Republic of Mauritius

TECHNOLOGY NEEDS ASSESSMENT

TECHNOLOGY ACTION PLAN & PROJECT IDEA REPORT FOR ADAPTATION

AGRICULTURE, WATER & COASTAL ZONE TNA REPORT III & IV

August **2013**

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TNA REPORT III

TECHNOLOGY ACTION PLAN ADAPTATION

(WATER, AGRICULTURE AND COASTAL ZONE)

(August 2013)

Disclaimer

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List of Acronyms

AREU	Agricultural Research and Extension Unit
CBA	Cost Benefit Analysis
CWA	Central Water Authority
GFD	Gravity Fed Drip
EE	Energy Efficiency
EIA	Environment Impact Assessment
EPA	Environment Protection Act
ESA	Environmentally Sensitive Areas
FAO	Food and Agriculture organization
FI	Financial Institution
GAP	Good Agricultural Practices
GEF	Global Environment Facility
IA	Irrigation Authority
IAEA	International Atomic Energy Agency
IFAD	International Fund for Agricultural Development
IOS	Indicators of Success
IPM	Integrated Pest Management
LPA	Logical Problem Analysis
MAIFS	Ministry of Agro Industry and Food Security
MI	Micro-irrigation
MSIRI	Mauritius Sugar Research Institute
MCIA	Mauritius Cane Industry Authority
MW	Mega Watt
NGO	Non-Governmental Organisation
NPV	Net Present Value
PV	Photovoltaic
RE	Renewable Energy
RET	Renewable Energy Technology
RWH	Rainwater Harvesting
SFWF	Small Farmers Welfare Fund
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WRU	Water Resources Unit

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1. Prime Minister's Office (Mauritius Meteorological Services , Mauritius Oceanography Institute)
2. Ministry of Energy and Public Utilities (Water Resources Unit, Wastewater Management Authority, Central Water Authority)
3. Ministry of Finance & Economic Development (Statistics Mauritius)
4. Ministry of Public Infrastructure, National Development Unit, Land Transport and Shipping (Land Transport Division, National Development Unit)
5. Ministry of Education and Human Resources
6. Ministry of Agro Industry and Food Security (Agricultural services, Agricultural Research Extension Unit, Food and Agricultural Research Council, Forestry Service, National Parks and Conservation Service, Irrigation Authority, Farmer's Service Corporation, Sugar Cane Planter's Association and Small Planters Welfare Fund)
7. Ministry of Environment and Sustainable Development
8. Ministry of Tertiary Education, Science, Research and Technology (Mauritius Research Council)
9. Ministry of Fisheries
10. Ministry of Local Government and Outer Islands (Outer Islands Development Corporation)
11. Ministry of Tourism and Leisure
12. Ministry of Industry, Commerce and Consumer Protection
13. University of Mauritius
14. Beach Authority
15. Mauritius Sugar Industry Research Institute
16. Mauritius Agricultural Marketing Cooperative Federation Ltd
17. Indian Ocean Commission
18. United Nations Development Programme Country Office
19. Association of Hoteliers and Restaurants in Mauritius
20. Mauritius Chamber of Commerce and Industry
21. Mauritius Chamber of Agriculture
22. Mouvement Autosuffisance Alimentaire
23. NGO Platform – Climate Change
24. Pesticide Action Network of Mauritius

Executive Summary

This report is the third in a series of reports that have been generated under the TNA project. It provides action plans for prioritized adaptation technologies in three sectors, namely: (1) water; (2) agriculture, and (3) coastal zone for Mauritius. Several parts of the Technology Action Plan (TAP) are derived from reports RI – TNA report and RII – Barrier Analysis and Enabling Framework for adaptation to climate change that have been generated under the TNA project. Consequently, TAP has to be used in concurrence with RI and RII for further details and references.

Mauritius has been grouped under the category of water stress countries, based on its current exploitable potential of the total rainwater recorded. The demand for water in all sectors is increasing with time, putting more and more stress on the wate sector. The island has been recording heavy intensity long duration rainfall over the recent years and these rainfall events give rise to high surface runoff, and consequently high loses to the sea. The water sector is under increasing pressure, with increase in demand in all sectors and the negative impacts of climate change. In addition to increasing its exploitable potential from the current 33% total rainfall and to reduce the high loses in the form of surface runoff to the sea (about 60%), the country has to adopt measures in order to ensure sustainable development and optimal use of water resources.

Rainwater harvesting is one of the adaptation technology which has been identified through stakeholder participation approach, and this technology targeted the residential sector. The main constraints that have so far hinder the promotion of RWH is the low cost of potable water, the availability of potable water (99.6% population having access to piped water supply) and the availability of plentiful of good quality water in the recent past. With increasing demand and impacts of climate change, the scenario is changing. The country has been witnessing extreme events which have impacted upon its water security. Flood type rainfall events are common and these give rise to high surface runoff, and long dry periods further reduce the recharge potential to groundwater. Implementation of the rainwater harvesting technology will serve two purposes, one of making optimal use of domestic water by using rainwater for secondary purposes and the second one as an artificial recharge system for groundwater. Among the measures that have to be considered to ensure successful implementation of RWH is first appropriate legislation, institutional support and financial incentives. Legislation is needed to ensure that the consumer is protected against bad quality products and institutional support is needed in order to monitor the concerns and benefits of implementing RWH at residential level. In addition, aggressive sensitisation campaigns are needed to make the general public aware of water security issues and the need for each and every one to contribute towards achieving sustainable development and consumption of water resources. Since RWH is a simple technology with significant benefits, the proposed measures in terms of legislation, institutional support and sensitisation campaigns should be considered within the first five years, though a span of at least 10 years will be needed to get the maximum number of housing units adopt the RWH technology.

The second technology that was retained was the Desalination Technology and this time the target group was the hotel sector. Currently some 17 hotels have implemented the reverse osmosis desalination technology in order to address water security during dry periods. A Governmental policy has been promulgated since August 2012 so as to encourage hotels located along the coastal areas to implement desalination plant. The Desalination Technology is gaining wider acceptance over time owing to major development in the energy

implications associated with this technology. This technology provides for an alternative source of water, for Mauritius depends heavily on rainwater to cater for water demand. Climate change is increasing the variability of rainfall patterns and hence, increasing the vulnerability of the water sector in Mauritius. An alternative source of water is much needed in Mauritius, as the island is isolated and cannot consider importing water from nearby countries. The main barriers to the successful implementation of the desalination technology are the high initial cost, the operational cost, the maintenance cost, the lack of skilled technical staff, the environmental impacts associated with brine disposal and the lack of a consolidated legislation for ensuring safe desalination practices in the country. In order to address water security though an alternative source of water supply, there will first be a need for a consolidated legislation that will address safe exploitation of brackish water or sea water, safe disposal of brine effluents and minimise the long term impacts of disposal of brine in the aquifers. There is also a need to encourage local training institutions to train skilled technicians who will ensure sound and safe operation of the desalination plants. In addition to legislation and training, institutional support in terms of logistics and financial support are also a major factor. Given that the Government has recently promulgated a policy for desalination technology in coastal hotel, the promotion of desalination technology has already started. Hence it is expected that there is an urgent need to promulgate the legislation and to train skilled technical staff and these are needed over the next 5 years. In the longer time, over the next 10 years, more and more hotels would be adopting the desalination plant.

The third technology that was identified by the stakeholders is the Hydrological models, and this was targeted at the local water institution for a more effective water management approach. The use of hydrological models for a more informed decision is commonly used in many countries. The complexity of a hydrological model is related to the accuracy of the analysis and also of the complexity of the data collection. In Mauritius, hydrological model has not been very successful so far, because of the lack of local training and research centres dedicated in the use of hydrological models. The initial capacity cost, including training, capacity and logistics, are viewed as being a very high initial costs and the benefits are long term and often intangible, being associated with comfort and well-being. Hydrological model also requires highly skilled technical staff to understand how the model works and to critically make use of the results of the analyses for decision making. In order to promote the use of hydrological models, there is firstly a need to set up a dedicated unit at the offices of the concerned water authority, provide regular training to the technical staff, train trainers from local research and training centres to ensure transfer of know-how, and to cater for capacity building over a period of 2 years. There are a large number of hydrological models which are available on the market and the promotion of this technology would not take a long time, though the reliance of this working tool will take longer as this depends on the time taken by the highly skilled technical staff to master the use of this technology. The appropriate legislation, especially in terms of digital data security and sharing may take a longer time, more than 5 years. Overall it is possible within the first five years, to reap both the tangible and intangible benefits of hydrological model.

Agriculture being highly vulnerable to climate change was prioritised as one of the sector for adaptation for the Technology Need Assessment. The TNA study however focused only on foodcrop and livestock subsectors rather than the entire agricultural sector to ensure that adaptation technologies of interest can be translated and implemented in the most effective manner. Thus, firstly, the target subsectors were identified based on their vulnerability to climate change and contributions to the country's economic development and food security and the immediate need in terms of technology development and transfer. The criteria used in

the prioritization of adaptation technologies were 1) the technical potential of the technology, 2) contribution of the technology to improve climate change resilience and sustainable development, 3) cost and ease of implementing the technology and 4) contribution of the technology to national development strategy and policy. Based on stakeholders' consultation and multi-criteria analysis, the adaptation technologies identified, prioritised and retained for the Technology Action Plan (TAP) were:(1) Up-scaling of proven IPM technologies in order to reduce risk of damage from pests and diseases likely to increase with rising temperature as well as to reduce excessive use of synthetic pesticides while improving productivity and minimising environmental and health impacts and (2) micro-irrigation to reduce risk of crop failure or loss while improving water use efficiency and. The TAP process involved: (1) setting up preliminary targets for technology transfer and diffusion of each technology option, (2) identifying barriers, (3) investigating possible solutions to address the barriers for the transfer and diffusion of technology, (4) and eventually developing a technology action plan for each technology option by considering legislation and regulation, financial incentives, institutional arrangement, infrastructure, R&D support, and human resource development.

During the TNA process, it was noted that many of these technologies were cross-cutting and could be applied across agricultural sub-sectors. Lack of financial support and knowledge/expert were identified as the fundamental barrier for technology development and implementation in Mauritius. The following major common barriers for the sector were identified (1) economic, (2) technology capacity, (3) policy and regulation and (4) infrastructure and analysed.

The common barriers of technology implementation that cut across the adaptation technologies and the 3 highly-impacted sectors: agriculture, water and coastal zone sector were identified and the possible cross-sectoral capability development actions were analysed. The common measures and possible synergies between technologies and across sectors were also identified and analysed.

Subsequently, the Technology Action Plans (TAPs) for each technology were developed. In this process, barriers to the transfer and diffusion of the two prioritized technologies were identified. The TAPs were established and divided into 3 phases, namely short-term (<0-5 years), medium term (5- 10 years) and long term (10-20 years). Food security being a national priority and climate likely to impact on agricultural productivity, emphasis is to identify actions to support small-scale farmers to cope with water stress and increasing pest and diseases pressure while promoting sustainable production systems. Actions to address most of the common barriers require policy enforcement or supporting mechanism such as policy enhancing 1) research collaboration, 2) R&D budget and 3) MOU with developed countries on technology transfer or research collaboration.

The TNA for the Coastal Zone sector has retained four technologies, namely; Restoration of coastal vegetation, Wetland protection, Dune restoration and Rock revetment. Mauritius with its varied coastline ranging from sandy beaches to rocky shores and cliff is very much affected by coastal erosion. The causes of erosion as identified by several studies including the Study on Coastal Erosion in 2003 were from the direct interaction of the sea with the shoreline, mainly during extreme events such as cyclones and storm surges. The extent of erosion is however exacerbated in certain places because of the negative anthropogenic impacts on the health of lagoons, beaches and dunes.
The coastal zone of Mauritius is important not only for providing income through tourism and fisheries but also protecting the island from the natural forces of the ocean. The viability of the major economic activity and

protective functions are wholly dependent on the vitality, aesthetics and ecological functioning of the coastal ecosystems.

Three of the four technologies retained, Restoration of coastal vegetation, Dune restoration and Rock revetment are applicable directly on the shoreline and would provide direct benefits to the location where they are applied. In contrast, wetland protection would act indirectly in mitigating the erosion impacts on an adjacent coast. Wetland, through their hydrological services they provide, contribute to improve the water quality of the lagoon around Mauritius and thus a healthy marine environment which in turn would contribute to the stability of the shoreline.

This present report provides an insight of the various strategies, national policies and action plans that have been developed over time and supports the sustainable development of the coastal zone in the Mauritius.

The various barriers to the diffusion of each technology have first been identified and then analysed in view of putting forward the most appropriate plan of action for each technology. It has been found that one common aspect leading to the barrier in the implementation of the technology has been the high costs involve and thus the need to make provision for appropriate financial incentives in certain cases. The legislation and regulations should also be reviewed and improved so as to support the actions and it was observed that lack of information and awareness in the use and benefit of the technology has also contributed to the implementation of these in Mauritius.

1. Technology Action Plan for Water

1.1 Actions at sectoral level

1.1.1 Short sector description

Mauritius exploits both surface water and groundwater to cater for its demand. Groundwater resources presently contribute about 50% total domestic water demand. The water demand per sector is as follows: Domestic (including tourism) – 22%, Agriculture (47%), Industrial (surface water and boreholes) – 1%, Hydropower – 30%. The island receives on average 2500mm of rainfall, with the higher elevation regions receiving some 4000 mm of rainfall annually, amounting to about 3700Mm3 of water annually. The total volume of potable water treated by the different treatment plants was 202 Mm3 recorded in 2011, with 46% of the average water production being from surface water and 54% from groundwater sources, (CSO, 2011). About 99.6% of the population have access to safe drinking water.

The current existing facilities, in terms of capturing of rainwater and storage facilities, results in a maximum exploitable potential of only 33% of total rainwater recorded annually. The latest figures indicate that about 23% of the total rain water recorded is already been exploited (Sharma, 2007). Another constraint influencing the water sector is the topography of the island. The ground surface elevation changes from about 500m in the Central Plateau to some 10m along the coast, over a distance of about 20km. Some regions are characterised by even steeper gradients and this results in low infiltration of surface runoff underground. Changes in land use patterns have resulted in an increase in tarred surfaces within residential zones, thus increasing surface runoff. Water balance calculations indicated that surface runoff constitutes up to 60% of the total rainfall recorded, while groundwater recharge is about 10% and evapotranspiration some 30%. The impacts of climate change is already been felt in Mauritius. The Meteorological Services has reported a decrease of 8% of annual rainfall recorded over time and an increase in surface temperature. Recent long periods of dry weather have emphasised the country's vulnerability to extreme dry events and this has further strengthen the need for sustainable development of water resources.

National studies undertaken in the water sector have most of the time focused on increasing the storage capacity, and increasing the capacity of treatment plants to cater for the increasing storage. This approach follows the fact that the island loses about 60% of the total rainfall in the form of surface runoff.

	National Report on the Water Sector	Brief	Remarks	Date Published
1	Geophysical studies in Mauritius	Detailed geophysical studies were carried out in order to map the geological structure of the aquifers of the island.	This report noted that all the aquifers of the island are in hydraulic contact with sea. Furthermore, the Northern Plains aquifer is highly sensitive to salt water intrusion.	1963

2	Food and Agricultural Organisation (FAO)	This study was carried out to evaluate the potential of the groundwater bodies over the island for the agricultural sector.	Groundwater exploitation increased significantly since this study.	1972
3	Huntings' & MacDonald.	This study was also about the groundwater resources of the island.	Groundwater exploitation on a large scale was further enhanced.	1974
4	John Talyor and Sons	Development of Water Supplies for Mauritius.	All these studies have recommended increasing the storage capacity and increasing the capacity of treatment plants.	1974
5	Sigma & Sogreah	Study of a Master Plan for the Development of water utilisation in Mauritius.		1981
6	French Corperation and CWA	Master Plan for the Study of Water Resources in Mauritius		1991
7	GIBB	Master Plan for the Development of Sustainable Water Supply in Mauritius		2007
8	Economic Accounting of Water Use [ACP-EU Water Facility Grant No - 9ACP RPR 39 – 90] Mauritius Pilot Report - Final Report, September 2010	This report was prepared for SADC and is one of the products of SADC's regional project on "Economic Accounting of Water Use". Economic accounting for water is a new topic to many water professionals and there is a need to raise the awareness. This report presents a method for economic accounting of water.	The Central Statistical office of Mauritius has started working on this approach but this is yet to be fully implemented in Mauritius.	2010
9	Regional Water Infrastructure Investment – SADC Report	This study analysed the country needs for enhancing water supply infrastructure projects in Mauritius.	Telemetry systems, water Supply projects for low cost housing units, Data logging systems for hydrological units were some of the projects identified.	2011
10	Design Sheets for Desalination Plants	This is an official regulations regarding the conditions to be satisfied for the implementation of a desalination plant.	This is a working document used by the Planning Department to check whether hotels abide by these regulations in a safe manner.	August 2012

1.1.2 General barriers and proposed measures

One of the main challenges in the water sector in Mauritius, is the capacity to ensure water security specially during extreme events. Presently the country loses 60% of its total rainfall in the form of surface runoff. The three technologies that were retained for detailed analysis; rooftop rainwater harvesting, desalination and hydrological models, aimed at improving water resource management, reducing surface runoff to the sea and providing for an alternative source of water. The objectives behind promoting rainwater harvesting are both to promote optimal use of potable water and also to promote groundwater recharge within the residential zones. Mauritius being a small island it is subjected to high climate variability, and this situation requires sound water management approaches. The effective use of hydrological models will considerably help in providing sound technical background for decision making especially during water crisis situations. The desalination technology is gaining wider acceptance over time and this technology can both help to alleviate the pressure on treated surface and ground water and to ensure water security in hotels during dry periods.

Barriers that affect particular technologies are specific to the particular technology and prevailing conditions, but there are also some barriers which cut across all the technologies. Mauritius has a low water tariff scheme and this was identified as one of the barriers common to all the three technologies. Access to piped water supply for potable water was another common barrier. The cost of potable water is relatively very low, and about 99.6% of the whole population have access to safe drinking water. The existing legislation is another common barrier which has to be addressed specially for inhabitants to become more aware of the need to make optimal use of treated water. Current legislation does not promote sustainable consumption of water resources, the public has not learnt how to adapt to water crisis given that water has so far always been plentiful and of good quality, the capacity to harness surface runoff is low and needs major financial investments in infrastructure. Another common barrier is the lack of awareness to the impacts of climate change and the need for a change in mind set as far as water development and consumption is concerned. The Central Water Authority regularly conducts awareness campaigns use of potable water for secondary usage is common but this campaign is not reaching a major part of the population and needs to be reinforced. In addition for the desalination technology, the cost of the technology (initial capital, operation and maintenance) is a barrier against the successful implementation of the technology. The initial high cost of implementing the hydrological model (software and logistics) is a barrier for this particular technology.

As far as measures are concerned, the first step will be to take a commitment towards sustainable development and consumption of water and a commitment towards ensuring water security in both the short and the long term. A number of measures are needed to achieve these goals. Appropriate legislation is needed in order to promote use of rainwater harvesting for secondary usage at residential level and this can be included as a regulation under the Building Act 2011. Legislation is need to effectively monitor the long impacts of exploitation of brackish water and also saline water for coastal hotels. Financial incentives are needed in the form of soft loans and rebates in order to encourage the general public to accept rainwater harvesting for secondary purposes and in the hotel sector in order to implement the desalination technology. Financial incentives should be given to encourage promoters to go for more energy efficient desalination plants. In additional to legislation and financial supports, there is also a need for an intensive sensitisation campaign on the prevailing and long term impacts of climate change on water availability. The awareness campaigns will help sensitize the general public on the need to optimise the use of potable water, the need to promote

groundwater recharge and thereby help in the reduction of surface runoff to the sea and the need to consider alternative water sources in order to ensure water security.

1.2 Action Plan for Desalination

The desalination technology discussed is the reverse osmosis desalination technology, whereby the desalination plant will be made up of non-corrosive components which are adapted to the treatment of saline water. The plant will be having a production capacity of 300m3/day and will be treating either seawater of salinity greater than 10,000ppm or brackish water with salinity varying between 1000 to 10,000 ppm. The brine produced will have to be channelled to a dilution tank, before it disposed of in sink wells or in sea outfalls. It is assumed that the plant will be in operation during the dry periods only.

1.2.1 About the technology

Desalination refers to any of several processes that remove some amount of salt and other minerals from water. Desalination involves removing the salt from water to make it drinkable. There are several ways to do it, and it is not a new idea at all. Sailors have been using solar evaporation to separate salt from sea water for at least several thousand years. Most of the world's 15000 or so desalination plants use distillation as the process, and there are also flash evaporation and electrodialysis methods. All these methods are very expensive, so historically desalination has only been used where other alternatives are also very expensive, such as desert cities. However, an exploding world demand for potable water has led to a lot of research and development in this field and a new, cheaper process has been developed that involves heating sea water and forcing it through membranes to remove the salt from the water. Desalination, which was so costly in the past that few considered it a reliable alternative to treating fresh water, has now become cost-effective and streamlined as a result of energy-efficient filtering technologies such as reverse osmosis. There is also a lot of interest in using local, brackish groundwater as a source for desalination instead of ocean water. Such waters typically have only one-tenth the salinity of sea water, so desalination can be accomplished more easily and transportation is less of an issue. Even so, it is still more expensive than other alternatives, but it is indeed becoming more competitive.

Mauritius is characterized by some 75 main coastal villages and about 112 three to give star hotels along the coasts with a total of 12,000 rooms. The potential of using desalinated water is high. In addition the drought season (October–March) coincides with peak season of hospitality industry. Hotels spend some MUR 90/m3 for purchase of water from the CWA through tanker services. The social perception that hotel water supply occurs at the expense of the coastal villages and this may lead to social conflict. Currently, in Mauritius some 10 hotels are already equipped with desalination plants, which they tend to operate specially during the dry periods of the year. In January 2011, the Government informed that it was currently working on a bill to encourage hotels and IRS projects to make provision for desalination plants. It was also pointed out that since 1999 when Mauritius was hit by a severe drought, the Government had since then encouraged coastal hotels to implement a desalination plant. This policy has been strengthened last year, 2012, with the promulgation of a regulation on desalination plant under the Policy Planning Guidelines.

The cost elements associated with this technology are the initial capital cost, the operational cost and the

maintenance cost. For a desalination plant operating at 300m3/day, the initial capital cost is MUR Rs. 14 Million and the operational and maintenance cost amounts to MUR Rs. 3 million per year for plant operating on a year basis. The cost benefit analysis of this technology yielded a value of 0.17. This technology is costly and can cause damage to the environment if the waste disposal is not properly monitored, however it provides for an alternative source of water. It therefore represents a sound and reliable water supply especially during long dry periods, crucial to a small isolated island which cannot consider the option of importing water from nearby countries.

1.2.2 Target for technology transfer and diffusion

Though there are potentially some 120 hotels which are located along the coastal zone, not all the hotels will be able to implement a desalination plant owing to the cost implications and owing to their location, should they wish to desalinate seawater. The target is to get at least 50% of these hotels to adopt the technology, over the next 10 years. The Government is already providing financial incentives and this has to be supported by appropriate legislation in order to achieve the set target.

1.2.3 Barriers to the technology's diffusion

The barriers which have to be overcome in order to successfully promote the desalination technology have been grouped as follows: Economic & Financial, Market Failure & Imperfections, Legislation and Social & Cultural.

Though much development has taken place for desalination of saline water into potable water, this technology remains by far one of the most expensive technologies for the production of potable water. The cost of producing water by the desalination technology becomes comparable to the cost of potable water purchased from the local water authority only during the dry periods. During that period, many hotels buy water from tankers at the rate of MUR Rs. 30. Per m3 and this is more costly than the tap water. So during that time, the cost of producing water by the desalination technology (MUR Rs. 27 per m3) and hence appears to be an attractive alternative. Another major barrier is the lack of experts, both in the development of desalination plants and in the operation and maintenance aspects. As far as legislation is concerned, the Environmental Protection Act, 2011 and the Planning and Development Act, 2004, cater for desalination plant. However there is no appropriate legislation with regards to safe brine disposal, safe exploitation of brackish water, long term monitoring of the impacts of these activities on the quality and quantity of groundwater and no dedicated institution to oversee these activities. Socially, the desalination technology is not well looked upon, owing to the perception that it is highly energy intensive, it is costly and it harms the environment.

A number of measures would be needed in order to address the barriers. Firstly there will be a need for an institution to oversee the setting up and operation of a desalination plant and its short and long term impacts on the environment. There is a need to raise awareness of the benefits and safe practices linked to the implementation of the desalination technology. Mauritius already falls under the category of water stressed countries and in order to address water security there is a need for the country to find alternative sources of water, and this has to be strongly emphasized at national level.

Currently there are 17 hotels which are already operating a desalination plant, and with the recent Government policy, more hotels will be embarking on this technology in the near future.

1.2.4 Proposed action plans for Desalination

The Technology Action Plan for the successful implementation of the Desalination Technology will have to be developed based upon the following framework:

1. The legal and regulatory framework
2. The institutional support
3. The financial support

	Barriers Category	Barriers	Potential measures	Responsible Institution	Time Frame	Cost implications MUR Rs.	Indicators of Risk
1	Economic and financial	High capital, operational and maintenance cost.	Government to provide financial incentives	Ministry of Finance	0-10 years	Rs. 17 Million per desalination plant at the rate of 5 plants per year over 10 years.	The hotels may not be able to invest in this technology owing to financial constraints on their part.
		Highly energy intensive and no regulations to impose on conditions of renewable energy	Encourage companies to look for more energy efficient systems	Ministry of Environment & Sustainable Development	0-5 years	Need to invest in Research & Development projects – Rs. 2 Million	
2	Market Failure/ Imperfection	Lack of local experts involved in the development of desalination plants	Local companies to work in collaboration research centres and international partners in order to provide the skilled workers needed to encourage more hotels to adopt the desalination technology. companies to look for more energy efficient systems	Research organisation, and Experts in the field of water and environment.		Cost of training by experts from abroad – Rs. 200,000 per training session Total number of training sessions – at least 2 per year over 10 years.	The training would have to be sustained and hence involved higher cost elements.
		Lack of technical experts for the operation and maintenance of the plants					
		Lack of technical known-how locally, need to rely on external support.					
3	Policy, Legal and Regulatory	By-product, brine, has to be disposed of in a safe manner but no regulation specific to brine disposal exists so far.	Promulgate appropriate legislation – safe exploitation of brackish water, safe disposal of brine, monitoring of impacts of both brackish water exploitation and brine disposal.	Ministry of Environment & Sustainable Development	0-5 years	Consultancy services to be paid for in order to work out appropriate legislation Rs. 1 Million.	Geological structure differs from country to country and off shelf policies may not work in the local context.
		Lack of appropriate legislation governing safe exploitation of brackish water.					

		Lack of appropriate legislation/regulation governing the monitoring of the impact of exploitation of brackish water and disposal of brine on the groundwater.					
4	Social, Cultural & Behavioral	Lack of awareness of the development of desalination in the world. Social impact of this technology as viewed by coastal villagers.	Undertaking of intensive and focus groups awareness campaigns with regard to the need for desalination and the benefits of this technology.	Central Water Authority	0-5 years	Awareness campaigns at the rate of Rs. 200,00 per session, with at least 1 session over 10 years.	
5	Institutional & Organisational Capacity	No local institution to monitor the impacts of this activity on the environment and the country's resources.	Setting up monitoring programmes specific along the coasts to monitor that the practice of desalination	National Environmental Laboratory (NEL)	0-5 years	Cost to cover tests and services from MoESD – NEL, to amount to Rs. 2 Million per year over 10 years.	Unless this required is supported by appropriate legislation it may be difficult to ensure sound monitoring.

1.3 Action Plan for Rainwater Harvesting

The rainwater harvesting technology is aimed at residential level, a roof top rainwater harvestor, with a simple design. The main features consisting of the collection system (pipe and gulleys), the connecting pipe with an outflow for discharge of settleable solid particles, a container (500litres), and an overflow with drainage facilities, in the form of absorption pits, in order to promote groundwater recharge.

1.3.1 About the technology

Rainwater harvesting is a simple technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. Rainwater harvesting captures, diverts, and stores rainwater for later use. Captured rainwater is often used in landscaping and for secondary uses. Commonly used rainwater systems are made up of three principal components; namely, the catchment area, the collection device, and the conveyance system. These systems can range from the low tech, hence low cost to the more advanced technology and thus relatively higher cost.

Typically, independent trials in some countries have shown that domestic rainwater harvesting system can reduce mains-water consumption by around 50%. The rainwater harvesting technology requires relatively very low investments, low skilled labour and low operational costs, but provides high benefits. Many countries are realizing that in the future surface and groundwater supplies will not be able to meet future water demand. Water conservation and development of alternative water supplies would become a necessity in the near future in order to meet our growing demand for fresh water.

In Mauritius, the latest figures from the Central Statistical office reported that there are 297, 500 housing units. If one rainwater harvestor was to be implemented in each of these buildings, the total sum would be around MUR Rs. 2 million as indicated in the SCP report of 2008. Since rainwater harvesting is not commonly practiced yet, there will be a need to retrofit systems, and this may be looked upon as a deterrent. Opportunities are high, both in terms of creativity to come up with rainwater harvestors which will merge in the environment to the implementation of such systems at national level. Rainwater harvesting is not a new technology, but what will be of market value are systems which are robust and durable to withstand cyclone seasons and tropical climates. Such systems will have sound market potential both in Mauritius and in other similar countries. However, socially inhabitants may not be ready for the adoption of this technology, as almost 99.6% inhabitants are connected to tap water and the cost of water is very low. There will thus be a need for a change in mindset.

The rooftop rainwater harvestor referred to in this project is a 600 litres capacity tank, with a complete piping system from collection from the roof, to the outflow from the tank. The system will also have to provide for an absorption pit to channel unused or excess rainwater collected into it, in order to promote groundwater recharge. The overall cost has been estimated around MUR Rs. 10,000 for a single individual complete unit. A simple benefit to cost analysis ratio yielded a value of 1.37, with the assumption that only 20m3 water can be collected annually and 250,000 housing units are targeted over 10 years. It should be noted that rainfall vary significantly over space and over time, some locations will not be appropriate to implement a RWH. The project will start in the first five years in locations receiving annual average rainfall greater than 1500mm.

1.3.2 Target for technology transfer and diffusion

The objective is to encourage inhabitants to implement a rooftop rainwater harvestor at residential level. The total number of housing units is about 250,000, and incentives will be needed in order to encourage the inhabitants to implement this technology. Since the rainwater harvesting is a simple technology, with the appropriate encouragements and legislation, some 25000 housing units can be targeted every year, over a period of 10 years. The aim is not only to encourage inhabitants to use rainwater harvesting for secondary purposes, but also to provide a medium to reduce losses of surface runoff to the sea and promote groundwater recharge through an absorption pit.

1.3.3 Barriers to the technology's diffusion

The barriers affecting the successful implementation of rainwater harvesting have been classified under the following categories; Economic & financial, Market Failures & Imperfection, Policy, legal & regulatory, Social, Cultural & Behavioural and Information & Awareness. Though rainwater harvesting is a well-established very simple technology, it has not been successful in Mauritius so far, owing to a number of reasons. Firstly the cost of water is low and water availability was not an issue in the past. With development and increasing population, coupled with the impacts of climate change, water availability is now becoming an issue of concern, hence demanding a change in mind set.

A simple but robust rainwater harvestor was estimated around Rs. 10,000, a price which many consider as being too high. The actual cost of tap potable water is very low and investing into a system which provides

lower quality water does not seem an attractive option. Because water has always been plentiful, inhabitants have not had to learn how to adapt to water scarcity. Current legislation does not encourage the residential sector to consider rainwater harvesting, though the new Building Act 2011, does stress on sustainable use of water. The public in general are not aware of the country's need to adapt to climate change and consequently its impact on water resources.

Incentives are needed in order to promote rainwater harvesting at residential level. Financial incentives in the form of soft loans, legislation to promote sustainable development of water resources, awareness campaigns will be needed in order to address both impacts of climate change and the need for optimal use of potable water and adequate technical and institutional support are needed so as to safe guard the interests of the inhabitants. Presently there is low applied research in the field of rainwater harvesting and few local manufacturers of rainwater harvestors. Locally organisations in collaboration with research institutions will need to research into more adapted and low cost systems, instead of promoting off the shelf technologies.

1.3.4 Proposed action plans for Rainwater Harvesting

	Barriers Category	Barriers	Potential measures	Responsible Institution	Time Frame	Cost implications MUR Rs.	Indicators of Risk
1	Economic and financial	High Cost Capital Financially not viable Inappropriate financial incentives and disincentives	Government to provide financial incentives in the form of a soft loan to cover at least 50% of the	Ministry of Finance and Economic Development	0-5 years	Cost of one RWH unit is Rs. 10,000, and total number of potential housing units	Rainfall varies both spatially and temporally. Not all sites are ideal for
2							
3	Policy, Legal & Regulatory	Insufficient and regulatory framework Policy intermittency and uncertainty	Government will need to come up with appropriate legislation/ regulation to ensure that RWH is well implemented.	Ministry of Environment & Sustainable Development	0-5 years	Consultancy services of a law firm will be needed in order to promulgate appropriate regulations under the Building Act 2011. Rs. 0.5 Million	The need for such regulations would also depend on whether the country will have Building Rating Index policy.
4	Social, cultural and Behavioural	Consumer preferences and social bases Traditions and habits	Awareness Campaigns on the impact of Climate Change on Water Resources – at all levels (General Public & Technical staff)	Central Water Authority & Water Resources Unit, Ministry of Energy and Public Utilities	0-5 years	Awareness campaigns at the rate of Rs. 200,00 per session, with at least 2 sessions over 10 years.	

5	Information & Awareness	Inadequate information Lack of media interest in promoting technologies Lack of awareness about issues related to climate change and technological solution	Awareness programmes to be targeted on Futuristic Scenarios to make the general public and the policy makers aware of the potential impacts of do nothing scenario.	Media	0-5 years	This awareness campaigns will require the services of experts and will be more costly. At least one session would be needed per year over 10 years. An estimate of Rs. 500,000 per session.	The futuristic scenarios that may be relevant to Mauritius (an island) would need to take this particular feature into consideration.

1.4 Action Plan for Hydrological Model

1.4.1 About the technology

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes. Two major types of hydrologic models can be distinguished between Stochastic and process-based models.

Stochastic models are black box systems, based on data and using mathematical and statistical concepts to link a certain input (for instance rainfall) to the model output (for instance runoff). Commonly used techniques are regression, transfer functions, neural networks and system identification. These models are known as stochastic hydrology models.

Process-Based models try to represent the physical processes observed in the real world. Typically, such models contain representations (infiltration and percolation) of surface runoff, subsurface flow, evapotranspiration, and channel flow, but they can be far more complicated. These models are known as deterministic hydrology models. Deterministic hydrology models can be subdivided into single-event models and continuous simulation models.

Recent research in hydrologic modelling tries to have a more global approach to the understanding of the behaviour of hydrologic systems to make better predictions and to face the major challenges in water resources management. The USGS (USA) has been a leader in the development of hydrologic and geochemical simulation models since the 1960's. USGS models are widely used to predict responses of hydrologic systems to changing stresses, such as increases in precipitation or ground-water pumping rates, as well as to predict the fate and movement of solutes and contaminants in water.

In Mauritius the use of hydrological models for decision making in the water sector is limited, owing to lack of capacity building and transfer of know how mostly. The objective behind the implementation of the hydrological model technology is an improvement in the forecasting process and an improved water resource management. The whole project will be structured in four (4) stages. During the first stage the dedicated unit will be created with the appropriate logistics (computers, printer, plotter, scanner and the hydrological model software). The second stage will focus mostly on a basic training course to the technical staff and the expert tailor making the software to adapt to the local context. The third stage will focus on a more advanced

training to the technical staff, to enable them to use the output from the model in order to take decisions. During the fourth and fifth stage of the project the emphasis will be on transfer of how-how and capacity building for improved decision making. The technical staff needs to be highly skilled in order to make the most of the training and the capacity building. The benefits behind improved decision making will be in terms of a more reliability water supply during long dry periods, better management of flood waters and long term planning of the resources in terms of quantity and quality. An overall budget of MUR Rs. 3.5 million has been earmarked for this particular project, hydrological model and its technical support amounting to MUR Rs. 1 million, the training component to MUR Rs. 1.5 million and the provision of logistics and data conversion to MUR Rs. 1 million.

1.4.2 Target for technology transfer and diffusion

Hydrological models are available off the shelf and in varying complexity. While the level of complexity directly relates to the accuracy of the analysis of the hydrological model, it also relates to the complexity of the data required for the analysis.

Based on the existing data collection system, the target for the technology transfer and diffusion will be a period of 5 years. In the first year, a dedicated unit will have to be created at the level of the institution. This unit will be provided with the required logistics in terms of computers and accessories within the same year. In the second year of the project the conversion of data to digital format wil start together with a major training component. Training will be conducted starting in the first and second year of the project. In the third year of the project the training will focus mostly on capacity building to the dedicated technical team so that they are able to use the output of the hydrological model for decision making. The technical team will however need constant technical support for at least 2 more years for both data conversion and for building confidence for decision making.

1.4.3 Barriers to the technology's diffusion

Cost elements are involved in several aspects of the successful implementation of a hydrological model: the initial investment in the cost of the software, the setting up of a dedicated computer laboratory and dedicated highly skilled technical staff, the initial training to be provided to the technical staff, the capacity building which may last over two years before the technical staff are able to use the hydrological model for decision making.

With respect to the financial implications, it was noted that the present telemetry system is not in full operation, the initial investment includes the software, the training to technical staff, the visits of experts for capacity building, the benefits are not tangible and cannot be readily evaluated, and the successful implementation of a hydrological model depends on heavy investments in logistics such as computer laboratories, accessories and dedicated staff. There is a lack of highly skilled technical staff and consequently a high dependency on experts from abroad. In addition, hydrological model is not a popular technology among the general public, and even among stakeholders, hydrological model concerns a few stakeholders. There are very few local experts who are familiar with the use of a hydrological model and there are no local experts familiar with the development of hydrological model in order to tailor made it to the needs of the country. Off shelf technologies

may not always fulfill the needs for the country, but local system are non-existent. With regards to legislation there is a lack of local regulations to encourage use of hydrological models for decision making in the water sector. There is no regulation regarding the issue of security of and access to digital information.

One of the key measures that will need to be addressed at the beginning is the creation of a dedicated unit with highly skilled staff, computers network, online connection to data loggers and other logistics such as scanner and printer. Another equally important measure is capacity building. Training will have to be provided on a regular basis and this should also include a component of training of trainers. In addition to training, there will be need for capacity building. Since presently there are few local experts in the field of numerical modeling, the need to encourage capacity building in the form of continuous professional development courses and research associated with decision making or detailed site investigations will have to be promoted in collaboration with both local and international institutions. In order to strengthen the local expertise in the field of hydrological models, local experts in the field of information technology should be encouraged to work with local water experts in order to develop tailor made hydrological softwares for the country. Legislation and regulations will have to be promulgated in order to encourage local authorities to make use of decision making tools such as Hydrological Models for better management of water resources.

1.4.4 Proposed action plans for Hydrological Model

Hydrological Models							
	Barriers Category	**Barriers**	**Potential measures**	**Responsible Institution**	**Time Frame**	**Cost implications MUR Rs.**	**Indicators of Risk**
1	Economic and financial barriers Hydrological Model	The telemetry system which serves as a sound data input is poor, and often not in working conditions.	Government to provide the required financial support.	Ministry of Finance and Economic Development	0-5 years	Financial support will be needed for almost all the elements: The software, hardware, training and technical support. Rs. 3.5 Million has been earmarked over 5 years.	If the concerned Ministry is already under staff, there will be need to employ additional graduates.
		The initial investment includes the software, the training to technical staff, the visits of experts for capacity building, and this is high. The benefits are not tangible and cannot be readily evaluated.					
		The successful implementation of a hydrological model depends on heavy investments in logistics such as computer laboratories, accessories and dedicated staff.					

		There will be high dependency on experts from abroad and this adds to the cost.					
2	Market Failure/ Imperfection	Hydrological model is not a popular technology among the general public. Even among stakeholders, hydrological model concerns a few stakeholders There are very few local experts who are familiar with the use of a hydrological model. There are no local experts familiar with the development of hydrological model in order to tailor made it to the needs of the country. Off shelf technologies may not always fulfill the needs for the country, but local system are non-existent.	Create awareness of the benefits associated with the use of Hydrological Models and encourage water and Information Technology experts to participate in research projects linked to modeling studies.	Water Resources Unit & Central Water Authority	0-5 years	Awareness campaigns at the rate of Rs. 200,00 per session, with at least 1 session for each Ministry concerned and 1 session for the general public, over at least the first 2 years of the project.	This is a highly complex technology and awareness complex may not reach all.
3	Policy, Legal and Regulatory	Lack of local regulations to encourage use of hydrological models for decision making in the water sector. The issue of security of information will have to be addressed as the data will be stored within the computerized system Lack of awareness of impacts of climate change on the water sector.	Appropriate legislation to be promulgated.	Ministry of Environment & Sustainable Development	0-5 years	Consultancy services of a law firm will be needed in order to promulgate appropriate regulations under the Building Act 2011. Rs. 0.5 Million	Presence of a hydrologist conversant with Hydrological Models will be needed in order to ensure that the legislation is appropriate for the local context.
4	Institutional & Organisational Capacity	Lack of local institution which promotes and develop tailor made hydrological models.	Research and training institutions to be encourage to develop know how in this field.	Research institutions and training institutions involved with tertiary education.	0-5 years	This project will also have to cater for a sustained local capacity building.	There is low level of collaboration between research centres, universities and Ministries and this will have to be looked into.

		Lack of interests amongst stakeholders to embark on this highly specialised technology Is relevant to only two main Governmental institutions which are directly concerned with water resources management				A sum of R. 1.5 Million is being earmarked for this training, research and development component.	
5	Human Skills	Hydrological model is not a popular technology among the general public Even among stakeholders, hydrological model concerns a few stakeholders. There are very few local experts who are familiar with the use of a hydrological model. There is a need to train dedicated highly skilled staff. There will be need for capacity building and hence regular visits of experts to train staff in using the software for decision making.	Regular training will be required to form highly skilled technical staff and to form trainers who will ensure transfer of know how in the future.	Private international organisations in collaboration with local training institutions	0-5 years	The training component has been earmarked in the promotion of this technology. Over the first 3 years, a sum of Rs. 1.5 million has been earmarked. There will also be specialised training component over the last 2 years, a sum of Rs. 0.5 million has been earmarked.	HM is a well established technology commonly used in many countries and it should not be difficult to organize these training sessions.

2. Technology Action Plan for Agriculture

2.1 Actions at sectoral level

2.1.1 Short sector description

The agriculture sector represented 3.7 % of the national economy and employed 7.4 % of the labour force (44,768) in 2011. 46% of the land area of the island of Mauritius is covered by agriculture and a further 23 % by forest. The sector is dominated by sugar cane which accounts for 85 % (63,780 ha) of agricultural land and of which about 70% is owned by corporate sector (3 units) and the remaining by some 23 500 individuals small scale farmers. Agriculture contributes to 34.1 % of the total domestic export including sugar, molasses, fruits and vegetables, fish and other food products. The sugar sector contributes to 25 % of the domestic

export and employs over half of the labour force in the sector. Foodcrop production occupies 7500 ha, involves some 8500 growers and produces annually around 100,000t of fresh vegetables and fruits including banana and pineapple. The country is self-sufficient in most fresh vegetables. Livestock is practiced by 6 000 producers at a relatively low level. Livestock and poultry account to 22 % of the share of agriculture in the economy. The country is self-sufficient in poultry and eggs. However, it is only 50 % self-sufficient in pork, 5 % in beef and 2.4 % in goat and sheep (including local production and Rodrigues). Agricultural production is mainly rainfed and around 30 % (19,885 ha) of cultivated areas are irrigated (90 % land under sugarcane and 10 % under food crop). The sector consumes around 48 % of the country's fresh water resources. With the decreasing trend in rainfall, coupled with increasing demand for water from other sectors, ensuring an adequate freshwater supply for agriculture is a challenge, threatening the country's food security.

Mauritius imports around 70 % of its net food requirement amounting to more than 690,000 tonnes annually. In light of the high dependence on food and the soaring food prices, government policy is to foster local food production and mitigate the country dependency of imported food products over the medium and long term. The policy aimed at mobilising land and aquatic resources, inputs for production, human resources, technology and financial resources in order to optimize food and livestock production locally for domestic consumption; promoting export of fruits, vegetables and food products; encouraging partnership with countries of the region, such as Madagascar and Mozambique to produce food crops, livestock and marine products for domestic consumption as well as for regional markets; promoting both public and private joint ventures and sensitising people on healthy eating and food safety.

Strategy and policy governing the agricultural sector were not particularly designed to address the climate change-Agriculture nexus directly. Nevertheless, the FSF plan promoted certain schemes to support climate change adaptation and thus increase climate resilience of this sector. The schemes included: rainwater harvesting at farm level, sheltered farming, fodder/pasture development, food crop insurance and compost subsidy scheme. An Agricultural Calamity Solidarity Scheme (ACASS) was also set up in January 2012 assist small planters registered with the Small Farmers Welfare Fund (SFWF) to recover after natural calamities such as cyclone, drought or flood.

The agricultural sector contributed to 4.51% of the national greenhouse gas emissions in 2006. The largest emission is from intensive use of synthetic fertilisers in crop production (61 %) and livestock sector (36%).

Table 1. GHG emissions (Gg CO2 eq) from Agriculture (2000 – 2006)(Second National Communication, MoESD, Nov 2010).

	2000	2001	2002	2003	2004	2005	2006	Annual Change (%)
Total Agriculture	234.96	243.13	218.59	223.52	217.42	211.88	206.04	-2.07
Agriculture % Total	*6.00*	*6.06*	*5.51*	*5.41*	*5.27*	*5.09*	*4.51*	*-4.57*
Enteric Fermentation	65.28	67.24	59.73	59.31	55.96	58.85	60.04	-1.22
Manure Management	18.50	18.46	18.62	17.97	17.56	19.25	18.00	-0.34
Agricultural Soils	139.19	144.37	130.94	137.98	137.30	128.22	122.73	-1.93
Field Burning of Agricultural Residues	12.00	13.06	9.30	8.26	6.61	5.56	5.27	-12.03

This sector is highly vulnerable to climate extremes and climate variability such as drought, cyclones, variable rainfall leading to flash flood, heat stress sea level rise (SLR) particularly affecting the coastal agro-ecological zones through salinisation of irrigation water in period of drought. With the volatility of fuel price, risk of food crisis couples with climate change, the food security situation is expected to worsen hence the need develop adaptation technologies that will minimise risk of crop failure and boost production.

Consequently, the Technology Need Assessment (TNA) exercise undertaken with stakeholders involvement identified and prioritised 3 adaptation technologies for the sector. The technologies and their targets were: 1) Integrated Pest management technologies to reduce risk of pest damage in small farmers food crops production, minimise use of synthetic pesticides while improve productivity, enhancing food safety, minimising environmental impacts and promoting sustainable agricultural practices, 2) micro-irrigation to optimise use of irrigation water resources, reduce risk of crop failure while improving productivity, food security and livelihood of small scale food crop growers in drought prone areas and 3) decentralisation of pest and disease diagnosis to provide a rapid and reliable diagnosis service to enable foodcrop growers to take timely decision for pest control thus reducing risk of crop failure while improving productivity and quality.

However, as the International Fund for Agricultural Development (IFAD) was supporting a project on "E-Pest Surveillance" (approved September 2012) which aimed at upgrading IT facilities for providing an on-line pest and disease diagnosis service in Extension offices and due to complementarities between IPM technology and decentralisation of pest and disease diagnosis technology, it was decided with stakeholders consultation that the Technology Action Plan (TAP) would focus only on 1) Integrated Pest management and 2) Micro-irrigation.

Though these two technologies had already been introduced and proved to be effective, their adoption rate among farmers is still relatively low. This is mainly attributed to weak policy support, limited research and development to customise the technology to local conditions, weak inter-institutional collaboration and market support and limited resources for demonstration projects and technical support to technology transfer to farmers.

2.1.2 General barriers and proposed measures

The general barriers hindering the transfer and diffusion of the adaption technologies targeted towards optimizing use of resources, reducing risk of crop failure, improving productivity, enhancing national food security and farmers livelihood in the sector were identified as: Low investment in R &D, research and institutional capability, policy and regulation, and technical capability for dissemination scope of each technology. Table 3 summarizes the general barriers cutting across the 2 technologies and the measures proposed to address each of them. The specific barriers to each of the technology target are discussed in the section 2.2.3 and 2.3.3, while the proposed measures specific for each technology are presented in section 2.2.4 and 2.3.4.

Table 2. General barriers to transfer of adaptation technologies in the agricultural sector and the proposed measures.

General Barriers to transfer of adaptation technology in the agricultural sector	Proposed measures
Absence of economic incentives to encourage farmers to invest in adaptation technology	Market incentives Review Pricing policy of certain inputs Financial support for capital investment through subsidy or credit
Low investment in agricultural R&D resulting in limited human, technical, infrastructural capacity and technology development	R&D supporting policy Seek international and national funding to train technical staff and upgrade infrastructure
Non conducive policy and inadequate institutional framework Weak collaboration between government agencies and research institutions at national level	R&D supporting policy Seek international and national funding to train technical staff and upgrade infrastructure
Farmers resistance to change due to limited know- how and perception that technology is complex	Training and Awareness
Weak linkages between research and extension and end users	Strengthen collaboration between Research and extension
Limited technical support and demonstration projects	Provision of fund to support extension and demonstration Encourage public /private partnership private Training of growers association and service providers (e.g irrigation system assemblers)
Limited market information Poor marketing network and after sale services	Improved access to technology through regional sale points and after sale services
Absence of information and awareness and successful case studies related to climate change adaptation technologies	Training of farmers Awareness campaign on climate change impacts and adaptation strategies Capacity building in Economic analysis Dissemination of economic analysis and successful case studies.
Limited technical capabilities and dissemination scope of the technology	Evaluation of technical capabilities (human , infrastructural and logistics Capacity building of research, extension and farmers

2.2 Action Plan for IPM technology

This section provides a description of IPM technology and the main reasons justifying the selection of this adpatation technology, the overall target for this technology, the main identified barriers hampering its transfer and diffusion, the existing overall enabling environment and the proposed measures/actions to overcome the barriers. It also includes a technology action plan which describes the specific, short, medium and long term actions proposed for the implementation of IPM technology.

2.2.1 About the technology

Integrated Pest Management (IPM) is a broad based approach that integrates a range of practices for economic control of pests. It aims to suppress pest populations below the economic injury level (EIL). It includes controlling insects, plant pathogens and weeds. IPM emphasizes on use of pest control techniques and subsequent integration of appropriate

measures that discourage the development of pest populations, encourage natural pest control mechanisms and keep pesticides to economic levels and reduce or minimize risks to human health and the environment. Chemical pesticides are used only where and when these natural methods fail to keep pests below damaging levels" (Frison et al, 1998; 10).

It comprises of six components namely:1) keeping pest population at acceptable level, monitoring, 2)preventive cultural practices (disease free seed, crop rotation, inter-cropping, pest-resistant varieties, timing of planting and harvest, water, soil and nutrient management, intercropping, mulching, trap crops and field sanitation), 3) pest monitoring, 4) physical control (traps, hand-pulling, hoeing, mowing, and tilling), 5)biological control(use of natural enemies: predators, parasites, and pathogens and sterile male insects, bio-pesticides, plant-based pesticides (biological pesticides)), and 6) responsible chemical control (safer and lower risk pesticides, pheromones and growth regulators) .

Technologies identified to assist local farmers to minimise crop damage and improve crop productivity and resilience to climate change include IPM techniques to control major pest of field and greenhouse crops of economic importance (e.g. mites, melon fly, fruit bats, leafminer and whitefly). A few examples of proven technologies that need to be upscaled includes

1. Demonstration of tree pruning and use of bird net to reduce damage by fruit bats
2. Inoculative releases of predators to control population of Tetranychus urticae a mite causing major damage on solaneceous crops, roses and strawberry.
3. Release of parasitoids(Encarsia formosa and Eretmocerus eremicus) for control of White fly, serious insect pest in greenhouse production
4. Field Sanitation using field cages (augmentorium), protein bait and MAT block to attract and suppress melon fly, Bactrocera cucurbitae, major pest in cucurbits

Over the last 15-20 years, IPM technologies for the control of melon fruit fly (B. cucurbitae), a major pest of cucurbit crops, Plutella xylostella (the diamondback moth DBM), a serious pest of cruciferous crops, have been successfully implemented on a pilot scale with the support of the International Atomic Energy Agency under the Insect Pest Control Sub-programme of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture. These projects have helped to develop and strengthen national technical, managerial and scientific skills required for the effective and efficient application of area-wide integrated pest management programmes (AW-IPM) which include a Sterile Insect Technique (SIT) component through fellowship training, scientific visit, technical consultancy and supply of equipment. Thus, expertise to support IPM technologies (use of SIT, rearing of predators/ parasitoids, mass trapping, pheromones sticky traps) exists at Entomology Division of AREU and Agricultural Services. These can be used to support the transfer an d diffusion of new IPM technologies to reduce crop damage, minimise human and environmental hazards and improve farmers' livelihood.

The cost benefit analysis of IPM was estimated to 1.6 (Annex 4 of Report II – Barrier Analysis and Enabling Framework Report), and the Net present Value (NPV) of the benefits derived from it over 10 years was Rs 49.432,000. This clearly justifies public investment in this technology for agricultural development program for food security. Investment in research and development in IPM technologies generally lead to increase in usage of more pest specific, efficacious, less toxic insecticides with lower rate of active ingredient, preventive and suppression strategies and other safer control methods which bring economic benefits to both producers less crop damage and consumers. It also helps to reduce dependence on costly chemicals which can have

adverse environmental and social effects. The technology helps to make savings on pesticides and improves farm profitability as a result of higher crop yield. It also enhances conservation of beneficial organisms such as pollinators and natural enemies. For more details on IPM technology refer to the technology factsheet in Annex of the RI - TNA Report (Mauritius).

2.2.2 Target for technology transfer and diffusion

Barriers to transfer and diffusion of specific IPM technology are closely related to the targets to be achieved and the beneficiaries. The technology is appropriate for present and expected climate scenarios impact on pest damage. This section gives an overall view of targets in terms targeted growers, the percentage crop loss reduction, reduction on reliance of synthetic pesticides, overall improvement in crop productivity and enhancement of farmers' livelihood.

Table 3. IPM technologies and the targeted pest and beneficiaries.

IPM technology	Targeted pest	Targeted beneficiaries
Pruning of fruit trees and use of bird net	fruit bat, a pest of economic importance on litchi, longan and mango	Fruit growers and general public
Inoculative releases of predators to control population of Tetranychus urticae	Mite, a pest of economic importance on solaneceous crops, roses and strawberry	Tomato, chilli, eggplant, rose and strawberry growers
Release of parasitoids (Encarsia formosa and Eretmocerus eremicus)	Whitefly, a pest of economic importance in a range of field and greenhouse crops	Growers of food crops and , ornamentals
Field Sanitation using field cages (augmentorium), protein bait and MAT block	Melon fly, Bactrocera cucurbitae, major pest in cucurbits	Around 70 % of food crop growers

Given that climate change is expected to facilitate the emergence and resurgence of invasive pests and plant disease vectors, current IPM strategies is bound keep pace with rapid and dynamic changes in pest diversity and population. To equipped farmers to cope with increasing levels of biotic and abiotic stress and enable them to continue to grow healthy and high-yielding crops with minimal inputs of agro-chemicals, the target and milestone set for the transfer of this technology is to bring significant changes in their knowledge, attitude and practice. Given the high cost and time required to successfully demonstrate IPM technologies, provide technical support to farmers, train farmers and create public awareness the target for the diffusion of the technology is set over a 10 years period with the aim of attaining 20 % of the land under food crop that is some 1200ha under food crops (involving approximately 2,400 small scale growers).

2.2.3 Barriers and measures to the technology's diffusion

Despite the support and experiences acquired from IPM projects funded by international organisations, the up-scaling and adoption of proven IPM technology have been low at national level. The main reason why it has not gained widespread adoption among local farmers is due to lack of public financing to sustain project-dependent IPM programs. Transfer of this technology is also constrained by the range of expertise and the innovative participatory approach required for its dissemination. The other identified barriers hampering the uptake of the technology are listed below:

1. **Economic and financial barriers:**

- Insufficient financial resources to sustain IPM pilot projects/ program initiated by donor funding and invest in research capacity development and infrastructure to support IPM technology which is resource intensive
- Lack of market incentives to encourage farmers adopt sustainable practices (such as Ecological Food Labelling or Pesticide Environmental Stewardship Programme) and disincentives to discourage the use of chemical pesticides (e.g. tax on chemical pesticides)
- Limited fund to support on-farm IPM demonstration on wide geographical area
- High cost of environment friendly alternatives to chemical pesticides as IPM is time consuming and labour intensive.

2. Non- financial barriers

Market failure and imperfections: Limited access to the technology due to inadequate on farm demonstrations at regional level, restrictive quarantine policy on introduction of predators an parasitoids due to insufficient capacity for pest risk analysis, aggressive promotion of synthetic toxic pesticides by private companies and government, limited availability of quality bio-pesticides and inadequate supplier of IPM technology products.

Policy and regulation: Absence of policy to promote IPM (emphasis still on agricultural intensification) encouraging use of bio-pesticides and low-risk pesticides instead of synthetic pesticides.

Network failures: Limited IPM technology suppliers (mostly government organization), weak collaboration between research, extension and farmers involved in IPM program, aggressive marketing of synthetic pesticides.

Institutional and organizational capacity: Limited human and infrastructure capacity to implement IPM program, weak inter-institutional collaboration, limited coordination between research and extension for IPM project implementation, limited capacity for pesticides residue monitoring and weak planning and assessment of IPM program at institutional level

Human skills: Staff trained in IPM program having to move leading to interruption in the program up-scaling, lack of local expertise in ecosystem evaluation and inadequate extension field officer trained in IPM to act as facilitator in implementation IPM program

Social, cultural and behavioural: Resistance to change from conventional pest control to IPM approach as they are not convinced of their effectiveness, perception of IPM being complex and difficult to implement compared to pesticides which are easy to apply and fast acting, pesticides regarded as an "insurance" against risk of cross loss caused by pests, lack of community efforts (non-adoption by neighbouring fields) and less concern about long term negative impacts of pesticides

Information and awareness: Poor communication between researchers and farmers, limited training of research, extension and farmers lack awareness on IPM techniques, lack of technical IPM information resources and package of IPM compatible practices (cost and effectiveness), lack of information on value of environmental damage due to chemical pest control, iinadequate consumer awareness of benefit of IPM to environment, and health and ineffective dissemination of IPM technology(top to bottom approach or one – way system based on teacher- learner model

Technical: Limited capacity (human and infrastructure) to support National IPM program, limited national expertise in IPM - multidisciplinary team to support IPM to farmers (field monitoring, pest scouting, pest surveillance and data collection), limited logistic support to undertake field demonstration (site, materials, maintenance, transport,), Crop and pest specificity of IPM package , effectiveness of IPM technology only if undertaken a wide-area level

Others: Limited information on weather forecast, and insufficient logistic facilities to encourage environmentally sound pest control (e.g no facility for disposal of pesticides and empty containers), given increasing pest outbreak and pressure as a result of changing climate, there is need review policies and undertake measures to provide farmers an understanding of the agro-ecosystem ecological concept , IPM practical application so as to assist them in reducing the risk of crop failure and thus improve their livelihood and national food security. .

Despite the above identified barriers hindering the transfer of IPM technologies, several national policy documents and the government vision to develop a cleaner and safer environment provides the appropriate enabling environment in favour of promoting IPM. The National Environment Policy which aims at reconciling environmental sustainability with economic and social development to provide a better quality of life to Mauritian population is one of the key conducive framework. It encourages adoption of Good Agricultural Practices (GAP) for long term sustainability of agricultural production system. National agricultural policy documents such **Strategic Options in Crop Diversification and Livestock Sector 2007-2015** and the **National Biodiversity Action Plan (2006-2015)** also directly or indirectly support integrated approach to pest management for the preservation and enhancement of the natural environment. Moreover, the government's strong commitment to promote sustainable development, the "Maurice Ile Durable" Policy, Strategy and action plan 2012 aims at promoting sustainable agriculture through minimising use of agrochemicals and pesticides so as to prevent deterioration of groundwater and lagoon water quality and protect health of farm workers and consumers. Other existing enabling environment to the transfer of IPM technologies includes the existing infrastructure and technical expertise in IPM, interest of ono-governmental agencies as well as pesticide companies to engage in IPM, existence of farmers' associations to take decision collectively, relatively high level of literacy among local farmers and farmers knowledge and involvement in decision making. These conditions are conducive to enable IPM control actions to be taken collectively thus ensuring greater success at an area-wide management.

In light of the key barriers and existing enabling environment, the main measures identified to overcome the barriers and promote IPM technologies are sustained investment in research and development in IPM techniques, building infrastructure and technical capacity, including human resources development to support IPM project implementation, economic evaluation of IPM techniques, establishment of market incentives such as IPM brand, enforcement of of relevant policies, financial disincentives to discourage use of synthetic pesticides, encourage farmers participation through Farmers field schools, strengthening institutional collaboration, encourage regional cooperation and awareness raising.

2.2.4 Proposed action plans for IPM technology

Following identification and detailed analysis of the barriers to the transfer and diffusion of IPM technologies, this section will focus on the proposed measures essential to create the enabling environment conducive to encourage widespread adoption and dissemination of this technology among local farmers. The technology action plan for promoting IPM technologies include the

- economic and financial measures (incentives and disincentives)
- policy and regulation tools
- market incentives
- research and development capacity
- information and awareness raising (demonstration projects); and
- support to farmers.

Table 4. Technology action plan for IPM technology.

Barrier Category	Barriers	Justification for action	Proposed measures /actions	Time Frame (yrs)	Estimated cost (Rs)	Implementing agencies	Funding sources	Indicators of success (IOS) & Risk
Economic and financial	Insufficient financial resources to sustain IPM pilot projects & investment in research capacity development and infrastructure	Need to sustain fund to promote and upscale IPM program to help to minimise crop losses and ensure food security	Information on economic impact of damage due to pest and diseases convey to policy makers for action and prioritisation of adaptation in agricultural sector Government to Increase R&D budget for up-scaling IPM Programs	0 - 5	15.0 M	government agency, private sector	Government & International organisation	IOS- IPM program sustained and demonstration undertaken Risk – IPM is not attractive to investors /donor
			Financial incentives to assist farmers shifting from conventional to ecological farming practices incentive	5 - 10	5.0 M			
			Economic feasibility study of IPM program	10- 20	1.5 M			
Policy and regulation	Absence of supportive policy to promote IPM and discourage promotion of chemical pesticides	Need to minimise use of chemical pesticides for sustainable agriculture / In line with food safety and MID policy	Develop an IPM strategy and policy across sectors to foster IPM adoption and ensure sustainable development in line with MID policy and strategy Disincentives to discourage use of synthetic pesticides	0 - 5	0.8 M	State law Office, MAIFS, MOESD	Government funding	IOS- Policy put in place and enforced Risk – Lack of political will
			Review of quarantine policy and regulation to facilitate introduction of IPM technology (biopesticides/ predators, parasitoids)	5 - 10	0.4 M			
			Regulating sale of pesticides and disposal of empty pesticide residuEnforce food safety regulation w.r.t. pesticide residue monitoring	10- 20				
Market failures and Imperfections	Lack of market incentives such as Ecological food Labelling	Provision of market / financial incentives to encourage farmers to shift to sustainable practices	Public awareness on alternative to chemical pesticides	0 - 5	1.5 M	Govt of Mauritius, Private sectors, Mauritius Standard Bureau and Certification bodies	Government and private sector and NGOs	IOS- setting of Standard for Ecological food label , No. of farmers trained and certified Risk- Low demand for IPM products
			Encourage setting up of private standard for Ecological food labelling (voluntary) Setting of certification scheme Introduce subsidy on inputs used in IPM Public awareness of Ecological food label/ low risk food	5 -10	3.5 M			
R&D capacity	Limited capacity for Research and development on IPM / Lack of skilled human resources Limited pesticide residue monitoring facility	Build sustainable R &D capacity in IPM In line with food safety and to improve market access	Develop IPM training program for researcher, extension, farmers and market actors Strengthen institutional capacity (human and infrastructural) Upgrade Infrastructure to support IPM program Setting of Farmers Field School in IPM Development of locally adapted IPM technology specific to crop & pests under local conditions	0 - 5	0.8 M	MIAFS, AREU, UoM, , International Research centres	Government and International funding	IOS-No of researcher, extension and farmers trained, No. of IPM compatible technologeis tested and disseminated IPM integrated in School curriculum Risk- Trained staff moving out of IPM program

			IPM principles to be include in school curriculum	5 – 10	0.5 M			
			Continuous investment in institutional capacity (human resource development and infrastructural and logistic support)	5- 20	20.0M			
	Limited pesticide residue monitoring facility	In line with food safety and to improve market access	Inventory of pesticide commonly used and capacity for determination of pesticide residue Enforce capacity of pesticide residue analysis at food Lab (human and infrastructure)	0-5	4.0 M	MAIFS- Food Lab Ministry of Health AREU Extension	Gov of Mauritius	IOS-No of pesticide residue analysis Risk- Poor linkage between Research , extension and market actors Risk –there is no enforcement / sanction
Institutional and organizational capacity	Lack of cooperation and communication between the involved institutions leading to failure of IPM projects	Need to foster collaboration between all stakeholders involved in agriculture	Strengthen collaboration between institutions (Govt. Research institute, academia , private sectors, extension and farmers) and cooperation at regional level and promote data and information sharing	0-5	0.25 M	MAIFS, Govt of Mauritius , COI, farmers associations	Regional and national	IOS- No. of exchange meetings/ workshop
Social and behavioural	Resistance to change from chemical control to IPM	To demonstrate overall benefits of IPM practices	Encourage Farmers / community participation in IPM	0-5	1.0 M	MAIFS, AREU, SPWF, NGOs,	National	IOS- No. of farmers implement ing IPM Risk – cheaper pestcides
Information and awareness	Inadequate public awareness of IPM and training of farmers	Need to inform public for decision making	Public awareness of potential impacts of pesticide on env. and health and alternatives sound pest and disease control	0-5	0.4 M	MAIFS, AREU . SPWF, NGOs, Farmers associations , Mins of Health &QL, Media	National	IOS- No. of TV spots, Radio talk Risk – Lack of fund
			Economic analysis of IPM program	5 -10	0.35M			
			Continuous training of farmers	5 - 20	1.2 M			

2.3 Action Plan for Micro Irrigation

2.3.1 About the technology

Micro-irrigation is of 2 types: the low-cost micro irrigation such as low-head, low-cost gravity-fed drip (GFD) irrigation kits, micro sprinklers, micro-tube drip system suited for smallholder farmers and highly sophisticated, capital intensive pressurised commercial drip irrigation. It is commonly used for irrigation of high value horticultural crops such as high value vegetables, fruits and ornamentals in open field, greenhouses or orchards. It delivers water precisely and efficiently and is thus useful in addressing the growing competition for scarce water resources and has shown to have positive effects on yield, incomes, and food security. It reduces labour requirement, weed problem and can also be used for fertigation, which is the application of fertiliser through irrigation system. It is applicable to operate with large or small water capacities and over a range of field sizes, topographic and soil conditions and is well suited for automation. This technology requires:

- a water source which can be from small streams, boreholes, tank, reservoir, field pond and rainwater harvesting;
- a water storage facility;
- design/ layout of irrigation system;
- installation of irrigation system which consist of pipes, valves, filters and small drippers or emitters for drip irrigation and a network of pipes with spray heads;
- a pump to lift or pressurised pump to convey and apply irrigation efficiently (except, in case of a

gravity fed system);

- a filtration system in case of poor water quality and
- regular maintenance to ensure that the emitters are not plugged.

Water source can be from borehole, reservoirs, field pond or potable source. Unlike surface or furrow irrigation, it improves water use efficiency by 50-70 % under micro-sprinkler and up to 90 % under drip irrigation. The technology can work in conjunction with rainwater harvesting and protected cultivation where it can be used for fertigation. This technology requires relatively high cost of initial investment. The cost varies depending on the water source and quality, the field size, topography and the type of irrigation system. The benefit cost analysis of micro irrigation over 250 ha over a period of 10 years was estimated to 4.67. This clearly indicated the overall market benefit of this technology in term of reducing risk of crop failure, increasing productivity, saving in water and fertiliser and additional land brought under production was well as non-market social and environmental benefits such as reduction of water wastage, job creation for installation and maintenance of irrigation equipment, minimising risk of nutrient leaching and groundwater contamination as a result of using fertigation and increase cropping intensity. Depending on the value of the crop produced, this technology can have a payback period of 8 -10 years to recover the cost from investment. This technology can be considered as a long-term investment for water saving, to improve or sustain income and output of vulnerable farmers and to promote sustainable agriculture.

2.3.2 Target for technology transfer and diffusion

The technology is appropriate for adaptation under present and expected climate scenarios as a mean to save water, increase or sustain farmer's income and enhance food security. Considering the areas with soil moisture deficit and the vulnerability of farmers, this technology is targeted to improve and sustain productivity and income of small scale farmers in the drought prone regions such as the north, west and some of the southern part of the island. It is targeted to cover a total of 250 ha under food crop production over a period of 5 years in highly vulnerable areas with high soil moisture deficit (Table 5) and a reliable access to freshwater. The technology may benefit around 500 small scale foodcrop growers including female farmers suffering from frequent crop failure and yield loss due to water shortage.

Table 5. Soil moisture deficit in different parts of the island and the projected irrigated areas.

Region of the island	Soil moisture deficit M^3/ha/yr	Projected irrigated areas (ha)		
		2020	2025	2030
North	1200	9598	9598	9598
West	1400	5800	6300	6300
East/Centre	800	5700	6300	6300
South	1000	5140	5440	5440
Total		21108	27638	27638

Source: Irrigation Authority and AREU

Identifying the appropriate areas and beneficiaries for this technology will have to consider also the access to water, the prevailing cropping pattern, the level of education and the financial capacity of farmers to invest and support from non-governmental organization.

2.3.3 Barriers and measures to the technology's diffusion

Despite the introduction of the family drip irrigation system (suited for 250 m2) by AREU in 2007 and the introduction of the gravity fed KARI Drip irrigation system(suited for 1250 m2) in 2010 and the multitude of benefits provided by micro irrigation system , its adoption has been restricted to only few farmers who have benefited materials from demonstration projects. This low adoption is mainly attributed to the high initial cost of investment,lack of information on the rate of return on investment and insufficient technical economic benefits of using the technology. The other barriers were summarised into 7 aspects: economic and financial, policy and regulation, technical capability, institutional, market failures, social/ behavioural and information and awareness.

Economic and financial barriers: This involves the cost of equipment (main pipes, lateral, sub-lateral pressurised PVC pipes, water tanks, fittings, pump), cost of transport, design and installation and maintenance. The overall cost varies depending on the field size, the quality of the material and the source of water and is often perceived as a high initial investment for small-scale resource poor farmers whose production depends on rainfall. Thus access to appropriate financial incentives for purchase and installation of micro-irrigation and efficient pricing of water are recognised as the main barriers.

Policy and regulation: the absence of a conducive policy and institutional framework with respect to water management including water rights in the agricultural sector and irrigation water pricing which does not encourage the adoption of this technology.
Technical capability: Access to a reliable water source, high cost of energy, inadequate water quality, land tenure, lack of socio- economic analysis and lack of information of water savings , lack of economies of scale, clogging of emitters, lack of skilled labour for design and installation, high level of skilled required management of MI were identified as the technical barriers.

Institutional: Limited Human and infrastructural capacity for R&D, weak linkages between research, extension, irrigation equipment suppliers, weak inter-institutional collaboration between institutions dealing with water resource management (Water Resources Unit, Central Water Authority, AREU, Irrigation Authority and Wastewater Management Authority) were the barriers to implementation of micro-irrigation technology.

Market failures: the small size of the market, poor access to farmers, absence of a standard and quality control for the equipment, low prices of horticultural produce, shortage of after sale services, insufficient market information, lack of transparency are key barriers identified under local conditions.

Social/ behavioural: Resistance to change, limited know how on the technology, theft and vandalism and perception that water is not a limiting factor and that increased management effort is required for micro irrigation were the reason deterring farmers to invest in micro irrigation.

Information and awareness: lack of awareness on the economic, environmental benefits of the technology, limited access to technical information and training, absence of knowledge on success case studies are the factors limiting its uptake.
Faced with water stress due to climate change and increasing competition for diminishing water resources from other expanding sectors, the agricultural sector which is mainly rainfed with only 30 % its land under irrigation is

likely to be highly vulnerable. Thus to address food security under this condition of water scarcity in agriculture, the water and agricultural policy is to reduce water loss, encourage rainwater harvesting and promote efficient irrigation system to optimise water use and improve productivity. The Irrigation Authority who is responsible to provide irrigation facilities to small planters' community have operated some 18 irrigation projects covering some 4170 ha under different methods of irrigation already has the technical expertise and experience in planning , designing, construction and monitoring of micro-irrigation project. In addition, technical expertise in designing low cost drip irrigation system also exists at AREU to support the farming community.

Considering the above barriers to the uptake of micro-irrigation technology and the existing enabling framework, several measures have been identified to promote the adoption of this technology. These measures include: provision of credit facilities and economic incentives, institutional support for MI dissemination, training of assemblers and extension officers in design of MI, training of farmers in operation and maintenance and MI demonstration, review of water pricing, subsidy on MI products, provision of after sales service , establishment of a quality control on MI equipment, provision of technical and economic information (cost, payback period , pressure requirement, compatibility to cropping system , ease of operation and maintenance uniformity of irrigation) to farmers , provision of inputs (seed, fertiliser) and capacity building of farmers in water management, irrigation scheduling and fertigation.,

2.3.4 Proposed action plans for Micro Irrigation

In view of providing enabling environment to encourage market actors and farmers to invest micro-irrigation technologies to improve efficient water use and improve overall agricultural productivity in the event of diminishing water resources, it is important for the following measures /actions to be taken:

- Provision of financial incentives;
- Improve legislations and regulations;
- Support research and development;
- Increase awareness and technical support; and
- Improve after-sales service.

Table 6. Technology action plan for micro-irrigation technology.

Barrier Category	Barriers	Justification for action	Proposed measures /actions	Time Frame (yrs)	Estimated cost (Rs)	Implementing agencies	Funding sources	Indicators of success (IOS) & Risk
Economic and financial	Absence of financial incentives to encourage farmers to adopt the technology	Need to Improve R&D budget in irrigation and water management and to provide financial incentives to optimise water use	Institutions to provide information on risk of crop failure associated with water stress to policy makers for decision making on need for promoting adaptation Survey of potential zones in water deficit areas and target group Conduct Feasibility study of implementing MI project	0 - 5	0.8 M	Water Resources Unit , Irrigation Authority private sector, AREU, SPWF, MAIFS	National or international funding	IOS- Survey report and cabinet paper Risk - There is no water stress
			Provision of Financial incentives in form of a scheme/grant (40 % of the cost)or soft loan to assist farmers in investing in MI equipment Investment on agricultural research and on farm field demonstration of MI	5 - 10	45.0 M			

			Investment of water infrastructure (reservoir, pipes, canals) to improve access to water to support irrigation projects in water deficit areas Provision of economic incentive to invest in water efficient irrigation system Provision of special incentives and technical support to first MI adopters (act as model and drive others)	10- 20	110.0M			
Policy and regulation	Inadequate policy to promote efficiency water use in agriculture	Promoting efficient use of water resources is In line with Food security policy and sustainable development	Policy framework to enhance access to and productive use of water in agricultural sector Review of water rights ,pricing of water and electricity Encourage investment in support services for design , installation and advice on trouble shooting	0-5	0.5 M	State law Office, MAIFS, MOESD, Sugar Estates	National and Private sectors	IOS- Policy put in place and enforced
			Promote market oriented approach to disseminate MI Technology Policy to enhance private sector investment in irrigated agricultural development	5- 10	2.0 M			
Policy and regulation	Inadequate policy to promote efficiency water use in agriculture	Promoting efficient use of water resources is In line with Food security policy and sustainable development	Policy framework to enhance access to and productive use of water in agricultural sector Review of water rights ,pricing of water and electricity Encourage investment in support services for design , installation and advice on trouble shooting	0-5	0.5 M	State law Office, MAIFS, MOESD, Sugar Estates	National and Private sectors	IOS- Policy put in place and enforced
			Promote market oriented approach to disseminate MI Technology Policy to enhance private sector investment in irrigated agricultural development	5- 10	2.0 M			
Institutional and organisational Institutional	Limited resources and weak linkage between R&D and MI equipment suppliers	Capacity building and improve linkages	Policy to encourage inter-institutional collaboration and data and information sharing	0 -5	0.4 M	MIAFS, Research Institution , Private sectors, Irrigation Authority(IA), AREU, MSIRI, SFWF, farmers associations	National , regional and international	IOS- MOU between institution , Role of each institution clearly defined
Market mechanism	Limited market and lack of competition Poor standard of MI equipment	Identify ways to reduce cost and make technology affordable	Conduct cost benefit analysis and feasibility study for MI technology on different farm size and crop types Establish of a Quality Control to monitor quality of MI equipment put on sale on local market		5.0 M			IOS- Report of study,Quality standard and quality control established Risk – increase in freight cost and cost of rrigation equipment
Research and Development capacity	Lack of research network and collaboration	Build a network of relevant stakeholders	Build a research network though public and private partnership Enhance skills of researchers through training / workshop and visits	0-10	4.0 M	MIAFS, Irrigation Authority ,AREU, MSIRI, UoM	National and regional	OIS- No of research and technical publication on irrigation and water management No of farmers receiving assistance in MI

	Inadequate research to support appropriateness of Irrigation technologies for small scale farmers	To improve R& D capacity / linkage between research and extension alleviate poverty , improve farmers income and welfare and improve productivity	Research to enhance yield in irrigated areas through improve agronomic practices Assessment of small scale irrigation performance in terms of water use efficiency under different crop water requirement / under different soil types, Training of extension irrigation specialist Technical assistance to farmers on cultural practices to improve productivity under irrigation Capacity building of entrepreneurs involved in design , installation and maintenance of irrigation system	0 – 5	10.0 M	MAIFS, Irrigation Authority , AREU , MSIRI, NGos, Sugar Estates , Water Users Association		
			Survey of potential areas for development of water resources based on hydrological information Benefit-cost analysis for alternative MI technologies taking into account affordability, accessibility, maintenance and sustainability Identification of appropriate water use agricultural model and strategies to assist farmers					
Information and awareness	Inadequate capacity building in MI Absence of technical know-how on MI	Build capacity of researcher, extension, farmers and entrepreneurs involved in design and installation / after sale service	Identify training needs of beneficiaries in areas related to MI technologies, water management , operation and maintenance and input supply Human resource development through training of research, extension, farmers and active players involved in MI Workshop / seminar/ exhibition to promote MI at regional and national level Demonstration of MI on recognised farms of Research Institute/ progressive farmers of horticultural crops (0.5 ha each) Promote sustainable business for designing and producing and marketing MI technologies	0 – 5	6.8 M	MAIFS, AREU, IA, SFWF, NGOs	Government and private	IOS- No. of training / workshop , exhibition No. of field demonstration, video,, factsheet Risk –unavailability of sufficient funding
			Development of guidelines for micro irrigation system design and management Factsheet on micro irrigation , video show and radio talks with successful case studies on benefit of MI	5- 10	2.2 M			

3. Technology Action Plan for Coastal Zone

3.1 Actions at sectoral level

3.1.1 Short sector description

The island of Mauritius has approximately 320 km of coastline that is almost completely surrounded by fringing coral reefs. The coastal zone plays a vital role in protecting settlements, infrastructure, agriculture and important ecological systems from climate-related hazards. For instance, coral reefs protect against persistent wave action and frequent cyclones, and endow the island with sandy beaches and 'turquoise blue' lagoons that are coveted by tourists. Coastal zone impacts, including coastal erosion and flooding, will undermine coastal development, which will hinder the foundation of a proposed increase in tourism, a government intended pillar of the economy. The coastal zone of Mauritius is important not only for providing income through tourism and fisheries but also protecting the island from the natural forces of the ocean. The viability of the major economic activity and protective functions are wholly dependent on the vitality, aesthetics and ecological functioning of the coastal ecosystems.

The coastal land, estuaries and inshore waters that make up the island of Mauritius and its associated islets are rich in natural resources and wildlife. They support a large proportion of the population and varied economic activity including recreation, tourism, fisheries, trade and industry. Approximately 20% of the population is resident in the coastal areas.
Further the socio-economic contribution of the coastal activities cannot be overruled. The Financial Strategies Report of the ICZM Project estimates the revenue directly generated from the coastal zone as just under Rs 74 billion, equivalent to 36% of GDP – out of which 99% is generated by tourism. The coastal zone is also the focus of many leisure activities by Mauritians and it also provides the prime residential lands. The total economic value of the coast, in present value terms, is of the order of Rs 1 trillion.

The coastal zone is affected by a host of climate and non-climate changes, and although the two types of drivers take place simultaneously, their relative influences depend on the time horizon for their respective actions.
There are several national policies, strategies and action plans that have been developed over time that supports the sustainable development of the coastal zone in the Mauritius (please see table below).

Coastal Policies, Strategies or Action Plan	Priority Areas	Gaps
Vision 2020 Policy Document	Developed in 1997 The document is focused on providing consistent long term development strategies for several sectors including Society and Culture, Science and Technology, Environment, Economy, Employment, Industry, Tourism and Agriculture. The Environment sector had the following goals: To develop a vision for Mauritius 2020 considering the function and values of the environment and the evolution of environmental Management. The following were also addressed: • The legacy of past developments in Mauritius (population and fertility changes, physical planning, economic growth, structural adjustment, environmental degradation), • Major environmental issues (climate change, freshwater resources, conservation and biodiversity, solid waste management, atmospheric pollution), • Environmental policy and practice (policy & governance legal framework, social change and attitudes, project sustainability issues, institutional constraints etc).	The strategies developed in the document for the sectors were based on discussion with relevant stakeholders. The document does not deal explicitly on issues like climate change.

2nd National Environmental Strategy and Action Plan (2000 – 2010)	Developed in 1999; The documents focused on projects geared towards improving environmental quality. Projects such as monitoring of water resources, setting up of a cleaner production centre, a framework for Integrated Coastal Zone Management, the demarcation of Environmentally Sensitive Areas, development of an Environment Information System and industrial management, were given high priority. In a second phase, projects were geared towards integrated air quality management, industrial pollution prevention, quality and ecological assessment of fresh water bodies, facilitation of sustainable environmental practices, reforming environmental management framework, capacity building of environmental agencies, and environmental education awareness and community empowerment.	Reviewed in 2008 and recommendation made for its further implementation
National Environment Policy	Consolidation of scattered policy statements into a common approach for cohesive sectoral and cross sectoral environmental management; Updated in 2007 Objectives: (1) Conservation of environmental resources; (2) inter- and intra-generational equity; (3)include environmental concerns in socio-economic development; (4) achieve 'garden island' concept; (6) enhance partnership across society; (7) development of environmental ethics in citizens; (8) Promote policy dialogue	Deals with climate change issues in a general manner.
Climate Change Action Plan	Formulated in 1998 The document provides a list of actions with a view to reduce the negative impacts of climate change covering adverse impacts, measures for abatement and enhancing sinks for greenhouse gases, policy options for monitoring systems and for strategies to respond to the impact of climate change, and policy frameworks for implementing adaptation measures and response strategies.	Actions not implemented.
National Physical development Plan (NPDP) – Development Strategy and Policies	National Level strategy and policy framework to guide the efficient implementation of public and private sector infrastructure and development projects within a sustainable environment. Reviewed in 2003	Consideration of effects of climate change is scarce.
National Development Strategy	The NDS, the main planning instrument providing the spatial framework, was approved in 2003. Subsequent proclamation part of the Planning and Development Act in 2005 gave legal force to the NDS. In 2006, the policies and proposals were successfully translated at the local level through the preparation and approval of local development plans. In line with the principles of sustainability advocated in the NDS, a thorough review of the local plans for the main urban areas which have coalesced into a linear conurbation is planned so that an up to date framework for development is available for the next 10 years. The NDS is supported by sectoral or subject plans for issues like irrigation, land transport or for agricultural diversification, including the reform of the sugar and non-sugar sectors.	The document considers little the effects of climate change
National Biodiversity Strategy and Action Plan (NBSAP)	Finalised in 2006. A ten year strategy to ensure the conservation of biodiversity, its sustainable use and the fair and equitable sharing of its benefits. The NBSAP reflects and aims to meet the measures of the	The document gives little indication of the advent of biodiversity in direct relation with climate change.

	Convention on Biological Diversity (CBD). This country study addressed biodiversity issues under the headings of forest and terrestrial biodiversity, freshwater, coastal and marine biodiversity, and agricultural biodiversity, biotechnology and biosafety. The principal highlights of the study were (a) habitat loss as the major historical cause for terrestrial biodiversity loss and the small remaining forest area being under intensive pressure from invasive alien species, (b) the marine inshore waters have been overfished and tourism development is impacting significantly on the coastal zone (c) the freshwater ecosystems of the island are degraded due to deforestation, pollution and water extraction for agriculture (d) local agro-biodiversity is in decline due to introduction of modern commercial varieties/breeds, and (e) investment in biotechnology is ongoing but caution is needed through appropriate biosafety provisions.	
Development of an Integrated Coastal Zone Management Framework (ICZM)	Proposed in 2009; To secure clean, healthy, safe, productive and biologically diverse marine and coastal environments; ensuring that natural resources including those of the Exclusive Economic Zone are managed to meet the long term needs of nature and people through their sustainable use and development; and at the same time, acknowledging the multiple uses and objectives of different sectors and stakeholders (e.g. tourism, fisheries, conservation) Under Implementation	Recommendations are being implemented but on an ad-hoc basis.

The TNA for the Coastal Zone sector has retained four technologies, namely; Restoration of coastal vegetation, Wetland protection, Dune restoration and Rock revetment. Because of the close interaction of dunes and the vegetation found thereupon and their simultaneous and coherent processes in controlling the stability of the shoreline, these two technologies have been merged to the single technology of Dune and Vegetation Restoration.

Three of the four technologies retained, Restoration of coastal vegetation, Dune restoration and Rock revetment are applicable directly on the shoreline and would provide direct benefits to the location where they are applied. In contrast, wetland protection would act indirectly in mitigating the erosion impacts on an adjacent coast. Wetlands, through their hydrological services they provide, contribute to improve the water quality of the lagoon around Mauritius and thus a healthy marine environment which in turn would contribute to the stability of the shoreline.

3.1.2 General barriers and proposed measures

The general barriers that are challenging the implementation of the identified technologies remains almost directly or indirectly linked to the cost involved in the use of the technologies. Majorly, the technologies require a high initial investment and eventually some periodic inputs to cater for their maintenance in view of ensuring their sustainability on the long run.

While securing funds from funding agencies through various programme or project proposals in view of implementing works remain an uncertain venture, it is proposed that there is a participatory or cost sharing approach to the implementation of the technologies. This shall have the added benefit of resolving the issues in an integrated way.

Another barrier to the implementation of the technologies that have been identified is the lack of information on the technology at various levels ranging from officials to the general public through private bodies. It is thus proposed

that information and awareness campaigns be undertaken in the use of the technologies and this would contribute to the better acceptance and appreciation of the benefits of these technologies.
Lack of experience and capacity to design and implement the technologies has also been identified as a barrier to their use. However, the experience and capacity is being fostered through the implementation of projects related to the technologies.

The legal framework, including the enforcement of existing laws and regulations, to deal with the implementation of the technologies is also a barrier especially for wetland protection. Appropriately enforcing the laws and regulations would partly resolve the problem as some wetlands are under private ownership and as such ensuring proper protection may be problematic. Having wetlands under some official jurisdiction can address the issue with the appropriate legal instrument such as a dedicated protection law to support such measure.

3.2 Action Plan for Dune and Vegetation Restoration

3.2.1 About the technology

Coastal dunes offer a buffer against storm extreme tides and storm surges. This buffering capacity, however, is minimized and potentially eliminated when dunes are over-stabilized by invasive plant species or other alterations brought about by urbanization and development. Over-stabilization makes dunes more susceptible to loss from erosion by not enabling them to move or migrate naturally in response to sea level rise and changes in erosion patterns.
Coastal vegetation is a vital part of a reef-lagoon-beach ecosystem. The restoration of native coastal vegetation normally takes places as part of bigger projects, namely dune and coastal wetland restoration. Healthy dunes are vegetated by native vegetation: self-tolerant with dense root system, effective at holding onto the sand, thus diminishing rate of dune erosion caused by waves and winds. The succession of creeps and shrubs also acts as filtering/regulation run off during rainstorms and are able to recover rapidly from erosion events.
The implementation of this technology would require an initial investment of the order of MUR 75000 per meter of coast. This investment shall ensure that the stretch of beach is rehabilitated and protected and indirectly it shall contribute to the economy of the country by preserving its beaches therefore ensuring the continued development of the tourism industry. It will also enhance the local recreational areas used by the local population.

3.2.2 Target for technology transfer and diffusion

The target to be achieved for the transfer and diffusion of dune and vegetation restoration would be during the next five years.

3.2.3 Barriers to the technology's diffusion

3.2.3.1 Lack of appropriate space for implementation

The major barrier in the implementation of the dune restoration technology in Mauritius is the inappropriateness and unavailability of space along the shoreline. The Pas Géométriques around Mauritius comprises of Hotels, the public beaches and also the Campement site. These areas are in great demand and of high value and they have undergone major transformation to accommodate the hotels and bungalows.
It is a major challenge to restore the dunes to their original height over most part of the shoreline due to

the now exiting infrastructure over those areas. In certain areas though along with public beaches, it is still possible to restore the seaward face of the dunes especially where adequate setback exist.

3.2.3.2 High cost involved in terms of materials required

Dune restoration requires large quantity of sand and availability of such material is very limited in Mauritius given that only inland quarries are allowed to supply these. Moreover there is a high cost associated with dune restoration as the material itself and its implementation cost including machinery and labour is also high.

3.2.3.3 Inadequate legislative / regulatory framework

The dunes in Mauritius do not have per say a legislative or regulatory framework for it specific protection. The setback requirement of having no hard construction within 30 m from high water mark is more of a measure to control erosion than the actual protection of the dunes. Beach reprofiling for the upgrading of the beach is an undertaking requiring an EIA Licence.

3.2.3.4 Lack of information to concerned stakeholders

Given the limited area that is available as public beaches and for dune restoration it is difficult to convince the public and the officials of the need and usefulness of dune restoration as this measure may appear to hinder access to the beaches. Conflicts of interest may also arise, especially if dune construction takes place in an area primarily used for residential or tourism purposes, where local landowners or lease owners may be concerned about maintaining sea views.
The local population appreciate h the Casuarina sp. trees, and removal of these trees to be restored with native species may find public opposition as they are not familiar with the specifics of both. Native plants on the other hand are often perceived as being house to various little animals, insects and reptiles and thus their limited popularity.

3.2.4 Proposed action plans for Dune and Vegetation Restoration

In view of ensuring the dune and vegetation restoration it would be important for following actions to be taken:

a) Provision of Financial incentives
b) Improve Legislations and regulations and
c) Information and awareness raising

a) Provision of Financial Incentives

Why	The cost for implementing Dune and Vegetation restoration is relatively high due to the cost of materials, labour and machinery to be used at around MUR 75,000 per meter of beach.
Who	The financial incentives should come from the Government for implementation of the technology in places other than public beaches
When	0 – 5 years
How much the measure/ action will cost, how can it be fundedyears	The cost for implementing dune and vegetation restoration is estimated to be around Rs 75,000 per meter Funding for such action can be through participatory or cost sharing with the lessee of the Pas Geometrique and through International Funding Agencies
Indicators of success, risks	Implementation of the technology would be an indication of success along with the control of erosion at the site A risk would be the unwillingness and non-participation of the Lessee of the Pas Geometrique

The Government should provide incentives that would encourage the lessee of the plot of land adjacent to the shore to undertake such appropriate measure to protect and restore the dunes and vegetation within their plot. Such incentives could be a decrease in their rent upon completion of works or facilities at attractive rates for the implementation of works.

Participatory and cost sharing between neighbors, as most areas along the shore are under lease, and also with the government is a measure that can be put forward in view of implementing dune and vegetation restoration despite the high cost that can be involved especially if sand has to be replenished. The protection of the shoreline from erosion is usually to be addressed in an integrated way over large areas and this participatory and cost sharing approach would make the implementation of the technology more affordable and feasible.

This participatory and cost sharing approach is an adaptation from the usual practice of the Government to initiate projects under a Built-Operate-Transfer basis whereby a technology or project is implemented with the government as partner in the venture and eventually following an agreed period of operation, the assets are transferred to the government.

b) Improve Legislations and regulations

Why	Dunes are not properly protected under actual legislation
Who	The Government
When	0 – 5 years
How much the measure/action will cost, how can it be funded	Approximately MUR 1,000,000 for consultancy services for review and putting forward appropriate legislation. Domestic Funding
Indicators of success, risks	The success would be the enactment of specific legislation for the protection of Dunes and native vegetation A risk would be the time usually taken from drafting to enactment of a proper legislation.

The proper legislative or regulatory framework for the implementation of the technology should be promulgated in an Act that is closely related to the coastal zone. Usually the best candidates for amendments would be the Pas Géométriques Act of 1982 and the Environment Protection Act of 2002. These should be amended so that the implementation of the technology becomes feasible and also the dunes become appropriately protected especially from developments.

c) Information and awareness raising

Why	Lack of awareness of the importance and role of Dune and vegetation along the shoreline
Who	The government with the support of NGOs
When	0 – 5 years
How much the measure/action will cost, how can it be funded	MUR 1,000,000 for the production of leaflets and sensitization materials. Can be funded domestically and through the support of International Funding Agencies under environmental programmes.
Indicators of success, risks	Increase awareness of the Officials and the public in general

A three tier approach can be envisaged for the proper dissemination of the information regarding the benefits and use of dune and vegetation restoration. The approach would have to touch different level of stakeholders including official and Authorities, the lessee as the direct beneficiary and the public at large.

The information and awareness campaign could further be merged into a larger programme which aims at providing appropriate information with regards to climate change and coastal erosion to the stakeholders and the public at large.

The most pertinent information to be disseminated would be to explain how such measures can help in controlling erosion, any alternatives that can be used and also the benefits of the use of such technology especially in terms of being environment friendly with little negative impacts on the surroundings.

3.3 Action Plan for Wetland Protection

3.3.1 About the technology

The backfilling of wetlands along the Mauritius coast has significantly decreased the area of wetlands and significantly increased surface water flow to the sea. This has resulted in elevated levels of suspended solids, nutrients from sewage and fertilizers, and contaminants entering coastal lagoons. Declining water quality and algal growth has already been detected in several portions of the lagoon (Baird report 2003). Coral-reef ecosystems are also highly sensitive to eutrophication (such as algal blooms that rob the water of oxygen) from nutrient runoff, sedimentation, and temperature changes, and must be protected from such sources if possible.

Wetland restoration re-establishes these advantageous functions for the benefits of coastal flood and erosion protection. Techniques have been developed to reintroduce coastal wetlands to areas where they previously existed and to areas where they did not, but conditions will allow.

The major cost involve in the implementation of this technology would be in the purchase properties that holds wetlands and a buffer area of 30 m. The benefit of having these wetlands under official jurisdiction would ensure its proper protection and rehabilitation and also ensure that the wetlands provide their services to the environment.

3.3.2 Target for technology transfer and diffusion

The target group for the implementation of this technology would be those private property owners with portions of land under wetlands or in the buffer of 30 m from the wetlands. The target to be achieved for the transfer and diffusion of wetland protection would be during the next five years. It is urgent to address the issue of wetland protection as these are sustaining enormous pressure from property developer.

3.3.3 Barriers to the technology's diffusion

3.3.3.1 High Cost

Wetlands usually occur close to the coastal zone and as such are in areas where properties are of very high value, examples are Grand Bay and Flic en Flac. In view of offering the best protection

to wetlands, it must be ascertained that the wetland is under some official control and being under private ownership does not afford wetland this protection. In view of getting such control, acquisition of the wetlands should be undertaken and thus the high cost to achieving wetland protection.

3.3.3.2 Inadequate legislative / regulatory framework

Wetlands need to have a specific legal instrument for its protection. Till now there has been the Wetland bill and the ESA Bill which have been drafted with the main objective to protect the wetlands in Mauritius and properly manage these sensitive areas. Both bills are still under consideration and have not been passed through the parliament for eventual enactment. This is seriously hindering the protection and conservation effort as there is an inadequate legislative and regulatory framework for such environmentally sensitive areas as wetlands.

3.3.3.3 Inefficient enforcement

Enforcement measures are limited with existing legislation and thus the pressures and threats over wetlands are constantly accruing. Most coastal wetlands are found in the immediate vicinity of highly developed and built up area and this proximity makes them prone to be backfilled in view of a forthcoming development.

3.3.3.4 Lack of participation and communication between Institutions

Wetlands in Mauritius fall under the responsibility of the Ministry of Agro Industry and food security through the National Parks and Conservation Services. However, when it comes to enforcement, it is mostly the Ministry of Environment who has the legal instrument to take actions under the EPA act 2002. Wetlands in Mauritius are legally framed under various section of the law and different Authorities have jurisdiction over them. The proper management of wetlands is thus challenging under such situation.

3.3.3.5 Lack of information on wetland ecosystems

Wetlands are wrongly perceived, by the general public, as being wastelands and proliferation ground for mosquitoes and other insects or pests. This misperception is directly related to lack of information on wetlands and their importance in the ecosystem and the services it provides. This misperception over the wetlands is the main reasons for these to be at risk of being backfilled. Thus it becomes more challenging to protect the wetlands under those circumstances.

3.3.4 Proposed action plans for Wetland Protection

In view of ensuring wetland protection it would be important for following actions to be taken:

a) Acquisition of Wetlands
b) Improve Legislations and regulations and
c) Information and awareness raising

a) Acquisition of Wetlands

Why	Some wetlands are privately owned and it efficient protection can only be under Official jurisdiction
Who	The government
When	0 – 5 years
How much the measure/action will cost, how can it be funded	Approximately MUR 1,000,000 for consultancy services for review and putting forward appropriate legislation. Domestic Funding
Indicators of success, risks	Enactment of a Wetland Protection Legislation A risk would be the time usually taken from drafting to enactment of a proper legislation.

In view of better protecting the wetlands, the government could acquire the plots which are under wetlands or in the 30 m buffer zone. Whilst compulsory acquisition for plots of land is usually a long process, the Government may provide incentives to wetland land owners to either voluntarily give or exchange their plot for other plots which would be more appropriate for development.

The above measure has been spelled out in the ESA Study (2009) Policy Report. This measure would make the wetlands come under an official jurisdiction thereby facilitating its proper protection.

b) Improve Legislation and regulation

Why	No specific Legislation for Wetland Protection
Who	The Government
When	0 – 5 years
How much the measure/action will cost, how can it be funded	Approximately MUR 1,000,000 for consultancy services for review and putting forward appropriate legislation. Domestic Funding
Indicators of success, risks	Enactment of a Wetland Protection Legislation A risk would be the time usually taken from drafting to enactment of a proper legislation.

In view of ensuring the proper protection of wetlands, it would be of utmost importance to have a dedicated law that would fulfill this gap. Up and until such law is passed, the wetlands would only be protected under ancillary laws such as under EPA 2002. The ESA bill as prepared under the ESA Study (2009) would have been most appropriate in ensuring the protection of wetlands and other ESA in Mauritius. Moreover the legislation should also contain appropriate enforcement actions and measures of the laws with severe penalties.

c) Information and awareness raising

Why	Lack of awareness of the importance and role of wetlands
Who	The government with the support of NGOs
When	0 – 5 years
How much the measure/action will cost, how can it be funded	MUR 1,000,000 for the production of leaflets and sensitization materials. Can be funded domestically and through the support of International Funding Agencies under environmental programmes.
Indicators of success, risks	Increase awareness of the Officials and the public in general

An information and awareness campaign on wetlands in general would be most appropriate as the importance of wetlands in the ecosystem and the services it provides remains unknown to the public at large. The ignorance of the above is usually the source for wetlands being backfilled. It is far too common for people to realize their importance following heavy rainfall causing flooding in the surrounding areas.

The most pertinent information to be disseminated would be the services provided by the wetlands, its importance and of course how to ensure that it fulfills these in the best of their capacity. It would also be appropriate to provide information on what would happen in the surrounding areas following backfilling of the wetland.

3.4 Action Plan for Rock Revetment

3.4.1 About the technology

Revetments are hard engineered structures with the primary function to prevent further erosion of the shoreline. They are built usually with stone, concrete or other durable materials and are shaped in a slope facing the sea and they aim at holding or preventing a scarp or embankment against erosion by wave action (UNFCCC, 1999). Revetments are to be differentiated with seawalls which are vertical or near vertical shoreline protection works separating the land and water areas.

Revetments are frequently used in locations where further shore erosion will result in excessive damage, e.g. when roads and buildings are about to fall into the sea.

Rock Revetments aim at controlling erosion of the land behind the structure due to direct wave attack. They act by blocking the dynamic removal and return of dune and beach material during and following an extreme event such as cyclone or storm surges.

Rock revetments do not address the root causes of erosion and therefore the erosion processes will persist unabated and any beach that is present may gradually diminish in width and height eventually creating escarpments and severe damages to the beach and dunes. Rock revetments do not preserve or enhance beaches. In addition beach may be lost is surrounding areas due to wave reflection and refraction from the structure.

Rock revetments when appropriately designed, may have a high amenity value. It is common practice in many countries to have rock revetments incorporating promenades and other amenities which encourage recreation and tourism. Rock revetments are potentially long-lived structures provided they are adequately maintained.

Rock revetments are at a rate of MUR 10 Million for 100 meter of coastline. This technology is implemented in areas where infrastructure such as roads and houses are at risk. It shall provide the appropriate protection and would not necessitate relocation of local population and also prevent cut-off access to certain areas especially when roads are concerned.

3.4.2 Target for technology transfer and diffusion

The government would be the major stakeholder for the implementation of this technology. However,

the local force-vive where the technology would be implemented would have to be sensitised to the importance and use of the technology.

The timeline for the transfer and diffusion of rock revetment would be during the next five years as the problem of erosion is critical in certain region. It must be mentioned that the use of this technology is well underway in certain region of Mauritius

3.4.3 Barriers to the technology's diffusion

3.4.3.1 High cost for implementation of rock revetment

One of the main barriers to the implementation of a well-designed rock revetment is cost. The design of an effective rock revetment requires good quality, long-term environmental data such as wave heights and extreme sea levels and requires a combination of engineering and oceanographic expertise and experience.

The construction of a rock revetment would usually require several thousand tons of massive boulders, large excavators and other specialized equipment to put these in place and the cost of these together with the time required for such construction thus becomes very high of the order of Rs 10 M for 100 m of revetments (cost estimates from Beach Authority).

3.4.3.2 Policy intermittency and uncertainty

Rock revetments have been implemented in Mauritius more frequently during the last 5 years. The use of rock revetments have been mainly following severe erosion of the shoreline and where buildings or infrastructure are being left exposed to damages. The use of this technology is being implemented on an ad-hoc basis in the absence of the specific national plan for the control of erosion.

Rock revetments do not address the source or cause of the erosion and this implies that erosion will persist unabated in those areas and at times the significant impacts on the region could be more damaging following the placement of these structures.

3.4.3.3 Limited Capacity and experience

The design of the rock revetments does not usually include consideration of coastal dynamics, sediment transport and the hydrodynamics. This has for effect that erosion, to various degrees, occurring at the end of the structure is exacerbated because of the mere presence and design of the structure. The use of this technology might entail additional environmental cost especially in the case of wrong design and implementation of works.

3.4.3.4 Lack of awareness and information to coastal communities

The use of rock revetment may provide an erroneous sense of protection against erosion. It will usually control the erosive forces at specific location whereas adjacent areas remain or can become more vulnerable. Also the use of this technology largely affects the aesthetics of our beaches and may be regarded as an eyesore especially for a

country which is betting a large portion of its economy on the tourism industry. Moreover the use of rock revetment may limit the accessibility to the sea and thus find public opposition to its implementation.

3.4.4 Proposed action plans for Rock Revetment

In view of implementing rock revetments it would be important for following actions to be taken:

a) Provision of Financial Incentives

b) Support to research and development and

c) Information and awareness raising

a) Provision of Financial Incentives

Why	The cost for implementing Rock Revetments is high due to the cost of materials, labour and machinery to be used.
Who	The financial incentives should come from the Government for implementation of the technology in places other than public beaches
When	0 – 5 years
How much the measure/action will cost, how can it be funded	The cost for implementing rock Revetment is estimated to be around Rs 10 Million for 100 m of coastline. Funding for such action can be through participatory or cost sharing with the lessee of the Pas Geometrique and through International Funding Agencies
Indicators of success, risks	Implementation of the technology would be an indication of success along with the control of erosion at the site A risk would be the non willingness and non participation of the Lessee of the Pas Geometrique

Rock revetments are usually associated with high cost of the order of MUR 10 M for around 100 m (figures from implemented projects and from Beach Authority). Up till now most major works in the implementation of rock revetments have been made by the Government. In view of decreasing the load on the government, it can be contemplated that hotels or other private bodies contribute to the cost of the rock revetment. This contribution should not be in the form of tax but rather as a social contribution for the benefit of the area.

This participatory and cost sharing approach would assist in the implementation of the technology and thus providing for some protection to the shoreline from erosion. Several projects have been undertaken under the Corporate Social Responsibility (CSR) by private institutions and implementation of rock revetments could fit in well under this scheme.

b) Support to research and development

Why	The cost for implementing Rock Revetments is high due to the cost of materials, labour and machinery to be used.
Who	The financial incentives should come from the Government for implementation of the technology in places other than public beaches
When	0 – 5 years
How much the measure/action will cost, how can it be funded	The cost for implementing rock Revetment is estimated to be around Rs 10 Million for 100 m of coastline. Funding for such action can be through participatory or cost sharing with the lessee of the Pas Geometrique and through International Funding Agencies
Indicators of success, risks	Implementation of the technology would be an indication of success along with the control of erosion at the site A risk would be the non willingness and non participation of the Lessee of the Pas Geometrique

Revetments can be made from different materials and the use of other materials in lieu of rock to form revetments should be studied as it can have major impacts on the cost of the structure. Geotextile bags with sand could be a possible alternative whereby the cost is reduced to one third of conventional rock revetment (www.geofabricsinternational.com).

The research can further develop a national plan for the control of erosion for Mauritius in as much as it would give the various methods which can be most appropriately used upon consideration of the individual characteristics of the eroded site. This national plan would identify the measure or technology to be used for the various locations and it would have the added advantage that works would be done following a schedule plan and thereafter the monitoring of the works shall be undertaken.

c) Information and awareness raising

Why	Lack of awareness of the benefits of Rock Revetments along the shoreline
Who	The government with the support of NGOs
When	0 – 5 years
How much the measure/action will cost, how can it be funded	MUR 1,000,000 for the production of leaflets and sensitization materials. Can be funded domestically and through the support of International Funding Agencies under environmental programmes.
Indicators of success, risks	Increase awareness of the Officials and the public in general

An information and awareness campaign on the problem of erosion along the shoreline and the various methods that exist to control the erosion would be most appropriate for Mauritius. The benefits and disadvantages of each method should be given. This campaign should be targeted towards the public at large and the authorities and this would ensure early detection of erosion. Whilst several degree of erosion exists if dealt with at its very early stage, the effort and cost incurred in controlling it could be consequential.

The most pertinent information to be disseminated with regards to climate change and coastal erosion to the stakeholders and the public at large, would be to explain how such measures can help in controlling erosion, any alternatives that can be used and also the benefits of the use of such technology especially in terms of being environment friendly with little negative impacts on the surroundings.

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Annex 1 – List of Stakeholders Involved and their Contacts.

Water

List of stakeholders involved in identification of barriers and development of enabling framework				
Sector - Water				
Name(s) of contact person	**Organisation**	**Approach of consultation**	**Date**	**Topic**
Sales Manager	Supermarkets	Informal Interview	28.04.2012 & 11.11.2012	Rainwater Harvesting – whole unit
Mrs. R. Ramrekha	Water Resources Unit	Meeting / discussion	11.05.2012	Rainwater Harvesting & Desalination
Mr. D. Jahajeeah	Water Resources Unit	Meeting / discussion	18.05.2012	Rainwater Harvesting & Desalination
Mr. A. K. Gopaul	Central Water Authority	Meeting / discussion	15.06.2012	Rainwater Harvesting
Mr. Caullychurn	Water Resources Unit	Bilateral meeting	8.08.2012	Rainwater Harvesting & Hydrological Models
Sales Manager	Retailers	Informal Interview	25.08.2012 & 30.08.2012	Rainwater Harvesting – Storage tanks
Mr. R. Bissessur	Water Resources Unit	Meeting / discussion	9.11.2012	Rainwater Harvesting & Desalination
Mr. R. Pokun	Water Resources Unit	Bilateral meeting	12.11.2012	Hydrological Models
Mr. E. Seenyen	Scene-Ries Consult Ltd	Informal Interview	10.12.2012	Desalination

Agriculture

List of stakeholders involved in identification of barriers and development of enabling framework				
Sector - Water				
Name(s) of contact person	**Organisation**	**Approach of consultation**	**Date**	**Topic**
Mr Gannesh	Farmers Service Cooperation	Bilateral meeting	26.08.12	Microirrigation
Mr S. Mulloo	Irrigation Authority	Bilateral meeting	August 2012	Microirrigation
Mr A. Goolaub	Agricultural Research and Extension Unit (AREU)	Informal Interview	September 2012	Microirrigation & IPM
Mr S. Benimadhu	Pathology Division< AREU	Informal Interview	12.10.12	IPM and
Mr Dunhawor and Mrs L. Unmole	Entomology Division, AREU	Meeting / discussion	12.10.12	Integrated Pest Management
Mr K. Permalloo and Mr Sookar	Agricultural Services	Meeting / discussion	12.09.12	Integrated Pest Management
Mr S. Seeruttun	Agricultural Services	Bilateral Meeting	04.09.12	Microirrigation & IPM
Mrs R. Brizmohun Gopaul	Faculty of Agriculture , University of Mauritius	Bilateral Meeting	22.09.12	Microirrigation & IPM
Mr Koonjal	Mauritius Sugar Research Institute	Bilateral Meeting	27.10.12	Microirrigation
Mr S. Pandoo	Agricultural Research and Extension Unit	Bilateral Meeting	20.09.22	Microirrigation
Mr Ram Vencatasamy	Agricultural Research and Extension Unit	Bilateral Meeting	20.10..12	Microirrigation

Coastal Zone

List of stakeholders involved in identification of barriers and development of enabling framework				
Sector – Coastal Zone				
Name(s) of contact person	**Organisation**	**Approach of consultation**	**Date**	**Topic**
Mr Magho	ICZM Division Ministry of Environment and SD	Meeting	29.11.2012 15.01.2013	All identified technologies
Mr Jheengut	ICZM Division Ministry of Environment and SD	Meeting	29.11.2012 15.01.2013	All identified technologies
Mr Mosaheb	Mauritius Oceanography Institute	Meeting	29.11.2012 15.01.2013	All identified technologies
Representative Mr Seervansingh	Beach Authority	Meeting	29.11.2012 15.01.2013	All identified technologies
Mr Gujadhur	Ministry of Tourism	Meeting	29.11.2012	All identified technologies
Representative	National Parks and Conservation Service	Meeting	29.11.2012 15.01.2013	All identified technologies
Mr Mohit and Representative	Albion Fisheries Research Centre	Meeting	29.11.2012 15.01.2013	All identified technologies
Representatives	Ministry of Environment and SD	Meeting	29.11.2012 15.01.2013	All identified technologies
Mrs Soogun	ICZM Division Ministry of Environment and SD	Informal Meeting	11.01.2013	All identified technologies

TNA REPORT IV

PROJECTS IDEA REPORT ADAPTATION

(WATER, AGRICULTURE AND COASTAL ZONE)

(August 2013)

Disclaimer

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 Regional Centre ENDA 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 Ministry of Environment and Sustainable Development.

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1. Prime Minister's Office (Mauritius Meteorological Services , Mauritius Oceanography Institute)
2. Ministry of Energy and Public Utilities (Water Resources Unit, Wastewater Management Authority, Central Water Authority)
3. Ministry of Finance & Economic Development (Statistics Mauritius)
4. Ministry of Public Infrastructure, National Development Unit, Land Transport and Shipping (Land Transport Division, National Development Unit)
5. Ministry of Education and Human Resources
6. Ministry of Agro Industry and Food Security (Agricultural services, Agricultural Research Extension Unit, Food and Agricultural Research Council, Forestry Service, National Parks and Conservation Service, Irrigation Authority, Farmer's Service Corporation, Sugar Cane Planter's Association and Small Planters Welfare Fund)
7. Ministry of Environment and Sustainable Development
8. Ministry of Tertiary Education, Science, Research and Technology (Mauritius Research Council)
9. Ministry of Fisheries
10. Ministry of Local Government and Outer Islands (Outer Islands Development Corporation)
11. Ministry of Tourism and Leisure
12. Ministry of Industry, Commerce and Consumer Protection
13. University of Mauritius
14. Beach Authority
15. Mauritius Sugar Industry Research Institute
16. Mauritius Agricultural Marketing Cooperative Federation Ltd
17. Indian Ocean Commission
18. United Nations Development Programme Country Office
19. Association of Hoteliers and Restaurants in Mauritius
20. Mauritius Chamber of Commerce and Industry
21. Mauritius Chamber of Agriculture
22. Mouvement Autosuffisance Alimentaire
23. NGO Platform – Climate Change
24. Pesticide Action Network of Mauritius

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1. Project Ideas for Water Sector

1.1 Brief summary of the Project Ideas for Water Sector

The project idea report for the water sector highlights the key actions that will be required in order to enable the successful implementation of the three technologies (Rooftop Rainwater Harvesting Technology, Desalination, and Hydrological Models), selected in collaboration with stakeholders. The project ideas have been developed based on the enabling framework and measures that were identified in the TNA Report II for Mauritius – Barrier Analysis and Enabling Framework and the technology plan report – TNA Report III for Mauritius - Technology Action Plan. These documents provide the detailed information that were used to prepare the Project Idea Report. The Project Idea Report summarises the key factors that will determine the success behind the projects, in terms of the institutional framework, the policies, the regulations, the technical know-how, the needs for additional training, and the needs for awareness campaigns.

1.2 Specific Project Ideas

1.2.1 Specific Project Ideas - Rooftop Rainwater Harvesting Technology (RWH)

The rooftop rainwater harvesting technology is targeting the residential sector. The objective is to encourage the inhabitants to use treated water more optimally, by making use of rainwater for secondary uses. The system proposed will ensure storage of good quality water, and will also cater for groundwater recharge through a nearby absorption pit for any excess unused rainwater.

RWH is not a complex technology and it requires low technical knowhow and maintenance. However it is not currently widely used in Mauritius because water is relatively cheap and plentiful. In general people are not well aware of the impacts of climate change and of the need for a change in mind set towards consumption of water. In the first time there will be a need to create awareness of the need for such a technology at residential level, the short and long term impacts of climate change, the need to optimise on the use of treated potable water, the need to contribute to sustainable development of water resources on an individual level. Regulations will be needed together with the new Building Act (2011) to encourage people to implement RWH. Encouragement will need to be provided in terms of soft loans and there will need to be monitoring of these loans and type of RWH on the market to safeguard the interests of the people investing in RWH at residential levels.

1.2.1.1 Summary sheet for rainwater harvesting

WATER PROJECT SHEET: Rooftop Rainwater Harvesting Technology

Brief Project description
The collection of rainwater by using rooftops as catchment areas can help reduce the use of treated water for secondary purposes, thus preserving water resources destined for primary purposes (e.g. drinking water).

Results Oriented Framework

Overall Goal
i. Conservation of water resources
ii. Raising awareness of the need to conserve water

Development Objectives
At least 25,000 residential housing units should be able to install rainwater harvesting systems in the first year of the project

Inputs
i. Source or offer rainwater collection systems suitable for residential, commercial and industrial buildings.
ii. Demonstrate the effectiveness of the system
iii. Promote the commercialisation of the technology

Outputs
i. Small scale enterprises should offer the systems and installation service
ii. Awareness of the national benefit is raised

Impacts
I. Alleviate water demand
II. Reduction in wastage of potable water
III. Increase in groundwater recharge.

Estimated costs
MUR 2,500,000 – for purchase and installations only.
A simple complete unit of RWH costs around Rs. 10,000 and this will require an installation cost of Rs. 1000. In the first year and a maintenance cost of Rs. 100 as from the third year since installation. The life span of a complete RWH unit is around 20 years. There are 250,000 housing units which can be targeted.

Proposed timeframe
2 YEARS (primarily to stimulate market uptake)
But 10 years to reach all potential housing unit.
The project will span over 10years, starting with housing units located in high rainfall regions, 25,000 units targeted each year.

Executive bodies
Ministry of Energy and Public Utilities

Cost-benefit analysis
The estimated benefit-to-cost ratio of 1.37 demonstrates a good return on investment. This technology will, in addition to ensuring an optimal use of treated water, contribute to enhancing groundwater recharge, thus reducing the surface runoff which is lost to the sea.

Risks
- Rainfall varies over space and over time, and some areas are dry. Such areas need to be investigated for the viability of the project.
- The public may be resistant to retroffing an existing system which will involve adding a RWH.

Expertise required (based on market maps)

Profile
Local expertise in water systems usage and dissemination.

Key tasks
- Identify critical areas for, and facilitate participatory workshops
- Identify adequate media to reach the different targeted groups

Identification of key stakeholders
Ministry of Energy and Public Utilities
Ministry of Finance & Economic Development
Ministry of Education and Human Resources
Ministry of Agro-Industry and Food Security
Ministry of Environment and Sustainable Development
Ministry of Health and Quality of Life
Private businesses involved in the marketing or development of RWH

1.2.1.2 Project overview

The rainwater harvesting technology is aimed at residential level, a roof top rainwater harvestor, with a simple design. The main features consisting of the collection system (pipe and gulleys), the connecting pipe with an outflow for discharge of settleable solid particles, a container (500litres), and an overflow with drainage facilities, in the form of absorption pits, in order to promote groundwater recharge.

• Project Scope and Possible Implementation

The project itself is based is based on the use of a simple system, which require low level of skills to install, operate and maintain. It is practically feasible, being relatively easy to handle. Rainwater Harvesting is not a completely new technology is Mauritius; it has been implemented both at residential and commercial level, but mostly on a voluntary basis. To date, the level of implementation of RWH is very low. With increasing water demands, the country's water sector is under much pressure and this calls for a change in mindset. Recent studies linked to sustainable development such as the Sustainable Consumption and Production project, the Maurice Ile Durable project and the Working group on water from the MRC, have recommended the use of RWH at residential level for a more optimal use of potable water.

• Timelines

There are about 250,000 housing units in Mauritius and the objective is to get most of these units, who are able to, set up a RWH. The timeline for achieving this objective is 10years, as the Government will need to identify funds in order to provide financial support in the form of soft loans.

• Budget/Resource requirements

A simple rainwater harvestor has been estimated at around Rs. 10,000 for a complete unit. It is expected that the Government will provide financial support, either up to a maximum of Rs. 8000. Or up to 75% the total cost, whichever is the lowest.

• Goals and objectives

The project is aiming at encouraging inhabitants to use rainwater for secondary purposes such as watering or cleaning. In addition the inhabitants will be made aware of the individual responsibility in the sustainable consumption of water resources.During very wet periods, excess rainwater will then be channelled in an absorption pit and this will promote groundwater recharge.

• Components

Collection system from the roof, pipe connections to the storage tank allowing for a scour to remove trapped dirt, a storage tank 500litres capacity, an absorption pit and necessary simple accessories.

1.2.1.3 Project framework

Project Goal: Adaptation to climate change by diversifying the source of water supply.					
Development objective: To remove barriers for the large-scale diffusion of rainwater harvesting technology at the household level using a market-based mechanism supported by incentives.					
Project Component	**Expected Outcomes**	**Expected Inputs**	**Expected Outputs**	**Objectively Verifiable Indicators**	**Expected Impacts**
1. Regulations for a robust RWH	Specifications of a RWH	Technical details of size of tank, pipe connections and size of absorption pit.	Ensure that RWH complete system will be reliable for at least 10years.	Quality of materials used for the construction of the system.	Residents are protected against frauds.
1. Develop a Scheme at the level of the concerned Governmental Institution to provide financial and technical support.	Eligibility for this financial support and ceiling.	Details about cost of RWH units availability on the market & details about owners of housing units.	Control to ensure that owners who can implement such system benefit through this scheme.	Monitor the application process.	Financial scheme achieves its objectives.
3. Monitor the implementation of this unit at Residential level through water bills.	Highlight the benefits of RWH at individual and national level.	Water Bills details from CWA.	Drop in water consumption over time.	Individual Water consumed over time & water consumed in the residential sector at national level.	Reduction in potable water consumed at both individual and national level.

1.2.1.4 Project Justification

• Relationship to the country's sustainable development priorities

The implementation of RWH at residential level is very low to almost inexistent. RWH is a simple technology which requires low level of technical input and provides sound benefits to the water sector. Mauritius is already witnessing the impact of climate change with extreme events such as long dry periods and flood type rainfall. RWH will also help in changing the mind-set of the inhabitants towards optimal use of potable water.

• Relationship to existing national strategies and plans or reports and assessments under relevant conventions, if applicable:

The updated Building Act (2011) has stressed on the need for sustainable consumption of water. New regulations in terms of Building rating is expected to be promulgated in the very near future and RWH is likely to contribute towards the good practice expected.

• Project Deliverables

RWH will help to alleviate some of the stress on the water sector and contribute towards the reduction in surface losses. A cost benefit analysis has confirmed the viability of this project in the Mauritian context.

1.2.1.5 Monitoring and Evaluation (M&E)

Monitoring of the impact of this activity can be carried out by the following:

1. Change of water consumed by the residents who have implemented a RWH;

2. Change of water demand in the residential sector by the Central Water Authority; and
3. Change in groundwater level in those areas, will indicate whether this technology is enhancing groundwater recharge.

1.2.1.6 Risks and their mitigation

Indicate risks, including climate change risks that might prevent the project objectives from being achieved, and if possible, propose measures that address these risks to be further developed during the project design:

Risk	Level (Low, Medium, High)	Response
Climate Variability – long wet or even long dry periods	Medium	Sensitization campaign to emphasize on optimal use of potable water and behavioural change.
Low level institutional support responsible for providing guidance	High	Dedicated staff will be needed at the level of the institution.

1.2.1.7 Stakeholder mapping

Identify key stakeholders involved in the project including the private sector, civil society organisations, local and indigenous communities, and their respective roles, as applicable:

Stakeholder	Roles and responsibilities
Ministry of Finance and Economic Development	To provide soft loans and ensures that the loan is used for the stated purpose
Ministry of Industry, Commerce and Consumer Protection Ministry of Business, Enterprise and Cooperatives	To provide the enabling framework in terms of contacts, training and visibility, in order to encourage small local business to join the market.
Ministry of Environment & Sustainable Development	To promulgate appropriate legislation in order to protect the interest of the general public.
Central Water Authority & Water Resources Unit, Ministry of Energy and Public Utilities	To monitor that provision for groundwater recharge has been taken into consideration in the design.
Media	To sensitise the general public towards sustainable development and consumption of water resources, water security and impacts of climate change.

1.2.2 Project Ideas for Desalination

The desalination technology is increasingly being implemented in many parts of the world. This technology provides for an alternative source of water which is independent of rainfall. In Mauritius some 10 hotels located along the coastal zones have implemented small capacity reverse osmosis desalination plants, mostly to alleviate water problems during the dry period. The cost of water produced using the desalination plant becomes an attractive option when the hotels have to buy water from tankers. The Government is encouraging the hotel sector to implement this technology in order to alleviate the stress of water sector of the island.

There has been many developments in the technologies of desalination in order to lower the cost and to lower the energy consumption. The present report refers to the reverse osmosis desalination technology. This particular technology is bought off shelf together with the technical support. In order to successfully implement this technology there is a need to train technicians to provide the support needed during the operation and maintenance of the system. The EPA (2011) requires that an EIA report be submitted for a desalination plant and in August 2012,

design sheets for desalination plants have also been promulgated. However the impact of this activity on the long term is not catered by the current legislation. There is thus a need for legislation to ensure safe exploitation of brackish water and for safe disposal of brine. The desalination technology is highly capital intensive and is costly to operate and maintain. The Government in the last budget speech has provided for financial incentives. Soft loans schemes may also help to encourage more hotels to embark on this particular technology.

1.2.2.1 Summary sheet for desalination technology

WATER PROJECT SHEET: Reverse Osmosis Desalination Technology

Brief Project description
The desalination plant will be having a production capacity of 300m3/day and will be treating either seawater of salinity greater than 10,000ppm or brackish water with salinity varying between 1000 to 10,000 ppm. The brine produced will have to be channelled to a dilution tank, before it disposed of in sink wells or in sea outfalls.

Results Oriented Framework

Overall Goal	Development Objectives
i. Tap alternative sources of water.	i. Alleviate the stress on potable water demand. ii. Addressing water security for hotels and building local capacity in the use of the desalination technology.

Inputs	Outputs	Impacts
i. Define new regulation to monitor impacts of brine disposal and abstraction of brackish water. ii. Provide for the enabling environment. iii. Enforcing agency to monitor quality of groundwater. iv. CWA to monitor the demand from these particular beneficiaries.	i. Technology implementation under control. ii. Encourage more hotels to participate in this project. iii. Groundwater quantity and quality well protected. iv.Drop in water demand from the beneficiaries.	i. Minimise local dependence on rain water. ii. Alleviate stress on potable water resources. iii. Increase acceptance of this technology in the country. iv. Further encouragements to be given in this sector to implement a desalination plant.

Estimated costs
MUR 19 Rs Million – Capital cost, installation, operation and maintenance cost of a 300m3/day production plant.

Proposed timeframe	Executive bodies
10 years, with at least 5 successful system every year.	Ministry of Energy and Public Utilities – Central Water Authority & WRU
Cost-benefit analysis	**Risks**
Good option if this technology is used over the whole year and not only during 3 dry months.	Climate variability – long wet periods increasing water availability Lack of technical know-how

Expertise required (based on market maps)

Profile	Key tasks
Few local experts, need to rely on international expertise	• Desalination plant to be purchased from abroad. • Technical experts be called in when needed.

Identification of key stakeholders
Ministry of Energy and Public Utilities
Ministry of Finance & Economic Development
Media
Ministry of Environment and Sustainable Development - National Environmental Laboratory
Private businesses involved in the marketing or development of components of the Desalination Technology

1.2.2.2 Project overview

The desalination technology discussed is the reverse osmosis desalination technology, whereby the desalination plant will be made up of non-corrosive components which are adapted to the treatment of saline water. The plant will be having a production capacity of 300m3/day and will be treating either seawater of salinity greater than 10,000ppm or brackish water with salinity varying between 1000 to

10,000 ppm. The brine produced will have to be channelled to a dilution tank, before it disposed of in sink wells or in sea outfalls. It is assumed that the plant will be in operation during the dry periods only.

Project Scope and Possible Implementation

• Timelines

The project is aiming at encouraging at least 50% of the total number of potential hotels to implement the desalination technology, over a period of 10 years, at least 5 each year.

• Budget/Resource requirements

A 300m3/day reverse osmosis desalination plant involves an initial capital cost of MUR Rs. 14 million. In addition an organisation requires about MUR Rs. 5 milion annually, in order to cater for operation, maintenance and replacement cost. The financial incentives will cater only for part of the initial capital cost. The operation and maintenance cost will be borne by the hotels.

• Goals and objectives

This project aims at alleviating the stress on potable water demand through an alternative source other than rain water. In addition, this project aims at addressing water security for hotels and building local capacity in the use of the desalination technology.

• Components

Robust desalination plants are available on the international market. In addition provisions will have to be made to install a borehole in case brackish water is being pumped, infrastructure to house the desalination plants, sink well for disposal of diluted brine, storage tanks for diluting the brine and pipeline for abstracting seawater and sea outfalls to dispose of brine where needed. In addition, the entire pipe network will have to be catered for.

1.2.2.3 Project framework

Project Goal:					
Development objective:					
Project Component	**Expected Outcomes**	**Expected Inputs**	**Expected Outputs**	**Objectively Verifiable Indicators**	**Expected Impacts**
1.Promulgate legislation/ regulation to ensure environmental protection.	Minimise environmental degradation.	Define new regulation to monitor impacts of brine disposal and abstraction of brackish water.	Technology implementation under control.	Regulations should take local conditions into consideration.	Minimise local dependence on rain water.
2. Provide financial support in the form of rebates	Encourage more hotels.	Provide for the enabling environment.	Encourage more hotels to participate in this project.	The financial support is attractive.	Alleviate stress on potable water resources.
3. Monitor the environmental impacts	Ensure environmental protection.	Enforcing agency to monitor quality of groundwater.	Groundwater quantity and quality well protected.	All those implementing the technology are concerned with environmental protection.	Increase acceptance of this technology in the country.
4. Monitor the impacts on the water demand at national level.	Alleviate stress on potable water resources.	CWA to monitor the demand from these particular beneficiaries.	Drop in water demand from the beneficiaries.	What volume of water is being saved, through this project?	Further encouragements to be given in this sector to implement a desalination plant.

1.2.2.4 Project Justification

• Relationship to the country's sustainable development priorities

Currently about 17 hotels have already implemented a desalination plant, with the objectives of ensuring water security and hence comfort to their customers. As per the Environmental Protection Act 2011 and EIA licence is needed so as to get a development permit and this approach ensures that any potential environmental hazards is given due consideration prior to the development. In addition, since August 2012, guidelines have been promoted under the Planning and Development Act 2004, and this legislation now requires that coastal hotels need to consider the desalination technology.

So promoting the desalination technology does fall in line with the Government policy, and given that this technology targets an alternative water supply source other than rainfall, it contributes to addressing water security.

• Relationship to existing national strategies and plans or reports and assessments under relevant conventions, if applicable:

While the desalination technology does not fall into the category of sustainable development of resources, being relatively highly energy intensive and its by product is not environmental friendly, much progress has been made and worldwide it is gaining wide acceptance.

The current Government policy since August 2011, in the form of Planning Policy Guidelines has been promulgated to encourage coastal hotels to implement desalination technology.

• Project Deliverables

- This project aims at encouraging at least 5 coastal hotels to implement a desalination plant in the first year of the project.
- Over a period of 10 years more coastal hotels would be encouraged to follow the same trend.
- The water demand will be monitored in order to highlight the benefits of this project on the water sector.

1.2.2.5 Monitoring and Evaluation (M&E)

Monitoring of the impact of this activity can be carried out by the following:

1. Change of water consumed by the hotels which have a desalination plant;
2. Satisfaction level of visitor in hotels with regards to water availability; and
3. Change in water demand at the national level.

1.2.2.6 Risks and their mitigation

Indicate risks, including climate change risks that might prevent the project objectives from being achieved, and if possible, propose measures that address these risks to be further developed during the project design:

Risk	Level (Low, Medium, High)	Response
Climate variability – long wet periods increasing water availability	Medium	Hotels may lose interest in using this more costly option. More incentives will be needed to encourage this sector.
Lack of technical know-how	High	A long term training programme is required in order to ensure the technical support over time.

1.2.2.7 Stakeholder mapping

Identify key stakeholders involved in the project including the private sector, civil society organisations, local and indigenous communities, and their respective roles, as applicable:

Stakeholder	Roles and responsibilities
Ministry of Finance and Economic Development	To provide rebates in order to encourage existing coastal hotels to adopt the desalination technology.
National Environmental Laboratory	To undertake regular long term monitoring of disposal of brine in sink wells, on groundwater quality.
Media	To sensitise the general public towards sustainable development and consumption of water resources, water security and impacts of climate change.
Research organisation, and Experts in the field of water and environment.	To help develop accessories and encourage local companies to be involved in the market of desalination technology.

1.2.3 Project Ideas for hydrological model

Hydrological models are sound working tools to ensure effective water resources management. There are different levels of complexity of hydrological models and the selection of a particular model depends on the use of such model. This particular technology is usually operated by a dedicated team of highly skilled technicians. The cost elements of this technology are the cost of the software, the logistics (computers, scanner, and printers), the training of technicians, and the transformation of data into digital format. The benefits are mostly intangible, a better management of water resources will help towards ensuring reliability of water supply over a longer period, will increase the level of water supply satisfaction and will contribute to the economical development of the country with the creation of new jobs, linked to availability of water.

Hydrological models are used to a very low level in Mauritius. The high investment cost in terms of creation of a dedicated unit with all the necessary logistics, the lack of supporting regulations to encourage use of hydrological models and lack of awareness of its potential benefits are some of the barriers which can hinder the success of this technology. In order to ensure the successful implementation of this model, there will firstly be a need to create a dedicated unit, with the logistics such as the software, the computers, printers, scanners, train the technical staff and ensure capacity building for decision making using the hydrological model. The Water Resources Unit is the institution which is directly involved with water resource management of Mauritius, and hence would be the ideal location for creating the dedicated unit.

1.2.3.1 Summary sheet for Hydrological Models

WATER PROJECT SHEET: Hydrological Models

Brief Project description
This project will require Hydrological models for forecasting and for improved water resource management and this has to be tailor made for local water organisations such as CWA and WRU. Tailor made models are required by WRU so as to fit the local context and adapt to their requirements.

Results Oriented Framework

Overall Goal
i. Improved water management and address sustainable development of water resources as well as water security.

Development Objectives
i. Encourage technical staff to make use of historical hydrological in hydrological models, for simulating catchment boundaries and characteristics, and groundwater system, in order to predict the response of the catchment system to extreme events.

ii. Provide for sound information improved decisions for water management.

Inputs
i. Training, capacity building, one to one transfer of know how.

ii. International expertise needed.

Outputs
i. Technical staff become more confident with the use of this technology.

ii. More technical staff are conversant with this technology

Impacts
i. Better understanding of the local hydrological systems,

ii. Improvement in decision making related to water distribution and management.

iii. A move towards Sustainable development and consumption of water resources

Estimated costs
Stage 1: Setting up the logistical support: Computers , Printers, Scanner, Plotter, and Hydrological Model Software and first training (including visits of training experts) – MUR Rs. 2.5 Million
Stage 2: Second training session & Visits of Experts – MUR Rs. 0.5 million
Stage 3: Training for Capacity Building & Visits of Experts – MUR Rs. 0.5 million
Total of MUR Rs. 3.5 Million

Proposed timeframe
2 Years for the training component and capacity building and at least 5 years for the creating of a dedicated unit.

Executive bodies
Ministry of Energy and Public Utilities – Water Resources Unit & CWA

Cost-benefit analysis
Most benefits are intangible, social benefits and noticeable in the long term.

Risks
i. Lack of highly skilled technical staff
ii. Lack of logistics

Expertise required (based on market maps)

Profile
International Experts

Key tasks
To provide basic and advanced training and also ensure capacity building and transfer of know-how.

Identification of key stakeholders
Ministry of Finance and Economic Development
Water Resources Unit & CWA
Research institutions and training institutions involved with tertiary education.
Private international organisations in collaboration with local training institutions

1.2.3.2 Project overview

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes. Recent research in

hydrologic modelling tries to have a more global approach to the understanding of the behaviour of hydrologic systems to make better predictions and to face the major challenges in water resources management.
This project will require Hydrological models for forecasting and for improved water resource management and this has to be tailor made for local water organisations such as CWA and WRU. Tailor made models are required by WRU so as to fit the local context and adapt to their requirements.

Project Scope and Possible Implementation

• Timelines

The hydrological model tailor made for the local context will be set up with a period of 2 years. During the same period, a dedicated unit, computer facilities and training will be provided.

• Budget/Resource requirements

Budget to include 5 computers, printers, scanners, training of technical staff and of trainers, visits of experts, is estimated at around MUR Rs. 3.5 million.

	Computers, Printers, Scanners, Plotters, and other minor accessories MUR Rs. (Million)	Training of 10 participants & Visits of Experts MUR Rs. (Million)	Hydrological Model MUR Rs. (Million)	Creation of the digital database
Stage 1	0.5	0.5	1	0.5
Stage 2		0.5		
Stage 3 (training of trainers)		0.5		

• Goals and objectives

The objective is for the technical staff to make use of historical hydrological in hydrological models, for simulating catchment boundaries and characteristics, and groundwater system, in order to predict the response of the catchment system to extreme events. From there it would be possible for the technical staff to take improved decisions for water management.

• Components

A hydrological model is simply a software-generated artefact, but it requires appropriate logistics for it to work effectively and these have been highlighted under the budget section.

1.2.3.3 Project framework

Project Goal: Enhance the capacity of Mauritius to carry out hydrological modelling for the better management of water resources.

Development objective: Remove barriers for the adoption of hydrological modelling at the Water Resources Unit and Central Water Authority.

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Objectively Verifiable Indicators	Expected Impacts
1 Creating a dedicated unit, staff and logistics	Local expertise to be developed	Training, capacity building, one to one transfer of know how	Improved water management	Water crisis situation	Better understanding of the local hydrological systems,
2. Training of staff from the dedicated unit trainers	Local expertise	International expertise needed.	Technical staff become more confident with the use of this technology.	Decision made on the basis of analysis using hydrological model.	Improvement in decision making related to water distribution and management.
3. Training of trainers	Raise awareness to the benefits of this technology & raise the interest of technical staff.	International expertise needed.	More technical staff are conversant with this technology	Increasing use of this technology in water related organisations	A move towards Sustainable development and consumption of water resources

1.2.3.4 Project Justification

• Relationship to the country's sustainable development priorities

Hydrological models can provide sound technical information based on historical data and long term trend for predicting impacts of variability in climate on availability of water resources. Such information can help towards an improved water management approach, thus a step towards addressing water security specially during long dry periods.

• Relationship to existing national strategies and plans or reports and assessments under relevant conventions, if applicable:

Hydrological model is a highly specialised technology and often not well known to many. To date there has not been any direct regulation that promotes the use of hydrological model in the local context.

• Project Deliverables

Trained technical staff to carry out monthly analysis of the water situation at both catchment level (for each catchment) and overall. These reports should be published so that other related authorities are able to use them for planning and decision making on their side.

1.2.3.5 Monitoring and Evaluation (M&E)

Monitoring of the impact of this activity can be carried out by the following:

1. Number of training sessions carried out every 6 months;
2. Number of people trained;
3. Evaluation report on the understanding and performance of the trained staff; and
4. Use of the hydrological model for improved decision making during the dry periods – case studies.

1.2.3.6 Risks and their mitigation

Indicate risks, including climate change risks that might prevent the project objectives from being achieved, and if possible, propose measures that address these risks to be further developed during the project design:

Risk	Level (Low, Medium, High)	Response
Lack of highly skilled technical staff	High	Recruit new technical staff with qualifications at degree level at least.
Lack of logistics	High	Provide the technical staff with dedicated computers.

1.2.3.7 Stakeholder mapping

Identify key stakeholders involved in the project including the private sector, civil society organisations, local and indigenous communities, and their respective roles, as applicable:

Stakeholder	Roles and responsibilities
Ministry of Finance and Economic Development	To provide complete financial support over the first 2 years.
Water Resources Unit & CWA	To make use of the hydrological models and set up dedicated units.
Research institutions and training institutions involved with tertiary education.	To increase local expertise and contribute in the training and decision making process for sustainable development and consumption of water resources.
Private international organisations in collaboration with local training institutions	To provide capacity building to both the concerned institutions and to local research & training organisations.

2. Project Ideas for Agriculture

2.1 Brief summary of the Project Ideas for Agriculture

The project Idea report for the agricultural sector provides all the concrete actions required to support the realisation of the overall target of optimising irrigation water use among small scale growers in the regions with soil moisture deficit and minimising crop losses due to pest and disease and improving crop yield and food security while enhancing farmers income and livelihood as indicated in the Technology Action Plans for adaptation in the Water, agriculture and coastal zone

(TNA Report III, Mauritius), The project idea for each of the two adaptation technologies for the agriculture namely Integrated pest management (IPM) and micro-irrigation (MI) was developed based on enabling environment and action and measures identified and discussed in the TNA report II Barrier Analysis and Enabling Framework for adaptation to climate change and that were retained in TNA report III and the Technology action plan-Adaptation (Water, agriculture and coastal zone) that have been generated under the TNA project. The project idea provides a detailed of the important actions/measures (financial and market incentives, policy and regulatory, Technical capacity, information and awareness) to be taken to contribute to the transfer, diffusion and adoption of IPM and micro irrigation technologies

2.2 Specific Project Ideas

2.2.1 Project Idea for Integrated Pest Management

Climate extremes such as drought, heat waves , flood and storm with anticipated increase in atmospheric temperature and carbon dioxide is likely to disrupt predator-prey relationship thus increasing insect population particularly crop pests which is a menace to local agriculture. The emergence and resurgence of invasive pests of economic increase risk of crop damage and crop failure thus putting at risk the livelihood of farmers and national food security. This may lead to increase use of pesticides and loss of biodiversity that contribute to plant pest outbreak thus also resulting in adverse environment and health impacts. Therefore to be able to cope with challenge of suppressing crop pest population while ensuring minimal risk to the environment and public health, this project idea proposes to address the barriers and enhance the enabling environment to promote integrated approach to management of crop pest in view of minimising crop damage or failure and reduce famers' vulnerability to climate change while also sustaining or improving crop productivity.

2.2.1.1 Summary sheet for Integrated Pest Management

AGRICULTURE PROJECT SUMMARY SHEET : INTEGRATED PEST MANAGEMENT

Brief Project description
This project aims to disseminate IPM technology as an environmentally sound alternative to chemical control of pests and diseases likely to increase with temperature rise as a result of climate change. This technology will help to reduce risk of crop damage and increase crop yield and food security while minimising environmental and health hazards. It will help to improve the quality of food produced in terms of less risk of pesticide residue and improve the ecological balance in agricultural production zone. It is targeted to train some 3000 growers using the participatory approach through the Farmers Field Schools and to establish at least 2 demonstration plot of 25 ha each per year over a period of 6 years. This project will be in synergy with other projects such as breeding for stress (drought, diseases and heat) tolerant crop varieties promoting integrated crop management and integrated nutrient management.

Results Oriented Framework

Overall Goal	**Development Objectives**
i. Minimise crop losses and promote long term sustainable agricultural production system ii. Improve crop productivity, food security and farmers' livelihood iii. Minimise use of chemical pesticides and environmental and health hazards iv. Improve quality and safety of food produced	Removal of barriers to enhance uptake of IPM using policy and regulation measures , support to R& D, capacity building and market incentives

Inputs	**Outputs**	**Impacts**
i. Survey of agricultural zones and identifying crops grown and pest management practices ii. Awareness campaign on negative impact of chemical control and need for IPM iii. Training of farmers on basic IPM concept iv. Establishing of demonstration for IPM v. Training of researchers and extension in IPM	i. Awareness raised on benefits of shifting from chemical P & D control to IPM ii. Capacity build in researcher and extension specialised in IPM and farmers iii. Make farmer participate in decision making in IPM iv. Improve farmers' resilience to climate change impacts	The long term impact is to improve farmers capacity for ecological pest & disease management, to minimise crop losses while improving overall sustainability of production system

vi. Upgrading of infrastructure to support IPM programs (lab equipment , greenhouses for rearing of predators) vii. Setting of Farmers Field Schools (FFS)for IPM viii. Training of farmers to act as Trainers in FFS ix. Capacity building of extension specialist in the field of IPM x. Production of publication , video, radio and TV programs on IPM technology with successful case studies	v. Improve production and quality of produce	

Estimated costs
This project is estimated to cost USD 1.62 M or MUR 48.6M over a period of 10 years and will involve The Ministry of Agro Industry and Food Security and AREU in partnership with private sectors and the International Atoic Energy Agency. The potential sources of funding are :International donors (United Nation Fund for Climate Change , Adaptation Fund, UNDP, GEF, FAO, Strategic Climate Fund, African Development Bank), national government, regional partners and co-financing between government and private sectors

Proposed timeframe
Over 10 years

Executive bodies
Ministry of Agro-Industry and Food Security and its departments (Agricultural Services-Entomology Division, National Plant Protection Officer, Agricultural Chemistry Division of the Food Technology Laboratory, Forestry Services and National Parks and Conservation Service) and parastatal bodies(Agricultural Research and Extension Unit, Irrigation Authority , Small Farmers Welfare Fund) with the support of International Atomic Energy Agency – FAO, Joint Programme

Cost-benefit analysis
The estimated benefit to cost ratio of 1.6 demonstrates the overall benefits of IPM technology over conventional pest control . It also provided the following avoided future costs:
• Loss of agricultural production due to damage by pest and diseases
• Ground water contamination and other environmental hazard due to chemical pesticides
• Human health risk due to pesticides

Risks
• New pest emergence
• Limited fund for research in development of IPM package suited for local conditions
• Famers resistance to change
• Inability of farmers to work in group at a wide area level

Expertise required (based on market maps)

Profile
Local technical expertise required for training and technical support to farmer and to develop and manage IPM program.
International expertise required to develop compatible IPM technologies

Key tasks
• Increase funding for R & D in IPM
• Identify demonstration sites and farmers group likely to collaborate
• Recruit and train Extension officer in IPM to support FFS
• Seek international and regional support in IPM.
• Training of farmers
• Upgrade existing infrastructure to support IPM programs
• Organise Farmers Field Schools in IPM
• Setting and managing demonstration site as experimental plot for teaching of IPM techniques

Identification of key stakeholders
Ministry of Agro Industry and Food Security –(Entomology Division, National Plant Protection Office and Agric Chemistry Division at the Food Technology Lab – for pesticide residue analyses) of Agricultural Services, Agricultural Research and Extension Unit, Small Farmers' Welfare Fund, NGOs, University of Mauritius

2.2.1.2 Project overview

Project scope:

It is proposed that to promote the transfer of technology, there is need to invest in research for development of IPM compatible technologies, build human and infrastructural capacity to support IPM program, establish farmers field schools in IPM , training of farmers in IPM, establishment of demonstration plot to act as experimental lab for farmers capacity building , market incentives to promote production of ecological food , dissemination of successful case studies. Existing enabling environment conducive to the technology transfer include the following:

• famers are already grouped under association for purchase of inputs and may collaborate for implementing IPM efficiently at a wide area

• Agricultural Research and Extension Unit (AREU) and Entomology Division of AREU and Agricultural Services already have some expertise in IPM and the latter already implements a wide-area IPM to control certain fruit fly species in vegetable growing areas with high density of cucurbitaceous crops, and other wide-area control of fruit fly species in mango-growing areas, plus national environment-friendly baits and widespread traps against other fruit flies

• AREU is already equipped to conduct regular training of farmers in identification of pest of economic importance, pest scouting, and alternative to chemical control of pest

• AREU responsible for both research and extension in the non-sugar crops uses a client-oriented approach to improve farmers' knowledge in ecological pest management and empower them to make informed decisions.

• Good linkage and feedback mechanism is maintained between research and extension to raise the success of technology transfer

However, the other measures necessary to create the appropriate environment to overcome the barriers hampering the adoption of locally proven IPM technologies for the rapid transfer of IPM technology include:

• Legal provision for assessing pesticide residues and penalties

• Provision of sustained financial resources to support R&D in IPM

• Setting of more field demonstration to serve as show case for interested farmers

• Training of farmers using innovative participatory approach

• Technical support to farmers in implementing IPM programme

• Train extension irrigation specialist to provide support pertaining to choice of MI system and crop types, design & installation

• Economic analysis of IPM and alternatives to chemical pest control

• Consumer education on IPM and IPM products to create the market for safe food

• Market incentives available to encourage farmers to invest in IPM (premium on crops grown through IPM practices

• Policy supporting the promotion of ecological pest management through creation of incentives via a scheme offering payment for environmental services

Project timeline:

The transfer of IPM technology is targeted to around 30 % of food crop growers, to the minimization of

crop loss by 20 %, reduction on reliance of synthetic pesticides, overall improvement in crop productivity and enhancement of farmers' livelihood. It is recommended that investment in IPM project be implemented along with integrated crop management, nutrient and water management, and use of environmentally safe products.

IPM technologies and the targeted pest and beneficiaries

IPM technology	Targeted pest	Targeted beneficiaries
Pruning of fruit trees and use of bird net	fruit bat, a pest of economic importance on litchi, longan and mango	Fruit growers and general public
Inoculative releases of predators to control population of Tetranychus urticae	Mite, a pest of economic importance on solaneceous crops, roses and strawberry	Tomato, chilli, eggplant, rose and strawberry growers
Release of parasitoids(Encarsia formosa and Eretmocerus eremicus)	Whitefly, a pest of economic importance in a range of field and greenhouse crops and its also an important vector for major diseases e.g. in potatoes	Growers of food crops and ornamentals
Field Sanitation using field cages (augmentorium), protein bait and MAT block	Melon fly, Bactrocera cucurbitae, major pest in cucurbits	Around 70 % of food crop growers

Budget:

The cost of this adaptation measure is estimated to around MUR 486,100,000 over a period of 10 years.

2.2.1.3 Project framework

Project Goal: Adapting to climate change through Integrated pest management as a substitute for chemical control measures for pest and disease control

Development objectives: Removal of barriers for the uptake of Integrated pest management using investment in R& D, capacity building and appropriate enabling framework

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Objectively Verifiable Indicators	Expected Impacts
1. Generation of information of impact of pest and disease on agricultural production	To convince policy makers to prioritise adaptation as a priority	Economic evaluation of impact of pest and disease on agriculture	Report and cabinet paper produced	No .of economic evaluation study conducted	To secure fund for upscaling of IPM program
2. Provide Financial disincentives to chemical control	Reduce use of chemical pesticides	Development of IPM strategy and policy ,Establish tariffs, regulate sale of chemical pesticides	Alternative to chemical control being encouraged	- Policy enforced - Volume of chemical pesticides imported for local market - No of suppliers of IPM technology	Improve food safety and quality and improve market access
3. Market incentives to promote ecological food label IPM	Encourage shift from conventional farming to ecological farming	Setting up of private standards, certification scheme , subsidy on IPM inputs, public awareness raising on alternative to chemical pesticides	Information are available to all stakeholders	-No. of farmers shifting to Ecological farming -No of locally produced certified product on the market	Reduce risk of crop losses due to pest and enhance production of low risk food

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Objectively Verifiable Indicators	Expected Impacts
4.Strengthen institutional capacity (human and infrastructural)	To build sustainable national R&D capacity in IPM	Develop IPM training program for researcher, extension and market actors ,upgrade Infrastructure to support IPM program, and development of locally adapted IPM technology specific to crop & pests under local conditions, promote regional collaboration	Improve technical and infrastructural capacity to support implementation of IPM program	- No. of researcher, extension trained - No of field demonstration conducted - No. of IPM technology tested and disseminated - No. of regional projects	Build national capacity to support IPM
5. Awareness and information on IPM technology	Farmers understanding of IPM increased and confidence post to adopt IPM	Training of farmers on pest ecology, agro-ecological processes ,	Farmers are better able to manage pest and diseases	- No, of farmers trained - No of field demonstration and Farmers Field school established	More farmers joining IPM programme and farmers themselves acting as trainers
6. Enforce capacity of pesticide residue monitoring	Enhance food safety and market access	Inventory of pesticide commonly used and capacity for determination of pesticide residue Enhance capacity of pesticide residue analysis at food Lab (human and infrastructure	Stakeholder aware of pesticide monitoring and sanction	-No. of pesticide residue analyses conducted / year	Build national capacity for pesticide residue monitoring

2.2.1.4 Project Justification

Sustainable development priorities:

This project is aligned with the revised Food Security Strategic plan (2013-2015) which aims at promoting sustainable production system through ecological pest management and recommendation of the agriculture sector of the African Adaptation Project (AAP) (2012) as well as its objectives of enhancing food security and minimising environmental and health impacts

Benefit-cost analysis:

Based on the target of attaining some 20 % of the land under food crop comprising of 30 % of foodcrop growers, the benefit/cost ratio for IPM technology was estimated to 1.6 showing the project is viable due to the overall benefits of using IPM over conventional pest control as a result of higher yield and saving on pesticides and labour. The cost elements included cost of investment in R & D, training of field staff and farmers, development of appropriate IPM package, cost of pest monitoring and evaluation activities and cost of public awareness while the market benefits accounted included increase in revenue as a result of improved yield and quality of produce(less pesticide residue), saving in pesticides and saving in labour required in pesticide spraying. This technology also provides non-market benefits such as positive environmental effects, i.e. an increase in biodiversity and stock of beneficial insects, reduced probability of pest developing resistance against pesticides, reduced risk of health impairments due to a reduction in pesticide exposure of

farmers and lower pesticide residue in horticultural produce which was not valued in the cost benefit analysis. This technology is also compatible with a range of other agronomic practices such as mulching, use of wind break, sue of improved cultivars, sheltered farming .

2.2.1.5 Monitoring and Evaluation (M&E)

Monitoring and evaluation of indicators of success will be conducted as the project is implemented in terms of number of IPM technologies developed and validated through research, number of training conducted, number of farmers attending Farmers Field Schools and participating in demonstrations. The project framework (section 2.2.1.3.) provides the indicative monitoring and evaluation indicators.

2.2.1.6 Risks and their mitigation

Risk	Level (Low, Medium, High)	Response
Unavailability of funds for R&D	High	Report of impact of climate change on agricultural production to inform policy makers of need to investing in R&D for adaptation
Trained staff moving out	Low	Financial incentives and recognizance
Farmers resistance to change	Medium	training of farmers and engagement in demonstrations
Not attractive for investors	Medium	Seek national funding

2.2.1.7 Stakeholder mapping

Stakeholder	Roles and responsibilities
Farmers Service Cooperation	Responsible for improving the efficiency and productivity of small sugarcane planters through the provision of necessary guidance and services
Agricultural Services of the Ministry of Agro-Industry & FS	Entomology Division, National Plant Protection Office, Agricultural Chemistry Division at the Food Tech Lab: responsible for environment-friendly fruit fly baits, national area-wide fruit fly control and general quarantine and containment facilities
Agricultural Research and Extension Unit (AREU)	Responsible for Research and development in the non-sugar sector through high-quality research and extension for better agricultural production, and to meet the policy requirements of the government in terms of agricultural diversification and food production
Pathology Division, AREU	The division is responsible for research on all aspects on the biology, prevention and control of plant diseases in the non-sugar sector and to serve the planting community by providing plant disease diagnosis service to growers and adequate, pragmatic and sustainable solutions
Entomology Division, AREU	The division is responsible for devising IPM strategies for improvement of current pest control practices, promoting biological control among growers, testing and recommended safer control measures and providing services to growers on pest diagnosis and recommend on appropriate control measures
Faculty of Agriculture , University of Mauritius	Responsible for academic teaching in sustainable agriculture and research on integrated pest and disease management
Mauritius Sugar Research Institute	Responsible for carrying out high quality research and development on sugar cane and other crops that meet the agricultural, commercial, and societal needs of Mauritius.

2.2.2 Project Idea for micro-irrigation

Mauritius is classified as a water-stressed country and faces water scarcity problems during periods of droughts. The decreasing trend in annual rainfall and increasing number of consecutive dry days recorded over the past decade along with increasing water demand for growing population, industry, tourism and agriculture have resulted in increased pressure on our diminishing freshwater resources. Currently, the agricultural sector consumes around 48 % our total fresh water resources with about 30 % of the cultivable land area under irrigation (mainly overhead) while the rest is under rain fed and thus highly susceptible to droughts. Given that climate change is expected to further worsen the situation in the future, this will have a profound effect on crop productivity, farmers' livelihood and national food security. To address this issue, the project idea for micro irrigation technology proposes a list of measures to overcome the barriers hindering investment in this technology.

2.2.2.1 Summary sheet for micro-irrigation

AGRICULTURE PROJECT IDEA : PROMOTING MICRO-IRRIGATION IN DROUGHT PRONE AREAS

Brief Project description
As a measure to help small scale farmers to cope with diminishing water resources in the event of climate change and sustain their production, this project aims at providing support to farmers to establish micro irrigation facilities to optimise water use. The project is targeting some 500 small scale food crop growers (approx 250 ha) in the next 5 years. This will be achieved by provision of a financial support through a subsidy (Rs 120,000/ha) for the purchase of micro irrigation equipment, capacity building of farmers and support to R&D and measures to encourage private sector involvement. This project will also encourage other water conservation measures such a s rainwater harvesting, mulching and minimum tillage. This project will also provide opportunity for farmers to cultivate during the dry season, to grow high value crops and improve their crop yield and income.

Results Oriented Framework

Overall Goal
Reduction of crop failure due to water stress, optimise water and nutrient use while enhancing crop productivity, food security and farmers income and welfare

Development Objectives
Removal of barriers to the uptake of Micro-irrigation through financial incentives, technical support and capacity building

Inputs
i. Survey of drought prone area with a reliable water source

ii. Identification of farmers who can benefit from this micro irrigation scheme

iii. Improve R& D budget to provide technical information on irrigation requirements and economic analysis

iv. Reinforce extension services with capacity building of extension specialist in the field of irrigation

v. Sensitisation on the impact of climate change and the measures of adaptation including optimising water use

vi. On farm demonstrations of micro irrigation

vii. Training of farmers in operation and maintenance of irrigation system

Outputs
i. Awareness created on the benefit of investing in micro irrigation and water management among farming community

ii. Improve farmers' resilience to climate change impacts

iii. Promote optimum use of water resources

iv. Enhance crop productivity by reducing water stress

Impacts
Long term impacts include sustaining crop production and contributing to food security.

viii.Training of installers of irrigation system in design and installation ix. Setting up of national standard for irrigation equipment x. Put in place a quality control or irrigation equipment xi. Measuring of impacts of micro irrigation on water resource use, crop productivity and farmers livelihood iv. Production of newsletters, radio and TV programs on use of micro irrigation		

Estimated costs
This project is estimated to cost USD 1.80M or MUR 54.0M over a period of 5 years and will involved Irrigation Authority department of the Ministry of Agro Industry and Food Security, AREU, Water Resources Unit, Water Users Associations and the International Atomic Energy Agency. The sources of funding are:International donors (United Nation Fund for Climate Change , Adaptation Fund, UNDP, GEF, FAO, Strategic Climate Fund, African Development Bank), national government, regional partners and co-financing between government and private sectors.

Proposed timeframe
Over 5 years

Executive bodies
Ministry of Agro-Industry and Food Security and its parastatal bodies (Irrigation Authority, Agricultural Research and Extension Unit)

Cost-benefit analysis
The estimated benefit to cost ratio of 4.67 clearly demonstrate a high return from investment due to a shift to high value crop and higher productivity. This technology will also provide the following avoided future costs:
• Loss of agricultural production
• Ground water contamination and other environmental hazard due to nutrient leaching
• Impoverishment of farmers

Risks
• High renewal cost of equipment
• Improper maintenance by farmers resulting in inefficient operation of irrigation system Theft or vandalism
• Poor quality of irrigation equipment
• Weak after sales service
• Fire

Profile
Technical expertise required in irrigation water management, design and installation of irrigation system , water manager for training of farmers and technical support to farmer

Key tasks
• Identify critical areas with water deficit and resource poor farmers to which the technology is likely to benefit
• Identify and offer options of different micro irrigation system based on crop type, crop spacing , water source, field size and topography
• Human resource development of extension, researcher, farmers and entrepreneurs active in MI technologies
• Need to survey each farmer's field to recommend most appropriate irrigation system
• Technical support of farmers to on cultural practices to improve productivity under irrigated agriculture
• Introduce a certification scheme for ecological food / pesticide environmental Stewardship program

Identification of key stakeholders
Ministry of Agro Industry and Food Security, Irrigation Authority, Mauritius Sugar Research Institute, Farmers Service Cooperation, Agricultural Research and Extension Unit , Small Farmers Welfare Fund , importer and supplier Irrigation equipment, Water tank manufacturer and supplier, University of Mauritius Engineering Department,

2.2.2.2 Project overview

Project scope

The purpose of micro irrigation technology is to optimise use of irrigation water, reduce wastage, improve productivity and quality while reducing the risk of crop failure in period of water shortages, minimising risk of nutrient leaching and environmental hazards and also enhancing food security and farmers livelihood.

Project timeline:

The technology is appropriate for present and expected climate scenarios impact and likely diminishing water resources. The overall targets of this technology are to reduce risk of crop failure and improve agricultural productivity and enhancement of farmers' livelihood. Considering the areas with soil moisture deficit, this technology will target some 250 ha to be attain over 5 years and involving some 500 small scale farmers. The MI scheme will benefit some 50 ha per ha.

2.2.2.3 Project framework

Project Goal: Adapting to climate change through Integrated pest management as a substitute for chemical control measures for pest and disease control

Development objectives: Removal of barriers for the uptake of Integrated pest management using investment in R& D, capacity building and appropriate enabling framework

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Objectively Verifiable Indicators	Expected Impacts
1. Financial incentives to encourage farmers to invest in MI technology	Reduction of crop failure and optimise water use due to water stress,optimise water and nutrient use while enhancing crop productivity, food security and farmers income and welfare	Generate information on risk of crop failure associated with water stress,survey of drought prone area ,and farmers eligible to most of the micro irrigation scheme(40 % cost of investment in MI for a maximum of 0.5ha /beneficiary . Economic feasibility of the implementing MI project	Awareness created on the benefit of investing in micro irrigation and water management among farming community	Survey report No of farmers eligible to benefit from MI scheme	Improve farmers' resilience to climate change impacts in soil moisture deficit regions
2. Investment in R&D related to irrigation and water management	Enhance crop yield in irrigated areas through improve agronomic practices	Investment in R& D to provide technical information on irrigation requirements and economic analysis, human resource development, improvement of infrastructural capacity, reinforce extension services with capacity building of extension specialist in the field of irrigation	Adequate technical capacity built for supporting irrigation projects	-No. of trained researcher and extension officer - No. of training conducted - Guidelines developed for MI design, installation and maintenance for different soil types . . crop types - Extension irrigation specialist available	To improve agricultural production despite diminishing water resources

Project Component	Expected Outcomes	Expected Inputs	Expected Outputs	Objectively Verifiable Indicators	Expected Impacts
1.Information and awareness	Improve awareness of benefits of MI and build adequate capacity to support MI project implementation	-Identify training needs of beneficiaries in areas related to MI technologies, water management , operation and maintenance and input supply - Sensitisation on the impact of climate change and the measures of adaptation including optimising water use -Human resource development through training of research, extension, farmers and active players involved in MI -Workshop / seminar/ exhibition to promote MI at regional and national level -Demonstration of MI on recognised farms of Research Institute/ progressive farmers of horticultural crops (0.5 ha each)	Farmers know how on the technology is improved	No. of training / workshop , exhibition No. of field demonstration No. of dissemination tool developed (video, factsheet)	Increase uptake of MI to optimise water sue and improve productivity
4. Promote quality irrigation equipment	Improve efficiency of MI system	- Training of farmers in operation and maintenance of irrigation system - Training of installers of irrigation system in design and installation - Setting up of national standard for irrigation equipment - Put in place a quality control or irrigation equipment	- Training an d information available to farmers	List of suppliers of irrigation equipment selling certified materials	Increase farmers confidence in MI and improve production and food security
5. Improving after sale service	Improve efficiency of MI system and farmers yield and income	Training of entrepreneurs in design , installation and maintenance	Adequate after-sale service providers on local market	No. of after -sale service providers	Improve performance of MI and increase it lifespan
6. Provision of soft loan	Beneficiaries able to cover their own capital investment	Information of financial institutions providing soft loan	Awareness and cooperation of financial and banking services to help promote the measure	No of farmers applying of soft loan for micro-Irrigation project	Ease of access to finance and services

2.2.2.4 Project Justification

This project is in line with Strategic Options in Crop Diversification and Livestock Sector2007-2015, Food Security Strategic plan (2013-2015), and the Sustainable diversified Agri-food sector strategy for Mauritius 2008–2015 aimed at fostering local food production and modernising the non-sugar sector in a competitive and sustainable manner through efficient irrigation system in view of optimising water use and improving crop productivity for national food security.

Benefit-cost analysis:
Based on the target of providing micro irrigation to some 500 food crop growers with average plot size of 0.5 ha each (total 250 ha) in water stress areas over the period of 5 years, the benefit/cost ratio for IPM technology was estimated to 4.67. This figure clearly shows that the return from investment in micro irrigation (drip or sprinkler) is high due to increase in crop yield, increase market access and saving on labour. It is thus worth to invest in this technology.

Benefit to Cost Ratio of financial incentives for investing in micro-irrigation
Taking into account the cost of implementing micro-irrigation technology involves cost of capital investment in irrigation equipment, cost of subsidy of 40 % by the government, cost of interest on capital, cost of operation and maintenance and that the benefits include incremental increase in yield, saving on water and labour for irrigation, the benefit/ cost was estimated to 4.67. This ratio shows the viability of this technology to cope with water stress conditions with forecasted decreasing trend in rainfall. This adaptation technology also provides other non market benefits such as increase cropping intensity; reduce risk of nutrient leaching which in turn minimises the risk of environmental contamination and allowing cultivation of high value crop sensitive to water stress. Micro-irrigation also allows the application of fertilisers in irrigation water (fertigation). Besides making efficient use of water, it can also improve fertiliser use while enhancing crop productivity. Water saved though this efficient irrigation system may be used to irrigate additional land. The uptake of this technology can also provide opportunity to create farm employment for design, installation and maintenance of irrigation system and also expand the local supply chain of irrigation equipment and other agricultural inputs.

2.2.2.5 Monitoring and Evaluation (M&E)

The results-oriented framework will be used for M&E of project implementation. More specifically, the progress made against the Objectively Verifiable indicators (OVIs) will be monitored and reported under the governance structure of the project.

2.2.2.6 Risks and their mitigation

Risk	Level (Low, Medium, High)	Response
Theft and vandalism	medium	Not much can be done
Fire	Low	Keeping a buffer zone from sugar cane fields
Poor quality of irrigation equipment	Medium	Establishment of a quality control system
Poor aftersales services for equipment maintenance and trouble shooting	Medium	Encourage entrepreneurs to invest in design, installation and maintenance service

2.2.2.7 Stakeholder mapping

Stakeholder	Roles and responsibilities
Farmers Service Cooperation	Responsible for improving the efficiency and productivity of small sugarcane planters through the provision of necessary guidance and services
Irrigation Authority	Responsible for identifying, investigating, planning, designing and implementing irrigation projects and advising planters on irrigation matters related to water availability, design, and irrigation equipment
Agricultural Research and Extension Unit (AREU)	Responsible for Research and development in the non-sugar sector through high-quality research and extension for better agricultural production, and to meet the policy requirements of the government in terms of agricultural diversification and food production
Aquatec Ltd	Manufacturer, importer and supplier of water tank
Ashoka Ltd	Importer an d supplier of irrigation equipment
Watertech Ltd	Responsible to import, supply and install irrigation equipment for home garden, farm and industrial application
Aqualia Ltd.	Responsible to import, supply and install irrigation equipment
Mauritius Sugar Research Institute	Responsible for carrying out high quality research and development on sugar cane and other crops that meet the agricultural, commercial, and societal needs of Mauritius.

3. Project Ideas for Coastal Zone

3.1 Brief summary of the Project Ideas for Coastal Zone

The TNA for the Coastal Zone sector has retained four technologies, namely; Restoration of coastal vegetation, Wetland protection, Dune restoration and Rock revetment. Mauritius with its varied coastline ranging from sandy beaches to rocky shores and cliff is very much affected by coastal erosion. The causes of erosion as identified by several studies including the Study on Coastal Erosion in 2003, were from the direct interaction of the sea with the shoreline, mainly during extreme events such as cyclones and storm surges. The extent of erosion is however exacerbated in certain places because of the negative anthropogenic impacts on the health of lagoons, beaches and dunes.

Three of the four technologies retained, Restoration of coastal vegetation, Dune restoration and Rock revetment are applicable directly on the shoreline and would provide direct benefits to the location where they are applied. In contrast, wetland protection would act indirectly in mitigating the erosion impacts on an adjacent coast. Wetlands, through their hydrological services they provide, contribute to improve the water quality of the lagoon around Mauritius and thus a healthy marine environment which in turn would contribute to the stability of the shoreline.

The project ideas for the coastal zone as presented in this present report has been put forward following discussions at a committee in January 2013 with the various stakeholders including the Ministry of Environment, Beach Authority, Ministry for Fisheries, Ministry of Agro Industry and the Mauritius Oceanography Institute. Ranking of sites for implementation of the identified technologies were made based on several criteria and also considering the basic characteristics of each sites.

Some of the chosen sites were actually or will soon be under a project of coastal rehabilitation or control of erosion and these sites have been left out so as to avoid any duplication of effort.

3.2 Specific Project Ideas

3.2.1 Project Idea for dune and vegetation restoration

Sand dunes are an important component of the lagoon-beach ecosystem. Naturally occurring sand dunes are wind-formed sand deposits representing a store of sediment in the zone just landward of normal high tides. Dunes effectively store excess beach sand and serve as natural erosion buffers for shorelines during extreme events such as cyclones and storm surges. However, dunes remains fragile features that are easily altered by the actions of people e.g., trampling by pedestrians, destruction by vehicular traffic, levelling for development, mining for construction, introduction of inappropriate invasive or exotic species. Sand dunes also provide a valuable coastal habitat for many highly specialised plants and animals. As such, sand dunes may be considered important both ecologically and recreationally.

Vegetation planting may be used to stabilise natural or artificial dunes. This promotes the accumulation of sand from wind-blown sources around their stems – over time, this causes dune growth. Over time, dune vegetation root networks also help to stabilise the dune. Planting can be achieved by transplanting vegetative units from nursery stocks or nearby intact dunes. One advantage of vegetation planting over dunes is that it can be undertaken at the community level using widely available tools and thus a major reduction in cost.

3.2.1.1 Summary sheet for dune and vegetation restoration

COASTAL ZONE SAMPLE PROJECT SHEET: Dune and Vegetation Restoration		
Brief Project description The control of erosion through the restoration of existing coastal dunes and vegetation along 2 identified public beaches in Mauritius.		
Results Oriented Framework		
Overall Goal i. Control of erosion along 2 identified public beaches ii. Improve legislation for the better protection of the dune areas iii. Raising awareness on the importance of dunes and the need to protect them	**Development Objectives** Implementation of beach and dune reprofiling works for dune restoration and planting of native coastal vegetation along the dune areas.	
Inputs i. Sand from inland quarry or from offshore site ii. Native coastal plants from specialised nursery or from other beaches having these plants iii. Publication of leaflets and other media campaigning materials iv. Review and amend existing laws and regulations for the better protection of Dunes	**Outputs** i. Newly reprofiled beach at the identified sites. ii. Dunes planted with native plants and exotic species removed. iii. Leaflets and other media advert material iv. Improved legislation	**Impacts** It is expected that the dune and vegetation restoration work will provide some control over the erosion occurring at those sites. Public users become more informed of the importance of dunes Dunes legally are better protected
Estimated costs MUR Flic en Flac – MUR 53.2 Million for 700 m of coast Le Morne – MUR 40.28 Million for 530 m of coast Leaflets and media campaign– MUR 1 Million		

Proposed timeframe 2 Years	**Executive bodies** Beach Authority
Cost-benefit analysis 700 m of coastline restored for Flic en Flac and offering better protection for an area of 4.2 Ha of Public beach 530 m of coastline restored for Le Morne and offering better protection for an area of 5.3 Ha of Public beach	**Risks** Erosion of material put in place during an extreme event Reluctance and opposition from general public as access to beach may be restricted
Expertise required	
Profile Local expertise in Coastal Processes (Physical Oceanographer) Coastal engineer Environmental Educators Media professional Legal Consultant	**Key tasks** • Identify and assess root causes of erosion • Put forward most appropriate technical details for beach reprofiling works including beach slope and grain size to be used. • Put forward mitigation measures • Prepare leaflets and other media material to reach the different targeted groups • Formulate appropriate amendments to better protect the dunes under existing legal instruments
Identification of key stakeholders Beach Authority Ministry of Environment Ministry of Fisheries Ministry of Housing and Lands Local NGOs and Force Vive	

3.2.1.2 Project overview

Project Scope

The main objective of this project is to provide control of erosion at two sites, namely Flic en Flac and Le Morne, through dune and vegetation restoration. Moreover, as an integral part of the project, there shall be an information and awareness campaign in view of sensitising the general public on the importance of dunes and the need for having native plants. In addition, the legislative and regulatory framework around dunes shall be reviewed and appropriate amendments will be brought so as to better protect the dunes around Mauritius.

The project shall be implemented at Flic en Flac and Le Morne. These shall be restricted to areas which are proclaimed public beaches so as to facilitate the implementation of works and in view of benefitting the public in general.

In Flic en Flac the dune to be restored shall be from Pearl Beach to around 700 m north ending near Manisa Hotel. The dune shall be restored over a width of approximately 15 m and shall be stabilised though the use of native vegetation. The dune profile shall be such that the beach as well shall be to some extent reprofiled. Part of the beach is already under management with vehicle access restricted.

The public beach between Dina Robin and Les Pavillions hotel will find the implementation of works for dune and vegetation restoration. Part of the beach is already under management with vehicle access restricted. The dune in this area shall be restored over a length of 530 m and 15 m wide. The beach shall also be reprofiled. Native vegetation shall be planted over the dunes.

Preliminary works at both sites shall comprise the removal of exotic trees like the Filao trees. Additional measures should be taken in view of mitigation the possible effects of major events like cyclones at both areas. The use of breakwaters close to the reef edge is recommended and this shall have the added benefit of providing an appropriate substrata for coral to colonised or be transplanted upon.

This dune and vegetation restoration projects could involve many volunteers that require hands on training

about effectiveness of different grass species in dune restoration. The local community should have a prominent role in this project and this will form an integral part of an education process that would raises awareness of likely coastal hazards if dunes are not preserved and protected. At a larger scale, it is useful for governments to adopt proactive coastal management plans to protect, enhance, restore and create marine habitats, and through that align the dune and vegetation restoration projects around the country.

In addition to the above, leaflets shall be designed and printed and eventually distributed to the general public mainly at the public beaches where the project shall be located. Other media campaign shall formulated and thereafter shall be broadcasted on the national television, national and private radios, and printed in local newspaper.

The review of the existing legislation shall be effected and amendments would be proposed for the eventual enactment. Enforcement measures will also have to be devised in view of ensuring better protection of the dunes and vegetated areas.

Project Timeline

The whole project shall have a timeline of 2 years for its implementation. However there shall need to have a rigorous monitoring and maintenance programme that shall follow the evolution of the dunes after works have been effected.

The time line shall include the following

- Expression of Interest – 2 Months
- Tender exercise – 4 months
- Design and implementation of works- 6 months
- Legal review – 4 months
- Information and awareness campaign – 1 year

Budget and Resource requirement

The project would require a budget of around MUR 95 Million for its implementation. Funding can be sought from international agencies in view of securing the necessary funds for implementation of works.

Components

The major component of this project would be the implementation of works for the dunes and vegetation restoration. Technologies used in this project are quite low tech and most of the times rely on the local natural material and community volunteering and monitoring services. Dune and vegetation restoration technologies involve:

- Removal of exotic vegetation (e.g. Casuarina trees) that dramatically reduces dune effectiveness.
- Filling and re-grading the slope with bulldozers.
- Installing sprinkler or dripsystems
- Constructing dune walkovers to protect from erosion caused by human access
- Re-vegetating with native dune plants. Additional research might also be needed to identify key vegetation species that need to be produced.
- The application of fences to stabilise bare sand, encourage dune growth and protection.
- Monitoring and maintaining the dune.

The other component of this project would be the information and awareness campaign whereby leaflets and other media support would be designed and developed. The target for these campaigns shall be the public in general.

The review of the existing local legislation would play a vital role in view of ensuring the better protection of the dunes in the future. As such the legal review shall put forward amendments of local legislation in view of attaining this objective.

3.2.1.3 Project framework

Project Goal: Control of erosion through dune and vegetation restoration					
Development objectives: • **Dune and vegetation are restored** • **Information and awareness campaign targeting the local population** • **Legal review of legislation and propose amendments for better protecting the dunes**					
Project Component	**Expected Outcomes**	**Expected Inputs**	**Expected Outputs**	**Objectively Verifiable Indicators**	**Expected Impacts**
1. Dune restoration at two public beach	Control of erosion at the identified sites	Graded sand and machinery for implementation works	Dunes reshaped and restored	Dune in place	Control of erosion through the provision of sand source along the shoreline
2. Native vegetation restored at the two public beaches	Stabilisation of the dunes with the native vegetation	Native plants that are resilient to the coastal characteristics	Stabilisation of dunes	Native Vegetation planted over dunes	Dunes stabilised
3. Information and awareness campaign	Better informed public	Design and publication of appropriate media materials	Leaflets and other media materials including adverts	Better use of dune areas by the public	Local population informed of importance of dunes
4. Legal review for better protection of dunes	Better legislation for the protection of dunes and its vegetation	Review of existing legislation	Amendments to existing local legislation for better protection of dunes	Amendments proposed	Dunes better protected under local legislation

3.2.1.4 Project Justification

This project is in line with the various policies of the government including which treat the subject of erosion and biodiversity conservation and to which this project become directly or indirectly relevant. These include:

i. 2nd National Environmental Strategy and Action Plan (2000 – 2010)
ii. National Environment Policy
iii. Climate Change Action Plan
iv. National Physical development Plan (NPDP) – Development Strategy and Policies
v. National Development Strategy
vi. National Biodiversity Strategy and Action Plan
vii. Development of an Integrated Coastal Zone Management Framework (ICZM)

Moreover, Dune and Vegetation restoration was proposed by the Study of Coastal Erosion around Mauritius in 2003 as part of the soft nonstructural methods to be used to control erosion.

3.2.1.5 Monitoring and Evaluation (M&E)

The results-oriented framework will be used for M&E of project implementation. More specifically, the progress made against the Objectively Verifiable indicators (OVIs) will be monitored and reported under the governance structure of the project.

3.2.1.6 Risks and their mitigation

The risks in the implementation of this present project would be as follows:

Risk	Level (Low, Medium, High)	Response
Dunes are eroded following an extreme event	High	Appropriate measure would have to be taken within the lagoon and would include the use of breakwaters
Reluctance or opposition of general public	Medium	Information and awareness campaign would have to ensure proper understanding of measures put forward
Reluctance and delay in amending the local legislation	High	Proper briefing of officials and political actors on the importance of dunes and the necessary amendments.
Native plants not properly stabilizing the dunes	Low	Necessary research undertaken in view of ensuring the most appropriate plants are used.

3.2.1.7 Stakeholder mapping

The key stakeholders to be involved in this project would be as follows:

Stakeholder	Roles and responsibilities
Beach Authority	Responsible for the proper management and maintenance of public beaches around Mauritius
Ministry of Environment	Responsible for the management of the coastal zone
Ministry of Fisheries	Responsible for the management of coastal and marine resources
Ministry of Housing and Lands	Responsible for the management of the local land territory including beach areas
Local NGOs and Force Vive	Immediate actors and beneficiaries for proposed project

3.2.2 Project Idea for wetland protection

Coastal wetlands provide a number of important ecosystem services including water quality and climate regulation, they are valuable accumulation sites for sediment, contaminants, carbon and nutrients and they also provide vital breeding and nursery ground for a variety of birds, fish, shellfish and mammals.

3.2.2.1 Summary sheet for dune and vegetation restoration

COASTAL ZONE SAMPLE PROJECT SHEET: Wetland Protection	
Brief Project description Wetland protection and restoration for the region of Belle Mare and Palmar with the view to improve the biological and hydrological quality in the surrounding areas.	
Results Oriented Framework	
Overall Goal i. Improve water quality in surrounding areas ii. Improve the biodiversity of surrounding areas iii. Raising awareness of the need to conserve wetlands iv. Promulgation of a wetland protection bill	**Development Objectives** Wetland acquisition with the view to conserve and protect these environmentally sensitive areas along with raising awareness on the importance of wetlands in our environment and to have the necessary legal instrument to fully protect the wetlands.

Inputs	Outputs	Impacts
i. Acquisition of private wetlands ii. Publication of leaflets and other media campaigning materials iii. Review and amend existing laws and regulations for the better protection of wetlands	i. Wetlands under official jurisdiction ii. Leaflets and other media advert material iii. Improved legislation	better water quality within the lagoons of Belle Mare and Palmar

Estimated costs
MUR 30,000,000 – for acquisition of land with wetlands MUR 5,000,000 for wetland restoration MUR 1,000,000 for information and awareness campaign

Proposed timeframe	Executive bodies
5 years	National Parks and Conservation Services

Cost-benefit analysis	Risks
The acquisition of some 20 hectares of lands with wetlands and buffer areas from private property owners so as to improve water quality in around 400 Ha of lagoonal area	No improvement in water quality of lagoons due to other influencing factors Reluctance from property owners to sell or exchange their land

Expertise required	
Profile Local expertise in Hydrology Land surveying Environmental Educators Media professional Legal Consultant	**Key tasks** • Identify and prioritize areas for acquisition • Put forward mitigation measures • Prepare leaflets and other media material to reach the different targeted groups • Formulate appropriate Bill to better protect wetlands

Identification of key stakeholders
National Parks and Conservation Services Ministry of Environment Minsitry of Housing and Lands Ministry of Fisheries Local NGOs and Force Vive

3.2.2.2 Project overview

Project Scope

The proposed project has for main objective put existing wetlands and their buffer areas of 30 m in the region of Belle Mare and Palmar under official jurisdiction in view of protecting and restoring these ecologically important water bodies. These shall benefit the coastal areas and lagoon through an improved water quality along with a sound biologically diverse and hydrologically active area around those wetlands.

The main part of the project would be to acquire the lands from private property owners where wetlands exist. The area to be acquired should also have the buffer area of 30 m surrounding the wetlands. The acquisition could be done through compulsory acquisition by the government but realistically this option may be faced with several obstacles and thus exchange of lands may be a better option to consider along with offering a nice package for the plot of lands.

It would be important for the government to have control over the lands with wetland so as to be in a better position to protect those sensitive areas and to prevent eventual backfill. The ESA Study (2009) have identified most wetlands in Mauritius and have moreover identified all property owners of wetlands and buffer areas and

this should be used as starting point bearing in mind that there shall be the need to update the information as it is already 4 years old and properties may have changed ownership.

This wetland protection projects could involve many volunteers that require hands on training about the functions and importance of wetlands in our ecosystem. The local community should have a prominent role in this project and this will form an integral part of an education process that would raises awareness of likely effects on the coastal areas in absence of proper measures to protect wetland and these can include water degradation of water quality and flooding. At a larger scale, it is useful for governments to adopt proactive coastal management plans to protect, enhance, restore and create marine habitats.

In addition to the above, leaflets shall be designed and printed and eventually distributed to the general public mainly in areas where the project shall be located targeting with special attention the young school children. Other media campaign shall formulated and thereafter shall be broadcasted on the national television, national and private radios, and printed in local newspaper.

The review of the existing legislation shall be effected and previously proposed Bills such as Wetland Bill and the Environmentally Sensitive Area Bill (ESA Bill) and eventually recommend with or without amendments a Bill for enactment. Enforcement measures will also have to be devised in view of ensuring better protection of the wetlands especially in the case of backfill.

Timeline

The timeline for this project would be 5 years comprising of the following which would run concurrently

Negotiation with private property owners – 2 years

Expression of interest and tendering exercise – 6 Months

Wetland restoration – 2.5 years

Awareness campaign – 1 year

Enactment of a Wetland Protection Bill – 1 year

Budget

It is estimated that the cost for such a project would amount to around MUR 36 Million. The land acquisition or land exchange part can be finance domestically in as much as land from state land may be proposed for exchange.

The wetland restoration programme on the other hand can be financed through grants from international funding agencies

Components

The components of the project would be

- Acquisition of wetlands areas through direct purchase or exchange of land
- Wetlands restoration
- Information and awareness campaign
- Enactment of a Wetland Protection Bill

3.2.2.3 Project framework

Project Goal: Wetland Protection and Restoration through the acquisition of wetlands					
Development objectives: **Acquire wetlands through direct purchase or exchange of land** **Wetland Restoration** **Information and awareness campaign** **Enactment of a wetland Protection Bill**					
Project Component	**Expected Outcomes**	**Expected Inputs**	**Expected Outputs**	**Objectively Verifiable Indicators**	**Expected Impacts**
1. Acquisition of wetlands though direct purchase or exchange of land	Wetlands under official jurisdiction	Purchase of Land or land made available for exchange	Government owing wetlands	Wetlands as State lands	
2. Wetland restoration	Improved water quality in lagoons and improved hydrological and biological services from wetlands	Wetland native plants are restored	Ecologically sound wetland area	Improved water quality in lagoons	Improved coastal environment
3. Information and awareness campaign	Better informed public	Design and publication of appropriate media materials	Leaflets and other media materials including adverts	Better understanding of importance of wetlands by the public	Local population informed of importance of wetlands
4. Promulgation of a Wetland Protection Bill	Better legislation for the protection of wetlands	Review of existing legislation and previously proposed Bills	Enactment of a Wetland Protection Bill	Enactment of the Bill	Wetlands better protected under local legislation

3.2.3.4 Project Justification

This project is in line with the various policies of the government including which treat the subject of erosion and biodiversity conservation and to which this project become directly or indirectly relevant. These include:

i. 2nd National Environmental Strategy and Action Plan (2000 – 2010)
ii. National Environment Policy
iii. Climate Change Action Plan
iv. National Physical development Plan (NPDP) – Development Strategy and Policies
v. National Development Strategy
vi. National Biodiversity Strategy and Action Plan
vii. Development of an Integrated Coastal Zone Management Framework (ICZM)

Moreover, wetland protection and restoration was proposed by the ESA Study (2009) along with an ESA Bill for the protection and conservation of environmentally sensitive areas which include wetlands.

3.2.2.5 Monitoring and Evaluation (M&E)

The results-oriented framework will be used for M&E of project implementation. More specifically, the progress made against the Objectively Verifiable indicators (OVIs) will be monitored and reported under the governance structure of the project.

3.2.2.6 Risks and their mitigation

The risks in the implementation of this present project would be as follows:

Risk	Level (Low, Medium, High)	Response
Reluctant property owner to sell or exchange land	High	Proposal of nice package for acquisition of land
Reluctance or opposition of general public	Low	Information and awareness campaign would have to ensure proper understanding of measures put forward
Reluctance and delay in enacting the Wetland Protection Bill	High	Proper briefing of officials and political actors on the importance of the Bill.
Difficulty in restoring the wetlands	Medium	Necessary research undertaken in view of ensuring that the most appropriate techniques are used.

3.2.2.7 Stakeholder mapping

The key stakeholders to be involved in this project would be as follows:

Stakeholder	Roles and responsibilities
National Parks and Conservation Services	Responsible for the proper management and maintenance of wetlands and RAMSAR site in Mauritius
Ministry of Environment	Responsible for the management of the coastal zone
Ministry of Fisheries	Responsible for the management of coastal and marine resources
Ministry of Housing and Lands	Responsible for the management of the local land territory including beach areas
Local NGOs and Force Vive	Immediate actors and beneficiaries for proposed project

3.2.3 Project Idea for rock revetment

Revetments are hard engineered structures with the primary function to prevent further erosion of the shoreline. They are built usually with stone, concrete or other durable materials and are shaped in a slope facing the sea and they aim at holding or preventing a scarp or embankment against erosion by wave action. Revetments are to be differentiated with seawalls which are vertical or near vertical shoreline protection works separating the land and water areas.

Revetments are frequently used in locations where further shore erosion will result in excessive damage, e.g. when roads and buildings are about to fall into the sea.

3.2.3.1 Summary sheet for Rock revetment

COASTAL ZONE SAMPLE PROJECT SHEET: Rock Revetment	
Brief Project description The implementation of coastal protection works with ancillary amenities at BambousVirieux.	
Results Oriented Framework	
Overall Goal i. Construction of 500 m of rock revetment at BambousVirieux ii. Construction of ancillary amenities including boat ramp, promenade and sea access, iii. Raising awareness of the need for rock revetment	**Development Objectives** The construction of these infrastructure and its amenities will provide protection to houses and public infrastructure like road, from the effect of waves especially during extreme events

Inputs	Outputs	Impacts
i. Rocks, building materials and appropriate machinery ii. Demonstrate the effectiveness of the system iii. Promote the utilisation of the technology	i. Rock revetment with its ancillary amenities ii. Awareness of the benefit of such protection works is raised	Protection of civil and public infrastructures

Estimated costs
MUR 50 Million for Coastal Protection works MUR 1 Million for awareness campaign

Proposed timeframe	Executive bodies
2 years	Ministry of Environment
Cost-benefit analysis 500 m of coastal protection works would protect some 20 households and 500 m of roads from being washed away during an extreme event	**Risks** Reluctance from household owner to have such works implemented Persisting erosion on either sides

Expertise required	
Profile Local expertise in Coastal Processes (Physical Oceanographer) Coastal engineer Environmental Educators Media professional	**Key tasks** • Identify and assess root causes of erosion • Put forward most appropriate technical details for rock revetment works • Put forward mitigation measures for persisting erosion on either sides • Prepare leaflets and other media material to reach the different targeted groups

Identification of key stakeholders
Ministry of Environment Ministry of Public Infrastructure Road Development Authority Ministry of Fisheries Ministry of Housing and Lands Local NGOs and Force Vive

3.2.3.2 Project overview

Project Scope

The Project aims at protecting the houses and the adjacent road at Bambous Virieux through the implementation of a rock revetment structure which shall moreover possess boat ramp, sea access and a little promenade. The choice of Bambous Virieux was made on the basis that both houses and road infrastructure were at stake in the event of a naturally occurring extreme event like cyclones. The houses are known to be flooded during previous event.

The project shall comprise of rock revetments with a promenade that shall provide some recreational space to the local population. The boat access would moreover facilitate the existence of the local fishing community. The selling point of the project would be the ancillary amenities that shall be provided for by the project and include the promenade with appropriate parking spaces, boat ramp and sea access.

This coastal protection works should involve the local population in view of ensuring the sustainability of the project in the long run but most importantly the acceptability of such works immediately next to houses. The local community should have a prominent role in this project and this will form an integral part of an education process that would raises awareness of likely coastal hazards if the rock revetment were not placed. At a

larger scale, it is useful for governments to adopt proactive coastal management plans to protect, enhance, restore and create marine habitats.

In addition to the above, leaflets shall be designed and printed and eventually distributed to the general public mainly at the public beaches where the project shall be located. Other media campaign shall be formulated and thereafter shall be broadcasted on the national television, national and private radios, and printed in local newspaper.

Timeline

The whole project shall have a timeline of 2 years for its implementation. However an additional 5 year shall be required for proper and rigorous monitoring and maintenance programme that shall follow the evolution of the rock revetment and its surrounding areas after works have been completed.

The time line shall include the following

- Expression of Interest – 2 Months
- Tender exercise – 4 months
- Design and implementation of works- 12 months
- Information and awareness campaign – 1 year
- Monitoring and maintenance progamme – 5 years from the commissioning of the structure

Budget and Resource requirement

The project would require a budget of around MUR 51 Million for its implementation. Funding can be sought from international agencies in view of securing the necessary funds for implementation of works.

Financing can also be sought from the CSR scheme or from a participatory approach in partnership with hotel operators on the east coast of Mauritius.

Components

The major component of this project would be the implementation of works for the rock revetment. Technologies used in this project are quite low tech but would require the use of heavy machinery to put in place the massive boulders. The coastal protection works shall include the following

- Rock revetment with promenade
- Appropriate parking facilities
- Boat ramp and sea access
- Lights and shop stands in the vicinity

The other component of this project would be the information and awareness campaign whereby leaflets and other media support would be designed and develop. The target for these campaigns shall be the public in general but mainly the local population and shall have for major objective to ensure better acceptance of the structure.

3.2.3.3 Project framework

Project Goal: Coastal Protection Works at BambousVirieux					
Development objectives: **Rock revetment with promenade** **Appropriate parking facilities** **Boat ramp and sea access** **Lights and shop stands** **Awareness campaign**					
Project Component	**Expected Outcomes**	**Expected Inputs**	**Expected Outputs**	**Objectively Verifiable Indicators**	**Expected Impacts**
1. Construction of Rock revetment	Coast protected from extreme events	Rocks and appropriate design	Rock revetment with an embellished environment	Rock revetment with promenade in place	Coast fully protected and embellished landscape
2. Appropriate parking facilities	Location to become a recreational area as well	Appropriate infrastructure for parking	Parking available	Parking operational	Location to become a recreational area as well as being protected
3. Boat ramp and sea access	Facilitating the existence of the fishermen in the area	Appropriate design of rock revetment	Boat ramp and sea access	Regular use of boat ramp and sea access	Life and existence of fishermen improved
4. Lights and shop stands	Promoting small business and recreational use of the area	Appropriate design of rock revetment and facilities for opening small business	Lights and shop stand with set small businesses	Profitable small businesses	Improved quality of life of the local population
5.Information and awareness campaign	Better informed public	Design and publication of appropriate media materials	Leaflets and other media materials including adverts	Better understanding and acceptance of the rock revetments	Local population accepting the taking advantage of the rock revetment

3.2.3.4 Project Justification

This project is in line with the various policies of the government including which treat the subject of erosion and biodiversity conservation and to which this project become directly or indirectly relevant. These include:

i. 2nd National Environmental Strategy and Action Plan (2000 – 2010)
ii. National Environment Policy
iii. Climate Change Action Plan
iv. National Physical development Plan (NPDP) – Development Strategy and Policies
v. National Development Strategy
vi. National Biodiversity Strategy and Action Plan
vii. Development of an Integrated Coastal Zone Management Framework (ICZM)

3.2.3.5 Monitoring and Evaluation (M&E)

The results-oriented framework will be used for M&E of project implementation. More specifically, the progress made against the Objectively Verifiable indicators (OVIs) will be monitored and reported under the governance structure of the project.

3.2.3.6 Risks and their mitigation

The risks in the implementation of this present project would be as follows:

Risk	Level (Low, Medium, High)	Response
Reluctance of local population to the project	High	Awareness campaign to change the mind set and having the local population to participate in the project
Reluctance or opposition of general public	Low	Information and awareness campaign would have to ensure proper understanding of measures put forward
Rock revetment causing erosion on either sides	High	Proper mitigation measures to be identified at the design stages

3.2.3.7 Stakeholder mapping

The key stakeholders to be involved in this project would be as follows:

Stakeholder	Roles and responsibilities
Ministry of Environment	Responsible for the management of the coastal zone
Ministry of Public Infrastructure	Responsible for the management of public infrastructure like roads
Road Development Authority	Responsible for the development and management of roads
Ministry of Fisheries	Responsible for the management of coastal and marine resources
Ministry of Housing and Lands	Responsible for the management of the local land territory including beach areas
Local NGOs and Force Vive	Immediate actors and beneficiaries for proposed project

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