over a period of 2 years is US$ 0.295 million.

Policy, legal & regulatory, technical and 'Other' measures:

e) Barrier: *High altitudinal (montane) areas and other critical ecosystems are poorly protected due to non-enforcement of laws and management plans.*

Measure(s): *i)* Effective *enforcement and management of protected areas and increasing the level of protection*

ii) Include critical areas into protected area network.

High altitudinal areas are of utmost importance for migration of species and dispersal of biodiversity for climatic change adaptation. Currently there are adequate policies and laws for effective management of protected areas including those in the montane areas. However, the non-enforcement of these have led to degradation due to conversion into other land uses, encroachment etc. Therefore a mechanism to ensure effective law enforcement is vital for the sustenance of these critical ecosystems. Additionally, increasing the legal status of protection will be imperative to ensure strict protection and effective management through optimal use of resources will be vital for the conservation of these montane areas and other areas as well. It is also important to identify critical montane and other ecosystems that should be included in the existing national protected area system. This will significantly contribute to the protection of high altitudinal habitats.

Estimated cost of implementation over a period of 9 years is US$ 1.5 million.

f) Barrier: *Absence of matrix/landscape level planning of conservation (focus is only on isolated areas); lack of enabling policies and legislation for mandatory matrix level planning/conservation.*

Measure(s): *Landscape level planning for conservation, special management and implementation integrate into Forest and Wildlife Department management plans*

Landscape level planning of conservation and special management efforts are necessary to overcome the above barrier. It is also vital to explore avenues for integrating Forest and Wildlife Department management plans, and these two institutions need to work in closely collaboration. An institutional mechanism needs to be formalized to enable the respective institutions work in collaboration with each other so that such conservation practices are promoted and integrated.

Estimated cost of implementation over a period of 9 years is US$ 0.25 million.

Barrier: *Conflicting government policies on 'taking over unutilized land' – as 'unutilized' areas include patches of natural ecosystems vital for connectivity.*

Measure: *Policy harmonization (definition of 'unutilized' should not include areas vital for biodiversity).*

A suitable policy harmonization has to be carried out to address any ambiguities in interpretation of terms such as "unutilized/underutilized lands" when implementing related government land acquisition policies.

Such ambiguities in policies having actual or perceived conflicts would keep away the potential private sector parties from being involved in conservation activities. Additionally, an amendment to the policy will be necessary to ensure that the definition of "unutilized lands" shall not include valuable ecosystems having the potential for providing critical environmental services.

Estimated cost of implementation over a period of 1 year is US$ 0.02 million.

g) Barrier: *Procedural delays in land acquisition (eg: LRC and private sector).*
Measure: *Amend procedures to expedite land acquisition process*.

The existing policies related to land acquisitions has inherent procedural delays which are detrimental for acquiring lands for conservation purposes. Therefore, a comprehensive analysis of the existing policies and procedure is required to identify the underline reasons for such delays and introduce appropriate amendments, which would expedite the process. These amendments would be beneficial as delays in acquisition can result in the further degradation of the ecosystems to be conserved.

Estimated cost of implementation over a period of 9 years is US$ 0.03 million.

5.4 Barrier analysis and possible enabling measures for Technology 3: Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones

5.4.1 General description of the technology

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[58]. 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[59]. In Sri Lanka these vary from Strict Natural Reserves where access is strictly limited to Sanctuaries, which may contain even private lands[60]. It is vital to ensure that in these areas there is good representation of biodiversity. Effective management of existing protected areas is important as creating new areas is challenging as there is much demand for land in a developing country. However there are numerous areas that are earmarked as proposed reserves, which can be included into the protected area

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

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

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

network. Creating new protected areas or expanding existing areas does not require any advanced technologies.

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[61]. Additionally several Policies, Action Plans and Strategies in Sri Lanka have identified this essential for biodiversity conservation[62]. Some mechanisms suggested in this regard include the following (not in order of priority):

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

(Ref. Annex D-5: Technology Fact Sheet on 'Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones', Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

5.4.2 Identification of barriers for the technology

5.4.2.1 Economic & financial barriers:

a). Low funding allocations (nationally).

This barrier is primarily an economic & financial barrier. Currently, the main Government Departments involved with environmental and biodiversity management in the country, which include the Department of Wildlife Conservation and Forest Department do not have a financial allocation for this activity in the respective nationally allocated budgets. This is seen as a major barrier, as the required activities cannot be implemented without access to funds. Lack of priority given for this technology thereby no funds being allocated in the annual budgets is a major hindrance for success of this technology.

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

[62] National Forest Policy of Sri Lanka (1995), National Policy on Wildlife Conservation (2000), Biodiversity Conservation in Sri Lanka, A Framework for Action (1999), National Action Plan for *Haritha* (Green) Lanka Programme (2009)

b). Non-implementation of existing management plans due to lack of resources.

This barrier falls into several barrier categories viz; economic & financial, policy, legal & regulatory, institutional and organizational capacity. Lack of resources has led to the non-implementation of management plans impacting effective protected area management. Sri Lanka currently has many protected areas with various degrees of protection, from Strict Natural Reserve where visiting is prohibited to Sanctuaries, which may include even private lands. The two main departments involved in protected area management are the Department of Wildlife Conservation and Forest Department. All of these protected areas do not have management plans, but several have management plans. Often these are not implemented due to lack of resources such as finances, lack of skills and inadequate number of personnel. This is a major hindrance to effective protected area management.

c). Lack of management plans for some protected areas

This is as an economic & financial and policy, legal & regulatory related barrier. This is also related to the barrier (a) above. Whist some protected areas have management plans, which are often not effectively implemented, a number of many other protected areas in Sri Lanka do not have management plans. Therefore, it is of utmost importance to have adequate management plans, to enable identifying appropriate innervations for effective management of these protected areas. The existing protected areas need to be prioritized based on the importance of conservation and those requiring immediate management interventions. A management plan should be comprehensive and be done by a team of experts from within the management institution or from an expert institution. Interestingly, as required by the recently amended forest law (Forest Ordinance) preparation of management plans for forest areas is a mandatory requirement[63].

d). Capacity constraints in terms of number of personnel, knowledge, vehicles for adequate management and monitoring.

This barrier can be categorized as economic & financial, and institutional & organizational capacity related. Inadequate monitoring and management often occur due to lack of capacity/resources such as number of personnel, lack of knowledge, vehicles for monitoring etc. All these are essential components for effective management and long-term viability of protected areas. Declaration of a protected area, fencing and erecting sign boards only are not sufficient for conservation. Active conservation programs and management is necessary, and require adequate financing, personnel, equipment and skills. Monitoring is essential to gauge the effectiveness of management interventions and it also plays a major role in curbing illegal activities. Having skilled personnel is an important ingredient for optimizing personnel and resources. Therefore, inadequacy or total absence of these resources is a considerable

[63] The Forest Ordinance No. 16 of 1907, and its subsequent amendments, including Act No. 23 of 1995 as amended by Act No. 65 of 2009

hindrance to effective protected area management.

5.4.2.2 Non-financial barriers

Institutional & organizational capacity and information & awareness barriers

a). Demand for land from proposed reserves/parks for medium/large development projects.

This barrier relates to institutional & organizational capacity and information & awareness categories. Sri Lanka is fast developing and areas earmarked for conservation often get selected for economic development activities. Thus, some potentially important conservation areas are being utilized for other purposes primarily due to lack of legal protection under the relevant environmental laws. There have also been instances where lands from protected areas are also illegally utilized for certain activities. Often this appears to be a common occurrence despite the availability of already cleared or degraded state lands which could be used for development projects, without causing damage to valuable ecosystems.

b). Lack of effectiveness of relevant departments and staff (mainly field staff) in protected area management.

This is an institutional and organizational capacity related barrier. Availability of adequate finances or personnel shall not automatically guarantee the conservation. Staff, especially those in the field needs to be effective in ensuring that activities are adequately and efficiently carried out. Increasing the numbers of personnel, funds or resources only will not solve the issues at hand unless complimented by staff commitments.

Policy, legal & regulatory barriers

c). Conflicting land use in buffer zones.

Buffer zones of the protected areas should have land use practices that compliment conservation, as the buffer zones are declared or identified for the purpose of minimizing edge effects to protected areas. Certain agricultural practices, development and other projects in buffer zones can in fact cause damage to the core protected areas which is contrary to the objective of a buffer zone. Therefore buffer zone activities should be carefully evaluated before approval and activities that cause no harm, or provide additional protection only shall be encouraged.

d).Absence of legally defined buffer zone for protected areas

In Sri Lanka, a protected area category referred to as ‘buffer zone’ exists but such areas are usually not declared. Most Wildlife and Forest Department protected areas refer to a buffer zone but conservationists

often don't recognize these to be 'true buffer zones' as most activities are permissible in such areas with or without EIAs. Further, not all protected areas have such a buffer zone.

e). Insufficient physical demarcation of some protected area boundaries and all buffer zones. Lack of enforcement of and awareness on boundaries

In addition to this barrier being policy, legal & regulatory related it also has elements of information & awareness category. This can be considered a major hindrance to protected area conservation and management. Some protected areas have a buffer zone of 1-mile, while others have a buffer of 100 meters. Many activities in such areas are restricted, or require the EIA process to be followed. Often this is violated as physical demarcations are not visible, and in many cases even if the buffer exists, the lack of a physical demarcation is used as an excuse for illegal activities. Sign boards could be an effective way to demarcate buffer zones. Another major issue relating to protected area management is the enforcement of boundaries. All legally declared protected areas have its boundaries clearly stated in the gazette, and also have an accompanying detailed survey plan. However encroachments are frequent in protected areas, and have led to the destruction of many valuable areas. In some cases the physical boundary demarcations differ from what is stated in the gazette, resulting in degradation and numerous related issues. Therefore improper or lack of demarcation of legal boundaries is a major issue for protected area management.

f). No provisions for community or privately owned protected areas (outside the current protected area system).

This can be categorized as policy, legal & regulatory, and social, cultural & behavior related barrier. In many countries there are provisions, incentives and benefit sharing arrangements for communities to be involved in active conservation both within and outside the protected areas system. In Sri Lanka this is still at infancy. Moreover, privately owned protected areas are rare in the country and are not encouraged by the respective policies or legislation, nor do they receive any incentives. Community conservation, if carried out properly can make protected area management effective, while privately owned protected areas can increase the protected area estate of the country. The lack of these can be considered a significant hindrance to biodiversity adaptation.

Policy legal & regulatory, information & awareness, social, cultural and behavioral barriers

g). Lack of communities awareness on sharing habitats with biodiversity/critical species and lack of enabling policy and legal framework for benefit sharing.

This barrier can be considered as policy legal & regulatory, information & awareness, social, cultural and behavior related. When considering connectivity one cannot exclude the importance of communities that occupy the matrix. Therefore these communities must be included in matrix level planning. Many

communities are of the belief that habitats cannot be shared with biodiversity. However awareness on methods available to avoid human-animal conflicts need to be communicated to those living in areas which are important for connectivity. Furthermore, the lack of a benefit sharing arrangement is not conducive for co-habitation with biodiversity.

Network failures

h). Lack of inter agency coordination in managing adjacent protected areas.

In Sri Lanka, protected area management is carried out by two Government Departments, namely the Forest Department and the Department of Wildlife Conservation. These departments often have protected areas adjacent to each other, but do not appear to be working in coordination with each other. There is no enabling policy that encourages these two departments to work together. Currently these two departments function under two different Ministries, making the matters even more complicated. Sharing of specialized skills between the organizations is lacking due to weak inter-agency coordination. Working in collaboration can also make management and monitoring more effective.

i). Lack of ecological information in protected areas

There is limited or no information available on the ecology of protected areas. This is a major constraint as ecological information such as species inventories, their status of threat, populations, niches, ecosystems types, threats etc are often lacking. Without such information correct management decisions cannot be made, leading to ineffective protected area management. Therefore it is vital to identify areas where such information is lacking and carry out studies based on priorities.

5.4.3 Identified measures

5.4.3.1 Economic and financial measures

a). Barrier: Low funding allocation for this technology (nationally).
Measure: Portion of annual budgets of Forest and Wildlife Departments allocated for this technology based on above action plan.

Currently the annual budgets of the Forest and Wildlife Departments do not have a budget for this technology. Introducing a mechanism by which certain fixed amount or percentage is apportioned from the annual budget for this technology would ensure that necessary activities will take place. A list of priority areas needs to be prepared to enable allocating required funds annually based on the priorities. This will prevent ad hoc activities that may not yield desired benefits.

No additional cost is involved for implementation.

b) Barrier: *Non-implementation of existing management plans due to lack of resources.*
Measure: *Allocation of resources and implementation of management plans.*

The non-implementation of management plans is a major constraint to effective protected area management. The underline reason is lack of resources where finances being the major constraint. Therefore, planning and judicious allocation of resources including financial, human, equipments etc will lead to effective management. Availability of resources by itself will not guarantee effective management. Therefore utilizing the resources made available in an appropriate manner will determine the success of protected area management.

Estimated cost of implementation including (c) below over a period of 10 years is US$ 1.6 million.

c) Barrier: *Lack of management plans for some protected areas.*
Measure: *Prepare and implement management plans where it does not exist.*

Management plans are necessary tools for the effective management of protected areas. The Management Plans usually contain recommended prescriptions, an implementation plan, and methods to address challenges to protected area conservation. Many protected areas lack such management plans. Therefore producing management plans for protected areas, which do not have such a document, is an essential starting point for effective protected area management. Often such a document needs to be prepared by a team of experts and will often require financial resources. However a list of priority protected areas will ensure that these management plans are prepared based on priority.

Estimated cost of implementation including (c) below over a period of 10 years is US$ 1.6 million.

d). Barrier: *Capacity constraints in terms of personnel, knowledge, vehicles for effective management and monitoring.*
Measure: *Recruiting competent personnel as required by the job description.*

Adequate personnel, knowledge, vehicles etc are essential for management and monitoring. The financial aspects are already dealt under the financial measures above. It is of utmost importance to recruit adequately qualified competent personnel as required by the respective job descriptions to ensure effective service delivery. Required educational qualifications need to be considered in conjunction with other skills such as communication skills, leadership qualities etc.

Estimated cost of implementation over a period of 9 years is US$ 0.0025 million.

Non-financial measures

Institutional and organizational capacity and information measures

a). Barrier: *Demand for lands from proposed reserves/parks for medium/large development projects.*
Measure(s): *i) Incentives for using brown field/degraded areas.*
ii) Policies to discourage conversion of natural ecosystems for development projects.
iii) Upgrade proposed reserves/parks to a higher level of protection.

Demand for land for other uses is a major hindrance to protected area expansion. Often forested areas, which are earmarked for protection are utilized and cleared for development projects disregarding the availability of other unutilized degraded/cleared areas for such purposes. Utilizing these areas may require rehabilitation and therefore investors should be encouraged to opt for such land areas through provision of appropriate incentives such as tax breaks, cash payments, subsidies etc. Therefore, an investor will benefit while utilizing such a land, while the forested/intact ecosystem will remain undisturbed. Such a measure should be backed up by a strong policy that discourages the conversion of lands with intact ecosystems. Additionally proposed areas should be upgraded to higher levels of protection as soon as possible to ensure that such lands are not vested for development.

Estimated cost of implementation over a period of 3 years is US$ 1.01 million.

b). Barrier: *Lack of effective protected area management.*
Measures: *Ensure accountability coupled with performance based staff evaluations; incentives (financial and non-financial) for good performance.*

Ineffectiveness of departments and their staff, especially at the field level is a major constraint for effective protected area management. However, this constraint can overcome by creating accountability of responsible people. Often in the government sector there are no rewards for efficient performance. Performance based evaluations are vital for staff motivation. Those who perform best should be considered for recognition through provision of incentives such as certificates, badges, bonuses etc.

Estimated cost of implementation over a period of 9 years is US$ 0.02 million.

Policy, legal and regulatory measures

c). Barrier: *Conflicting land use in buffer zones.*
Measure(s): *i) Encouraging non-conflicting land use through incentives. ii) Enforcement of buffer zone legislation.*

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 by itself, but the methods and manner the land is used can be either beneficial or degrading (eg: intensive farming vs organic farming). Therefore encouraging non-conflicting/non-degrading land uses through incentives will probably be the most effective way of ensuring that the buffer zone creates a shield for the protected area. The National Environmental Act restricts certain activities in Wildlife and Forest Department protected areas. An EIA process is required for certain activities and many activities are allowed only if activities proposed do not lead to the degradation of the protected areas. There are many instances where this legislation is flouted by certain parties, and thus its strict enforcement will ensure that buffer zones provide its intended protection to protected areas.

Estimated cost of implementation over a period of 2 years is US$ 0.61 million.

d). Barrier*: No legally defined buffer zone for protected areas*
Measure: ***Amend and implement buffer zone legislation.***

Even though the National Environmental Act refers to buffer zones within a certain radius, many in the environmental sector point out that these are not buffer zones in the typical sense, especially as most activities are permissible in such areas with or without EIAs. Additionally, not all protected areas have such a buffer zone. Therefore a review needs to be carried out and amend the current buffer zone legislation to make it more effective. Further, the amendment and the current legislation relating to buffer zones should be implemented and monitored effectively. This is important as currently there are certain land users in buffer zones that violate the existing legislation. Implementing this effectively will have a positive impact on the protected areas.

Estimated cost of implementation over a period of 9 years is US$ 0.5 million.

e). Barrier*: Insufficient physical demarcation of some protected area boundaries and all buffer zones. Lack of enforcement of boundaries, Lack of awareness on boundaries*
Measure(s): ***i) Physical demarcation of protected area boundaries and buffer zones, ii) Effective law enforcement on boundaries/removing encroachments etc, iii) Create awareness on boundaries.***

Insufficient physical demarcation of buffer zones has caused many issues such as encroachment, clearing of lands and other violations. Therefore, it is of utmost importance to adequately demarcate these protected area and other boundaries leaving no room for speculation of boundaries and disputes. When a protected area is gazetted, its boundaries are specific in the legal document (Gazette), additionally they are usually accompanied by a detailed survey plan. Adherence to these legal demarcations, which are very clear, will ensure that there will be minimal boundary related disputes and issues. It is also equally important to enforce existing laws relating to boundaries, and rectify where the wrong boundaries have been demarcated. Measures should be taken to take back all lands that are

rightfully under the jurisdictions of the Forest and Wildlife Departments and to remove encroachments and restore degraded areas.

Estimated cost of implementation over a period of 9 years is US$ 1.85 million.

f).Barrier: *No provisions for community or privately owned protected areas outside the current protected area system.*
Measure: *Introduce enabling provisions for community owned protected areas and provide incentives for such activities.*

Currently there are no provisions for communities to own and manage 'protected areas' outside the traditional protected area system. Introducing such a system will be beneficial, especially where intact or good quality ecosystems exist 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.

Estimated cost of implementation over the project period is US$ 0.28 million.

Policy legal & regulatory, information & awareness, social, cultural and behavioral measures
g). Barrier: *Lack of community awareness on sharing habitats with biodiversity/critical species.*
Measure: *Create awareness, build capacity and provide material to promote coexistence with biodiversity (eg: Kandian home gardens, native plants seeds, materials etc).*

Awareness creation on cohabitation with biodiversity needs to be carried out in areas where people live in the environs of the high value ecosystems and protected areas to address the above barrier. In many areas communities have conflicts with certain faunal species such as elephants, wild boar etc. Sometimes animal related incidents in the communities cause negative attitudes towards conservation. This becomes an important issue especially when considering buffer zones. If matrix conservation is to be carried out successfully, community involvement in conservation is important as most areas outside protected areas have significant human populations. Patches of important habitats, key trees species etc, and home gardens are important pockets of conservation values.

Estimated cost of implementation over a period of 9 years is US$ 0.275 million.

Network failure measures

h). Barrier: *Lack of inter agency coordination in managing adjacent protected areas..*
Measure: *Enabling policies and initiatives to encourage Forest, Wildlife and other relevant departments to work together.*

Even though ecosystems have natural boundaries, declared protected areas rarely follow such boundaries. Additionally there are instances where the Forest and Wildlife Department manage two or more adjacent protected areas. However, there appears to be inadequate collaboration between these agencies when managing such areas. Improving coordination between the two government departments (and other institutions) will ensure effective management and monitoring through optimal utilization of resources. Therefore, it is recommended to have appropriate enabling policies that encourage such cooperation. Such an arrangement also would enable reducing costs and utilization of resources efficiently.

No cost is involved with the implementation of this activity as it is an administrative matter.

i). Barrier: *Lack of ecological information in protected areas*
Measure: *Identify areas to carry out studies, carry out biodiversity assessments*

Lack of ecological information in protected areas is a major bottle neck for effective conservation. Often there is limited or no information on the ecology of protected areas. This is a major constraint as lack of ecological information such as species inventories, their status of threat, populations, niches, ecosystems; threats etc are often not known. Therefore it is vital to identify areas where such information is lacking and carry out studies depending on priorities. Such information is a prerequisite for a comprehensive management plan.

Estimated cost of implementation over a period of 9 years is US$ 0.225 million.

5.5 Barrier analysis and possible enabling measures for Technology 4: Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems

5.5.1 General 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[64]. Thus it would target species that need special attention, with high vulnerability to climatic changes.

Recent studies have shown that the ecological changes in the phenology and distribution of plants and animals are already occurring, and have been linked to local and regional climate change. Range-restricted species show severe range contractions and certain such species have become extinct. Tropical coral reefs and amphibians have been most negatively affected[65]. The Sri Lanka Red List[66] which identifies threatened species and their locations can be used to identify and target specific species that may require additional conservation intervention. Globally the IUCN Red List is already being used to identify species at risk with climate change[67].

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[68,69]. Additionally several Policies, Action Plans and Strategies in Sri Lanka have identified this as essential for biodiversity conservation[70]. Some mechanisms suggested at stakeholder for include the following actions (not in order of priority).

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

(Ref. Annex D-5: Technology Fact Sheet on 'Focus on conservation of resources and carryout special management for restricted range, highly threatened species and ecosystems', Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I).

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

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

[66]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.

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

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

[69] 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.

[70] National Forest Policy of Sri Lanka (1995), National Policy on Wildlife Conservation (2000), Biodiversity Conservation in Sri Lanka, A Framework for Action (1999), National Action Plan for *Haritha* (Green) Lanka Programme (2009)

5.5.2 Identification of barriers for the technology

5.5.2.1 Economic & financial barriers

a) Minimal funding allocated for protecting highly threatened species.

Currently there are no specific financial provisions in the annual budget of the Department of Wildlife to carry out activities related to the conservation for highly threatened species, although certain funds are allocated for addressing the human elephant conflict. It is essential to have sufficient funds made available for interventions specifically targeted at point endemics and other species as categorized by the IUCN Red List. Without adequate funds, it would be a challenge to conserve highly threatened species with climate change. Current threats need to be minimized to provide species the best chance to survive and adapt to climate change.

b) Lack of national biodiversity action plans for highly threatened species.

This barrier is related to economic & financial, technical, and information & awareness categories. The main reason for the absence of national biodiversity action plans for highly threatened species is lack of sufficient funds and resources for preparation and implementation of such plans. Even though certain landscapes and ecosystems are protected, sometimes this is insufficient to conserve certain highly threatened species. These species may have a high threat due to a range of reasons. Therefore a comprehensive study is necessary to understand the current and future threats, and prepare an action plan accordingly. It is of vital importance to implement the action plans once prepared. These action plans should be made according to the level of threat, so that species that require urgent interventions will be addressed first. The level of threat highlighted in the IUCN Red List can be utilized for this purpose. Specific interventions would be imperative for some species to be able to adapt to climate change.

5.5.2.2 Non-financial barriers

Information & awareness and technical barriers

a) Lack of information (including modeling) on the impact of climate change on species/ecosystems.

Currently there is very little information on how climate change will impact on specific species and ecosystems in Sri Lanka. A basic preliminary GIS mapping exercise carried out based on available species data and broad climate predictions has drawn only broad conclusions. Detailed and localized information at a fine scale is required to get accurate predictions on potential climate change impacts on species. This information would be useful in climate change modeling to enable developing adaptation

strategies for specific species and ecosystems.

b) Inadequate information on threatened species (distribution data, ecological information including population size and genetics - (in-situ research)

Currently there is limited information available on the distribution, ecology, population size, genetics etc of threatened species. This information is vital when preparing management plans and strategies for their long-term conservation. Given the vulnerability of these species, it is proposed that such research should be done in-situ. Information thus generated will also be essential for biodiversity related climate change modeling; as such information will give an idea of possible migration/dispersal and other potential changes.

c) Poor awareness by general public and policy-makers on point endemics and other threatened species. Lack of recognition for voluntary (persuasive) conservation actions.

This barrier can be categorized as information & awareness, and social, cultural & behavioral. Currently the level of awareness of both the general public and policy-makers regarding the importance of point endemics and other threatened species is poor. Many do not know the importance, the role played in terms of ecosystem services and the potential 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 who do not consider conservation a priority. Effective and innovative communication methods will be essential to convince policy makers and the general public to secure their support for conservation. On the other hand, giving due recognition is necessary to reinforce conservation related voluntary actions. Therefore, it is necessary to create a mechanism by which voluntary conservation actions are recognized and rewarded.

d) Insufficient in-house knowledge on species management strategies.

This barrier falls under the categories of information & awareness, technical and human skills. Sri Lanka has a high diversity of species and it is impossible for one department to possess all the expertise on the country's biodiversity. Yet insufficient in-house knowledge is a major hindrance to species conservation, as the understanding on appropriate species management strategies is poor. 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 for planning and implementation of species conservation interventions.

Policy, legal & regulatory barriers

e) Not all sites that harbor threatened point endemic species are protected.

This barrier falls under the category of network failures as well. Currently there are certain point endemic species that are not found within the protected area system. Even though such species have legal protection, certain ecosystems/sites that harbor these species are not protected. Therefore activities in such sites could cause significant threats 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, affording due protection to these sites will ensure such species adapting to climate change. Legal protection of such sites, community involvement and support are essential for the long term viability of such species.

Network failure barriers

f) Insufficient partnerships for species conservation.

The Department of Wildlife Conservation which is the organization mandated to conserve species have limited partnerships that focus on species conservation. Currently there are numerous researchers and institutions working on biodiversity conservation, and carry out species focused research. Forming formal partnerships with specialists will provide vital information to carry out species specific conservation. Assistance can also be sought for carrying out specialist research, action plans, strategies for conserving such species etc. These partnerships will play a significant role in the conservation and adaptation of biodiversity to climate change.

Institutional & organizational capacity barriers

g) Difficulty in obtaining permission for conducting research by individuals and non-state sector institutions.

This barrier has elements of institutional & organizational capacity related and 'other' aspects as well. The existing administrative procedure available to obtain permission for conducting research by individuals and non-state sector institutions is long and acts as a disincentive for carrying out essential biodiversity related research works. In some instances, the long delays experienced results in lack of adequate time to conduct research activities at the correct season or shorten the available time period making research ineffective. Expediting the procedure is essential to encourage research activities whilst ensuring that the essential criteria for researches are met. Often this approval procedure causes either no or minimal cost to the State, while the information derived from research activities will be useful in conservation planning and conserving species. Hence such activities should be encouraged by the State making the procedures quick and effective.

Technical barriers

h) Lack of focused research on habitats for species migration.

This is purely a technical barrier. With climate change impacts, species tend to migrate into more favorable ecosystems and sites; while there will also be altitudinal migration. Often research is confined to the current habitats of species. However with climate change, potential migration/dispersal sites of species also become important. Climate change modeling could also indicate what these sites may be. This information should be used as a guide and potential sites should be researched to identify whether they are suitable for species migration/dispersal. It will also give an opportunity to minimize threats in such areas, and also protect such sites as they may become important future areas for conservation with the onset of climate change.

5.5.3 Identified measures

5.5.3.1 Economic and financial measures

a) Barrier: *Minimal funding allocated for protecting highly threatened species.*
Measure: *Allocate sufficient funds from annual budgets to implement above action plans based on priority.*

Currently a major barrier for species adaptation to climate change is the lack of finances for protecting highly threatened species. Therefore, it is vital to allocate sufficient funds from the annual budgets of relevant departments for the conservation of important species. Allocating funds by itself will not be sufficient. Funds need to be used efficiently based on a prioritized plan of action with the focus on species with high priority. This action is directly linked with the proposed measure of preparation and implementation of species-specific biodiversity action plans. Other projects targeting the conservation and adaptation of species will be essential and need to be aligned with the priority species based action plan.

No additional cost is involved in implementation of this measure. Approximately 5% of the annual budget of the relevant Department be apportioned for this purpose and it works out to be around US$ 750,000 per annum.

b) Barrier: *Lack of national biodiversity action plans for highly threatened species.*
Measure: *Develop and implement species action plans based on priority.*

In order to address this barrier, it is proposed to develop such action plans and implementation based on priority. Additional funding and use of expertise is essential in this regard. Therefore, action plans could be developed for a selected number of priority species depending on their importance, level of threat,

contribution to ecosystem services and other categories. The IUCN Red List will be an important resource in this prioritization exercise. Adequate resources will also be necessary for effective implementation of these plans.

Estimated cost of implementation over a period of 4 years is US$ 1.75 million.

5.4.3.2 Non-financial measures

Information & awareness and technical measures

a) Barrier*: Lack of information on potential climate change impacts on species/ecosystems including climate change modeling.*
Measure: *Generation of necessary information and climate change modeling on potential climate change impacts on species and ecosystems*.

There is currently a lack of information on the potential climate change impacts on species and ecosystems. This information is required to design and carry out adequate conservation programs that will help such species and ecosystems to adapt to climate change or at least increase its chance of survival. As in the case of the financial barriers, funds from annual budgets will also be required in this regard. The required information can be generated by collaborating with independent researchers, universities and other conservation organizations. Often such partnerships will require little or no investment from the government. Therefore, these opportunities should be harnessed, while ensuring that the research priorities are decided by the relevant Government agency with the support of experts.

Estimated cost of implementation over a period of 3 years is US$ 0.5 million.

b) Barrier: *Inadequate information on threatened species (distribution data, ecological information including population size and genetics - (in-situ research)*
Measure: *Carry out extensive surveys/research; obtain expertise on the subject/capacity building.*

Currently there is inadequate information on threatened species and there is a need to carry out extensive surveys and research. Additionally, external expertise shall be sought on specialized subject areas, groups of species etc and capacity building will also be required so that staff of the Wildlife Department will be able to continue carrying out research and surveys on their own.
Estimated cost of implementation over a period of 2 years is US$ 0.8 million.

c) Barrier: *Inadequate awareness of the general public and policy-makers on point endemics and other threatened species. Lack of recognition to reinforce voluntary conservation action*
Measure(s): *i) Awareness programs on point endemics and critically endangered species, the importance of their conservation; ii) Awareness (in an innovative manner) with the support of the government sector for policy makers, school children etc.*
iii) Introduce relevant mechanisms to reinforce voluntary conservation action.

Currently in Sri Lanka, the general public and policy-makers have poor awareness on the importance and role of endemic and threatened species, especially on point endemics. The uniqueness of such species and their role in ecosystem services should be highlighted. Awareness needs to be carried out in an innovative manner with the support of the government sector for the purpose of communicating effectively to policy makers and the general public. At present there is also a lack of recognition for voluntary conservation actions. Therefore, mechanisms should be introduced to encourage such voluntary action and also to appropriately recognize such efforts.

Estimated cost of implementation over a period of 8 years is US$ 0.8 million.

d) Barrier*: Insufficient knowledge on species management strategies within the relevant authorities*
Measure: *Build capacity and equip staff within departments to conserve and monitor threatened species/ecosystems (specialized knowledge).*

Knowledge on species management strategies existing within the relevant authorities is insufficient. While it may not be possible for one institution to have expertise on a wide variety of species groups yet they can benefit through capacity building programs that will enhance in-house knowledge and capabilities. Along with this capacity building exercise, the staff should be adequately equipped to enable assist in conservation and monitoring of threatened species and ecosystems. Opportunities for specialization also need to be provided for those having such inclination. Experts, universities, NGOs etc can play an important role in such capacity building programs.

Estimated cost of implementation over a period of 2 years is US$ 0.275 million.

Policy, legal and regulatory measures:

e). Barrier*: Not all sites that harbor threatened of point endemic species protected.*
Measures(s): i) *Legalizing the protection of sites where point endemics are found.*
(ii) Make recommendations on climate change and species related considerations into legislation – and publicize amendments.
iii) Incentives and alternatives for protection in areas outside protected areas.
iv) Inter departmental coordination for protection of point endemics.

Point endemics are often vulnerable and are at high risk. They are usually highly threatened as well. Despite such species being protected, there are instances where the habitats of such species are not within the protected area system. Declaration of such sites as protected areas will enable affording due protection to these species. Though the declaration by itself will not be sufficed but yet it will be an important starting point. In some instances it may not be practical to legally protect such sites due to the ownership status. In such cases, involvement of the landowners in conservation, creating awareness etc will be vital. They would need to be given incentives for co-habitation with the point endemics and to encourage conservation and activities that do not threaten such species. In cases where the existing land use can be destructive, assistance must be given for alternative livelihoods. In the event that the lands of interest are managed by other state institutions, inter agency cooperation will be vital for the viability of point endemic species. Amongst state institutions, an enabling policy and administrative environment need to be established to ensure this collaboration. Without cooperation with local communities and other departments, the survival of the species could be compromised. It is also important to consider incorporating enabling legislation for biodiversity conservation *vis a vis* climate change.

Estimated cost of implementation over a period of 8 years is US$ 2.865 million.

Network failure measures

f). Barrier: *Insufficient partnerships for species conservation.*
Measure: *Create effective partnerships between Ministries/Departments and Universities, NGOs, species Specialists etc for species conservation*.

Currently, adequate partnerships for species conservation do not exist in Sri Lanka. Partnerships are beneficial for research, implementation of conservation programs, carrying out biodiversity & other ecological studies, restoration, captive breeding, rehabilitation of injured species etc. Such partnerships can be formed between various Ministries, Department, Universities, NGOs, species Specialists, depending on the task at hand. Often such collaborative work with combined resources would make the task efficient, will have access to more expertise and reduce costs well. Therefore, an appropriate strategy or policy that encourages such partnership should also be formulated.

Estimated cost of implementation over a period of 5 years is US$ 0.115 million.

Institutional & organizational capacity and 'Other' measures:

g) Barrier: *Delay in obtaining permission for conducting research by individuals and non-state sector institutions.*

Measure: *Expedite the current process for obtaining research permission for individuals and non-state institutions.*

Delay in obtaining permission for conducting research by individuals and non-state institutions is a major barrier as it tends to discourage and restrict opportunities for important research works. The research information thus generated will be at minimal or no cost to the State and that information can be utilized for conservation action plans and related activities. Therefore, it is of utmost importance to have a less cumbersome administrative process to obtain research permission, in a manner that the set standards and procedures are not compromised.

Estimated cost of implementation over a period of 1 year is US$ 0.025 million.

Technical measures

h) Barrier: *Lack of focused research on habitats for species migration.*

Measure: *Research on habitats for species migration and identification/conservation such habitats.*

The potential site for species migration/dispersal which becomes especially important with climate change is often an aspect not considered or researched. Research on these potential habitats for species migration/dispersal, and the identification of such sites and habitats (with the aid of climate modeling) should be encouraged. Having predictions and information would help with planning for the future, identifying threats and taking steps for conserving such areas. These research priorities need to be incorporated into the research agenda of the Forest Department and the Department of Wildlife Conservation.

Estimated cost of implementation over a period of 4 years is US$ 0.5 million.

5.6 Barrier analysis and possible enabling measures for Technology 5: Ex-situ conservation for highly threatened species and possible reintroduction

5.6.1 General 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[71]. 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. Zoological Gardens and breeding centers have long been carrying out captive breeding, especially for keystone mammals. Sperm and egg banks would be rather extreme forms of this strategy, but may be necessary[72]. 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 may be the only chance of survival for some species. Ex-situ collections should have sufficient diversity to allow adaptation[73].

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[74]. Additionally several Policies, Action Plans and Strategies in Sri Lanka have identified this as essential for biodiversity conservation. Some mechanisms suggested by stakeholders in previous fora include the following (not in order of priority):

a) Establishing a program for captive breeding/propagation of the species selected for ex-situ conservation.
b) Implement a reintroduction program that will enhance/establish wild populations that would ensure their long-term survival.
c) Monitoring of captive breeding/propagation and the reintroduction programs and optimizing them.
d) Create space within wildlife legislation and policies.
e) Identify species' potential new habitats.
f) In the case of flora seed-banks and in-vitro gene banks.

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

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

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

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

Ref. Annex D-5: Technology Fact Sheet on Ex-situ conservation for highly threatened species and possible reintroduction, Report on Technology Needs Assessment and Technology Action Plans for Climate Change Adaptation in Sri Lanka (Part I)

5.6.2 Identification of barriers for the Technology

5.6.2.1 Economic & financial barriers

a) Lack of proper planning and funding for ex-situ conservation. No framework/protocol for reintroduction and monitoring.

This barrier can be categorized as economic & financial, and technical as well. Currently there is no proper planning and fund allocation for ex-situ conservation. Ex-situ conservation is usually considered a last resort for conservation, and thus an important technology for biodiversity adaptation. Ex-situ conservation requires proper planning and adequate budget allocation. Additionally there is no framework or protocol for captive breeding, reintroduction, monitoring etc, which is of utmost importance for the adaptation of biodiversity to climate change and its viability.

b) Lack of expertise and resources (suitable land/specialized locations, standard protocols) to carry out ex-situ conservation

This barrier too can be categorized into several categories including economic & financial, technical and human skills. Ex-situ conservation requires expertise and resources. Resources necessary include suitable land, 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. The type of expertise and resources required would also depend largely on which species require intervention thus the planning requirements mentioned in the above barrier, together with species priorities need consideration prior to securing expertise and resources.

5.6.2.2 Non-financial barriers

Policy, legal & regulatory, information & awareness and market failure barriers

a) Ex-situ conservation of wild fauna not a high priority in conservation related policies.

This barrier can be categorized as policy, legal & regulatory and information & awareness. Ex-situ conservation, as it is considered a last resort and also due to the complexity and high costs involved, is often not a high priority in conservation. However, with the onset of climate change it is vital to be

prepared as the fate of some species may depend entirely on ex-situ conservation. The importance of ex-situ conservation should be clearly communicated to decision makers so that it is given due priority when allocating annual budgets, drafting strategies and policies. If adequate priority is given in policy, ex-situ conservation planning and implementation can begin before the threats become too challenging to address.

b) Weak enforcement for improper ex-situ conservation

This barrier can be categorized purely as policy, legal & regulatory. Even though ex-situ conservation is rare, there have been instances where small scale private zoos, parks etc have been set up without due recognition of certain legislation or set up without following the proper procedures. Additionally, in some instances conditions of the facilities, procedures etc may be harmful to animals and therefore enforcement of procedure and protocols are vital. Given that ex-situ conservation will be needed in the future, any laws that need amendment, revision etc should also be addressed before hand.

c) Law facilitates only for some government sector institutions to carry out ex-situ conservation

This barrier has markets failure elements in addition to being policy, legal & regulatory related. According to the current legislation, only some government institutions are mandated to carry out ex-situ conservation. 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 be noted that, even if ex-situ conservation is allowed by external parties, it should be under the strict supervision of the relevant government institution.

Technical and information & awareness barriers

d) Poor understanding on species that may require ex-situ conservation (at present or in the future)

Currently little information is available as to which species urgently require ex-situ interventions. It may not be in the current context, but with the onset of climate change it is necessary to have some idea of such species through predictions. This will enable certain facilities to be set up in advance so that they will be ready when the interventions are actually necessary. Understanding on species that need ex-situ conservation will require a comprehensive analysis on current threats, how climate change will compound the issue etc. Capacity building, technology transfer etc will probably be required for this.

5.6.3 Identified measures

5.6.3.1 Economic & financial measures

a) Barrier*: Lack of proper planning and funding for ex-situ conservation and absence of framework/protocol for reintroduction and monitoring*
Measures(s): *i) Allocate a portion of annual budgets for setting up ex-situ facilities that may be required in the near future.*
ii) Identify ex-situ conservation facilities that are required, prioritize and estimate cost.
iii) Introduce framework/protocol for reintroduction and monitoring.

Currently the planning and funding for ex-situ conservation is minimal. And there is also no proper framework for ex-situ activities such as captive breeding, reintroduction and monitoring. With current threats and impending threats from climate change, it is likely that ex-situ conservation will be necessary for the survival and adaptation of certain species. Therefore, it is important to identify ex-situ conservation facilities that are required, based on level of threat and potential climate change impacts on species and prioritization. Depending on this prioritization, the facilities required should be identified and funds need to be allocated. Ex-situ conservation would mean planning for the future and some facilities and resources (including skills and expertise) would require time and it would be essential to allocate a portion of annual budgets to set up the required facilities so that they will be ready when it is required. Additionally, a framework or protocol for proper ex-situ conservation, including aspects concerning captive breeding, reintroduction, monitoring etc. is essential to ensure it is carried out in the correct manner.

No additional costs will be involved for implementation of item (i) of this measure. The estimated cost of implementing items (ii) and (iii) over a period of 2 years is US$ 2.25 million.

b) Barrier: *Lack of expertise and resources (suitable land/specialized locations, standard protocols) to carry out ex-situ conservation*
Measures(s): *Carry out capacity building on ex-situ conservation; ii) Establish partnerships with species specialists; iii) Facilitate exchange and sharing of knowledge; iv) Provision of suitable resources (eg: land etc) v) Standard protocols for ex-situ conservation (maintenance of facilities, disease control, quarantine etc).*

Inadequacy of expertise and resources is a major constraint barrier for ex-situ conservation. It requires various specialists' knowledge, which will vary depending on type of species to be conserved. Therefore, capacity building of staff is essential on the fundamentals, as well as specialist areas depending on the priorities identified. In order to obtain this expertise it is of utmost importance to begin formalized partnerships with experts both from local and foreign government & research institutions, Universities and specialist organizations. Such partnerships can help ex-situ conservation with little or no cost spent

on capacity building. A mechanism should be set up to facilitate exchange and sharing of knowledge between experts, institutions from both Sri Lanka and abroad to harness expertise on the subject, depending on the requirements. The agency responsible for ex-situ conservation will also need to consider other resources needed such as type of land/habitat, depending on the species to be conserved. Such resources should be acquired at early stages so as to ensure adequate facilities and resources are available to carry out a successful ex-situ conservation program. Standard protocol for ex-situ conservation and also for various aspects mentioned above including captive breeding, possible reintroduction, monitoring, maintaining the facilities etc should be produced and implemented. This is essential to ensure that ex-situ conservation occurs in a professional manner with high standards so that it is successful.

Estimated cost of implementation over a period of 5 years is US$ 1.825 million.

5.6.3.2 Non-financial measures

Policy, legal & regulatory, information & awareness and market failure measures

a). Barrier: *Ex-situ conservation of wild fauna not a high priority in conservation related policies.*
Measure(s): *i) Give ex-situ conservation high priority; ii) Create awareness on its importance*

Currently there are ex-situ conservation facilities and programs for plants species, especially seeds of traditional varieties. However, the ex-situ conservation of faunal species is minimal. There are several highly threatened and point endemic species which include invertebrates, fish species etc that require urgent interventions. Even though some of these smaller faunal species do not require very high costs, they still receive a very low priority in the general conservation agenda. Conservation policies and strategies should prioritize the ex-situ conservation of wild faunal species that are already threatened and also begin planning for those that will face high threats with climate change. The importance of conserving such species should be highlighted and awareness should be created targeting policy/decision makers and also the general public. If such a program is accepted and endorsed by the public, fund raising and convincing decision makers could be easier. Additionally, realization of the importance of conserving such species by the policy and decision makers would facilitate setting up a program with required assistance. There is also potential of revenue generation through eco-tourism if ex-situ conservation is carried out effectively.

Estimated cost of implementation over a period of 2 years is US$ 0.35 million.

b). Barrier: *Weak enforcement for improper ex-situ conservation*
Measure(s): *Enforcement of existing laws for improper ex-situ conservation activities.*

The laws relating to such conservation activities should be implemented whenever ex-situ conservation occurs either legally or illegally. Where the facilities are not maintained properly, monitoring should be carried out and laws enforced. Legal reforms would be required to raise the standards and implement proper protocols. If any ex-situ conservation occurs illegally or in an improper manner it should be stopped forthwith and appropriate legal action has to be taken and penalties should be imposed on such parties.

Estimated cost of implementation over a period of 5 years is US$ 0.15 million.

c). Barrier: *Law facilitates only for some government agencies to carry out ex-situ conservation*
Measure(s): *Introduction of a formalized system to allow ex-situ breeding by other parties, with supervision by relevant government authorities.*

Currently only limited government sector institutions are mandated to carry out ex-situ conservation. It is vital that ex-situ conservation is done in a proper manner according to the laws and regulations of the country. However, some collaboration with other institutions is necessary to secure resources, skills and reduce costs of ex-situ conservation. Therefore other institutions, including private entities should be allowed to carry out ex-situ conservation, with permission and guidance of the relevant government departments such as the Department of Wildlife Conservation. Such institutions should be given a protocol and be monitored by the DWC. Therefore, introduction of a formal system which allows ex-situ breeding etc by other parties is essential if ex-situ conservation is to be successful in the country. Giving overall responsibility to one or two institutions to carry out such a critical task may not be sufficient to face the challenges of climate change.

Estimated cost of implementation over a period of 2 years is US$ 1.04 million.

d). Barrier*: Poor understanding on species that may require ex-situ conservation (at present or in the future).*
Measure(s): *i) Studies including climate change modeling to identify vulnerable species and prioritize species for ex-situ conservation.*

Currently there is limited understanding on which species require ex-situ conservation. The IUCN Red List[75] is one source to identify critical species, which include highly threatened species and point endemics. Additionally, it is important to find out which species will be impacted by climate change and may require ex-situ interventions. Therefore, a comprehensive review of available information and a

[75] IUCN Red List of Threatened Fauna and Flora of Sri Lanka (2007)

study which includes field level research will be essential to determine which species are in dire need of interventions. Climate change modeling to identify species most vulnerable to climate change will also need to be done, to enable proper planning for required interventions and conservation of such species. If species are to be conserved, the process should begin early, before it is too late (and costly) to reverse the trends of declining populations.

Estimated cost of implementation over a period of 3 years is US$ 2.0 million.

5.7 Linkages of the barriers identified

Although the specifics vary from technology to technology, some of the broader/common barriers are highlighted below. However this analysis does not highlight other important barriers that are unique to each technology and those are not linked with each other.

5.7.1 Lack of incentives

The lack of incentives is one of the major barriers identified for various technologies. This is especially with the case of Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience*. In case of Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)*, currently there are no incentives given to protect isolated forest patches/ecosystems in private land (plantations/home gardens etc).

5.7.2 Low funding availability

Inadequate financial provision is a barrier for all the technologies. These include Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)*; Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones;* Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems* – currently there is minimal funding allocated for protecting highly threatened species and Technology 5, which focuses on *ex-situ conservation for highly threatened species and possible reintroduction*. The availability of low funding under the current scenario reflects the inadequate priority given for technologies essential for biodiversity adaptation to climate change.

5.7.3 Lack of understanding, awareness and appreciation of value of biodiversity/ecosystems.

Poor understanding/ lack of awareness and appreciation of value of biodiversity / ecosystems is a significant barrier. Such understanding is vital amongst political, general public and decision makers for the success of interventions. With regard to Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* the true value of restoration and its contribution to ecosystem services is not known. In the case of Technology 2 -*Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)*, the value and benefits of connectivity unknown and there is also a lack of communication and awareness. For Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*, poor awareness by 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 5 - *Ex-situ conservation for highly threatened species and possible reintroduction,* there is poor understanding on species that may require ex-situ conservation under the present context and for a future climate change related scenario as well.

5.7.4 Insufficient capacity

Lack of capacity, which includes expertise/skills and other resources, is also a major barrier for biodiversity adaptation. In the case of Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience*, there is insufficient technical capacity of the available technologies. For Technology 3 -*Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones*, currently there is insufficient capacity in terms of number of personnel, knowledge, vehicles for adequate management and monitoring. Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*, the main barrier is insufficient knowledge on species management strategies within the relevant authorities. With regard to Technology 5 -*Ex-situ conservation for highly threatened species and possible reintroduction,* lack of expertise and resources (suitable land/specialized locations, standard protocols) to carry out ex-situ conservation is a barrier.

5.7.5 Lack of information, research, climate modeling

For Technology 3-*Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones*, the lack of ecological information in protected areas are significant barriers. For Technology 4 -*Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*, the lack of information (including modeling) on potential climate change impacts on species/ecosystems, inadequate information on

threatened species (distribution data, ecological information including population size and genetics, n-situ research), and the lack of focused research on habitats for species migration are significant barriers.

5.7.6 No prioritization and use of climate models for this purpose

Research, studies, and a comprehensive analysis are necessary to identify conservation priorities. Climate change modeling is an essential tool for this purpose. In the case of Technology 1 – *Restoration of degraded areas inside and outside the protected area network to enhance resilience*, currently there is no national level prioritization scheme to identify the most important areas for restoration. For Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement*), critical areas for connectivity and priorities have not been identified at a national scale. For Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction*, ex-situ conservation of wild fauna not a high priority in conservation related policies.

5.7.7 Pressure from development/competing land use

Pressure for land for other development activities is a major constraint for Technology 1 – *Restoration of degraded areas inside and outside the protected area network to enhance resilience*. This is also an issue for Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement).* For Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones,* the demand for land (for medium/large projects) from proposed reserves/parks without utilizing the already cleared and degraded lands found outside the protected area system is a major barrier.

5.7.8 Weak law enforcement and implementation of policies

This is a major barrier for Technology 2-*increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement),* as high altitudinal (montane) areas are poorly protected due to non-enforcement of management plans and relevant laws. For Technology 3 -*Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones,* the non-implementation of existing management plans due to lack of resources is a major barrier. Also the insufficient physical demarcation of some protected area boundaries and all buffer zones together with the lack of enforcement of boundaries and awareness on boundaries is considered a serious constraint. In the case of Technology 5 -*Ex-situ conservation for highly threatened species and possible reintroduction*, weak enforcement for improper ex-situ conservation is a barrier.

5.7.9 Lack of partnerships

For Technology 1 – *Restoration of degraded areas inside and outside the protected area network to enhance resilience*, there is a lack of partnerships for restoration and management of lands outside protected areas. For Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones,* there is a lack of inter agency coordination where adjacent protected areas are managed by different authorities. For Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*, currently there are insufficient partnerships for species conservation.

5.8 Enabling framework for overcoming the barriers in the Biodiversity Sector

5.8.1 Common barriers and their enabling framework

The previous section identified some of the common barriers which can be broadly categorized into lack of incentives; low funding availability; lack of understanding, awareness & appreciation of value; insufficient capacity; lack of information, research, climate modeling; no prioritization and use of climate models for this purpose; pressure from development/competing land use; inadequate law enforcement and implementation of policies; and lack of partnerships.

Thus the enabling framework for the common barriers could be categorized broadly as follows (Table 5.3):

Table 5.3: Common barriers and their enabling framework in the Biodiversity Sector

No	Broad/common barriers	Enabling framework	Technology
1.	Lack of incentives	i) Create incentives for facilitating the diffusion of appropriate technologies for biodiversity adaptation	1 & 2
2.	Low funding availability	i) Recognize the need for funding at the National Planning level. ii) Incorporate such needs in External Resource Department and National Planning Department planning for external fund raising/obtaining funds, allocating from annual budgets for adaptation	1, 2, 3, 4 & 5
3.	Lack of understanding,	i) Create understanding through effective	1, 2, 4 & 5

	awareness and appreciation of value of biodiversity and ecosystems	awareness programs and innovative communication	
4.	Insufficient capacity	i) Capacity building and resource allocation	1, 3, 4 & 5
5.	Lack of information, research, climate modeling	i) Carry out studies, research and climate modeling to generate information	3 & 4
6.	No prioritization and use of climate models for this purpose	i) Carry out prioritization based on needs, urgency with the use of climate models	1, 2 & 5
7.	Pressure from development/competing land use	i) Engage tools such as Strategic Environmental Assessments for planning and implementation of both development and conservation programs. ii) Reduce pressure from development/competing land use by providing alternatives, encouraging compatible land use activities and providing incentives to utilize abandoned/brown field sites.	1, 2 & 3
8.	Weak law enforcement and implementation of policies	i) Strengthen agencies implementing existing legal framework and policies	2, 3 & 5
9.	Lack of partnerships	i) Recognize partnerships as effective means for implementing technologies at the policy level. ii) Create effective partnerships with other government institutions, NGOs, universities and private sector to implement adaptation technologies	1, 3 & 4

Enabling framework for common barriers in detail:

(1) Create incentives for facilitating the diffusion of appropriate technologies for biodiversity adaptation

Lack of incentives for facilitation of diffusing appropriate technologies for biodiversity adaptation is a major barrier for several technologies viz; Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience; and* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement).* As technologies for biodiversity adaptation are costly, incentives are required to encourage

other institutions to invest in such programs. Incentives could include tax breaks, subsidies, and cash payments etc.

(2) Recognize the need for funding at the National Planning level. Incorporate such needs in External Resource Department planning for external fund raising/obtaining funds, allocating from annual budgets for adaptation

Inadequate funding is a major constraint for technologies such as Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement);* Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones;* Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*; and Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction.* Securing funds is critical to implement the above technologies as these are costly, but yet important for biodiversity adaptation. Thus, financial needs should be recognized at the National Planning level. Such needs should be incorporated in External Resource Department and National Planning Department planning processes for external fund raising/obtaining funds. Additionally allocating from annual budgets for adaptation is also necessary.

(3) Create understanding through effective awareness programs and innovative communication

Inadequate understanding, awareness and appreciation of ecosystem values is a major constraint for several technologies, and therefore it is vital to create understanding through effective awareness programs and innovative communication methodologies. This should be carried out for the following technologies: Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement)*; Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*; and Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction*

(4) Capacity building and resource allocation

Insufficient in-house capacity is a major barrier for most of the technologies for biodiversity adaptation. Capacity building and resources allocation will be essential to address this issue. Capacity building, especially on specialist knowledge required by the respective technology, climate modeling etc will be necessary for the successful implementation of adaptation interventions. Resource allocation will also be necessary to ensure meeting material needs such as equipment required for the implementation of the technologies. Capacity building and adequate resource allocations is a priority for Technology 1 -

Restoration of degraded areas inside and outside the protected area network to enhance resilience; Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones*; Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems*; and Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction.*

(5) Carry out studies, research and climate modeling

Lack of information, research and climate modeling is a major barrier for certain technologies. Therefore it is essential to carry out studies, research and climate modeling to generate information. This is necessary for Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones*; and Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems.*

(6) Carry out prioritization based on needs, urgency with the use of climate models

Currently prioritization of sites, species for technologies is not available thus preventing the most urgent issues from being addressed. Therefore carrying out prioritization based on needs and urgency of actions with the use of climate models is essential. This is necessary for Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement);* and Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction.*

(7) Utilize tools such as Strategic Environmental Assessments for planning and implementation of both development and conservation programs. Reduce pressure on lands from development/competing land use practices by providing alternatives, encouraging compatible land use activities and also developing incentive schemes to utilize abandoned/brown field sites.

Pressure for lands from economic development ventures and other competing uses is a major constraint to implement several technologies. Pressure from development/competing land use can be reduced by providing alternatives, encouraging compatible land use activities and also by providing incentives to utilize abandoned/brown field sites. Additionally, it is vital to engage tools such as Strategic Environmental Assessments (SEA) for planning and implementation of both development and conservation programs. This is required for Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement);* and Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones.*

(8) Strengthen agencies implementing existing legal framework and policies

The non-implementation of the existing legal framework and policies is a major constraint for implementing most of the technologies. Implementation of existing legal framework and policies is vital for the success of Technology 2 - *Increasing connectivity through corridors, landscape/matrix improvement and management (includes altitudinal and other movement);* Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones;* and Technology 5 - *Ex-situ conservation for highly threatened species and possible reintroduction.*

(9) Policy level recognition of partnerships as effective means for implementing technologies. Create effective partnerships with other government institutions, NGOs, Universities and private sector entities to implement adaptation technologies

Currently there is a lack of partnership arrangements for biodiversity conservation. Therefore it is essential to create an enabling framework for effective partnerships with other government institutions, NGOs, universities and private sector to implement biodiversity related adaptation programs. Commitment at the policy is also vital to facilitate such a partnership arrangement as an effective means for implementing the technologies. Partnerships are considered necessary for Technology 1 - *Restoration of degraded areas inside and outside the protected area network to enhance resilience;* Technology 3 - *Improve management, and possibly increase extent of protected areas, buffer zones and create new areas in vulnerable zones;* and Technology 4 - *Focus conservation resources and carryout special management for restricted range, highly threatened species and ecosystems.*

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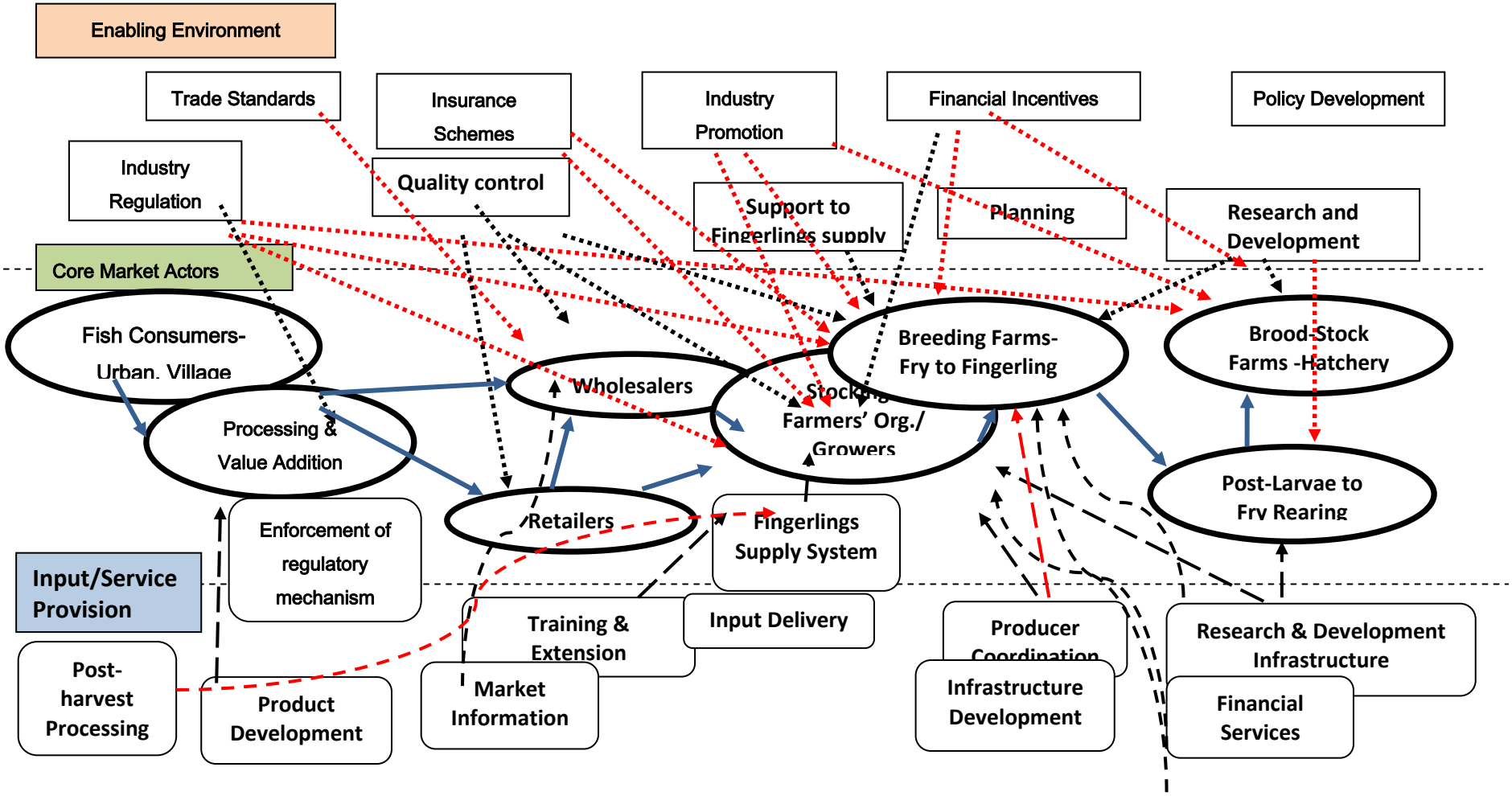
Annex I

Market Maps

FOOD SECTOR

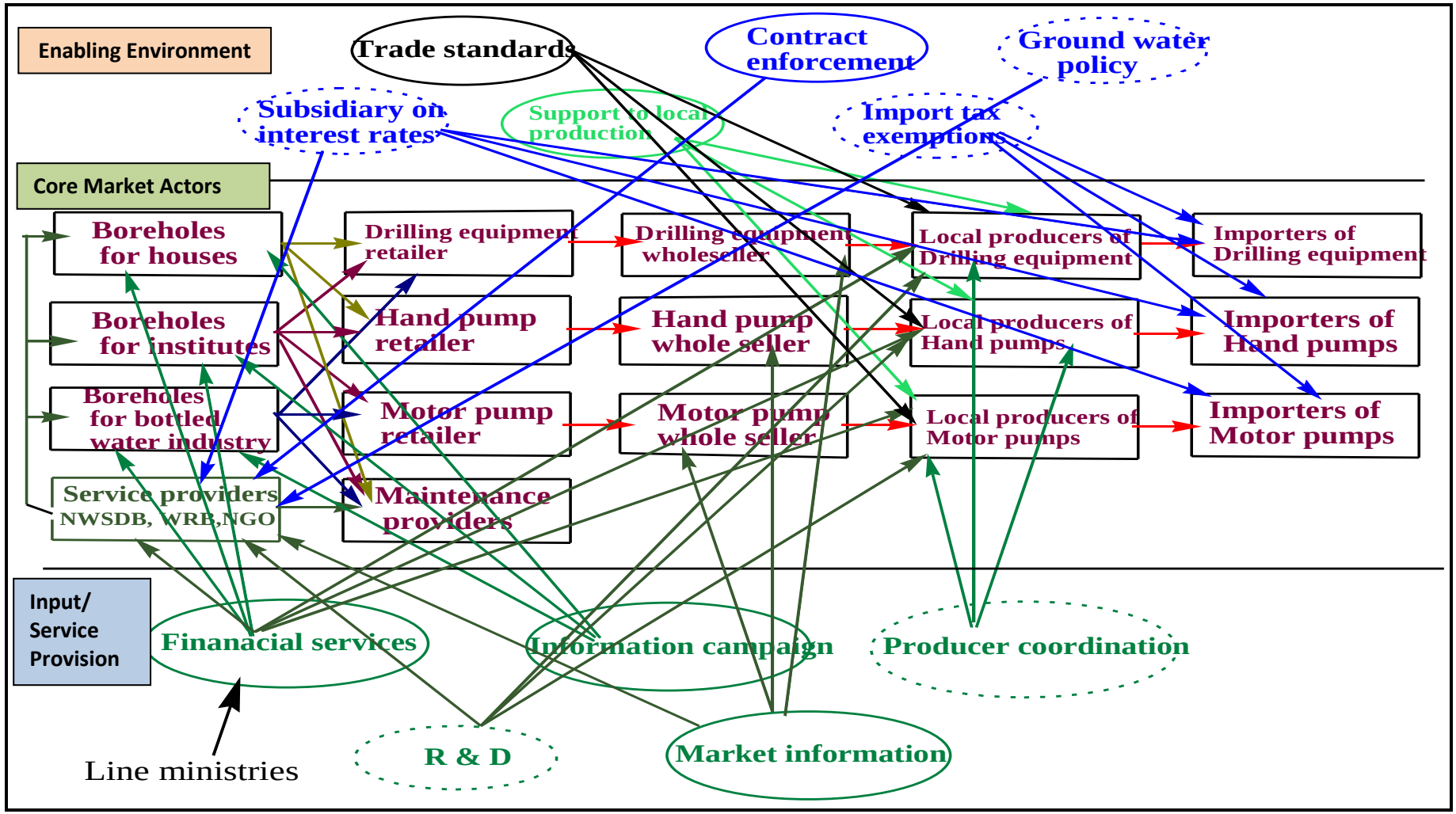
Market Map for Technology 1: Sustainable Inland Culture Based Fisheries



Legend for Market Map of Technology 1 - Food Sector: Sustainable Inland Culture Based Fisheries	
Enabling Environment	Enabling environment for promoting market chain.
	Legal & regulatory environment for promoting market chain, i.e. Industry regulations, insurance, financial incentives, R & D, Promotional activities etc.
	Other aspects of enabling environment for promoting market chain, i.e. quality control, R &D, incentives etc.
Core Market Actors	Core Market Actors i.e. Fish consumers, Processing industry, Retailers, Wholesalers, Stoking, Breeding farms, Hatcheries, Fry rearing etc.
Service Providers	Inputs & services to support the market chain
	inputs & services to support stocking and breeding farms
	Inputs & services to support processing & value addition, wholesalers & stocking. Financial services to Farmer organizations, growers & breeding farms

WATER SECTOR

Market map for Technology 3: Borehole Technology


Enabling Environment
Trade standards
Contract enforcement
Ground water policy
Subsidiary on interest rates
Support to local production
Import tax exemptions
Core Market Actors
Boreholes for houses
Boreholes for institutes
Boreholes for bottled water industry
Service providers NWSDB, WRB,NGO
Drilling equipment retailer
Hand pump retailer
Motor pump retailer
Maintenance providers
Drilling equipment wholeseller
Hand pump whole seller
Motor pump whole seller
Local producers of Drilling equipment
Local producers of Hand pumps
Local producers of Motor pumps
Importers of Drilling equipment
Importers of Hand pumps
Importers of Motor pumps
Input/ Service Provision
Finanacial services
Information campaign
Producer coordination
Line ministries
R & D
Market information

Legend for Market Map of Technology 3 - Water Sector: Borehole Technology	
Enabling Environment	Enabling environment for promoting market chain.
	Enabling legal & policy environment for promoting market chain, i.e. Interest rates, Contract enforcement, Ground water policy, Tax exemptions etc.
	Other aspects of enabling environment for promoting market chain, i.e. Favorable trade standards to promote local producers.
	Support to local production. i.e. Support to local producers of drilling equipments, hand pumps & motor pumps etc.
Core Market Actors	Core Market Actors i.e. Borehole users, Retailers, Wholesalers, Local producers, Importers of pumps & equipments.
Service Providers	Inputs & services to support the market chain
	Inputs & services to support the market actors. i.e. Financial services, R & D, Supply of information, Coordination etc.

Annex II

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

Individual interview List –

1) Dr. W.M.W. Weerakoon, Director	Field Crops Research and Development Institute	Department of Agriculture, Mahailuppallama
2) Dr. . B.V.R. Punyawardene Head, Climatology	Natural Resource Management Centre	Department of Agriculture, Sarasavi Mawatha, Peradeniya.
3) Dr. Priyantha Weerasinghe, Research Officer	Horticultural Crop Research & Development Institute	Gannoruwa, Peradeniya
4) Mr. D.M.R.D. Dissanayake, Executive Director	Hadabima Authority	PO Box 09, Gannoruwa Rd, Peradeniya

5)	Mr. T.H. Stanly Perera, Director	Socio Economic & Planning Centre	Department of Agriculture, Peradeniya
6)	Dr. W. M.H.K. Wijenayake, Senior Lecturer	Department of Aquaculture and Fisheries, Wayamba University of Sri Lanka.	Gonawila, Makandura

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 Hidellage,	Regional Director, Practical Action	5, Lionel Edirisinghe Mawatha 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

No	Name	Institution	Contact Address
1.	Mr. Anura Sathurusinghe	Conservator of Forest (Research & Education)	Forest Department Sampathpaya, Battaramulla
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. Program 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

Annex III

Policy Fact Sheets

FOOD SECTOR

Policy Fact Sheet 1: National Agriculture Policy

Name of the Policy	**Sri Lanka National Agriculture Policy**
Name of field	agriculture
Date Effective	2006
Date Announced	2006
Date Promulgated	2006
Date Ended	In force
Unit	
Country	Sri Lanka
Policy Status	National Policy
Agency	Ministry of Agriculture Ministry of Agriculture and Agrarian Services (at the time of formulation)
Funding	Budgeted or disbursed public funding for the policy/program. Can be broken down by year, and for total program length. If relevant and possible, national and international public funding, as well as any private funding (co-financing or leveraged) should be indicated.
Enforcement	Ministry of Agriculture
Penalty	None
Related Policies	National Land Use Policy (draft)
Policy Superseded by	N.A.
Policy Supersedes	N.A.
Stated Objective	Food Security
Evaluation	N,.A.
Policy Type	Agriculture
Policy Target	No targets sey.
URL	
Legal References	Ministry of Agriculture
Description	Increase domestic Agricultural production to ensure food and nutrition

	security of the nation. Enhance agricultural productivity and ensure sustainable growth. Maximize benefits and minimize adverse effects of globalization on domestic and export agriculture Adopt productive farming systems and improved agro-technologies with a view to reduce the unit cost of production and increase profits Adoption of technologies in farming that are environmentally friendly and harmless to health Promote agro-based industries and increase employment opportunities Enhance the income and the living standard of farming community

FOOD SECTOR

Policy Fact Sheet 2: National Land Use Policy

Name of the Policy	National Land Use Policy of Sri Lanka
Name of field	Land use and Policy Planning
Date Effective	2007.01.10
Date Announced	2007.01.10
Date Promulgated	2006
Date Ended	In force
Unit	
Country	Sri Lanka
Policy Status	National Policy
Agency	Ministry of Land and Land Development
Funding	Budgeted or disbursed public funding for the policy/program. Can be broken down by year, and for total program length. If relevant and possible, national and international public funding, as well as any private funding (co-financing or leveraged) should be indicated.
Enforcement	Ministry of Land and Land Development
Penalty	None
Related Policies	National Agricultural Policy, National Watershed Management Policy
Policy Superseded by	N.A.

Policy Supersedes	N.A.
Stated Objective	Ensure food security, a high quality of life, equity and ecological sustainability
Evaluation	N,.A.
Policy Type	Land Use Policy Planning
Policy Target	No targets set.
URL	
Legal References	Ministry of Land and Land Development
Description	- Prioritize agriculturally oriented uses relevant to the strengthening of national economy in order to ensure present and future food security - Expand the role of the state in matters related to lands i.e. In addition to the allocation of land, provide guidance for the productive utilization of the land resources. - Prevent the under use and improper use of lands. - Promote the capability of the land as a source of generating employment. - Rational allocation of land for different purposes and promotion of land suitability evaluation. - Protect, conserve and manage all sources of water on state as well as private lands. - Bring about a rational distribution of population and settlement in order to achieve a balanced regional development and orderly economic growth. - Minimize fragmentation of agricultural lands. - Prevention of encroachment of lands. - Introduce effective tenure reforms to promote the efficient use of land resources. - Take steps to minimize the vulnerability of land to natural and human induced hazards. - Promote land uses that minimize environmental hazard. - Promote gender equity in the ownership, utilization and conservation of lands. - Conserve bio-diversity.

HEALTH SECTOR

Policy Fact Sheet 1: Mahinda *Chinthanaya*

Name of the Policy	**Mahinda *Chinthanaya* – National Policy Framework**
Name of Field	Over all development policies of the government
Date Effective	From 2006
Date Announced	Last quarter of 2005
Date Promulgated	Since 2006
Date Ended	Ongoing
UNIT	All Ministries, Departments, corporations, Boards and Statutory Bodies are involved one way or the other. The best available data base to get information on all the above and even UN, NGOO and Private sector is the Government web portal, which is, http://www.gov.lk
Country	Sri Lanka
Policy Status	In force
Agency	As mentioned against 'UNIT'
Funding	Generally from the consolidated fund from the government there are co-funding partners from UN agencies, NGOO, Other International Agencies (ICRC, IFRC, JICA, ADB, ECHO, EU etc. And other donors.
Further information	Can be obtained from the link given against 'UNIT'
Enforcement	Yes, with regard to Environmental issues the CEA, which is under the Ministry of Environment.
Penalty	Yes and depends on the offence or violation of the respective act
Related Policies	Human resource development policy, Health Policy of Sri Lanka, Environmental health (draft), Healthcare Waste Management (draft), Policy on Risk Management, Dengue Prevention act and regulations
Policy supersede by	Yes
Policy supersedes	Yes
Stated objective	Sustainable development in all direction with minimal effect on environment
Evaluation	Individual agencies are evaluating the outcome of the projects and programs implemented and reports are available. In addition auditor General's Department is conducting an annual auditing process in the government sector annually.

Policy Type	Include many sectors, Industry, transport, environmental conservation, health, Education, Trade and tariff, Agriculture, Land to mention a few
Policy target	Sustainable development with minimal destruction to the environment
URL	http://www,gov.lk
Legal References	Attorney Generals Department, Ministry of Justice
Description	Sectors involved: Poverty alleviation, sustainable development, agriculture, education, health, environmental protection, energy and transport policies, science and technology policies, nation building, shelter, water and sanitation with some others. Donor agencies, international agencies, UN, NGOO, CBO and the Private sectors are partners in many projects. There is no set time target for many, but generally there are many projects which are time bound.

WATER SECTOR

Policy Fact Sheet 1: National Rainwater Policy and Strategies

Name of the policy	**National Rainwater Policy and Strategies**
Name of field	
Date effective	June 2005
Date announced	N.A.
Date promulgated	Sept. 2005
Date ended	In force
Unit	N.A.
Country	Sri Lanka
Policy status	National Policy
Agency	Ministry of Urban Development and Water Supply and the National Water Supply and Drainage Board jointly with the Lanka Rain Water Harvesting Forum.
Funding	Ministry of Urban Development and Water Supply
Further information	N.A.
Enforcement	Ministry of Urban Development and Water Supply
Penalty	N.A
Related Policies	

Policy Supervised by	Ministry of Urban Development and Water Supply
Policy Supersedes	
Stated Objective	To ensure that the 'City of Tomorrow' applies Rain Water Harvesting broadly, by the control of water near its source, in its pursuance of becoming a 'Green City' in the future.
Evaluation	N.A
Policy type	
Policy target	N.A
URL	
Legal references	N.A
Description	Rainwater harvesting shall be 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.

WATER SECTOR

Policy Fact Sheet 2: Participatory Irrigation Management (PIM) Policy

Name of the policy	Participatory Irrigation Management (PIM) Policy
Name of field	
Date effective	
Date announced	December 1988
Date promulgated	
Date ended	In force
Unit	
Country	Sri Lanka
Policy status	National Policy
Agency	
Funding	Under three government-sponsored programs: • The Integrated Management of Irrigation Schemes (INMAS) • The Management of Irrigation Systems (MANIS) program and in the systems under the Mahaweli Development Project.

	• Management reforms in the minor irrigation systems were implemented by the Department Agrarian Development (formerly Department of Agrarian Services).
Further information	N.A
Enforcement	
Penalty	N.A
Related Policies	National Watershed Management Policy
Policy Supervised by	N.A
Policy Supersedes	N.A
Stated Objective	
Evaluation	N.A
Policy type	
Policy target	
URL	
Legal references	
Description	• 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 FOs in charge of O&M of irrigation facilities below the distribution canal head.

WATER SECTOR

Policy Fact Sheet 3: National policy on Drinking Water

Name of the policy	**National policy on Drinking Water**
Name of field	
Date effective	2009
Date announced	N.A
Date promulgated	2009
Date ended	In force
Unit	

Country	Sri Lanka
Policy status	National Policy
Agency	The Ministry of Water Supply & Drainage, The National Water Supply & Drainage Board
Funding	The Ministry of Water Supply & Drainage
Further information	N.A
Enforcement	The Ministry of Water Supply & Drainage
Penalty	N.A
Related Policies	
Policy Supervised by	The Ministry of Water Supply & Drainage
Policy Supersedes	N.A
Stated Objective	The Policy aims at providing a direction to all stakeholders in the Drinking Water Sector in. i. Achieving the goals and objectives set by the government. ii. Resolving issues related to qualitative and quantative aspects. iii. Promoting commitment of service providers and users for sustainable utilization of drinking water.
Evaluation	N.A
Policy type	Management of drinking water
Policy target	To build a well coordinated and structured institutional set up which will ensure efficient and effective service delivery ensuring water safety and long term sustainability of rural and urban sub sectors.
URL	
Legal references	N.A
Description	The scope covered under this Policy aims at 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. This policy too aims at providing guidance to all the actors involved in the sector including the Ministry of Water Supply & Drainage, the NWSDB, Provincial Councils & Local Authorities, Lending Institutions, External Supporting Agencies, Community Based Organizations (CBOs), Non Governmental Organizations (NGOs) and the user. The policy covers institutional arrangements, cost recovery, investment, conservation, source protection, service level, R&D, quality assurance and regulatory aspects.

WATER SECTOR

Policy Factsheet 4: The National Policy on Water Supply and Sanitation

Name of the policy	**The National Policy on Water Supply and Sanitation**
Name of field	Drinking water provision and sewage and sanitation services
Date effective	2000
Date announced	N.A
Date promulgated	2000
Date ended	In force
Unit	CC: Climate Change
Country	Sri Lanka
Policy status	National Policy
Agency	Ministry of Housing and Plantation Infrastructure
Funding	• Establishment of a regulatory commission for water supply and sanitation services • Contracting of private operators in selected areas to improve operational efficiency • Provide private sector operational finance
Further information	Reference - Secure Water Through Demand Responsive Approaches- (ref:)The Sri Lankan Experience; Rajindra De S. Ariyabandu and M.M.M. Aheeyar
Enforcement	
Penalty	N.A
Related Policies	N.A
Policy Supervised by	Ministry of Housing and Plantation Infrastructure
Policy Supersedes	
Stated Objective	• To provide a frame work for the supply of safe drinking water and access to sanitation services • Contracting of private operators in selected areas to improve operational efficiency • To provide private sector operational finance • A division for rural water supply and sanitation will be set up under the Ministry
Evaluation	

Policy type	
Policy target	• Provision of drinking water from bulk water supply to consumers through piped networks and other means such as tankers, tube and dug wells, and other community distribution systems. • Access to sanitation services
URL	
Legal references	N.A

WATER SECTOR

Policy Factsheet 5: National Policy for Rural Water Supply & Sanitation Sector

Name of the policy	National policy for Rural Water Supply & Sanitation Sector
Name of field	
Date effective	July 2001
Date announced	July 2001
Date promulgated	2001
Date ended	In force
Unit	
Country	Sri Lanka
Policy status	National Policy
Agency	Ministry of Urban Development, Construction & Public Utilities
Funding	Government, International donors, Local Authorities, NGOs and Community Based Organizations
Further information	Ministry of Urban Development, Construction & Public Utilities
Enforcement	
Penalty	N.A
Related Policies	N.A
Policy Supervised by	Ministry of Urban Development, Construction & Public Utilities
Policy Supersedes	
Stated Objective	Introducing "people centered" and "demand driven" implementation mechanism with the objective of creating access for rural communities while implementing urban sector mega water and sanitation projects

Evaluation	
Policy type	
Policy target	N.A
URL	
Legal references	N.A
Description	The government will assist the promotion of the hygiene education as an integral part of the Rural Water Supply Sector (RWSS) Sector development

WATER SECTOR

Policy Factsheet 6: National Environment Policy

Name of the policy	National Environment Policy
Name of field	Environmental Protection
Date effective	2003
Date announced	2003
Date promulgated	2003
Date ended	In force
Unit	
Country	Sri Lanka
Policy status	National Policy
Agency	Ministry of Environment
Funding	Government of Sri Lanka and UNEP/GEF
Further information	
Enforcement	By Ministry of Environment through, Climate Change Secretariat (CCS) to serve as a node for the implementation of UNFCCC decisions including the preparation of the GHG Inventory and the country's National Communications.
Penalty	N.A
Related Policies	National Watershed Management Policy
Policy Supervised by	Ministry of Environment
Policy Supersedes	
Stated Objective	Protection and conservation of 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.
Evaluation	Not done
Policy type	Environmental Protection
Policy target	To achieve a healthy and pleasant environment sustaining nature for the well-being of the people and the economy
URL	http://www.theredddesk.org/policy/national_environment_policy_sri_lanka
Legal references	
Description	• The quality and quantity of surface water, ground water, coastal waters will be managed to balance the current and future needs of ecological systems, communities, agriculture, fisheries, industry and hydroelectric generation. • The policy supports securing land tenure rights including use rights on state land and long-term tenure for chena farmers. It is open to alternative mechanisms and policy tools to provide incentives while minimizing compliance costs to benefit the environment, the society and the economy. It emphasizes participation, transparency and public accountability in the management of natural resources.

COASTAL SECTOR

Policy Factsheet 1: National Policy on Wetlands

Name of the policy	**National Policy on Wetlands**
Name of field	
Date effective	2005
Date announced	N.A
Date promulgate	2005
Date ended	In force
Unit	
Country	Sri Lanka
Policy status	National Policy
Agency	Ministry of Environment
Funding	
Further information	

Enforcement	Central Environment Authority of Sri Lanka
Penalty	N.A
Related Policies	National Forest Policy, National Policy on Wild Life Conservation
Policy Supervised by	Ministry of Environment
Policy Supersedes	N.A
Stated Objective	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.
Evaluation	
Policy type	
Policy target	**Conserve wetlands** in order to enhance ecosystem services from wetland habitats and to assure sustainable use of wetlands and traditional practices by local communities
URL	http://www.theredddesk.org/fr/countries/sri_lanka/info/policy/national_policy_on_wetlands_sri_lanka http://www.ramsar.org/pdf/lib/lib_handbooks2006_e02.pdf
Legal references	

BIODIVERSITY SECTOR

Policy Factsheet 1: National Climate Change Policy

Name of the Policy	**The National Climate Change Policy of Sri Lanka**
Name of field	Climate change
Date Effective	Came into for force in January 2012 (published date)
Date Announced	2011
Date Promulgated	2012
Date Ended	In force
Unit	Climate Change Secretariat, Ministry of Environment
Country	Sri Lanka
Policy Status	In force
Agency	Ministry of Environment
Funding	Government of Sri Lanka, UNEP/GEF

Further Information:	Currently not available
Enforcement	If any particular enforcement provisions, institutions etc. Climate Change Secretariat, Ministry of Environment
Penalty	Not applicable
Related Policies	National Environmental Policy
Policy Superseded by	Not applicable
Policy Supersedes	Not applicable
Stated Objective	**Vision** – A future where climate change will have no adverse consequences on Sri Lanka **Mission** – Addressing climate change issues locally while engaging in the global context **Goal** – Adaptation to and mitigation of climate change impacts within the framework of sustainable development. **Objectives** – • Sensitize and make aware the communities periodically on the country's vulnerability to climate change. • Take adaptive measures to avoid/minimize adverse impacts of climate change to the people, their livelihoods and ecosystems. • Mitigate greenhouse gas emissions in the path of sustainable development. • Promote sustainable consumption and production. • Enhance knowledge on the multifaceted issues relating to climate change in the society and build their capacity to make prudent choices in decision-making. • Develop the country's capacity to address the impacts of climate change effectively and efficiently. • Mainstream and integrate climate change issues in the national development process.
Evaluation	Not applicable
Policy Type	Climate change
Policy Target	Not applicable
URL	
Legal References	Not applicable
Description	A description of the policy, with a reasonable amount of detail. It should

	clearly indicate major aims, requirements and functioning of the policy, the stakeholders involved, the time frames involved, etc. If possible, information on impacts, effects, or achievements of the policy are welcome.

BIODIVERSITY SECTOR

Policy Factsheet 2: National Forest Policy (NFP)

Name of the policy	**National Forest Policy (NFP)**
Name of field	Biodiversity & sensitive ecosystems
Date effective	1995
Date announced	1995
Date promulgated	1995
Date ended	In force
Unit	Ministry of Environment
Country	Sri Lanka
Policy status	National Policy
Agency	Forest Department
Funding	Government of Sri Lanka, Donor Agencies
Further information	
Enforcement	Forest Department
Penalty	N.A
Related Policies	National Policy on Wildlife Conservation and National Land Use Policy and other policies dealing with Rural Development and tourism etc
Policy Supervised by	Ministry of Environment
Policy Supersedes	
Stated Objective	• 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. • 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.

Evaluation	
Policy type	National Policy
Policy target	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
URL	http://www.forestdept.gov.lk/web/index.php?option=com_content&view=article&id=110&Itemid=105&lang=en
Legal references	
Description	The forestry policy approved by the government in 1995 states that all the forest areas are to be managed in a sustainable manner. It also recognizes and respects the traditional rights, cultural values and religious beliefs of people living in and adjacent to forest areas. There are adequate provisions for collaborative management of protected areas and for benefit sharing. Based on the National Forest Policy the current Forestry Sector Master Plan was prepared in 1995 covering bio-physical, environmental, socio-political, and economic aspects of the forestry sector. The plan covers the period 1995-2020. The Forestry Sector Master Plan puts particular emphasis on: • Conserving the remaining natural forests to maintain biological resources (flora & fauna) as reservoirs of biodiversity. • Empowering people and rural communities to manage and protect multiple use forests mainly for their own benefit. • Building partnerships in forestry development activities. • Developing home garden and other agro forestry systems as well as forest plantations to meet peoples basic needs and to supply industrial wood. • Policy and legal reforms. • Developing and strengthening forestry institutions, both state and NGOs.

BIODIVERSITY SECTOR

Policy Factsheet 3: National Policy on Wild Life Conservation

Name of the policy	**National Policy on Wild Life Conservation**
Name of field	Wild life conservation and Protected Area Management
Date effective	9th June 2000
Date announced	
Date promulgated	2000
Date ended	In force
Unit	
Country	Sri Lanka
Policy status	National Policy
Agency	Department of Wildlife Conservation (DWLC)
Funding	Government of Sri Lanka, Donor Agencies
Further information	
Enforcement	
Penalty	N.A
Related Policies	Policies related to Environment, Forest, Biodiversity
Policy Supervised by	
Policy Supersedes	

Stated Objective	• 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, with particular regard to primary production, hydrological balance, nutrient cycles, and prevention of erosion, siltation, drought and flood. • 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 new product and processes through bio-prospecting. • To ensure sustainable use and equitable sharing of benefits, arising from the direct and indirect use of wildlife resources and ecosystems. • 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
Evaluation	
Policy type	
Policy target	Conserve wildlife and nature by the sustainable utilization of men, material and land through participatory management, research, education and law enforcement and ensure the maintenance of biodiversity and forest cover as exist today
URL	http://203.143.23.34/index.php/policies-a-legislations.html
Legal references	
Description	The National Wildlife Policy involves the commitment of Government to conserve wildlife resources for the benefit of present and future and research in a transparent and equitable manner. It does so by linking together the activities, interests and perspectives of the people who use and benefit from wildlife resources with those of professional wildlife managers and scientists. It is the intention of Government to define a strategy to implement this policy through a Biodiversity Conservation Action Plan, supported by such legislative measures as may be necessary to achieve harmony and success among all those who seek to promote conservation and sustainable development in Sri Lanka.