Republic of Mauritius

# TECHNOLOGY NEEDS ASSESSMENT

## FOR AN ENHANCED CLIMATE CHANGE ADAPTATION AND MITIGATION

## TNA REPORT I

July 2012


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(June 2012)

Environment - Mauritius

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# Foreword

It is an established fact that the threat posed by climate change is real and unequivocal. The concentration of carbon dioxide reaching 400 parts per million in the atmosphere is a clear signal that climate change is heading on a dangerous pathway and there is the urgent need for global actions. The World Economic Forum's Global Risks 2013 Report rates the rising greenhouse gas (GHG) emissions as the third global risk and the failure of climate change adaptation as the fifth global risk. Stabilization of GHG concentrations in the atmosphere and adaptation to the impacts of climate change are therefore crucial and require a series of measures, out of which the transfer of or access to environmentally sound technologies is of utmost importance. In fact, promoting the transfer of such technologies to developing countries is in line with the Article 4.5 of United Nations Framework Convention on Climate Change (UNFCCC).

The Poznan Strategic Programme (PSP) on the transfer of technologies, adopted at the 14th Meeting of the Conference of Parties to the UNFCCC in Poland in 2008, is meant to facilitate funding to developing countries for assessing their needs for environmentally sound technologies. The Technology Needs Assessment (TNA) undertaken in Mauritius has thus benefited from the above programme. The priority sectors for Mauritius which have been assessed under the TNA are the Energy sector for mitigation and Agriculture, Water and Coastal Zone sectors for adaptation. I am therefore pleased to present the following five Reports:

(i) Technology Needs Assessment for an Enhanced Climate Change Adaptation and Reduction of Greenhouse Gas Emissions in Mauritius;
(ii) Barrier Analysis and Enabling Framework for Adaptation;
(iii) Barrier Analysis and Enabling Framework for Mitigation;
(iv) Technology Action Plan and Project Ideas for Adaptation; and
(v) Technology Action Plan and Project Ideas for Mitigation.

These Reports have been prepared in consultation with relevant stakeholders and I seize this opportunity to convey my heartfelt thanks for their collaboration and their contributions. I wish to highlight that the Reports recognise the vulnerability of Mauritius to the impacts of climate change. Furthermore, its recommendations reflect our national development priorities for promoting Sustainable Development in our Country.

The technologies recommended in the TNA for the priority sectors are meant to chart a pathway for enhancing climate change adaptation and mitigation for Mauritius. The recommended technologies for priority sectors are as follows:

(i) Agriculture: Integrated Pest Management and Micro-Irrigation;
(ii) Water: Rainwater Harvesting at Residential Level and Hydrological Modelling and Desalination Technology for effective water resources management;
(iii) Coastal Zone: Dune and Vegetation Restoration, Rock Revetment and Wetland Protection; and
(iv) Energy: Utility-scale Wind Energy and Industrial and Commercial Waste Heat Recovery Using Boiler Economizer.

I wish to convey my deepest gratitude to the UNEP RISOE Centre from Denmark, the UNEP's Division of Technology, Industry and Economics (Paris) and the Environment and Development Action (ENDA) based in Senegal for their technical support and also to the Global Environment Facility (GEF) for its financial support in the realization of this project.

**Hon. Devanand Virahsawmy, G.O.S.K, F.C.C.A**
**Minister of Environment and Sustainable Development**

## Table of Contents 4

## List of Figures

## List of Tables

## Acknowledgements

This report is the result of collaborative work across institutions facilitated by the TNA Consultant and Adaptation Experts. The institutions mentioned are duly acknowledged for their valuable contribution in the preparation of the report.

1. Prime Minister's Office (Mauritius Meteorological Services , Mauritius Oceanography Institute)
2. Ministry of Energy and Public Utilities (Central Electricity Board, 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. Central Electricity Board
14. Enterprise Mauritius
15. University of Mauritius
16. Beach Authority
17. Mauritius Sugar Industry Research Institute
18. Mauritius Agricultural Marketing Cooperative Federation Ltd
19. Indian Ocean Commission
20. United Nations Development Programme Country Office
21. Omnicane Management and Consultancy Limited
22. Energy Consulting IPA London
23. ECO-Bio-Tech
24. Association of Hoteliers and Restaurants in Mauritius
25. Mauritius Chamber of Commerce and Industry
26. Mauritius Chamber of Agriculture
27. Mouvement Autosuffisance Alimentaire
28. NGO Platform – Climate Change
29. Pesticide Action Network of Mauritius

## List of Acronyms

| | |
|---|---|
| AAP | Africa Adaptation Programme |
| BPO | Business Process Outsourcing |
| CCD | Climate Change Division |
| CDM | Clean Development Mechanism |
| CEB | Central Electricity Board |
| EKC | Environmental Kuznets Curve |
| EOI | Expression of Interest |
| ESA | Environmentally Sensitive Area |
| ESPA | Energy Supply Purchase Agreement |
| EST | Environmentally Sound Technology |
| FAR | Fourth Assessment Report (of IPCC) |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| HDI | Human Development Index |
| ICT | Information and Communication Technologies |
| ICZM | Integrated Coastal Zone Management |
| IPCC | Intergovernmental Panel on Climate Change |
| IPM | Integrated Pest Management |
| IPP | Independent Power Producer |
| IW | Inception Workshop |
| LDC | Least Developed Country |
| MCA | Multi-Criteria Analysis |
| MDG | Millennium Development Goal |
| MEA | Multilateral Environmental Agreement |
| MEO | Mauritius Environment Outlook |
| MID | Maurice Ile Durable |
| MoESD | Ministry of Environment and Sustainable Development |
| MSP | Multi-Stakeholder Process |
| NAPA | National Adaptation Plan of Action |
| OM | Operating Margin |
| PV | Photovoltaics |
| ROM | Republic of Mauritius |
| SIDS | Small Island Developing State |
| SNC | Second National Communication |
| SSDG | Small-Scale Distributed Generation |
| SST | Sea Surface Temperature |
| TAP | Technology Action Plan |
| TFS | Technology Fact Sheet |
| TNA | Technology Needs Assessment |
| UNFCCC | United Nations Framework Convention on Climate Change |

## Executive Summary

Mauritius is a Small Island Developing State (SIDS), and although its total emission of greenhouse gases is insignificant in global terms, it is extremely vulnerable to the impacts of climate change. Consequently, the TNA project in Mauritius has focused predominantly on adaptation to climate change, wherein three out of the four sectors analysed in this report deal with adaptation technologies. The Energy Industries has been identified as the priority mitigation sector because it accounts for around 60% of all national GHG emissions.

Being an island state, the coastal zone is of strategic importance in terms of its tourism industry, and location of large segments of its population and public infrastructure. This makes adaptation to climate change on the coastal zone of prime importance. Fresh water is yet another key sector for the socio-economic development of Mauritius. With Mauritius going through an intense period of drought, the detrimental impacts of climate change and climate variability are already being felt on water supply. Adaptation in the water sector is, therefore, of very high importance.Since agriculture, especially the production of vegetables is highly dependent on rain and is already impacted negatively by climate change and climate variability, adaptation in the agriculture sector is also covered by the TNA project.

The choice of priority sectors in the TNA project is consistent with national development priorities, while taking into account the inherent vulnerabilities of climate change impacts on an island state. The sectoral consideration in the climate-development nexus of Mauritius is clearly revealed in its Second National Communication under the UNFCCC, as well as flagship projects like the Africa Adaptation Programme (AAP), Maurice Ile Durable (MID), and the Adaptation Fund (AF) project on coastal zones. While all these projects deal with climate change from a policy and strategic perspective, the TNA project brings complementarity in terms of nationally appropriate technology options.

In sum, this TNA report has assessed the technology needs for adaptation in the water, agriculture and coastal zone sectors, and mitigation technologies in the energy Industries. A multi-stakeholder process (MSP) has been adopted for the identification and prioritisation of technological options using a linear additive Multiple Criteria Analysis (MCA) framework. All relevant information for prioritising technologies was provided in Technology Fact Sheets. The criteria proposed by MCA4Climate were used in MCA, and indicators were defined by local stakeholders. The technologies that have been retained for developing the Technology Action Plan (TAP) are summarised below for each sector:

| SECTOR | TECHNOLOGIES RETAINED FOR TAP |
|---|---|
| WATER | • Desalination<br>• Rainwater harvesting<br>• Hydrological model |
| AGRICULTURE | • Up-scaling of locally proven Integrated Pest Management technologies<br>• Micro irrigation (gravity fed drip & mini and micro sprinkler irrigation)<br>• Decentralised rapid pest and disease diagnosis service (plant clinic) |
| COASTAL ZONE | • Restoring coastal vegetation<br>• Wetland protection<br>• Dune restoration<br>• Rock revetment |
| ENERGY INDUSTRIES | • Wind (utility scale)<br>• PV (>1 MW)<br>• EE Boilers (heat recovery) |

# 1. Introduction

## 1.1 Objectives of the TNA project

The current TNA differs from the one carried out for Mauritius in 2004 by proposing an applied process to leverage funding for the implementation of prioritised technologies for climate change mitigation and adaptation. The main focus will be onTAPs which will pave the way forthe transfer of environmentally-sound technologies,andtheir diffusion and adoption.Once the TNA report has prioritised mitigation and adaptation sectors in the beneficiary country, and prioritised technology options in these sectors, an analysis of barriers to technology uptake will lead on the formulation of a framework and action plan for overcoming these barriers. The purpose and objectives of the TNA project are given below.

### 1.1.1 Purpose of TNA project

The purpose of the TNA project is to assist participant developing country Parties identify and analyze priority technology needs, which can form the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC.

### 1.1.2 Immediate objectives of TNA project

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA);

2. To identify the barriers that hinder the acquisition, deployment, and diffusion of the prioritized technologies for mitigation and adaptation; and 3. To develop Technology Action Plans (TAP) that specify activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries

### 1.1.3 Ultimate objective of TNA project

The ultimate objective of the TNA project is to enable the beneficiary country to develop fully budgeted adaptation and/or mitigation technologies in priority sectors to support sustainable development.

## 1.2 Brief introduction about the national circumstances

The economic development has progressed significantly over the past decades, and the country has attained a GDP per capita around US$ 6,700 in 2009. From 1999 to 2009, GDP in real terms grew on average by 4.7% per annum. However, growth rate for 2009 was 3.1% lower than the 5.1% growth registered in 2008, largely due to the global economic crisis. The economy expanded by around 4.1% in 2010, with positive growth in all sectors. This is expected to go up slightly to 4.2% in 2011. The sectors that have contributed to the economic development of Mauritius constitute tourism, financial services, construction and manufacturing sectors.

Due to changes in international trade regime, the on-going economic reform programme in Mauritius aims at putting the economy on a higher growth trajectory by moving away from an economy based on trade preferences to that based on global competitiveness and a wider range of employment opportunities. This new orientation has seen the emergence of new economic sectors such as Information and Communication Technology (ICT), Business Process Outsourcing (BPO), seafood sector, real estate, energy industries as well as health and education hubs. The share of the services sector in the economy was around 69% in 2009, revealing the transition to a service-based economy.

The social development of Mauritius can be gauged through its status as an upper-middle-income country with a HDI of 0.85. The rapid socio-economic development of Mauritius has been accompanied by several environmental challenges, such as coastal erosion and loss of biodiversity, among others. A review of these challenges and their implications is provided in the Mauritius Environment Outlook (MEO) Report 2010.i

A bird's eye view of national circumstances (social, environmental and economic) can be obtained by looking at progress made in achieving the MDGs. Mauritius is doing well in areas of the MDGs like poverty alleviation, universal primary education, and on some aspects of gender equality. It has eradicated malaria, is combating HIV/AIDS and also the prevalent problems of non-communicable diseases such as diabetes, heart and lung diseases and mental illness. Access to safe drinking water and basic sanitation are largely in place, but the country still needs to progress on reversing trends on GHG emissions and loss of threatened animal and plant species. These trends have been analysedin MEO 2010 that discusses the achievements on MDG Goal 7: "Ensure Environmental Sustainability" in details.

### 1.3 National sustainable development strategies

Mauritius has ratified numerous MEAs that have been translated at the national level in changes and amendments in national legislations.1Some of the main outcomes of the various global conferences held that have had positive impacts on Mauritius as a SIDS are:Agenda 21, the Barbados Plan of Action, the Johannesburg Plan of Implementation, and the Mauritius Strategy. Further, MEO 2010 reflects a growing recognition of environmental issues as an integral part in the pursuit of sustainable development.[2]

There are several policies, strategies and action plans that support sustainable development to differing extents. The main ones are summarized at Annex 1. In order to mainstream sustainable development at all levels, Mauritius has embarked on the Maurice Ile Durable (MID) initiative. MID is emerging as the model for sustainable development for Mauritius, and it has highest political support. National consultations leading to a MID Green Paper and the deliberations of multi-stakeholder working groups on six issues of national priority – i.e. Education, Energy, Environment, Employment and Equity - have been completed.3A MID Policy and Strategy is expected to be finalized in the first quarter of 2012.

### 1.4 National climate change policies and actions

To date there are no overarching national climate change policies and actions regarding both adaptation and mitigation. This does not imply that government is not making efforts to bridge this gap. Since 1991,

[1] Some of the main MEAs are: Ramsar Convention, The Nairobi Convention, The Montreal Protocol, The Convention on Biological Diversity; The UN Convention on the Law of the Sea (UNCLOS);The United Nations Framework Convention on Climate Change (UNFCCC).

[2] In order to achieve its objective, the AAP has the following outputs: (i) Dynamic, long-term planning mechanisms to manage the inherent uncertainties of climate change introduced; (ii) Leadership capacities and institutional frameworks to manage climate change risks and opportunities in an integrated manner at the local and national levels strengthened; (iii) Climate-resilient policies and measures implemented in priority sectors implemented; (iv) Financing options to meet national adaptation costs expanded at the local, national, sub-regional and regional levels; and (v) Knowledge on adjusting national development processes to fully incorporate climate change risks and opportunities generated and shared across all levels.

[3]Please see http://environment.gov.mu – accessed 10 January 2012.

Government has supported the integration of climate change mitigation and adaptation measures into core development processes. While a Climate Change Action Plan was developed in 1998, follow-up of the proposed action plan was fragmented and uncoordinated due to a lack of technical, human and institutional capacity. Furthermore budgetary, policy, development and implementation gaps also acted as barriers in implementation of the Climate Change Action Plan.ii Furthermore, the MEO 2010 quotes that "other ad hoc mitigation and adaptation projects have been implemented in areas such as: ecosystem restoration and addressing sea level rise. Nevertheless, the scope and magnitude of these projects are limited and isolated. As a result, their outcomes are far from being necessarily sustainable." Since Mauritius is not a LDC, it did not have any obligation to develop a NAPA. These comments need to be qualified since the AAP is currently putting in place a national framework to integrate and mainstream climate change adaptation into the institutional framework and into core development policy, strategies and plans of Mauritius.Similarly, the Energy Strategy 2011-2025 Action Plan (please see Annex 2) provides the future orientations of Mauritius concerning GHG emission reductions from a combination of energy efficiency measures and renewable energy technologies.

In order to demonstrate the country's willingness to mainstream climate change in policies and strategies, Government has institutionalised a Climate Change Division at Ministry of Environment and Sustainable Development since 1 March 2010. The division is responsible for implementing international climate change agreements (i.e. UNFCCC, Kyoto Protocol, Conference of Parties4 decisions, Bali Action Plan5, Copenhagen Accord6 and Cancun Agreements7), preparing, monitoring and implementing the national climate change adaptation plan and mitigation strategy, undertaking GHG inventories, developing economic instruments and exploring potential funding opportunities to facilitate climate practices.

### 1.5 TNA relevance to national development priorities

The previous sections have revealed the recognition for integrating climate change into national development policies, strategies and actions.Although there is the recognition that technology transfer is important to address climate change mitigation and adaptation, there is currently no methodology in place at the national level to address this issue. At best, technology transfer takes place within the context of a project that has a limited lifespan. Although the TNA is also a project of finite lifespan, its incremental contribution is to provide a methodology and tools for analysing and prioritizing technology options for climate change mitigation and adaptation, as well as providing capacity building to national and institutional stakeholders. In addition, the TNA project will leave a legacy (methodology, tools and human capacity) to address technology transfer options in sectors over and above those discussed below.

[4] The Conference of Parties (COP) is a policy-making body that meets periodically to take stock of implementation of legally binding agreements and adopt decisions, resolutions or recommendations for the future implementation of these agreements.

[5] The Bali Action Plan was adopted by the 13th Conference of Parties (COP 13) of the UNFCCC in 2007. The purpose of the Bali Action Plan was to enable full, effective and sustained implementation of the Framework Climate Change Convention. It also called for the articulation of a shared vision for long term cooperative action and included a goal for reducing GHG emissions. The Bali Action Plan also set a deadline for concluding climate negotiations during the 2009 COP 15 in Copenhagen.

[6] The Copenhagen Accord is the outcome of the 15th Conference of Parties (COP 15) to the United Nations Climate Change Conference, which took place from 7 – 18 December 2009 in Copenhagen Denmark. The Accord is a three-page, non-binding expression of political intent. Some of the elements included in the Copenhagen Accord are: long term goals to limit the increase of global temperatures to below 2°C; support adaptation in developing countries by providing adequate and sustainable financial resources, technology and capacity building; emissions reductions amongst others.

[7] The Cancun Agreements are the outcome of the 2010 United Nations Climate Change Conference (COP 16) held in Cancun, Mexico, from 29 November to 10 December 2010. The Cancun Agreements include a comprehensive package agreed by governments to help developing nations deal with climate change, including new institutions, funding channels and a technology transfer mechanism to help the developing world build its own sustainable, low-emissions future, adapt more effectively to climate change and preserve and protect its forests for the good of all nations. The Agreements also call for countries to list under the UNFCCC the emission reduction targets and actions which they announced in 2010.

## 2. Institutional arrangement for the TNA and the stakeholders involvement

This section discusses the organisational structure of the TNA project, and the MSP that has been put in place to devolve project ownership to key stakeholders.

### 2.1 Organisational structure of TNA project

The organisational structure of the TNA project for Mauritius is shown in Figure 1. It consists mainly of the National TNA Team and facilitators, with the flow of resources and outputs as indicated by the arrows defined in the legend. The structure of the project can be detailed as follows:

- TNA Coordinator: The TNA project is coordinated by the Director, Department of Environment, MoESD. The alternate TNA Coordinator is the Head, Climate Change Division, MoESD;
- TNA Secretariat: Secretariat facilities are provided by the staff of CCD, MoESD;
- Sectoral Work Groups: The technical work of technology identification, prioritisation and technology action plan development is carried out at the level of multi-stakeholder sectoralworking groups (see section 2.2 for more details). The sectoral working groups have a core constituency as discussed in section 2.2, but are able to co-opt additional members on a needs basis. Based on sector prioritisation (see section 3) the four working groups are Water, Agriculture, Coastal Zone and Energy Industries.
  Each sectoral working group is chaired by the national apex institution, which are WRU, MoA, ICZM Division (MoESD), and CEB, respectively;
- National Consultants: The bulk of the technical work is facilitated by a group of 3 consultants. One is the TNA Consultant who has the responsibility to ensure project completion as well as its quality standards. The TNA consultant also has the responsibility of Adaptation Expert for the Coastal Zone and Mitigation Expert for Energy Industries. The remaining two consultants are Adaptation Experts for the Water and Agriculture Sectors;
- National TNA Committee:The role of the National TNA Committee is to provide leadership to the project in association with the TNA coordinator. The Chairs of the sectoral working groups are by de facto members of this committee; and • National Steering Committee: The main role of the steering committee is to provide guidance in terms of the process leading towards the political and stakeholder acceptance of TNA outcomes.

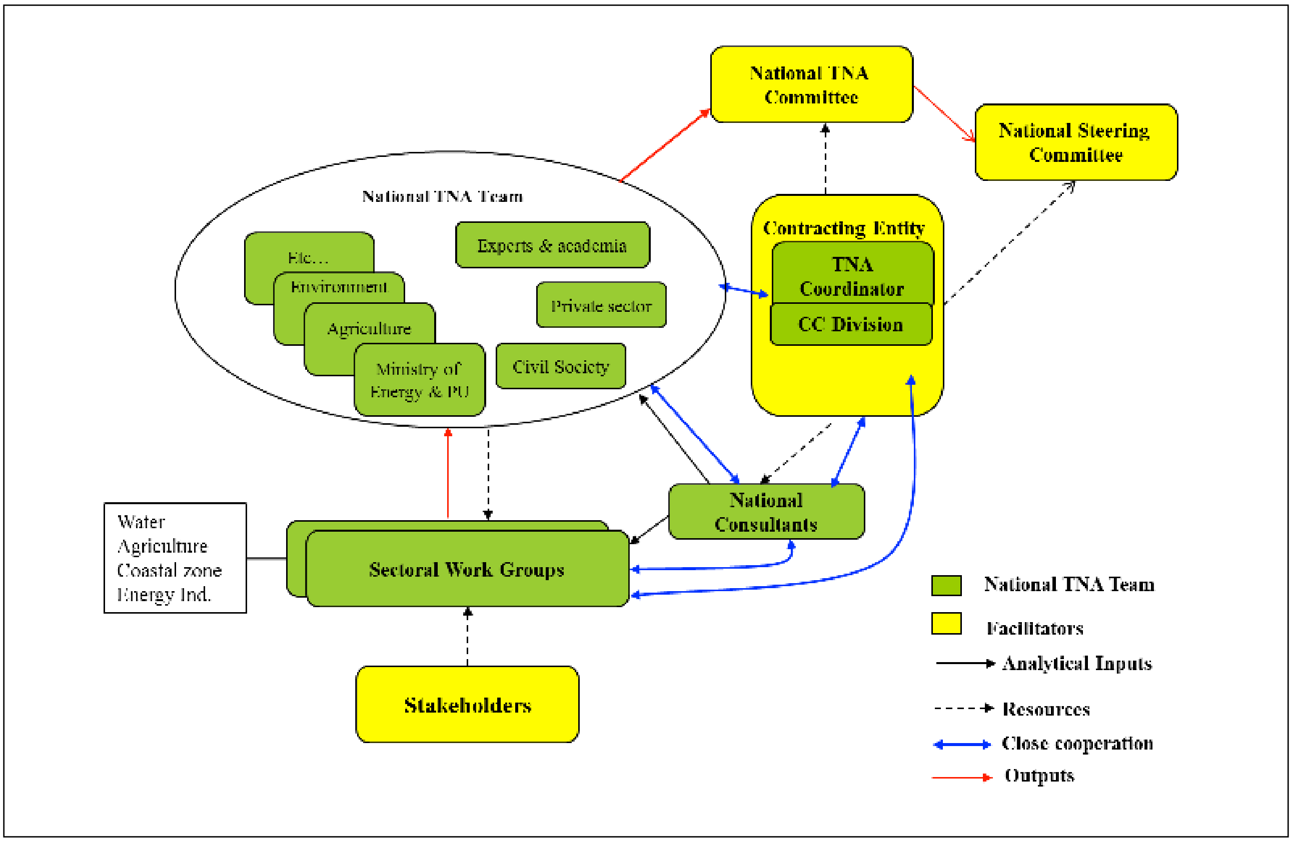


Figure 1. Organisational structure of the TNA project, Mauritius.

## 2.2 Stakeholder Engagement Process followed in TNA

One of the success factors for the TNA project, especially for the subsequent steps of leveraging financing for technology implementation in priority sectors is to ensure maximum local stakeholder ownership of the project. The best approach is recognized to be the bottom-up approach wherein all the key stakeholders, who know the local context and priority sectors better than anybody else, are given a central role in the project.

The TNA project has employed a MSP. With the bottom-up approach in mind, the TNA coordinator and staff of the Climate Change Division, MoESD, with input from the TNA Consultant, carried out a stakeholder mapping exercise prior to the IW. This process was facilitated following the acceptance of the priority mitigation and adaptation sectors by the National TNA Committee. Hence, the stakeholders were mapped using a sectoral approach. The list of stakeholders mapped is given at Annex 3. At this stage the stakeholder mapping exercise was only a proposal, and it was presented for review and validation at the IW.

Participants reviewed the proposed list of stakeholders, and validated the consolidated list of TNA stakeholders shown at Annex 3. For sake of clarity, the changes made to the proposed list are highlighted in bold.

## 3. Sector prioritization

The prioritization of adaptation sectors followed the inherent climate vulnerabilities of Mauritius as a SIDS. The unique vulnerabilities of island states have been highlighted in FAR of the IPCC.[iii] Its analysis showed that there was either very high confidence or high confidence of detrimental socio-economic impacts of climate change and extreme events on water resources; coastal systems and resources; agriculture, fisheries and food security; biodiversity; human settlements; infrastructure and transport. This is what motivated FAR to focus predominantly on adaptation to climate change in small island states.As is characteristic of many island states, the impacts of climate change on the coastal communities, infrastructure and ecosystems should be given due consideration in any attempt to address adaptation to climate change using a sectoral approach. Prioritization of the mitigation sectors followed primarily the criterion of relative contributions of sectoral GHG emissions to the national inventory.

It is pointed out that, although it would be highly desirable and relevant to carry out TNA for all socioeconomic and environment sectors, the restrained scope of the current TNA project both in terms of funding and time schedule allows the coverage of a maximum of four priority sectors. The methodology proposed here can be extended to other sectors in the future.

The following sections provide overviews of observed climate change and climate variability in Mauritius, and their impacts on the key priority sectors.

### 3.1 Trends and projections in climate change and climate variability in Mauritius

Climate research provides compelling evidence that increases in global temperatures are influencing the global hydrological cycle. Average temperature is projected to increase by varying amounts over all major landmasses and during all seasons. Higher temperature increase evaporation, glacial melt and thermal expansion of oceans. It also increases the holding capacity of water vapor in the atmosphere, leading to increased climate variability and a more intense hydrological cycle.[iv]

Some of the pertinent trends that have been observed for the island of Mauritius are:[v]

- Long-term time series of rainfall amount over the past century (1905 to 2008) show a decreasing trend in annual rainfall over Mauritius. The decreasing rainfall trend is about 8% when compared to the 1950s;

- The duration of the intermediate dry months, the transition period between winter and summer, is becoming longer. While in the 60s and 70s summer rains used to start by November, they now occur only in late December. Since the past four summer seasons, the rains started only in January of the following year. Furthermore, and as if to catch up with the delay, when it starts to rain it really pours with recurrent flash floods in February and March. This shift in the onset of summer rain is highly significant as it translates into increasing pressure on the water sector to increase storage capacity to cater for longer periods of dry spells and to meet equally increasing demands of the agricultural, tourism, industrial and domestic sectors;

- The temporal distribution of rain is no longer what it used to be. The number of rainy days has decreased but the frequency of heavy rainfall events has increased. This means that Mauritius has to increase our rain harvesting capacity; and

- While in the old days (say prior to 2000), most of the summer rains resulted from cyclones, since the past ten years or so years summer rains have been harvested outside cyclones. Records show that only five storms were observed in the south Indian Ocean and none came to within 100 km of Mauritius. Yet, only five heavy rainfall events, unrelated to storms, replenished the country’s reservoirs.

• Average temperature on the island of Mauritius between 1998 and 2008 was higher than that of the decade 1951-60 by between 0.74 and 1.1°C;

• An increase in the annual number of hot days and warm nights, as well as an increase in the minimum temperatures (i.e. winters are getting milder);

• The mean sea level rise during the past decade (1998-2007) was 2.1 mm/yr (measured at Port Louis) An increase in 5 cm in the relative sea level may translate into an increase of one meter during cyclones or tidal surges; and

• Explosive intensification rate of tropical cyclone. With the current global warming trend, it is likely that tropical cyclone will continue to intensify at above climatological rate.

The Second National Communication 2010 has also reported on down-scaled climate modeling using MAGICCSCENGEN 5.3 that gives results with a spatial resolution of 2.5degrees x 2.5degrees.vi Using the 1980 to 1999 observed data, the baseline temperature and rainfall were derived. The 1990 to 2008 data were then used to identify a set of nine General Circulation Models (GCM) that best reflects the locally-observed trends, and changes in rainfall and mean temperature were simulated to 2100.vii The results across 9 GCM and 4 emission scenarios are summarized in Table 1.

The projection indicates that the utilizable water resources will decrease by up to 13% by 2050. Despite the fact that the difference in projected values under the two scenarios used in the analyses was only less than 1% for 2020, around 1% for 2030 and 4% for 2050, the changes in pattern of rainfall with more episodes of heavy rainfall and more extreme weather events are expected to allow only a reduced amount of precipitation to go into the storage system. There is an immediate need to increase storage capacity to be able to meet demands in the short term.

Table 1. Range of the projected changes in temperature, rainfall and seal level rise (Source: Second National Communication, 2010).

| Time horizon | Temperature (oC) | | | Rainfall (%) | SLR (cm) |
|---|---|---|---|---|---|
| | Mean | Minimum | Maximum | | |
| 2020 | 0.43 – 0.47 | 0.58 – 0.64 | 0.37 – 0.41 | (5.41 – 6.02) | 5.3 – 5.5 |
| 2030 | 0.59 – 0.73 | 0.81– 0.99 | 0.51 – 0.63 | (6.90 – 8.20) | 7.8 – 8.2 |
| 2050 | 0.94 – 1.40 | 1.28 – 1.91 | 0.82 – 1.21 | (9.19 – 13.96) | 13.8 – 16.2 |
| 2080 | 1.48 – 2.64 | 2.02 – 3.60 | 1.29 – 2.29 | (14.75 – 22.22) | 24.5 – 34.6 |
| 2100 | 1.86 – 3.28 | 2.54 – 4.48 | 1.61 – 2.85 | (17.57 – 26.76) | 32.7 – 48.6 |

Note: Values given in brackets represent negative changes – i.e. decreases relative to the baseline.

### 3.2 An overview of sectors

Conducting an exhaustive overview of all socio-economic sectors is plainly beyond the scope of this report. The approach carried out here is therefore guided by national sectoral priorities based on vulnerability to climate change and climate variability, and trends in GHG emissions. The overview presented here has been facilitated by exhaustive assessments found in the MEO 2010 and the SNC 2010.viii Broadly speaking, the sectors or areas that are vulnerable to the impacts of climate change have been found in the SNC to be: water, agriculture, fisheries, coastal zones, tourism, infrastructure, health and biodiversity. Since above 95% of tourism infrastructure is found on the coastal zones of Mauritius, they can be grouped together. To date no adequate assessments have been made concerning the linkages between climate change and health hazards in Mauritius, making any such discussions tenuous.The same observation stands concerning linkages between climate change and biodiversity.The overview of coastal zones will also cover coastal ecosystems, tourism, infrastructure and human settlements. The overview of the mitigation sectors is made possible by the availability of quantifiable GHG emissions data by sectoral scope, as well as from the perspective of final energy use.Please note that the sectoral overviews cover the impacts of both climate- and non-climate driver (where applicable).

#### 3.2.1 Water sector

Water is essential for healthy living and is vital for economic development. Water is the primary medium through which climate change will influence the Earth's ecosystem and, thus, human livelihoods and wellbeing. According to the Intergovernmental Panel on Climate Change (IPCC), many experts have concluded that the availability and quality of water will be the main pressure on, and issues for, societies and the environment under climate change.[ix]

##### 3.2.1.1 Water balance

In Mauritius, the main sources of water supply are reservoir, river and underground water. The island receives an average annual rainfall of about 3,700 Mm3 (million cubic meters). However, owing to its topography, hydro-geological conditions and tropical location, Mauritius experiences high levels of rapid run off. 8 Only 10 % of the precipitation goes as ground water recharge, while evapo-transpiration and surface runoff represent 30% and 60% respectively. Table 2 summarizes the water balance for the island of Mauritius for selected years between 1999 and 2010 that demonstrates the variability in water availability. A severe drought afflicted the island of Mauritius in 1999, whereas 2009 experienced above average precipitation. The years 2006 and 2010 can be taken as the baseline since they give the typical water balance in the absence of variability. The figures in brackets correspond to the (unchanging) percentages relative to total average rainfall. Part of the surface runoff is conveyed to the impounding reservoirs, abstracted from rivers for domestic, agricultural and industrial uses and the remaining flows to the sea. Mauritius has a network of 25 major river basins and 21 minor river basins. There are 5 main aquifers, 11 reservoirs and 350 boreholes.[x]

Table 2. Water balance (Mm3) for the island of Mauritius, 1999-2010 (Source: Digest of Energy and Water Statistics – 2003 and 2010, Central Statistics Office, Port Louis).

| Year | 1999 | 2006 | 2009 | 2010 |
|---|---|---|---|---|
| Rainfall (average) | 2,184 (100%) | 3,571 (100%) | 4,470 (100%) | 3,368 (100%) |
| Surface runoff | 1,311 (60%) | 2,143 (60%) | 2,682 (60%) | 2,021 (60%) |
| Evapo-transpiration | 655 (30%) | 1,071 (30%) | 1,341 (30%) | 1,010 (30%) |
| Net ground water recharge | 218 (10%) | 357 (10%) | 447 (10%) | 337 (10%) |

In 2010, the total water demand was estimated at 975 Mm3. The agricultural sector accounted for most of the water utilized with 454 Mm3 despite the fact that this sector accounts for around only 4% of the country's GDP.xi Water utilization was followed by hydro-electric power generation (295 Mm3), domestic, industrial and tourism uses (212 Mm3), and industrial applications from private boreholes (14 Mm3). Figure 2 shows the percentage breakdown of total water utilization by application.

8 Runoff is defined as that part of precipitation that flows towards the stream on the ground surface or within the soil (International Glossary of Hydrology, World Meteorological Organisation no. 385).

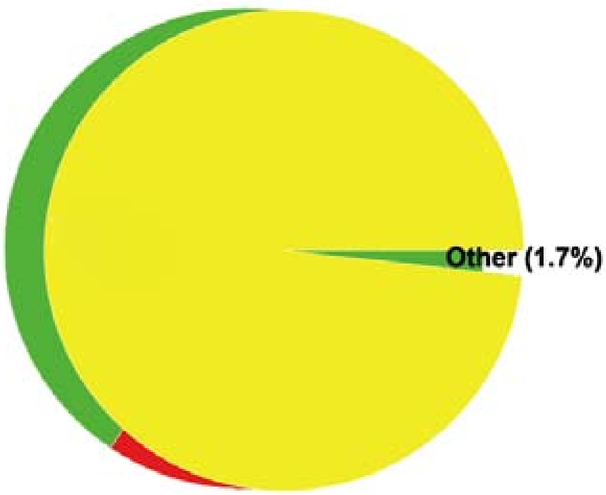


Figure 2. Final water use in 2010 (Source: Energy and Water Statistics – 2010, Central Statistics Office, Port -Louis).

The extraction by source of sectoral water demand in 2010 is summarized in Table 3. Around 56% of freshwater used came from surface water (rivers and streams), 29.8% from reservoirs and the remaining 14.3% came from groundwater aquifers.

Table 3. Extraction by source of sectoral water demand in 2010 (Mm3) (Source: Table 17, Environment Statistics – 2010, Central Statistics Office, Port Louis).

| | Surface Water | | | | |
|---|---|---|---|---|---|
| | Rivers | Reservoirs | Aquifers | Total Mm3 | % |
| Agricultural irrigation | 356 | 80 | 18 | 454 | 47% |
| Hydropower[9] | 148 | 147 | - | 295 | 30% |
| Domestic, Industrial & Tourism | 36 | 64 | 112 | 212 | 22% |
| Industrial (Private boreholes) | 5 | 0 | 9 | 14 | 1% |
| Total $Mm^3$ | 545 | 291 | 139 | 975 | |
| Percentage (%) | 55.9% | 29.8% | 14.3% | 100% | |

### 3.2.1.2 Trends and projections – nonclimate drivers

Time-series data reveals that water demand has not changed significantly in the Domestic, Industrial & Tourism, and Industrial (private boreholes) sectors over the past decade. Water used for irrigation in agriculture has decreased steadily from over 500 $Mm^3$ in 2002, reflecting mainly the steady reduction in the area under sugarcane cultivation. A cyclical pattern with troughs (2001 & 2006; 210-240Mm3) and peaks (2004 & 2009; 350-370 $Mm^3$) is observed for water used in hydro-power generation.[xii]

Fresh water availability for human use is affected by both climate and non-climate drivers. The main nonclimate drivers in the water sector arise due to increasing demand from economic development, agriculture, 9It must be noted that part of the water used for hydropower generation is also used for irrigation. industry, tourism and a growing urban population. These in turn result in heavy water extraction and also pollution of water resources. During the first decade of the 21st century, per capita water consumption has increased by 7.1%, and it is expected to increase further into the future with the more affluent lifestyle of the local population. Analysis carried out in the Mauritius Environment Outlook shows that total water demand is projected at 1,200 $Mm^3$ per year by 2040 based solely on changes in population dynamics. This demand, which does not take into account water demand in other growing sectors of the economy like tourism and Integrated Resort Schemes, is in excess of projected supplies and close to the present utilisable renewable potential of 1,233 Mm3 per year.xiii Using this present usable freshwater potential, it is noted that water availability in 2010 was equivalent to 965 m3/person, which is below the threshold for classification as a 'water-scarce' country.[10]

Groundwater-quality monitoring at 23 Interface Control Piezometers and in boreholes in use for industrial, agricultural and domestic purposes have shown deterioration in groundwater quality in coastal aquifers. [xiv]Sources of freshwater pollution include industrial effluents, dumping of liquid and solid waste in rivers and streams, run off from agricultural fields and untreated sewage.[xv]

### 3.2.1.3 Climate change and variability impacts in the water sector

Although temperature is projected to continue to increase globally, the effects of this increase on precipitation will vary from one area to another. The effect on precipitation may also vary seasonally; in some areas, precipitation is expected to increase in one season and decrease in another. Although the field of climate modeling has progressed rapidly in recent years, quantitative projections of changes in precipitation, river flows and water levels remain highly uncertain.

Nevertheless, the observed decrease in rainfall, increase in rainfall variability, increase in the occurrence of high-intensity rainfall and the shift in the onset of the summer rains have impacted negatively on the water resources. The Central Plateau with the largest catchments in the common recharge zones has seen a significant decrease in rainfall. This is reflected in changes in ground water and river-flow regimes.These changes will only exacerbate the water scarcity on the island of Mauritius.

### 3.2.2 Agriculture sector

This section provides an overview of the vulnerability of the Mauritian's agriculture to climate change. Although the sugarcane sector is covered, it is not the main focus of the analysis. Mauritian agriculture occupies around 38 % of the island's land resources in 2010 (around 70,800 hectares), with sugar cane accounting for 85 % (63,780 ha) of agricultural land and involved some 23,051 planters.xviThe Digest of Agricultural Statistics 2010 (i.e. reference xvi) provides the following information: Food crops, tea, tobacco, palm, fruit and ornamentals are produced on the remaining cultivated land area. About 7,570 ha are occupied annually by some 6 000 food crop growers producing annually around some 110,000 tonnes of fresh vegetables and fruits namely pineapple and banana mainly for the domestic market. Food crop production is undertaken on permanent gardens and on rotational and sugar cane interlines and the production system dominated by small scale farming with an average holding of 0.25 ha and a few large farms is mostly rainfed.

Some 30 % (21,543 ha) of the agricultural land is under irrigation, out of which some 18,755 ha (87%) is occupied by large sugar planters including corporate estates. Adverse climatic conditions and water stress over the past 10 years have severely constrained agricultural development with a regression in agricultural activities. The decrease in precipitation coupled with increasing water demand from other sectors, ensuring freshwater supply to the agriculture is a challenge and a threat to our food security. [10]Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor water quality restricts its use. Hydrologists typically assess scarcity by looking at the population-water equation. An area is experiencing water stress when annual water supplies drop below 1,700 $m^3$ per person. When annual water supplies drop below 1,000 $m^3$ per person, the population faces water scarcity, and below 500 $m^3$ "absolute scarcity".

The agricultural sector employed about 8.1 % of the labour force in 2010 and contributed 3.6 % to the GDP, of which sugar cane, tea and tobacco accounts to 33 % followed by food crops (28 %) and livestock and poultry (22 %). The country is self-sufficient in poultry and egg but produces only 6 % of the national meat goat, mutton, venison, pork, beef)and 2% of its milk requirement. Despite the importance of agriculture in the  Mauritian scene, and the large area of lands under agriculture, Mauritius is a net food importer. Major imported food items include the staples (rice and wheat), pulses, oils and fats, meat and milk products. Agriculture provides around 26% food self-sufficiency. About 25% of the total land area of the Republic of Mauritius11 is under forest cover which is mostly devoted to silviculture along with deer ranching practiced on an extensive basis, over some 10,000 ha while other livestock, a population of some 20,000 animals are reared mainly in closed system. Special efforts have been made to promote conservation and protection with the creation of National Parks and Nature Reserves.

### 3.2.2.1 Expected climate change impacts

The vulnerability of this sector has been observed and climate change is expected to exacerbate the situation. xvii This is expected to be particularly detrimental for small-scale farming that relies almost exclusively on rain-fed agriculture. The agriculture sector has a strong link with the water sector since the bulk of water extraction is used for irrigation. Consequently, large-scale irrigation projects are also severely affected during periods of water shortages as the supply of irrigation water is halted to favour potable water supply. In 2010, 47% of the total of fresh water on the island of Mauritius was used for irrigation in agriculture.xviiiThe various dimensions of climate-change-related impacts on agriculture are summarized in Table 4.

Table 4. The multiple effects climate change is likely to have on ROM's agriculture sector.

| Climate change impacts | Consequences for the agriculture sector |
|---|---|
| Temperature rise<br><br>Increasingly variable rainfall | - Change in soil moisture status;<br>- Shift in agricultural zones from lower to higher altitudes;<br>- Change in cropping pattern and crop cycle;<br>- Heat stress, which will lead to:<br>• Lower crop productivity12<br>• Reduced feed intake by livestock<br>• Lower livestock productivity<br>• Increased mortality in poultry<br>- Increased incidence of agricultural pests and crop diseases;<br>- Lower pasture productivity and lower carrying capacity of grazing land.<br>- Increased risk of flooding and crop damage in certain agricultural zones; |
| Climate extremes (e.g. | - Severe soil erosion on sloping land, loss of fertile top soil;<br>- Severe drought affecting crop establishment;<br>- Loss of crop production and livestock production.<br>- Change in frequency and intensity of drought leading to: severe |
| drought, tropical cyclones, flash flooding) | drought affects crop establishment; reduced crop/livestock production; shortage of fodder/low quality feed for livestock<br>- Flooding of food crop production areas.<br>- Increased soil erosion on slopping cultivated land.<br>- Increased leaching of plant nutrients and fertilizer from agricultural land to groundwater.<br>- Damage to crops; farming infrastructure; loss of animals. |
| SLR | - Salinization of irrigation water in coastal zones;<br>- Coastal flooding;<br>- Loss of agricultural land around the coast. |

The following sections provide more detailed impacts on three agriculture sub-sectors.

### 3.2.2.2 Sugarcane

The sugarcane sector is covered here for the sake of completeness, and also to demonstrate the wider impacts of climate change on agriculture. Sugarcane productivity and sugar extraction rate are reduced by extreme weather events like cyclones and drought. The magnitude of the impact varies according to the timing, severity and duration of the extreme event and may have carry-over effects on the productivity of subsequent years. Assessment made using the Agricultural Productions Systems Simulator (APSIM) biophysical model for a range of climate change scenarios has shown that for a decrease in rainfall of 10% to 20% and an increase in temperature of 2°C, reductions in cane yield is expected to range from 34% and 48% while reductions in sugar yield is expected to range from 47% to 65%. Under the projected increase in temperature and the narrowing of the temperature amplitude between day and night temperatures, it is expected that vegetative growth will be favoured at the expense of sugar accumulation.xix

### 3.2.2.3 Nonsugarcane

Vegetables and other crops will suffer similarly. With increased temperatures and lower temperature amplitude the vulnerability is expected to worsen. As an example, such a change in temperatures will result in a change in phenology and a decrease in flowering intensity. Expected decrease in rainfall will exacerbate the stress intensity while temperature increase will result in higher demand from evapo-transpiration. Increase in temperature will also have adverse impacts on yield and productivity.

A rising temperature will fasten the reproductive cycle of insect pests and vectors, increase disease transmission rate and lead to expansion of the geographical ranges of agricultural pests and diseases as well as increase the duration that they are prevalent. Intense rainfall events may cause inundation of cultivated areas and the complete loss in vegetable production.

Climate is thus expected to directly impact on profitability and may lead to abandonment of cultivable areas. Such cases would lead to soil erosion and leaching of nutrients.

A recent study has investigated the impacts of climate change on the regional yield of tomatoes on the island of Mauritius using a Ricardian Model.xx The econometric results have shown that increased temperatures and a decrease in precipitation would negatively affect tomato yields over the whole island, where monthly tomato yields in the Eastern region would decrease by 8.2% in the short-run and 13.3% in the long-run with a 1°C temperature increase and 10% precipitation decrease for instance. The results of the sensitivity analysis of the study are summarized in Table 5. It would be desirable to extend this study to production of other food crops in the future.

Table 5. Sensitivity analysis of the impacts of climate change on monthly tomato yields per hectare in the North, East, West and South (Source: Jonsson 2011, pg.53 [xx]).

| | Climate change scenarios | | Impacts on average monthly yields | | | |
|---|---|---|---|---|---|---|
| Time period | Δ T | Δ Rain | North | East | West | South |
| Short run (<5 years) | +1°C | - | -6.0% | -8.0% | -0.8% | - |
| | +3°C | - | -18.0% | -24.0% | -2.4% | - |
| | +2°C | -5% | -11.8% | -16.1% | -1.7% | -0.02% |
| | +2°C | -10% | -11.5% | -16.2% | -1.8% | -0.04% |
| | +2°C | -20% | -11.1% | -16.4% | -2.0% | -0.08% |
| | -2°C | +10%? | 11.5% | 16.2% | 1.8% | 0.04% |
| Long run (>10 years | +1°C | - | -13.0% | -13.0% | 1.0% | - |
| | +3°C | - | -39.0% | -39.0% | 3.0% | - |
| | +2°C | -5% | -26.0% | -26.2% | 1.8% - | 0.05% |
| | +2°C | -10% | -25.9% | -26.3% | 1.6% - | 0.1% |
| | +2°C | -20% | -25.8% | -26.6% | 1.2% | -0.2% |
| | -2°C | +10%? | 25.9% | 26.3% | -1.6% | 0.1% |

#### 3.2.2.4 Fisheries

The fishing industry is a primary example for an industry subject to nature's variability, including climate change. Climate change affects fisheries along two main axes, changes in productivity in a given location and changes in fish migrations or the location of their habitats. From an economic point of view, the changes will have impacts on fisheries and coastal communities in different ways. These expected changes require adaptable and flexible fisheries and aquaculture management policies and governance frameworks. However, the forms of future climate change and the extent of its impact remain uncertain. Fisheries policy makers therefore need to develop strategies and decision-making models in order to adapt to climate change under such uncertainty while taking into account social and economic consequences.

In the fisheries sector, significant losses have been noted as a result of fish mortalities around Mauritius due to abnormal SST over the last decade. Any further rise will highly jeopardize the livelihood of many and endanger food security.xxi With anticipated warming, the following effects are expected:[xxii]

• Migratory shifts in tuna aggregations thereby disrupting fish based industries and may result in conflict over the stock both at an international and national level;

• Changes in fish stock distribution and fluctuations in abundance of conventionally fished and "new" species may disrupt existing allocation arrangements;
• Spatial management schemes such as closed areas to protect spawning or migration areas, or those based on EEZ boundaries may become inappropriate;
• The calcification rate of corals could decrease by about 14% to 30% by 2050 based on the projected rise in Carbon dioxide levels. Thus corals will be threatened due on one hand, to bleaching and on the other, to their restricted growth as a result of ocean acidification. It is estimated that live corals will be reduced by 80% to 100% in the event of 3.28oC rise in temperature by the year 2100; and

Due to the rise in SST, coral bleaching events have been observed since 1998 in Mauritius. This phenomenon is occurring more frequently such as in 2003, 2005 and 2009 with drastic effects on the coral community.13

### 3.2.3 Coastal Zones

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.[14] They support a large proportion of the population and varied economic activity including recreation, tourism, fisheries, trade and industry. Approximately 20% of the population are resident in the coastal areas.[xxiii]

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.xxiv 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. The next two sub-sections address the non-climate and climate drivers affecting the coastal zones of the island of Mauritius separately.

#### 3.2.3.1 Impacts of non-climate drivers on coastal zones and ecosystems

Several human-assisted, non-climate changes have affected or continue to affect coastal zones and its ecosystems. Some of the main detrimental impacts of human activities are:[xxv]

- Inappropriate use and unplanned construction and urbanisation around the Northern and Eastern tourist zones have sustained ongoing degradation of the fringing coral reefs and the marine communities within the lagoons;
- Land-clearing, reclamation and construction activities have caused an increase in sedimentation within the lagoons;
- Coastal construction, marine pollution and over-harvesting threaten the lagoon coastal habitats;
- Inappropriate shoreline construction, such as impervious jetties and groynes, designed to protect property has increased frontal beach erosion;

[13] Communication received from the Ministry of Fisheries – 13 June 2012.
[14] The richness in natural resources and wildlife is also characteristic to the islands of Rodrigues and Agalega.

- The widening of natural passes in the lagoons or the blasting of new passes on the fringing reef to provide easy access to the outer reef for dive boats and pleasure craft has dramatically changed the wave energy in specific locations, initiating long-term changes in the beach dynamics;15

- Previously sand was extracted from the lagoons for construction work and water purification purposes. This has altered the water circulation and sand replenishment patterns resulting in the erosion of nearby beaches. Sand mining the lagoon is proscribed on the island of Mauritius since October 2001, but still practiced in Rodrigues. Regular monitoring of ex-sand mining sites, namely Grand Gaube, Poudre d'Or, GRSE and Mahebourg, has shown that there is gradual decolonisation of the seabed with sea-grass and other associated marine organism;

- Some lagoons along the Eastern Tourist Zone have suffered from eutrophication through subsurface groundwater discharge.
  Some additional past practices that have affected the integrity and health of coral ecosystems are:xxvi

- Damage to reefs by practices such as walking on the reef, spearing octopus and collecting shellfish;

- Use of dynamite as a fishing practice in lagoons;

- Removal of patch coral from the lagoon by hotels to create more benign swimming and boating areas.

#### 3.2.3.2 Impacts of climate change in coastal zones and ecosystems

The visible and measurable effects of climate change in the coastal zone of ROM have become more apparent over the last ten years, reflecting increases in the rate of negative changes in the coastal zone, due to climate change,xxvii and an increase in the number of vulnerable sites. For example, Mauritius Meteorological Services data indicate that the rate of sea level rise (measured in Port Louis) has averaged 3.8 mm/year over the last five years (albeit a short timeframe sample); this compares to an average of 2.1 mm/year over the last 22 years. The net measured sea level reflects a compounded effect of real sea level rise (absolute water volume increase and more low pressure systems) and a higher frequency and height of waves; i.e., water piled up at that location – both of which have real implications for coastal areas. For example, on May 12, 2007, an extratropical cyclone south of the island of Mauritius created 10 m offshore swells within a period of 18 seconds, traveling 50 km/hr, and hitting the south coast as 5-6 m swells on top of a high tide, resulting in extensive flooding and erosion. The state of coastal vulnerability is therefore not stable; there is no time to spare, as the potential cost of remediation will continue to go up, and not likely in a linear manner.

There is a direct linkage between climate change effects on coastal ecosystem services (especially coral reefs and lagoons) and the integrity of the whole coastal zone of ROM. In particular, there is scientific evidence that increases in sea temperature have led to increased frequency and areal extent of coral bleaching, which may contribute to a failure of the wave attenuation function of reefs. However, the Baird Report of 2003 noted that the back reefs of island of Mauritius were still of good enough quality to serve their function of high energy wave breakers.xxviii This leads to increased beach erosion rates and loss of lagoonal sediments, especially during storm events (for example, intense tropical cyclone Gamede, in February 2007, which resulted in severe beach erosion on the northern and western coasts of the island of Mauritius and at St. Brandon).xxix There is also evidence that coral growth rates, especially in the passes through the barrier reef, are unable to maintain equilibrium with the current rate of sea level rise16, due to the compound effect of recently accelerated SLR, bleaching, accumulated storm damage, increased frequency of freshwater and turbidity events in lagoons (due to storms), and ongoing stresses from local human activities (discharge of wastewater, and anchor damage); Mon Choisy in the north is a good example. Measurements at five key beaches around the island of Mauritius indicate that erosion rates in the last 10-15 years have increased, relative to earlier periods, reflecting this lagging coral growth rate, as well as SLR and storm events.

[15] It is pointed out that such practices are no longer used in Mauritius, and that the observed changes in near-shore dynamics are the result of past practices. The widening of natural passes to provide access to fishermen boats and pleasure crafts is carried out through dredging only in exceptional cases (communication from the Ministry of Fisheries – 13 June 2012).

It is, therefore, imperative that the critical ecosystem function of wave attenuation be enhanced in some manner (such as detached, submerged berms in lagoons, adjacent to eroding beaches, to encourage retention of sand in the littoral cell, and eventual beach replenishment). There are few practical alternatives. Rehabilitation of coral reefs is extremely challenging, since traditional methods, such as coral transplants and artificial reefs, are such small interventions in a coral reef system that is under pervasive pressure. Any new coral patches or rehabilitated areas would still be under the same pressures as the whole reef system, including rising sea level (accelerating), increased storm frequency, and bleaching events. Equally important is the need for a monitoring system that tracks the correlation between key ecosystem functions and weather events, to sharpen the understanding of coastal processes in Mauritius and the extent to which their variability is driven by climate change, which will in turn continue to inform and fine-tune the design of appropriate interventions.

### 3.2.3.3 Impacts of Climate Change on Tourism

The vulnerability to the effects of climate change, including tidal waves and surges, and deterioration of the coral reef through global warming were issues that had been considered when the Mauritius Sector Strategy Plan on Tourism (2008-2015) was being formulated.[xxx]Approximately 23% of the beaches on the island of Mauritius are at risk. It can be assumed that over the next 50 years half of these beaches will be lost to the point of not supporting visitors, if there is no intervention (this is realistic, given some observed erosion rates of 1-2 metres per year at beaches which are only 10-15 metres wide, and more during storm events). Thus, 11% of the tourist draws on the island of Mauritius will be lost, progressively over time, as alternative sites for beach tourists do not present themselves. If we take the cumulative 50-year value of beach tourism (US$ 45.5 billion, assuming no increase in tourist numbers from 2010, to be conservative), then the revenue loss per year will range from US$ 2 million in 2011 to US$ 100 million/year in 2060 (in 2010 terms), assuming a constant rate of beach erosion.17 A more likely case is that the erosion rate will continue to accelerate, and the beach losses will occur sooner, rather than later, with the source of the beach sediments (the lagoonal sediments, which are quite shallow, uniquely so on the island of Mauritius) no longer providing a sink and buffer, as these sediments get pumped beyond the reef, and lost from the littoral system during increasingly intense storm events.[xxxi]

The coastal zone of the island of Mauritius is critically important to the economy of the country, in terms of domestic and international tourism, as well as fisheries. The tourism link is the main concern in the coastal adaptation strategy for the country, since so much revenue and so many jobs are at risk if beaches continue to erode. There are 90 public beaches around the island of Mauritius, with a total length of 26.6 km, making up 8% of the coastline. These attract both domestic and international tourists. As of June 2010, there were 104 registered hotels operational on the island of Mauritius, of which 86 are located immediately adjacent to beaches – these having 21,444 bed places, which represents 92.5% of the hotel guest capacity on the island of Mauritius.xxxii Clearly, most tourists come to enjoy the beaches (34% of tourists are "repeaters"), xxxiii and the market response in the hotel industry (building hotel capacity in proximity to beaches, although often misinformed as to climate change risks, and causing local problems of beach loss) reflects that. The beaches on the island of Mauritius are near capacity, in terms of visitor use. While new beaches cannot be created, existing ones can certainly be lost. One might argue, then, that the percentage of beach loss, due to climate change, could translate into a similar percentage reduction in the number of tourists, and a correlated loss of revenue and jobs in Mauritius.

[16]Ministry of Environment and Sustainable Development; ICZM Division observations.

[17]Assuming a constant erosion rate, that leads to a loss of half of the 21 vulnerable beaches by 2060, with the total revenue loss due to the absence of these beaches being US$100 million/year (11% of the US$ 0.91 billion/year that derives from beach tourism revenue), then Year 1 revenue loss due to beach erosion is US$ 2 million, Year 2 loss is US$ 4 million, etc. up to Year 50 at US$ 100 million.

### 3.2.3.4 Damage to Physical Infrastructure in Coastal Areas

In addition to the risk of physical loss of beaches, infrastructure that is immediately adjacent to the dynamic beach zone is at risk, and there is clear evidence of this risk in some areas, with seawalls collapsing and erosion of roadbeds, especially after storms. In addition, all future design and construction of coastal infrastructure in Mauritius will be informed by the ICZM guidelines that will help reduce or eliminate future infrastructure losses in the coastal zone. For example, assessment of the potential cost of repairs to coastal roads on the island of Mauritius damaged by wave incidence and erosion during a 4-metre wave run-up storm indicates US$ 20 millionxxxiv could be saved during each storm, if present coastal infrastructure were protected and if all future coastal infrastructure were properly designed and located for climate resilience. Assuming one such storm every two years over the next 50 years (based on current MMS data), then US$ 0.5 billion in infrastructure repair costs could be precluded with appropriate climate resilient coastal infrastructure.18 This is a benefit to all Mauritians, who use the coastal infrastructure, and allows re-direction of these funds to investments and services with a higher return.

### 3.2.3.5 Population Exposed to Storm Surges and Coastal Flooding

The surge risk modeling for Baie du Tombeauxxxv and the surge event in May 2007 in Riviere des Galets[xxxvi] were used to determine a typical surge-flooded area for a sustained one-metre surge in areas that are vulnerable (assumed to be, on average, 0.25 km2 at each surge-prone site). When overlain with the population density data, and assuming standard building occupancy patterns, it can be assumed that over 3,400 people in about 1,100 buildings (houses, businesses, public buildings) are currently at risk from storm surges (this number will increase over time, due to natural population growth). These people have suffered (and will possibly again in the future) the consequences of surge flooding, including: loss of goods due to seawater contamination; fear and anxiety during storms; inhibition of investment in local communities; disruption of livelihoods; damage to buildings; and potential risk of loss of life. For these people, the alternatives include relocation, which is both expensive and logistically challenging, or developing the necessary coastal protection structures, which together with the early warning system, would allow these communities to continue to live in proximity to their livelihoods, with a sense of security.

## 3.2.4 Energy Sector

This section provides an overview of the trends in emissions of greenhouse gases (GHGs) in Mauritius. It provides sector specific analysis of GHG emissions that paves the way for sector prioritization for the TNA project in Mauritius. It is pointed out that the categorization of 'sectors' is aligned with the methodology used by the national statistics office. GHG emission data is published on a yearly basis for the 'sectors'.

### 3.2.4.1 Introduction

Energy is a meta-technology and is central to all human activities. Typically, there is a positive relationship between the amount of energy used, standard of living and economic output of a society. When countries rely on fossil fuels to meet their energy needs, the positive relationship between energy use and economic activity translates directly in emissions of GHGs. A recent study looking at any correlations between CO2 emissions and economic growth in Mauritius has failed to validate the EKC hypothesis, which, if present, would have implied a decrease in GHG emissions at higher economic output.xxxviiFigure 3 shows the increasing dependence of Mauritius on imported fossil fuels (solid triangles), as well as the general decrease in the energy intensity of the economy except for the marginal increase in 2010 (solid circles). The following discussions will show that absolute emissions have increased despite the relative increase in the energy efficiency of generating a unit of economic output.

[18]The calculations have assumed 2010 constant repair costs and constant risks over 50-year period.

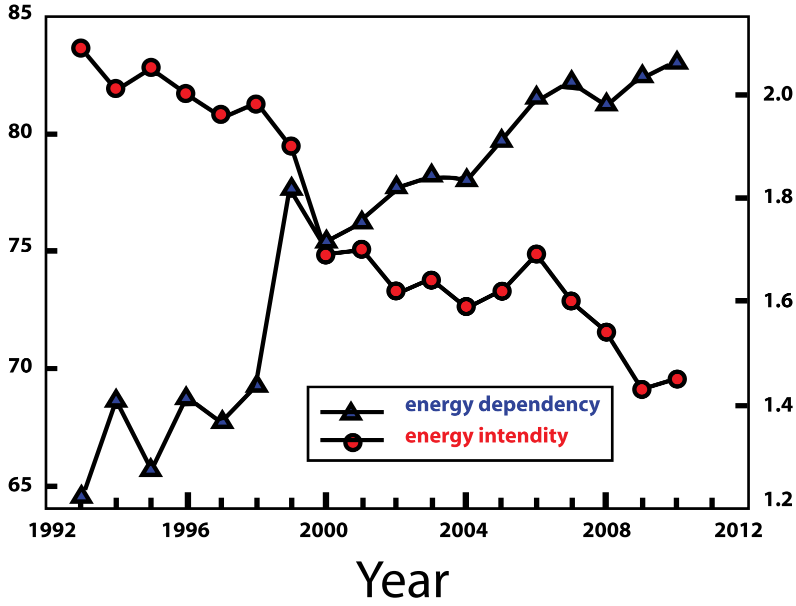


Figure 3. Import dependency and energy intensity of Mauritius, 1994-2010 (Source: CSO, Digest of Energy and Water statistics – 2003 and 2009, Energy and Water Statistics – 2010, [xviii]).

The increasing energy dependency comes at an expense with surging prices and price volatility of imported fossil fuels, and the growing concern for energy security. These concerns provide the motivation for Mauritius to invest more in ESTs, including supply and demand side energy efficiency and renewable energy resources. In addition to enhancing energy security and reducing GHG emissions, investment in mitigation technologies provides prospects for job creation.[19]

Table 6 shows the breakdown of primary energy consumption by sector. Several observations can be made:

1. The share of energy use has shifted away from Manufacturing towards Transport, Household and Commercial & Distributive Trade. This reflects the gradual shift from a manufacturing towards a service-based economy;
2. The Transport sector accounts for close to 50% of final energy consumption, implying its significant role on energy security and energy bills; and 3. The share of energy consumed by the agriculture sector has been constant, which may reveal its maturity and stagnant investment in the primary sector of the economy.

[19] Renewable energy resources should also provide net social benefits arising from generation of employment and health improvements from abatement of air pollution. The prospects for the existing energy sector to generate employment are limited. In fact, the study by Halsnaes, Markandya and Taylor (2002) [Climate Change & Sustainable Development – Prospects for Developing Countries, Eds. Anil Markandya and Kirsten Halsnaes (Earthscan, London, 2002)] has shown that rationalisation of electricity generation from bagasse (i.e. co-generation using bagasse and coal) in Mauritius is expected to result in job losses. Investment in wind energy and photovoltaics can be expected to generate new jobs and also an industry based around infrastructure support; The benefits and constraints, as well as the policies, for using renewable energy to achieve sustainable development in Small Island Developing States has been outlined in Energy as a Tool for Sustainable Development for Africa, Caribbean and Pacific Countries, Ed. Ugo Farinelli (United Nations Publications, 1999).

Table 6. Percentage share of final energy consumption by sector, 1994-2010.

| Sector | 1994 | 1998 | 2002 | 2004 | 2008 | 2010 |
|---|---|---|---|---|---|---|
| Manufacturing | 41.7 | 40.6 | 32.6 | 30.9 | 29.4 | 27.7 |
| No bagasse | 16.2 | 18.9 | 23.3 | 21.0 | 24.9 | 22.6 |
| bagasse | 25.5 | 21.7 | 9.3 | 9.9 | 4.6 | 5 |
| Transport | 41.9 | 42.0 | 47.6 | 48.8 | 48.3 | 49.3 |
| Household | 12.2 | 12.2 | 13.4 | 13.2 | 13.1 | 13.8 |
| Commercial & Distributive Trade | 3.5 | 4.4 | 5.5 | 6.1 | 8.2 | 8.3 |
| Agriculture | 0.5 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 |
| Other & losses | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 |

Source: CSO, Digest of Energy and Water Statistics 2003; Energy and Water Statistics – 2009 & 2010 [xviii].

#### 3.2.4.2 Trends in GHG Emissions in Mauritius

The emission of the three main Kyoto GHGs is shown in Table 7 for 2010.xxxviiiAfter taking the global warming potential (GWP) of the gases into consideration, the total emission was 4718.5 ktCO2e in 2010. Carbon dioxide (CO2) was the main contributor to total emissions at 75.9%, followed by methane (CH4) and nitrous oxide (N2O) with 17.5% and 6.6%, respectively. This high level analysis shows that the most significant leverage for reducing GHG emissions is by addressing the drivers of $CO_2$ emissions.

Table 7. Total emissions of CO2, CH4 and N2O in 2010.

| GHG | Emission (1000 t) | GWP | CO2e (1000 t) | % |
|---|---|---|---|---|
| CO2 | 3583.2 | 1 | 3583.2 | 75.9 |
| CH4 | 39.3 | 21 | 825.3 | 17.5 |
| N2O | 1 | 310 | 310 | 6.6 |
| | | | 4718.5 | 100.0 |

Source: CSO, Environment Statistics – 2010 [xxxviii].

The historical trend in $CO_2$ emission is shown in Figure 4. The bar charts shown in red depict the projected $CO_2$ emissions under the 'business-as-usual' scenario until 2020, and the data are taken from the Initial National Communication under the UNFCCC.[xxxix] The solid line serves only to guide the eyes to follow the projected trend in emissions. The black bar charts show the measured quantities of $CO_2$ emitted. Although the projections were made more than a decade ago, the measured data agree very well with the projected values of $CO_2$ emissions. The bar charts in white demonstrate the relatively unchanging $CO_2$ sequestration by sinks. The lower-than-expected emission in 2009 corroborates very well with a global dip in $CO_2$ emissions due to the global financial crisis. The increase in 2010 shows a recovery in economic activity but is still less than the projected emission.

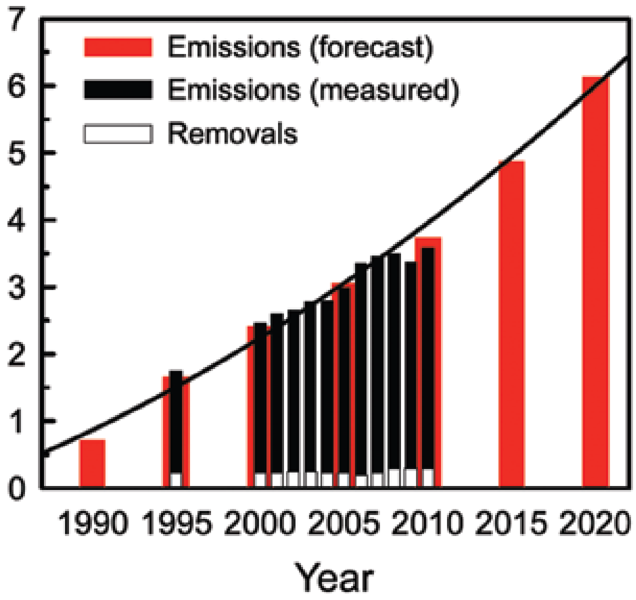


Figure 4. Projected (red) and measured (black) emissions of carbon dioxide (Sources: CSO, Energy and Water Statistics (annual indicators); Initial National Communication under the UNFCC, 1999).

### 3.2.4.3Sectoral breakdown of CO2 emissions

In order to identify mitigation priority sectors for the TNA process, it is important to first investigate the sectoral emissions of the main GHG, namely $CO_2$, in Mauritius. Table 8 summarises $CO_2$ emissions in five sectors for the past 3 years both in absolute terms and as percentages. The largest source of $CO_2$ emissions is from the burning of fossil fuels to produce electricity – i.e. Energy Industries. This sector accounts for around 60% of national $CO_2$ emissions. The Transport sector is the second largest emitter and accounts for around 25% of $CO_2$ emissions. It is worth noting here that the total emission from the Transport sector is not the largest despite it representing the largest sector in terms of final energy consumption (see Table 1). Stationary combustion of fossil fuels (mainly LPG) for thermal energy needs places the Manufacturing sector as the third largest emitter with around 10% of total $CO_2$ emissions. The Residential sector accounts for roughly 4% of total $CO_2$ emissions, which arises from the combustion of mainly liquefied petroleum gas (LPG) and fuel wood for thermal needs, such as cooking and heating water.

Table 8. Sectoral CO2 emissions from fuel combustion activities, Republic of Mauritius, 2008-2010.

| Sector | 2008 Quantity (1000 t) | % | 2009 Quantity (1000 t) | % | 2010[1] Quantity (1000 t) | % |
|---|---|---|---|---|---|---|
| Energy industries (electricity) | 2,032.0 | 58.3 | 1,997.0 | 59.3 | 2,158.3 | 60.3 |
| Manufacturing industries | 456.0 | 13.1 | 351.6 | 10.4 | 360.4 | 10.1 |
| Transport | 813.0 | 23.3 | 844.8 | 25.1 | 887.0 | 24.8 |
| Residential | 131.0 | 3.8 | 122.8 | 3.6 | 135.6 | 3.8 |
| Other (incl. Agriculture and Trade) | 53.8 | 1.5 | 49.1 | 1.5 | 39.7 | 1.1 |
| Total | 3485.8 | 100.0 | 3,365.3 | 100.0 | 3,581.0 | 100.0 |

Source: CSO, Environment Statistics – 2010 (with corrections made to sectoral % emissions for 2008 and 2009 by the author).

[1] Provisional.

### 3.2.4.4 Energy industries (power sector)

The generation of electricity has grown by 4-5% annually over the past decade in order to match demand (see Figure 5), reaching 2,687.7 GWh in 2010. Thermal energy currently generates 96.2% of this electricity and primary sources like hydro and wind the remaining 3.8%.

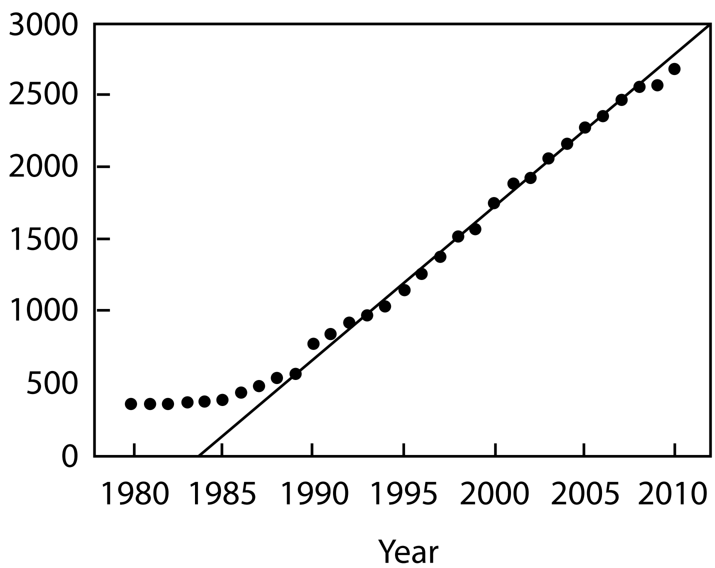


Figure 5. Electricity generation in Mauritius, 1980-2010 (Source: CSO – Digest of Energy and Water Statistics – various, Energy and Water Statistics – 2009 and 2010).

In 2010, bagasse, a renewable source of biomass obtained after sugar cane is crushed to extract its juice, accounted for 20.5% of total electricity generation (and 21.3% of all thermal generation). Fossil fuels, such as coal (38.7%), and diesel & heavy fuel oil (36.3%), accounted for 75% of electricity generation. The combination of hydro and bagasse meant that the share of renewable energy in the electricity mix of Mauritius (island) was 24.3% in 2010. The renewable component of the electricity mix is vulnerable to the impacts of climate variability, especially during periods of drought when reduced precipitation has adverse impacts on hydroelectric generation, as well as reducing the yield of sugar cane, and hence, bagasse. In such circumstances, demand for electricity is met by adding more fossil fuels in the electricity mix.

Public and private generation of electricity

Electricity is produced both by CEB and IPPs. In 2010, the CEB and IPPs generated 44.9% and 55.1%, respectively, of all electricity on the island of Mauritius. In fact, IPPs have generated more than 50% of total electricity needs of the country since 2007. This breakdown shows the prominent role of both the public utility and private producers in addressing emission reductions in the power sector.

Final electricity consumption

Since the generation of electricity is the main source of $CO_2$ emissions, a better understanding of the end uses of electricity can assist in identifying mitigation technologies for demand-side management. Figure 6 shows the breakdown in final electricity use in 2010. Three activities – domestic, commercial and industrial – account for over 98% of electricity use, and each activity uses approximately one third of total electricity. In terms of identifying mitigation technologies in the power sector, it would then be worthwhile investigating the potential of demand-side management in these three sectors.

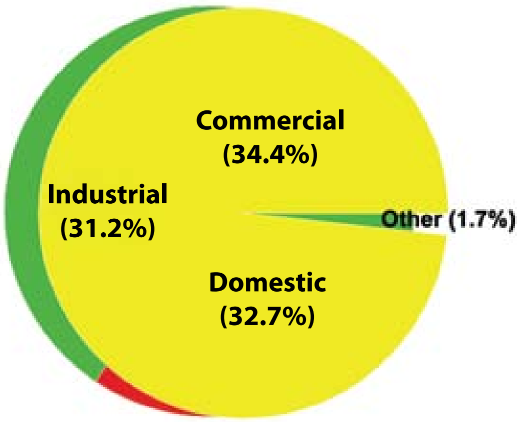


Figure 6. Breakdown of final electricity use, 2010 (Source: CSO, Energy and Water Statistics – 2010).

### 3.2.4.5 Transport

As shown in Table 8, the Transport sector is the second largest emitter of $CO_2$ at around 25% of total emissions. This sector is virtually completely dominated by the use of imported fossil fuels, and it accounts for close to 50% of final energy consumption. Land transportation and civil aviation are the two major end uses of transport. In 2010, some 418 ktoe of energy were used for transportation, representing an increase of 6.9% over the previous year's figure of 391 ktoe. Comparing year-on-year changes (i.e. from 2009 to 2010), it is noted that the consumption of gasolene increased from 121 ktoe to 128 ktoe (+5.8%) and that of diesel oil from 155 ktoe to 162 ktoe (+4.5%). Consumption of aviation fuel increased from 111 ktoe in 2009 to 123 ktoe in 2010 (+10.8%), while the use of LPG in the transport sector remained stagnant at 5 ktoe.

Mitigation initiatives in the transport sector

While noting that Mauritius does not have a large leverage in implementing emission reduction projects of significance in the civil aviation sector,[20] this section will focus on land transportation. There are several ongoing measures and investment of resources in the land transport sector, and the main ones are listed The below based on the typology of mitigation technologies provided in the TNA Guidebook on the Transport Sector:[xl,21]

- Measures to encourage public transport: Mass rapid transit (and land use planning to support such an initiative); free travel to students/senior citizens in public transport; introduction of end-to-end services to avoid interchanges; and public transport services accessing the city centre to provide a door-to-door service;

- Renewable fuel technologies: Several studies have been carried out to investigate the feasibility of both biodiesel and bioethanol as a substitute for fossil fuels. There are also tested and proven uses of waste vegetable oil and coconut oil as direct substitutes for diesel oil in land transportation;

- Private vehicle demand management: Some examples include behavioural change awareness programmes (e.g. benefits of car-pooling, and use of public transport), control on public and private parking, government proposal to introduce toll or road pricing charges, and vehicle registration charges that favour smaller and alternative cars (e.g. road taxation);

- Reducing the need for travel: Land use planning allows mixed development zones, one benefit of which is expected to be to reduce the need for travel;

- Improving private vehicle operating standards: There are various policy areas that directly or indirectly aim to reduce GHG emissions from private vehicles: (i) carbon emission tax to favour most fuel efficient vehicles; (ii) standards for vehicle emissions; (iii) standards on fuel quality; (iv) driver or owner education; and (v) government proposal to privatize vehicle examination for enhancing vehicle emission control and roadworthiness;

- Traffic management: For instance, traffic 'calming' measures such as mixed use of speed limits, pedestrian crossings, traffic control at intersections, and speed breakers

20 The International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) have taken a resolution to transform the civil aviation and sea transportation carbon-free by 2050. It is pointed out that air transportation has already binding emission reduction targets in the EU, and that this sector was recently included in Phase 2 of the EU Emission Trading Scheme (EU ETS). This will have an impact on our local carrier, which already practices an initiative of planting one endemic, in collaboration with the Mauritian Wildlife Foundation, for each take-off. Several commercial airlines already offer carbon-offset schemes to passengers on a voluntary basis, but all these initiatives remain marginal.

## 3.3 Process and criteria of prioritization

The process of sector prioritization followed the MSP discussed in section 2.2. Although a consensual approach was used, by first having formal approval of the National TNA Committee and then broader validation at the national TNA Inception Workshop, the sector prioritization process was carried out by taking into consideration constraints and the national context that are illustrated by the following criteria:

- Because of funding and time constraints, the TNA project would cover 4 sectors (adaptation and mitigation) in total;

- The beneficiary country has the flexibilityto choose the number of mitigation and adaptation sectors – i.e. need not be 50%/50%, and the final choice should be on analysis of inherent vulnerabilities and resilience to climate impacts and relative share in terms of GHG emissions;

- While noting that addressing climate change is permeated by a nationally-determined political process, it would be best to choose sectors that have political support;

- A sector should necessarily not be one that is already receiving much attention as far as climate change is concerned;

The remaining two constraints are necessary but not sufficient conditions for the identification of priority sectors and are further discussed below.

- Sectors for adaptation should be those that are most vulnerable to the impacts of climate change; and

- Sectors for mitigation should be those that account for most of the national GHG emissions.

21 Some of the examples were provided by the Road Transport Commissioner, National Transport Authority – 14 June 2012.

### 3.3.1 Selection of priority sectors

Based on the abovesectoral analysis, and the criteria for prioritization, four priority sectors had been retained for adaptation, and one sector retained for mitigation. These sectors are revealed by the sectoral MSP described in section 2.2. Since an adaptation expert could not be found to work on the fisheries sector, and in order to avoid further delays in TNA project implementation, this sector was dropped. Consequently, the priority adaptation and mitigation sectors retained for Mauritius are:

1. Priority adaptation sectors: Water; Agriculture; and Coastal Zone.

2. Priority mitigation sector:EnergyIndustries.

For both adaptation and mitigation sectors, the sectoral political support has been one of the key deciding factor, as well as the last two criteria given in section 3.2. For adaptation, the three priority sectors are also the same ones that had been identified by the Africa Adaptation Programme as key to enhancing the resilience of Mauritius in line with the sectoral overviews discussed in section 3.1. A recent qualitative assessment of the vulnerability to climate change in Mauritius also identified the same key sectors.xli

Since the inception of the Maurice Ile Durable (MID) project, transforming the power sector towards renewable energies and energy efficiency has featured prominently in national debates and has been high on the political agenda. This has been further revealed at the recent broad multi-stakeholder meetings that have revolved around the Energy Sector in order to formulate a coherent MID policy and strategy.

Consequently, it is investment in these sectors where the TNA project can play the biggest catalyst role, and in which the best return on investment can be expected in a relatively short time (say within the next 5 years).

## 3.4 Current status of technologies in the selected sectors

This section looks at the current status of technologies in the four priority sectors.

### 3.4.1 Water sector

Examples of adaptation strategies in the water sector are provided in the IPCC Summary for Policy Makers: expanded rainwater harvesting; water storage and conservation techniques; water re-use; desalination; efficiency in water-use; and efficiency in irrigation (see [iv]).Desalination and re-use of secondary treated water are already adopted in Mauritius in the hotel and agriculture sectors, respectively.[22]

In order to adapt to the impacts of climate change, the following strategies are ongoing and or planned:[xlii]

1) Increase in surface water storage capacity through the construction of two new dams and increase in the storage capacity of existing ones;

2) Incorporation of climate variability into water management;

3) Quantitative projections of changes in rainfall, river flows and groundwater levels and systematic monitoring of water resources systems and coastal aquifers;

4) Protection of common recharge zones of aquifers and rivers as a priority through appropriate land use management strategies including legal aspect;

5) Water recycling rationalization of grey water;

6) Recharge of artificial groundwater;

7) Control of sea water intrusion through groundwater licensing; and

8) Desalination especially for Rodrigues which is water-scarce, despite the relatively high investment cost.

A WaterMaster Plan Study for the development of water resources is being drawn up. This will take into consideration impact studies of climate change on the sector.

### 3.4.2 Agriculture sector

TheBlueprint for a Sustainable Diversified Agri-food Strategy for Mauritius, 2008-2015xliiiaddresses the food security through improving self-sufficiency status of a number of strategic crops in the short to medium term. It aims at reducing the gap between local food production and consumption and the dependency on imported food through investment in the following priority areas such as modern production techniques, sustainable land management and water conservation, quality improvement, integrated pest management, irrigation facilities and meat and milk production.

A Food Security Fund[23](policy instrument)has been set up to increase the resilience of Mauritius towards food self-sufficiency and to face subsequent global food and feed crisis by increasing production of foodstuff locally and at the regional level by partnering with neighboring countries. The strategy and policy instrument were not designed to address the climate change-Agriculture nexus directly. Nevertheless, they cover several'no regrets'24 measures such as regional diversification of food production that will reduce vulnerability to the adverse effects of climate change, and hence increase climate resilience of this sector. Further, the Fund also provides for promoting local seed production to improve seed security, fodder production, livestock genetic improvement , research and development to develop improved crop varieties, training in agro-processing value addition, meat and milk production and other adaptation measures such as the Food Crop Insurance Scheme, Post harvest treatment and storage facilities and Sheltered Farming.The Fund also makes provision to modernize irrigation schemes for small planters.

Being aware of the impact of climate change, variability and climate extremes, a number of adaptation technologies have already been identified and proposed to assist farmers to cope with the challenge of climate change (and climate variability) and increase the resilience of the sector. These are summarized in Table 9. The options have been implemented to varying degrees and levels of success, but their systematic application has been lacking.

Table 9. Adaptation measures proposed for agriculture in national documents.

| National documents | Proposed adaptation options |
|---|---|
| First Technology Need Report | - Increasing water use efficiency through more performing Assessment irrigation systems; |
| (2004)xliv | - Trash blanketing / green cane harvesting (sugar cane)<br>- Changing harvest period;<br>- Land use change (shifting areas);<br>- Crop change - Adopting drought tolerant cultivars<br>- Introduction of more performing cultivars<br>- Integrated Pest management<br>- Rational use of fertilizers and herbicides |
| Second National Communication (2010)[xlv] | - Introduction of new varieties or cultivars;<br>- Shifting crop production zone.<br>- Increasing irrigation water requirement<br>- Sustainable land/ soil management of land/soil<br>- Promoting conservation and sustainable agricultural practices;<br>- Combating land degradation;<br>- Biotechnologies to improve water-use efficiency of crops or plant more resistant crop varieties;<br>- Provide farmers with Insurance and security for their investments;<br>- Application of new and sustainable technologies, e.g. protected cultivation; and<br>- Establishment of an early warning system for pest and disease management. |

23 Please see http://www.gov.mu/portal/goc/moa/file/straplan.pdf - accessed 18 May 2005.
24 Defined as adaptation options (or measures) that would be justified under all plausible future scenarios, including the absence of manmade climate change.

### 3.4.3 Coastal zones

A study for the Development of an Integrated Coastal Zone Management (ICZM) Framework has been completed with the objectives of: [xlvi]

1. Developing an ICZM Strategy for Mauritius;
2. Reviewing and Preparing a National Policy and Comprehensive Legislative Framework; and
3. Preparing ICZM Area Plans for Pressure Zones in Mauritius.

The implementation of the ICZM Strategy is currently under way, and it is pointed out that the adoption of climate change adaptation technologies for addressing coastal erosion and flooding should be done within the ICZM context in order to maximize the likelihood of their success.

Several technologies have been implemented in Mauritius with varying successes to deal with the issue of coastal erosion. They include the use of break waters, groynes, increasing the setback, removal of hard structures below the high water mark, enhancing coastal vegetation, and the creation of artificial beaches. The systematic study of the status of these technologies has not been undertaken. Nevertheless, several of these technologies have been retained for MCA analysis. A more detailed discussion of coastal adaptation options is given in section 6.1. Further, Annex 7 and TFS summarize the status of many technologies in Mauritius.

### 3.4.4 Energy industries (power sector)

Two parallel tracks were used to gauge the current status of technologies in the power sector. The first track consisted of a survey carried out with CEB and an IPP before the IW, and the results are summarised in Table 10.

Table 10. Current status of mitigation technologies and enabling conditions.

Table 10. Current status of mitigation technologies and enabling conditions.

| Index | Technologies in the Pipeline (including | Status of technology implementation | Supporting technologies/enabling frameworks would be required to facilitate being implemented) the pipeline technology identified |
|---|---|---|---|
| 1 | Wind farms<br>• 10-30 MW at Plaine Sophie<br><br>• 22 MW Britannia (Omnicane) | • Proposal made one bidde.<br><br>• Britannia- Wind Measurement in progress, and request submitted to CEB for consideration | • Utility regulatory Authority<br>• Differential feed-in-tariff (part financing from MID/Govt)<br>• Standardised Energy Purchasing Agreement<br>• Extending the geographical spread of wind energy resource measurements over the territory to gauge the further potential of wind energy in Mauritius (may be offshore wind measurement)<br>• Mapping the stability of the national grid to know the maximum input of wind energy<br>• Mitigation measures for wind turbines interference with communication bodies |
| 2 | SSDG (3MW total – wind; PV; hydro) | • Permits have been granted for 1.8 MW by CEB<br>• Implementation, monitoring and evaluation of pilot phase before deploying a second phase in second half of next year | The result of the grid assessment from the first phase shall govern the SSDG capacity addition for the second phase. |
| 3 | PV Farm (1-10 MW) | • Closing date for bids is 29 August 2012 | Power system study to determine maximum amount PV grid connected systems that can be added to CEB's network.<br>• Differential feed-in-tariff (part financing from MID/Govt)<br>• Standardised Purchasing Power Agreement<br>• Establish a solar map of Mauritius |

| | | | |
|---|---|---|---|
| 4 | Carbon burn-out unit able to reduce the carbon content of the fly ash and bottom ash of spreader stoker boiler to less than 5% | • Feasibility study being completed<br>• Ready to order the boiler to Indian supplier | • Homologation by the Mauritian standard office of the fly ash and bed ash as an additive of cement and sand material in order to use them in the construction in Mauritius |
| 5 | New and habilitation of the existing Minihydro<br>• Midlands Dam (350 kW)<br>• Britannia (50 kW)<br>• Riche en Eau (150KW)<br>• Bois Cheri (100 KW)<br>• Saint Felix (50 kW) | • Implementation of the Midlands Dam hydro project will be completed in September 2012<br>• Britannia in operation to supply the garage | • Possibility to sell the excess to the CEB as SSDG to get the return on investment |
| 6 | Mare Chicose Landfill Gas to Energy (3 MW) | • Implementation of the Midlands Dam hydro project will be completed in September 2012<br>• Britannia in operation to supply the garage | • Possibility to sell the excess to the CEB as SSDG to get the return on investment |
| 7 | Combustion trial of bio-pellets in OTEO Saint Aubin | Combustion trial of bio-pellets in OTEO Saint Aubin | • Production of 2000 t of pellets with cardboard, food, used oil, and other biomass |
| 8 | Liquefied Natural Gas (LNG) for electricity generation | Liquefied Natural Gas (LNG) for electricity generation | |

During the IW, a detailed analysis of baseline technologies was carried out. The starting point was the mitigation technologies listed in Annex 7 of the TNA Handbook.xlviiSixty (60) technologies were reviewed. This list is shown at Annex 9, including a brief description of the status and applicability of the technology in Mauritius.

## 4. Technology prioritization for water sector

### 4.1 Possible adaptation technology options in watersectorand their benefits

The potential adaptation technology options in the water sector were identified during a brainstorming session at the IW. The list emanating from the IW is given at Annex 4(a). Following feedback during subsequent working group meetings a short-list of potential technologies (see Table 11) that could be considered in the process of adaptation to climate change was prepared. The first column categorizes the type of technology according to the typology used in the TNA Guidebook for the water sectorxlviii, while the second column gives the current technology requirements for Mauritius following consultations with stakeholders. The third column makes a comparison of the current propositions with the technology options proposed in the first TNA report of 2004. The short-listed technologies are given in the last column.

Table 11. Short-list of adaptation technologies retained for the water sector.

| | IPCC(2007) [iv]/ UNEP/RISOE(2011) | Technology Needs Gap Analysis<br>Working Group on Water<br>IW Sep 2011 | TNA (2004) – Mauritius [xliii] | Technology Retained under the TNA study |
|---|---|---|---|---|
| 1 | Efficiency in Water-Use | • Sustained sensitization campaigns on water saving at all level whole year round (software) | | Sensitisation Campaigns At National Level |
| | | • Promote use of water efficient fixtures, | | Water Efficient Fixtures |
| | | devices/appliances | | |
| 2 | Desalination by Reverse Osmosis in Coastal Hotels | • Rain water harvesting at household level/ industrial level | | Rainwater Harvesting – Rooftop |
| | | • Desalination of sea water at level of hotels (e.g. reverse osmosis)<br>• Desalination plant – much larger scaled for several hotels | | Desalination by Reverse Osmosis in Coastal Hotels |
| 3 | Water Reuse | • Tertiary wastewater treatment for industrial purpose | | Post tertiary treated – reuse of treated wastewater for food crops |
| 4 | Water storage and conservation techniques | • Create artificial ground water recharge (e.g. grass-crete) | | Stormwater – Grass Crete |
| | | • Close monitoring of water systems and aquifers | | Telemetry System |
| | | • Integrated surfacegroundwater models | | Hydrological Models |
| | | • Reduction of losses at Reservoir level | | Rehabilitation of Feeder Canals |

## 4.2 Criteria and process of technology prioritization

A pre-screening step was not judged necessary since 9 potential adaptation technologies were identified by the stakeholders in section 4.1 for subsequent prioritisation using MCA.

Technology Fact Sheets

TFS were prepared for each short-listed technology (Table 11). TFS were used to assist members of the technical working group to score the technologies against indicators during MCA. Theyhighlight the technical aspects of the technology, the capital, the operational and the maintenance cost associated with the implementation of the technology, the benefits that can be obtain should the technology be implemented, and the barriers that are likely to influence the successful implementation of the technology. Bilateral meetings were held with key stakeholders, both from the public and the private sector in order to discuss the status of the technology, its market potential and any Government policy likely to influence the success of the particular technology. Bilateral meetings contributed significantly to getting local information on cost implications associated with the technology. Technical working group meetings were held to finalise and validate the TFS prior to MCA.The TFS for the 3 prioritized adaption technologies in the water sector are included in Annex 4(b).

MCA criteria and indicators

In order to prioritize the adaptation technologies, a set of locally-validated criteria and indicators was selected based on the generic framework proposed by the MCA4Climate projectxlix and expert views on the ease of assessment of each of the criteria and availability of measurable indicators. The criteria and indicators used for MCA for adaptation options in the water sector and the scoring scale for quantifying each indicator are summarized in Table 12. Only criteria which are independent of each other (or mutually exclusive) were retained for compatibility with the linear additive MCA technique used in this project. However, two of the technologies listed in Table 11,namely the Hydrological Models and the Telemetry were analyzed separately becauseseveral locally-validated criteria and indicators could not be applied to thetwo technologies. This was particularly the case forthe indicators‘volume of water saved’ and ‘total average revenue from water saved’. Hence, as will be shown below, the two technologies were treated separately and did not undergo MCA.

| Criteria | Indicators | Scoring Scale | Weight | Sensitivity Analysis |
|---|---|---|---|---|
| Public financing needs | Direct cost. | Cost/m3 produced OR Cost/m3 saved over the life span of the technology | 0.15 | 0.05 |
| Implementation barriers | Ease of implementation. | Likert scale: 1 (lowest) to 10 (highest) | 0.2 | 0.1 |
| Climate-related | Enhance resilience to climate change | m3 of water used/produced | 0.25 | 0.25 |
| Economic | Improvement in economic performance. | Total Average revenue from water saved or soldover the life span of the technology. | 0.1 | 0.05 |
| Environmental | Protect environmental resources | 0: Yes<br>10: No | 0.1 | 0.15 |
| Social | Improve health | Likert scale: 1 (lowest) to 10 (highest) | 0.1 | 0.15 |
| Political and institutional | Improve governance | Likert scale: 1 (lowest) to 10 (highest) | 0.1 | 0.25 |

Scoring Scale: The indicators ease of implementation, social acceptance and improve governance, were analysed on a Likert scale: 1 (lowest) to 10 (highest). The indicator environmental protection was analyzed on the scale: 0 (Harm to the environment) and 10 (Protect environment). The indicator Direct Cost was then rated on a scale of 1 to 10, with the lowest cost being given the highest number. For the indicators, enhance resilience to climate change and improvement in economic performance, the technology providing highest resistance to climate change was assigned a value of 10 and the technology providing highest economic performance was assigned a value of 10. The technology which was most easy to implement was assigned a higher value, the technology offering least social acceptance was assigned a higher value and that which improve governance was assigned a higher value. For the indicator environment protection, only two possibilities were concerned, either this technology would cause harm to the environment, in which case it was assigned value of 0, or it would help to protect the environment, in which case it was assigned a value of 10

Weightage: The next step in the analysis was to define a weightage for each of the 7 analysis criteria (see Table 13). Members of the working group considered that costs, ease of implementation and improve resilience to climate change were three very important factors, and the 7 criteria were assigned weightsbased on this reasoning. MCA was carried out and the weightage was subjected to sensitivity analysis in order to highlight the importance of the weighing factor on the prioritization of the technology. The set of weights used for sensitivity analysis reflects the choice of the working group to balance the social and environment criteria in the analysis.

Combining weights and scores: After the criteria were scaled from 1 to 10, a linear additive model was used to work out the total weighted score of each technology. The score for a given criterion was multiplied by the weightage associated with that particular criterion, to obtain a weighted value. This was repeated for all the nine technologies and the ranking was carried out as per the weighted scale, with the topmost being the technology having the highest score.

### 4.3 Results of technology prioritization

A MCA calculator was customized to prioritize technologies in the Water sector (please see Annex 4(c)). Having ranked the technologies based on the weighted score, the first three technologies prioritized in this exercise are highlightedin Table 13. Members of the working group debated in depth on the outcomes of this exercise. The MCA grouped both tangible issues (costs, revenue) and intangible issues (social acceptance, environmental protection, improve governance), and this exercise had provided further insight into the proposed adaptation technologies. Members of the working group agreed that some of the proposed technologies could not be considered within the TNA framework. The proposal for 'sensitisation programme' was based on the creation of a dedicated unit with 3 staff which would focus on a regular sensitisation programme. It was debated and concluded that the TNA project would not sustain the cost associated with this technology on a long term basis. Also, it was argued that it may be better to have sensitization programmes targeted to individual/ specific technologies.For'rehabilitation of feeder canals', it was noted that necessary actions had already been taken for large projects (as a response to a severe drought of 2010-2011), and that the concerned authority was already looking into the need to implement small feeder canals. In the case of the 'telemetry project', the concerned authority reported that there was a need for a full network and presently the existing similar facilities were not in working conditions and the causes had first to be addressed before investing further. Finally, the proposal for the 'reuse of treated wastewater' was discussed, and it was noted that social acceptance for this technology was very low, and given that there was the government policy for improving water storage facilities, the need to treat wastewater forpotable purposeswas not justified.

| | PROPOSED ADAPTATION TECHNOLOGY | RANK |
|---|---|---|
| 1 | Sensitisation Programme | 1 |
| 2 | Reuse Treated wastewater | 2 |
| 3 | Rehabilitation Feeder Canals | 3 |
| 4 | Desalination | 4 |
| 5 | Stormwater Harvesting | 5 |
| 6 | Rainwater Harvesting | 6 |
| 7 | Water Fixtures & Fittings | 7 |
| 8 | Hydrological Models* | 1 |
| 9 | Telemetry Systems* | 2 |
| *Technologies analyzed separately from the rest (Refer to section 4.2) | | |

Final prioritization exercise

The following four technology options: (1) Sensitisation Programme; (2) Rehabilitation of Feeder Canals, (3) Telemetry Systems, and Reuse of Treated Wastewater were notretained after the first MCA exercise. The MCA proceeded with fivetechnologies; Rainwater harvesting, Stormwater Harvesting, Desalination, Water fixtures and fittings, and Hydrological Models.After the ranking of these five technologies, debates followed on 'stormwater harvesting' and 'water fixtures and fittings'. Members of the working group agreed that the latter was indeed a good proposal and given its benefits, including low cost, that it could be considered under a local programme rather than the TNA. As for 'stormwater harvesting', members of the working group noted that this technology is important in the local context given some 60% of annual rainfall goes off as surface runoff. The implementation of this technology by large commercial project would be challenging, hence it was not considered a priority under the TNA project. The results shown in Annex 4(c) reveal that the 'efficient water fixtures and fittings' and 'stormwater harvesting' ranked 3rd and 4th, respectively, behind 'desalination' and 'rainwater harvesting (rooftop)'.

Results of sensitivity analysis

The ranking of technologies was carried out based on their weighted scores. A sensitivity analysis was carried out using the weights shown in the last column in Table 12.This set of weightsreflects the thinking of the working group that cost and revenue were not priorities for the Water sector. Rather the social acceptance, environment protection and improved governance could be more important factors.Sensitivity analysis did not change the relative rankings of'desalination' and 'rainwater harvesting' as the first two technologies. The 'hydrological model' was considered a priority for the country, and it was therefore retained. Finally the prioritized proposed adaptation technologies were agreed by all members of the working group and the results are summarized in Table 14.

| | PRIORITISED Proposed Adaptation Technology | Comments |
|---|---|---|
| 1 | Desalination | This proposed adaptation technology is about promoting the use of Desalination plants by hotels located close to the coast.<br>Falls within the Government Policy |
| 2 | Rainwater Harvesting | This proposed adaptation technology is based on encouraging each household to have a rain water harvestor for secondary uses.<br>Falls within the recommendations of the Build ing Codes currently being reviewed |
| 3 | Hydrological Model | This proposed adaptation technology is based on the need for improved decision making at the level of water resource management in the country. |

## 5. Technology prioritization in agriculture sector

### 5.1 Possible adaptation technology options in agriculture and their adaptation benefits

Based on the current challenges faced by the agricultural sector with climate events over the past decade and the vulnerability of the sector to predicted climate change, a list of 25possible adaptations technologies were identified to improve the resilience of the agro-ecosystems and the livelihood of farmers through expert views and brainstorming with relevant stakeholders during the sectoral working group session at the IW. Technologies of benefits to small-scale vulnerable foodcrop growers, livestock breeders and to local biodiversity and forest resources were integrated. The technology identification exercise drew from multiple sources and the socio-cultural context, including (1) adaptation technologies proposed in previous national documents;(2) technologies currently in practiceand supported by national agricultural policy; (3) initiativesin the pipeline (e.g. sheltered farming and rainwater harvesting);(4) appropriateness of technologiesin the local context (e.g. fog harvesting, grain storage); and (5)social acceptability (e.g. use of genetically modified organisms), among others.

As per the TNA Guidebook,I the adaptation technologies identified were then regrouped under different categories (or typologies):sustainable water use and management, planning for climate change variability, soil management, sustainable crop management, sustainable livestock management, sustainable farming system, land use management, and capacity building and stakeholders. The classification of adaptation technologies and their status are summarized in Annex 5(a).

### 5.2 Criteria and process of technology prioritization

Two steps were used to arrive at a shortlist of technology options for adaptation in the agriculture sector. The first step consisted of pre-screening most likely implementable adaptation technologies from the long-list of identified technologies.The second step consisted of developing technology factsheet (TFS) for each of the short-listed technologies, and establishing the criteria and indicators for technology prioritization usingMCA.

#### 5.2.1 Prescreening of technologies in agriculture sector

The pre-screening of the technologies involved assessing the technical feasibility and adaptation benefits of each of the 25identified potential adaptation technologies based on the likely future scenarios of climate impacts on Mauritian agriculture, expert knowledge and pre-screening criteria as prescribed in TNA Handbook (see reference I) namely:(i)technical potential of the technology; (ii)contribution to improve adaptation resilience; (iii) costof the technology and (iv)contribution of the technology with national development strategy and policies. The pre-screening was conducted through discussion with a wide group of stakeholders in technical working group meetings, and a short-list of nine most appropriate technologies were retained based on national priorities and knowledge on ease of adoption of technologies in the local context.

#### 5.2.2 Technology Fact Sheets and criteria for MCA

Technology fact sheets (TFS) were produced for each short-listed technology. The TFS contain relevant information on the technical aspects of the technology implementation, including its installation, operation and maintenance, efficiency, cost, and the benefits / opportunities, as well as the barriers for each short-listed adaptation technology. Bilateral meetings werealso held with key stakeholders to discuss themarket potential and status of thetechnologies in Mauritius,and to acquire technical information to estimatethe incremental cost of the adaptation technologies. The TFS for the three prioritized adaptation technologies in agriculture that have been retained for TAP are given at Annex 5(b). TFS for remaining technology options had the same format and similar contents.

In order to prioritize the adaptation technologies, a set of locally-validated criteria and indicators was selected based on the generic framework proposed by the MCA4Climate project [xlviii] and expert views on the ease of assessment of each of the criteria and availability of measurable indicators. The criteria and indicators used for MCA for adaptation options in the agriculture sector and the scoring scale for quantifying each indicator are summarized in Table 15. Only criteria which areindependent of each other (or mutually exclusive)were retained for compatibility with the linear additive MCA technique used in this project.Climate-related criterion such as GHG reduction was found to be irrelevant, and economic criterion such as job creation was found to be difficult to calculate.

Table 15. Criteria and indicators for MCA for prioritization of adaptation technologies in agriculture sector.

| Criteria | | Indicators | Scoring Scale |
|---|---|---|---|
| Institutional/ implementation barrier | 1 | Ease of implementation | 1 - Very difficult<br>2 - Difficult<br>3 - Moderately difficult<br>4 - Easy<br>5 - Very easy |
| | 2 | Use and maintenance /replicability | 1 - Very difficult<br>2 - Difficult<br>3 - Moderately difficult<br>4 - Easy<br>5 - Very easy |
| Public financing needs Economic | 3 | Cost to set up and operate the technology (resources, skills, infrastructure..) | Additional cost of per beneficiary /yea (Rs) |
| | 4 | Catalyzing private investment | 1 - Very low<br>2 - Low<br>3 - Medium<br>4 - High<br>5 - Very high |
| | 5 | Improving farmer income and ability to reinvest | 1 - Very low<br>2 - Low<br>3 - Medium<br>4 - High<br>5 - Very high |
| Environmental | 6 | Contribution of the technology to protect and sustain ecosystem services | 1 - Very low<br>2 - Low<br>3 - Medium<br>4 - High<br>5 - Very high |
| Climate-related | 7 | Enhancing resilience against climate change (i.e. to what extent the technology will contribute to reduce vulnerability to climate change impacts) | 1 - Very difficult<br>2 - Difficult<br>3 - Moderately difficult<br>4 - Easy<br>5 - Very easy |
| Social | 8 | Contribution to social and sustainable development (benefit to society) | 1 - Very low<br>2 - Low<br>3 - Medium<br>4 - High<br>5 - Very high |
| Political | 9 | Coherence with national development policies and priority | 1 - Very low<br>2 - Low<br>3 - Medium<br>4 - High<br>5 - Very high |

## 5.3 Results of technology prioritization

The TFS were circulated to allmembers of the technical working group for familiarization with the technology options prior to the MCA prioritization exercise,which involved scoring, weighting, and sensitivity analysis. The MCA calculator used for technology prioritization in agriculture is shown at Annex 5(c). The calculator also contains the methodologies and calculations used to estimate the incremental cost of adaptation technologies.

Scoring: A performance score card in which each row describes a technology option and each column describes the performance score of the options against each criteria was developed and filled following thoroughly discussion with technical working team during 2 MCA working sessions. The assumptions made and methodology used to work out the public financing needs (cost to set up and operate the technology) was discussed and agreed was cost per beneficiary per year. The cost was then standardized between 1 (most costly) and 5 (least costly). For the other criteria, technology options were scored on a Likert scale anchored at 1 (lowest score) and 5 (highest score) based on the expected merits of the technology.

Weighting: Expert judgements were sought from members of the agriculture technical working group to assign a numerical weight (between 0 and 1) to each indicator to reflect their relative importance in the decision-making process. The cumulative sum of weights across all indicators was equal to 1. In order to minimize bias, weights were assigned to indicators prior to scoring the technologies.

Combining weights and scores: The linear additive model was used to derive the total weighted score of each
technology option. This was done for a technology by multiplying its score for each criterion by the corresponding weight of that criterion,and then adding the weighted scores to give the total weighted score for this technology. The9 adaptation technologies were then ranked according tooverall preference. The option scoring the highest total weighted score was rank as the most preferred options, whereas the one with the lowest score was ranked as the least preferred option.

Sensitivity Analysis:The results of the MCA exercise were carefully examined by members of the technical working group to see if the ranks were logical. Firstly, it was ensured that the scores given to different criteria were consistent and reflective of the technological merits. The scope of the technology options was rediscussed and fruit bat control was then included as one of the proven IPM technology to be up-scaled due to the extensive damage they cause.

In order to investigate the sensitivity of technology ranking on allocated weights, the weight assigned to each criterion was reassessedby taking into consideration any uncertainty and conflicting objectives of multiple stakeholders. Hence, the ranking of adaptation technologies was carried out for different sets (or cohorts) of weights as shown in the MCA calculator for agriculture (see Annex 5(c)).The overall ranking of the adaptation options was finally agreed by all stakeholders and technical expert based on the sensitivity analysis. The results are summarized in Table 16.

| Ranking order of priority | Adaptation technologies for the agriculture sector |
|---|---|
| 1 | Reforestation of the water catchment area of the main Reservoirs of Mauritius |
| 2 | Up-scaling of locally proven IPM technologies for control of pest of economic importance |
| 3 | Micro irrigation (gravity fed drip & mini and micro sprinkler irrigation) |
| 4 | Decentralised rapid pest and disease diagnosis service (plant clinic) |
| 5 | Reinforce breeding and conservation programme for crop adapted to change in climate |
| 6 | Education and awareness raising among farming community to promote adaptation to climate change |
| 7 | Low cost postharvest technology (crates and evaporative cooling chambers) |
| 8 | Improving Agro-meteorology Information network for forecasting and Early Warning System |
| 9 | Index based weather disaster subsidized agricultural insurance scheme for food crop |

Though reforestation of the water catchment area of the main reservoirs of Mauritius was identified as the highest priority, it was not considered among the first three prioritised technology options retained for the preparation of TAP. This was decided following discussions with relevant stakeholders, and on the basis that funding has already been earmarked for watershed management, including reforestation of water catchment areas,25 at the national level. Consequently, the 3 prioritised adaptation technologies that are retainedfor TAP are:

1. Up-scaling of locally proven IPM technologies for control of pest of economic importance: to minimise on use of chemical pesticides and reduce risk of damage by pest and diseases;
2. Micro irrigation (gravity fed drip & mini and micro sprinkler irrigation): to optimise use of irrigation water, improve on crop productivity and reduce risk of crop damage by drought among small scale farmers; and
3. Decentralised rapid pest and disease diagnosis service (plant clinic): to provide a rapid and reliable pest and diagnosis service to enhance farmers' ability for damage due to pest and disease and thus improve productivity and quality.

Please note that the TFS for these technologies can be found at Annex 5(b).

## 6. Technology prioritization for coastal zones

### 6.1 Possible adaptation technology options in coastal zones and their adaptation benefits

Several coastal management approaches have been proposed for the island of Mauritius by the Baird Report of 2003.IiThe main benefit accruing from the technology options is to curb beach erosion, as revealed by the following objectives:

1. Determine and assess the extent of coastal erosion at critical sites around the island of Mauritius;
2. Analyse the various causes of coastal erosion;
3. Assess the performance of existing protection works along the beach and suggest remedial measures if any;
4. Propose abatement measures to arrest the erosion problem; and
5. Prepare tender documents for the recommended remedial works.

[25] Information that funding had been allocated for watershed management, including reforestation of water catchment areas, became available after the technology pre-screening step has been carried out. This is an example of the dynamic nature of the technology prioritisation process.

The study found that there were signs and hard evidence for irreversible erosion of the sandy beaches on the island of Mauritius, and which would become widespread if no immediate actions were taken to restore the health and integrity of the reef-lagoon-beach-dune system. It also showed that the impacts of climate change on the reef ecosystems were uncertain, and that negative anthropogenic impacts on the health of lagoons, beaches and dunes were more serious problems to be addressed in the short-term. Although the study did not focus on the climate change impacts on coastal zones, the proposed alternative coastal management approaches (or technologies) are still applicable as adaptation to climate change. These approaches or technologies were classified under three broad categories as follows:

<u>Prevention</u>

- Setbacks (including minimum elevation requirements)
- Relocation

<u>Non-structural</u>

- Shore and beach management (e.g. controlled access, onshore grading, vegetation enhancement, dune enhancement etc ..)

- Beach nourishment

<u>Structural intervention</u>

- Groynes
- Artificial headlands
- Detached breakwaters
- Shoreline armouring (e.g. revetments and sea walls)

It should be noted that physical works to date have not been very effective at reducing beach erosion rates due to inappropriate technical designs. A lessons learned exercise and stock taking has been undertaken in the Baird Report of 2003.

More recently, the Second National Communication (2010) has proposed several adaptation options for the coastal zone, including:lii

a. Management of ESAs and implementation of Integrated Coastal Zone Management Plan

b. Coastal protection and rehabilitation works – consolidation of existing reefs and or building of artificial ones. An example is the placement of break water structures at Rivière des Galets for the protection of the residential zone in the village. Beach protection works at affected beaches, such as at Mon Choisy, Grand Baie, Mon Choisy, Pointe aux Sables, Flic en Flac, Rivière des Galets, Bain Boeuf, Cap Malheureux and Poudre d'Or. The costs of coastal protection works and beach maintenance would undoubtedly become very high. The present estimated cost of construction of 100 m of wavebreaker is of the order of Rs 100 million. For a 3.28°C rise in temperature by the year 2100 under the worst case scenario, the cost for 200 km of coastal protection (wave breaker) would be of the order of Rs 20 billion on top of rising infrastructural maintenance costs;

c. Preparation of detailed inundation maps and monitoring of flood prone areas;

d. Policy review in the Environment sector;

e. Adaptation of public infrastructure on the coastal zone and the Ports Area; and

f. Strengthening of capacities for disaster risk reduction and disaster management.

The applicability of several technologies for adaptation in the coastal zone was investigated at the IW and subsequent meetings of the corresponding sectoral working group. The outcome of the MSP is shown at Annex 6(a). Based on the review process, seven technologies were retained by stakeholders for adaptation in the coastal sector. The short-listed technologies are: (1) beach nourishment; (2) break waters; (3) coastal development setbacks; (4) wetland protection and restoration; (5) dune restorations; (6) restoration of coastal vegetation; and (7) rock revetment.

## 6.2 Criteria and process of technology prioritization

A pre-screening step was not needed since only 7 adaptation technologies were identified by the stakeholders in section 6.1 for subsequent prioritisation using MCA.

At the IW, the working group on coastal zone had the task of identifying the criteria they considered that would be important to carry out technology prioritisation using MCA. The MCA4Climate methodology (see [xlix]) was retained for defining the criteria for MCA, while corresponding indicators were defined by the technical working group. Table 17 lists the criteria, as well as their corresponding indicators. This set of indicators was finalized during post-IW technical working sessions.

Creating a common understanding of the meaning of criteria and indicators

One of the crucial tasks during the finalisation of the MCA criteria and indicators was to ensure that all members had the same understanding of the meanings of the criteria and indicators. This was an important step to be accomplished before scoring the retained technologies against the MCA indicators.

Table 17. Summary of criteria and indicators for prioritizing coastal adaptation technologies.

| Criteria | Indicators | Measurement scale | Weight | Sensitivity Analysis | |
|---|---|---|---|---|---|
| Public Financing needs | Direct incremental costs | Rs/linear m | 0.15 | 0.2 | 0.25 |
| Implementation of barriers | Ease of implementation (e.g. all non-financial barriers) | Likert scale: 0 (highest barrier) – 100 (lowest barrier) | 0.1 | 0.1 | 0.1 |
| Climate - related | Enhance resilience to climate change | Likert scale: 0 (lowest resilience) – 100 (highest resilience) | 0.2 | 0.2 | 0.25 |
| Economic | Job creation / maintenance | Likert scale: 0 (lowest creation) – 100 (highest creation) | 0.1 | 0.05 | 0.1 |
| Environment | Biodiversity conservation | Likert scale: 0 (lowest conservation) – 100 (highest conservation) | 0.15 | 0.1 | 0.1 |
| Social | Social sustainability, SS (e.g. social acceptance, job maintenance, community involvement etc...) | Likert scale: 0 (lowest SS) – 100 (highest SS) | 0.1 | 0.15 | 0.1 |
| Political & institutional | - In line with government policy<br>- Improve institutional capacity | - Binary scale: 0 (yes) or 100 (no)<br>- Likert scale: 0 (lowest improvement) – 100 (highest improvement) | 0.1<br>0.1 | 0.1<br>0.1 | 0<br>0.1 |

Table 17 also gives the unit (for direct incremental cost) and scales for scoring technologies relative to each other for qualitative indicators. The incremental cost of adaptation technologies was calculated from inputs obtained from key stakeholders and from the literature. For qualitative indicators either a Likert (0-100) or binary (0 or 100) scale was used. The methodology and data used to estimate the incremental cost of technologies was reviewed by members of the technical working group. The scoring of technologies on Likert scales was carried out using the expert knowledge of team members.

Allocation of weights and sensitivity analysis

Members of the working group also allocated weights to the different indicators that reflected the group understanding of how the different indicators (and criteria) helped to achieve the objectives of the TNA project. Further, members of the working group also allocated two additional sets of weights that were used in sensitivity analysis. The sensitivity analysis therefore consisted of investigating the relative changes in technology ranking based on relative changes in a combination of: (1) public financing since this criterion could be a significant barrier to technology adoption; (2) social sustainability since members felt that successful technology adoption was highly dependent on community participation; (3) biodiversity conservation that was deemed not to be a direct objective of the TNA project and could be taken to be partially covered by the indicator on enhancing resilience (especially for ecosystem-based adaptation options); (4) job creation which members felt could be less important than community participation. It is pointed out that the assignment of weights was carried out prior to scoring of technologies in order to minimize bias in their allocation; and (5) increasing the contributions public financing and climate-related criteria at the expense of 'in line with government policy'. The relevance of (5) is that all short-listed technologies were supported by government policy.

Sensitivity analysis was also carried out for the incremental cost of rock revetment since data provided by two key institutions differed (Rs40,000/m versus Rs100,000/m)

Technology fact sheets

TFS was developed for each adaptation technology, and information was provided on all aspects of the criteria and indicators given in Table 17. In addition to using their expert knowledge in the field, working group members could also use the TFS when needed. The TFS were validated after members of the working group had been given ample opportunities to provide their comments and suggestions. Bilateral meetings were also held with key institutions before finalizing the TFS. The TFS for the technologies retained for TAP are found at Annex 6(b).

Scoring of technologies against indicators

The members of the technical working group were provided with all the TFS and a MCA calculator customized for the Coastal Zone. The MCA calculator for the Coastal Zone is found at Annex 6(c). The MCA calculator for the Coastal Zone was customized so that only the fields in the Performance Matrix (PM)sheet and weights needed to be changed. During the technology scoring session, only the PM sheet (see MCA calculator for Coastal Zone) was provided to the participants. Hence, they were able to score the technologies without seeing the evolution of the cumulative scores. This was one way to avoid bias in scoring to favour any particular technology. As part of the sensitivity analysis, participants were allowed to review their scores once the final results were known. The scoring was carried out through consensus based on shared expert knowledge.

## 6.3 Results of technology prioritization

The results of the MCA for Coastal Zone are summarized in Table 18 for the first four ranked technologies. The ranking (similar to results shown in the MCA calculator at Annex 6(c)) is for the incremental cost of rock revetment set at Rs100,000/m, which is the higher of the two cost data for this technology. The ranking of the first four technologies is maintained for all the three sets of weights given in Table 17. The rankings of the remaining three short-listed technologies are not shown because they showed variations during sensitivity analysis of weights. Further, they are not significant for TAP.

Table 18. Ranking of coastal adaptation technologies using MCA.

| Rank | Technology |
|---|---|
| 1 | Restoration of coastal vegetation |
| 2 | Wetland protection |
| 3 | Dune restoration |
| 4 | Rock revetment |

When the incremental cost of rock revetment is set at Rs40,000/m, the same list constitutes the top four ranked technologies. Further, the ranks are conserved except for the swap between dune restoration and rock revetment when the last set of weights (right-hand column) shown in Table 17 is used. In this case, the difference between rock revetment and dune restoration is marginal – i.e. only 1.1 absolute points.

The results show that the MCA analysis is quite robust.

# 7. Technology prioritization for energy industries

## 7.1 Possible mitigation technology options in energy industries and their mitigation benefits

As mentioned in section 3.3.4, a detailed review of possible mitigation technologies has been performed by the project stakeholders. The cross-cutting benefits of all these technologies are: (1) GHG emission reduction; and (2) lower dependence on imported fossil fuels. The latter enhances energy security and also has positive financial and economic returns through decreases in the energy import bill.

The first step was to identify all technologies ranging from low applicability/technically feasible to high applicability based on expert knowledge of the local context in terms of factors such as: (1) technologies must be related to Demand and Supply Sides management in the Energy Industries; (2) applicability of technologies for a sub-tropical country; (3) necessity for large capacities (e.g. scale of economies) for a small island like Mauritius; (4) baseline situation of technology (i.e. technology is current practice; technology is supported by ongoing initiatives or initiatives in the pipeline); and (5) time horizon for technology implementation. Sixty (60) technologies were reviewed. This list is shown atAnnex 7(a), including a brief description of the status and applicability of the technology in Mauritius.

It is pointed out that several mitigation technologies are not applicable in Mauritius because of a combination of context (e.g. climatic conditions implying no need for heating; topography that limits hydro-electricity; feed-in-tariffs to promote micro-generation of renewable energy technologies in place); technology already adopted (e.g. CFL and solar water heating for household and industrial applications); low socio-cultural acceptability (e.g. solar cook stoves); and/or the stage of development of Mauritius (e.g. use of modern fuels like LPG for cooking automatically excludes biomass/coal/kerosene cook stoves).

### 7.2 Criteria and process of technology prioritization

#### 7.2.1 Prescreening of longlisted mitigation technologies

The second step consisted of a pre-screening of the retained technologies based on expert knowledge of the local political context and technology requirements for mitigation. Here, the factors that were used to retain technologies were: (i) contribution of technology to development priorities and existing policy orientations, (ii) GHG abatement potential, and (iii) cost estimates. These indicators are prescribed for technology prescreening in Annex 7(a) of the TNA Handbook ([I]). The list of 15 hardware technologies is shown in Table 19.

Table 19. Pre-screened mitigation technologies for the energy industries.

| Index | Technology | Index | Technology |
|---|---|---|---|
| 1 | Solar PV (above 1 MW) | 9 | Biogas production from waste for domestic and industrial use |
| 2 | Wind turbines (utility-scale) | 10 | Micro-cogeneration/Biomass Heat and Power |
| 3 | Small-scale hydro (>50 kW) | 11 | Geothermal electricity |
| 4 | High Efficiency HVAC (industrial application) | 12 | Electricity Storage for intermittent RE |
| 5 | Efficient building design (façade /exterior wall insulation) | 13 | Ocean wave (hydro-kinetic) electricity generation |
| 6 | Building automation and management systems | 14 | Conventional Natural Gas combined Cycle |
| 7 | High efficiency compressors (industrial) | 15 | Humidity control systems |
| 8 | High efficiency boilers / heat recovery (industrial) | | |

Sectoral priorities of Mauritius are drawn up in updated Energy Strategy 2011 – 2025 Action Plan (see Annex 2).26In order to be in line with government policy, the first 8 technologies given in Table 19 have been retained for prioritization using MCA.

### 7.2.2 Technology prioritization using MCA

Defining MCA criteria and indicators

The first step was to define the MCA criteria and indicator for the energy industries (power sector). The MCA4Climate methodology (see [xlix]) was adopted at the IW and MCA indicators were identified for the criteria in subsequent technical working group meetings.Table 20 lists the criteria, their corresponding indicators, as well as their units of measure (for quantitative indicators) or measurement scales (for qualitative indicators). The process of identifying indicators also allowed member of the working group to develop a common understanding of the meanings attached to each indicator.

Table 20. Sustainability criteria and indicators for prioritization of mitigation technologies.

| Criteria | Indicators | Measurement scale | Weight | Sensitivity analysis | |
|---|---|---|---|---|---|
| Public Financing needs | Direct incremental cost, e.g. direct government budgeting | Rs/tCO2 | 0.15 | 0.2 | 0.15 |
| Implementation Barriers | Ease of Implementation e.g. non-financial barriers | Likert scale: 0 (highest barrier) – 100 (lowest barrier) | 0.15 | 0.1 | 0.1 |
| Climate-related | GHG reduction | tCO2 (to 2025) | 0.2 | 0.25 | 0.2 |
| Economic | - Catalysing private investments | Likert scale: 0 (lowest) – 100 (highest) | 0.15 | 0.1 | 0.05 |
| | - Reduction in energy import bill | MRs (million Rs) (to 2025) | 0.1 | 0.1 | 0.1 |
| | - Replicability | Likert scale: 0 (lowest) – 100 (highest) | 0.05 | 0.05 | 0.05 |
| Social | - Impact on health | Likert scale: 0 (lowest) – 100 (highest) | 0.05 | 0.05 | 0.05 |
| | - Job creation | Quantity (to 2025) | 0.10 | 0.15 | 0.15 |
| Political and Institutional | Contribute to political stability | Likert scale: 0 (lowest) – 100 (highest) | 0.05 | 0.05 | 0.15 |

[26] The Energy Strategy 2011 – 2025 Action Plan can be downloaded at http://www.gov.mu/portal/site/mpusite - accessed 5 February 2012.

Four of the indicators were quantified. Cumulative GHG emissions were calculated up to 2025, which is also the timeline for the Long-Term Energy Strategy Action Plan (see footnote 24). For GHG emissions related o electricity use, emission reductions were calculated using the 2011 Operating Margin (OM) for the national grid.27Where energy efficiency reduced the use of fossil fuels, the emission factors of fossil fuels were used to calculate emission reductions. The penetration of renewable energy and economy-wide efficiency gains in the power sector were derived from the Long-Term Energy Strategy, while the efficiency of technologies was obtained from the literature or from case studies conducted locally. References of all sources are given in TFS. The incremental costs of technologies were calculated using either the feed-in-tariffs (for renewable energy technologies) or from the difference between the energy efficient technology and the replacement cost of the baseline technology. Reduction of energy bill was calculated based on the reduction imported fossil fuels due to production of electricity using renewable energy technologies or through energy efficiency gains. Jobs were calculated using the methodology employed in the UNEP Green Economy Report.liii

Qualitative indicators were measured on a Likert anchored at 0 and 100. The scoring of technologies on Likert scales was carried out using the expert knowledge of team members.

Allocation of weights and sensitivity analysis

The procedure for the allocation of weights for MCA and sensitivity analysis is described in section 6.2. The sensitivity analysis therefore consisted of investigating the relative changes in technology ranking based on relative changes in a combination of: (1) public financing since this criterion could be an important barrier to technology adoption; and (2) balancing the social criterion by reallocating the weight of 'catalysing private investment' to 'job creation' (and GHG emission reduction). The weight allocated to improvement of health was kept low at 0.05 reflecting the observation of working group members that the direct benefits of technology adoption and diffusion on health was weak in Mauritius.

Technology fact sheets

TFS were developed for each adaptation technology, and information was provided on all aspects of the criteria and indicators given in Table 20. In addition to using their expert knowledge in the field, working group members could also use the TFS when needed. The TFS were validated after members of the working group had been given ample opportunities to provide their comments and suggestions. Bilateral meetings were also held with key institutions before finalizing the TFS. The TFS for the technologies retained for TAP are found at Annex 7(b).

Scoring of technologies against indicators

The procedure described in section 6.2 was used. The MCA calculator that was customizedfor the Energy Industries is found at Annex7(c).

## 7.3 Results of technology prioritization

The results of the MCA for Energy Industries are summarized in Table 21. The ranking shown did not change with sensitivity analysis showing that the MCA was quite robust.

Table 21. Ranking of “Energy Industries” technologies using MCA.

| Rank | Technology |
|---|---|
| 1 | Wind (utility scale) |
| 2 | PV (>1 MW) |
| 3 | EE Boilers (heat recovery) |
| 4 | HE compressors (industrial) |
| 5 | Small-scale hydro (>50 kW) |
| 6 | Energy Efficient Building Design (Façade insulation) |
| 7 | EE HVAC (industrial) |

During MCA, ‘building automation and management system’ was dropped after discussions with working group members. Research carried out while developing the TFS showed that this technology was always implemented concurrently with numerous energy efficiency and renewable energy technologies, making the calculation of technology-related emission reductions difficult to be carried out. Further, the investment cost seemed related to the size of the building and examples were scarce in Mauritius. The IPCC (2007) concludes on the building automation and management system that it is as yet unclear how much the technology can reduce energy usage and at what costs. Estimates provided on the technology energy savings differ considerably and therefore the technology requires more research and development to determine the financial requirements and costs. In this context, it was felt that inclusion of this technology in the TNA was premature.[liv]
The first three technologies have been retained for TAP.

## 8. Summary

The TNA report has reviewed the multi-stakeholder process that has been put in place in Mauritius to prioritize adaptation and mitigation sectors, as well as identifying climate change technologies for the priority sectors. The sectors that have been retained for the TNA project are: water, agriculture and coastal zones for adaptation, and energy industries for mitigation.

MCA, including sensitivity analysis of scores and weights, was used to prioritize and rank technologies. The resultsare summarized as follows:

| SECTOR | TECHNOLOGIES RETAINED FOR TAP |
|---|---|
| WATER | • Desalination<br>• Rainwater harvesting<br>• Hydrological model |
| AGRICULTURE | • Up-scaling of locally proven Integrated Pest Management technologies<br>• Micro irrigation (gravity fed drip & mini and micro sprinkler irrigation)<br>• Decentralised rapid pest and disease diagnosis service (plant clinic) |
| COASTAL ZONE | • Restoring coastal vegetation<br>• Wetland protection<br>• Dune restoration<br>• Rock revetment |
| ENERGY INDUSTRIES | • Wind (utility scale)<br>• PV (>1 MW)<br>• EE Boilers (heat recovery) |

Annex 1 Status and progress of key national policies, strategies and actions plans that support sustainable development in Mauritius.

| NSDS or Equivalent & Other Key Sector Strategies and Plans | Comments/Status |
|---|---|
| 'Vision 2020' policy document. | Developed in 1997 |
| 2nd National Environmental Strategy and Action Plan (2000-2010). | Developed in 1999;<br><br>Reviewed in 2008 and recommendations 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;<br><br>Updated in 2007;<br><br>Objectives: (1) conservation of environmental resources; (2) inter- and intra-generational equity; (3) include environmental concerns in socio-economic development; (4) achieve sustainable consumption and production patterns; (5) achieve "garden island" concept; (6) enhance partnerships across society; (7) development of environmental ethics in citizens; (8) promote policy dialogue; |
| National Solid Waste Management Strategy. | Based on three pillars: (1) minimisation of solid waste; (2) maximisation of value derived from waste; and (3) environmental waste treatment and management;<br><br>Priority measures according to action plan are: (i) construction of additional transfer stations and upgrading of existing ones; (ii) construction of additional waste disposal facilities; and (ii) setting up of a compost plant; |
| Blueprint for a Sustainable Diversified Agri-food Strategy for Mauritius, 2008-2015; | addresses the food security through improving self-sufficiency status of a number of strategic crops in the short to medium term; |
| Food Security Fund | set up to increase the resilience of Mauritius towards food selfsufficiency and to face subsequent global food and feed crunches by increasing production of foodstuff locally and at the regional level by partnering with neighbouring countries;<br><br>provides funds for adaptation such as the Food Crop Insurance Scheme and Sheltered Farming; |

| NSDS or Equivalent & Other Key Sector Strategies and Plans | Comments/Status |
|---|---|
| Climate Change Action Plan. | Formulated in 1998;<br>Although most actions have not been implemented, many recommendations are still relevant; |
| 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;<br>Reviewed 2003; |
| National Development Strategy | The NDS, the main planning instrument providing the spatial framework, was approved in 2003. Subsequent proclamation of part of the Planning and Development Act in 2005 gave legal force to the NDS.<br><br>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. |
| National Biodiversity Strategy and Action Plan. | Finalized 2006;<br><br>A ten-year strategy to ensure the conservation of biodiversity, its sustainable use and the fair and equitable sharing of its benefits; |
| National Tourism Policy<br><br><br><br><br><br>Tourism Sector Strategy Plan (2009-2015)<br><br><br>Hotel Development Strategy. | Government vision to attract 2 million tourists by 2015;<br>Emphasizes low impact, high spending tourism. Selective, upmarket,<br>quality tourism is favoured, and although such tourism is not the only type, it constitutes the major segment of our tourists who stay in high class hotels;<br><br>Recommends ways and means of achieving an environmentally sound, socially acceptable and economically viable tourism development.<br><br>October 2009; |

| NSDS or Equivalent & Other Key Sector Strategies and Plans | Comments/Status |
|---|---|
| | In conformity with Planning Policy Guidance for Hotels and Resorts. |
| Development of an Integrated Coastal Zone Management Framework (ICZM) | Proposed 2009;<br><br>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).<br><br>Under implementation; |
| National Programme and Action Plan on Sustainable Consumption and Production (SCP) | Covers period 2008-2013;<br><br>44 projects estimated to cost around Rs25.6million have been identified for implementation;<br><br>Strategic priorities include: Resources Use Efficiency with a Focus on Energy and Water and Sustainable Buildings; Education and Communication for Sustainable Lifestyles; Integrated Waste management and Recycling; Sustainable Public Service Practices; and Improve the Market Supply of Sustainable Products and Services; |
| White Paper on Health Development & Reform. | Action Plan for Health sector;<br>The principal actions proposed include a 24 hour family doctor service, major expansion of high tech, diagnostic and treatment services, new and improved hospitals and health centres and a greater emphasis on health promotion and preventive medicine; |
| Education and Human resources Strategy Plan 2008-2020 | Formulated in October 2009;<br>formulated in line with the vision of providing a quality education for all and developing a Human Resource base to transform Mauritius into an intelligent nation state in the vanguard of global progress and innovation through the development of a culture of achievement and excellence; |
| Water Sector Master Plan | Under study |
| Long-Term Energy Strategy 2009-2025 | Finalised October 2009<br>Long-term energy action plan currently being reviewed; |

| NSDS or Equivalent & Other Key Sector Strategies and Plans | Comments/Status |
|---|---|
| | Renewable Energy Master Plan being articulated with support of the World Bank; |
| Maurice Ile Durable (MID) Policy & Strategy | MID Fund of US $40 M set up in June 2008 with resources mobilized through various taxes to finance a scheme for the preservation of natural resources and adapting to climate change;<br>Initially focused on achieving energy independence, but has evolved to include social and economic considerations;<br>MID ‘Green paper’ has been finalized;<br>10-year MID Policy & Strategy, with multi-annual (3 years) action plan are in the process of formulation |

Annex 2 – Energy Strategy 20112025 Action plan

| REGULATORY | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Energy Efficiency Act 2011 | Proclamation of Energy Efficiency Act<br><br>Part III Setting up of Energy Efficiency Committee | 2011/2012<br><br>September 2011 | The Act was enacted in March 2011 but will come into force on proclamation.<br><br>Proclamation will be made by Sections |
| | Part II – Setting up of Energy Efficiency Management Office | December 2011 | |
| | Part IV and V – Energy Audits and Miscellaneous sections | 2012/2013 | |
| Electricity Act 2005 | Proclamation of Act | 2011/2012 | The Act will be proclaimed after the setting up of the Utility Regulatory Authority |
| Energy on Efficiency Regulations | Regulations to prescribe standards for products and standards for auditing | 2012 | Consultant is working the standards |

| INSTITUTIONAL | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Utility Regulatory Authority | Set up an independent utility regulatory body | 2011/2012 | |
| Energy Efficiency Management Office | Set up the Energy Efficiency Management Office | December 2011 | Parts I, II and III of the Energy Efficiency Act to be proclaimed. |
| | Filling of posts | 2011/2012 | Posts to be advertised once Schemes of Service are approved by the PSC. |
| Observatoire de l'Energie | Set up a data base on energy efficiency | 2011-2012 | Assistance of ADEME,Reunion obtained to establish the data base |
| Mauritius Land Transport Authority (MLTA) | Set up and operationalize the Mauritius Land Transport Authority to implement reforms in the transport sector | 2012 | Relevant sections of the MLTA Act has been proclaimed to allow the setting up of the MLTA. The Consultants have submitted the draft final report. |
| Institutional mechanism for implementation of Action Plan | Reinforcement of technical capacity within the implementing agencies | 2011- 2014 | Training to be organized with the assistance of Indian Ministry of New and Renewable Energy and ADEME Reunion |
| Capacity Building | Develop training and capacity building programmes with the collaboration of tertiary institutions | 2011- 2015 | |

| ENERGY EFFICIENCY | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Sustainable energy budget | Establish appropriate budget for the setting up of Energy Efficiency Management Office | 2011- 2025 | Funds provided in the 2011 PBB and forecasted budget for 2012/2013 appear in PBB. |
| Minimum energy performance standards and energy efficiency labeling | performance prepared and enforced for the following appliances | | Regulations to prescribe standards under preparation. |
| | Refrigerators and air conditioners | 2012 | |
| | Electric lamps and washing machines | 2013 | |
| | Electric ovens and dishwashers | 2014 | |
| | Electric water heaters and storage types | 2015 | |
| | Clothes dryer | 2015 | |
| Certify energy auditors | Develop a certification system for energy auditors and energy managers | 2012-2013 | |
| Energy Management Education | Develop professional courses in energy auditing, energy management, monitoring and targeting of sustainable building design | 2012-2013 | |
| Targeted incentives | Develop incentives to encourage purchase of energy efficient appliances | 2012-2016 | |
| Incentives for suppliers | Develop and introduce incentives to encourage suppliers to supply energy efficient appliances | 2012-2013 | No customs duty applicable on equipment for renewable energy |
| Energy Service Companies | Provide incentives to promote energy service companies | 2012 | |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| Clean development mechanism (CDM) | Secure financing for projects to release 1.8 million tons of CO2 emissions savings per year from: | 2010-2015 | The CDM designated national authority is under the Ministry of Environment and Sustainable Development. Letters of no objection have already been issued for four projects including the Lanfill gas-to-energy project, the Plaines des Roches and Bigara wind farm projects. |
| | Landfill gas | 2011 | |
| | Solar water heaters | 2012-2013 | |
| | Solar photovoltaic | 2013-2015 | |
| | Wind energy | 2013-2014 | |
| | Energy efficient lighting | 2012 | |
| | Transport projects | 2014 | Project proponents in Mauritius face several constraints in developing CDM projects, namely, high transaction costs, complex and timeconsuming procedures for obtaining CDM approvals and problem of economies of scale where individual projects cannot generate significant volumes of CERs to make the projects cost effective. |
| Sustainable building design | (i) Introduce Building Control Bill for mandatory sustainable energy design standards for new buildings, including housing, hotels and offices offices, including natural ventilation; day lighting; appropriate orientation; solar hot water systems; time-of day and smart metering; intelligent lighting systems that are suitable for low-energy lamps; and building energy management systems for buildings more than 500m2 | 2012 | Ministry of Environment and Sustainable Development is embarking on the development of a national policy, guidelines and rating system for sustainable buildings under European Union funding. |
| | (ii) Guidelines for Passive Solar Design for buildings <500 m2 | 2012 | |
| | (iii) Guidelines for Green Buildings (Min of Environment and sustainable Development) | | |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| Low-energy consumption | Incentive schemes developed so that existing hotels and rented spaces make use of solar water heating systems, low-energy lighting and appliances. Rented houses/apartments to gradually use low-energy lamps as well as appliances with the highest energy efficiency label. | 2011-2015 | One million CFL lamps sold at subsidized prices to households. Budgetary provision made for two millions lamps in 2011-2012. All traffic lights replaced by LED. |
| Sustainable energy education | Introduce sustainable energy topics into the curriculum and provided appropriate teaching materials for schools. | 2012 | |
| Public awareness | Run programmes as a permanent activity to create awareness of the benefits of energy efficiency, renewable energy and sustainable living, including information on incentives/deterrents and rights/obligations for consumers. | 2011-2025 | Enhancement of Demand Side Management with special focus on contracts with big industrial/ commercial consumers to achieve peak shaving targets. |
| Energy efficient public | Implementation of a programme to | 2011-2025 | 50,000 street lights being |
| lighting | eliminate energy-inefficient lamps, reconfigure lighting patterns as appropriate, and address issues such as over-lighting. | | replaced by low energy bulbs in urban and rural areas. Consultant to be recruited to review lighting systems of major roads and motorways |
| Energy Audit Management Scheme (Non-residential Buildings) | (i) Adoption of Energy Audit Management Scheme<br>(ii) Mandatory energy audits for designated consumers | 2011<br>2012 | |
| Training &Certification of Energy Auditors (Auditing and Energy Code compliance) | (i) Training in building auditing | 2011- 2012 | |
| | (ii) Training in compliance with Energy code in Building Control Bill | 2012 | |
| | (iii) Interim Certification of Auditors (Auditing & compliance) | 2012 | |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| | (iv) Training of MITD Trainers in building energy auditing | 2011 | |
| | (v) Capacity building of Mauritius Standard Bureau to be a | 2012 | |
| | Certification Body | | |
| | (vi) Capacity building of MAURITAS as Accreditation body | 2012 | |
| Energy Management (Industrial Processes) | (i) Development of Guidelines for energy management in industries | 2012 | |
| | (ii) Mandatory energy audits in industries | 2013 | |

| RENEWABLE ENERGY | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Renewable Energy Development Plan | Finalize the Renewable Energy Development Plan | End 2011 | Draft plan being finalized with assistance from Indian Ministry of New and Renewable Energy |
| Feed-in tariff | Development of feed-in-tariffs for renewable energy power plants: | | |
| | (i) 50-400 kW | 2012 | |
| | (ii) above 400 kW | 2012 | |
| Wind Energy Projects | (i) Comprehensive wind assessment study and identification of potential onshore and offshore sites, as feasible, for development of wind farms | 2012-2013 | |
| | (ii) Construction of a 4x275 kW wind farm at Bigara | 2012 | |
| | (iii) Construction of a 20-30 MW wind farm at Curepipe Point | 2013 | |
| | (iv) Construction of an 18 MW wind farm at Plaines des Roches | 2013-2014 | 10MW in 2013.<br><br>8 MW in 2014. |
| | (v) Construction of 20MW wind farms every three years, as from 2017 | 2017, 2020, 2023 | |

| | | | |
|---|---|---|---|
| Bagasse Based Power Plant | (i) Increase bagasse-based energy from 350 to 520 Gwh | 2015 | Subject to the outcome of high level negotiations following the independent study on IPP's carried out in 2009 |
| | (ii) Commissioning a study on the potential of cane residues for electricity generation | 2012 | |
| | (iii) Setting up of a pilot plant for handling and feeding cane residues | 2013-2014 | Subject to outcome of study |
| | (iv) Using cane residues for electricity generation by existing IPPs | 2015-2020 | Subject to outcome of study and successful pilot plant |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| Waste Management | (i) Production of electricity from 3 MW gas-to-energy plant at Mare Chicose | 2011-2016 | Plant to be commissioned in August 2011. Energy potential 20Gwh/year |
| | (ii) Management of municipal waste and composting | 2014 | |
| Hydro Power | (i) Construction of a micro hydro power plant at Midlands dam | 2012 | To be commissioned in 2012. |
| | (ii) Study on increasing hydro storage capacity at existing sites | 2012-2013 | |
| | (iii) Construction of two micro hydro power plants, one at Bagatelle Dam and the other upstream of the water treatment plant. | 2015-2016 | |
| Geothermal energy | (i) Preliminary study on the geothermal potential of Mauritius | 2011 | |
| | (ii) Feasibility study, including geophysical survey and borehole drillings, for the development of geothermal energy in Mauritius | 2012 | Subject to outcome of preliminary study |
| | (iii) Construction of a geothermal energy pilot power plant | 2015 | Subject to outcome of feasibility study. |
| Solar photovoltaic PV projects | (i) Installation of 5 kW photovoltaic systems in 10 Government schools | 2011-2012 | Energy potential, 70MWh/year |
| | (ii) Installation every two years of a capacity of 50 kW photovoltaic panels in Government buildings, as from 2013 | 2013-2025 | |
| | (iii) Setting up of a gridconnected photovoltaic plant of up to 10MW | 2013 | |
| | (iv) Setting up of a gridconnected photovoltaic plant of 10MW, every 3 years after 2013 | 2016, 2019, 2022, 2025 | |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| Small scale distributed generation | 2MW of solar/wind/micro hydro small scale generation plants connected to the grid, on a net metering basis | 2011 | |
| | Review of grid code and feed-in-tariff | 2012 | |
| | 2MW of solar/wind/micro hydro small scale generation plants connected to the grid, on a net metering basis | 2013 | |
| Solar water heaters | (i) Subsidy for the purchase of solar water heaters Phase II | 2011-2013 | Provision made in PBB for Rs 100M in 2012 and Rs 50M in 2013. |
| | (ii) Introduce a range of complementary policies, incentives to promote solar water heating systems to achieve in a short-tomedium term the target of 50% households and businesses, and in the longer term neareliminating the use of LPG and electricity for water heating purposes. | 2012 | |
| | (iii) Provision of solar water heater systems in 4 hospitals | 2011-2012 | |
| | (iv) Provision of solar water heater systems in 7 hospitals | 2013-2015 | |
| | (v) 50% of the hot water requirements of all new large buildings to be met from solar water heaters, in accordance with the Energy Efficiency Building Code. | As from 2013 | |
| Grid Study | Study on smart grid | 2012 | |
| Studies on: Biomass, biogas, Trigeneration and Ocean energy | Studies to assess the technologies for long-term options for energy generation and interaction with other sectors. | 2013-2015 | |
| Policy for financing of renewable energy | Define a clear framework for financing of renewable energy technologies | 2011-2012 | |
| Research and Development | Develop research and innovation strategy along with MID framework | End 2011 | |
| Regional cooperation | Develop regional cooperation in field of renewable energy and energy management | 2011-2012 | |

| TRANSPORT | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Lower average age of vehicles | Regularly review and implement measures to lower the age and improve the composition of vehicle fleets. | ongoing | |
| Control of high emission vehicles | Regulate imports of high emission vehicles and tax vehicles based on CO2 emissions<br><br>Privatization of vehicle examination centre in order to introduce modern vehicle testing systems | 2012-2015<br><br>2014 | Control of emission of vehicles regulations made in 2002. Additional Smoke meters being procured for enforcement Excise duty halved on electric cars |
| Public transport incentives | Introduce economic incentives to choose public transport over private transport. | 2012 | |
| Bus ModernisationProgramme | Create high safety, comfort and cleanliness standards for new buses, which should all be low floor, multiple-entrance, air conditioned models, with minimum fuel efficiency standards and maintenance, inspection and emissions standards. | 2011-2016 | |
| Public transport information | Enhance bus and taxi service information. | 2012 | |
| Taxi regulations | Introduce a transparent, published, regulated tariff for taxis, to make them more attractive | 2014 | |
| Optimise traffic flow | Monitor traffic and travel demand patterns to improve traffic flow, which also lowers energy use. | 2015 | |
| Congestion charge | Introduce congestion charges in Port Louis, to encourage the use of public transport, discourage the use of private cars and reduce congestion. | 2013-2015 | Goods vehicles above 3.5 tons already restricted on motorway and A1 roads between 07.00 a.m and 09.30 a.m. |
| Introduction of mass transit system | Implementation of modern mass transit system | 2017 | |

| ACTION | DESCRIPTION | TARGET | NOTES |
|---|---|---|---|
| Ethanol - E10 | Introduce E10 | 2012 | Steering Committee set up at PMO to look into the introduction of ethanol. |
| Ethanol - E20 | Carry out studies to determine whether and when E20 should become mandatory, taking into account the experience of the introduction of E10. | 2014 | |

| POWER SECTOR | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Electricity pricing | Set cost-reflective electricity prices. Costs may also include support schemes for energy savings, for Demand Side Management and for renewables. | 2012-2013 | |
| Feed-in tariffs | Introduce preferential feed-in tariffs for electricity generation from renewable energy sources for plants above 50kW. | 2012 | |
| Time-of-day metering | Introduce sophisticated meters for larger customers to provide better information about electricity use and costs. | 2012 | |
| | Introduce time-of-day metering and tariffs that provide an economic incentive for customers to move daytime electricity loads to night time, hence increasing the overall efficiency of the power system | 2012/2013 | |
| | Create consumer awareness of day/night tariffs, for example, washing clothes at night represents a cheaper and more sustainable lifestyle option. | 2012/2013 | |
| Capacity expansion | Commissioning of new power plants:<br>(i) 50MW coal unit<br>(ii) 50MW coal unit or LNG plant<br>(iii) 50MW coal or LNG plant<br>(iv) 50MW coal or LNG plant<br>Review of capacity expansion plan and future site selection for power plants | <br>2014<br>2015<br>2019<br>2023<br>2015 | |

| CONVENTIONAL FUELS | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Minimum stocks of petroleum products and coal | Construction of strategic and operational storage tanks: | | |
| | (i) Mogas: 15000 MT (2x7500 MT) | 2013 | |
| | (ii) Gasoil: 10000 MT | 2013 | |
| Low-sulphur diesel fuel | Shifting from 500 ppm sulphur diesel oil to 50 ppm for land transport and industrial use, making a substantial, and noticeable improvement to air quality. | 2012 | As from August 2010, sulphur content in gasoil has been reduced from 2500 ppm to 500ppm<br><br>Importation of 2500 ppm sulphur gasoil will continue for marine bunkering |

| INDUSTRY AND TOURISM | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Encourage sustainable programme for Industry and Tourism Sectors | Create energy efficiency programmes such as voluntary agreements with industries; sub-sector technology and know-how transfer projects; training in specialist sustainable energy topics; awareness building, promotion and transfer of know-how; proposals for new financial and fiscal tools.<br>Resource Efficient and Cleaner Development Centre to be set up | 2011-2014<br><br>2014 | Resource efficient and cleaner production programme being Industry with UNIDO funding.<br><br>Further funding is sought to support enterprises during the implementation of the programme |
| Energy audits | Carry out Energy Audits by licensed Energy Auditors for the largest companies and develop energy management plans. | 2012-2015 | Energy audit reports drawn up by Enterprise Mauritius for 71 enterprises. |
| Sustainable tourism | Develop close working relationships between the Tourism Industry, the Land Transport Authority and the Energy Efficiency Management Office, in the context that fuel security, environmental sensitivity and tourism goals are mutually reinforcing. | 2011-2012 | |
| Fisheries sector | Economic incentives to be provided to use sails to complement outboard motors<br><br>Use of wind and solar energy for operating water pumps and aeration equipment | 2012-2015 | |

| PUBLIC SECTOR | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| The Public Sector Leads the Way | Introduce sustainable energy projects for public sector adhering to the principle ‘The Public Sector Leads the Way’. | 2011-2025 | |
| | Provision of 5 KW solar PV systems in 10 schools | 2012 | |
| | Provision of solar water heaters in 4 hospitals | 2012-2013 | |
| | Provision of solar PV systems in all Government buildings | 2012-2025 | |
| | Energy audits in 100 government buildings | 2011 - 2025 | |
| | Capacity building for sustainable energy projects in Government buildings | 2012-2025 | |
| Sustainable procurement | Introduce sustainable procurement as a mandatory practice for all public services, for example-lamps, computers, airconditioning and fans, freezers, vehicles etc are energy efficient and have energy saving/stand-by modes and that all photocopiers and printers are equipped with a duplex mode to use both sides of the paper.<br><br>The Energy Efficiency Management Office should develop expertise in these areas and advise all public sector institutions. | 2012-2016 | Procurement Policy Office has embarked on a project for sustainable procurement with collaboration of UNEP |

| GENDER | | | |
|---|---|---|---|
| ACTION | DESCRIPTION | TARGET | NOTES |
| Gender and Energy Use | Study on needs/assessment/capacity building for women, especially for the vulnerable groups.<br><br>Information, Education and Communication programmes for women so that women are fully familiar with the efficient usage of energy. | 2012<br><br>2011-2012 | |

Annex 3 – Validated Composition of Sectoral Working Groups

| | Group 1: Energy | Group 2: Agriculture | Group 3: Water | Group 428.: | Group 5: Coastal Zone & Tourism |
|---|---|---|---|---|---|
| Proposed Chair | CEB | Agricultural Services/AREU | WRU | Ministry of Fisheries | ICZM Division, MoESD |
| | Ministry of Energy and Public Utilities, | Mauritius Chamber of Agriculture | Central Water Authority | Mauritius Oceanography Institute | Ministry of Tourism and Leisure |
| | Enterprise Mauritius | Ministry of Agro-Industry and Food Security | Wastewater Management Authority | Indian Ocean Commission | Beach Authority |
| | Ministry of Industry, Commerce and Consumer Protection | University of Mauritius | Statistics Mauritius | Statistics Mauritius | Mauritius Oceanography Institute |
| | Ministry of Local Government and Outer Islands | Mauritius Sugar Industry Research Institute | Mauritius Meteorological Services | Association pour le Developpement Durable | AHRIM |
| | Mauritius Chamber of Commerce and Industry | Agricultural Research Extension Unit | Mauritius Research Council | Policy Planning, MoESD | United Nations Development Programme |
| | Energy Consulting IPA London | Food and Agricultural Research Council | Pesticide Action Network of Mauritius | CPI, MoESD | CCD, MoESD |
| | OMNICANE Management and Consultancy Ltd | Forestry Service | Pollution Prevention and Control Division, MoESD | ICZM Div, MoESD | AFRC – Fisheries Division |
| | CCD, MoESD | National Parks and Conservation Service (NPCS) | Environmental Law Division, MoESD | Private Sector | Indian Ocean Commission |
| | CEB | CCD, MoESD | CCD, MoESD | NGO – MMCS, | |
| | Statistics Mauritius | NGO – Mouvement Auto-Suffisance Alimentaire | Sustainable Development Division, MoESD | Sustainable Development Division, MoESD | |
| | ECO-BIO-Tech (private sector) | Mauritius Sugar Planters Association | Mauritius Sugar Planters Association | Fishermen Investment Trust | |
| | We love Mauritius (NGO) | Farmers Service Corporation (FSC) | National Development Unit | Rodrigues Regional Assembly | |
| | University of Mauritius | Irrigation Authority<br><br>Small Planters Welfare Fund (SPWF) | Irrigation Authority | | |
| | | Mauritius Agricultural Marketing Cooperative Federation Ltd | | | |

Annex 4(a) – Adaptation options in the water sector.

| Index | Technologies in the Pipeline (including being implemented) | H = hardware; S = software | Status of technology implementation | Benefits of technology |
|---|---|---|---|---|
| | saving at all level whole year round | | | |
| 11 | Close monitoring of water systems and aquifers | H | Ongoing | To make periodical assessment of water availability and to take appropriate actions as and when required |
| 12 | Review water tariff (e.g. differential tariff) | S | Recently done | Enhance judicious use of water and encourage use of treated wastewater and rain water harvesting |
| 13 | Protection of common recharge zones, aquifers and rivers (e.g. policy) | H/S | Already taken care in appropriate legislation | For protection of water quality |
| 14 | Promote use of water efficient fixtures, devices/appliances | H | Low level of implementation | Enhance judicious use of water |
| 15 | Integrated surfacegroundwater models | S | Not yet implemented | Forecasting/ planning and optimize use of water resources |
| 16 | Integrated Water Resource Management | S | | This is a framework and not a technology |

# DESALINATION
## Technology Fact Sheet for Adaptation

**ANNEX 4(c)**

| **Technology:** | **Desalination** |
|---|---|
| Technology characteristics | |
| Introduction | Desalination, desalinization, or desalinisation 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. Even so, it is still more expensive than other alternatives, but it is indeed becoming more competitive.<br><br>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/$m^3$ 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. |
| Technology characteristics/highlights | 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 groundwaters 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. |
| Institutional and organizational requirements | Currently, in Mauritius some 7 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 is 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 insisted that all hotels should adopt a desalination policy. Since 2005, it is compulsory for all new hotels to make provision for desalination as well as for recycling and the reuse of water. |
| Operation and maintenance | Operating experience with reverse osmosis technology has improved over the past 15 years. Fewer plants have had long-term operational problems. Assuming that a properly designed and constructed unit is installed, the major operational elements associated with the use of RO technology will be the day-to-day monitoring of the system and a systematic program of preventive maintenance. Preventive maintenance includes instrument calibration, pump adjustment, chemical feed inspection and adjustment, leak detection and repair, and structural repair of the system on a planned schedule.<br><br>The main operational concern related to the use of reverse osmosis units is fouling. Fouling is caused when membrane pores are clogged by salts or obstructed by suspended particulates. It limits the amount of water that can be treated before cleaning is required. Membrane fouling can be corrected by backwashing or cleaning (about every 4 months), and by replacement of the cartridge filter elements (about every 8 weeks). The lifetime of a membrane has been reported to be 2 to 3 years, although, in the literature, higher lifespans have been reported.<br><br>Operation, maintenance, and monitoring of RO plants require trained engineering staff. Staffing levels are approximately one person for a 200 $m^3$/day plant, increasing to three |

| **Technology:** | **Desalination** |
|---|---|
| | persons for a 4 000 $m^3$/day plant. |
| Endorsement by experts | Stress on existing water supplies expected to grow by 56% by 2050, and traditional sources aren't going to be able to meet the growing demand for water worldwide. Desalination is being selected in relatively wet locations in direct commercial competition with traditional water sources. Desalination is growing more rapidly globally than in the regions where it is perceived to be most used.<br><br>Experts note that desalination is an important option which can be encouraged by Regulatory and Developmental Agencies. |
| Adequacy for current climate | Mauritius is an isolated island surrounded by the sea and tourism is one of the pillar of the economy. In additional the Government is encouraging hotels to adopt this technology. |
| Scale/Size of beneficiaries group | Hotels having more than 75 rooms need to provide for desalination facilities if they are located near the coast. |
| Disadvantages | Environmental impacts of the concentrated brine water. |
| Capital costs | |
| Cost to implement adaptation technology | The cost factors of desalting include capital costs and operating and maintenance costs. Costs can vary considerably from one locality to another based on a number of issues in general; the amount of salt to be removed greatly affects the cost of desalting plant operation. The more salts to be removed, the more expensive the desalting process capacity of the facility also impacts costs, with larger plants generally being more economical.<br>**A desalination plant operating at a capacity of about 360$m^3$ per day would cost around MUR Rs. 14 million rupees.**<br>**A plant operating at a capacity of 500 to 600 $m^3$ per day would cost around MUR Rs. 27-30 million.** |
| Additional cost to implement adaptation technology, compared to "business as usual" | Additional yearly cost for operation and maintenance would cost about MUR Rs. 3 million rupees for a 360$m^3$ per day capacity plant. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | Water constantly available for use. |
| Reduction of vulnerability to climate change, indirect | Rainfall variability in time and pattern will not affect the smooth running of the organization. |
| Economic benefits, indirect<br>Employment<br>Growth & Investment | <br><br>Creation of jobs with regards to implementation, operation and maintenance.<br>Can create investments with regarding to the desalination units.<br>Reduce public and private expenditures associated with water infrastructure. |
| Social benefits, indirect<br>Income<br>Education<br>Health | <br>Availability of water will not affect the clients and hence satisfaction of the service.<br>Low level of capacity building to skilled workers.<br>Increases per capita water availability. Lack of water can have serious health effects and allow for the spread of disease and illness if the reductions continue for even modest lengths of time. |
| Environmental benefits, indirect | Desalination process involves a byproduct which is not environmentally friendly. The impact can be reduced by diluting it before discarding. |
| Local context | |
| Opportunities and Barriers | The barriers are the cost implication, the need for skilled personnel and the impacts on aquifers due to seawater intrusion.<br>The opportunity will be to look for the most economical way of implementing this technology – such as a cluster of hotels. |
| Market potential | Opportunities for investment is high not only due to climate change but also due to the need for alternative water sources as the demand on the limited amount of freshwater is increasing over time. |

| Technology: | Desalination |
|---|---|
| Status | The technology is already being practiced by a few hotels located along the coastal zone. |
| Timeframe | Present in some areas, lacking in other. This will involve an assessment of the requirements of the hotel, setting up the appropriate infrastructure facilities, training skilled workers, importing the desalination unit, installing and commissioning. |
| Acceptability to local stakeholders | At the level of the stakeholders concerned, there will be a need to convince them as this will require some initial financial investments. |

**Hydrological Models**
**Technology Fact Sheet for Adaptation**

| **Technology:** | **Hydrological Models** |
|---|---|
| Technology characteristics | |
| Introduction | 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:<br>• Stochastic Models.<br>These 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.<br>• Process-Based Models.<br>These 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.<br>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 |
| Institutional and organizational requirements | Hydrological models for forecasting and for improved water resource management to be tailor made for local water organizations such as CWA and WRU. Tailor made models are required by WRU so as to fit the local context and adapt to their requirements. |
| Operation and maintenance | Operation and maintenance consist essentially of regular training, and expert services that will be required for particular situation analysis. Technical support in the field of IT and hydrology will also be needed. |
| Endorsement by experts | 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. |
| Adequacy for current climate | Not climate dependent, but will be a very useful tool that will improve water resource management in the face of climate change. |
| Size of beneficiaries group | The public at a large – as this will involved better water resource management.<br>The local water organizations, who will be provided with a decision making tool, especially during crisis periods. |
| Disadvantages | • If staff is not well trained, this facility can behave as a black box and lead to wrong decisions. |

| Technology: | Hydrological Models |
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| | • Off shelf softwares have a number of limitations and are often not developed to take into consideration tropical basaltic conditions.<br>• This can lead to the water organization being too dependent on the provider and the developer of the software. |
| Capital costs | |
| Cost to implement adaptation options | The price of a hydrological model varies with the level of complexity provided for in the model and also varies with the technical support that comes with the software.<br>A simple hydrological model that is used for educational purposes will be around 1000US$ while a much complex model at organizational level will start as form 10,000US$.<br>Tailor made complex softwares, including regular capacity building and technical support will involve higher costs.<br>**COST: 1000$ (US) to around 10,000$(US)**<br>**More complex and site specific requirements will increase the costs.** |
| Additional cost to implement adaptation option, compared to "business as usual" (extra storage capacity) | Computer facilities and networking within the organizations and with sister organizations.<br>Costs: 1000 US$ per computer<br>Total costs: 20,000$ for 10 computers, assessories and networking requirements. |
| Development impacts, indirect benefits | |
| Reduction of vulnerability to climate change, indirect | |
| Economic benefits<br>Employment<br>Investment | <br>Creation of jobs as this will require skilled workforce and a dedicated unit.<br>Can indirectly lead to investments as the result of implementing the model will be improved water resource management. |
| Social benefits<br>Income<br><br>Learning<br>Health | <br>The decrease in water wastage will contribute to productive and economic livelihood purposes.<br>Training elements from capacity building<br>Increases per capita water availability. Lack of water can have serious health effects and allow for the spread of disease and illness if the reductions continue for even modest lengths of time. |
| Environmental benefits | Promotion of improve water resource management leading to less wastage and controlled development in the water infrastructure sector. |
| Local context | |
| Opportunities and Barriers | Barriers are seen owing to:<br>-Lack of such a system even at very low level of complexity has resulted in a lack of trained personnel presently.<br>- Lack of a dedicated unit at the local water institutions who can take this responsibility.<br>These translate in opportunities for the setting up of a dedicated unit, appropriate capacity building and technical support at national level.<br>To capacitate local water institution to take this responsibility in terms of capacity |

| Technology: | Hydrological Models |
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| | building, expenditure and equipments. |
| Market potential | The technology is relatively small-scale, proven and less capital-intensive. It has market potential nationwide, specially for similar small island states. |
| Status | Not used presently. |
| Timeframe | The implementation of a relatively simpler form of a hydrological model which is to be used for analysis and forecasting at national level can start almost immediately. This will at the same time involve the need to purchase the IT accessories needed and the need for capacity building.<br>The model will have to be developed so that it takes into consideration also online data acquisition, once the telemetry systems have been set up and are operational. |
| Acceptability to local stakeholders | Easy to accept by stakeholders concerned. |

# Rooftop Rainwater Harvesting
# Technology Fact Sheet for Adaptation

| **Technology:** | **Rooftop Rainwater Harvesting** |
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| Technology characteristics | |
| Introduction | Rainwater harvesting is a 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. Typically**, independent trials in some countries have shown that a domestic rainwater harvesting system can reduces mains-water consumption by around 50%.**<br><br>Only rooftop rainwater harvesting is discussed here. |
| Technology characteristics/highlights | Commonly used rainwater systems are made up of three principal components; namely, the catchment area, the collection device, and the conveyance system.<br>These systems can range from the low tech, hence low cost to the more advanced technology and thus relatively higher cost. |
| Institutional and organizational requirements | Though rainwater harvesting can be practiced on an individual basis, it will have to be supported by an institution for it to be successful. There is a need to impart know how as to the implementation and maintenance of the system, and to some extent some financial incentives will be needed.<br>Presently none of the water institution is promoting rooftop rainwater harvesting. |
| Operation and maintenance | Rainwater harvesters are based on simple technologies, and require no special skills. However users will need to become aware of the importance of maintenance and the financial implications this would entail. |
| Endorsement by experts | 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. |
| Adequacy for current climate | Mauritius is a tropical country, characterized by wet and dry periods, and is often visited by cyclones. So rainwater harvesting would serve their purpose well during the wet periods. |
| Scale/Size of beneficiaries group | Rainwater harvestors can be implemented at residential level, commercial and industrial level. This will alleviate the demand of treated water which is presently used for secondary purposes. |
| Disadvantages | Retrofitting systems would entail additional costs, as this is not commonly practice in Mauritius. |
| Capital costs | |
| Cost to implement adaptation technology | Rainwater harvestors based on concrete storage tanks would be costing some Rs. 20,000 per unit, and the ongoing country project Sustainable |

| **Technology:** | **Rooftop Rainwater Harvesting** |
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| | Consumption and Production (**SCP) (2008) had earmarked a budget of R. 2million** for encouraging rainwater harvesting in Mauritius. This cost included a sound equipment, fittings and installation costs.<br><br>Latest figures from the Central Statistical office reported that there are 297, 500 buildings, 344700 housing units and 329.950 Private households. If one rainwater harvestor was to be implemented in each of these buildings, the total sum would be some **MUR Rs. 2 million** as indicated in the SCP report of 2008. |
| Additional cost to implement adaptation technology, compared to "business as usual" | Maintenance cost would amount to a maximum of Rs. 1000. per month. The system will have to be updated every 5 years. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | Reduction in demand of treated water, reduction in wastage and more efficient use of treated water. |
| Reduction of vulnerability to climate change, indirect | No negative impacts associated. |
| Economic benefits, indirect<br>Employment<br><br>Growth & Investment | <br>There will be a need for trainers who will be responsible to provide the know how to resident.<br><br>This will open avenue for small scaled enterprises that would be concerned with the developing rainwater harvesting system as per the requirement of the residents. |
| Social benefits, indirect<br>Income<br><br>Education<br><br>Health | <br>Additional water can encourage back yard farming.<br><br>Awareness will be raised as to the need of adopting conservation water measures.<br><br>Reduction of health risks to those who do not have access to water on a regular basis specially during dry periods. |
| Environmental benefits, indirect | Reduction in water losses/wastage. |
| Local context | |
| Opportunities and Barriers | Since rainwater harvesting is not commonly practiced yet, there will be a need to retrofit sytems, and this may be looked upon as a deterrant.<br>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. |
| Market potential | 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. |
| Status | This technology is currently implemented on a very low level. |
| Timeframe | Short Term – as it all the requirements are readily available on the local |

| Technology: | Rooftop Rainwater Harvesting |
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| | market. |
| Acceptability to local stakeholders | Socially may not be readily accepted as almost 99.6% inhabitants are connected to tap water. There will be a need for a change in mindset and this will take some time. |

1. http://www.savetherain.info/media-centre/rainwater-harvesting-faqs.aspx#five
2. http://www.thewatercalculator.org.uk/faq.asp

Estimating total volume which can be collected from rainwater harvesting:

Average annual rainfall = 2500mm per year for the whole island

Surface area – roof top – one housing units = about 100$m^2$
Total housing units – 250,000

Potential volume that can be collected = 2.5x100x250,000/1000000= **62.5$Mm^3$** per year as compared with the total annual potable water harnessed for use which is 212 $Mm^3$ per year.

## Annex 5(b) – Technology fact sheets for 3 prioritised adaptation technologies in the agriculture sector

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| **Technology: Upscaling of locally proven IPM technologies for control of pest of economic importance** | |
| **Sector : Agriculture** | |
| **Subsector : Crop sector** | |
| **Technology characteristics** | |
| **Introduction** | Integrated Pest Management (EPM) is an effective and environmentally sensitive approach to agricultural pest management that uses a range of practices to manage population and maintain at level below at which it can cause economic injury and affect agricultural production while providing protection against hazards to humans, animals, plants and the environment.<br>IPM makes full use of natural, physical and cultural processes and methods, including host resistance and biological control as opposed to synthetic chemicals. IPM emphasis the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural pest control mechanisms.<br>Chemical pesticides are used only where and when these natural methods fail to keep pests below damaging levels" (Frison et al, 1998; 10). This IPM technology include up-scaling of 4 locally IPM techniques to control major pest of field and greenhouse crops (mites, melon fly, fruit bats and leafminer and whitefly). They are<br>1.Demonstration of tree pruning and use of bird net<br>2.Inoculative releases of predators to control population of *Tetranychusurticae* a mite causing major damage on solaneceous crops, roses and strawberry.<br>3. Release of parasitoids(*Encarsiaformosa* and *Eretmocerusaremicus*) for control of White fly, serious insect pest in greenhouse production<br>4. Field Sanitation using field cages (augentorium) , proten bait and MAT block to attract and suppress melon fly, Bactroceracucurbitae, major pest in cucurbits<br>The primary goal is to implement a system that results in greater yields, reduced growers' costs and eliminate human and environmental hazards.The use of sticky is to trap the adult insects and prevent multiplication and control pest population |
| **Technology characteristics/highlights** | IPM needs group action, that is neighboring fields to with common goal of ecological pest management at a locality level<br>The upscaling of the locally proven IPM techniques will requires<br>- Setting up of 3 greenhouse facilities for<br>(1) production of plants required for the production of host insects that are reared for biological control programs,<br>(2) rearing of predatory mite, *Phytoseiluspersimilis*<br>(3)rearing of parasitoids (*Encarsiaformosa* and *Eretmocerusaremicus*)for control of whitefly<br>(4)Demonstration of fruit tree pruning and and use of bird net (5)construction and distribution of augentoriumin or field cages, protein baits, MAT block for field sanitation<br>- R & D to set optimum insect pest threshold<br>- Regular monitoring of insect pest using traps<br>- Logistic for release of predators and parasitoids<br>- Capacity building of extension officer and farmers (scouting, IPM Principle/ |

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| | strategies that include a combination of behavioural, biological, chemical, cultural and mechanical methods to reduce pest populations to acceptable levels)<br>- Provision of IPM starter kit to farmers |
| **Institutional and organizational requirements** | The entomology division of AREU and agricultural services has the necessary expertise in IPM, rearing of predators, Yellow sticky traps and blue sticky traps tested on pilot scale have been found very efficient in mass trapping of adult flying insect pests. Farmers are grouped in association and to control actions may be taken collectively at a regional level.<br>Implementation of IPM requires collaboration of local service providers (such as NGOs, producer organisations, technical service providers, Implementation of IPM requires collective actions between researchers, extension and farmers for monitoring and feedback. Farmers grouping can help to reduce cost of IPM and ensure high rate of success. |
| **Operation and maintenance** | Once rearing of predatory mite is developed and implemented, maintenance will have to be undertaken on sanitation to avoid contamination.<br>Sticky traps can be made with local materials and have to be replaced at regular intervals. Maintenance of baits and traps is quite easy |
| **Endorsement by experts** | Due to over-reliance on chemical pesticides and associated problems such as development of pesticide resistance, elimination of natural enemies of pests, outbreaks of formerly suppressed pests, hazards to non-target species, threat to human health and environmental contamination, IPM has been identified as a key element in sustainable agricultural development (Frison et al, 1998; 9).<br>During the last 15-20 years, IPM strategy has been implemented in cabbage and cauliflower plantation. Experts were present to give their support.<br>Use of traps, baits have been found to be effectively if properly maintained. |
| **Adequacy for current climate** | The technology is appropriate for present and expected climate and is applicable islandwise |
| **Scale/Size of beneficiaries group** | Some 8,**500** farmers will benefit at first and no doubt population will be gaining from organic production |
| **Disadvantages** | - Some pest may be very difficult to control, if biological control not yet identified<br>- Production of biological control agents have the probability to<br>- High investments for rearing and research |
| **Cost to implement adaptation technology** | The cost of implementation of this technology will required<br>-capacity building of extension and farmers in IPM<br>- research to test efficacy of control measures locally and develop IPM package<br>-Mass rearing of biological control agent<br>-Monitoring of pest population and release of biological control agents<br>- Construction and distribution of augmentaroium, sticky traps with pheromone , protein baits , MAT block on an area-wide scale<br>- Running regular IPM field schools/ training<br>The developed technology usage depends on growers adaptation. All depends on consignment needed for release of the natural enemies and predators. If demand by growers increases then automatically cost of production of natural enemies will increase. Vegetable growers are well grouped and this will reduce cost of production.<br>Cost will include laboratory for rearing of predators, sticky traps , pheromone traps , baits for demonstration, training of extension officer (30)and farmers |

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| | (2000), development of training programme ( visual, video)<br>**Estimated cost of implementation of the technology Rs 2,441/ beneficiary/year**<br>**Total implementation cost Rs 28 564,000** |
| **<u>Additional</u> cost to implement adaptation technology, compared to "business as usual"** | Additional cost to implement technology Rs 20,000,000 |
| **Long term cost (i.e. 10, 30, or 50 years) without adaptation** | Increasing crop damage by pest and disease, lower crop productivity and risk of farmers to abandon their production leading to reduction in supply of food |
| **Long term cost (i.e. 10, 30, or 50 years) with adaptation** | Reduce damage due to pest and disease/ farmers are better prepared to manage pest and disease in their field / reduce reliance on chemical pesticides and reduce cost of production and improve income and food safety |
| **Development impacts, direct and indirect benefits** | |
| **Direct benefits** | Reduce crop damage , increase yield and quality ( less pesticide residue) andimprove income of farmers |
| **Reduction of vulnerability to climate change, indirect**<br>**Growth & Investment** | Control insect population , thus reducing crop damage, increase crop yield and income of farmers<br>In long run, less insecticide will be used/ minimize air and water pollution.<br>Reduction in public & private expenditures in insecticides and fungicides cost |
| **Social benefits, indirect** | |
| **Income** | Reduce crop damage by pest and this improve yield and farm income<br>Reduce cost of production |
| **Education** | Farmers become experts /get basic understanding of the agro-ecological system, and decision making processes for long term management of soil, crop and pests |
| **Health** | Reduction in use of insecticides leads to safer food( no pesticide residue), improve health of farmers and preserve beneficial insects better quality of air and water |
| **Environmental benefits, indirect** | Reduce use of chemical pesticides minimize risk of contamination thus conserve natural enemies |
| **Local context** | |
| **Opportunities and Barriers** | **Opportunities-** Farmers are empowered to take or organize actions collectively for better control of pest<br>If implemented , farmers can sell their produce as organic, healthy products and can fetch higher prices<br>**Barriers** - inability of farming community to access needed information and knowledge - can cause a slight drop in productivity<br>Farmers prefer pesticides as they are easy to apply and provide effective control<br>Poor linkage between research and extension<br>Lack of policy to favour IPM over pesticides |
| **Market potential** | IPM technology is very effective with less risk, low investment with long term gain. It has market potential for commercial production of predators and parasitoids (Agri-business) Limited application at individual farm level but would be more successful if applied at group or regional level. |
| **Status** | -Expertise exists at AREU in the rearing of predators of mites.<br>-Pilot IPM project is ongoing for monitoring and mass trapping of thrips using blue sticky traps with kairomones .<br>-The use parasitoids (*Encarsiaformosa* and *Eretmoceruseremicus*) to control whitefly , a seious pest in greenhouses production is used in Reunion island |

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| | and has also been found to give good control of the best under local conditions<br>- The use of augentarium with protein baits and mat blocks on a pilot scale in Plaine Sophie region was found to effective in area-wide melon fly suppression by the Agricultural services<br>AREU has already undertaken pilot projects the results have been positive. These need to be upscale and replicated in different agro-ecological sites This technology can be implemented immediately with concrete results within 1-2 years but the majority still relying heavily on synthetic pesticides |
| **Timeframe** | Short term for traps and bio-pesticides and medium term for biological control |
| **Acceptability to local stakeholders** | The technology is already known to planters and will be easily accepted provided there is research and extension support |

| **Technology: Micro irrigation system for efficient water use and management (gravity fed drip & mini and micro sprinkler irrigation)** | |
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| **Sector :Agriculture** | |
| **Subsector : food crop sector** | |
| Technology characteristics | |
| **Introduction** | Small scale micro irrigation for lifting, conveying and applying irrigation efficiently include gravity fed drip and pressurized sprinkler irrigation used to improvewateruse efficiency and food production. They may be gravity fed or pressurized system. Water source can be from borehole, reservoirs, field pond or potable source. Unlike surface or furrow irrigation, it improve water use efficiency by 50-70 % under sprinkler and up to 90 % under drip irrigation. Mini sprinkler is used for open field production, while drip and micro-irrigation is used for field crops, greenhouse, nursery , orchards and container plants |
| **Technology characteristics/highlights** | This technology mainly earmarked for small scale farmers with less than 2 ha under vegetable or fruit production. It comprises of<br>- Water source which can be from boreholes, tank, reservoir, field pond.<br>- Design of irrigation system<br>- Installation of irrigation system which consist of pipes, valves and small drippers or emitters for drip irrigation and a and network of pipes with spray heads and a pump if not gravity fed<br>- a filtration system in case water quality is poor<br>- The drip system can be used for fertigation and improve fertiliser use efficiency<br>- Trained and skilled labour for installation of irrigation system and in operation and maintenance of irrigation system |
| **Technology characteristics/highlights** | Drip irrigation technology uses less water than sprinkler irrigation (30-40 % water saving), / is not affected by wind . It enables to irrigate irregular structured fields (odd-shaped and narrow areas), It optimize the use of fertilizers and water ( water-use efficiency exceeds 90% / minimizes crop stress by slow release of water close to the root zone as per the irrigation requirement of the crop. It minimizes wetting of foliage and foliar diseases. It applied water in low volume to plant roots providing optimal growth conditions.<br><br>Mini-sprinkler irrigation is appropriate for all types of soils and open field vegetables |

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| | production. It is movable/ requires labour, can be adapted to different field shape. /size. Its efficiency is around 50 to 70 %. It provides efficient coverage for small to large areas Both irrigation system may be gravity–fed or pressurised by a pump. |
| **Institutional and organizational requirements** | – Irrigation Authority and AREU have technical capacity to design the irrigation system based on crop, / shape and size of the field / the topography of the land soil profile/ infiltration rate/ water source–accessibility(surface or ground water)<br>– Investment will also be required to build workers capacities in order to accurately manage operation and maintenance of the irrigation system<br>– Several suppliers with wide experience exist locally<br>– Water users associations exist to monitor water resources and quality<br>– DBM provide Loan scheme is available for financing purchase of irrigation equipment (80% of project cost up to a ceiling of Rs 2 Million at 8.5 % p.a up to 8 years) |
| **Operation and maintenance** | – Drip irrigation requires regular flushing of irrigation pipes to prevent build up of sediments & cleaning of emitters to avoid blockage from chemical deposits and requires a filter to prevent clogging.<br>– Sprinkler irrigation requires regular cleaning of the component parts. Seals on pipes and sprinkler nozzles should be checked to avoid water leakage.<br>– Training in installation, pipefitting , operation of the system ,general repair, maintenance and irrigation scheduling |
| **Endorsement by experts** | Both drip and sprinkler irrigation system are recognized as climate change adaptation measure to optimise use of water which becoming a scarce resource |
| **Adequacy for current climate** | The technology can support farmers to adapt to climate change by providing efficient use of water supply particularly in areas where water is limited. Drip irrigation reduces demand for water and reduces water evaporation losses. It is applicable to all annual/seasonal moisture deficit agro-ecological zones with flat to gentle slopes |
| **Scale/Size of beneficiaries group** | The technology is applicable to all farming scales (small farms to plantations)having access to irrigation water ( approximately 2000) and can also work in conjunction with rainwater harvesting and greenhouse producers who can use gravity fed irrigation technology for fertigation in production of high value crops . There are currently some 270 greenhouse producers. |
| **Disadvantages** | – Initial investment cost associated with pumps, pipes, tubes, emitters and installation is higher than other systems<br>– Irrigation systems will depend on terrain characteristics, soil structure, crops and water source.<br>– Drip systems may be affected by heavy rainfall that floods emitters and can be damage by rodents or dogs<br>– It can be difficult to combine drip irrigation with mechanised production as tractors and other farm machinery.<br>– Root development may be restricted by the limited soil area wetted.<br>– Regular maintenance inspections are needed to maintain system effectiveness.<br>– Efficiency of sprinkler irrigation system is reduced by wind which affects the distribution pattern.<br>– Labour is required to move the sprinkler system.<br>– Limited regulations for the distribution and allocation of water as a mechanism for conflict resolution.<br>– Irrigation equipment may be stolen from fields. |
| **Capital costs** | |

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| **Cost to implement adaptation technology** | Irrigation system options<br>Drip irrigation = Rs 300,000/ha for hardware + maintenance cost Rs 500/ha/yr<br>Sprinkler irrigation= Rs 200,000/ha for hardware+ maintenance cost Rs3000/ha /yr<br>Family drip kit - Rs10,000 ( recycle blue plastic tank + drippers) for 250 $m^2$<br>Gravity fed drip kit - Rs 30,500 for 1250 $m^2$ ( no power required )<br>**Estimated cost of implementing the micro-irrigation technology per beneficiary Rs 7 585 ( USD)**<br>Total cost for targeted area = Rs 187,125,000 |
| **Additional cost to implement adaptation technology, compared to "business as usual"** | The additional cost of per beneficiary =Rs 2,000<br>Total additional cost (Rs 2000X2680) |
| **Long term cost (i.e. 10, 30, or 50 years) without adaptation** | Crop failure and low yield and low income , field abandonment, affecting livelihood of farmer, food insecurity, wastage of water and less irrigable area |
| **Long term cost (i.e. 10, 30, or 50 years) with adaptation** | The cost of implementing the technology can be easily recovered by higher yield and quality. Micro-irrigation can increase crop yield by 30- 40 % .Construction, maintenance and repair cost will be easily recovered with improve yield in less than 2 years. Improve livelihood of planters & resilience to climate change. |
| **Development impacts, direct and indirect benefits** | |
| **Direct benefits** | It improves water use efficiency and crop yield and quality. It reduces irrigation water cost / enable year round production / improve or stable income |
| **Reduction of vulnerability to climate change, indirect** | Improve food security and resilience to climate change by increasing productivity per unit area and enabling to use the same volume of water to irrigate more crop |
| **Economic benefits, indirect** | |
| **Employment** | Creation of job to support sale , development of tailor -made irrigation design, installation and maintenance to users |
| **Growth & Investment** | can create investment in supplying irrigation equipment and service in installation |
| **Social benefits, indirect** | |
| **Income** | Increase crop yield and quality / increase crop intensity ,thus improving farm income |
| **Education** | Reduces family labour thus leaving more time for other activities – education |
| **Health** | Drip irrigation reduces disease pressure as foliage are kept dry. It presents no health risk. Drip allows application of low volume of water to plant roots and hence optimal growth conditions |
| **Environmental benefits, indirect** | It helps to optimse use of water resources / can be employed in conjunction with other adaptation measures such as integrated nutrient management. Drip can be used for fertigation, thus minimising risk of nutrient leaching and ground water contamination and reduce run off. |
| **Local context** | |
| **Opportunities and Barriers** | **Opportunities**<br>– The technology can be employed in conjunction with other adaptation measures<br>– It can be low-cost (gravity-fed) or more sophisticated (automatic and pressurized ). |

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| | – It enables increase areas of arable land./ cropping intensity ( no. of crops /year)<br>– It contributes to efficient water use, reduces requirements for fertilisers and increases soil prod uctivity.<br>– Drip allows fertigation /Reduced reliance on agrochemicals for weed control<br>– Require less labour/ enable planter to engage other commercial high-value agriculture<br>**Barriers**<br>– It involves a high amount of initial investment<br>– Limited market for repurchased equipment.<br>– Technical conditions such as soil clay presence, irregular rainfall or steep slopes can increase implementation and maintenance costs or affect drip system efficiency<br>– Uncertainty in availability of water for irrigation due to climate change and increasing pressure from other sectors |
| **Market potential** | With water becoming scarce, farmers are concern with the need to optimize use of water .Benefits of micro-irrigation have been demonstrated to growers for production of high value crops. Suppliers of equipment are available locally With water becoming scarce, there is need to scale up this technology in the north, west , south and east of the island to optimize of water use, irrigate more land area and increase productivity by at least 20- 30 %. |
| **Status** | With a decline in rainfall, areas where production was previously under rainfed need to be equipped with irrigation facilities. The technology need to be promoted among a larger number of farmers to help them to cope with decrease in optimising irrigation water use. |
| **Timeframe** | – Implementation can be immediate but may require some leveling in field<br>– Ready- made plastic tank is available.<br>– Technical skill is available for construction of frame to hold tank 3-4 ft above the ground and design and installation of the pipelines and dripper lines /Suppliers of this technology is available locally |
| **Acceptability to local stakeholders** | Technology would be easily acceptable as it would help to improve crop yield and provide a stable income. |

| **Technology: Decentralised rapid pest and disease diagnosis service** (plant clinic) | |
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| **Sector :Agriculture** | |
| **Subsector :foodcrop** | |
| Technology characteristics | |
| **Introduction** | A decentralized pest and disease diagnosis is an innovative/ rapid way to ensure better plant health advisory services for small-scale farmers. It involves delivering primary plant health care to planters through on-site diagnosis in fields for timely management and to mitigate their negative impact on crop production, rationalise use of pesticides and reduce risk of crop loss. It will allow pest & disease to be rapidly managed and contained thus preventing spreading to new areas or fields.<br>This service help to **e**mpower farmers to improve food security and protect the environment |
| **Technology characteristics/highlights** | A decentralized pest and disease diagnosis service requires linking the farmer with an integrated support network consisting of input suppliers (e.g. pesticide supplier), diagnostic laboratories, researchers and national plant protection office (NPPO). This also requires also supports the trained local lead farmers, extension |

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| | officers and researchers with long experience. It also requires the sharing or knowledge in surveillance, pest distribution data gathered, diagnostic techniques, treatment support, integrated pest management and pesticide use.<br>The setting of this technology relies on the support of the extension service to disseminate /delivers free plant health advice to farmers to overcome their plant health problems and improve their crop yield and income. It requires<br>- A mobile plant health clinic that visit main agro ecological zones to provide diagnosis service<br>- training of local lead farmers in scouting, examination and identification of P & Diseases and taking appropriate treatments<br>- Advertising for decentralised plant clinic (banners,posters, radio, TV..)<br>- Field equipment for diagnosis<br>- Pest & disease identification kit /<br>- Field demonstration |
| **Institutional and organizational requirements** | Implementation of this technology requires a broad institutional commitment backed up by the necessary formal agreements between P & D diagnosis /Plant clinic operators, MAIFS, NPPO, Extension services, Researchers and other relevant actors(input suppliers (e.g. pesticide manufacturers), diagnostic laboratories) to ensure its sustainability. The role and responsibilities of all partners is to be clearly defined to create ownership, ensure effective operations and for seeking financial sustainability.<br>AREU Entomology and Pathology Division along with extension can support this project but require an equipped utility van with both light and stereomicroscopes and construction of a specialized mini lab for support in diagnosis to the mobile unit.<br>Access to ITC is required to offer online diagnosis and treatment support information to best assist farmers.<br>Setting of such a service will require expert support and capacity building |
| **Operation and maintenance** | Maintenance of microscopes and equipment will be required. |
| **Endorsement by experts** | Plantwise initiative led by CAB International (Centre for Agricultural Bioscience International, CABI), has supported some 14 countries to establish community–based plant health clinics designed to improve plant health service available to farmers. The aim is to reach small scale farmers and help them to tackle pest and disease problem so as to produce healthy crop and productive yield. The expertise(plant Extension/Entomology / Pathologist) to running a decentralised, mobile plant diagnosis service for potato exist locally and could be upscaled to other major foodcrops such as tomato, crucifers, onion |
| **Adequacy for current climate** | Adequate for present and on-coming climate. |
| **Scale/Size of beneficiaries group** | Some 8,500 planters including large and small farmers as well as general public can benefit from this service . |
| **Disadvantages** | Quality of service may be hampered after natural calamities due to inaccessibility of farm roads. |
| **Capital costs** | |
| Cost to implement adaptation technology | The cost of implementing the service will include<br>1. Utility van<br>2. Construction of mini-diagnosis lab<br>3. Stereomicroscope<br>4. Light microscope/ hand lens<br>5. Resources for regular field visit |

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| | 6. Camera , computers for online diagnosis<br>8. Capacity building of extension and farmers/ publications<br>Estimated cost per implementing the technology per beneficiary/yr = Rs 234<br>Total estimated cost (6375 beneficiaries)Rs 912,500 |
| | Total additional cost per = Rs 580,000 |
| Long term cost (i.e. 10, 30, or 50 years) without adaptation | Increase crop damage and economic loss / food insecurity / farmers becoming more vulnerable. It is reported that some 40 % of the food grown in the world is lost due to pest and diseases before it can be consumed ( CABI, 2006) |
| Long term cost (i.e. 10, 30, or 50 years) with adaptation | Maintenance or repair of diagnosis equipment<br>Continuous training of extension and farmers due to new emerging pest & disease problems |
| **Development impacts, direct and indirect benefits** | |
| **Direct benefits** | Decrease crop damage by pest and disease. Reduce expenses on pesticides, improve crop yield , farm income and farmers livelihood |
| **Reduction of vulnerability to climate change, indirect** | Improve farmer capacity to deal with outbreak of pest and disease and reduce risk of crop damage<br>The technology contributes to climate change adaptation at planters level primarily through:<br>-Provision of advice to planters on how to handle diseases problems through on -site diagnosis,<br>-monitoring pest and diseases outbreak and act as surveillance |
| **Economic benefits, indirect** | |
| **Employment** | The setting up of such rapid diagnosis service will require additional staff |
| **Growth & Investment** | The mobile clinic is expected to play a major role in assisting the planters to better manage diseases in their crops. / increase crop yield and reduce dependence on imports |
| **Social benefits, indirect** | |
| **Income** | With timely management of diseases via on-site diagnosis, increase in agricultural production with judicious use of pesticides is expected. Thus, decreasing the cost of production for planters which in the long run will increase their income |
| **Education** | Improve knowledge for the plant pathologists when regularly confronted with different disease situations in the field itself, for e.g, occurrence period of diseases, climatic conditions and management practices. |
| **Health** | With a decrease in the use of pesticide due to timely management of diseases, both planters and consumers will be less exposed to pesticides; planters while spraying less in their plantation and consumers while consuming agricultural produce free from pesticides. |
| **Environmental benefits, indirect** | With a reduction in the use of pesticides, environmental pollution will be reduced. |
| **Local context** | |
| **Opportunities and**<br><br><br><br>**Barriers** | **Opportunities -**The establishment of the mobile plant clinic will give opportunities to planters to improve their livelihood by serving them rapidly and efficiently on-site. It will also allow planters' fields to be under continuous disease surveillance in cases of new disease emergence and epidemics.<br>**Barriers**<br>- inaccessible fields and funding to sustain the service over time<br>-limited information sharing for effective monitoring and reporting for control<br>-weak national ownership and commitment |

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| | - to make the service sustainable over long term ( may charge for diagnosis) |
| **Market potential** | This service provision can be adopted by public or private sector as a service to the farming community |
| **Status** | Plant Pathology Laboratory of AREU has experience in running a similar rapidly and efficient pilot pest and disease diagnosis service for potato growers during the growing season but due to lack of fund the service has stopped. The service need to be revived, expanding /upscaling to a larger number of crops (onion ,tomato, cucurbits, crucifers,…)to service farmers in the main agro ecological zones . |
| **Timeframe** | Implementation will be as soon as the utility van equipped with the microscopes is made available. |
| **Acceptability to local stakeholders** | The easy accessibility and quality of this quality service with trained and equipped personnel is likely to increase its acceptability by the farming community and general public to help to efficiently deal with pest and disease problems. |

**Annex 6(b)**

Technology Fact Sheet for Adaptation

| **Technology: Restoration of coastal vegetation** | |
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| **Sector : Coastal Zone** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | 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. Salt marshes, mangroves, and seagrasses, part of coastal wetlands play the same role and in addition are reservoirs of natural, free, and sustainable carbon storage potential. This is jeopardized by alarming trends in coastal habitat loss, totaling 30–50% of global abundance over the last century alone. [1] Introduction of exotic vegetation species has been party responsible for this decline. Non-native species disrupt vegetative communities, pollination cycles, water use, nutrient transfer, and patterns of erosion. |
| Technology characteristics/highlights | This technology consists of :<br>• Removal of exotic vegetation<br>• Additional research (when necessary) to identify native vegetation species. Sometimes the plants would need to be produced first in nurseries or plants could be salvaged from ecologically similar sites, and used in restoration to decrease the recovery time.<br>• Re-vegetating the dunes or wetlands with native plants.<br>• In case of wetlands: preparing the soil increases the successful growth of plants and often includes loosening of compacted soils and addition of organic material, such as decaying leaves.<br>• In case of dune restoration, fencing of replanted areas and building pedestrian dune crossings is complementary to re-vegetation efforts.<br>• Stream bank stabilization methods, often required for wetland restorations along stream channels generally include use of plants (either as live plants or seeds) in combination with natural or artificial fiber rolls or mats.<br>• Ongoing management |
| Institutional and organizational requirements | This technology is in line with government's national priorities in implementing adaptation activities to reduce the adverse impacts of and risks |

[1] Irving AD, Connell SD, Russell BD (2011) Restoring Coastal Plants to Improve Global Carbon Storage: Reaping What We Sow. PLoS ONE 6(3): e18311. doi:10.1371/journal.pone.0018311

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| | posed by climate change in Mauritius. Restoration of coastal vegetation projects normally relies on community participation and requires hands on training about different plant species and their usefulness in protecting shorelines. |
| Operation and maintenance | An ongoing commitment to weed and animal pest management is needed until the plants have successfully established. It may also be necessary to maintain coastal planting by replanting areas that have been damaged by slips and harsh coastal conditions. |
| Endorsement by experts | Internationally, coastal vegetation is recognized as a natural tsunami mitigation strategy that is cheap, easy and locally beneficial. |
| Adequacy for current climate | Fits well, both for present and expected climate |
| Scale/Size of beneficiaries group | Beneficiaries groups include residents, beach users and industries dependent of healthy coastal ecosystems (e.g. fisheries and tourism). |
| Disadvantages | For the investment in restoring coastal vegetation to be most effective, this technology should be made part of wetland and dune restoration efforts and other hard defenses such as dikes or seawalls. See opportunities and barriers section for more information. |
| Capital costs | |
| Cost to implement adaptation technology | The Adaptation Fund project for Mauritius has provided estimates for beach crest vegetation at Riviere des Gallets (US$20,000 for 60m) and Mon Choisy (US$30,000 for 100m) that correspond to Rs9,400/m and Rs8,460/m, respectively. This gives an average cost of around **Rs9,000/m**.<br><br>Information obtained from the practical experience of the Beach Authority puts the cost of re-vegetation of a beach with endemic species, including labour and fencing costs, at Rs 40,000 for an area 15m x 90m. This translates into **Rs 444/m** with a 15m re-vegetated area across the dynamic beach.<br><br>Please note that the cost does not include removal of Casuarina trees from the dynamic beach. This would add significantly between Rs1,000 and Rs10,000 depending on size and quantity of trees, and accessibility of terrain (ICZM Division, Ministry of Environment & SD). |
| Additional cost to implement adaptation technology, compared to "business as usual" | The above cost is additional since no re-vegetation is carried out in the baseline or 'doing nothing' scenario. Vegetation is the most effective method of stabilizing coastal dunes. The preservation of dunes prevents sediment deficit and subsequent erosion, thus mitigating the need for more costly erosion prevention or compensation operations. |
| Long term cost (i.e. 10, 30, or 50 years) without adaptation | Limited ability of wetland and dune ecosystems to protect shoreline from erosion and onland from storms. Increased vulnerability and a sense of insecurity in coastal areas. |
| Long term cost (i.e. 10, 30, or 50 years) with adaptation | Ongoing implementation of coastal management plans and protection of coastal vegetation. |

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| Development impacts, direct and indirect benefits | |
| Direct benefits | Reduced rate of erosion during cyclones and fast rate of recovery of the shoreline. |
| Reduction of vulnerability to climate change, indirect | Reduction in human casualties, reduction in physical damage to property and contribution to resilient coastal ecosystems. |
| Economic benefits, indirect<br>Employment<br><br>Growth & Investment | <br>The tourism industry could benefit as native coastal vegetation creates a beach environment unique to Mauritius.<br>Reduced risk of damage from surges and erosion could save considerable amounts of money which would otherwise go towards maintenance and repairs of hard defenses. Also native plants require less maintenance and save energy – planted properly, they require little or no extra water, fertilizer, or pesticides. In addition, they display resistance to insects and disease and often attract desirable wildlife including birds, butterflies, and pollinators. |
| Social benefits, indirect<br>Income<br><br>Education<br><br>Health | <br>Job security and maintenance of current quality of life, as the beach is maintained<br>Community awareness of National's adaptation plans and understanding of natural ecosystems<br>Lowered risk from surge flooding. |
| Environmental benefits, indirect | <br>In the long term, coastal vegetation modifies shorelines in a ways that increase its integrity and thus provide a lasting coastal adaptation measure that can protect against accelerated seal level rise and more frequent storms. |
| Local context | |
| Opportunities and Barriers | A possible barrier to keep in mind is that it is crucial for people and animals to stay off the newly planted areas for the period it takes the plants to become established. To educate people about this, restoration programs can be linked to environmental education initiatives that also aim at re-establishing an appreciation for naturally functioning coastal landscapes.<br><br>Property owners, who have removed native vegetation and natural debris and replaced it with non-native ornamentals, might argue to keep it that way. |
| Market potential | Not a market technology. Generally technology initiated by government incentives and carried out by NGOs and volunteers. |
| Status | Re-establishment of native coastal vegetation and removal of the Filao trees is one of the actions recommended in Ministry of Environments, Mauritius Coastal Erosion report. |
| Timeframe | The technology can be implemented in conjunction with dune restoration and raising public awareness of their importance. The vegetation should only |

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| | require maintenance in the medium term, and become part of the ecosystem in the long term. |
| Acceptability to local stakeholders | Property owners, who have removed native vegetation and natural debris and replaced it with non-native ornamentals, might argue to keep it that way. |

| **Technology: Coastal Wetland Protection and Restoration** | |
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| **Sector : Coastal Zone** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. They induce wave and tidal energy dissipation (Brampton, 1992) and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilise shore sediments, thus reducing erosion (USACE, 1989). 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 diversity of wetland types means there are numerous methods for restoring wetlands. The method adopted will depend on the habitat which is being restored. |
| Technology characteristics/highlights | The most commonly restored wetland ecosystems for coastal protection are salt marshes and mangroves. Sea grass may also be employed as a coastal defense, to dampen waves but on their own are seldom considered an adequate shore protection alternative.<br>Salt marshes are widely re-established:<br>• through managed realignment schemes.<br>• whilst maintaining the present coastline position through vegetative transplants from healthy marshes, and<br>• may require the site's elevation to be raised using appropriate fill material.<br><br>Mangrove restoration includes:<br>• collecting plant propgules from a sustainable source,<br>• preparation of the restoration site for planting at regular intervals at an appropriate time of year<br>• Establishment of nurseries to stockpile seedlings for future planting<br>• Planting dune grasses. These grasses provide a stable, protective substrate for mangroves to establish their root systems in. |
| Institutional and organizational requirements | At a local level, proactive measures can be implemented to ensure wetland habitats are maintained and used in a sustainable manner. This will preserve habitats into the future, reduce or even avoid the cost of restoration and planting schemes and avoid the many potential problems encountered in the course of wetland restoration efforts. It is important that the multiple agencies involved in shoreline management avoid providing conflicting guidance (e.g. clear mangroves because these areas are a breeding ground for malaria-transmitting mosquitoes v. Valuing the ecosystem services provided by mangroves, including their coastal protection function). At a larger scale, it is useful for governments to adopt proactive coastal management plans to protect, enhance, restore and create marine habitats. Without such a framework, action to restore wetlands is likely to be fragmented and uncoordinated. |

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| Operation and maintenance | In contrast to hard defenses, wetlands are capable of undergoing ‘autonomous’ adaptation to SLR, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level. Provided wetlands are not subjected to coastal squeeze, and the rate of SLR is not too rapid to keep pace, wetlands are capable of adapting to SLR without further investments. |
| Endorsement by experts | The restoration and recreation of wetlands can also reduce or even reverse wetland loss as a result of coastal development. This is important in terms of maintaining the global area of wetlands and in sustaining wetlands in the face of climate change. Wetland creation may also fulfill legal obligations for the compensation of habitats lost through development, treatment of wastewater and reduction on non-point pollution. Evidence from the 12 Indian Ocean countries affected by the 2004 tsunami disaster suggested that coastal areas with dense and healthy mangrove forests suffered fewer losses and less damage to property than those areas in which mangroves had been degraded or converted to other land use (Kathiresan & Rajendran, 2005). |
| Adequacy for current climate | Fits well, both for present and expected climate. |
| Scale/Size of beneficiaries group | Wetland creation can bring about various economic, social, and environmental benefits to local communities (see direct and indirect benefits section below). |
| Disadvantages | The disadvantages of wetland restoration are minimal. One possible disadvantage is the space requirement in locations which are often of high development potential (but also increasingly high flooding potential). Wetland restoration is also likely to require a degree of expertise, especially in locations where wetland re-colonisation has to be encouraged by transplanting wetland plants and wetland habitats are difficult to recreate. |
| Capital costs | |
| Cost to implement adaptation technology | Different types of wetland will require different restorative measures with varying costs and labour requirements. A number of factors which are likely to contribute toward variations in costs are given below (Tri et al. 1998):<br>• Type of wetland to be restored, expertise availability, and consequent chances of success<br>• Degree of wetland degradation and consequent restoration requirements<br>• Intended degree of restoration (for example, it may not be possible to restore all the ecosystem functions of a wetland if it is located in a highly industrialised/urbanised environment and the planned restoration measures may be less ambitious)<br>• Land costs if land purchase is required to convert to wetlands<br>• Labour costs<br>• Transportation distance between seedling source and planting site<br>• Seedling mortality rate between collection and planting<br>• Cost of raising specific species in nurseries before transplantation because they cannot be directly planted on mud flats due to strong wind and wave forces<br>In general, restoring wetlands costs US$3,500 to $80,000 per acre |

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| | (http://www.bnl.gov/erd/peconic/factsheet/wetlands.pdf). This translates into costs of the order of Rs~6,000/m to Rs~141,000/m for 25m wide restored areas.<br><br>Mangrove plantation at Mon Choisy, Mauritius has been estimated at **Rs5,640/m** (Adaptation Fund project, pp54-55)<br><br>Restoration of estuarine areas in Australia (Dumaresq island and Tuross) have cost between Rs750/m to Rs1,250/m.<br><br>Tri et al. 1998 have studied the cost of establishing mangroves in Vietnam, and found cost of plantation to be US$41/ha (in 2009 prices). Assuming that the width of the mangrove plantation was 25m, this corresponds to a cost of **Rs31/m**. This cost includes the cost of planting and thinning 6 years onwards. |
| Additional cost to implement adaptation technology, compared to "business as usual" | To make the case for wetland protection, flood mapping might be a necessary pre requisite as well as educating the public about usefulness of wetlands for coastal eco-system protection and preservation.<br>Scale of post-implementation monitoring operations might also affect the cost. |
| Long term cost (i.e. 10, 30, or 50 years) without adaptation | Low water quality, coast erosion and flooding. |
| Long term cost (i.e. 10, 30, or 50 years) with adaptation | Because the wetlands require little maintenance, long-term costs are quite low and are mainly due to monitoring program of sediment retention and its ability of dealing with contaminants. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | The restoration of natural ecosystem services, including flood and erosion protection benefits. Coastal wetlands improve the productivity of coastal waters for fishing and offer recreation opportunities. Coastal Wetlands are a sustainable source of timber, fuel and fibre. |
| Reduction of vulnerability to climate change, indirect | Reduction in physical damage to property, source of sustainable materials and reduction in human casualties in case of large waves caused by storms. |
| Economic benefits, indirect<br>Employment<br><br><br><br><br><br><br>Growth & Investment | <br>Given the importance of the fishing sector in many coastal communities in developing countries, coastal wetlands are highly beneficial. Improved fishing effect may increase incomes of local communities and contribute toward local sustainable development. Other goods and services provided by wetlands, such as the provision of wood and fibers could also prove highly beneficial to local communities, especially in developing countries.<br><br>Wetland recreation can also create opportunities for eco-tourism and increase recreational opportunities. |
| Social benefits, indirect<br>Income<br>Education | <br>See above.<br>Creation of wetlands, especially in or in close proximity to urban areas can even serve to increase awareness of the important functions performed by |

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| Health | these habitats.<br>Improved water and habitat quality with lowered risk of storm flooding |
| Environmental benefits, indirect | 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. |
| Local context | |
| Opportunities and Barriers | **Opportunities:**<br>There is an opportunity to implement wetland restoration or creation together with hard defenses such as dikes or seawalls. In such a case, the presence of wetlands on the seaward side of the defense leads to lower maintenance costs over the lifetime of the structure.<br><br>**Barriers:**<br>The establishment of wetlands which provide full coastal flood and erosion protection takes time, and the approach does not offer immediate benefits. As such, wetland recreation may not be practicable where coastal management is reactive and focused on hard defenses. A desire to improve wetland habitats also needs to exist before the strategy can go ahead. This may involve raising public awareness of the benefits of wetland restoration and (re)creation, the lack of which is itself one of the most significant barriers. |
| Market potential | The technology has been in use for past 20-30 years worldwide. The market for learning from successful implementation and management restoration and protection projects exists worldwide. |
| Status | Tourism Development Plan for Mauritius calls for initiatives that will maintain a pristine coastal zone. They call for wetlands protection through prohibitation on filling in wetlands and destroying mangroves. The Ministry of environment has retained consultants to assess the environmental risks in the Grand Baue area specifically with respect to the development of wetland areas and the potential impact on flooding and water quality. |
| Timeframe | Short term to Medium Term |
| Acceptability to local stakeholders | Without additional understanding, local communities might oppose the restoration of coastal wetlands, seeing it as a loss of land with development potential. |

| Technology: Dune Restoration | |
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| **Sector : Coastal Zone** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Coastal environments are considered among the most vulnerable to changes from climate change, including direct changes (e.g. changes of temperature and precipitation) and indirect changes (e.g. sea level rise, wind and water circulation, increasing storm events). With rising sea levels, there will be more frequent and more serious flooding of low-lying coastal areas by extreme tides, storm surges, and wave effects. 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. |
| Technology characteristics/highlights | Technologies used here are quite low tech and most of the time rely on the local natural material and community volunteering and monitoring services. Dune restoration involves:<br>• Removal of exotic vegetation (e.g. Casuarina trees) that dramatically reduces dune effectiveness.<br>• Filling and re-grading the slope with bulldozers.<br>• Installing sprinkler or drip systems<br>• Constructing dune walkovers to protect from erosion caused by human access<br>• Re-vegetating with native dune plants. Additional research might also be needed to identify key vegetation species that need to be produced.<br>• The application of fences to stabilise bare sand, encourage dune growth and protection.<br>• Monitoring and maintaining the dune. |
| Institutional and organizational requirements | Dune restoration projects could involve many volunteers that require hands on training about effectiveness of different grass species in dune restoration. In case of community based dune restoration programs – this is seen as a part of an education process that raises awareness of likely coastal hazards if dunes are not preserved. 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 restoration projects around the country. |
| Operation and maintenance | Movement and reshaping of the material is achievable with limited technology requirements. The use of a bulldozer or other earth moving equipment is sufficient to undertake ad-hoc operations to reshape or repair dunes. Sediment may even be bulldozed from dune crests and placed in lower areas if the dune crest height exceeds design specifications. |

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| Endorsement by experts | Dune protection meets multiple management objectives, such as habitat protection, public access to environmental and recreational resources and hazard mitigation. Because of these benefits and the fact that they are less expensive and more aesthetically pleasing than some engineering solutions, dunes have found broad public support in United States, Australia, Canada, New Zealand, United Kingdom, Spain and Netherlands.<br><br>The Baird Report (2003) specifically mentions in the case of Mauritius that healthy dunes must be vegetated with endemic species, which have evolved over thousands of years, are able to survive sand accumulation, flooding, salt spray, sandblast, wind and water erosion, temperature fluctuations, drought and low nutrient levels. |
| Adequacy for current climate | Fits well, both for present and expected (future) climate change. |
| Scale/Size of beneficiaries group | Beneficiaries groups include residents, beach users and industries dependant of healthy coastal ecosystems (e.g. fisheries and tourism). |
| Disadvantages | Reconstruction of dunes may receive local opposition if it affects communities' direct access to beaches and views straight onto the sea. Land loss is another issue; dunes have a reasonable sized footprint. It could be controversial to use land with development potential for dune restoration if the full benefits are not made clear. There might also be an opposition to restoring natural dunes as they could sometimes be seen to be untidy and aesthetically not pleasing. |
| Capital costs | |
| Cost to implement adaptation technology | Since the most basic sand dune construction projects consist simply of the deposit of *dredged* material onshore, followed by shaping using bulldozers, simple dune construction costs are not expected to be significantly different from beach nourishment costs in terms of cost per cubic meter of sediment used.<br><br>Expert information obtained from the ICZM Division of the Ministry of Environment and SD shows that the cost of dune restoration will be of the order of **Rs 2,500 per $m^3$ of sand refilled**.<br><br>The cost of beach nourishment has been estimated at an average of **Rs75,000/m** (please see corresponding Technology Fact Sheet).<br><br>Additional costs may however, be introduced through the requirement for dune grass planting, fencing, board walks, and establishment of appropriate demonstration sites and development of realistic guidelines and protocols for restoration: important steps in convincing stakeholders that return to a more natural system is achievable and desirable.<br><br>Typically, dune restoration is accompanied with revegetation for better impacts. The cost associated with the regeneration of coastal vegetation has been estimated at **Rs 444/meter** of beach. Please see the relevant Technology Fact Sheet for more details.<br><br>Factors which are likely to influence the unit costs of dune construction are:<br>• Whether dredged material is required for dune |

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| | construction/restoration or whether fences or vegetation can be used to promote sand accumulation<br>• Availability and proximity of appropriate construction material from onshore or offshore sites<br>• Dredger type, size and availability<br>• Requirement to fence newly constructed dunes to prevent erosion<br>• Requirement for planting new dunes with vegetation<br>• Frequency with which the dune needs to be artificially replenished or whether the structure naturally accumulates sand<br>• Project size and resulting economies of scale |
| Additional cost to implement adaptation technology, compared to "business as usual" | There is no additional cost to implement the technology since it is the same cost without or with climate change. |
| Long term cost (i.e. 10, 30, or 50 years) without adaptation | Erosion of beaches, damages to coastal real estate by waves. |
| Long term cost (i.e. 10, 30, or 50 years) with adaptation | Ongoing dune maintenance. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | Dune stabilization, maintenance of a buffer zone and restoration of healthy coastal ecosystem. |
| Reduction of vulnerability to climate change, indirect | Reduction in physical damage to property and lives lost during storms. |
| Economic benefits, indirect<br>Employment<br><br>Growth & Investment | <br>Restoration of dunes will preserve the beaches ecosystems the tourist and fishery industries depend on.<br>Increased market value for traditional and industrial economies (residences, resorts, mines). Can create investment in specialist study for the combination of native plants best suited for dune environment. |
| Social benefits, indirect<br>Income<br><br>Education<br><br>Health | <br>Job security and maintenance of current quality of life, as the beach is maintained<br>Dune restoration projects can be practical activities for environmental education initiatives.<br>Dunes provide sites for active recreation, have aesthetic, psychological, therapeutic opportunities. |
| Environmental benefits, indirect | Provision of nesting sites, habitable substrate, refuge areas for wildlife and food for higher trophic levels of the food chain. Dune systems also filter pollutants and in some cases contain groundwater reservoirs. |
| Local context | |
| Opportunities and Barriers | **Opportunities:**<br>Dune restoration can be much more than mitigation or reparation, in that it can lead to increased understanding and appreciation of a threatened ecosystem. Restoration programs can be linked to environmental education initiatives aimed at re-establishing an appreciation for naturally functioning coastal landscapes. This may increase the likelihood of implementing similar |

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| | programs elsewhere.<br><br>**Barriers:**<br>See acceptability to local stakeholders. |
| Market potential | Not a market technology. Generally technology initiated by government incentives and carried out by NGOs and volunteers. |
| Status | Mauritian Ministry of Environment conducted a study on coastal erosion. 21 public beach sites were identified as potential erosion sites, 15 of which were found to be in need of beach stabilization. The technology is presently being implemented at some locations. |
| Timeframe | Can be implemented immediately with adequate communication measures to ensure public cooperation. Maintenance must be continued over the medium and long term. |
| Acceptability to local stakeholders | A possible barrier could be local opposition and competition with development plans and interests (see Disadvantage box). A particular concern is that private landowners and hotels undertake their own remedial measures (usually trying to save a beach using seawalls) that are poorly informed, leading to adjacent beach loss. |

## Technology: Rock Revetment

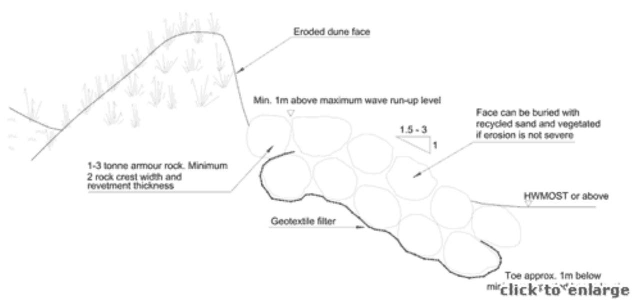
## Sector : Coastal Zone

## Subsector :

Technology characteristics

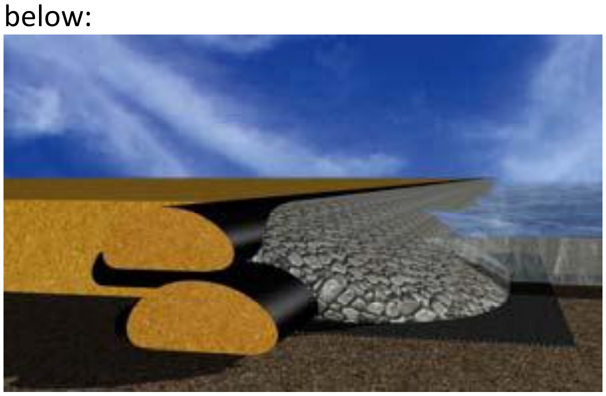
**Introduction**

A revetment is a sloped facing of stone, concrete or other durable materials build to protect a scarp or embankment against erosion by wave action (Baird & Associates – Reef Watch, 2003). In this Fact Sheet, some reference may be is made to sea walls, as a revetment can be viewed as a sloped sea wall. Vertical sea walls reflect wave energy, whereas sloped sea walls (or revetments) also dissipate this energy.




Cross-sectional view of revetment.

Revetments can also be carried out using synthetic geotextile technology in conjunction with vegetation techniques. An example of revetment is illustrated below:



**Technology characteristics/highlights**

- Depends on the underlying embankment for support.
- Can be considered as flexible as the structure can endure some settlement or other movement without failing.

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| | • The size of the material depends on the severity of the current or wave attack.<br><br>(Baird & Associates – Reef Watch, 2003) |
| Institutional and organizational requirements | At present, the advice given in developing countries for modern seawall construction appears to be informal, if given at all. If effective design and construction is to occur, local communities must be given at least basic design guidance. This may come from government or voluntary organizations.<br><br>The design and construction of revetments is relatively straightforward for experienced practitioners. Additionally, contractors can achieve good outcomes, as can land manager works teams with general civil experience supervised by an experienced coastal engineer.<br>Some complexities and sensitivities in design include:<br>• estimating design conditions (wave or flow dominance)<br>• consideration of existing bank conditions and history of change<br>• selection and specification of filter layers and geotextiles<br>• ensuring the toe is well founded and risk of undermining is low<br>• appropriate crest height with consideration of overtopping scour, amenity and drainage<br>• specification of locally available materials<br>• site access<br>• maintaining public access<br><br>(Swan River Trust, 2009) |
| Operation and maintenance | The design life of revetments depends on the initial design conditions and maintenance regime. A robustly designed and constructed revetment should have a design life in excess of 20 years, with a modest degree of maintenance. Generally, a significant maintenance exercise would be required in the first few years of construction as the structure settles and is bedded down. Inspections undertaken biannually and following severe storms and floods would determine the ongoing maintenance requirements. Maintenance of well designed and constructed revetments should be limited to occasional repacking and replacement of armour. Other types of structures may be more dependent on the maintenance regime for their intended design life.<br><br>Responsive approaches to a severe erosion event (emergency works) often result in poorly sized and poorly interlocked dumped rock revetments. These structures may meet the immediate needs of the foreshore manager but require a high level of ongoing maintenance or significant upgrade to meet engineering standards, provide a reasonable design life and maintain the amenity of the foreshore (Swan River Trust, 2009). |
| Endorsement by experts | Rock revetments are a well-accepted method of coastal protection worldwide. |
| Adequacy for current climate | Adequate for current climate. May support dune and vegetation preservation and restoration. |
| Scale/Size of beneficiaries group | Variable depending on location. Beneficiaries may be villages, touristic developments, cultural sites, coastal infrastructures such as roads. |

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| Disadvantages | • Revetments do not address the root cause of erosion. The underlying erosion process will continue unabated and any beach that is present will gradually diminish in width and eventually disappear altogether. Beach loss may be accelerated by wave reflection from the structure (Baird & Associates – Reef Watch, 2003).<br>• By encouraging development, hard defences necessitate continued investment in maintenance and upgrades, effectively limiting future coastal management options. Although authorities may not have a responsibility to continue providing protection, the removal of defences is likely to be both costly and politically controversial.<br>• In the absence of a seawall (or revetment), natural shoreline erosion would supply adjacent stretches of coastline with sediment, through a process known as longshore drift. Once a seawall is constructed however, the shoreline is protected from erosion and the supply of sediment is halted. This causes sediment starvation at sites located alongshore, in the direction of longshore drift and this has the capacity to induce erosion at these sites.<br>• The down-drift end of the seawall (or revetment) is also typically subjected to increased erosion as a result of natural processes. This flanking effect can cause undermining and instability of the wall in extreme cases.<br>• Seawalls increase security by reducing the risk of flooding and erosion. However, the coastal zone remains a high risk location not least due to the presence of residual risk. To combat unwise development of the coastal zone, future developments need to be carefully planned. |
| Capital costs | |
| Cost to implement adaptation technology | Construction costs (particularly at the time of writing) are highly variable and can escalate rapidly. Factors influencing price include proximity of quarry, availability of required size range, demand, site access and complexity of design. Unit rates for the construction plant and operators can vary depending on needs for smaller bobcats to larger excavators and loaders.<br><br>A price schedule for a larger revetment should typically include the following items.<br>• Preliminaries: insurances; mobilisation of plant and equipment; site establishment; survey; construction management plans.<br>• Materials (supply, deliver and place): armour (various size ranges or classes) core; geotextile.<br>• Plant hire: excavator; loader<br>• Reinstatement works: as-constructed survey; demobilisation; and site clean-up. (Swan River Trust, 2009)<br><br>For these reasons, it is difficult to provide a cost estimate.<br><br>In Wicklow (Ireland), a revetment for coast protection of the frontage north of the Broad Lough Bridge was installed at a cost of approximately €6,300 per meter – i.e. about Rs 239,000/m (The Murrough Coastal Protection Study – RPS Consulting Engineers).<br><br>Cost estimates of a rock revetment provided by Beach Authority: ~**Rs 100,000/m**.<br><br>[Rocks are obtained for free. However, situation can be expected to change when MAAS |

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| | has been completed. In that case, the cost could be similar as in the case of Wicklow assuming that cost of rock was Rs 400 / ton.]<br><br>Information obtained from the ICZM Division, Ministry of Environment & SD puts the cost of rock revetment as **Rs40,000/m**.<br><br>The cost of carrying out revetments with synthetic geotextile technology has been estimated to be around one third of the cost of conventional rock revetments, while providing the similar level of protection. (http://www.geofabricsinternational.com/webfiles/GeofabricsInternationalAU/files/TP-Cost_effective_coastal_protection_works_using_sand_filled_geotextile_containers.pdf) |
| Additional cost to implement adaptation technology, compared to "business as usual" | The cost of implementing the technology can be recovered at the level of the local economy, thanks to direct and indirect benefits provided (see next section). |
| Long term cost (i.e. 10, 30, or 50 years) without adaptation<br><br>Note: This comment is extended to coastal protection of the island at large. | With regard to economic losses associated to no coastal protection, if no action Is taken, then the total cost to the island of Mauritius, which would have to be made by other sources of revenue, would be US$ 3.362 billion over 50 years, which is a composite of loss of beach tourism revenue ($2.55 billion), the cost of making repairs to coastal infrastructure and buildings ($0.5 billion), and the cost of re-locating communities which are exposed to storm surges and frequent flooding ($312 million). |
| Long term benefits (i.e. 10, 30, or 50 years) with adaptation<br><br>Note: This comment is extended to coastal protection of the island at large. | Reinforcement of coastal infrastructure and development of coastal defences will save US$ 0.5 billion in infrastructure repair costs over 50 years. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | • Revetments are primarily intended to control the erosion of the backshore (i.e. the land behind the structure) due to direct wave attack – this will block the dynamic removal and return of dune material during and following a storm.<br>• If appropriately designed, revetments and sea walls have a high amenity value – in many countries, seawalls incorporate promenades which encourage recreation and tourism.<br>• Potentially long-lived structures provided they are adequately maintained.<br>• Direct economic benefit by growth in material and construction expertise demand. |
| Reduction of vulnerability to climate change, indirect | Reduction in physical damage to property, infrastructure and economic output (caused by evacuated facilities). |
| Economic benefits, | |

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| indirect<br>Employment | Creation of jobs:<br>• For leisure, touristic or other commercial activities on the amenities provided necessary agreements are made or permits are issued.<br>• Supporting associated operations, such as quarry operations or construction of infrastructures and operating loading equipment.<br>• For the implementation of complementary coastal protection technologies. |
| Growth & Investment | Can create investment in:<br>• Supplying equipment and service in installation.<br>• Specialist coastal erosion studies for guiding maintenance, upgrade and complementary operations. |
| Social benefits, indirect | |
| Income | Potential income from above-mentioned employment and investments. |
| Education | Increased awareness of SLR, flooding risks and coastal protection for development. |
| Health | Similarly to sea walls, revetments provide coastal flood protection against extreme water levels. |
| Environmental benefits, indirect | • Causes problems of sediment starvation<br>• Potential re-growth of vegetation and marine life on the revetment. |
| Local context | |
| Opportunities and Barriers | **Opportunities:**<br>• Seawall construction is one of several options available when high value land cannot be protected in other ways. The approach provides a high level of protection to valuable coastal areas although the long-term sustainability of the approach should also be taken into account.<br>• Less technologically advanced designs can be implemented at local levels, utilising local knowledge and craftsmanship. This requires less investment and a reduced need for involvement of large organisational bodies such as national or sub-national government or non-governmental organisations (NGOs). While ad-hoc implementation is possible, technological guidance from expert organisations is desirable to ensure sufficient levels of protection.<br>• Seawalls can also be implemented as part of a wider coastal zone management plan which employs other technologies such as beach nourishment and managed realignment. Placement of seawalls inland, following managed retreat, reduces interference with coastal zone processes and creates a buffer zone to protect against coastal flooding and erosion (French, 2001). The seawall therefore acts as a last line of defence. Use of seawalls in conjunction with beach nourishment can also address some of the negative impacts of seawall construction, such as beach lowering and down drift erosion.<br>**Barriers:**<br>• Cost: The design of an effective seawall requires good quality, long-term environmental data such as wave heights and extreme sea levels. This is |

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| | frequently unavailable in developing countries and can be costly to collect. Secondly, because seawalls are frequently exposed to high wave loadings, their design must be highly robust, requiring good design, significant quantities of raw materials and potentially complicated construction methods. In locations of high energy waves, additional cost must be expended on protective measures such as rip-rap (Wide-graded quarry stone normally used as a protective layer to prevent erosion (Coastal Research, 2010)) to protect the structure's toe.<br>• A case study from the Pacific island of Fiji (Mimura & Nunn, 1998) shows seawall construction to be very costly even when local materials were utilised in conjunction with other materials supplied by the government. Seawall construction in Fiji consumed the villagers' time and also required significant time and money to be spent on the provision of catering services for workers.<br>• The availability of experience, materials, labour and specialised machinery for the construction of seawalls may also pose a barrier to the implementation of this technology.<br>• French (2001) recommends proactive construction of seawalls at some distance inland. This reduces interference with coastal processes and creates a buffer zone to protect against coastal flooding and erosion. A key barrier to this type of approach lies in convincing and educating landowners of the necessity for, and benefits of, these measures (Mimura & Nunn, 1998). |
| Market potential | Yes, construction contractors may develop expertise with this technology and bid for works tendered. |
| Status | Practiced. The recent Adaptation Fund proposal entitled "Climate Change Adaptation Programme in the Coastal Zone of Mauritius" mentions that revetments and sea walls have been implemented in the past as 'stop-gap' measures within the dynamic beach zone leading to local scour. These technologies have had limited life spans. |
| Timeframe | Short term, with long term maintenance and upgrades. |
| Acceptability to local stakeholders | Seawalls (or revetments) may reduce beach access for handicapped people and for emergency services. This can be problematic if the beach fronting such structures is to be used for recreation. The appearance of seawalls can be aesthetically displeasing which can further negatively affect beaches dependent upon a tourist economy. |

**Annex 7(b)**

# Technology Fact Sheet for Mitigation

| **Technology: Wind (on-shore) utility-scale** | |
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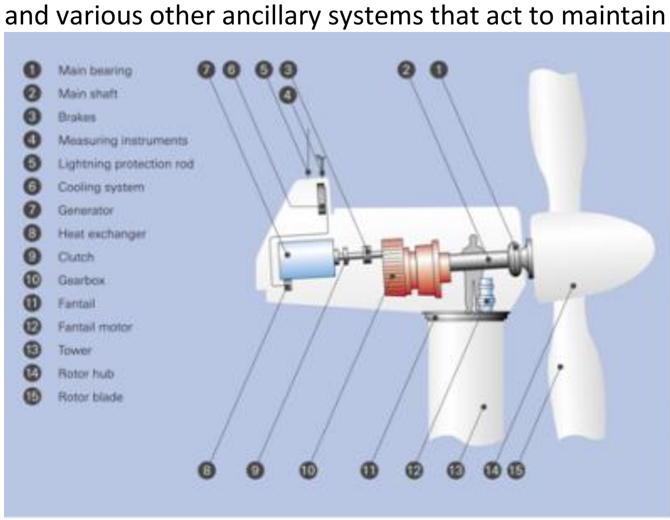
| **Sector : Energy** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Besides conventional hydropower, onshore large-scale wind energy is presently the cheapest form of renewable energy. At locations with a good level of wind resource, it can be cost competitive with some forms of traditional/thermal power production. Global wind energy capacity has been growing very rapidly over the past decade. In 2009, newly installed capacity was more than 34GW (GWEC, 2010) representing more than 25% of total new generation capacity globally. In 2009 wind energy contributed approximately 1.8% of worldwide electricity demand, a percentage that has doubled since 2006 (Wiser and Bolinger, 2010). |
| Technology characteristics/highlights | A large wind turbine primarily consists of a main supporting tower upon which sits a nacelle (the structure containing the mechanical to electrical conversion equipment). Extending from the nacelle is the large rotor (three blades attached to a central hub) that acts to turn a main shaft, which in turn drives a gearbox and subsequently an electrical generator (Fig 1). In addition to this there will be a control system, an emergency brake (to shut down the turbine in the event of a major fault) and various other ancillary systems that act to maintain or monitor the wind turbine.<br><br><br>Figure 1: Cut-away view of a typical wind turbine (source ZF, 2010)<br><br>Modern turbines reach a conversion efficiency of approximately 50 percent, close to the theoretical limit (59%) and very close to the practical limit that is imposed by the drag of the blades. Nevertheless there is a significant body of ongoing global R&D into construction methods/materials for larger turbines, conversion efficiency refinements, lower cost components and improved reliability. |
| Institutional and organizational requirements | There is extensive experience in many countries with permitting and planning frameworks for wind parks including in many developing countries. Generally, the following are necessary:<br>• A lease/payment-scheme for the area of interest for deployment of the wind park. This land may be government owned which makes negotiations potentially straightforward, but in many instances wind parks are deployed |

<table>
<tr><td></td><td>on agricultural land and can coexist with the existing agricultural practices. In areas where the land is owned by a small number of stakeholders direct payments to these parties are often arranged. In a country where a larger number of small-scale land users might own an area of interest, this may present problems and should be considered in the development of a wind park; payments to communities may assist in overcoming this issue.<ul><li>Appropriate environmental permits based on an environmental impact assessment (EIA) that can take between 1-2 years depending on the level of baseline data demanded by the permitting authority and the sensitivity of the area.</li><li>Permits from local/district planning officials that control the use of land within a region. These have been known to cause problems/delays/cancellations in instances where local communities/councils are not in favour of erecting wind turbines.</li><li>Grid connection agreement / power purchase agreement with the relevant body to ensure distribution and a market for the resulting electricity.</li></ul></td></tr>
<tr><td>Operation and maintenance</td><td>Negligible as it relates to maintaining electronics and interfaces (software).</td></tr>
<tr><td>Endorsement by experts</td><td>It can generally be said that the level of acceptance of wind parks onshore is high if appropriate measures are taken to ensure the limited noise and shadow effects do not affect local communities. It is endorsed by experts</td></tr>
<tr><td>Adequacy for current climate</td><td>Fits well, both for the current and future climate.</td></tr>
<tr><td>Scale/Size of beneficiaries group</td><td>Utility-scale wind farm requires private investment (could be in form of public private partnerships). The beneficiaries will be the entire population.</td></tr>
<tr><td>Disadvantages</td><td>Can be perceived as threatening to birds, making noise, and visually not desirable.</td></tr>
<tr><td colspan="2">Capital costs</td></tr>
<tr><td>Cost to implement mitigation technology</td><td>“Though the cost of wind energy has declined significantly since the 1980s, in most regions of the world, policy measures are required to make wind energy economically attractive” (IPCC, 2010). However in areas where prices of conventional electricity supply are high due to imported fuels or other factors but which have a good wind resource, wind power can be economically competitive without subsidies. For modern turbines the levelised cost of electricity in 2009 (accounting for capital costs, lifetime O&M and typical financing costs) ranges between US$50 to 100/MWh at good to excellent sites (IPCC, 2010). The site specific costs are influenced by the nature of the local wind resource, local capital costs (for example wind power capital costs are lower in China) and the financing arrangements for the specific project. Figure 4 presents a slightly different set of cost estimates for onshore wind energy from the IEA (2010) and compares this to conventional sources of electricity across a number of regions.<br>Onshore a large majority of the costs are associated with the turbine and tower which should be considered when studying the socio-economic impact a project might have on a local community. Without localisation of manufacture, the economic benefits may prove to be limited.
<table>
<tr><th>Cost Component</th><th>Onshore</th><th>Offshore</th></tr>
<tr><td>Turbine</td><td>71% - 76%</td><td>37% - 49%</td></tr>
<tr><td>Grid connection</td><td>10% - 12%</td><td>21% - 23%</td></tr>
<tr><td>Civil works</td><td>7% - 9%</td><td>21% - 25%</td></tr>
<tr><td>Other capital costs</td><td>5% - 8%</td><td>9% - 15%</td></tr>
</table>
Installed cost distribution for onshore and offshore wind power plants (IPCC, 2010).</td></tr>
</table>

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| Additional cost to implement mitigation technology, compared to "business as usual" | The above cost is additional since the reference scenario is 'doing nothing'. |
| Long term cost (i.e. 10, 30, or 50 years) without mitigation technology | Operation and maintenance of conventional power plants. |
| Long term cost (i.e. 10, 30, or 50 years) with mitigation technology | Negligible operating and maintenance costs over lifetime of systems (20 years).<br>Need to change electronics (e.g. inverter) maybe once during lifetime. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | • GHG emission reductions<br>• Savings on energy bill<br>• Job creation<br>• Enhanced environmental and health benefits |
| Reduction of vulnerability to climate change, indirect | The renewable nature of wind energy, the large available resource and the relatively advanced nature of the technology mean that it has the potential to make a significant contribution to climate change mitigation. By acting to displace generation from thermal power plants onshore wind energy can prevent the emission of roughly 2,000 tonnes of $CO_2$ per year per megawatt of installed wind capacity (assuming it replaces coal and is located at a reasonable wind energy site).<br>Although there is some amount of carbon used in the manufacture of the devices, studies have shown that the payback period (the time it takes for the wind energy to offset the emissions associated with its fabrication and installation) is relatively low, typically in the order of 6 months or less (IPCC, 2010). |
| Economic benefits, indirect<br>Employment<br><br><br><br>Growth & Investment | <br><br>Creation of jobs to:<br>• Install and commission systems (e.g. suppliers of hardward, interface electronics, switching and interconnections at sub-stations, installers; energy resources assessments etc ..)<br>Can create investment in developing and supplying consulting and training services. |
| Social benefits, indirect<br>Income<br>Education<br><br>Health | <br>Income generation from the abovementioned employment and investment<br>Training in the technology may lead to more training and spread of technology application.<br>Improvement of health conditions through improved comfort. |
| Environmental benefits, indirect | Reduction in GHG emissions.<br>Although wind energy has a net positive impact on climate change mitigation (see below) local environmental impacts must also be considered. The most well publicised potential issue is the impact that wind turbines can have on bird and bat populations due to collisions. IPCC (2010) provides a good summary of the specific studies that have looked at the number of fatalities of these species. There is a strong argument that the number of recorded fatalities, while site specific, is relatively low compared to other anthropogenic causes of bird and bat deaths such as cars, collisions with buildings, feral cats and transmission lines.<br>In terms of other ecological effects related to the installation, the turbines have a |

<table>
<tr><td></td><td>relatively small environmental footprint and are often constructed on agricultural or brown-field sites, which limits their impact on local habitats or ecosystems. In instances where they are being installed in more pristine environments, a more rigorous environmental impact assessment may be required.</td></tr>
<tr><td colspan="2">Local context</td></tr>
<tr><td>Opportunities and Barriers</td><td><table><tr><th>Opportunities</th><th>Barriers</th></tr><tr><td>Wind SIPP already implemented in Mauritius</td><td>Higher initial costs for design and installation</td></tr><tr><td>In line with government policy</td><td></td></tr><tr><td>Grid code exists in Mauritius</td><td>Need for a skilled installers (accreditation)</td></tr><tr><td>Good wind regime</td><td></td></tr></table></td></tr>
<tr><td>Market potential</td><td>Long-term energy strategy 2011-2025 mentions the following large-scale wind projects.<table><tr><td>(i) Construction of a 20-30 MW wind farm at Curepipe Point</td><td>2013</td></tr><tr><td>(ii) Construction of an 18 MW wind farm at Plaines des Roches</td><td>2013-2014</td></tr><tr><td>(iii) Construction of 20MW wind farms every three years, as from 2017</td><td>2017, 2020, 2023</td></tr></table></td></tr>
<tr><td>Status</td><td>Grid-tied SIPP systems are eligible in Mauritius. There are no utility-scale grid-connected systems in Mauritius. Mauritius does have experience with the operation of small wind turbines in Rodrigues.</td></tr>
<tr><td>Timeframe</td><td>Can be implemented immediately provided incentives like feed-in-tariff is provided.</td></tr>
<tr><td>Acceptability to local stakeholders</td><td>The technology is easily acceptable to all stakeholders once barriers are overcome.</td></tr>
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| **Technology: Solar PV systems (>1MW)** | |
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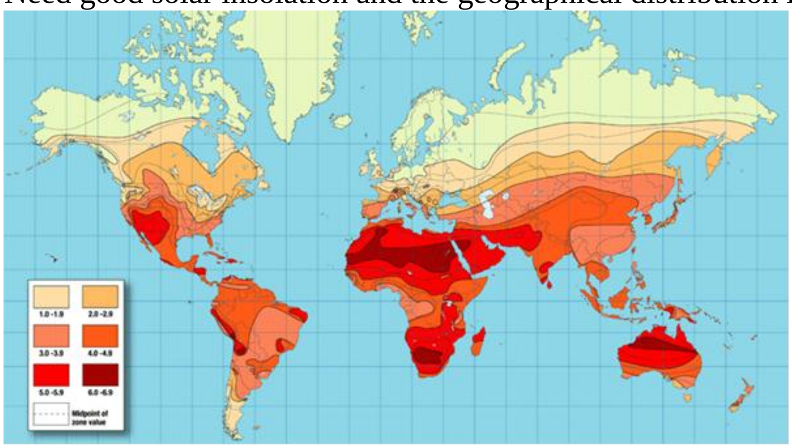
| **Sector : Energy** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Solar photovoltaic, or simply photovoltaic (SPV or PV), refers to the technology of using solar cells to convert solar radiation directly into electricity. A solar cell works based on the photovoltaic effect. R&D and practical experience with photovoltaics have led to the development of three generations of solar cells: Crystalline silicon based solar cells, thin film solar cells and third generation PV. Solar PV is very likely to play a significant role in climate change mitigation in the future. However, today, inspite of significane decreases in the cost for solar PV systems, the majority of PV deployment is still driven by substantial subsidy schemes. |
| Technology characteristics/highlights | Grid connected solar PV also can have differences in the approach used depending on the way in which customers purchase the electricity. If the solar array is distributed, for example over a larger number of residential houses, then the single installations are operated by the consumer directly. The advantage of this to the consumer is that the cost of electricity, that the consumer must compete with, is the distributed cost, i.e. the cost to purchase power at the location of demand which is normally significantly higher than the actual levelised production cost of electricity (that doesn't account for transmission/distribution charges/losses and profit margins along the value chain). Solar installations can also be large and centralised but this demands that the power is sold into the common grid at market prices and must compete directly with other technologies (bearing in mind any subsidies that might be applicable for solar generation).<br><br>Need good solar insolation and the geographical distribution is shown in the map.<br><br><br>Worldwide average solar irradiation (kWh/m2 per day)(source: BP, 2009) |
| Institutional and organizational requirements | The legal and regulatory requirements for solar PV are relatively few compared to some other renewable technologies. They have a low local environmental impact and are not very visible (for small applications they are often mounted on the roofs of buildings) typically making public/permitting acceptance high. Grid connected systems require an appropriate licence or permit to export to the grid along with the necessary metering equipment, connected by a professional, to ensure that the level of export to the grid is measured for any subsequent compensation. Larger installations obviously require the appropriate planning permissions that would accompany any moderate to large infrastructure project. Currently, the main policy instruments that have an impact on solar PV are |

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| | incentives that subsidise its use and offset its currently uncompetitive cost; a handful of countries with strongly supportive policies account for 80% of global installed PV capacity (IEA, 2010). |
| Operation and maintenance | Negligible as it relates to maintaining electronics and interfaces (software). |
| Endorsement by experts | Increasingly seen as an integrated approach to energy management in buildings. One main characteristic of the technology is that it is capable to provide real-time and extensive data on energy consumption to the facility operator. |
| Adequacy for current climate | Fits well, both for the current and future climate. |
| Scale/Size of beneficiaries group | Beneficiary groups can be substantial depending on the adoption of the technology (industrial, large buildings, residential buildings). However, applicable mainly to new buildings. |
| Disadvantages | Requires competent HVAC engineers or specialists in order to account for all components necessary for cooling load calculation and thus design an efficient system. |
| Capital costs | |
| Cost to implement mitigation technology | There has been a large decrease in the cost of solar PV systems in recent decades; the average global PV module price dropped from about 22 USD/W in 1980 to less than 4 USD/W in 2009, while for larger grid connected applications prices have dropped to roughly 2 USD/W in 2009 (IPCC, 2010). A review of the available literature on historical solar PV learning rates (the percentage reduction in price for every doubling of installed capacity) shows a range of estimates from 11 to 26 percent (IPCC, 2010).<br>Using a slightly different approach (based on a study of solar PV module and consumer electricity prices, i.e. a grid-parity study) Breyer et al. (2009) estimated that the "cost of PV electricity generation in regions of high solar irradiance will decrease from 17 to 7 €ct/kWh in the EU and from 20 to 8 $ct/kWh in the US in the years 2012 to 2020, respectively". |
| Additional cost to implement mitigation technology, compared to "business as usual" | The above cost is additional since the reference scenario is 'doing nothing'. |
| Long term cost (i.e. 10, 30, or 50 years) without mitigation technology | Operation and maintenance of conventional power plants. |
| Long term cost (i.e. 10, 30, or 50 years) with mitigation technology | Negligible operating and maintenance costs over lifetime of systems (20 years). Need to change electronics (e.g. inverter) maybe once during lifetime. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | • GHG emission reductions<br>• Savings on energy bill<br>• Job creation<br>• Enhanced environmental and health benefits |
| Reduction of vulnerability to climate change, | Solar PV is very likely to play a significant role in climate change mitigation in the future. As described above it is a rapidly growing market and is forecast by the IEA (2010) to contribute more than 10 percent of global electricity supply by |

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| indirect | 2050. It has energy payback periods ranging from 2 to 5 years for good to moderate locations and lifecycle GHG emissions in the order of 30 to 70 $gCO_2e/kWh$ (IPCC, 2010) depending on panel type, solar resource, manufacturing method and installation size. |
| Economic benefits, indirect<br>Employment<br><br><br>Growth & Investment | <br><br>Creation of jobs to:<br>• Install and commission systems (e.g. suppliers of hardware like PV modules and inverters; installers; energy resources assessments etc ..)<br>Can create investment in developing and supplying consulting and training services. |
| Social benefits, indirect<br>Income<br>Education<br><br>Health | <br><br>Income generation from the abovementioned employment and investment<br>Training in the technology may lead to more training and spread of technology application.<br>Improvement of health conditions through improved comfort. |
| Environmental benefits, indirect | <br><br>Reduction in GHG emissions.<br>Solar PV systems, once manufactured, are closed systems; during operation and electricity production they require no inputs such as fuels, nor generate any outputs such as solids, liquids, or gases (apart from electricity). They are silent and vibration free and can broadly be considered, particularly when installed on brownfield sites, as environmentally benign during operation. The main environmental impacts of solar cells are related to their production and decommissioning. In regards to pollutants released during manufacturing, IPCC (2010) summarises literature that indicates that solar PV has a very low lifecycle cost of pollution per kilowatt-hour (compared to other technologies). Furthermore they predict that upwards of 80% of the bulk material in solar panels will be recyclable; recycling of solar panels is already economically viable. In terms of land use, the area required by PV is less than that of traditional fossil fuel cycles and does not involve any disturbance of the ground, fuel transport, or water contamination (IPCC, 2010). |
| Local context | |
| Opportunities and Barriers | **Opportunities** / **Barriers**:<br>PV SIPP already implemented in Mauritius / Higher initial costs for design and installation<br>In line with government policy /<br>Grid code exists in Mauritius / Need for a skilled installers (accreditation)<br>Good solar insolation regime / |
| Market potential | Long-term energy strategy 2011-2025 mentions the following large-scale PV projects. |

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| (i) | Installation of 5 kW photovoltaic systems in 10 Government schools | **2011-2012** |
| (ii) | Installation every two years of a capacity of 50 kW photovoltaic panels in | **2013-2025** |

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| | Government buildings, as from 2013 | |
| | (iii) Setting up of a grid-connected photovoltaic plant of up to 10MW | **2013** |
| | (iv) Setting up of a grid-connected photovoltaic plant of 10MW, every 3 years after 2013 | **2016, 2019, 2022, , 2025** |
| Status | Grid-tied SIPP systems are in place in Mauritius. There are no utility-scale grid-connected systems in Mauritius. | |
| Timeframe | Can be implemented immediately provided incentives like feed-in-tariff is provided. | |
| Acceptability to local stakeholders | The technology is easily acceptable to all stakeholders once barriers are overcome. | |

Technology Fact Sheet for Mitigation

| **Technology: High efficiency boilers/heat recovery** | |
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| **Sector : Energy** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Industrial boiler systems are used for heating with hot water or steam in industrial process applications.<br>The major source of GHG emissions from a boiler system is carbon dioxide (CO2) from the combustion of fossil fuels in the boiler. Other minor sources of GHGs can include methane (CH4) from leaks in the natural gas distribution system and CH4 and nitrous oxide (N2O) as byproducts of combustion processes. |
| Technology characteristics/highlights | Improved efficiency of industrial boilers used for heat for industrial process applications by adding advanced technologies (such as advanced heat recovery, controls and burners) to the boiler system. These technology-based efficiency improvements can be achieved when retrofitting or replacing an existing boiler with new technology, when purchasing a natural gas boiler to meet new demand, and/or when switching from a fuel oil, coal or electricity based boiler to a natural gas boiler.<br>Retrofit projects are defined as those that add technological components to an existing boiler unit to improve overall efficiency. Projects that involve replacement of the boiler itself are considered new capacity or early replacement projects. |
| Institutional and organizational requirements | The combination of the fuel-specific boiler design (that meets the engineer's specifications) with a non-condensing economizer integrated into the system is already considered standard on industrial boilers. To achieve superior efficiency/$CO_2$ emissions performance, technologies such as the following can be added to the boiler system:<br>• Condensing economizer (condensate heat recovery)<br>• Combustion air pre-heaters<br>• Blowdown waste heat recovery<br>• Turbulators for firetube boilers<br>• Electronic ignition<br>• Automated tuning ($O_2$ trim control)<br><br>The engineer's specification to establish the new "nominal thermal efficiency" for the boiler should include the following performance information, and will depend on whether the boiler uses coal, fuel oil, or natural gas:<br>• Nominal output capacity<br>• Fuel<br>• Steam delivery pressure<br>• Steam delivery temperature<br>• $NO_X$ limitations<br><br>An example of the process is where the technology added results in a thermal efficiency of 85% (nominal boiler (80%) with non-condensing economizer (+5%)). With the advanced burner and controls (+1%), condensing |

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| | economizer (+1%), combustion pre-heater (+1%) and blowdown heat recovery (+1%) the efficiency is increased to 89%. Note that the condensing economizer replaces the non-condensing one with a marginal increase in efficiency of 1%. |
| Operation and maintenance | Maintenance should be carried out as per the equipment manufacturers' recommendations, with precautionary measures depending on the system design or upgrade. |
| Endorsement by experts | In the United States, an important objective of the Climate Leaders program is to focus corporate attention on achieving cost-effective greenhouse gas (GHG) reductions within the boundary of the organization (i.e., internal projects and reductions).<br>Climate Leaders is an EPA industry-government partnership that works with companies to develop comprehensive climate change strategies. Partner companies commit to reducing their impact on the global environment by setting aggressive greenhouse gas reduction goals and annually reporting their progress to the EPA. |
| Adequacy for current climate | Fits well, both for current and future climate. |
| Scale/Size of beneficiaries group | A majority of these (71% in the united states) are located at facilities in the food, paper, chemicals, refining, and primary metals industries. |
| Disadvantages | Upstream or downstream adjustments to the physical boundary may be required:<br>• Electricity use associated with the boiler auxiliaries (e.g., fans, pumps, conveyors) may change as a result of the new boiler.<br>• Changes in CH4 leakage from the natural gas distribution system, for example, from a switch from fuel oil to natural gas in the boiler. A small section of new natural gas distribution line from a nearby distribution main line will typically be installed and the leakage from this incremental section should be accounted for. |
| Capital costs | |
| Cost to implement mitigation technology | Implementation costs are variable depending on the industry, size and location of affected operations, and includes the following components:<br>• Re design or design review, depending on new installations or retrofits,<br>• Procurement of new equipment<br>• Shipping costs<br>• Project management<br>• Retrofitting or new installation equipment purchase or hire<br>• Hiring of specialist personnel<br>• Site specific structural modifications<br>• Commissioning and testing personnel & equipment<br>• Overall production shut down and commissioning time costs<br>• Adjustment of Health and Safety policies |
| <u>Additional</u> cost to implement mitigation technology, compared | All costs are additional since the baseline scenario is 'doing nothing'. |

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| to "business as usual" | |
| Long term cost (i.e. 10, 30, or 50 years) without mitigation technology | • Expenses from increased commodity prices,<br>• Loss of savings potential,<br>• Potential loss of competitive advantage due to high in-house costs |
| Long term cost (i.e. 10, 30, or 50 years) with mitigation technology | Maintenance and upgrades of installed equipment. |
| **Development impacts, direct and indirect benefits** | |
| Direct benefits | Other than savings from increased efficiency, benefits can be multiple:<br>• Reduced health and safety hazards due to heat losses<br>• Marketing potential<br>• Reduced operational expenses<br>• Profit increase potential<br>• Potential to attract investments |
| Reduction of vulnerability to climate change, indirect | The technology does not provide reduction of vulnerability, as compared to traditional boiler systems. |
| Economic benefits, indirect<br>Employment | Jobs for retrofits, new installation, measurement of energy savings and green house gases reduction monitoring. |
| Growth & Investment | Can create investment in:<br>• Development of new technologies<br>• Use of natural gas<br>• Monitoring capability |
| Social benefits, indirect<br>Income | Income generation and distribution from the above-mentioned employment and investment benefits. |
| Education | Capacity Building for new technologies & education in energy efficiency |
| Health | With new efficiency measures such as piping insulation, health and safety risks may be reduced as compared to traditional systems. |
| Environmental benefits, indirect | Reduction in GHG emissions, local pollutants, ecosystem degradation. |
| **Local context** | |
| Opportunities and Barriers | **Opportunities:**<br>Several small boilers can also be grouped together in parallel to provide staged heating capacity. This approach is usually more economical and efficient than using a single large boiler because:<br>• The boilers can be staged to operate at or near their highest efficiency points<br>• Small boilers are more efficient than large commercial boilers<br>• Multiple boilers provide redundancy, which can reduce system downtime<br>• Small boilers can reduce installation costs because each boiler is small enough to be handled without a crane. |

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| | **Barriers:**<br>• High initial investment<br>• Existing boilers may still have a long operating life, preventing investment<br>• A change of boiler system requires modification of operation and maintenance schedules. |
| Market potential | Various suppliers may distribute the technology; however this could be encouraged by government subsidies. |
| Status | Not prevailing practice in Mauritius. Limited experience in industry. |
| Timeframe | Implementation can be planned in the short to medium term in cost effective ways. For new projects, design, procurement and installation can utilize the new technology potential. For existing operations, implementation can be planned to coincide with major equipment replacements and/or retrofitting operations. |
| Acceptability to local stakeholders | The technology is easily acceptable to stakeholders, who may also be neutral in its regard. |

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