Republic of Mauritius

NATIONAL CLIMATE CHANGE ADAPTATION POLICY FRAMEWORK FOR THE REPUBLIC OF MAURITIUS

UNDP

Africa Adaptation Programme

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Table of Contents

Foreword

Climate change is one of the main challenges that mankind is facing today. Its wide-ranging effects are not only threatening the world's environment, but are also having serious impacts on the social and economic prospects of many countries. There is increasing scientific evidence that the world is heading towards an unprecedented climate crisis with greenhouse gas concentrations reaching new record level of 400 parts per million. In Mauritius, the impacts of climate change are already apparent with accelerating sea level rise, beach erosion and the increase in the frequency and intensity of extreme weather events, such as floods and droughts. Climate change is indeed a serious threat to our hard-won development.

As a Small Island Developing State Mauritius is highly vulnerable and climate change will continue to affect our country and our livelihoods. In this respect, Government has made climate change adaptation a high priority. In order to prepare the country to adapt to the impacts of climate change, Government commissioned the preparation of the National Climate Change Adaptation Policy Framework.

I am pleased to present this Framework which is the first of its kind in the region. The Framework has been prepared under the Africa Adaptation Programme on adaptation to climate change and comprises a National Climate Change Adaptation Policy, a Climate Change Adaptation Strategy and Action Plan and an initial Three-Year Climate Change Adaptation Investment Plan.

The National Climate Change Adaptation Policy Framework for the Republic of Mauritius aims at integrating climate change into core development policies, strategies and plans. The main objectives of this Framework are to enhance the resilience of key economic sectors, mitigate risks and damages to human settlements, infrastructure and avoid the loss of lives due to extreme climatic events.

The Framework has focused, amongst others, on the assessment of socio-economic impacts of climate change on key sectors, namely water, agriculture including terrestrial ecosystem, fisheries and marine ecosystem as well as tourism and coastal management. It will thus enable policy makers and stakeholders concerned to understand the challenges posed by climate change and take appropriate actions. It will further guide investments in climate change adaptation projects while offering benefits to many sectors by reducing risks and avoiding potential future losses.

I wish to thank the Government of Japan and the United Nations Development Programme for their valuable support in the preparation of this Framework. I also thank all stakeholders who have contributed to the framework and I look forward to their continued support in mainstreaming climate change in their respective sectors.

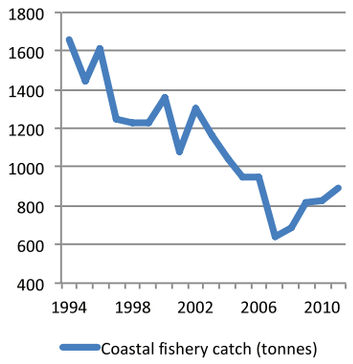
Hon. Devanand Virahsawmy, G.O.S.K, F.C.C.A

Minister of Environment and Sustainable Development

Executive Summary

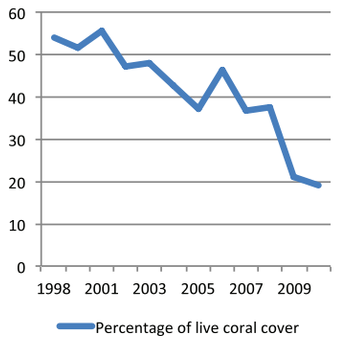
Introduction and rationale for this work

Mauritius is highly vulnerable to the threat of climate change, manifesting itself in several ways, including among others cyclones, tidal surges, droughts, floods, crop and livestock as well as human diseases. The challenges ahead are substantial, especially when considering that (1) water supply by 2030 may not be sufficient to satisfy projected demand, (2) agriculture production may decline by as much as 20-30% in the medium and longer term due to rainfall variability, (3) the ecosystem and natural habitat of fish and other marine species is being rapidly eroded, with some coral reefs being now extinct (trend determined also by drivers other than climate change), and (4) that the natural assets, such as beaches, that are the pillars of the tourism industry may slowly disappear, carrying away with them possibly over $50 million in value added in the sector by 2050.



On the other hand, it is possible to turn climate change challenges into opportunities by developing long-term policies that both address short-term vulnerability and increase long-term resilience.

It is also possible to quantify the cost of climate change in Mauritius based on different scenarios (e.g., no-regret and a worse-case scenario), to effectively support policy formulation and evaluation. In fact, the upcoming challenges call for action to adapt to climatic changes in the best possible way, also acknowledging that the impacts mentioned above would make the sustainable development journey even more challenging. Various sectoral Reports have highlighted that Climate Change is not usually, or insufficiently mainstreamed in the current policies of RoM. As a consequence, and to effectively support ROM's long-term vision, decision makers should prioritize and review current policies to evaluate their adequacy in the face of current climate variability and upcoming climate change-related challenges. This requires a new approach to policy analysis that is cross-sectoral and integrated by nature, and which would build on existing sectoral frameworks. The integrated approach will also combine knowledge and skills across stakeholders to provide a new perspective on the best path to reach climate-resilient growth and development in the context of a changing climate.



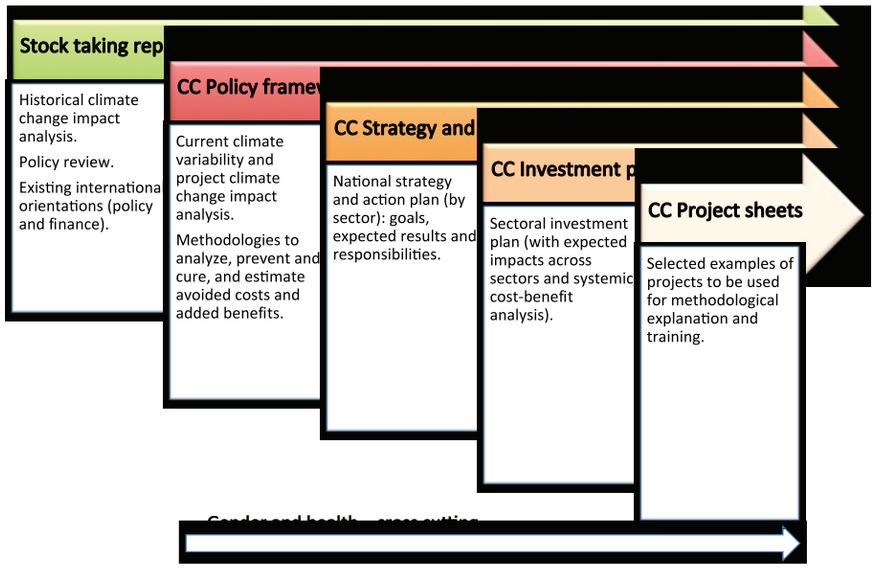
The analysis is carried out acknowledging that there are costs to adapt to climate change. However, a key objective of the proposed strategy and action plan, is to ensure that **investing in adaptation to climate variability and climate change provides multiple benefits across sectors** in the form of avoiding potential future losses and, where possible, securing extra benefits (such as job creation). In other words, there will be costs to adaptation, but risks will be reduced and additional benefits (social, economic and environmental) will be gained.

The present National Climate Change Adaptation Policy Framework consists of several deliverables, and the main goal of the document is to integrate and mainstream climate change adaptation into core development policies, strategies and plans of the ROM. Given the level of details and data availability, a more detailed analysis is available for the island of Mauritius, while specific considerations are made for Rodrigues. More specifically, this report contains (1) a National Climate Change Adaptation **Policy** (time frame: 20 years), (2) a Climate Change Adaptation **Strategy** and **Action Plan** (time frame: 10 years), (3) a Climate Change Adaptation **Investment Plan** (time frame: 3 years), and (4) selected **Project Concepts**. Further, sections on methodologies and tools, as well as the use of indicators for policy formulation and evaluation are included in the study.

Concerning the sectoral coverage, water demand and supply, agriculture and terrestrial ecosystem, fisheries and marine ecosystem and tourism and coastal management, are analysed in detail, and gender and health are considered as cross-cutting. The impacts of climate change are also analysed from a broader perspective, including socio-economic indicators, and the strategy, action and investment plans include considerations on disaster risk reduction (DRR), capacity building and the strengthening of institutions and institutional arrangements to support the successful implementation of the interventions proposed. Nevertheless, the study could be improved with a broader cross-sectoral coverage.

The main elements of the study are presented in the chart below; the key findings are then introduced, emphasizing the overall policy principle at first, to then explore in more detail the proposed sectoral action and investment plans. It is worth noting that, while not being analysed in isolation in the report, gender and health are very relevant and cross-cutting themes addressed throughout the study.

Figure ES1. Climate Change Adaptation Policy Framework, main elements and flow.



National Climate Change Adaptation Policy

Policy Goals and Objectives

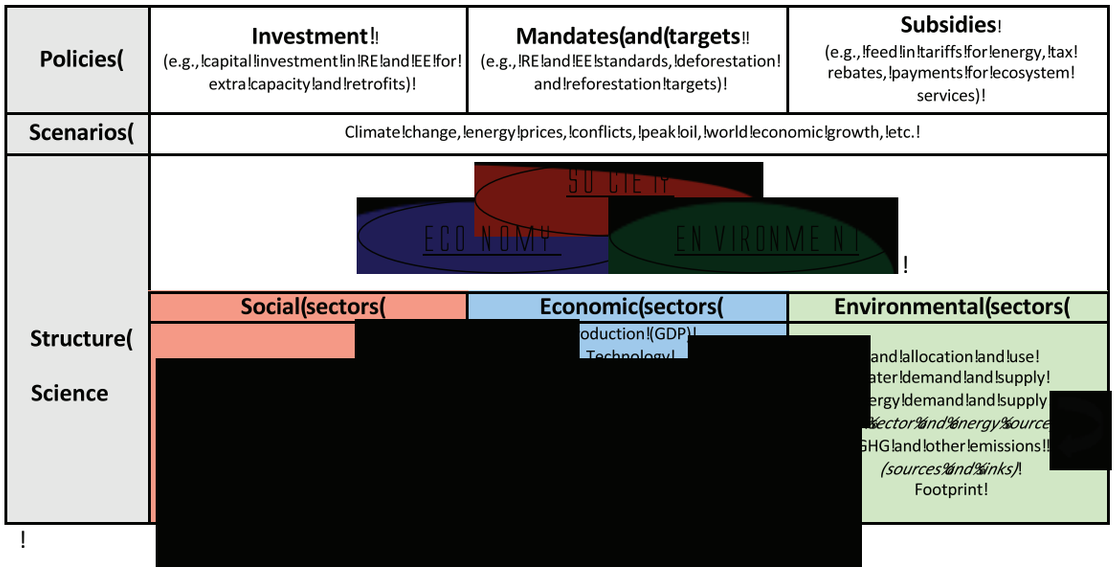
Acknowledging that actions towards climate change resilience are aimed at supporting sustainable development to ensure an equitable future and where society is engaged at all levels in defining and

shaping ROM's path towards sustainability, the strategic objectives of the climate change adaptation policy framework are to:

- **Foster the development of strategies, plans and processes to:**
  - Avoid, minimise or adapt to the negative impacts of climate change on key sectors and assets of Mauritius, namely agriculture, water, fisheries and ecosystems.
  - Avoid or reduce damage to human settlements and infrastructure, and also possible loss of lives caused by climate change.
  - To build capacity to understand, analyse and pre-empt in a timely manner in the wake of future climate change impacts within the ROM.
- **Integrate and mainstream climate change adaptation into core development policies, strategies and plans of the ROM.**

Policy goals and objectives, as well as the strategy and actions plan, are defined considering that policy formulation and evaluation need to be carried out in the context of scenarios (e.g. technological development, natural disasters), and policies (e.g. subsidies, incentives and/or mandates) have to be evaluated across a variety of indicators (social, economic and environmental) simultaneously. How these three levels are supported with solid and coherent information, and interact with each other, will greatly determine the success of any national development plan over the medium to longer term. This information is also crucial to truly understand the drivers of change and design policies that have the desired impacts, effectively.

Figure ES2. The three main layers for carrying out integrated policy formulation and evaluation: structure, scenarios and policies.



Key Policy Principles

The Government of Mauritius, in collaboration with other relevant entities, and taking into consideration three core principle of the Agenda 21 (UN, 1992), namely common but differentiated responsibilities, the polluter pays principle and the precautionary principle, will:

Concerning the definition and introduction of long term planning mechanisms:

- **Undertake adequate planning** (biophysical, socio-economic etc.) with periodical reassessment based on progress and needs to address the impacts of climate change. Such planning should be undertaken, not in isolation but in the wider context of sustainable development, and using an integrated, cross-sectoral and trans-disciplinary approach (i.e. systems approach).[1]

Concerning improving climate resilience:

- **Do all possible to enhance and maintain environmental quality**, recognizing that the resilience of the natural environment (i.e. ecosystem service flows) is key to coping with climate change;
- **Do all possible to promote the development of a strong and diversified economy**, recognizing that economic resilience is key to coping with climate change;
- **Create an enabling environment for the adoption of appropriate technologies and practices** that will assist in meeting national and international commitments with respect to the causes and effects of climate change.

Concerning strengthening capacities and institutional frameworks:

- **Endeavour to ensure that society, at all levels and in all sectors is adequately informed** on climate change and its implications for the nation and the role that it must play in this respect;
- **Endeavour to obtain the involvement and participation of all stakeholders** at the national level in addressing issues related to climate change, to the extent feasible;
- **Endeavour to minimise duplication of effort and conflict**, ensuring that stakeholder involvement and participation occur on an appropriately coordinated basis, which guarantees the efficient use of resources and the creation of synergies.

The main means of implementation include:

The availability of financing options to meet national adaptation needs:

- Procure and allocate financial and other resources, as appropriate and feasible (including domestic, regional and international sources of funding), to ensure that climate change is addressed in the manner required.[2]

The creation of capacities and institutional frameworks to ensure a correct implementation:

- Develop national human and institutional capacity in all aspects of climate change research, response, planning, project/programme development, implementation, monitoring and evaluation, and resources mobilization;
- Create an institutional, administrative and legislative environment which engenders/ supports the effective implementation of climate change adaptation activities;
- Collaborate as appropriate and feasible, with other regional and international states and organisations which pursue confluent agendas in climate change;
- Promote and support research and information gathering at the national, regional and international levels on aspects of climate and its impacts as they pertain to Mauritius.

[1] For instance, variability in precipitation and projected declines in water precipitation will have economy-wide impacts that may constrain food security, as well as other impacts. Hence, an integrated medium-to-long-term planning approach is required to understand such complexities of socio-economic development against the backdrop of a changing climate.

[2] It is pointed out that this National CC Adaptation Policy Framework, including the Adaptation Strategy, Action Plan and Investment Programme will serve to improve the climate change preparedness of ROM, placing it in a better position to leverage international financing for implementing climate-resilient development.

Sectoral Strategy and Action Plan

An important recommendation stressed by many stakeholders regards the need to organize cross-ministerial meetings on a regular basis to ensure that cross-sectoral issues and opportunities are properly analyzed and coordination is ensured. The sectoral action plans are presented below.

Water demand and supply

	Strategies	**Action List**
W1	Fully develop the potential of integrated water management	**W1.1.** Develop hydrological models. **W1.2.** Identify strategies that can improve the coordination of local groundwater storage with local surface storage and other options. **W1.3** Promote the use of wastewater for agriculture needs.
W2	Aggressively increase water use efficiency	**W2.1.** Implement strategies to achieve a nation-wide 20% reduction in per capita water use by 2020. **W2.2.** Apply all feasible Efficient Water Management Practices to reduce water demand and improve the quality of drainage and return flows. **W2.3.** Recycle water, as a drought-proof water management strategy that may also be an energy efficient option in some regions. **W2.4.** Authorize and fund new incentive-based programs to promote the mainstream adoption of water conservation.
W3	Practice and promote integrated flood management	**W3.1.** Integrate flood management with watershed management on open space, agricultural, wildlife areas, and other low-density lands.
W4	Enhance and sustain ecosystems	**W4.1.** Expand setback levees and bypasses to retain and slowly release floodwater, facilitate groundwater recharge, and more. **W4.2.** Identify and strategically prioritize for protection lands that will provide the habitat range for tidal wetlands to adapt to sea-level rise. **W4.3.** Increase green areas to improve CO_2 absorption capacity and reduce evapo-transpiration, also reducing landslide risk and land erosion.
W5	Expand Water Storage and Conjunctive Management of Surface and Groundwater resources	**W5.1.** Increase surface water storage capacity through the construction of two new dams and increase in the storage capacity of existing ones. **W5.2.** Expand the rainwater harvesting capacity to ensure higher volumes of stored freshwater in the ROM. **W5.3.** Desalination to be considered as a means of increasing freshwater availability, also taking into account ecosystem protection and potential side effects of desalination. **W5.4.** Develop conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage. **W5.5.** Encouraged the adoption of local ordinances that protect the natural functioning of groundwater recharge areas.
W6	Preserve, upgrade and increase monitoring, data analysis and management	**W6.1.** Improve the measurement of water use to facilitate better water planning and management.

W7	Plan for and adapt to Sea-Level Rise	**W7.1.** Support research and provide expert guidance regarding long-range sea-level rise estimates and their application to specific planning issues.

Agriculture and terrestrial ecosystem

	Strategies	**Action List**
A1	Water Supply and Conservation Support	**A1.1.** Incentivise water pricing systems that reward conservation, accounting for regional differences in growing conditions, crops, and other agronomic needs. **A1.2.** Dissemination of micro irrigation systems for efficient water use and management shall be facilitated. **A1.3.** Floodplain Easements. Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance.
A2	Preventing, preparing for, and responding to agricultural invaders, pests and diseases	**A2.1.** Up-scale locally proven IPM technologies for pest control. **A2.2.** Put in place decentralised rapid pest and disease diagnosis services. **A2.3.** Provide information to the agricultural community to enable growers to improve and modify farm management practices as needed.
A3	Sustainable land use planning practices	**A3.1.** Encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture. **A3.2.** Explore ways of introducing carbon trading in the agriculture sector, as incentive for improving farming practices towards more sustainable farming practices.
A4	Promote working landscapes with ecosystem services to improve agro-biodiversity	**A4.1.** Provide technical and financial assistance and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e. seedless crop varieties). **A4.2.** Support identification, research, development and breeding of crop varieties, cultivars, and mixtures of crops capable of adapting to expected climate change in order to assist growers in the selection of crop and livestock most likely to succeed. **A4.3.** Promote composting and support the use of compost as a substitute to traditional fertilizers in order to enrich soils.
A5	Building and sustaining institutional support	**A5.1.** Build the capacity of institutions; train their human resources as well as those of local communities to help them adapt to the adverse impacts of climate change.
A6	Research, technology development and communication	**A6.1.** Link up technologies with activities aimed at enhancing agricultural production, processing and storage protecting the environment and preventing degradation of soil and water quality, and the evaluation of ecosystem services (including their economic value). **A6.2.** Help the development of appropriate models for communication to transmit and disseminate information on climate change (this should not be restricted to farmers, but extended to public in general and policy makers also).

Fisheries and marine ecosystem

	Strategies	Action List
F1	Sustainable utilization of fisheries resources	**F1.1.** Promote collaboration with regional and international bodies on determining the frequency of stock assessments and other necessary research, to ensure that shared fisheries resources are managed sustainably. **F1.2.** Establish guidelines for the level of exploitation of fisheries resources from the best available scientific information and proven indigenous knowledge. **F1.3.** Negotiation of favourable Fisheries Access Agreements with Distant Water Fishing Nations. **F1.4.** Identification and promotion of effective linkages between various fisheries, value addition and infrastructure development, among others. **F1.5.** Develop an effective monitoring, control and surveillance (MCS) system for marine fisheries. **F1.6.** Make the penalties for offenders more stringent as well as restrict access through appropriate adjustment of fees on various permits and registrations.
F2	Protect critical habitat and plan for future hazards	**F2.1.** Promote, in a participatory manner, good fishing practices and facilitate integrated approaches to mitigate adverse environmental and climate change impacts in the catchments and coastal areas. **F2.2.** Patrol fishing grounds, in collaboration with the Coast Guards and other relevant institutions and preserve the marine habitat (e.g., corals). **F2.3.** Review water management laws with a view to increasing their sensitivity to fisheries needs. **F2.4.** Encourage the creation of new marine protected areas and monitor the socio-economic development of people depending on these areas.
F3	Ensure the sustainability of aquaculture development in ROM	**F3.1.** With careful consideration of the impacts, aquaculture should be promoted in its ocean ranching form. **F3.2.** For fish farms, consideration should be given to shifting species grown to those more tolerant of warmer and less-oxygenated waters. **F3.3.** Evaluate the role of currents and surrounding ecosystems for in-lagoon and off-lagoon aquaculture.
F4	Support essential data collection and information sharing	**F4.1.** Involve local fishing communities in the identification of fragile ecosystems, including wetlands. **F4.2.** Undertake an economic valuation of marine and coastal ecosystems. **F4.3.** Build the capacity of stakeholders for their effective participation in the development and implementation of fishery-specific management plans. **F4.4.** Convene interdisciplinary researchers to exchange information on observations and research results, and meeting with fisheries managers to ensure the proper interpretation of results and the relevance of research.

Tourism and coastal management

	Strategies	Action List
T1	Provide national guidance for protecting existing critical ecosystems, existing coastal development, and future investment	**T1.1.** Establish decision guidance at the national and local level in preparation of adaptation plans. The guideline should be in line with the Tourism Sector Strategy Plan 2009-2015 and should consider three key questions: 1. Is the existing or proposed structure either necessary for the health, safety, or welfare of an entire region, or is it located within a hazard area for which protection will be provided because of surrounding high-value development? 2. Is it infeasible to relocate an existing structure or site a new structure outside the hazard area and still provide this health, safety, or welfare function? 3. Will relocating an existing or proposed structure provide habitat protection or recreational opportunities that may be otherwise lost if that structure is built or is protected along the coast? Additional questions that should be considered in the preparation of the framework include: - Is there a feasible "soft" protection solution (i.e., can a barrier beach or wetland be used instead of a seawall)? - Will the protection approach, retrofit, or new design: a. Be resilient over a range of sea-level rise possibilities? b. Protect structures of high cultural or social value? c. Provide for a natural shoreline (i.e., can seawalls be designed to include habitat)? d. Be coordinated with proposed actions for other infrastructure in the same flood hazard area? e. Cost less than the value of the structure to be protected? **T1.2.** Develop pilot studies in cooperation with developers that will examine the efficacy and utility of the framework highlighted above.
T2	Engage the Tourism sector in adaptation and sustainable development	**T2.1.** The Ministry of Tourism and Leisure, in collaboration with other relevant bodies, shall promote micro-finance schemes that sustain adaptation and sustainable development programmes. Tourists contributing finance are then provided the opportunity to witness benefits through visits of financed activities, thus placing the ROM as “responsible” destination. An example is financing the dissemination of drip irrigation for agriculture, contributing to poverty alleviation and food security. **T2.2.** Coastal and wetland attractions, as well as non-coastal attractions shall be developed and offered to demonstrate approaches to using adaptation mechanisms against climate change. **T2.3.** In coordination with Action F4.2 of the fisheries sector, the tourism sector shall assist the economic valuation of coastal and marine ecosystems.

Investment Plan for Climate Change Adaptation

The following table shows cross-sectoral and sectoral investments recommended for climate change adaptation over the following three years. Projects and programmes are listed by increasing costs, however the colour coding (see table 28 for legend) gives a preliminary indication of the projects cost, feasibility and effectiveness.

Project / Programme	Duration	Cost (MUR)	Action Plan items addressed
Cross-sectoral investments			
Preserve healthy natural environment	2013-2015	45,000,000	W4.2, A4.1, A4.3, F2.1, F4.1, F4.2, T2.2, T2.3
Coastal management plans for inundation	2013-2015	60,900,000	W4.2, W7.1, A6.1, A6.2, F2.3, T1.1
Sound spatial data Infrastructure	2013-2015	270,000,000	W4.1, W6.1, W7.1, A6.2, F4.2, T2.3
Flood management plans	2013-2015	937,000,000	W1.2, W3.1, W4.1, W5.4, A1.3, F2.3
Sectoral investments			
Water			
Hydrological models	TNA	574,200	W1.1
Rooftop rainwater harvesting	TNA	2,000,000	W5.2
Desalination	TNA	14,000,000	W5.3
Tourism			
Climate Change Awareness	1 YEAR	1,722,600	T1.1, T1.2
Training and capacity building on climate change in the tourism sector	3 YEARS	6,172,650	T1.1, T1.2
Extreme Events Damage Control	3 YEARS	10,048,500	T1.1, T1.2
Coral Reef Bleaching Reduction	5 YEARS	14,355,000	T2.2, T2.3
Water Supply Enhancement	7 YEARS	21,532,500	W5.1
Tropical Storms Damage Minimization	5 YEARS	25,839,000	T1.1, T1.2
Management of Sand Movement and Accumulation	5 YEARS	27,274,500	T1.1, T1.2
Beach Erosion Management	5 YEARS	35,887,500	T1.1, T1.2
Product Enhancement and Diversification	5 YEARS	143,550,000	T2.2
Fisheries			
Support programme 1: Fisheries Management			
Capacity building	2013/2014	2,000,000	F4.1, F4.3, F4.4
FMP prep and Implementation	5 TO 10 YEARS	12,000,000	F1.1, F1.2, F1.4
MCS & VMS vigilance	CONTINUOUS	15,000,000	F1.3, F2.3

Stock assessment & resource potential	2013/2014	20,000,000	F1.1, F4.2, F4.4
Support programme 2: Institutions Strengthening			
Stakeholder consultation	2013/2014	500,000	F4.1
Encourage aquaculture projects	2013/2015	1,500,000	F3.1, F4.1
Comprehensive training programme	2014 Onwards	2,900,000	F2.1, F4.3
Skills and equipment provision	2013/2020	50,000,000	F1.1, F1.2, F1.5
Support programme 3: Infrastructure			
Quay space adapted to SLR	2013/2020	50,000,000	F1.4
Support programme 4: Aquaculture			
Assistance to start aquaculture projects	2013/2020	20,000,000	F3.1, F3.2, F3.3
Support programme 5: Conservation of the Marine Environment			
Capacity building	2013/2014	4,000,000	F1.2, F1.6, F4.1, F4.3, F4.4
Audit of Marine resources	2013/2014	4,500,000	F2.1, F4.1, F4.2
Revisit legislation & regulations	2013/2014	6,000,000	F1.6, F2.4
Promote ecotourism	2013/2014	9,000,000	F4.1, F4.2
Agriculture			
Pest and disease diagnosis service	TNA	912,500	A2.2
Climate Change Awareness	1 YEAR	9,388,170	A2.3, A5.1, A6.2
Soil & Water conservation	1 YEAR	10,995,930	A1.1, A1.3, A3.2, A4.3
Forest Development Plan	3 YEARS	26,700,300	A3.2
IPM Technologies	TNA	28,564,000	A2.1
Food/crop production and security	5 YEARS	33,303,600	A4.2, A4.3
Research and Technology Development	3 YEARS	34,164,900	A4.2, A4.3, A6.1
Training and capacity building on climate change in the Agriculture sector	3 YEARS	49,094,100	A2.3, A3.2, A4.2, A4.3, A5.1, A6.2
Micro irrigation	TNA	187,125,000	A1.2, W2.1, W2.2

Note that a certain number of activities within the Action Plan can be well integrated into existing programmes and/or existing budgetary exercises done at the ministerial level and do not imply medium and longer term sectoral transformations.

Indicators for agenda setting, policy formulation and evaluation

As can be seen in the cross-sectoral nature of the analysis carried out in this document, adapting to the impacts of climate change at the national level rhymes with sustainable development: preserving the long term ability of the country to meet its own needs. In the context of this policy framework, indicators can provide a contribution that reaches beyond the identification of key environmental impacts.

Agenda setting indicators (issues): these indicators highlight the presence of issues relating to the environment and climate change.

Policy formulation indicators (interventions): economic by nature, this group of indicators assesses the potential cost and performance of various interventions options that could be utilized to solve the issue. Costs relate to investment needed to achieve desired goals, and the allocation across the key actors in the economy. This category would include a cost benefit and cost effectiveness analysis and a multi-criteria assessment.

Policy evaluation indicators (impacts):

- CCA investments, jobs, and sectors. This group has an economic focus and represents indirect impacts of target policy intervention and investments aimed at solving specific (environmental) issues. These indicators aim at estimating the performance of economic sectors, including the investment leveraged and the employment generated.
- Indicators of progress and well-being. This group refers to overall measures of economic progress and human well-being, including dimensions such as poverty alleviation, equity, social inclusiveness, overall well-being, capital resources and inclusive wealth.

An excerpt from the fisheries and marine ecosystem set of indicator sis presented below.

Issue	Interventions	Indicators for interventions	Impacts	Indicators for impacts
Fish stock depletion, ecosystem degradation	Sustainable utilization of fisheries resources, protect critical habitat and plan for future hazards	Investment in education, management practices and conservation (Rp per year)	Increased production Higher stock Job creation	Fish production (ton per year) Fish value added (Rp per year)
	Economic valuation of ecosystem services, reduction of water pollution, ecosystem protection	Coral cover and coral condition (live, bleached, broken, etc.)	Job creation Incentive for conservation Protection of coastal land and ecological infrastructure	Job creation (jobs per year) Protected marine area (km2)

Acknowledgement

The author wishes to extend his sincere thanks to the Permanent Secretary, the Director of Environment and the Officers of the Ministry of Environment and Sustainable Development, Ministry of Agro-Industry and Food Security, Ministry of Fisheries, Ministry of Tourism and Leisure, Water Resources Unit and the Rodrigues Regional Assembly for their contribution and support throughout the study.

Special thanks goes to the Climate Change Division of the Ministry of Environment and Sustainable Development for effective overall coordination and organisation, including arranging meetings with key stakeholders, making available necessary documentation and making arrangements for stakeholder workshops.

Stakeholders have shown commitment throughout this study and have provided valuable inputs and comments which have helped to shape this document. The author wishes to commend their efforts and contribution.

Lastly, the author wishes to thank all those persons/consultants who have in one way or another contributed towards the successful completion of this study.

List of acronyms

AAP	Africa Adaptation Programme
ADB	African Development Bank
AP	Action Plan
BAP	Bali Action Plan
BAU	Business As Usual
BOD	Biological Oxygen Demand
CC	Climate Change
CCA	Climate Change Adaptation
CDM	Clean Development Mechanism
COMESA	Common Market for East and Southern Africa
COP	Conference of Parties
CREM	Centre for Research on the Epidemiology of Disasters
CRM	Climate Risk Management
CV	Climate Vulnerability
CVM	Climate Vulnerability Monitor
CWA	Central Water Authority
DOE	Department of Environment
DPSIR	Driving force – Pressure – State – Impact – Response
DRR	Disaster Risk Reduction
EAC	East Africa Community
EC	European Community
ECC	Environment Coordination Committee
EE	Energy Efficiency
EEZ	Exclusive Economic Zone

EIA	Environmental Impact Assessment
EMG	Environment Management Group
EP	Eutrophication Potential
EPA	Environmental Protection Act
ESA	Environmentally Sensitive Area
ESA-IO	Eastern and Southern Africa – Indian Ocean
ESE	Environment, society and economy
EU	European Union
FAO	Food and Agriculture Organization
FMP	Fisheries Management Programme
FPA	Fishery Partnership Agreement
FT	Water Footprint
GCM	General Circulation Models
GDP	Gross Domestic Product
GE	Green Economy
GHG	Greenhouse Gas
GLU	Global Land Use
GOM	Government of Mauritius
GRNW	Grand River North West
GWh	Gigawatt hour
ICZM	Integrated Coastal Zone Management
IGAD	Inter-Governmental Authority on Development
ILO	International Labour Organization
IOC	Indian Ocean Commission
IOD	Indian Ocean Dipole
IOTC	Indian Ocean Tuna Commission
IP	Integrated Policymaking

IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRS	Integrated Resort Schemes
IUU	Illegal, Unreported and Unregulated
IWRM	Integrated Water Resources Management
LOA	Length Overall
LTFO	Lake Tanganyika Fisheries Organization
LU	Land Use
LVFO	Lake Victoria Fisheries Organization
MAAS	Multi-Annual Adaptation Strategy
MAT	Male Annihilation Technique
MCS	Monitoring, Control and Surveillance
MEO	Mauritius Environment Outlook
MID	Maurice Ile Durable
MOAIF	Ministry of Agro Industry and Fisheries
MOESD	Ministry of Environment and Sustainable Development
MSIRI	Mauritius Sugar Industry Research Institute
MSP	Multi-Stakeholder Process
MUR	Mauritian Rupees
NAMA	National Appropriate Mitigation Actions
NCCC	National Climate Change Committee
NES	National Environmental Strategies
NF	Nutrient Footprint
NNSD	National Network for Sustainable Development
OECD	Organization for Economic Co-operation and Development
PPP	Purchasing Power Parity
RE	Renewable Energy

RES	Residential Estate Schemes
ROI	Return on Investment
ROM	Republic of Mauritius
SADC	Southern Africa Development Community
SCP	Sustainable Consumption and Production
SD	System Dynamics
SDI	Spatial Data Infrastructure
SEEA	System of Environmental-Economic Accounting
SIDP	Sustainable Integrated Development Plan
SLR	Sea Level Rise
SNA	System of National Accounts
SST	Sea Surface Temperature
SWIOFC	Southwest Indian Ocean Fisheries Commission
TCCA	Tourism Carrying Capacity Assessment
TMR	Total Material Requirement
TNA	Technology Needs Assessment
UNCLOS	United Nations Convention on the Law of the Sea
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNWTO	United Nations World Tourism Organization
USGS	United States Geological Survey
VA	Value Added
VMS	Vessel Monitoring System
WB	World Bank

WDI	World Development Indicators
WHO	World Health Organization
WIO	Western Indian Ocean
WMO	World Meteorological Organization
WU	Water Use

List of Figures

List of Tables

Glossary

The following terms and concepts are regularly used in the climate and development field. Of special attention is the definition of "vulnerability to climate change", which is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). [3]

Adaptation

Adjustments in human and natural systems, in response to actual or expected climate stimuli and/or their effects, that moderate harm or exploit beneficial opportunities (IPCC 2007). Adaptation may be spontaneous (triggered by ecological changes in natural systems and by market or welfare changes in human systems) or planned (a result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required). It can also be in response to ('ex post'), or in anticipation of ('ex ante'), changes in climatic conditions. Adaptation entails a process by which measures and behaviours to prevent, moderate, cope with, and take advantage of the consequences of climate events are planned, enhanced, developed, and implemented (UNDP 2005). [4]

Adaptive Capacity

The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and/or to cope with the consequences. It can also be defined as the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability or future climatic conditions (IPCC, 2007) [5]. A "system" can take the form of a country, a community, a family, or an individual.

Climate Change

Any change in climate over time, whether due to natural variability or because of human activity (UNDP, 2005). [6]

Climate Change Mainstreaming

The integration of priority climate change adaptation responses into development, so as to reduce potential development risks and take advantage of opportunities. The objective is for adaptation

[3] IPCC (2007), "Climate Change 2007: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* "Chapter 17: Assessment of Adaptation Practices, Options, Constraints and Capacity", Cambridge University Press, Cambridge, pp. 717-743.
[4] UNDP (2005). *Adaptation Policy Framework f or Climate Change: Developing Strategies, Policies and Measures.* Lim, B., E. Spanger-Siegfried, I. Burton, E. Malone and S. Huq (Eds). Cambridge University Press, 258p.
[5] IPCC (2007), "Climate Change 2007: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* "Chapter 17: Assessment of Adaptation Practices, Options, Constraints and Capacity", Cambridge University Press, Cambridge, pp. 717-743.
[6] UNDP (2005). *Adaptation Policy Framework f or Climate Change: Developing Strategies, Policies and Measures.* Lim, B., E. Spanger-Siegfried, I. Burton, E. Malone and S. Huq (Eds). Cambridge University Press, 258p.

measures to be implemented "as part of a broader suite of measures within existing development processes and decision cycles" (OECD, 2009).[7]

Climate Proofing

The process of guarantying the viability of investments in property or infrastructure by taking climate change into account. Its purpose is to reduce climate risks to "acceptable levels through long-lasting and environmentally sound, economically viable, and socially acceptable changes" (ADB, 2005).[8]

Climate Risks

The probability of harmful consequences or expected losses (deaths, injuries, property, disruption to livelihoods and economic activities, or environment damaged) resulting from interactions between climate-related hazards and vulnerable conditions.

Climate Risk Assessment or Screening

A systematic process to determine the nature and extent to which existing development projects and programmes already consider climate change risks and opportunities, so as to identify opportunities for incorporating climate change explicitly into future projects (Klein et al., 2007)[9]. It involves analysing potential impacts on activities, outputs, and programmes, while evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, and/or livelihood, not to mention the environment on which these depend (UNISDR, 2004).[10]

Climate Risk Management (CRM)

A body of work that bridges the topics of climate change adaptation, disaster management, and development. Hellmuth *et al.* (2007)[11] describe CRM as an approach to promote sustainable development by reducing vulnerability associated with climate risks. This approach involves implementing proactive 'no regrets' strategies, aimed at maximizing positive and minimizing negative outcomes in climate-sensitive areas such as agriculture, food security, water resources, and health, across communities and larger societies. 'No regrets' decisions or actions are those that are expected to lead to positive development outcomes regardless of whether a specific climate threat actually materializes in the future.

Disaster Risk Reduction (DRR)

The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened

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[7] OECD (2009). *Integrating Climate Change Adaptation into Development Co- operation.* Policy Guidance. OECD Publishing, 196p.

[8] ADB (2005). *Climate Proofing: A Risk-based Approach to Adaptation.* Asian Development Bank: The Philippines, 219p.

[9] Klein, R.J.T., S.E.H. Eriksen; L.O. Næss, A. Hammill; T.M. Tanner, C. Robledo and K.L. O'Brien (2007). *Portfolio Screening to Support the Mainstreaming of Adaptation to Climate Change into Development Assistance.* Tyndall Centre for Climate Change Research, Working Paper 102.

[10] UNISDR (2004). *Living with Risk: A Global Review of Disaster Reduction Initiatives.* 429p.

[11] Hellmuth, M.E., Moorhead, A., Thomson, M.C., and Williams, J. (eds) (2007). *Climate Risk Management in Africa: Learning from Practice.* International Research Institute for Climate and Society (IRI), Columbia University, New York, USA, 104p.

vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.[12]

Climate Variability (CV)

Refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).[13]

Enabling environment

The set of resources and conditions within which the policy and the target beneficiaries operate. The resources and conditions that are generated by structures and institutions that are beyond the immediate control of the beneficiaries should support and improve the quality and efficacy of the adaptation policies.

Exposure

The nature and degree of climatic stress upon a system, including long-term changes in climate conditions and changes in climate variability. To assess exposure, one must consider how humans and materials may be affected by change, as well as the change in climate itself (sea level rise, precipitation, and temperature change) (IPCC, 2001). [14]

Maladaptation

An action or process that increases vulnerability or exposure to climate change- related impacts. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits, but lead to exacerbated vulnerability in the medium to long-term.

Resilience

The capacity of communities to absorb external tensions and disturbances as a result of social, political or environmental changes. Three conditions enable a social or ecological system to absorb change: ability to self-organize, ability to buffer disturbance, and capacity for learning and adapting (Trosper, 2002)[15].

[12] Catherine Pettengell (2010) Climate Change Adaptation – enabling people living in poverty to adapt, Oxfam International, Great Britain.

[13] IPCC definition found at http://www.ipcc.ch/ipccreports/tar/wg1/518.htm - accessed 11 July 2012.

[14] IPCC (Intergovernmental Panel on Climate Change) (2001), "Climate Change 2001: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Third Assessment Report of the Intergovernmental Panel on Climate Change,* "Chapter 18: Adaptation to Climate Change in the Context of Sustainable Development and Equity", Cambridge University Press, Cambridge, pp. 877-912.

[15] Trosper, R.L. (2002). Northwest Coast Indigenous Institutions that Supported Resilience and Sustainability. *Ecological Economics,* 41: 329-344.

Sensitivity

The degree to which a system is affected – either adversely/beneficially, directly/ indirectly – by climate variability and/or change (IPCC, 2007). [16]

Vulnerability

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extreme events. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

Vulnerability = Exposure + Sensitivity – Adaptive capacity

[16] IPCC (2007), "Climate Change 2007: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* "Chapter 17: Assessment of Adaptation Practices, Options, Constraints and Capacity", Cambridge University Press, Cambridge, pp. 717-743.

1. Introduction

1.1. Scope of the work

The present National Climate Change Adaptation Policy Framework consists of several deliverables, and the main goal of the project is to integrate and mainstream climate change adaptation into core development policies, strategies and plans of the ROM.

More specifically, the objective of this project is to prepare a National Climate Change Adaptation Framework which comprises (1) a National Climate Change Adaptation Policy, (2) a Climate Change Adaptation Strategy and Action Plan, (3) a Climate Change Adaptation Investment Program, and (4) Project Concepts.

This work requires the creation and elaboration of the following knowledge:

i. An analysis of current and projected impacts of climate change for time horizon of 2012-2100 for: (a) business as usual scenario, and (b) no-regret scenario, also assessing and quantifying the impacts of climate change on key sectors in monetary terms to better inform decision making;
ii. To identify key gaps and needs for mainstreaming climate change adaptation in key sectors;
iii. To propose and recommend climate change adaptation policy options/measures for the key sectors under consideration under AAP in light of socio-economic evidence produced.

This knowledge is incorporated in the National Climate Change Adaptation Framework, and is created by a variety of stakeholders and consultants working at the AAP project. In fact, the Framework is primarily a collection of existing materials, coherently organized to define a clear and rigorous national climate change adaptation policy for the Republic of Mauritius (ROM). Worth clarifying, the study does not include a complete macroeconomic analysis of the impacts of climate change, and of the policies and investments included in the respective plans. This analysis may be considered for follow up work, to complete, with a quantitative assessment, the work done in this study.

1.2. Summary of the stocktaking report

1.2.1. Observed and forecasted trends in climate change and climate variability

Mauritius is not spared of the impacts of climate change: frequency and intensity of natural extreme events are increasing, with noticeable effects of larger inter-annual variations in oceanic and atmospheric conditions, and increased drought and enhanced erosion. Geographical and topographical characteristics of the island limit its capacity to adapt to and mitigate climate change and sea level rise impacts (GOM and EC, 2008)[17].

Mauritius is highly vulnerable to the threat of natural and environmental hazards and disasters like cyclones, tsunamis, droughts, floods, diseases and environmental hazards, such as spills. The

[17] Government of the Republic of Mauritius, European Community (2008). Country Strategy Paper and Indicative Programme for the period 2008-2013.

changes due to these calamities represent additional stresses on already weakened environmental systems.

While there is strong agreement among computer models of the climate system about large-scale changes in temperature, and recent versions of the models tend to show improved agreement on changes in subcontinental climate patterns, there is more uncertainty regarding the precise changes in rain, and particularly changes in variability and extremes. Therefore, while much of the available information is clear enough to warrant and guide decision making, climate science is not, and possibly will never be, in a position to provide precise quantitative forecasts for all aspects of the climate in a specific location for the next few years, decades or centuries. Instead, uncertainties, often about the likely extent of the change, but sometimes even about the direction of change (e.g. for precipitation) are part of the challenge.

1.2.2. Sectoral impacts

For illustrative purposes, the impacts of climate change in Mauritius are presented for four sectors, namely agriculture, water, fisheries and tourism (coastal zones).

Water: Baseline data for 1990, (average for period 1980-1989) and modelled projections by have been used to estimate water availability and utilizable water resources up to a time horizon of 2050, taking into account the effect of population growth. 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 reach the storage system. These changes will only exacerbate the water scarcity on the island of Mauritius. Increase in storage capacity is already being implemented, responding to the immediate need to be able to meet demands in the short term[18].

Agriculture: The main changes in climate that have been observed in Mauritius, and which are relevant to the agriculture sector are temperature rise, increasingly variable rainfall, drought, tropical cyclones, climate extremes and sea level rise (SLR). These climate change impacts incur a variety of consequences for the agricultural sector which include (but are not limited to) change in soil moisture, heat stress on crops and lower productivity, increased risk of flooding and soil erosion, salinization of irrigation water in coastal zones, etc.

Concerning prospective scenarios, simulation results from General Circulation Models (GCM) that best reflects the locally-observed trends, and changes in rainfall and mean temperature are summarized in Table 1. [19]

[18] Government of Mauritius (2010). Second National Communication under UNFCCC (Mauritius Meteorological Services, Vacoas, 2010).
[19] Government of Mauritius (2010). Second National Communication under UNFCCC (Mauritius Meteorological Services, Vacoas, 2010).

Table 1. Range of the projected changes in temperature, rainfall and sea level rise (SLR).

(Source: Second National Communication, 2010).

Time horizon	Temperature (°C)			Rainfall (%)	SLR (cm)
	Mean	Maximum	Minimum		
2020	0.43 – 0.47	0.58 – 0.64	0.37 – 0.41	(5.41 – 6.02)	5.3 – 5.5
2050	0.94 – 1.40	1.28 – 1.91	0.82 – 1.21	(9.19 – 13.96)	13.8 – 16.2
2100	1.86 – 3.28	2.54 – 4.48	1.61 – 2.85	(17.57 – 26.76)	32.7 – 48.6

Fisheries: Climate change is impacting on the fisheries sector with lowered and erratic fisheries productivity and availability (MOESD, 2011)[20]. For instance, between 2009 and 2010, fish production fell by 19.1%, from 6,978 tonnes to 5,647 tonnes. Fresh coastal fish catch and other catch (such as bank fishing) decreased by 2.6% and 26.5% respectively. Additionally, it is predicted that as the El Niño phenomenon becomes more frequent, intense and of longer duration, the size and location of fish stocks and fish migration patterns will be affected (IPCC, 2007)[21]. Any additional impact of climate change risks jeopardizing the livelihood of many and endangering food security.[22] With anticipated warming, additional effects are anticipated, including spatial management schemes becoming inappropriate, and coral threatened due to bleaching and ocean acidification.[23]

Tourism: With its close relationship to the environment and climate, tourism and travel is considered to be a highly climate-sensitive economic sector (UNWTO, 2008)[24]. Climate directly affects various facets of tourism operations (e.g. water supply and quality, heating-cooling costs, irrigation needs, pest management, evacuations and temporary closures) that affect profitability. The tourism link is the main concern in the coastal adaptation strategy for Mauritius, since much revenue and jobs are at risk if beaches continue to erode, not to mention the infrastructure at risk. 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.[25]

[20] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report.

[21] IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22.

[22] Government of Mauritius (2010). Second National Communication under UNFCCC (Mauritius Meteorological Services, Vacoas, 2010).

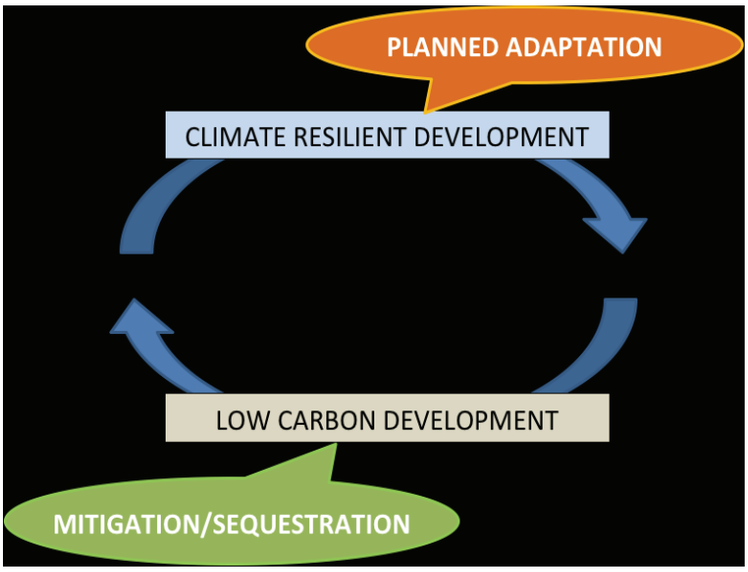
[23] Ibid.

[24] UNWTO and UNEP and WMO (2008) *Climate Change and Tourism: Responding to Global Challenges,* (prepared by Scott, D., Amelung, B., Becken, S., Ceron, J.P., Dubois, G., Gössling, S., Peeters, P. and Simpson, M.C.), UNWTO, Madrid, and UNEP, Paris

[25] Quoted in, Landell Mills (2009) ICZM Strategy Part I: Introduction to ICZM and Stock-take for Mauritius, pg. 99.

1.3. Considerations on climate mitigation

Figure 1: Climate change adaptation and mitigation.



Climate change is still often seen as an environmental issue and not a developmental one. It is becoming clearer however that climate change adaptation is all about "climate resilient" development, while the focus of climate change mitigation is in low carbon development – one which reduces and eventually eliminates GHG emissions. The main GHG in Mauritius is CO_2, and arises from the burning of fossil fuels (coal, fuel oil, diesel oil, gasoline and kerosene).

Although the national emission for Mauritius is small by global standards, it nevertheless has a relatively significant per capita CO_2 emission: 2.9 tCO_2 for Mauritius in 2010[26]. This figure is 2.5 times higher than the per capita emission of Africa (~1.1 tCO_2/person), and 1.8 times higher than that of India (~1.5 tCO_2/person).[27] The Second National Communication under the UNFCCC[28] has made projections of GHG emissions to 2040, and it has considered several options for emission reductions, including sequestration.[29] The results are summarized in Table 2. The analyses did not take into consideration the need to constrain GHG emissions.

Table 2: Business as usual total GHG emissions and their reduction potential to 2040 (1000 tCO_{2e})

Year	**2020**	**2030**	**2040**
Business as usual	5382	6286	7822
Reduction potential	1528	2317	3309

Although the Republic of Mauritius is among the first countries to ratify the Kyoto Protocol under the UNFCCC, it does not have national strategies to guide medium-to-long term mitigation and adaptation actions to tackle climate change. Research is currently under way however to elaborate the viable pathways that would enable Mauritius to achieve reductions in GHGs, and hence strive towards a low-carbon society, under different atmospheric GHG stabilization scenarios by 2050. Nationally Appropriate Mitigation Actions (NAMAs) for Mauritius will also be developed. NAMAs are

[26] Environment Statistics – 2010, Central Statistics Office, Port Louis, Mauritius
[27] C. Flavin, Building a Low-carbon Economy, Chapter 6 in State of the World 2008 (WorldWacth Institute, DC, USA).
[28] Government of Mauritius (2010) Second National Communication of the Republic of Mauritius under the United Nations Framework Convention on Climate Change (UNFCCC), pp 71-75
[29] Second National Communication (2010), Table 4.15, pg. 100

the translation of the Bali Action Plan (BAP) (adopted by the Conference of Parties (COP) as decision 1/CP.13 in December 2007), and are to be supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable (MRV) manner.

1.4. Green jobs in the context of climate change interventions

In the recent research conducted by International Labour Organisation (ILO) with a research team in Mauritius, it was calculated that in 2010, green jobs made up 6.3% of total employment (35 160 out of a total of 558 100).[30]

"Green Jobs"

In the ILO study, three methods to measure Green Jobs are considered:

i) The process-based method and

ii) The output-based method captures employment in 'market valued' products and processes, while

iii) The natural resource conservation method involves jobs providing public goods (no market value).

The process based method defines as Green those jobs that are in enterprises which are among the 10% most energy and water efficient.

The output based method referrers to the characteristics and use of the final product or service having a beneficial environmental purpose. An example is a solar powered water heater or geyser.

The natural recourse conservation method seeks to identify sectors and employment which have a direct link with protecting or enhancing environmental quality.[31]

Through the above methodology, Green Jobs can be attributed to both Climate Change adaptation efforts and mitigation (low carbon development). For instance, under the process based method, energy efficiency pertains to low carbon development and water efficiency to climate change adaptation. Under the output-based and natural resource conservation methods, jobs rather pertain to climate change adaptation as they support the resilience of natural systems.

In Mauritius, most green jobs were found in:

- Electricity generation – with 23% of jobs in supplying bagasse from sugar cane to electricity plants
- Agriculture – 12% share of employment can be considered green as well as decent
- Textiles – 5% of companies due to reduction in their energy consumption through greening of their operational processes (i.e. solar water heating systems, natural air cooling and grey water use).
- Tourism (hotel) 3% of jobs found in highly energy and water efficient tourist resorts.

This research also provides a short tem projection of a green growth scenario as opposed to a conventional one, indicating in its result that redirecting growth towards a greener scenario (through investment and increased demand) can result in higher output and more jobs. The model used to

[30] International Labour Organization, Assessing current and potential Green Jobs: the case of Mauritius, Policy Brief

[31] The process based method has been used notably for manufacturing and tourism. The output based method has been utilised for the agriculture and renewable energy sector and follows the European Industrial classification of environmental goods and services. Natural resource conservation activities typically provide public goods where no private markets exist. Green jobs in these sectors are found in national parks and marine conservation activities.

simulate the two scenarios assumes a conservative 2.5% growth on total industrial output per year (which is roughly around Rs. 10 billion) and focuses on four main sectors – agriculture (sugar), manufacturing (textile) tourism (hotel) and energy (renewable versus fossil fuel). Within all four sectors an increase of 21 600 jobs was calculated in the green scenario as opposed to 15 250 jobs when following a conventional growth path.

Furthermore, the model uses *the output and employment multiplier*, calculated to account for the indirect supply chain linkages between the different industrial sectors and an effect a strategy to enhance production in a particular sector (by investment and/or rising demand) would have on the employment and production in other interrelated sectors (see the table below). The result of using this output and employment multiplier to compare the two scenarios within energy sector itself is especially encouraging. In terms of employment, the increase in jobs in the renewable scenario would be nearly double compared to the effect of simulated output growth in the fossil fuel sector. And in terms of industrial input, assuming a green growth with investment of 2.5% of the total energy sector (or roughly 280 million Rs) would result in a total 700 million Rs output growth of all industries combined. In comparison increasing output in the fossil fuel sub sector by the amount would only lead to an overall output growth of around 450 million Rs.

The differences between the green and the conventional growth scenario as illustrated in the Renewable energy sector are due to the higher integration of green industries and notably renewable energy based activities through linkages into the value chains of the Mauritian economy. Conversely fossil fuels are imported and have much weaker linkages into the domestic economy therefore generating less additional employment and value added.

Table 3: One million MUR increase in final demand and its effect on output, direct and indirect jobs on selected sectors

	Contribution to GDP as % of total	Employment per sector as % of total with sub conventional and green % of sector totals		Output multiplier	Direct jobs created by an Rs 1 million increase in final demand	Indirect jobs created by an Rs 1 million increase in final demand	Total jobs created by an Rs 1 million increase in final demand
Agriculture (sugar)	**4%**	**8%**					
Conventional			88%	1.21	2.28	0.29	2.57
Green			12%	1.3	2.28	0.41	**2.69**
Manufacturing (textile)	**18%**	**21%**					
Conventional			95%	1.58	0.7	0.8	1.5
Green			5%	1.54	1.7	0.8	**2.5**
Services (hotel)	**7%**	**7%**					
Conventional			97%	1.37	0.67	0.55	1.23
Green			3%	1.37	1.49	0.55	**2.05**
Energy	**2%**	**1%**					
Fossil fuels			77%	1.6	0.2	0.6	0.8
Renawable			23%	2.5	0.2	1.2	**1.4**
Other sectors	**69%**	**63%**					
Total	**100%**	**100%**	**6.3%**				

1.5. Methodology for an Integrated Climate Change Adaptation Policy formulation and evaluation

Thanks to the growing body of knowledge in the climate change field, it is now possible to create a single national policy framework that integrates existing research and policy work on sustainable development, climate change mitigation and adaptation strategies, as well as other sectoral strategies.

A "climate change adaptation framework" can enable policymakers to identify synergies and avoid conceptual and implementation bottlenecks by providing a framework for policy formulation and evaluation. This is intended to support the incorporation of climate change adaptation in national development planning and bridge the interests (and professional language) of various ministries and other stakeholders as needed.

Designing the framework involves coupling existing materials at the national level with knowledge and best practices on Integrated Policymaking, identifying and using indicators to support both the formulation and evaluation of intervention options in an integrated manner (using cross-sectoral dimensions to evaluate the performance, and effectiveness, of various policy options).

This work does not generate necessarily new technical or scientific knowledge, as it uses existing reports developed at the national level, but it is innovative in the cross sectoral approach, finding synergies across the existing materials to maximize the effectiveness (coherence and coordination) of various intervention options within and across sectors. In fact, this document can be considered as a guideline for future exchanges at the national level, a platform to build on in order to improve stakeholder engagement and coordinate action for a more climate resilient future.

The proposed approach combines several deliverables in an integrated framework, as shown in Figure 2. Part I of this document addresses the "Climate Change Adaptation Policy Framework" and introduces processes to be used in subsequent parts (policy, strategy, action plan, investment plan and project samples).

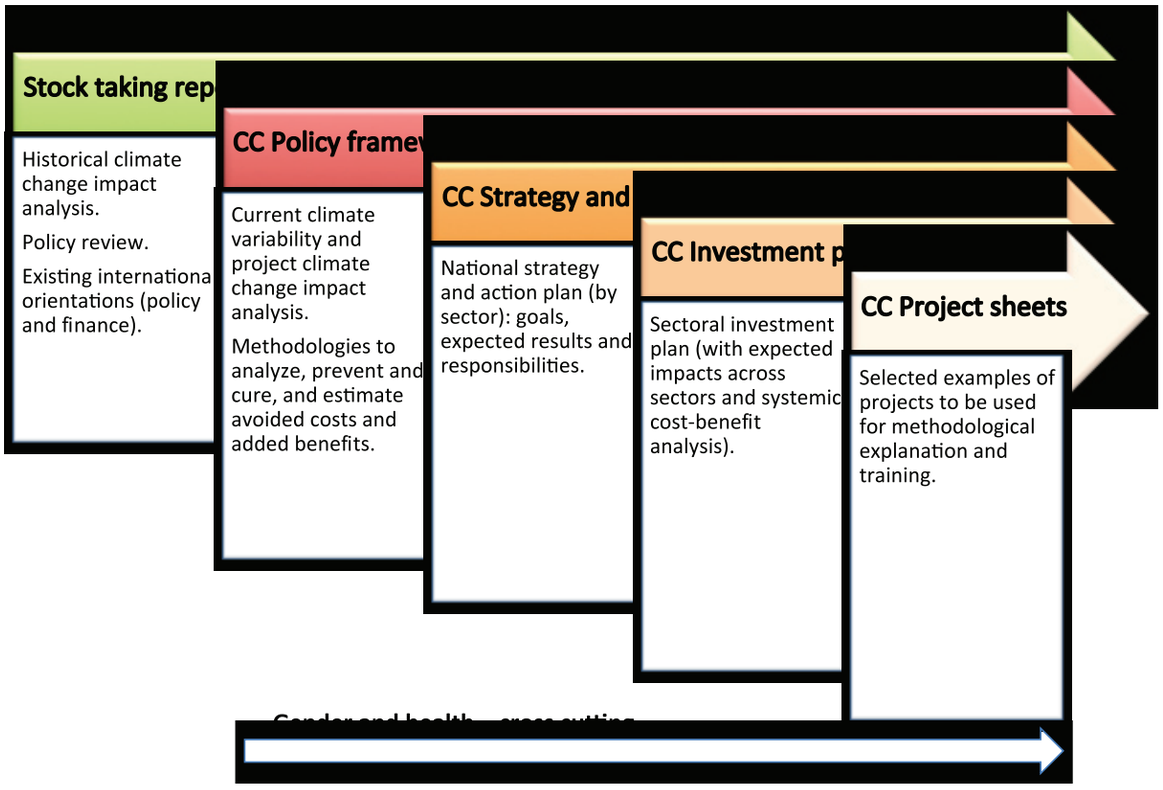
More specifically, these documents have each a specific purpose and build on each other:

- **Stock taking report**: this study serves to review historical climate change impacts in Mauritius, as well as existing legislation. Knowledge on future climate events is also considered.
- **Climate Change Adaptation Policy Framework**: this study provides the framework of analysis for creating a climate change adaptation policy, indicating the tools available for policy formulation and evaluation and integrate climate change adaptation in national development planning.
- **Climate Change Adaptation Policy**: this section identifies and lists the key policy principles and responsibilities from a national and sectoral perspective. Time frame: 20 years (2030).
- **Climate Change Adaptation Strategy and Action Plan**: this study defines the main elements of a climate change adaptation strategy at the national level and provides a sectoral action plan to improve climate resilience, making use of synergies and avoiding bottlenecks. Time frame: 10 years (2020).

- **Climate Change Adaptation Investment Plan**: this section provides a cross-sectoral cost benefit analysis of the most relevant investment options that would be triggered by the strategy and action plan. Time frame: 3 years (2015).
- **Climate Change Adaptation Project Sheets**: the project briefs provide more detailed information on the cross-sectoral pros and cons of selected sectoral interventions. Time frame: 3 years (2015).

These different elements of the climate change adaptation framework are developed according to the flow shown in the figure below.

Figure 2. Climate Change Adaptation Policy Framework, main elements and flow.



In order to curb existing trends and progress towards a more climate resilient economy, an integrated approach that incorporates environmental, social and economic (ESE) implications of policy implementation is needed. Underlying this approach is the recognition that the algebra among the social, economic and environmental pillars of sustainable development (how the variables relate and affect one another in context; how they combine towards the equation of sustainable development) is more important than the arithmetic among them (added or subtracted as convenient) (EMG, 2011)[32].

Policy formulation and evaluation need to be carried out in the context of scenarios (e.g. technological development, natural disasters), and policies (e.g. subsidies, incentives and/or

[32] United Nations Environment Management Group (EMG), *Working Towards a Balanced and Inclusive Green Economy, A United Nations System-wide Perspective* (2011).

mandates) have to be evaluated across a variety of indicators (social, economic and environmental) simultaneously. How these three levels are supported with solid and coherent information, and interact with each other, will greatly determine the success of any national development plan over the medium to longer term. This information is also crucial to truly understand the drivers of change and design policies that have the desired impacts, effectively.

More specifically, firstly, in order to design and evaluate national development policies the structure of the system analysed (e.g. social, economic and environmental) should be properly analysed and understood. Using the example of the energy sector, this includes the investigation of the main drivers of demand, and how supply can respond to its needs; in the case of poverty reduction, this implies understanding what are the key factors influencing poverty and what are the main drivers for their behaviour. This is a broad investigation heavily relying on soft and hard data analysis, as we are in rapidly changing times and various cross-sectoral interdependencies are emerging.

Secondly, economic volatility, as well as climate impacts, natural disasters and other unexpected events, can have a considerable impact on the effectiveness of energy and environmental policies over time. For these reasons scenarios have to be defined, to reduce the uncertainty coupled with the analysis carried out. Policies would then be evaluated based on the structure of the system analysed as well on a variety of possible scenarios.

Thirdly, the implementation of policies for climate change adaptation, in the context of longer-term national development, should be tested. In order to do so effectively -and evaluate whether they create synergies, bottlenecks or side effects across sectors-, the impact of policies has to be evaluated for a variety of social, economic and environmental indicators. Policies are “shocks” to the system, which in turn responds to these changes. For this reason, the system itself should be analysed focusing on feedbacks and causal relations, with a specific interest on medium to longer-term impacts (which go beyond the implementation delays of policies -i.e. inertia of the system-).

To conclude, the understanding of the functioning mechanism of the system allows for the identification of medium to longer-term sectoral and cross-sectoral implications of policy implementation. These impacts have to be analysed with the understanding that different sectors are influenced by different key causes defining the success (or failure) of policies. In other words, a policy can have very positive impacts for certain sectors and create issues for others. Furthermore, successful policies in the longer term may have negative short-term impact, for which mitigating actions may be designed and implemented.

The main methodologies and tools utilized to carry out this systemic analysis are presented in detail in Annex A.

2. National Climate Change Adaptation Policy

2.1. Policy Goals and Objectives

Acknowledging that actions towards climate change resilience are aimed at supporting sustainable development, in an equitable future and where society is engaged at all levels in defining and shaping ROM's path towards sustainability, the objectives of the climate change adaptation policy are to:

- **Foster the development of strategies, plans and processes to:**
  - Avoid, minimise or adapt to the negative impacts of climate change on key assets of Mauritius, namely agriculture, water, fisheries and ecosystems.
  - Avoid or reduce damage to human settlements and infrastructure caused by climate change.
  - To build capacity to understand, analyse and react in a timely manner in the wake of future climate change impacts within the ROM.
- **Integrate and mainstream climate change adaptation into core development policies, strategies and plans of the ROM.**

2.2. Key Policy Principles

The Government of Mauritius, in collaboration with other relevant entities, and taking into consideration three core principle of the Agenda 21 (UN, 1992)[33], namely common but differentiated responsibilities, the polluter pays principle and the precautionary principle, will:

Concerning the definition and introduction of long term planning mechanisms:

- Ensure that adequate planning (physical, socio-economic etc.) is undertaken with periodical reassessment based on progress and needs to address the impacts of climate change. Such planning should be undertaken, not in isolation but in the wider context of sustainable development, and using an integrated, cross-sectoral and trans-disciplinary approach (i.e. systems approach).

Concerning improving climate resilience:

- Recognizing that the resilience of the natural environment is key to coping with climate change, do all possible to enhance and maintain environmental quality;
- Recognizing that economic resilience is key to coping with climate change, do all possible to promote the development of a strong and diversified economy;
- Create an enabling environment for the adoption of appropriate technologies and practices that will assist in meeting national and international commitments with respect to the causes and effects of climate change.

Concerning strengthening capacities and institutional frameworks:

[33] United Nations (1992) Agenda 21, The United Nations Programme of Action from Rio.

- Endeavour to ensure that society, at all levels and in all sectors is adequately informed on climate change and its implications for the nation and the role that it must play in this respect;
- Endeavour to obtain, to the extent feasible, the involvement and participation of all stakeholders at the national level in addressing issues related to climate change;
- Endeavour to ensure that such involvement and participation occurs on an appropriately coordinated basis which minimises duplication of effort and conflict and which ensures efficient use of resources and the creation of positive synergies.

The main means of implementation include:

Financing options to meet national adaptation financial needs:

- Procure and allocate financial and other resources, as appropriate and feasible (including domestic, regional and international sources of funding), to ensure that climate change is addressed in the manner required.

Capacities and institutional frameworks:

- Develop national human and institutional capacity in all aspects of climate change research, response, planning, etc.;
- Create an institutional, administrative and legislative environment which engenders/ supports the effective implementation of climate change adaptation activities;
- Collaborate as appropriate and feasible, with other regional and international states and organisations which pursue confluent agendas in climate change;
- Promote and support research and information gathering at the national, regional and international levels on aspects of climate and its impacts as they pertain to Mauritius.

2.3. Sectoral Policy Directives

The Government of Mauritius recognises that it is vital to consider the sectoral policy directives as interconnected and interdependent. Thus application of the directives mentioned in the next sections should be undertaken as such. For example, limiting the use of chemicals in agriculture can preserve water quality and prevent run-offs that are dangerous for coastal ecosystems and fisheries, thereby preserving their natural resilience and maintaining the provision of tourism resources.

2.3.1. Water demand and supply

The protection, sustainability, and enhancing of freshwater quality and availability in Mauritius are of key importance and are threatened due to the multiplied effects of increased demand, climate change, contamination and other factors. In addressing these and other related issues, the Government of Mauritius, in collaboration with other relevant entities, will:

- Develop a long-term national water management plan which incorporates and addresses climate change concerns including catchment and watershed protection and saltwater intrusion;
- Incorporate the national adaptation strategy for the water sector into the land use planning and management processes;

- Promote the strengthening of national water management agencies to ensure the sound management of water resources, through, *inter alia*:

  - The Integrated Water Resources Management approach, incorporating climate variability;
  - Sustainable watershed management;
  - Review of water related legislation and improvement of enforcement mechanisms for water resources protection;
  - A National Programme on Sustainable Consumption and Production;

- Assess and address needs for water storage and distribution infrastructure to ensure water availability during drought periods;

- Undertake measures to increase the resilience of aquifers and rivers to maximise water availability and reduce degradation of water quality;

- Promote initiatives to identify and, where necessary, exploit non-traditional water resources such as sea-water through desalination.

2.3.2. Agriculture and terrestrial ecosystem

In order to address climate change impacts and to promote the implementation of appropriate adaptation measures, the Government of Mauritius, in collaboration with other relevant entities, will:

- Develop a national adaptation strategy for the agriculture sector, as part of the national climate change adaptation strategy, to address impacts over the short, medium and long term;

- Include adaptation policies into the national policy formulation process;

- Formulate and implement any other such strategies and measures which may help to ensure food security and sustainable food production;

- Endeavour to transform the food crisis into an opportunity for farmers and to build resilience in order to reduce the country's food dependency on imports. This will be achieved through, *inter alia*:

  - Promoting the use of proper irrigation methods and fertilization techniques that improve crop productivity while optimizing water use and minimizing runoff and risk of salinity,
  - Extending the period of vegetable and fruit production,
  - Encourage the production of novel and healthy food crops,
  - Strengthening of farmer organisations,
  - Improving research and farmer training,
  - Grow crops suitable for import substitution:
    - To reduce dependency on imports, often from countries frequently affected by weather extremes such as drought and floods in Australia which is a major source of our imported pulses;
    - To create opportunities for employment and crop diversification;
    - To reduce the foreign exchange loss for importing;
    - To reduce carbon footprint (energy used for transportation of produce from overseas).
  - Improve storage capacity for agricultural produce to increase resilience in times of disasters (local or overseas sources),

- Improve processing facilities for improved products which can be stored for off-season consumption;
- Ensure the maintenance and operation of a Food Security Fund to sustain the implementation of adaptation measures.

2.3.3. Fisheries and marine ecosystem

The Government of Mauritius recognises the importance of the fisheries sector in terms of providing employment, export revenues, foreign license fees and other services for sea-food activities and its supporting vessels. To adapt to the effects of climate change and maintain a climate resilient sector, the Government of Mauritius, in collaboration with other relevant parties, will:

- Promote and facilitate the undertaking of ongoing multi-disciplinary assessment of coastal and marine ecosystems, to ensure that needs of marine life are understood and taken into account for fisheries and coastal zone management;
- Strengthen fisheries governance at national and regional levels, to ensure:
  - The elimination of Illegal, Unreported and Unregulated (IUU) fishing;
  - Communication and coordination with key sectors affecting or affected by fisheries (e.g. effluent of terrestrial pollutants affecting marine ecosystems, and threat to human health and coastal activities from marine pathogens and toxins, respectively);
- Ensure the continuation, expansion and strengthening of capacity for artisanal fishermen to:
  - Fish outside the lagoon, so as to preserve fragile lagoon ecosystems;
  - Take part in semi industrial fishing activities;
- Identify and promote alternative fishery and resource use activities (e.g. aquaculture) where impacts on ecosystems and natural resources preclude the continuation of traditional activities;
- Endeavour to create and maintain appropriate infrastructure for storm forecasting, signalling systems and safe refuges for dealing with rising sea level and increased storminess.

2.3.4. Tourism and coastal management

In an effort to use appropriate approaches to adaptation in the tourism sector, the Government of Mauritius, in collaboration with other relevant parties, will:

- Ensure that appropriate physical planning guideline such as coastal setbacks are enforced for new tourism developments, and possibly consider the extension of the coastal setback to 45 meters (from 30 meters);
- Undertake measures to incorporate tourism development with natural resources management such as Integrated Coastal Zone Management (ICZM) to preserve ecosystem services;
- Facilitate the protection and rehabilitation of tourism resources, including natural resources such as beaches, and man-made resources (infrastructure);
- Continue working with stakeholders in the tourism sector to develop a strategic plan that incorporates climate change considerations and appropriate measures such as water conservation programmes as well as general safety and sustainability concerns (e.g., hotels with over 75 rooms are already requested to recycle and reuse water).

3. Strategy and Action Plan for Climate Change Adaptation

3.1. Estimating the socio-economic impacts of climate change

Climate change affects the environment and hence habitat of humans and their support system, the living biosphere, which public health and industries rely on. This section provides analyses of the impacts of climate change in the water, agricultural, fisheries, and tourism sectors.

For the purpose of an introductory overview however, the Climate Vulnerability Monitor (2nd Ed) provides a reassessment of the human and economic costs of the climate crisis. The reassessment is based on a wealth of the latest research and scientific work on climate change and the carbon economy[34], and offers some estimation of impacts, including costs, that Mauritius may incur as a result of climate change (and the carbon economy) for the years 2010 and 2030.

In Figure 3, the top half-circles indicate vulnerability due to climate change, the bottom half-circles represent vulnerability due to the carbon economy, and the middle circles are a combination of these two. As shown, the vulnerability of Mauritius to climate change is moderate in terms of deaths, up to 2030. In terms of economic cost however, vulnerability changes from high to severe between 2010 and 2030.

Figure 3: The Climate Vulnerability Monitor for Mauritius

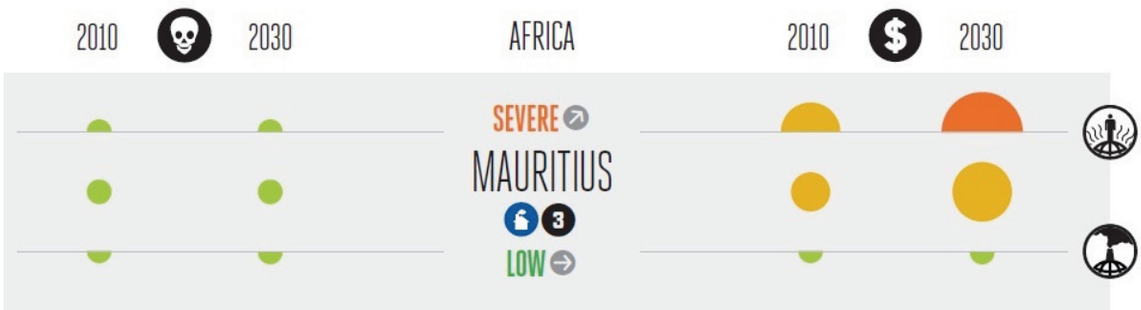


Table 4 lists the impacts established by the Climate Vulnerability Monitor for Mauritius specifically. While some findings are indicated as robust, other findings must be considered as possible scenarios, along with the analysis present in the following subsections for the sectors of water, agriculture, fisheries and tourism. Table 4 also shows additional impacts on biodiversity, heating and cooling, labour productivity, and the severity of desertification and sea-level rise, with different metrics. Table 5 shows some health impacts of climate change for Mauritius, in terms of additional mortality and additional number of people affected.

[34] DARA and the Climate Vulnerable Forum 2012, Climate Vulnerability Monitor 2nd Edition – *A Guide to the Cold Calculus of a Hot Planet.*

Table 4: Additional economic costs and persons affected due to climate change in selected impact areas

		Additional economic costs due to climate change (million USD PPP) - yearly average		Additional persons affected/in need of emergency assistance due to climate change - yearly average		
Climate change effect	**Confidence**	**2010**	**2030**	**2010**	**2030**	**Affected groups**
Drought	Indicative	5	25	-	-	Arid regions, farmers
Floods & landslides	Indicative	-	-	1,500	1,500	Small children, pregnant women, elderly, river basins, small islands, mountainous communities
Storms	Speculative	25	150	500	400	Small islands, cyclone belt countries
Biodiversity	Indicative	5	20	-	-	Deforestation zones, farmers
Desertification	Indicative	-5	-40	-55,000	-150,000	Outdoor workers, farmers
Heating and cooling	Robust	1	20	-	-	Small children, elderly, pregnant women, humid tropical countries, Africa
Labour productivity	Robust	550	3,500	-	-	Humid tropical countries, outdoor occupations, subsistence farmers, pregnant women, elderly, heavily labouring workers
Sea-level rise	Robust	20	100	-	-	Small islands, low elevation coastal communities, coastal cities, farmers
Water	Speculative	-10	-65	-	-	Water intensive industries, outdoor workers, subsistence farmers
Agriculture	Indicative	25	200	-	-	Farmers, Subsistence farmers, eventually with repercussions to consumers also
Fisheries	Robust	5	55	-	-	Livelihoods derived from fishing, tropical countries

Tables 5a and 5b: Additional climate change socio-economic and health impacts.

		2010	2030
Biodiversity	Contraction of biological zones due to climate change (km^2) – Yearly average	50	100
Desertification	Additional land degraded due to climate change (km^2) – Yearly average	90	200
Heating and cooling	Additional/reduced energy load due to climate change (GWh) - yearly average	20	45
	Additional CO2 generated/reduced for heating and cooling due to climate change (Kt CO2) - yearly average	10	30
Labour productivity	Share of workforce particularly affected by climate change (%) - yearly average	35%	27%
Sea-level rise	Additional land lost due climate change (km^3) - yearly average	1	1

		Additional mortality due to climate change - yearly average		Additional persons affected due to climate change - yearly average change		
Climate change effect	**Confidence**	**2010**	**2030**	**2010**	**2030**	**Affected groups**
Diarrheal infections	Robust	1	1	5,000	10,000	Lower income communities, Africa, elderly, children, infants
Heat and cold illnesses	Indicative	5	5	200	300	Elderly, cities, outdoor workers, chronic disease sufferers
Hunger	Indicative	5	5	1,000	1,000	Remote communities, fishermen, subsistence farmers, elderly, children, infants
Meningitis	Speculative	1	1	5,000	5,000	Young adults, children

3.1.1. Economic impacts on water demand and supply

Analysis carried out in the Mauritius Environment Outlook (MEO, 2010) shows that total water demand is projected to reach 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 Mm^3 per year.[35] Using this present usable freshwater potential, it is noted that water availability in 2010 was equivalent to 965 m^3/person, which is below the threshold for classification as a 'water-scarce' country.[36]

A master plan or the development of water resources is being drafted. Unaccounted-for water (non-revenue water) averages 47 per cent of production, of which at least 65 per cent is lost through leakage and 35 per cent through illegal consumption. The Central Water Authority has embarked on an ambitious project for the reduction of unaccounted-for water to a more acceptable level of 25 per cent (Government of Mauritius, 2010a).

In the context of the projected impact of climate change in Mauritius, it should be noted that the utilisable renewable potential is extremely hard to be totally exploited, and planning should not be based on this figure, especially due to high variability of supply. To provide a reference value, during the 2008 to 2010 period, on average 88% of total rainfall was utilised, leaving only 12% unutilized, as shown in table 6.

Table 6 : Total rainfall and water utilisation (m^3)[37]

	2008	2009	2010
Rainfall	4,440,000,000	4,470,000,000	3,368,000,000
Utilization	947,000,000	1,000,000,000	975,000,000
Remaining water (lost or unused)	700,240,000	658,370,000	274,740,000
Remaining water as % of total rainfall	15.77	14.73	8.16

The economic impact of climate change on water was estimated by considering future water demand, climate change, and climate variability, under two water utilisation scenarios[38]:

A. Business As Usual (BAU), where current policies continue to apply in the water sector[39]. This is also to be considered as a worst case scenario, as Mauritius is already a water-scarce country.

[35] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report, pg. 46.

[36] 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".

[37] Of the 4,400 million (100%) of rainfall, 60% is surface runoff, 30% evapo-transpiration, and 10% is net ground water recharge. Utilization and remaining water sum up to approximately 40% of this amount, depending on the year. Evapo-transpiration is subtracted from rainfall, from which 47% of losses are also removed, as explained in Annex B.

[38] See Annex A for the methodology used.

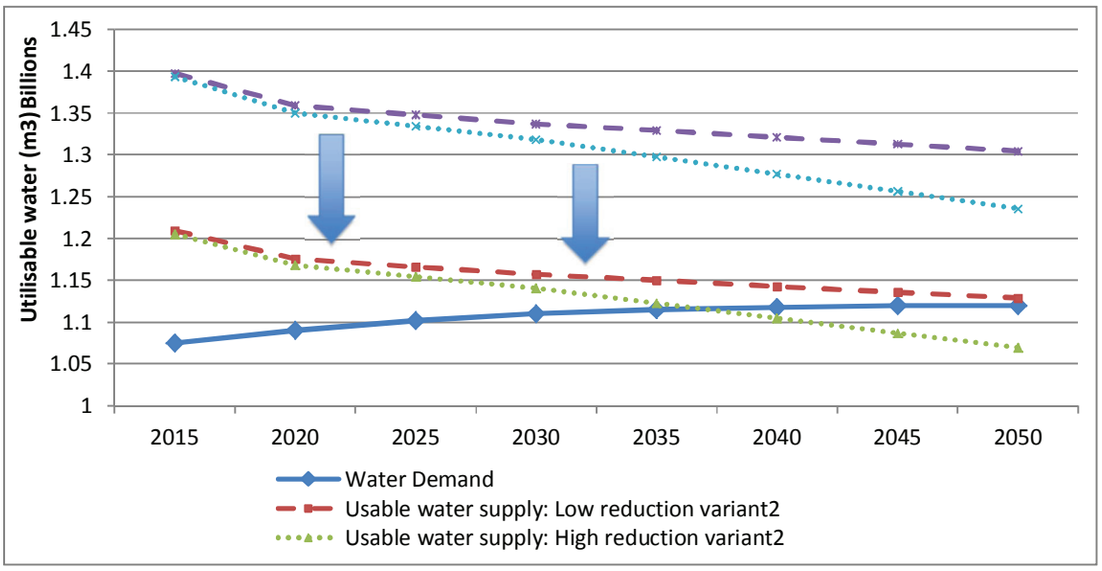
B. "No-regret" scenario where measures to reduce unaccounted-for water are fully implemented as per the ambition of the CWA to reduce unaccounted-for water to 25%. For the sake of this analysis, successful implementation is assumed to be achieved over 25 years (with 20% of the goal being achieved every 5 years) from 2010 to 2035 (100% complete in 2035).

Under both scenarios, two assumptions on water availability are used – this represents a medium and high impact of climate change. Short-term climate variability considerations are subsequently added.

Scenario A – Business As Usual

Figure 4 shows the evolution of water demand, total utilisable renewable water potential ("low reduction variant 1" and "high reduction variant 1", which follow rainfall decrease factors presented in table 1), and actual usable water ("low reduction variant 2" and "high reduction variant 2"), which accounts for a reduction -from potential to usable- equivalent to 5% the annual rainfall[40].

Figure 4: Demand and effect of mean Climate Change conditions on water availability

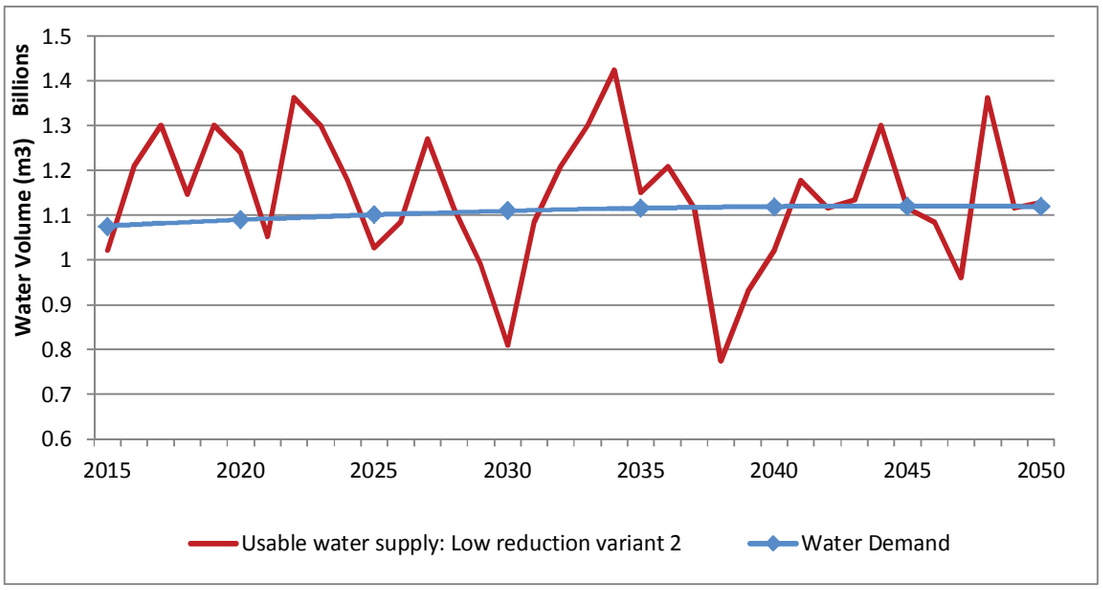


Year on year variations in precipitation must be taken into account in order to get a more realistic estimate of the potential economic impacts of climate variability in the water sector. In the past two decades, although less pronounced in the 2000's, yearly variability in rainfall compared to the long-term mean has ranged between -45% (1999) and 22% (1995). For future variations, it is assumed that variability remains within the historical range observed since 1993. In the methodology used here, year on year precipitation fluctuations have been randomly chosen to mimic changes within these historical limits, and the trend is shown in the figure below.

[39] An underlying assumption of this scenario is that the water system doesn't further depreciate, which would result in further losses.

[40] Not all surface runoff (included in the value for total utilisable renewable water potential) can be harvested, additionally; depletion of the renewable water potential is to be avoided. Thus, we make the conservative assumption that 5% of annual rainfall can/should not be used.

Figure 5: Example of climate variability effect, 2015 - 2050



Scenario B – No Regret

The following figures show the effect of reducing water losses (water unaccounted-for), along with the same effects of climate change (Figure 6) and climate variability (Figure 7) presented in scenario A. The most direct effect of reducing losses is an increase in potential water supply (i.e., usable water).

Figure 6: Water availability with losses reduction under mean climate change conditions

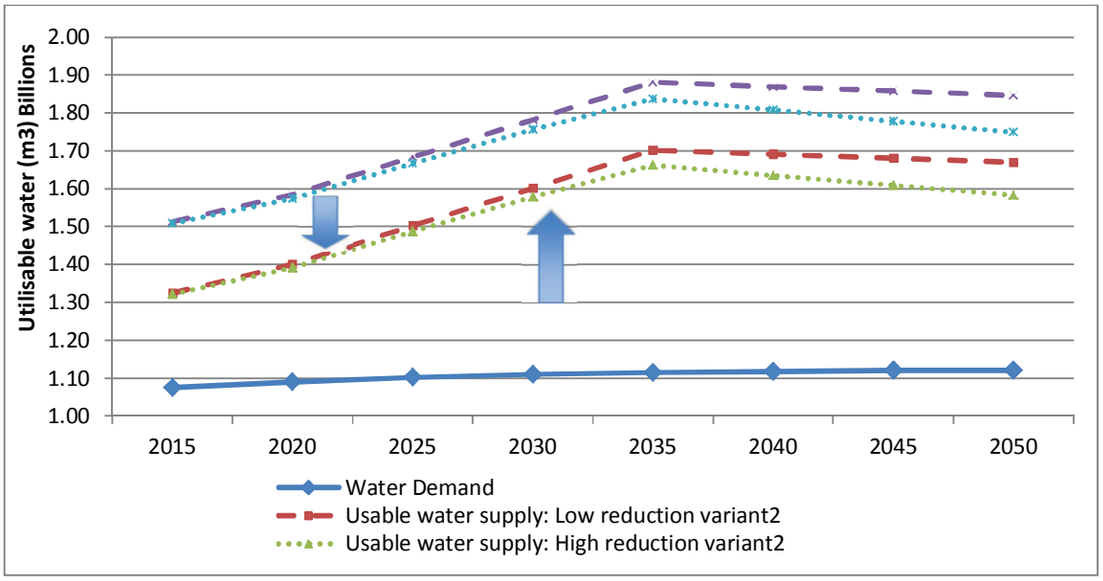
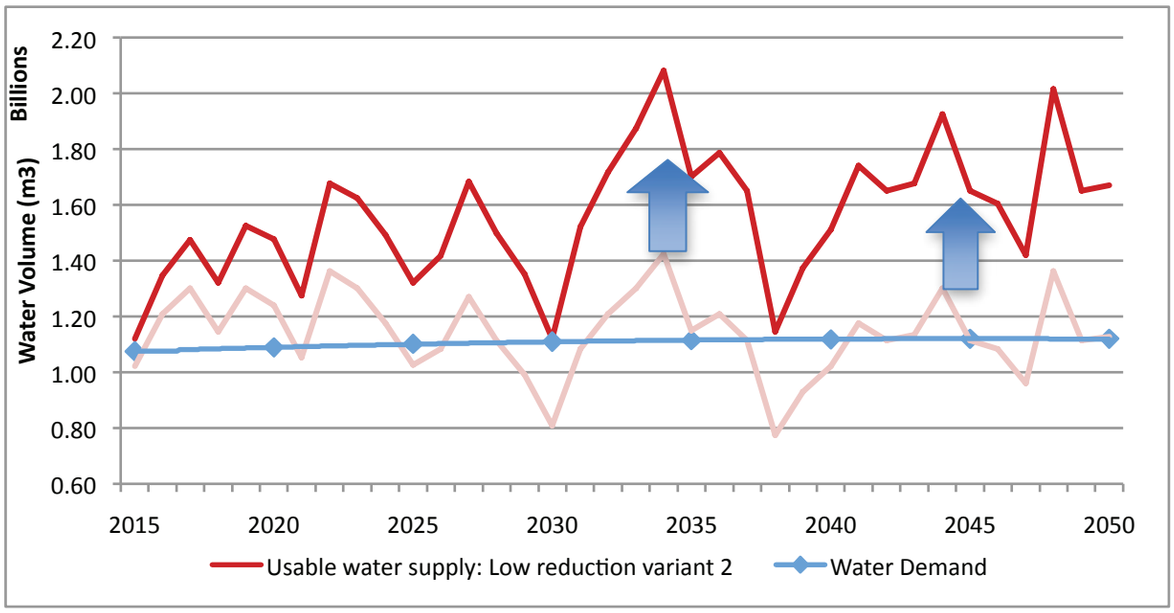


Figure 7: Losses reduction under climate change and variability conditions, 2015 - 2050



Scenario observations

Although simple, this analysis shows that reducing system losses can help to curtail the effects of climate change on water availability. The climate variability presented here however remains arbitrary, as is the rate of implementation of loss mitigation. Thus, it is important to anticipate situations where conventional water supply may not meet demand in the next years.

Costs of water conservation, efficiency measures and alternative supply.

For scenario B above, climate variability may have a worse effect than presented in Figure 7. This means that whenever the utilisable water curves are in the proxinmity of, or under the demand curve, more stringent or costly water resource management measures (e.g., water conservation and rationing, provision of alternative supply) must be considered to "close the water gap".

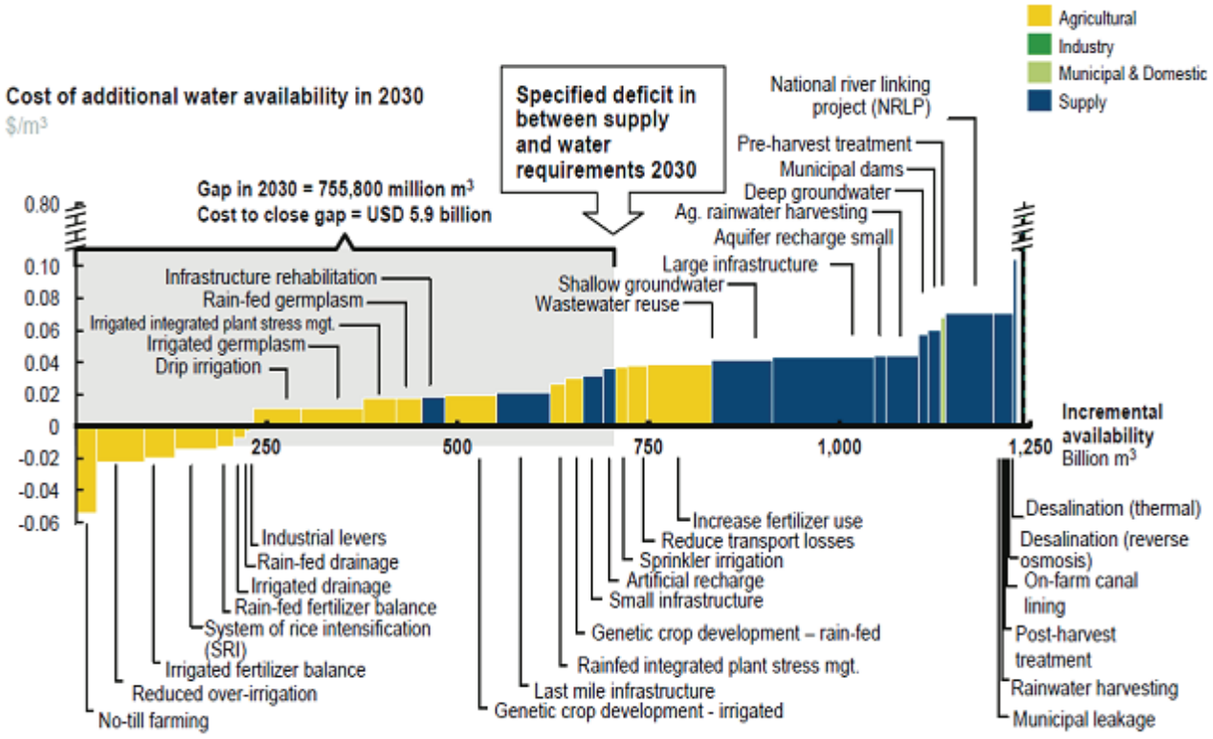
In order to estimate the cost of intervention (and similarly, the cost of water gaps), marginal cost curves provide a microeconomic analysis of the cost and supply potential for a range of existing measures and technologies[41]. For instance, Figure 8 shows an example of cost curve for India[42] . The cost curve for India is illustrated here since the majority of technologies are related to the agricultural sector. There is a close similarity with Mauritius wherein water abstraction for agricultural purposes is close to 50% of total water use. Although the abatement cost curve provides realistic adaptation technologies for Mauritius, the abatement cost of these technologies may be

[41] For a given level of withdrawals, the cost curve lays out the technical options to maintain water-dependent economic activities and close the gap, comparing on a like-for-like basis demand management measures and additional supply. Each of these technical measures is represented as a block on the curve. The width of the block represents the amount of additional water that becomes available from adoption the measure. The height of the block represents its unit cost.

[42] 2030 Water Resources Group (2009) "Charting Our Water Future – Economic frameworks to inform decision-making", pg. 12.

different. As can be seen, early efficiency measures are negative in cost, indicating positive returns over the lifetime of the intervention implemented.

Figure 8: Water availability cost curve for India



Although abatement costs have not been calculated for specific technologies in Mauritius, the TNA project has calculated the investment and operational costs for some technologies in the water sector, as show in table 7[43].

Table 7: Investment and operational costs for selected adaptation technologies in the water sector

Technology	Cost (Rs/m^3)
Stormwater harvesting	38.75
Desalination (brackish water)	33.79
Rainwater harvesting (households)	30.00
Water efficient fixtures	7.83

It is recommended that water supply and demand gap be estimated for the ROM under different climate scenarios, and that a portfolio of different adaptation technologies (e.g., infrastructure upgrade for loss reduction, agricultural efficiency for lowered consumption) be analyzed carefully in order to estimate intervention costs accurately.

[43] Please see Annex 4c, Ministry of Environment and Sustainable Development (2012)Technology Needs Assessment Report, Republic of Mauritius.

3.1.2. Economic impacts on agriculture and terrestrial ecosystem

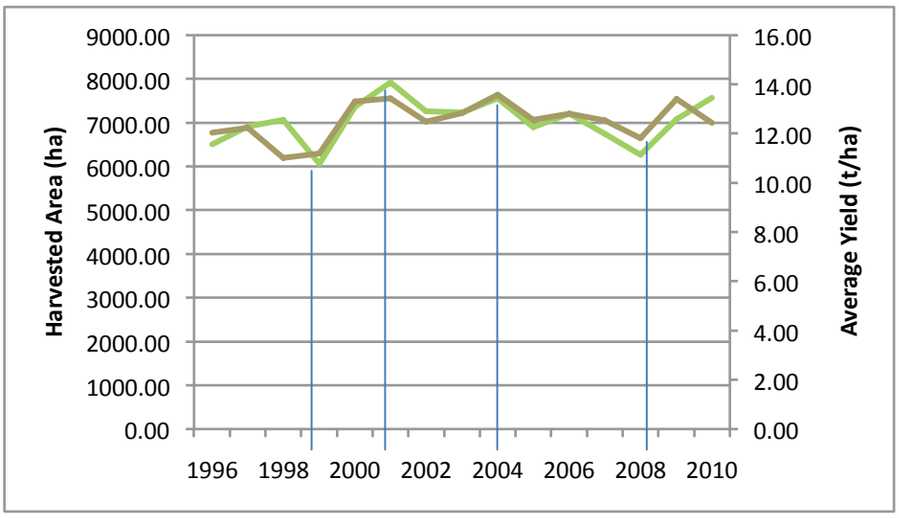
About 7,570 ha of land are used in Mauritius by around 6,000 food crop growers producing annually approximately 110,000 tonnes of fresh vegetables and fruits, such as pineapple and banana, mainly for the domestic market. Food cropping is predominantly rain fed. Table 8 below summarises the recent progress of food crops in the agricultural sector. From 2008 to 2010, value added of food crops increased by 30.4%, benefiting from a harvested area increase of 20.8% (6,266 to 7,570 hectares)[44].

Table 8: Food crops and the agricultural sector, 2008 - 2010

	2008	2010
Share of agriculture in GDP	4.1%	3.6%
Share of sugar cane in agriculture (value added)	42.5%	31.5%
Value added of food crops (million Rs)	1,682	2,193
Food crop harvested area (Hectares)	6,266	7,570

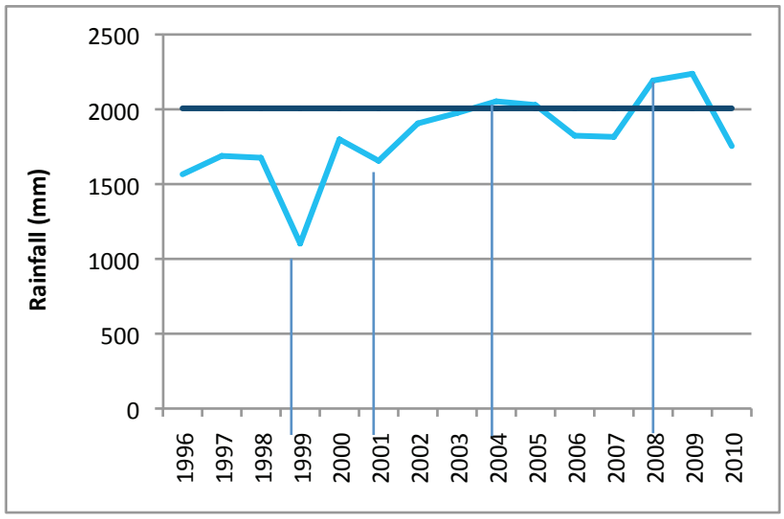
Despite this encouraging progress, adverse climatic conditions and water stress over the past ten years have severely constrained agricultural growth. The historical decrease in precipitation, coupled with increasing demand for water from other sectors, means that ensuring an adequate freshwater supply for agriculture is a challenge, threatening the country's food security[45]. To estimate the impact of future climate change on food crop production and its economic value added, the impact of past years droughts and excessive rainfall is observed[46].

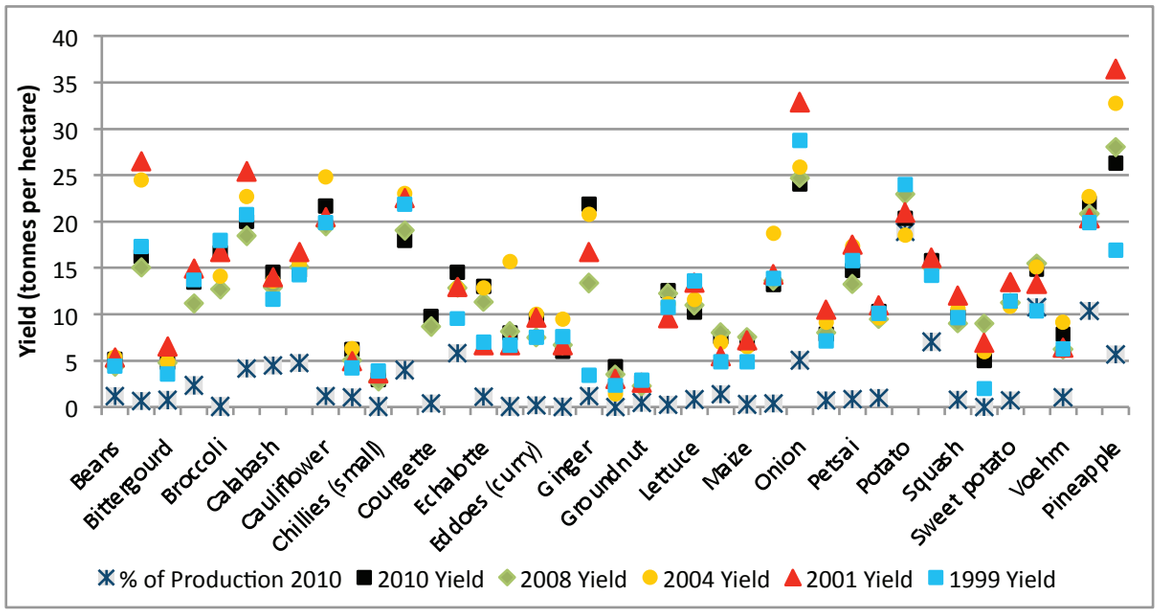
Figure 9 a) Harvested Area and Yield, b) Rainfall, c) Food-crops production and yield for selected years. Source: Central Statistics Office, Agriculture historical series



The vertical lines point to selected years of drought and high rainfall (see Figure 10)

[44] Ministry of finance & economic development, central statistics office, *digest of agricultural statistics 2010*
[45] Mauritius Environment Outlook 2010, pg. 146.
[46] The effect of temperature cannot be neglected and is here indirectly associated to the effects of drought, although historical data shows that rainfall and temperature are not exclusively interdependent.





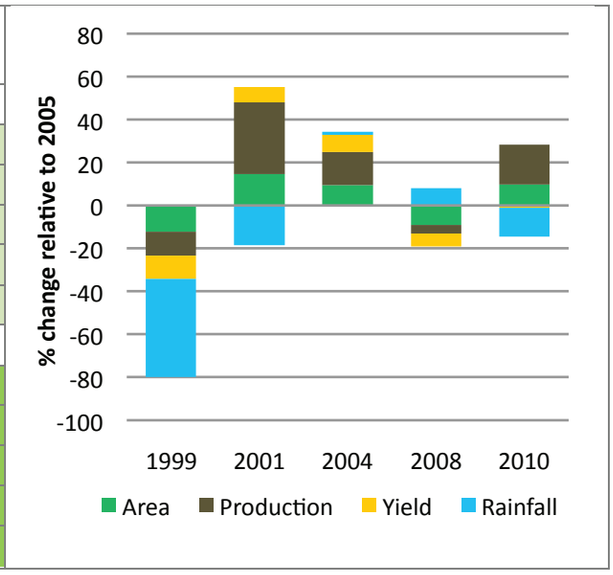
As can be seen from Figure 9 c)[47], specific yield variations occur per food-crop, under different climatic conditions. Yield (production/area) alone doesn't capture the effect of climate change on agricultural production; Figure 9 a) and b) show a correlation between change in area harvested and rainfall variations. Reduced area harvested combined with reduced yield can therefore have a strong negative impact on food-crops production, value added, and food security. Clear examples are the 1999 drought and the high rain year of 2008. Note that the capacity for irrigation, however beneficial, is also subject to water availability.

Reduced harvested area however is not an automatic situation under such conditions. Food-crops appear to adapt in some measure to lengthened conditions of drought or high rainfall, and the agricultural sector is able to work with more land if necessary to increase production. 2001 for instance was a high-drought year with greater average yield, when larger areas were harvested, and higher production was achieved. Figure 10 provides illustration for some past food-crop production behaviours.

[47] Plotted from data of Central Statistics Office (2012) Agriculture Historical Series, accessed 15 August 2012.

Figure 10: Rainfall, food-crops harvested area, production and yield for selected years with respect to 2005[48].

	Area (Ha)	Production (t)	Yield (t/Ha)	Rainfall (mm)
2005	6901	96782	12.6	2027.9
1999	6059	86083	11.2	1102.4
2001	7918	129119	13.4	1653.4
2004	7553	111633	13.6	2054.6
2008	6266	93021	11.8	2192.1
2010	7570	114844	12.4	1753.3
% Change relative to 2005				
1999	-12.2	-11.1	-11	-45.6
2001	14.7	33.4	6.9	-18.5
2004	9.4	15.3	8.1	1.3
2008	-9.2	-3.9	-5.9	8.1
2010	9.7	18.7	-1	-13.5



As seen here, climate variability affects food-crops production in a manner that is not always predictable. Or, at least, it can be said that mitigating measures can be implemented, to a certain extent, when variability is within the range of historical events, while the capability to adapt and mitigate sudden changes is reduced when drastic variations in precipitation are observed (e.g., 1999). With the added consideration to the water sector previously observed and the lack of capacity in estimating climate variability in the long term[49], adaptation measures such as increasing harvesting area, when coupled with more water-efficient irrigation, appear justified to the extent that water scarcity is not further exacerbated.

Economic impacts are estimated for 2 scenarios:

I. Business as Usual (BAU): Land is degraded by droughts and floods, and rehabilitated in a reactive manner in an effort to increase production after these climatic events.
II. No Regret: as sugar cane cultivation is decreasing under the MAAS[50], this scenario assumes that 5,000 Ha can be added to food-crop cultivation between 2015 and 2050[51].

For consistency, we take the same climate change and variability circumstances as used in section 4.1.1. (Water), up to 2050. In this methodology, the values of yield and harvested area were chosen within the historical range and in correlation with the rainfall scenario. Under the No-regret

[48] 2005 was taken as baseline so as to be relevant to the agricultural context of the other years observed, and because rainfall approached the long-term mean of 2006mm per year.
[49] 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.
[50] Agreco Consortium, 2007, Implementation of the Multi-annual Adaptation Strategy for the Mauritian Sugarcane cluster (2006-2015), Strategic Environmental Assessment, pg. 43, 44.
[51] The land under sugar cane is to go down from 70 550 ha in 2005 to some 63 000 hectares by 2015. In 2005-2006 MSIRI identified 12,341 Ha of difficult lands where the abandonment of sugar cane will give rise to environmental, economic and social problems. Of this area 5000Ha would be converted to over uses specifically under the MAAS.

scenario, the baseline harvested area taken is the average of the harvested area between 1996 and 2010. Please see Annex B for the methodology used. Table 9 shows a set of outcomes of these particular scenarios.

Table 9: Rainfall, harvested area, yield and production under BAU, No-regret and Best-case scenarios

			BAU		No-regret	
Year	**Rainfall**	**Yield**	**Area**	**Prod**	**Area**	**Prod**
2015	1,650	12	6,500	78,000	7,040	84,500
2020	2,000	12.6	7,040	88,730	7,750	97,730
2025	1,650	11	7,500	82,500	8,470	93,180
2030	1,300	11	6,050	66,550	9,180	101,030
2035	1,850	12.5	6,600	82,500	9,900	123,740
2040	1,650	11	7,600	83,600	10,610	116,750
2045	1,800	12	7,000	84,000	11,330	135,930
2050	1,820	12.8	7,200	92,160	12,040	154,140

Units: mm (rainfall), t/Ha (Yield), Ha (Area), t (Production)

In this analysis, the value added generated and costs of food crop production per hectare were calculated:

- Value added figures were calculated for both scenarios using the 2010 average value added per ton of food-crops, approximately Rs 19,100 per ton[52].
- Costs were calculated for both scenarios using the 2005 average cost of production per hectare for selected vegetables[53]; approximately Rs 109 million per hectare[54]. Note that this calculation does not take into account the cost of adapting to climate variability, which would affect the cost of production per hectare. It is calculated here only to show the cost of increasing harvested area in both scenarios.

To enable meaningful observation of value added and costs, both parameters are adjusted to 2006 monetary value using a GDP deflator from the World Bank's WDI database. Thus, in 2006 terms, value added per ton equals approx Rs 15,750, and production cost per hectare equals approximately Rs 116,600.

Figure 11 shows value added and costs of production from 2015 to 2050 for both scenarios.

[52] Calculated from *Digest of agricultural statistics 2010*, Central Statistics Office.
[53] Calculated as average of production costs per hectare for selected food-crops, Central Statistics Office 2005, Agricultural Cost of Production Survey.
[54] This cost is composed of Intermediate consumption + Land preparation + Imputed cost of seeds/seedlings + Paid labour + Rent on land (Rent paid on leased land or rental value of owned land) + Interest on working capital + Depreciation of machinery and equipment + Imputed family labour.

Figure 11: Value added and costs under BAU and No-regrets scenarios

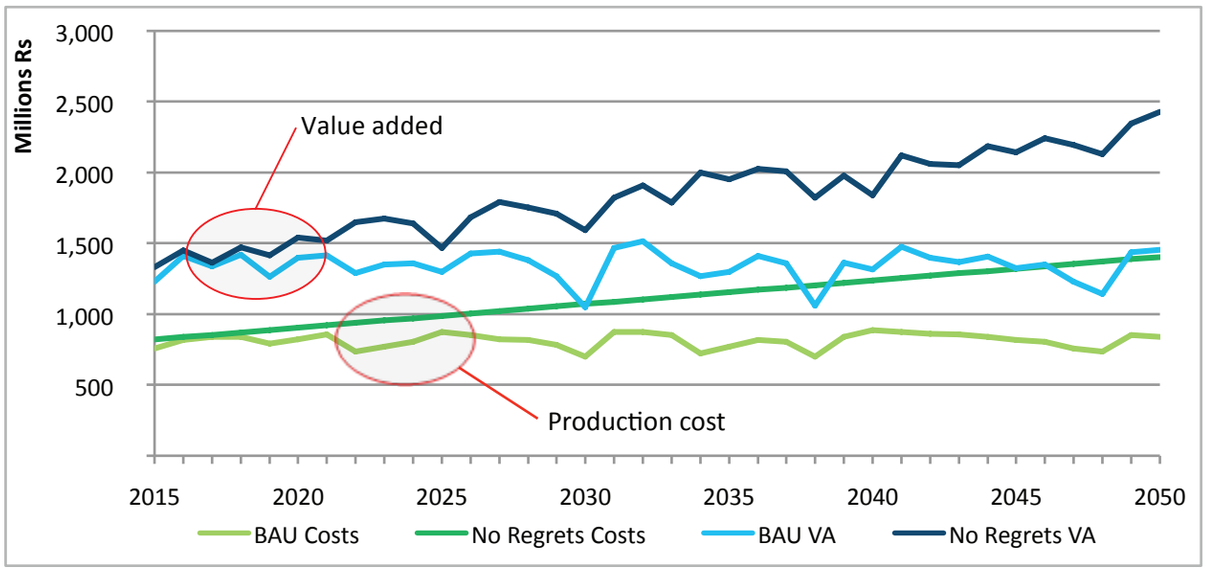


Table 10 below gives the overall potential costs and value added of food crops under the three scenarios – cumulated "over 35 years" (2015-2050), and spread evenly "per year" for the sake of getting insight on the potential average. This is important because climate most certainly will vary differently than presented here, however similar impact should be expected in a different sequence.

Table 10: Future value added for food-crops and production costs

	over 35 yrs	per year
Value added for No-regret over BAU	17,759,791,335	507,422,610
Cost of No-regret over BAU	9,379,712,878	267,991,797

Units : Rs2006

Adapting to climate change in this sector will however likely incur more costs than that of utilising additional land, including the potential transition to ecological agriculture practices (estimated to be costing on average an additional $100/ha, but generating higher yields in the range of 70-80%)[55] and water requirements will be substantial. More specifically, these cost generally relate to increasing agricultural productivity and enhancing resilience to climate change and estimates by the UNFCCC (2007) and McCarl (2007) refer to three distinct cost items: better extension services at the farm level; the cost of additional global research[56] (e.g. on new cultivars), and extra capital investment at the farm and national level. An increase in capital investment costs could relate to an increase in irrigation demands. An increase in research (including new techniques and technologies of production, processing and storage to ensure resilience) and extension expenditure could relate to

[55] Pretty, J. N., A. D. Noble, D. Bossio, J. Dixon, R. E. Hine, F. W. T. Penning de Vries, and J. I. L. Moriso (2006). Resource-Conserving Agriculture Increases Yields in Developing Countries. Environmental Science and Technology, Vol. 40, No. 4, 2006.

[56] Local research is also required in order to maintain relevance to local climate, soil conditions, and other specific factors.

the development of new crop varieties and plant breeding and/or the provision of inputs such as fertilisers as well as technical assistance related to crop management techniques.[57]

3.1.3. Economic impacts on fisheries and marine ecosystem

It is very difficult to evaluate the economic impact of climate change on fisheries due to the high complexity of the patterns affecting fish populations (e.g., migratory behavior) and their habitat. On the other hand, trends can be observed, and some considerations can be drawn while new research is developed.

The following paragraphs present key factors of climate vulnerability for fisheries, mangroves and corals.

Fisheries

The impacts of climate change on fisheries are complex and in some cases are indirect. As with other renewable resources, an assessment of climate change impacts on fisheries is complicated by the presence of anthropogenic and other non-climate-related stresses, such as habitat loss and overexploitation. Many breeding grounds for commercially important fish and shellfish are located in shallow waters near coasts. These areas include mangroves, coral reefs, seagrass beds, and salt ponds—all of which are likely to be affected by climate change. Generally, fisheries in the small island states are not expected to be adversely affected by sea-level rise *per se*. Higher sea level would be a critical factor for fisheries only if the rate of rise were far more rapid than the current succession of coastal ecosystems (e.g., mangroves, seagrasses, corals) on which some fish species depend. Fish production obviously would suffer if these habitats were endangered or lost.

Scenarios developed by the Intergovernmental Panel on Climate Change has forecast certain effects (positive and negative) of climate change, such as local shifts in production, longer growing periods, and faster growth rates among others, with varying levels of confidence. The effects will be uneven, depending on the geographic area. The global climate change is expected to cause many changes including increased air and sea surface temperatures, rises in sea level, changes in weather patterns, more frequent storms and other extreme weather in some places, possible alteration of ocean circulation patterns and changes in seawater chemistry due to increased carbon dioxide concentrations.

A warming of the oceans around small islands has been detected and this trend is expected to continue. Projections have shown that this warming will be accompanied by increased rainfall, with other changes in precipitation patterns over time and space. Some other impacts include loss of mangrove forests due to sea level rise, loss of coral reefs due to bleaching, acidification of the oceans among others. There are numerous adaptation options however, we should not overlook the constraints that limit the options such as inadequate data and technical capacity, weak human and institutional capacity, and limited financial resources.

[57] Keane, J., Page, S., Kergna, A., and Kennan, J. (2009). *Climate change and developing country agriculture: an overview of expected impacts, adaptation and mitigation challenges, and funding requirements*. International Centre for Trade and Sustainable Development (ICTSD), Geneva and International Food & Agricultural Trade Policy Council (IPC), Washington, DC. Pg10.

Observations have shown that the sea surface temperatures have been increasing by 0.1^0C per decade in the oceans where most small island are located. Projections for global warming indicate a warming trend of 2.10^0 C by the 2050s and 2.61^0 C by 2080s for small island states of the Indian ocean while sea surface temperatures are projected to increase by 1^0 C. Impacts of climate change on marine biodiversity have been observed because of the availability of long term data series. However, in the South West Indian Ocean, because of few long-term data sets that could not detect the impacts, evidence is rather sparse.

Data collected at fish landing stations around Mauritius have shown a gradual decline in the overall landings for artisanal fishery. However, being given the long time overexplotaion of our lagoonal resources, it cannot be attributed directly as an effect of climate change. However, small scale fishers are particularly vulnerable to impacts of climate change. Some may see the disappearance of their target species and some may experience an increase in their landings of some species of commercial values. As fisheries contribute to the GDP, the socio economic implications of the impacts of climate change will be significant.

Climate change has an effect on the distribution pattern of species. Movement of tuna stocks may disrupt fish based industries. Changes in fish stock distribution and fluctuations in abundance of conventionally fished and "new" species may disrupt existing allocation arrangements. Changes in migration patterns and depth of fish stocks are the main factors affecting the distribution and availability of tuna. It is also expected that changes in climate may cause migratory shifts in tuna aggregations. If forecast temperature changes lead to tuna moving to higher latitudes, conflict over the stock may arise both at an international and national level. With the rise in sea surface temperature, benthic and demersal fish will shift their distributions southwards and may decline in abundance.

During the 1997 – 2008 decade two major anomalous events related to the Indian Ocean Dipole (IOD) events reduced the catch rates of the purse seines fleets in the Western Indian Ocean (WIO). During these events, the WIO had above average SST, a deeper than average thermocline and low chlorophyll concentrations. These factors are believed to produce unfavourable conditions for tunas in the surface layers. The most recent IOD event (2006-2007) did not reach the magnitude of that of 1997 -1998 but purse seine catches declined sharply. Between the two major events, there was enhanced biological productivity (peaked in 2003-2004) which resulted in favourable conditions for tuna and thus corresponded in high catches of tunas. However, variations in tuna catches are especially significant during El Nino and La Nina years. Changes in migration patterns and depth of fish stocks are two main factors affecting the distribution and availability of tuna during such periods. It is expected that changes in climate may cause migratory shifts in tuna aggregations to other locations.

Mangroves

Global change for instance changes in temperature, effects of changes in CO_2, precipitation, cyclones and sea-level rise coupled with anthropogenic threats can threatens the resilience of mangroves.

Effects of changes in temperature

It has been pointed out that at temperature above 25°C some species of mangroves show a declining leaf formation. At leaf temperature of 38-40 °C, almost no photosynthesis occurs. Most mangroves produce maximal shoot density when mean air temperature rises to 25°C and stop producing leaves when the mean air temperature drops below 15 °C. Based on the above, mangroves are not expected to be adversely impacted by the projected increases (2-6 °C by 2100) of sea temperature.

Effects of changes in CO_2

Atmospheric CO_2 increased from 280 parts per million by volume (ppm) in the year 1880 to nearly 370 ppm in the year 2000. Increased levels of CO2 are expected to enhance photosynthesis and mangrove growth rates. Studies carried out in Australia have shown that increased level of CO_2, significantly increased photosynthesis and the average growth rates in some species. However, one indirect impact of increased temperature and CO_2 on mangroves can be the degradation of coral reefs caused by mass bleaching. Damage to coral reefs may adversely impact mangrove systems that depend on the reefs to provide shelter form wave action.

Effects of changes in Precipitation

In response to global warming precipitation rates are expected to increase by about 25 % by 2050. It has been suggested that decreased precipitation results in a decrease in mangrove productivity, growth and seedling survival and may change species composition favoring more salt-tolerant species. However, increased precipitation may increase mangrove area, diversity of mangrove zones, and mangrove growth rates in some species. Silting and sediment flow increases during heavy rains. Too much sediment can cover the aerial roots of the trees, possibly resulting in their death.

Effects of Storms

Large storm impacts have resulted in mass mortality of mangroves in many areas of the world. It has been argued that an increase in the intensity of cyclones can result in a decrease in the average height of mangroves. Storm surges can flood mangroves and when combined with sea-level rise can lead to mangrove destruction. Inundation is also projected to decrease the ability of mangrove leaves to conduct water and to photosynthesize.

Effects of sea-level rise

Mangroves can adapt to sea-level rise by growing upward or by expanding landward. The ability of mangrove to migrate landward depends on the local conditions such as infrastructure and topography. Mangrove produces peat from decaying litter fall and by trapping sediments in the water. The process of building peat helps mangrove keep up with the sea-level rise.

There is no estimate of the cash value of the catch from mangrove area in Mauritius but there is direct evidence that a number of the extractive values (crustaceans - crab carlet, shrimps and fish) have declined considerably (traditional knowledge from fishers). In comparison, an example may be cited of mangrove forest in western Malaysia where it supports a fishery worth $ 2,500 per ha per year.

One of the constraints in management of mangrove may be the single sectoral management system. For example, clearing mangroves for water-front or hotels will benefit some, but will reduce the

long-term value of fishing due to removal of the nursery area of fish and prawns. Hence, a cross-sectoral management involving all stakeholders will resolve the management problem, which would results in decision that will benefit the communities.

Corals

Effects of rise in sea surface temperature -SST- (coral bleaching)

The bleaching events will be more frequent and more intense (increase in SST for a longer period of time) and will cause mortality of fragile species mainly the branching acropora.
The massive and other resistant corals may survive and adapt to the high SST and thus the number of species will be reduced and there will be decrease in biodiversity of fish and coral species.
Due to the general shift from corals to algae, the corallivorous fish will slowly disappear and the grazers will increase and there will also be a proliferation of sea urchins.
More cases of algal blooms can occur due to high SST and this may cause mass mortality of corals in shallow areas of the lagoon

Table 11: Percentage of live coral cover, 2010 relative to 1998 (Source: Ministry of Fisheries)

Back reef sites	
Albion	0.0%
Pointe aux Sables	1.5%
Ile aux Benitiers	1.1%
Poudre d'Or 2	0.0%
Shore reef sites	
Anse la Raie	0.0%
Ile aux Benitiers	2.2%

Effects of rise in carbon acidification

Due to the rise in carbon acidification of the sea, the calcification rate of corals will be slow and they will grow slower than before. This will make the island more prone to high intensity wave action that will further cause coastal erosion.

Effects of heavy rainfall

Heavy rainfall causes the movement of sediment from the land sources to the sea and in small island states this is a very huge problem due to the lack of proper watershed management. The sediment runoff causes the smothering of corals and ultimate death.

Effects of sea level rise

Corals need light to survive and a rise in sea level will cause the corals at the depth limit of coral growth to have further reduction in light exposure, which is not suitable for their growth and they will perish. Corals that exist at these depths will become extinct with rising sea levels. The ones on the near surface will be in gain as the effect of light will be much less due to the increase in depth.

Socio economic loss

Due to the loss of coral reefs, the socio-economic state of users will be affected negatively. The fishermen, tourist operators and other stakeholders depending on this ecosystem to provide services will be impacted.

3.1.4. Economic impacts on tourism and coastal management

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 (2009-2015) was being formulated.[58] Approximately 23% of the beaches on the island of Mauritius are at risk, and the growth of the sector will result in increased demand for water with the construction of new hotels and the development of Integrated Resort Schemes IRS and Residential Estate Schemes (RES) projects.

Concerning beaches, it can be assumed that over the next 50 years half of these 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).[59] Thus, 11% of the tourist draws on the island of Mauritius might 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.[60] 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.[61]

The coastal zone of ROM 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 local and international tourists. As of June 2012, there were 113 registered hotels (6 of which are currently not on operation because of renovation work) on the island of Mauritius, of which 86 are located immediately adjacent to beaches. The total room capacity of the registered hotels in operation was 11,822 with 24,089 bed places. Clearly, most tourists come to enjoy the beaches (34% of tourists are “repeaters”),[62] 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 during weekends and public holidays, in terms of visitor use. While new beaches cannot be created, existing ones can certainly be lost. One

[58] Quoted in, Landell Mills (2009) ICZM Strategy Part I: Introduction to ICZM and Stock-take for Mauritius, pg. 99.

[59] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius.

[60] 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, equivalent to 1% of the 2010 current GDP.

[61] W.F. Baird and Associates Coastal Engineers. 2003. Study on Coastal Erosion in Mauritius. For Ministry of Environment.

[62] Page, S. 1999. Tourism and Development: The Evidence from Mauritius, South Africa, and Zimbabwe.

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. Beaches at different locations are subject to different impact and require different combinations of adaptation measures. Thus, intervention options and costs for adaptation in this sector are site-specific to an extent that prevents a detailed economic analysis here, for a no-regret or best case scenario.

3.2. Sectoral strategy and action plan

3.2.1. Water demand and supply

	Strategies	Action List
W1	Fully develop the potential of integrated regional water management	**W1.1.** Develop hydrological models **W1.2.** Identify strategies that can improve the coordination of local groundwater storage and banking with local surface storage along with other water supplies including recycled municipal water, surface runoff, flood flows, urban runoff, storm water, imported water, water transfers and possibly desalinated groundwater and seawater.
W2	Aggressively increase water use efficiency	**W2.1.** All relevant parties should implement strategies to achieve a nation-wide 20 percent reduction in per capita water use by 2020. **W2.2.** Agricultural entities should apply all feasible Efficient Water Management Practices to reduce water demand and improve the quality of drainage and return flows, and report on implementation in their water management plans. **W2.3.** Recycled water is a drought-proof water management strategy that may also be an energy efficient option in some regions. **W2.4.** It is recommended that the Legislature authorize and fund new incentive-based programs to promote the mainstream adoption of aggressive water conservation by urban and agricultural water systems and their users.
W3	Practice and promote integrated flood management	**W3.1.** To reduce flood peaks, reduce sedimentation, temporarily store floodwaters, recharge aquifers and restore environmental flows, flood management should be integrated with watershed management on open space, agricultural, wildlife areas, and other low-density lands.
W4	Enhance and sustain ecosystems	**W4.1.** Flood management systems should seek to re-establish natural hydrologic connectivity between rivers and their historic floodplains. Setback levees and bypasses help to retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native forests and create shaded riverine and terrestrial habitats. **W4.2.** The relevant authorities should identify and strategically prioritize for protection lands that will provide the habitat range for tidal wetlands to adapt to sea-level rise. Such lands help maintain estuarine ecosystem functions and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level rise and storm surges. **W4.3.** Increase green areas to improve CO_2 absorption capacity and reduce evapo-transpiration, also reducing landslide risk and land erosion.

	Strategies	Action List
W5	Expand Water Storage and Conjunctive Management of Surface and Groundwater resources	**W5.1.** As planned for future development, increase in surface water storage capacity through the construction of two new dams and increase in the storage capacity of existing ones. **W5.2.** Expanding the rain water harvesting capacity can ensure higher volumes of stored freshwater in the ROM. This technology is addressed in the national Technology Needs Assessment document (2012). **W5.3.** Desalination should be considered as a means of increasing freshwater availability, also taking into account ecosystem protection and potential side effects of desalination and possibly in conjunction with the use of renewable power generation. This technology is addressed in the national Technology Needs Assessment document (2012). **W5.4.** National, district and local authorities should develop conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage. **W5.5.** Districts and cities will be encouraged to adopt local ordinances that protect the natural functioning of groundwater recharge areas.
W6	Preserve, upgrade and increase monitoring, data analysis and management	**W6.1.** The accurate measurement of water use can facilitate better water planning and management. To better project future rain patterns on a regional scale, oceanic and atmospheric observations are needed to define and understand the mechanisms underlying atmospheric processes that lead to seasonal and geographic distribution of precipitation.
W7	Plan for and adapt to Sea-Level Rise	**W7.1.** Support research and provide expert guidance regarding long-range sea-level rise estimates and their application to specific planning issues.

Disaster Risk Reduction - Flood management:

Flood management should be addressed in river basin and catchment water management plans. Watershed basin planning and feasibility studies for the rehabilitation and upgrading of existing flood protection schemes should be developed or reviewed in light of climate change projections. Flood management also includes floodplain zoning, development of land use plans, protection of investments, and implementation of regulations. (Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.)

Rodrigues

Rodrigues has a comprehensive *Sustainable Integrated Development Plan* (SIDPR) document which has outlined, for the water sector, a short-term action plan for the period 2009-2011 (not considered

here), a development programme for the medium term (2012-2015) and elements of what should constitute a long term plan for the sector[63].

Table 12: Medium-term development programme for the Water & sanitation sector - Rodrigues

Action Plan	Indicative costs (MUR million)
Extension of rehabilitation works / improving the distribution system in the North and Centre of Rodrigues	100
Other rehabilitation works related to the water treatment stations, pressure filters, pumping stations, chlorination units, etc	20
Commission consultancy firms for:	
- a comprehensive study of the site identified for a dam as well as supervision or works;	30
- a feasibility study for setting up a sewerage network in Port Mathurin and a wastewater treatment plant	
Continued support to capacity building and strengthening of governance mechanisms - Modelling	30
Construction of "retenue collinaries" for irrigation by small water users associations (N.B. The exact number has yet to be determined)	200
Continued investment in 1,000 water tanks per year for 4 years	60
Launching of the pilot project "Stockage Energie Eolienne"	20
Total medium-term investments	**460**
Source: Chene, J.M, "Appui au Developpement Durable du Secteur de l'Eau de l'ile de Rodrigues," *Rapport de Mission et Proposition d'un Plan d'Action Chiffre*, UNDESA, 2009	

Table 13: Long-term development programme for the water & sanitation sector (beyond 2015) - Rodrigues

Investments required in the long term	Indicative costs (MUR million)
Construction of small and mid-size dams as well as the necessary related equipment required	To be studied in the medium term
Strengthening of the distribution network	
Sanitation:	
Water and Wastewater treatment plants	
Upholding of good governance across all levels and its integration with renewable energy, food security, job creation and revenue-generating activities – namely in the tourism sector – and its adaptation with issues related to Climate Change.	
Source: Chene, J.M, "Appui au Developpement Durable du Secteur de l'Eau de l'ile de Rodrigues," *Rapport de Mission et Proposition d'un Plan d'Action Chiffre*, UNDESA, 2009	

[63] Rodrigues Regional Assembly (2009) *Final SIDPR – Sustainable Integrated Development Plan for Rodrigues.*

3.2.2. Agriculture and terrestrial ecosystem

The following action plan seeks to limit overlap with existing policies, strategies and instruments which support the development of the agricultural sector in the ROM. An example is the *Food Security Fund* which provides funds for adaptation such as the *Food Crop Insurance Scheme and Sheltered Farming*. This helps curtail the adverse effects of climate change and the action plan presented herein should be seen as complementary.

The following action plan was established with the support of the 2012 Draft Baseline Assessment Report for the agriculture sector[64].

	Strategies	**Action List**
A1	Water Supply and Conservation Support	**A1.1.** Water conservation incentives – incentivise water pricing systems that reward conservation, accounting for regional differences in growing conditions, crops, and other agronomic needs. **A1.2.** Dissemination of micro irrigation systems for efficient water use and management shall be facilitated. **A1.3.** Floodplain Easements - Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance. These actions will also enhance economic sustainability and protect urban residents from flooding, provide improved shallow water and seasonal wetland habitat, improved nursery conditions, while protecting agricultural lands for the continued production of food and sugarcane.
A2	Preventing, preparing for, and responding to agricultural invaders, pests and diseases	**A2.1.** Up-scaling of locally proven IPM technologies for control of pest of economic importance. **A2.2.** Decentralised rapid pest and disease diagnosis service (plant clinic) shall be put in place. **A2.3.** Information Distribution - Provide information to the agricultural community to enable growers to modify farm management practices and adapt to new pests and diseases. This is to be supported by well-designed research and development.
A3	Sustainable land use planning practices	**A3.1.** Encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture. **A3.2.** Explore ways of introducing carbon trading in the agriculture sector, as incentive for improving farming practices, sustainable farming practices, sustainable land management and afforestation geared towards

[64] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the agriculture, tourism, fisheries sectors of the Republic of Mauritius and the water sector in particular for Rodrigues in the context of the Africa Adaptation Programme (AAP)*, Agriculture Sector, Draft Baseline Assessment Report, Republic of Mauritius.

	Strategies	Action List
		decreasing vulnerability and improving productivity and carbon dioxide sequestration.
A4	Promote working landscapes with ecosystem services to improve agro-biodiversity	**A4.1.** Provide technical and financial assistance and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e. seedless crop varieties). **A4.2.** Support identification, research, development and breeding of crop varieties, cultivars, and mixtures of crops capable of adapting to expected climate change (e.g. with respect to changes in temperature, precipitation, pest and disease resistance, air quality, salt tolerance and drought tolerance) in order to assist growers in the selection of crop and livestock most likely to succeed. **A4.3.** Promote composting and support the use of compost as a substitute to traditional fertilizers in order to enrich soils.
A5	Building and sustaining institutional support	**A5.1.** A deliberate policy shall be put in place targeting a capacity-building framework that will build the capacity of institutions, train their human resources (e.g., on integrated modelling for forest management, including silviculture, deer hunting, leisure activities and biodiversity) as well as those of local communities to help them adapt to the adverse impacts of climate change.
A6	Research, technology development and communication	**A6.1.** Policies should be put in place, that (1) support the creation of a methodology for the evaluation of ecosystem services and research should be carried to implement the methodology, (2) fuse technologies with activities aimed at enhancing agricultural production, processing and storage protecting the environment and preventing degradation of soil and water quality. **A6.2.** A policy should be put in place that helps in the development of appropriate models for communication to transmit and disseminate information on climate change (this should not be restricted to farmers, but extended to public in general and policy makers also). The essential characteristics on climate change must be available at a minimum cost.

Disaster Risk Reduction – Non-structural flood prevention:

Prevention includes non-structural activities reducing flood impacts such as restricting the development of flood plains, risk-proofing of buildings and infrastructure, flood sensitive land use, agricultural and forestry management practices. It is important to consider future hazard when planning the expansion of urbanized areas and to properly design for higher surface run-off generated through soil sealing.

Flood protection:

Flood protection investments that safeguard particular localities may include riverbank protection; improvement of reservoirs and dykes, retrofitting of dams for safety with larger spillways and gates, enlarging floodways, building levees, floodwalls, seawalls/bulkheads, dam monitoring, reviews and revisions of operating rules for dams, etc.

Inundation protection:

For inundation protection dams, levees, seawalls, groins and other structural measures could be planned often causing adverse impacts. Feasibility studies that incorporate economic, environmental, and social assessments should precede decisions on flood and inundation protection investments. In cases where it is economically and technically feasible, slope stabilization and erosion control measures can be employed. (Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.)

Rodrigues

The overarching goal of the SIDPR for the agricultural sector is to ***strengthen*** and ***modernise*** the agricultural and agri-business sectors. The various aspects of the overarching goal have been transcribed into eight goals and a set of four distinct strategies[65], however for the purpose of this document and adaptation to climate change, the focus here is on the agricultural sector, i.e. agricultural production, rather than market and commercial aspects.

Goals
1. Increase the production of selected commodities to maintain or achieve self-sufficiency
2. Reform the Agricultural Services
3. Train operators and build capacity along the commodity supply chain
4. Sustain the natural resource base

Strategies
Strategy 1: Sustainable agriculture - Empowerment - Sustaining soil fertility - Sustainable use of water
Strategy 2: Integrated development - Fostering backward and forward linkages - Sharing of the natural resource base

[65] Rodrigues Regional Assembly (2009) *Final SIDPR – Sustainable Integrated Development Plan for Rodrigues.*

3.2.3. Fisheries and marine ecosystem

The following action plan was established with the support of the 2012 Draft Baseline Assessment Report for the fisheries sector[66].

	Strategies	Action List
F1	Sustainable utilization of fisheries resources	**F1.1.** Determining the frequency of stock assessments and other necessary research, and the institutional responsibilities for such research, shall be done in close collaboration with regional and international bodies to ensure that shared fisheries resources are managed sustainably. **F1.2.**Establish guidelines for the level of exploitation of fisheries resources from the best available scientific information and proven indigenous knowledge. Where these lack, the precautionary principle shall apply. Principles of international conventions such as the FAO Code of Conduct for Responsible Fisheries and UNCLOS shall be observed so as to ensure sustainable conservation, management and utilization of the fisheries resources. **F1.3.** Negotiation of favourable Fisheries Access Agreements with Distant Water Fishing Nations. Such agreements shall ensure fair financial compensation for accessed stocks, assistance in development of the country's fisheries and conservation of natural resources and the ecosystem, and partnership in value addition activities and monitoring, control and surveillance (MCS) and now to incorporate climate change impact mitigation in the sector. **F1.4.** Identification and promotion of effective linkages between various fisheries, value addition and infrastructure development, among other development objectives. **F1.5.** An effective monitoring, control and surveillance (MCS) system for marine fisheries should be developed. In particular, the Department of Fisheries shall require that all foreign fishing vessels operating in the country's EEZ install tracking devices such as Vessel Monitoring Systems (VMS). To ensure that fishing vessels are fishing legally and responsibly, aerial surveillance unites will be established. **F1.6.** The Government, through the Department of Fisheries, shall make the penalties for offenders more stringent as well as restrict access through appropriate adjustment of fees on various permits and registrations.
F2	Protect critical habitat and plan for future hazards	**F2.1.** The Department of Fisheries shall promote, in a participatory manner, good fishing practices and facilitate integrated approaches to mitigate adverse environmental and climate change impacts in the

[66] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the agriculture, tourism, fisheries sectors of the Republic of Mauritius and the water sector in particular for Rodrigues in the context of the Africa Adaptation Programme (AAP)*, Fisheries Sector, Draft Baseline Assessment Report, Republic of Mauritius.

	Strategies	Action List
		catchments and coastal areas. **F2.2.** Fishing grounds should be patrolled and monitored by the Department of Fisheries, in collaboration with the Coast Guards and other relevant institutions. **F2.3.** Review of water management laws should be undertaken with a view to increasing their sensitivity to fisheries needs. In particular, nutrients entering the marine environment should be reduced, as well as pollutants release due to sea-level rise. **F2.4.** The creation of new marine protected areas having flourishing ecosystems like coral reefs, mangroves and occurrence of special marine animals (dolphins, whales, turtles) should be encouraged so as to protect the sensitivity of the areas and the economic benefits derived from them in a sustainable manner.
F3	Ensure the sustainability of aquaculture development in ROM	**F3.1.** With careful consideration of the impacts, aquaculture should be promoted in its ocean ranching form, as when young fish are released into the Ocean for growth and later harvesting to augment wild stocks. **F3.2.** For fish farms, consideration should be given to shifting species grown to those more tolerant of warmer and perhaps less-oxygenated waters in some areas. **F3.3.** Appropriate attention should be given to currents and surrounding ecosystems for in-lagoon and off-lagoon aquaculture, to ensure lowest possible impacts on ecosystems and nearby economic activity.
F4	Support essential data collection and information sharing	**F4.1.** As part of fisheries management, the Ministry of Fisheries shall involve local fishing communities' knowledge to identify and survey fragile ecosystems, including wetlands, which act as fish breeding ground and buffer zones. **F4.2.** Economic valuation of fisheries, marine and coastal ecosystems shall be undertaken to stress their value and encourage conservation and good practices. **F4.3.** The Department of fisheries shall build the capacity of stakeholders for their effective participation in the development and implementation of fishery-specific management plans. **F4.4.** Interdisciplinary researchers should be convened to meet periodically to exchange information on observations and research results, and meeting with fisheries managers to ensure the proper interpretation of results and the relevance of research.

Disaster Risk Reduction – Management of ESAs:

DRR should be mainstreamed into the regime applicable to ESAs as envisaged in the ESAs Conservation and Management Act. This would ensure a better management of ESAs and would lead

to an enhanced system of protection of biodiversity from disasters. (Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.)

Rodrigues

According to the SIDPR, The overall strategy aims at the creation of employment in various sub-sectors of the fishing industry including processing and value addition. The multiplier effect of good fisheries management and an integrated development will not only impact on the fisheries sector, but also on other sectors of the economy. Five strategies are proposed below for the development of the fisheries sector taking into consideration the preoccupations of the Rodrigues administration, stakeholders of the industry and where the vision of the fisheries sector is being reflected[67].

- Strategy 1: Knowledge of Resource Potential

  Ensure a thorough knowledge of the resource potential in the waters around Rodrigues and develop appropriate technologies, management plans/measures, policy guide lines and build capacity for the sustainable and responsible exploitation of these resources.

- Strategy 3: A modern legislative and institutional framework

  Provide for a modern legislative framework/ guidelines/code of conducts to ensure sustainable exploitation and committed to observing and enforcing the decisions of relevant regional fisheries management organisations and international fisheries agreements to ensure effective conservation, management and development of aquatic resources.

- Strategy 4: Capacity building

  To ensure appropriate transfer of technology/capacity building to staff/ fishers/ stakeholders of the fisheries sector and educate the population through regular awareness programmes as to the preservation of the marine environment and the resources therein with finality a better living standard for all concerned.

- Strategy 5: Redeployment of fishers and new developments

  To relocate fishers as per a socially-acceptable programme with a view to move away from the unsustainable system of bad weather allowance system; and to develop a modern seafood industry

Note that strategy 2 is not mentioned here as it addresses market and commercial aspects rather than climate change adaptation.

[67] Rodrigues Regional Assembly (2009) *Final SIDPR – Sustainable Integrated Development Plan for Rodrigues.*

3.2.4. Tourism and coastal management

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 as a result of sea-level rise and environmental degradation. An Integrated Coastal Zone Management (ICZM) framework has been drawn for Mauritius, which addresses a number of climate change impacts. The following strategies and action plan seek to bring additional adaptation options, both relevant for coastal and non-coastal tourism.

The following action plan was established with the support of the 2012 Draft Baseline Assessment Report for the tourism sector[68].

	Strategies	**Action List**
T1	Provide national guidance for protecting existing critical ecosystems, existing coastal development, and future investment	**T1.1.** Establish decision guidance. The relevant authorities shall develop a framework that can be used at the national and local level as guidance in preparation of adaptation plans. The guideline should be in line with the Tourism Sector Strategy Plan 2009-2015 and the Hotel Development Strategy (whereby priority consideration is given to hotel projects of the highest standard providing high quality service and belonging to the four and five start categories) and should consider three key questions for helping to design and locate proposed or existing structures that may be threatened by sea-level rise, in line with the Planning Policy Guidelines: • Is the existing or proposed structure either necessary for the health, safety, or welfare of an entire region, or is it located within a hazard area for which protection will be provided because of surrounding high-value development? • Is it infeasible to relocate an existing structure or site a new structure outside the hazard area and still provide this health, safety, or welfare function? • Will relocating an existing or proposed structure provide habitat protection or recreational opportunities that may be otherwise lost if that structure is built or is protected along the coast? Additional questions that should be considered in the preparation of the framework include: • Is there a feasible "soft" protection solution (i.e., can a barrier beach or wetland be used instead of a seawall)? • Will the protection approach, retrofit, or new design: o Be necessary to protect an existing structure threatened by erosion? o Allow continuation of important natural processes, such

[68] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the agriculture, tourism, fisheries sectors of the Republic of Mauritius and the water sector in particular for Rodrigues in the context of the Africa Adaptation Programme (AAP)*, Tourism Sector, Draft Baseline Assessment Report, Republic of Mauritius.

	Strategies	Action List
		as littoral drift, and avoid any impacts to neighbouring habitats or structures? ○ Result in the loss of state tidelands or beaches? ○ Provide a long-term solution to the threats caused by sea-level rise? ○ Be resilient over a range of sea-level rise possibilities? ○ Provide broad protection to existing developed areas? ○ Protect structures of high cultural or social value? ○ Provide for a natural shoreline (i.e., can seawalls be designed to include habitat)? ○ Be coordinated with proposed actions for other infrastructure in the same flood hazard area? ○ Cost less than the value of the structure to be protected? ○ Provide mitigation for adverse impacts that cannot be avoided? **T1.2.** Develop pilot studies in cooperation with developers that will examine the efficacy and utility of the framework highlighted above.
T2	Engage the Tourism sector in adaptation and sustainable development	**T2.1.** The Ministry of Tourism and Leisure, in collaboration with other relevant bodies, shall promote micro-finance schemes which sustain adaptation and sustainable development programmes. Tourists contributing finance (directly or indirectly) are then provided the opportunity to witness benefits through visits of financed activities, thus placing the ROM as "responsible" destination. An example is financing the dissemination of drip irrigation for agriculture, contributing to poverty alleviation and food security. **T2.2.** Coastal and wetland attractions, as well as non-coastal attractions shall be developed and offered to demonstrate approaches to using adaptation mechanisms against climate change. **T2.3.** In coordination with Action F4.2 of the fisheries sector, the tourism sector shall assist the economic valuation of coastal and marine ecosystems, in addition to existing efforts in involving the community in development projects that would help preserve the ecosystem.

Disaster Risk Reduction – Tourism

DRR (in connection with sustainable development and climate change) should be also integrated into policies aiming at tourism development, consistently with the mission of the RoM Ministry of Tourism and Leisure, which pursues the establishment of sustainable development patterns of tourism. To this end, a Sustainable Tourism Strategy for RoM may be developed as an effective tool to ensure that DRR and sustainable development issues are integrated into tourism policies and

services, as a way to formalize the many activities that are already ongoing in the tourism sector to effectively support sustainable development. Accordingly, touristic infrastructures should be built and managed in safe areas and in conditions ensuring disasters prevention. (Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.)

Rodrigues

The overarching goal is to develop the Tourism sector as a core pillar of the economy so as to be able to share the accruing benefits in an equitable manner with all sections of the population, while at the same time ensuring that any development taking place is deeply rooted in, or complements, the sustainable use of Rodrigues natural resource base.

The SIDPR gives comprehensive consideration to a variety of factors affecting tourism, including the Tourism Carrying Capacity Assessment[69] of the island. As a result, highly environmental sensitive tourist sites to be protected, and the concept of zoning plan (among others) are addressed[70].

3.2.5. Integrating disaster risk reduction in climate change adaptation

Adaptation and its implementation are of growing significance within the context of the international negotiations on climate change such as the Cancun Adaptation Framework[71], as well as within international processes, particularly within the context of the Hyogo Framework on Disaster Risk Reduction (DRR). DRR and adaptation share commonalities in purpose in that they aim to reduce the vulnerability of societies to hazards by improving the ability to better anticipate, resist and recover from their impact. Climate change can significantly change the predictability of known hazards, and affect the variability in their frequency, duration and intensity. While climate change and disasters have different origins, they overlap a great deal through the common factor of weather and climate and the similar tools used to monitor, analyse and address adverse consequences (i.e. adaptation). [72] So CC is no longer seen as something distinct from DRR, and going forward it will be important for ROM to integrate adaptation to CC and DRR into a single framework by building on ROM's long experience in dealing with disasters.

The following strategies, taken from the DRR strategic framework and action plan [73] (under development for the ROM), create synergies between DRR and climate change adaptation[74]:

[69] The World Tourism Organisation (WTO) was the first to propose a workable definition of Tourism Carrying Capacity Assessment (TCCA). It states that TCCA is "*...the maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic and socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction*".

[70] Rodrigues Regional Assembly (2009) *Final SIDPR – Sustainable Integrated Development Plan for Rodrigues.*

[71] United Nations Convention on Climate Change (2012) Cancun Adaptation Framework, http://unfccc.int/adaptation/cancun_adaptation_framework/items/5852.php - accessed 11 July 2012.

[72] Climate Change and Disaster Risk Reduction, ISDR Briefing Note 01, September 2008; Adaptation to Climate Change by Reducing Disaster Risks: Country Practices and Lessons, ISDR Briefing Note 02, November 2009.

[73] Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.

[74] The Action Plan (AP) contains 9 specific areas of intervention, introduced in the subsections 4.3.1 – 4.37, and 25 actions, each further described in a separate sheet (see Ministry of Environment and Sustainable Development (2012) Development of a DRR strategic framework and action plan, detailed report (draft version), Republic of Mauritius.

DRR Phase	Action sheets	Title	Brief description
Protection & prevention	L1-3, LR, F1-7 I1-7, IR	Reduce risk in areas prone to very high and high risk	Substantial investments are needed to safeguard areas prone to very high and high risk to flood, inundation and landslide hazards. The current vulnerabilities are to some extent results of unsound development practices and insufficient preservation of environment including wetlands and coral reefs.
	H2, H3	Adopt a sound development strategy	Spatial planning and land management play an important role in risk prevention, by limiting the development in flood prone areas, and by encouraging flood risk-sensitive land use and management practices. High proportion of areas identified for future development are placed in areas prone to very high and high risk.
	H6	Preserve healthy natural environment	Healthy environment and ecosystems provide (regulatory) services reducing the impact of natural hazard events. Nevertheless the area occupied by coastal and inland wetlands has declined. This trend should be reverted and more emphasis should be paid to ability of ecosystems to mitigate or offset the effects of the natural hazard. Public buyback programs may be considered to ensure the quality of wetlands and the ecosystem services they provide.
Preparedness	H5	Sound (spatial) data infrastructure	A sound disaster risk management is data-intensive. Monitoring of precipitation (regimes), surface run-of, river discharges, wave heights, cyclone activity should be centrally stored and made accessible to all relevant institutions. The lack of a consistent spatial data infrastructure obstructed the conduct of this risk assessment. The acquisition of detailed topographic data in very high and high risk areas should become a high priority.
	H1	Early warning and alerting system	The existing early warning system for tsunami and cyclones should be extended to include river discharge and high tide, as well as other natural hazards such as drought. The issued alerts should find an easier way to all concerned citizens through media, internet, and Internet-based social networks.
Recovery	H4	Emergency fund and insurance scheme	Post-disaster recovery should be facilitated by a national solidarity/recovery funds and private insurance schemes.

4. Integrated Policymaking for Climate Change Adaptation

4.1. Agenda setting: review of existing policies

The Integrated Policymaking process required to address climate change adaptation (including DRR) starts with the agenda setting, consisting in issue identification. Each institution, or unit, responsible for policy formulation at the sectoral level, normally carries out this task. For this reason, the following section highlight current legislation, policies and programs, as well as responsibilities. Mapping roles is very relevant to identify gaps in the policy process and address them effectively.

Acknowledging that several key issues affect the sectors analyzed in this study, specific indicators will be presented in Section 6.

4.1.1. Current legislation

Existing legislation implementing aspects of climate change are:

- Climate Change Bill (draft)
- Climate Efficiency Act
- Environment Protection (Designated National Authority) Regulations, 2010;
- Road Traffic (Vehicular Emissions) Regulations;
- Air Pollution Regulations (draft);

4.1.2. Current policies and programmes

Various policies and programmes are planned to or currently do implement interventions aimed at mitigating or adapting to climate change, either specifically or in the wider scope of sustainable development, which aims at reducing vulnerability and increasing resilience of the economic-social-environmental system of the ROM. The following are cross-sectoral policies and programmes; however sector-specific policies, plans and reports should inform and be informed by such cross-sectoral efforts in order to avoid conflicts and generate optimal implementation results at all levels.

For further information on cross-sectoral and sector specific policies, plans, green papers and reports, consult the *draft report the formulation of climate resilient policy and legislation and capacity building in the context of the Africa Adaptation Programme*[75].

National Climate Change Action Plan

The first Climate Change Action Plan was developed in 1998, detailing sectoral responses for water resources, waste management, agriculture and forestry, fisheries, coastal zone management, energy planning and transportation. Other cross-cutting actions included: education and awareness campaigns, data collection, monitoring programmes, regional and national climate modelling, improving technical capacity and providing institutional support. This was followed by the publication of the Initial National Communication under the UNFCCC in 1999 and the Second National Communication in 2010, and the Third Communication is currently under preparation.

[75] Ministry of Environment and Sustainable Development (2012) *Draft report for the formulation of climate resilient policy and legislation and capacity building in the context of the Africa Adaptation Programme (AAP),* Republic of Mauritius.

Maurice Ile Durable

Since 2007, "Maurice Ile Durable" (MID) has been adopted as the long-term vision for promoting sustainable development in Mauritius. The MID Fund established in June 2008, provides the financing mechanism for the preservation of local natural resources, for the promotion of renewable energies, including the use of local renewable sources, the encouragement of waste minimization and recycling, and for public-private partnerships as well as local and international networking for the promotion of renewable energies, energy conservation and efficiency.

Clean Development Mechanism projects

Mauritius presents many possibilities for Clean Development Mechanism[76] projects. The Energy Policy for the Republic of Mauritius has identified potential of energy-related Clean Development Mechanism projects for Mauritius. These have been estimated to be around 1.8 million tonnes of CO_2 reductions per year.

Technology Needs Assessment

Mauritius is implementing the 2nd Technology Needs Assessment. The key aim of this second round of Technology Needs Assessment is to bridge the gap between identification of appropriate technologies and design of action plans that would enable Mauritius to reduce greenhouse gas emissions and support adaptation to climate change. The project is scheduled for completion before the end of 2012.

Sustainable consumption and production

The 2008 National Programme on Sustainable Consumption and Production[77] encompasses 44 projects to be implemented within a period of five years. These projects focus on: sustainable energy consumption; sustainable water consumption; sustainable buildings and construction; integrated waste management and recycling; sustainable public service practices; improved market supply of sustainable products and education and communication for sustainable lifestyles. If implemented, many of these projects can contribute to decrease GHG emissions.

4.1.3. Coordination of responsibilities for existing and proposed programs

Table 14 summarizes institutional responsibilities across sectors, in the context of climate change adaptation[78].

[76] Clean Development Mechanism, one of the provisions of the Kyoto Protocol, is a means of promoting sustainable development in developing countries through carbon trading. For each tonne of Carbon Dioxide (CO_2) equivalent that is reduced as a result of a Clean Development Mechanism project, a 'carbon credit' is issued and can be purchased by industrialised countries for the fulfilment of their commitments to the Kyoto Protocol. In 2011, the value of the Clean Development Mechanism market totalled $2.9 billion.

[77] The National Programme on SCP is available on the following URL: http://www.gov.mu/portal/goc/menv/files/SCP/SCP.pdf

[78] Ministry of Environment and Sustainable Development (2012) *Draft report for the formulation of climate resilient policy and legislation and capacity building in the context of the Africa Adaptation Programme (AAP),* Republic of Mauritius.

Table 14: Key institutions and responsibilities for areas pertaining climate change adaptation

Institutions	Responsibility
Ministry of Environment and Sustainable Development	• EIA • Standards for Environmental Quality
Ministry of Agro Industry and Food Security • Forestry Service • National Parks and Conservation Service	• Forests • National Parks • Reserves
Ministry of Fisheries • Fisheries Division	• Fisheries and ecosystem management and protection
Ministry of Local Government and Outer Islets • Beach Authority	• Shoreline Development • Beaches
Ministry of Housing and Lands	• Planning Policy
Ministry of Public Infrastructure, Land Transport Shipping	• Marine Pollution from Vessels • Ports
Ministry of Tourism	• Coastal hotels • Recreation
Ministry of Renewable Energy and Public Utilities • Central Water Authority • Water Resources Unit • Waste Water Management Authority	 • Water Allocation; pollution • Assessment of Freshwater Resources • Wastewater Management

Each of these institutions' responsibilities is relevant to climate change adaptation, although they are not necessarily spelled out as such. Departments, divisions and committees however exist to ensure coordination on environment and climate change matters.

The **Coordination and Project Implementation Division** of the Department of Environment (DOE)[79] coordinates and implements the National Environmental Strategies (NES/EIP2), is responsible for environmental economics (cost-benefit analysis) and coordinates projects implemented by enforcing agencies, and regional and international organisations, also assisting other ministries in environmental projects, being involved with the development of an integrated national transport strategy.

Additionally, the **National Network for Sustainable Development** (NNSD) is chaired by the Minister of Environment and Sustainable Development and acts as a forum for discussion on, among other topics, the harmonisation of various sectoral, economic, social and environmental policies and plans operating in the country.

The **Environment Coordination Committee** (ECC) is chaired by the Permanent Secretary of the Ministry of the Environment and Sustainable Development and its mandate is, among others, to ensure cooperation and coordination among enforcing agencies and other public departments dealing with environmental protection.

[79] The Ministry of Environment includes the Department of Environment (DOE) which was established under Environmental Protection Act (EPA), 1991 (repealed in 2002 and amended in 2008).

The **National Climate Change Committee** (NCCC) comes under the Prime Minister's Office, and is co-chaired by the Mauritius Meteorological Services, and "*is responsible for developing national GHG inventories, evaluating climate change impacts, formulating climate change mitigation and adaptation programmes and promoting research, education and awareness on climate change"*

The **Climate Change Division** was created in the Ministry of Environment and Sustainable Development on March 1, 2010. The division is responsible for implementing international climate change agreements (i.e. UNFCCC, Kyoto Protocol, Conference of Parties decisions, Bali Action Plan, Copenhagen Accord and Cancun Agreements), 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[80].

A substantial amount of resources are therefore mobilized with good potential for synergies and mainstreaming climate change adaptation within national development.

4.2. Policy gaps and complementarity

Policy formulation should consider the successes and failures, and causes thereof, incurred through the implementation of past and/or existing policies. Learning from these experiences should enable policy formulators to identify, refine and formalise policy options to prepare the ground for decision-making.

4.2.1. Effectiveness and complementarity of existing programmes

Since 1991, the 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.

Furthermore, 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. Furthermore, since the scale of Clean Development Mechanism projects in Mauritius is small, a clustering of small activities or the setting up of a programme of action for the region or for SIDS will enable Mauritius participate in such projects.[81]

It should be noted that the National Development Strategy does not contain a comprehensive treatment of climate change issue. However the section in Chapter 10 (Environment and Fisheries) dealing with coastal zone management does address the impacts of global warming on the coastal zone. In addition Chapter 10 dealing with Environment and Fisheries does address a number of critical environmental issues. These relate to:

- Coastal area, including lagoon, offshore islets and outer islands;

[80] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report.

[81] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report.

- Groundwater aquifers and surface water catchment areas;
- Mountain ranges and forest reserves.

According to a gap analysis by HBHA[82] on legislation, regulations, guidelines and policy, there are some outstanding issues that still remain unresolved. These are: EIA and planning, and enforcement of environmental legislation. Within the legislative framework pertaining to climate change however, the following gaps were noted, also acknowledging the contribution of the AAP to address these challenges and the ongoing efforts to finalize the legislation for wetlands:

- Absence of legislation for Wetlands,
- Absence of comprehensive Climate Change Policy,
- Absence of comprehensive legislation to mainstream Climate Change.

It is important to highlight that a draft Climate Change Act has been proposed, which aims at filling the gaps of current climate change legal and institutional framework, and is likely to accelerate the development of comprehensive climate change adaptation and mitigation policies. The Act, which provides for the development of a National Climate Change Adaptation Strategy and a National Climate Change Mitigation Strategy, has the objective "to establish the legal framework and mechanism towards making Mauritius climate change-resilient and achieve a low-carbon economy in line with the overarching Government objectives of developing a green economy and the Maurice Ile Durable initiative"[83].

4.2.2. Sectoral progress and needs

Agriculture

The Blueprint for a Sustainable Diversified Agri-food Strategy for Mauritius, 2008-2015 (MOAIF, 2008)[84] addresses the food security through improving self-sufficiency status of a number of strategic crops in the short to medium term. The overall goal of this programme is to facilitate commercial production of such crops to ensure food security and quality, foreign exchange savings and sustainable development as well as improving the diet and health of the nation.

The government's decision to set up a Rs 2 billion Food Security Fund is dictated by its commitment to transform the food crisis into an opportunity for farmers, namely small ones, and to build resilience in order to reduce the country's food dependency on imports. Such policy will require heavy investments for a sustained agricultural growth in order to increase substantially field productivity and address some immediate food needs of the population (Food Security Fund Committee, 2008)[85]. The strategy and policy instrument were not designed to address the climate change-Agriculture nexus directly. Nevertheless, they cover several that will reduce vulnerability to the adverse effects of climate change, and hence increase climate resilience of this sector. Further, the Fund also indicates the need for a *Food Crop Insurance Scheme, Post harvest treatment and storage facilities* and *Sheltered Farming*, interventions that would support climate change adaptation.

[82] Draft report for the formulation of climate resilient policy and legislation and capacity building in the context of the Africa Adaptation Programme (2012), Ministry of Environment & Sustainable development.
[83] Draft Climate Change Act (2012)
[84] Ministry of Agro Industry and Fisheries (2008). Blueprint for a Sustainable Diversified Agri Food Strategy for Mauritius 2008 – 2015.
[85] Food Security Fund Committee (2008). Strategic Plan 2008 – 2011.

Table 15: Climate Change in current policies - Agriculture

Documents	Gaps: Key findings
The food security fund strategic plan 2008-2011	The future risk of climate change on the agricultural sector (plants and animals) has been considered in the document and proposal of an adaption strategy has been included. However adaptation strategy proposed is not explicit strategy towards the poor farmers. In addition it is not one of the major recommendations in the key priority area.
The forests and Reserves Act No.41 of 1983, as amended by Act No.1986 and No.7 of 2003	No explicit consideration of climate change in the document
Land (Duties And Taxes) Act 46 Of 1984 – 16 July 1984	No attention to climate change in the document
Plant Protection Act 2006	*No attention to incidence of new diseases and epidemic levels of existing diseases and pests'* behavior with respect to climate change.
The Mauritius Agricultural Marketing Act 1963	No attention to climate change, even where climate risks are obvious today such as storage , post harvesting , marketing infrastructure
Strategic Options in Crop Diversification and Livestock Sector 2007-2015	Little attention to climate change in the document only where cyclone risks
Sustainable diversified Agri-food sector strategy for Mauritius 2008 – 2015	No explicit consideration of climate change in the document
The Genetically Modified Organisms ACT 2004	No references to climate change in the document

Water

In order to increase the availability of water, Government has launched various initiatives aimed at increasing water supply, namely:

- Reformed institutional framework for the assessment, development, management and conservation of water resources in Mauritius.
- Implementation of the National Sewerage Programme.
- Preparation of a Wastewater Master Plan Study for the period 2014 – 2033.
- Preparation of a National Water Policy and an Integrated Water Resources Management Plan to meet water requirements till 2040.
- An ambitious project for the reduction of unaccounted for water to an acceptable level of 25% by 2030 (MEO) has been initiated.

Mauritius has to overcome a number of challenges in order to meet the water needs of individuals and for future development. Some of the issues Mauritius faces in the water sector are:

- 47% of water (unaccounted-for-water) is lost through leaks in the piping systems and illegal tapping.
- Rainwater harvesting is not widespread in Mauritius and more than half of rainwater is lost.
- Freshwater resources are threatened by dumping of solid waste in rivers, heavy use of agrochemicals, backfilling of wetlands and sewage disposal.
- Legislation to reduce pollution has been poorly implemented.
- Only 29% of the population is connected to the sewerage network. Little waste water is reused. Irrigation systems commonly use ground water supplies, which have a high potential to be used for potable purposes.

Fisheries

Table 16 provides an overview of the extent to which climate change is addressed in key national documents for the fisheries sector.

Table 16: Climate Change in current policies - Fisheries

Documents	Gaps: Key findings
Fisheries regulations	Emphasis only on sustainable fishing operations. No serious emphasis on climate change
Aquaculture Master plan	Climate change not taken into account except the government creates the right environment for potential investments
Fisheries Master Plan	Very little emphasis is directly related to climate change a part from sustainable fisheries
Fisheries and Marine Resources Act of 2007/ Maritime Zones Act 1977	No direct mention of climate change even in the amendment Govt. notice No.196 of 2007
Fishermen welfare Fund Act of 2000	No serious mention is made on climate change
Fishermen Investment Trust Act of 2006	Very little is clearly mentioned
Marine Protected Area Regulations of 2001/2007	No direct mention of climate change even in the amendment Govt. notice No.196 0f 2007
Environment Protection Act (EPA) 2002	Not seriously recorded
Wildlife and National Parks Act 1993, National Parks and Reserve regulations 1996 and wildlife regulations, 1998	Effects of climate change discussed in general but not in details
Forests and Reserve Acts 1983	Just high -lighted. Not seriously detailed
Town and planning Acts 1954	Enacted but not enforced
Pas Geometriques Act 1985	Not detailed
Continental Shelf Act, 1970	Only measures for protection are mentioned but not clearly elucidated
National Coast Guard 1985	Should elaborate more

The shallow fishing banks in the Mauritian EEZ have reached their Maximum Sustainable Yield and the lagoons are overexploited. The challenge is to overcome these limitations through a holistic

long-term plan and a national co-coordinated effort in promoting marine science research. One notable thing about fishing in ROM is the Fishers' allowance which is catered for when the weather is not permitting or if the climate is not favourable or if the fishing vessels are not seaworthy. The fishers however are trained in skipping methods and a little knowledge of climate awareness is provided and this would be a useful starting point in mainstreaming climate change into the development process.[86]

In order to promote sustainable use of the coastal resources and preservation of the marine biodiversity, various initiatives have been undertaken, including:

- Comprehensive legal framework for coastal zone management in place.
- Development of an ICZM Framework and a Study on ESAs for better management of the coastal zone.
- Regular monitoring programme for coral reef ecosystem at specific lagoon sites.
- Implementation of management measures for a sustainable fisheries sector.
- The mangrove propagation programme is ongoing;
- The Fisheries Master Plan is being finalised and will be implemented.

With respect to marine resources and coastal zone management, the Mauritius Environment Outlook reports insufficient monitoring and compliance with licences and enforcement of laws. Mechanisms of communication, collaboration and coordination among the various agencies involved in coastal management are also poor. Much remains to be done to prevent further degradation of coastal and marine resources. Main actions to be considered are to:

- Implement recommendations of the ESA Study and the ICZM Framework.
- Promote sound development practices in the coastal zone by strict adherence of coastal development to Outline Planning Schemes and Planning Policy Guidance.
- Develop and implement climate change adaptation strategy to increase resilience to climate change and sea level rise.
- Implement the Blue Flag programme for beaches.
- Strictly implement fisheries management measures in the lagoon and in the EEZ.
- Strengthen monitoring, data collection and ensure professional development.

Tourism

Table 17 provides an overview of the extent to which climate change is addressed in key national documents for the fisheries sector.

[86] Ministry of Environment and Sustainable Development (2012) Mainstreaming climate change adaptation in the development process in the Agriculture, Tourism, Fisheries sectors of the Republic of Mauritius and of the Water sector in particular for Rodrigues in the context of the Africa Adaptation Programme (AAP), Draft fisheries sector report.

Table 17: Climate Change in current policies - Tourism

Documents	Gaps: Key findings
The Tourism Authority Act 2006 (Act No. 32 of 2006)	Minimal attention to climate change
The Tourism Authority (Amendment) bill (No. 11 of 2008)	Minimal attention to climate change
Mauritius Sector Strategy Plan on Tourism (2009-2015) and its related Programme Budget	Acknowledges the effect of climate change on the industry but without explicit strategies
Development of an Integrated Coastal Zone Management Framework (ICZM) for the Republic of Mauritius (2008)	Acknowledges the effect of climate change on the industry but without explicit strategies
Sustainable Integrated Development Plan for Rodrigues (2009)	Acknowledges the effect of climate change on the industry but without explicit strategies
Planning Policy Guidance: Ministry of Housing and Lands (2004)	Limited attention to climate change
Islet Management Plan	Acknowledges the effect of climate change on the industry but without explicit strategies
National Environmental Outlook Report (Agalega)	Acknowledges the effect of climate change on the industry but without explicit strategies
Development of Management Plans for the Conservation and Management of Offshore Islets for the Republic of Mauritius (Phase II), 2008	Acknowledges the effect of climate change on the industry but without explicit strategies
Maurice Ile Durable Policy, Strategy and Action Plan for the Republic of Mauritius (Inception Report), February 2012	Acknowledges the effect of climate change on the industry but without explicit strategies

A number of bodies including, among other, the Ministry of Tourism and Leisure, Board of Investment, Tourism Authority, Beach Authority and Local Authorities are responsible for policy formulation and management of the tourism sector (MOESD, 2011)[87]. Sustainable tourism now forms an integral part of the national strategies, policies and action plans.

In terms of climate change adaptation, the tourism sector is strongly linked to coastal zone management and infrastructure. As indicated in the report *Revamping the Hotel Development Strategy to reinforce the competitive edge of Mauritius as an attractive tourism destination* (2009), in order to preserve the natural characteristics of Mauritius' seascapes, policies for coastal

[87] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report.

development should be strictly adhered to. The Second National Communication (2010)[88] has proposed several adaptation options for the coastal zone, including:

- Management of ESAs and implementation of Integrated Coastal Zone Management Plan,
- Coastal protection and rehabilitation works,
- Preparation of detailed inundation maps and monitoring of flood prone areas,
- Policy review in the Environment Sector,
- Adaptation of public infrastructure on the coastal zone and the Ports Area,
- Strengthening of capacities for disaster risk reduction and disaster management.

Other needs include:

- Monitoring the cumulative impacts of tourism development,
- Develop an ecotourism strategy,
- Establish Environment Management Systems, audits and verification in hotels and IRS,
- Adopt eco-friendly practices and eco-labelling schemes (already being done in some hotels),
- Encourage the tourism industry to adopt Carbon-offset programmes by paying for carbon emissions through investments in forest restoration (although programs exist and are being carried out by airlines and other organizations, with benefits being accrued in countries other than Mauritius).

4.3. Policy monitoring and evaluation

Due to the cross-sectoral nature of climate change impacts, and therefore the cross-sector effects of sector-specific policies and actions, the effectiveness of climate change policy will depend on three main factors:

- The synergy of efforts from relevant institutions and stakeholders, as enabled by appropriate communication and collaboration channels;
- The level of overlap between separate policies;
- The use of indicators for measuring both the state of the environment, and socio-economic progress (e.g. employment, wellbeing, sectoral production, resource efficiency).

Some adaptation measures implemented as of June 2012 are[89]:

- Long Term Energy Strategy 2009 – 2025;
- 18 measures identified for implementation during the Mauritius Transport Consensus Forum of 2006;
- National Forestry Policy, 2006;
- Hotel Development Strategy;
- Environment Protection Act amended to provide for the creation of a Multilateral Environment Agreements Coordinating Committee;
- National Environment Policy, 2007;
- Blueprint for a Sustainable Diversified Agri-food Strategy for Mauritius, 2008 – 2015;

[88] Government of Mauritius (2010). Second National Communication under the UNFCCC (Mauritius Meteorological Services, Vacoas, December 2010).
[89] Draft report for the formulation of climate resilient policy and legislation and capacity building in the context of the Africa Adaptation Programme (2012), Ministry of Environment & Sustainable development.

- Master Plan Study for the development of water resources is being created;
- ICZM Framework completed;
- Fisheries Development Plan, 1998;
- National Biodiversity Strategy and Action Plan, 2006 – 2016;
- Country Paper on the Health Sector, 2006.

Section 6 addresses monitoring and evaluation through the lens of nationally appropriate indicators for the key sectors of interest. Synergies and potential tradeoffs across various sectoral policy interventions will be evaluated for a variety of social, economic and environmental indicators.

5. Investment Plan for Climate Change Adaptation

This Investment Plan is composed of two sections: cross-sectoral investments and sectoral investments. The former are highly recommendable as they offer multiple co-benefits and require participation of different entities (e.g. different ministries), fostering more integrated action and supporting subsequent integrated policy making as a result. The latter are necessary as they require dedicated resources and expertise for adaptation in specific areas.

5.1 Cross-sectoral Investments

This section is composed of items identified and analysed by the DRR strategic framework and action plan[90], because of the synergies they enable with the climate change adaptation strategy and action plan, in the primary sectors addressed by this report: water, agriculture, fisheries and tourism. It is highly recommended that the DRR strategic framework and action plan be observed, especially regarding the vulnerability of infrastructure and urban areas to flooding, landslides, and inundation. For investment needs beyond 2015, refer to Annex 8 of the DRR strategic framework and action plan.

5.1.1 Implement a sound (spatial) data infrastructure

Modern disaster risk governance is hardly conceivable without an effective data infrastructure. A (spatial) data infrastructure (SDI) comprises a framework of (geographic) data and information, metadata, users and tools that are interactively connected in order to use (spatial) data in an efficient and flexible way. It includes technology, data acquisition and distribution policies, standards, human resources, and other activities necessary to acquire, process, distribute, use, maintain, and preserve (spatial) data. Underlying the SDI is the principle of a single data storage and maintenance at places where this is most effective; seamless combination and sharing of data from various sources; easy access to the existing data by all pubic administration and authorised citizens. Environmental data such as whether observation, river flow and quality monitoring, storm activity, monitoring of environmental sensitive areas etc. should be attached a high priority within the SDI.

Table 18: Cost for implementing a sound (spatial) data infrastructure

Cost:	270 million MUR within 2012-2015[91]
Future investment needs:	n/a

This intervention should take into account the following CC Adaptation Action Plan items:

Water sector

W4.1.	Flood management systems that re-establish rivers and historic floodplains connectivity, enlarge and maintain catchment areas

[90] Climate Change and Disaster Risk Reduction, ISDR Briefing Note 01, September 2008; Adaptation to Climate Change by Reducing Disaster Risks: Country Practices and Lessons, ISDR Briefing Note 02, November 2009.
[91] Please see Annex A8, Ministry of Environment and Sustainable Development (2012) Development *of a DRR strategic framework and action plan, detailed report* (draft version), Republic of Mauritius.

W6.1.	Accurate measurement of water use
W7.1.	Providing information on areas affected by sea-level rise
Agriculture sector	
A6.2.	Providing area-specific information on climate change and DRR relevant to agriculture
Fisheries sector	
F4.2.	Economic valuation of coastal ecosystems, especially reefs or wetland which act as storm protection
Tourism sector	
T2.3.	Economic valuation of coastal ecosystems for touristic benefit

5.1.2 Preserve healthy natural environment

Healthy environment and ecosystems provide (regulatory) services reducing the impact of natural hazard events. Integrated flood management should consider environmental stewardship as part of their management intervention. Preservation of wetlands and natural floodplains improve flood protection and provide other benefits. Restoration of riparian vegetation helps to regulate river flow (stages and speed), trap sediments and other materials carried by floodwaters, and provides habitat and migratory paths for a diversity of organisms. Riparian buffers may be constituted by any type of vegetation along riverbanks, lakeshores, or other adjacent land to other surface waters. The restoration of the natural vegetation in the seashore has been proved successful as an effective solution against coastal erosion and, in cases of mangrove forest, as an efficient barrier against the storm surges. Over the past years the area occupied by coastal and inland wetlands and riparial vegetation has declined. This trend should be reverted and more emphasis should be paid to ability of ecosystems to mitigate or offset the effects of the natural hazard.

Table 19: Cost to preserve healthy natural environment[92]

Cost: 45 million MUR within 2012-2015
Future investment needs: 45 million MUR (2015-2018)

This intervention should take into account the following CC Adaptation Action Plan items:

Water sector	
W4.2.	Identifying and strategically prioritizing for protection lands that will provide the habitat range for tidal wetlands to adapt to sea-level rise,
Agriculture sector	
A4.1.	Conservation of “bee pastures” and use of on-farm planting beneficial to native and non-native pollinators,

[92] Please see Annex A8, Ministry of Environment and Sustainable Development (2012) Development *of a DRR strategic framework and action plan, detailed report* (draft version), Republic of Mauritius.

A4.3.	Promoting composting and support the use of compost as a substitute to traditional fertilizers in order to enrich soils,

Fisheries sector

F2.1.	Promoting good fishing practices and facilitate integrated approaches to mitigate adverse environmental and climate change impacts in the catchment and coastal areas,
F4.1.	Involve local fishing communities' knowledge to identify and survey fragile ecosystems, including wetlands, which act as fish breeding ground and buffer zones.
F4.2.	Economic valuation of coastal ecosystems, especially reefs or wetland which act as storm protection,

Tourism sector

T2.2.	Developing coastal and wetland attractions, as well as non-coastal attractions to demonstrate approaches to using adaptation mechanisms against climate change,
T2.3.	Economic valuation of coastal ecosystems for touristic benefit.

5.1.3 Flood management plans

Flood management plans are site specific but generally take into account actions to reduce the frequency and severity of floods in high populated urban areas and when extreme flood events occur. Plan of interventions defines various steps to reduce, or mitigate, the damage caused when floods happen including:

- *Planning activities*

  River Basin Master Plan containing a detailed hydrologic study and topographics survey of interest area. The river basin study and programmes of measures (field data collected and included in a comprehensive database) are not intended as a once-only exercise, but as a dynamic process based upon a periodical updating. In this way, critical issues on a water body, can be recognised and new measures developed to overcome them. Furthermore, refinements to the monitoring programme, and the availability of further data, will enable fine-tuning to existing measures and give early warning of new problems so that appropriate action can be taken.

- *Structural and non-structural measures*
  - Flood peak retention works
  - Restoration of natural areas upstream to be used as retention areas
  - Restoration of wetlands that can be used to store water during floods
  - Construction of enbankments in critical river reach to protect urban areas
  - Channel widening (check dam, sill)
  - Channel re-sectioning (widening/deepening/check dams/sills)
  - Improvements of dam safety
  - Reconstruction of critical bridges
  - Bank protection works (reef) along critical river reach in urban area

- Non-structural measures

Table 20: Costs for flood management plans[93]

Costs within 2012-2015	
Port Louis basins flood management plan	30
Poste de Flacq and Seche basins flood management plan	40
GRNW, RivièRE du Rempart West, Belle Isle and Belle Eau basins flood management plan	165
Citrons basin flood management plan	30
Tabac, La Chaux, Des Creoles and Du Poste South basins flood management plan	30
Land drainage study	617
Flood management plan in Rodrigues island	25
Future investment needs: 2015-2018 Period.	

Units: Million MUR

This intervention should take into account the following CC Adaptation Action Plan items:

Water sector

W1.2.	Identifying strategies that can improve the coordination of water storage with water supplies including surface runoff, flood flows and storm water among others,
W3.1.	Integrating flood management with watershed management on open space, agricultural, wildlife areas, and other low-density lands,
W4.1.	Establishing flood management systems that re-establish connectivity between rivers and their historic floodplains,
W5.4.	Developing conjunctive use management plans that integrate floodplain management, groundwater banking and surface storage,

Agriculture sector

A1.3.	Identifying voluntary floodplain corridor protection (flowage) easements on agricultural land to maintain agricultural production that is compatible with flood conveyance.

Fisheries sector

F2.3.	Reviewing water management laws with a view to increasing their sensitivity to fisheries needs.

[93] Please see Annex A8, Ministry of Environment and Sustainable Development (2012) Development *of a DRR strategic framework and action plan, detailed report* (draft version), Republic of Mauritius.

5.1.4 Coastline management plans for inundation

Coastline management plans for inundation are site specific but generally take into account actions to reduce critical vulnerabilities, especially for in urban areas and infrastructure. Plan of interventions defines various steps to reduce, or mitigate, the damage caused when inundations happen including:

- *Structural measures*
  - Hard Engineering: Seawalls; Breakwaters, breakwaves or in general artificial reefs along the coastline; Groynes; Gabions; Riprap revetments; Overtopping dike or extending the existing dykes; Allow transgression of sea in wide dune areas, allow wash over of dikes.
  - Soft Engineering: Stabilising coastal dunes; Planting or restoring vegetation along the shore; Beach nourishment and dune replenishment; Encourage growth of coral reefs; Managed retreat of coastal defence; Relocation of the properties.

- *Non-structural measures*
  - Gather and share information on climate change trends and possible future hazards; Production of shoreline management plans and Support local planning for addressing sea-level rise impacts; Include risk-based planning in long-term planning.

Table 21: Costs for coastline management plans for inundation[94]

	Costs within 2012-2015	No of Hotels[95]
Port Louis coastal line management plan	10.5	2
Black River coastal line management plan	9.1	-
Savanne coastal line management plan	4.9	11
Grand Port coastal line management plan	5.6	-
Flacq coastal line management plan	7	16
Riviere du Rempart coastal line management plan	9.1	15
Pamplemousses coastal line management plan	9.8	10
Rodrigues Island coastal line management plan	4.9	2
	Future investment needs: 2015-2018, 2018-2021 and 2021-2024 periods	

Units: Million MUR

This intervention should take into account the following CC Adaptation Action Plan items:

[94] See Annex A8, Ministry of Environment and Sustainable Development (2012) Development *of a DRR strategic framework and action plan, detailed report* (draft version), Republic of Mauritius.
[95] Number of hotels prone to high risk of inundation – some are prone to very high risk.

Water sector

W4.2.	Identifying and strategically prioritizing for protection lands that will provide the habitat range for tidal wetlands to adapt to sea-level rise,
W7.1.	Providing information on areas affected by sea-level rise,

Agriculture sector

A6.1.	Putting policies in place that fuse technologies to enhance agricultural production, processing and storage, protect the environment and prevent degradation of soil and water quality,
A6.2.	Providing area-specific information on climate change and DRR relevant to agriculture,

Fisheries sector

F2.3.	Reviewing water management laws with a view to increasing their sensitivity to fisheries needs,

Tourism sector

T1.1.	Developing a framework that can be used at the national and local level as guidance in preparation of adaptation plans.

5.2 Sectoral Investments

This section includes several possible investments included in the TNA and in the sectoral reports prepared by Capital Guardians in the context of the AAP. The investment items proposed for water and agriculture are well addressed in the Technology Needs Assessment for Mauritius[96], with complete fact sheets that include (but are not limited to):

- Development impacts, direct and indirect benefits,
- Indirect social and environmental benefits,
- Long term cost with and without adaptation,
- Institutional and organisational requirements,
- Operation and maintenance,
- Opportunities and barriers,
- Endorsement by experts.

Sample project sheets, for selected investments, are presented in Section 7.

5.2.1 Investments in water demand and supply

Desalination

Mauritius is characterized by some 75 main coastal villages and about 112 three to five star hotels along the coasts with a total of 12,000 rooms. The potential of using desalinated water is high, if needed. Hotels spend some MUR 90/m^3 for purchase of water from the CWA through tanker services[97]. On the other hand, eco-system damage is potentially high in the desalination process (i.e., returning concentrated brine underground). The impact can be reduced however by diluting the brine by-product before discarding.

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.[98]

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

[96] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius.
[97] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 4b - Prioritized adaptation technologies – Water.
[98] Government Information Service (2011), Water Crisis: Desalination Project Once More in Limelight, accessed 28/09/2012 from http://www.gov.mu/portal/site/Mainhomepage/menuitem.a42b24128104d9845dabddd154508a0c/?content_id=2f9f80a3de37d210VgnVCM1000000a04a8c0RCRD

removed, the more expensive the desalting process capacity of the facility also impacts costs, with larger plants generally being more economical.

Table 22: Cost of desalination[99]

Cost: MUR 14,000,000/ desalination plant (360m^3 per day)
Cost: MUR 27,000,000 – 30,000,000/ desalination plant (500-600 m^3 per day)

This intervention directly supports the implementation of CC Adaptation Action Plan item W5.3.:

W5.3.	Desalination should be considered as a means of increasing freshwater availability.

Rainwater harvesting

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 reduce mains-water consumption by around 50%.** Presently none of the water institution is promoting rooftop rainwater harvesting.

Rainwater harvesters 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 (only rooftop rainwater harvesting is discussed here).

Consumption and Production (**Sustainable Consumption and Production) (2008) had earmarked a budget of R. 2million** for encouraging rainwater harvesting in Mauritius. This cost included a sound equipment, fittings and installation costs. Latest figures from the Central Statistical office reported that there are 297, 500 buildings, 344700 housing units and 329.950 private households[100]. If one rainwater harvester 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[101].

This intervention directly supports the implementation of the CC Adaptation Action Plan item W5.2:

W5.2.	Expanding the rain water harvesting capacity can ensure higher volumes of stored freshwater in the ROM.

[99] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 4b - Prioritized adaptation technologies – Water.
[100] Government of Mauritius (2011), 2011 Housing Census – Main Results, accessed 28/09/2012 from http://www.gov.mu/portal/goc/cso/ei915/esi2011.pdf
[101] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 4b - Prioritized adaptation technologies – Water.

Hydrological models

Water-resource risk assessment and planning are currently based on the notion that factors such as precipitation and streamflow fluctuate within an unchanging envelope of variability. Anthropogenic changes to Earth's climate are altering the means and extremes of these factors so that this paradigm of stationarity no longer applies, causing a basic principle that guides how infrastructure decisions are made to be in doubt.[102]

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:

- Stochastic Models.

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.

- Process-Based Models.

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.

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. United States Geological Survey (USGS) models for instance 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.

The beneficiary is the public at large – as this will involve better water resource management. The local water organizations, who will be provided with a decision making tool, especially during crisis periods.

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. 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$. Tailor made complex software, including regular capacity building and technical support will involve higher costs[103].

[102] Milly. P.C.D., Betancourt. Julio, Falkenmark. Malin, Hirsch. Robert M, Kundzewicz. Zbigniew W, Lettenmaier. Dennis P, Stouffer. Ronald J (2008) Stationary Is Dead: Whither Water Management? Science, Volume 319, Accessed 25/09/12 from http://www.gfdl.noaa.gov/bibliography/related_files/pcm0801.pdf

[103] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 4b - Prioritized adaptation technologies – Water.

Table 23: Costs of hydrological models

Total cost: 20,000 USD for 10 computers, accessories and networking requirements

The models may well complement (and/or be complemented by) the investment cross-sectoral investment item 7.1.1. Implement a sound (spatial) data infrastructure.

Additionally, this intervention directly supports the implementation of the following CC Adaptation Action Plan item:

W1.1.	Develop hydrological models

5.2.2 Investments in agriculture and terrestrial ecosystem

Up-scaling of locally proven Integrated Pest Management technologies

Integrated Pest and Disease Management 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.

IPM makes full use of natural, physical and cultural processes and methods, including host resistance and biological control as opposed to synthetic chemicals. IPM emphasizes the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural pest control mechanisms.

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:

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

During the last 15-20 years, IPM strategy has been implemented in cabbage and cauliflower plantation. Experts were present to give their support. The use of traps, baits have been found to be effectively if properly maintained. [104]

[104] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 5b - Prioritized adaptation technologies – Agriculture.

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. Calculation of costs assumes that some 8,500 farmers will benefit at first and no doubt population will be gaining from organic production. [105]

Table 24: Cost of up-scaling IPM technologies[106]

Cost: MUR 2,441/ beneficiary/year
Total implementation cost: MUR 28,564,000

The timeframe for implementation is short term for traps and bio-pesticides and medium term for biological control. Hence, the total implementation cost above is distributed over a period of 16 to 17 months.

This intervention directly supports the implementation of CC Adaptation Action Plan item A2.1:

A2.1.	Up-scaling of locally proven IPM technologies for control of pest of economic importance.

Micro irrigation (gravity fed drip & mini and micro sprinkler irrigation)

Small scale micro irrigation for lifting, conveying and applying irrigation efficiently include gravity fed drip and pressurized sprinkler irrigation used to improve water use 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 improves 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.

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.

[105] Frison E. A., C.S. Gold, E. B. Karamura, R. A. Sikora (1998) Mobilizing IPM for sustainable banana production in Africa Proceedings of a workshop on banana IPM held in Nelspruit, South Africa — 23-28 November 1998, INIBAP, 1998

[106] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 5b - Prioritized adaptation technologies – Agriculture.

Table 25: Cost of micro-irrigation[107]

Irrigation system options
Drip irrigation = MUR 300,000/ha for hardware + maintenance cost MUR 500/ha/yr
Sprinkler irrigation= MUR 200,000/ha for hardware+ maintenance cost MUR 3000/ha /yr
Family drip kit – MUR 10,000 (recycle blue plastic tank + drippers) for 250 m^2
Gravity fed drip kit - MUR 30,500 for 1250 m^2 (no power required)
Estimated cost: USD 7,585/ beneficiary
Total cost for targeted area: MUR 187,125,000

This intervention directly supports the implementation of the following CC Adaptation Action Plan items:

A1.2.	Dissemination of micro irrigation systems for efficient water use and management shall be facilitated.
W2.1.	All relevant parties should implement strategies to achieve a nation-wide 20 percent reduction in per capita water use by 2020.
W2.2.	Agricultural entities should apply all feasible Efficient Water Management Practices to reduce water demand and improve the quality of drainage and return flows (also using recycling systems when possible), and report on implementation in their water management plans.

Decentralised rapid pest and disease diagnosis service (plant clinic)

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 field. This service helps to **e**mpower farmers to improve food security and protect the environment.

Some 8,500 planters including large and small farmers as well as general public can benefit from this service.

Table 26: Cost of decentralised rapid pest and disease diagnosis service[108]

Cost: MUR 234/ beneficiary/year
Total estimated cost (6375 beneficiaries): MUR 912,500

[107] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 5b - Prioritized adaptation technologies – Agriculture.
[108] Ministry of Environment and Sustainable Development (2012) Technology Needs Assessment Report, Republic of Mauritius, Annex 5b - Prioritized adaptation technologies – Agriculture.

This intervention directly supports the implementation of CC Adaptation Action Plan item A2.2:

A2.2.	Decentralised rapid pest and disease diagnosis service (plant clinic) shall be put in place.

Additional projects and programmes

The sectoral report on agriculture[109] has identified several additional projects and programmes for Climate Change adaptation in the sector. They vary in cost, time of implementation and effectiveness. Table 27 uses these parameters with colour coding (see table 28 for more information) to provide a preliminary prioritisation of these investment items. Further analysis is however necessary for a more robust prioritisation, which can be done by the ministries involved in the formulation of interventions and by those affected by the same.

Table 27: Additional Projects and Programmes in the agriculture sector

Project / Programme	Duration	Cost (MUR)	Action Plan items addressed
Climate Change Awareness	1 YEAR	9,388,170	A2.3, A5.1, A6.2
Soil & Water conservation	1 YEAR	10,995,930	A1.1, A1.3, A3.2, A4.3
Forest Development Plan	3 YEARS	26,700,300	A3.2
Food/crop production and security	5 YEARS	33,303,600	A4.2, A4.3
Research and Technology Development	3 YEARS	34,164,900	A4.2, A4.3, A6.1
Training and capacity building on climate change in the Agriculture sector	3 YEARS	49,094,100	A2.3, A3.2, A4.2, A4.3, A5.1, A6.2

Table 28: Colour coding legend

	Duration	Cost (MUR)	AP items addressed
	1 YEAR	< 1 million	4 and above
	1 – 3 YEARS	1 – 10 million	3
	3 – 5 YEARS	10 – 100 million	2
	> 5 YEARS	> 1000 million	1

[109] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the agriculture sector of the Republic of Mauritius in the context of the Africa Adaptation Programme (AAP)*, Final Report, Republic of Mauritius

5.2.3 Investments in fisheries and marine ecosystem

Investments for the development of the fisheries sector which take climate change adaptation in consideration may be sizable. The cross-sectoral investment plan only addresses actions F2.1., F2.3., F4.1. and F4.2., which are relevant essentially to coastal habitat protection – key ecosystems for in- and out- lagoon fisheries.

The cost of managing fisheries in Mauritius was Rs 96.345 million in the financial year 2002/2003[110]. In the financial year 2002/2003, the revenue collected for fisheries was MR 25 217 414, of which license fees from fishing vessels represented 87 percent. The rest were contributed by fees for import permits (12 percent) and sales of produce (0.85 percent). Any revenue collected goes to the general government fund and is, therefore, not directly available for fisheries management activities. Revenue represented 26 percent of the running cost in 2002/2003.

A variety of investments are being made in the fisheries sector, including:

- EU – Mauritius Fishery Partnership Agreement
    - In February 2012 the European Union and Mauritius initiated a new Fishery Partnership Agreement (FPA) and protocol, provides the EU with fishing opportunities for vessels targeting tuna species. In return, the EU will pay Mauritius an annual compensation of EUR 660 000, out of which EUR 302 500 is earmarked to support the fisheries policy of Mauritius. Vessel owners will have to pay a license fee to be authorised to fish in Mauritius' waters (as is the case also now). The new Protocol is based on the scientific advice, to ensure the sustainability of the stocks, and takes into account the interests of artisanal fishermen. To avoid adverse effects on the small scale fishermen, EU vessels will only be allowed to fish beyond 15 miles (currently 12 miles) from the coastal baseline[111].

- SmartFish Programme
    - The SmartFish Programme[112] aims at contributing to an increased level of social, economic and environmental development and deeper regional integration in the ESA-IO region through improved capacities for the sustainable exploitation of fisheries resources[113]. The first phase of the Programme is being implemented over a period of 31 months (March 2011-September 2013).

[110] Capital Guardians fisheries baseline report.
[111] European Commission 2012, New Fisheries Partnership Agreement between the EU and Mauritius http://ec.europa.eu/fisheries/news_and_events/press_releases/2012/20120223_02/index_en.htm accessed 24/09/2012.
[112] The programme is implemented by the Indian Ocean Commission (IOC) in collaboration with the Common Market for East and Southern Africa (COMESA), the East Africa Community (EAC) and the Inter-Governmental Authority on Development (IGAD). Other regional institutions involved include the Southern African Development Community (SADC) and regional fisheries management organizations, such as the Indian Ocean Tuna Commission (IOTC), the Southwest Indian Ocean Fisheries Commission (SWIOFC), the Lake Victoria Fisheries Organization (LVFO), and the Lake Tanganyika Fisheries Organization (LTFO).
[113] Indian Ocean Commission 2011, Smart Fish http://fisheries.ioconline.org/smartfish.html accessed 24/09/2012.

The Programme aims at achieving five main results. These relates to fisheries development and management; fisheries governance; monitoring, control and surveillance; fish trade and food security.

- Private investments
    - During a press conference held on 27 July 2012, the Minister of Fisheries, Hon. L. J. Von-Mally announced that investments to the tune of 8 to 10 billion rupees would be made by the French group Sapmer[114] in the fisheries sector of Mauritius. With a view to expanding the development of its tuna activities in the Indian Ocean, Sapmer will make the acquisition of a fleet of 5 high performing purse seiners with -40^{0}C freezing capacity onboard and will operate from Mauritius. Each vessel will cost around at Rs. 1 billion and the 5 vessels will be acquired from 2012 – 2014 *(2 vessels of 90 m LOA [length overall] in 2013 and 3 vessels of 80 m LOA in 2014*). Construction of the vessels will be undertaken in Vietnam. The company will also invest in the construction of a high tech processing plant in the port area to the tune of Rs 3 to Rs 5 billion, which is expected to be ready in early 2013. During the Press Conference, Hon. L. J. Von-Mally stressed on the various advantages of such an investment for the economy of the country in terms of direct foreign investment, job creation, refueling, food supplies, dry docking and maintenance[115].

It should be ensured that such investments provide for climate adaptation measures, to support the implementation of the present Action Plan, in particular:

F1.5.	An effective monitoring, control and surveillance (MCS) system for marine fisheries should be developed.
F1.6.	Make the penalties for offenders more stringent as well as restrict access through appropriate adjustment of fees on various permits and registrations.
F2.2.	Fishing grounds should be patrolled and monitored by the Department of Fisheries, in collaboration with the Coast Guards and other relevant institutions.
F4.3.	Build the capacity of stakeholders for their effective participation in the development and implementation of fishery-specific management plans.
F4.4.	Interdisciplinary researchers should be convened to meet periodically to exchange information on observations and research results

Aquaculture

[114] Sapmer is a French fishing company involved in deep-sea fishing in the economic zone of the French Southern and Antarctic Territories operating from Reunion Island. The company is involved in lobster, tooth fish and tuna fisheries and processing. Sapmer is actually present in Mauritius in the processing of fish through its joint venture with Seafood Hub Ltd in Mer des Mascareignes. It also has a storage capacity of 3,600 tonnes of fish at -400C jointly with the Mauritius Freeport Development Ltd and Froid des Mascareignes.
[115] Ministry of Fisheries 2012, Significant investment in the fisheries sector by Sapmer, http://www.gov.mu/portal/goc/fisheries/file/sapmer.pdf accessed 24/09/2012.

An Aquaculture Master Plan was approved by Government in 2007 and aquaculture activities are regulated by the Fisheries and Marine Resources Act 2007, as amended in 2008. All marine fish farming projects in the fish farming zones have to comply with operational guidelines for responsible fish farming practices and require an EIA licence[116]. The Aquaculture Division also has the responsibility to follow-up on the type and amount of feed applied to fish farms to ensure there is no pollution[117].

Such procedures and the present action plan items concerning aquaculture (F3.1 – F3.3) are coherent, and shall be systematically applied.

Additional projects and programmes

The sectoral report has presented several projects and programmes for Climate Change adaptation in the fisheries sector[118]. They vary in cost, time of implementation and effectiveness. Table 29 uses these parameters with colour coding (table 28) to provide a preliminary prioritisation of these investment items. Further analysis is however necessary for a more robust prioritisation.

Table 29: Projects and programmes in the fisheries sector

Project / Programme	Duration	Cost (MUR)	Action Plan items addressed
Support programme 1: Fisheries Management			
Capacity building	2013/2014	2,000,000	F4.1, F4.3, F4.4
FMP preparation and Implementation	5 TO 10 YEARS	12,000,000*	F1.1, F1.2, F1.4
MCS & VMS vigilance	CONTINUOUS	15,000,000**	F1.3, F2.3
Stock assessment & resource potential	2013/2014	20,000,000	F1.1, F4.2, F4.4
Support programme 2: Institutions Strengthening			
Stakeholder consultation	2013/2014	500,000***	F4.1
Encourage aquaculture projects	2013/2015	1,500,000	F3.1, F4.1
Comprehensive training programme	2014 Onwards	2,900,000	F2.1, F4.3
Skills and equipment provision	2013/2020	50,000,000	F1.1, F1.2, F1.5
Support programme 3: Infrastructure			

[116] Ministry of Environment and Sustainable Development (MOESD) (2011). Mauritius Environment Outlook Report, pg. 97.
[117] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the agriculture, tourism, fisheries sectors of the Republic of Mauritius and the water sector in particular for Rodrigues in the context of the Africa Adaptation Programme (AAP)*, Fisheries Sector, Draft Baseline Assessment Report, Republic of Mauritius, pg. 66.
[118] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the fisheries sector of the Republic of Mauritius in the context of the Africa Adaptation Programme (AAP)*, Final Report, Republic of Mauritius

Quay space adapted to SLR	2013/2020	50,000,000	F1.4
Support programme 4: Aquaculture			
Assistance to start aquaculture projects	2013/2020	20,000,000	F3.1, F3.2, F3.3
Support programme 5: Conservation of the Marine Environment			
Capacity building	2013/2014	4,000,000	F1.2, F1.6, F4.1, F4.3, F4.4
Audit of Marine resources	2013/2014	4,500,000	F2.1, F4.1, F4.2
Revisit legislation & regulations	2013/2014	6,000,000	F1.6, F2.4
Promote ecotourism	2013/2014	9,000,000	F4.1, F4.2

* MUR/Fishery/Year

** MUR/Year

*** MUR/Year

5.2.4 Investments in tourism and coastal management

The sectoral report has presented several additional projects and programmes for Climate Change adaptation in the tourism sector[119]. They vary in cost, time of implementation and effectiveness. Table 30 uses these parameters with colour coding (table 28) to provide a preliminary prioritisation of these investment items. Further analysis is however necessary for a more robust prioritisation.

Table 30: Projects and programmes in the tourism sector

Project / Programme	Duration	Cost (MUR)	Action Plan items addressed
Climate Change Awareness	1 YEAR	1,722,600	T1.1, T1.2
Training and capacity building on climate change in the tourism sector	3 YEARS	6,172,650	T1.1, T1.2
Extreme Events Damage Control	3 YEARS	10,048,500	T1.1, T1.2
Coral Reef Bleaching Reduction	5 YEARS	14,355,000	T2.2, T2.3
Water Supply Enhancement	7 YEARS	21,532,500	W5.1
Tropical Storms Damage Minimization	5 YEARS	25,839,000	T1.1, T1.2
Management of Sand Movement and Accumulation	5 YEARS	27,274,500	T1.1, T1.2
Beach Erosion Management	5 YEARS	35,887,500	T1.1, T1.2
Product Enhancement and Diversification	5 YEARS	143,550,000	T2.2

[119] Ministry of Environment and Sustainable Development (2012) *Mainstreaming climate change adaptation in the development process in the tourism sector of the Republic of Mauritius in the context of the Africa Adaptation Programme (AAP)*, Final Report, Republic of Mauritius

5.2.5 Activities for existing budgets and institutions

A certain number of activities within the Action Plan can be well integrated into existing programmes. In fact, the actions proposed below can well be included in existing budgetary exercises done at the ministerial level and do not imply medium and longer term sectoral transformations.

Given the time frame of the investment plan proposed, only short term activities are analysed in this section. These include:

Agriculture sector

A2.3.	Provide information to the agricultural community to enable growers to modify farm management practices and adapt to new pests and diseases.	Short term
A3.1.	Encourage community land use planning to support sustainable agriculture at the urban interface, helping to give a level of certainty to growers of the future use of their lands for agriculture.	Short term
A5.1.	Capacity-building framework that will build the capacity of institutions	Short term

Water sector

W2.1.	All relevant parties should implement strategies to achieve a nation-wide 20 percent reduction in per capita water use by 2020.	Short to long term
W2.2.	Agricultural entities should apply all feasible Efficient Water Management Practices	Short term
W2.4.	It is recommended that the Legislature authorize and fund new incentive-based programs to promote the mainstream adoption of aggressive water conservation	Short term

6. Indicators for agenda setting, policy formulation and evaluation

As can be seen in the cross-sectoral nature of the analysis carried out in this document, adapting to the impacts of climate change at the national level rhymes with sustainable development: preserving the long term ability of the country to meet its own needs. In the context of Integrated Policymaking, green economy indicators can provide a contribution that reaches beyond the existing frameworks, which are focused on the identification of key environmental impacts (e.g., DPSIR framework) and on measuring the green economy (e.g., SEEA, decoupling and efficiency, OECD Green Growth indicators). This section addresses indicators for Integrated Policymaking, to support the ROM in implementation of climate change adaptation policies and draws upon the work carried out by UNEP (UNEP, 2012).

6.1 Agenda Setting indicators

In a green economy context, indicators are particularly useful for realising the direct link between economic development and related environmental impacts. All economic activities occur in the natural, physical world. They require resources such as energy, water, materials and land. In

addition, economic activity invariably generates material residuals, which enter the environment as waste or polluting emissions. The Earth, being a finite planet, has a limited capability to supply resources and to absorb pollution. As a large-scale natural feedback mechanism, climate change in turn affects the natural system that the economy depends on. As for climate change adaptation, a key objective of the green economy is therefore to reduce energy, water, material and land use by stimulating investment that would increase efficiency, reduce pressures on the environment and eventually enhance its adaptive capacity and productivity.

In the scope of this Climate Change Adaptation Framework, the following indicators were identified as most relevant and comprehensive for the selected sectors, and aim at addressing the root sources of environmental impacts from a production, consumption and materials perspective.

Topic	***Indicator (different perspectives)***			
	Production	Consumption	Intensity	Productivity
Water stress	Water Use(WU) for national production, considering the regionally varying water stress by adequate contextualization	Water Footprint (FT) for domestic consumption, considering the regionally varying water stress by adequate contextualization	Water Use(WU), considering the regionally varying water stress by adequate contextualization, per GDP	GDP per Water Use(WU), considering the regionally varying water stress by adequate contextualization
Eutrophication (particularly relevant for agriculture and food consumption)	Nutrient Flows due to national production corresponding to pollution with nitrogen and phosphorus	Nutrient Footprint (NF) as Eutrophication Potential (EP) corresponding to pollution with nitrogen and phosphorus over the full life cycle	Nutrient Flows (or Footprint) per GDP	GDP per Nutrient Flows (or Footprint)
Habitat change and resource competition	Land Use (LU) for national production divided in LUagriculture, LUcropland and LUforest	Global Land Use (GLU) for domestic consumption divided in GLUagriculture, GLUcropland and GLUforest	Land Use (LU) divided in LUagriculture, LUcropland and LUforest per GDP	GDP per Land Use (LU) divided in LUagriculture, LUcropland and LUforest
Depletion of biotic resources	Material Requirement for biotic resources (TMRbiotic), notably fish and wood, for national production	Total Material Requirement for biotic resources (TMRbiotic), notably fish and wood, for domestic and foreign harvesting	Material Requirement for biotic resources (TMRbiotic) per GDP	GDP per Material Requirement for biotic resources (TMRbiotic)

Source: UNEP, 2010.

The above indicators fall squarely within the sectoral areas addressed in the present Policies, Strategies and Action Plan:

- Water availability and usage, already measured throughout the ROM, enables reporting on the above Indicator perspectives concerning water stress.
- As indicated, eutrophication is particularly relevant for agriculture and food consumption, yet is also relevant for ecosystem preservation and fisheries. Relieving crops and ecosystems from there adverse impacts shall support their resilience to climate pressures.

- Previous sections underlined the importance of healthy ecosystems for the provision of ecosystem services, which include flood control, land-slide protection and water purification. Ensuring adequate Land Use shall play a critical role in this matter.
- Reporting on Material Requirement for biotic resources, fish in particular, shall facilitate assessment of safe harvesting levels.

Ultimately, agenda setting indicators can be the same as -or part of- policy evaluation indicators, as observing the impact of policies is essentially observing the state of the issues addressed by the policy.

6.2 Policy Formulation indicators

Policy formulators frame, refine, and formalize policy options to prepare the ground for the decision-making stage. In this regard, indicators can be useful at different levels of policy formulation, namely: definition of policy objectives, evaluation of intervention options and costs, cost-benefit analysis, and formulation of policy options.

- **Policy objectives indicators**
    - Indicators become useful tools for the identification of specific policy options and targets. For example, in the specific case of climate change adaptation, indicators for water intensity and their key drivers (e.g., per capita consumption) can be used to set a specific reduction target in water intensity (e.g., percent reduction of water intensity compared to 2010 level).
- **Intervention options and costs indicators**
    - Various intervention options are available to reach specific policy objectives and various indicators can be used to evaluate them.
- **Cost-benefit analysis indicators**
    - A cost-benefit analysis is necessary to evaluate the net investment required, by actor or economy-wide. This analysis would generally compare investment and avoided costs, or added benefits, depending on the issue to be solved.
- **Policy formulation indicators**
    - Once the investment required is estimated, policy options can be designed to allocate the amount across key economic actors. Options include capital investment, incentives and regulations. Indicators can be used to evaluate the best policy option (or mix of policies) that would not excessively impact on a single actor (e.g., households). For instance, regulations (e.g., mandates), in the absence of incentives, imply that the private sector would be required to place all the investment needed to comply with law (e.g., such as in the case of a mandate for the share of renewable energy in power generation, or the introduction of standards for fuel efficiency of vehicles). Indicators of household investment, as well as disposable income could be monitored to evaluate whether the new policy would require a considerable reallocation of resources (possibly reducing consumption and savings) that could

lead to negative economic impacts. In such case, incentives could be introduced, for which government accounts - especially indicators regarding the annual deficit and debt, should be monitored.

To conclude, the range of indicators to effectively support policy formulation is relatively broad and depends on the specific issue to be analysed. These indicators would normally be estimated using several methodologies across sectors, ranging from a detailed analysis of the present and future cost of technology to the macroeconomic balances provided by the System of National Accounts (SNA)[120].

6.3 Policy Monitoring and Evaluation indicators

Integrated policy evaluation refers to the effort of monitoring and determining how a policy has fared during implementation. It examines the means employed, the objectives served, and the effects caused in practice.

Macro-level indicators

To determine the actual effects of an implemented policy it is necessary to consider both the objectives established for that policy as well as its broader ESE impacts. In this respect, three main categories of indicators can support integrated policy evaluation:

- **Green investment, jobs, and sectors**
  - This group of indicators has an economic focus and captures indirect impacts of target policy intervention and investments aimed at solving specific (environmental) issues. These indicators aim at estimating the performance of economic sectors, including the investment leveraged and the employment generated.
- **Decoupling impacts and resource efficiency**
  - This group of indicators helps capturing driving forces and pressures, as well as monitoring the state of the environment and environmental impacts (agenda setting indicators). The inclusion of agenda setting indicators in this category makes visible the connection between the problem and the policy that has been implemented in order to solve it.
- **Indicators of progress and well-being**
  - This group refers to overall measures of economic progress and human well-being, including such dimensions as poverty alleviation, equity, social inclusiveness, overall well-being, capital resources and inclusive wealth. These indicators include a wide range of proposed indicators, mostly to complement GDP with social, environmental and more detailed economic criteria.

6.4 Sectoral indicators

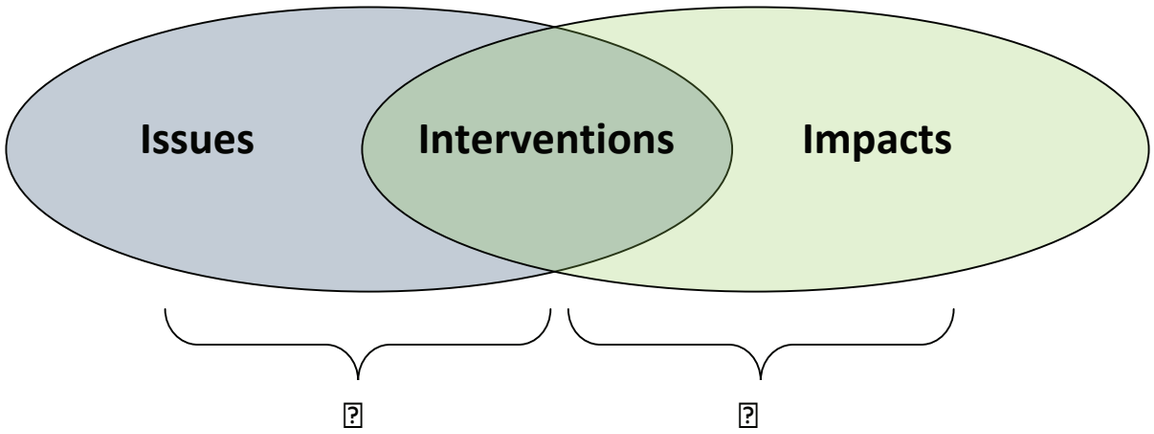
It is difficult to maintain the above indicator categories entirely separate. Policy formulation offers interventions on issues (from agenda setting), for which some impacts are expected (policy

[120] European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank (2009), System of National Accounts 2008.

evaluation). In turn, measuring impacts of the interventions is in many regards the same as measuring how the issues are resolved (or changed). Therefore, the following section provides sectoral indicators in two categories:

1. Issues and Interventions (agenda setting and policy formulation), thereafter called indicator subset 1.
2. Interventions and impacts (policy formulation and policy monitoring and evaluation), thereafter called indicator subset 2.

Figure 12: Indicator subsets



6.4.1 Water demand and supply [121]

Issues	Interventions	Indicator subset 1	Impacts	Indicator subset 2
Anticipated water scarcity	Expand water storage and conjunctive management of surface and groundwater resources (e.g., waste water recycling)	Renewable internal freshwater resources per capita (m3)	Increased capacity of storage system and increased buffer of resources	Importance of national expenditure for water supply and sanitation
		Annual freshwater withdrawals, total and by sector (% of internal resources)		Change in hydropower productivity
		Groundwater depletion		
Water use inefficiency	Aggressively increase water use efficiency	Water Footprint (FT) for domestic consumption, considering the regionally varying water stress by adequate contextualization	Reduced waste of water resources	Water productivity, total (constant 2000 US$ per m3 of total freshwater withdrawal)
			All of the above	Percentage of population using improved sanitation facilities
Water contamination, ecosystem degradation	Review of water management laws, regarding contaminants release in the environment	Organic water pollutant (BOD) emissions (kg per day)	Improved ecosystems health and productivity	Change in aquifers quality status (quality/salinity)
	Protection of wetlands	Inland and coastal wetland ecosystem condition	Improved aquifer quality, protection from storm damage	Value of land and infrastructure protected by wetlands

[121] More information on the above indicators is available at the World Development Indicators (World databank) of the World Bank, and UN-Water.

6.4.2 Agriculture and terrestrial ecosystem

Issues	Interventions	Indicator subset 1	Impacts	Indicator subset 2
Soil erosion and loss of arable land due to drought, floods, ecosystem degradation.	Preserve healthy natural environment, flood, landslide and coastline management plans (and avoid construction in disaster prone areas).	Fertilizer consumption (kilograms/hectare of arable land)	Improved soil quality, savings on fertilisers, reduced water pollution	Savings on fertilizer consumption (% of previous consumption)
		Forest area (% of total land area)		
		Arable land (hectares per person)		
		Extend of siltation and sediment transport in rivers (m3)		
Agricultural invaders, pests and diseases	IPM technologies, diagnosis service, information distribution	Pesticide consumption (kilograms/hectare of arable land)	Improved pest management, planter preparedness, ecosystem benefits	Savings on pesticide consumption (% of previous consumption), and residue level
	All of the above		Reduced freshwater contamination	Organic water pollutant (BOD) emissions (kg per day)
Anticipated water scarcity, effect of drought and floods on agriculture production	Water supply and conservation support.	Annual freshwater withdrawals, agriculture (% of total freshwater withdrawal)	Savings on water consumption, planter preparedness	Savings on water consumption (% of previous consumption)
	All of the above		Increased job creation	Job creation (jobs per year)
			Increased productivity	Productivity (tons per hectare)
			Increased production revenues	Production (value added per hectare)

6.4.3 Fisheries and marine ecosystem

Issues	Interventions	Indicator subset 1	Impacts	Indicator subset 2
Fish stock depletion, ecosystem degradation	Sustainable utilization of fisheries resources, protect critical habitat and plan for future hazards	Material Requirement for biotic resources (TMRbiotic), notably fish, for national production	Increased production	Fish production (ton per year)
		Fuel consumption for fishing activities (Toe per year)	Increased productivity	Fuel consumption per fish production (Toe per ton)
	Economic valuation of ecosystem services, reduction of water pollution, ecosystem protection	Coral cover and coral condition (live, bleached, broken, etc...)	Job creation, incentive for conservation, protection of coastal land and infrastructure	Job creation (jobs per year)
				Value of protected land and infrastructure
Lagoon and seawater contamination from contaminated streams and rivers	Reduced fertilizer and pesticide use through agriculture interventions	Nutrient Flows corresponding to pollution with nitrogen and phosphorus	Increased lagoon production	Lagoon fish production (ton per year)
	All of the above		Regeneration of fish stocks	Fish species, threatened

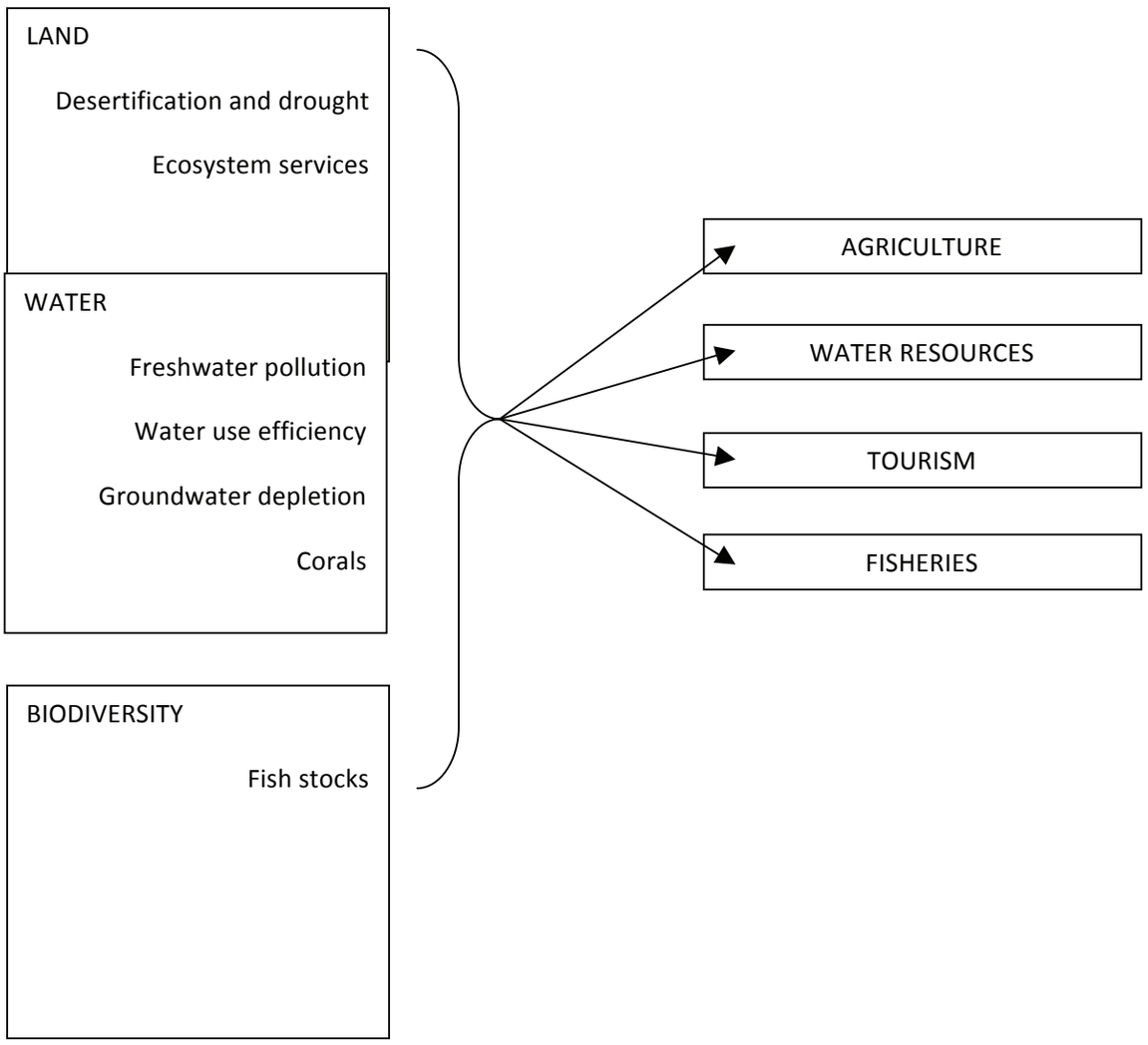
Note: as fish stocks replenish over long periods, the effects of interventions may be delayed. Care should be taken to consider measurements systemically, i.e. high aquaculture production should not be achieved at the expense of the surrounding ecosystems and hence the fishers depending on these ecosystems. Monitoring must be integrated to enable the prevention of such scenarios.

6.4.4 Tourism and coastal management

Issues	Interventions	Indicator subset 1	Impacts	Indicator subset 2
Water needs competing with needs of local communities	Water efficiency, rainwater harvesting, desalination	Number of desalination plants in operation in hotels	Increased water autonomy from hotels and increased water availability for local communities	Water availability in communities nearing hotels
		Number of rainwater harvesters in operation in hotels		
Coastal erosion affecting infrastructure, beaches and tourist attractions	Protection of critical ecosystems such as coral reefs and mangroves, economic valuation of ecosystem services	Beach erosion rate (meters per year)	Increased quality of tourist product and increased quantity of visitors	Proportion of "repeaters" (% of total visitors)
		Coral cover and coral condition (live, bleached, broken, etc.)		Tourism revenue
	Implement setbacks and protection measures	Infrastructure affected by sea-level rise	Existing and planned infrastructure protected or reviewed	Avoided losses in infrastructure
			All of the above	Job creation

A wide range of indicators is available from the Global Environment Outlook, which directly relate to the sustainability of key sectors under climate change scenarios, as presented below. By the systemic nature of the entity considered (the ROM facing climate change), sectoral indicators are also inherently cross sectoral.

Figure 13: Cross-sectoral indicators



7. Selected Project Prospects

7.1. Guidance for project selection

This section provides general guidance on project identification, analysis and prioritisation to enable the ROM to implement the most appropriate climate change adaptation projects from a cost-feasibility-effectiveness perspective. In terms of vulnerability reduction and increasing resilience to climate change, this should translate into a healthy mix of:

- low-hanging fruit projects,
- projects that represent a platform for further progress beyond their own scope, and
- programmes that offer good return on investment

As such, prioritisation is critical and should use sector-specific indicators (see section 6) in cost-benefit analyses, and also capitalise on co-benefits in different sectors. Actions taken should also be spread, depending on the specific needs, among the following categories:

- Human capacity building,
- Technical projects,
- Institutional capacity building,
- Research and Development,

The following example shows a selection of projects, taken form the sectoral reports and the TNA, which is more focused on low-cost, capacity building, and faster returns on investment in terms of vulnerability reduction and resilience to climate change. Note that, with an integrated approach, actual overall costs of implementations may be lower than the per-sector costs presented in the following tables.

A programmatic example for climate change adaptation.

Short term projects

Costal management plans for inundation		
CROSS-SECTORAL	3 YEARS	60,900,000
Climate change awareness		
TOURISM SECTOR	1 YEAR	1,722,600
AGRICULTURE SECTOR	1 YEAR	9,388,170
Hydrological models		
WATER SECTOR	TBC	574,200

Hotels, villages and agricultural activities are present in high-risk zones all around Mauritius Island.
Hydrological models provide a tool for planning and future development in the water and agricultural sectors.

√ Low hanging fruit	√ Technical projects
√ Platform	√ Human capacity building
√ ROI	√ Institutional capacity building

Medium term project: Preserve a healthy natural environment

CROSS-SECTORAL	3 YEARS	45,000,000
SOIL AND WATER CONSERVATION	1 YEAR	10,995,930
FOREST DEVELOPMENT PLAN	3 YEARS	27,700,300
TOTAL	3 YEARS	83,696,230

This project should contribute enhancing ecosystem services such as erosion control, water cycling, water purification and waste treatment, maintenance of soil quality, pest mitigation, pollination, climate regulation, maintenance of air quality, recreational and tourism, etc.

Focus should be placed on critical ecosystems which provide most services. Biomass should be used for building soil quality in agricultural activities, and mangroves should be promoted as fish nurseries in fish farming activities.

√ Low hanging fruit	√ Technical projects
√ Platform	√ Research and development
√ ROI	√ Institutional capacity building

Long term project: Capacity Building

TOURISM	3 YEARS	6,172,650
FISHERIES MANAGEMENT	2 YEARS	57,420,000
FISHERIES INSTITUTIONS STRENGTHENING	ONGOING	83,259,000
FISHERIES CONSERVATION	2 YEARS	114,840,000
AGRICULTURE	3 YEARS	49,094,100
TOTAL	ONGOING	310,785,750

Despite the above timeframes, capacity building should be ongoing and budgets secured adequately distributed across sectors. It is critical that cross-sectoral capacity building is also carried out to prevent operation in “silos” and promote a systemic approach. All stakeholders must be aware of their impacts, positive and negative, beyond their own sector. Reinforcement of capacities shall reduce vulnerability and increase production.

√ Low hanging fruit	√ Human capacity building
√ Platform	√ Institutional capacity building
√ ROI	√ Research and development

7.2. Project Sheets

The following are sample project sheets for each of the key sectors.

<table>
<tr><th colspan="2">WATER SAMPLE PROJECT SHEET: Rooftop rainwater harvesting</th></tr>
<tr><td colspan="2">Project description
The collection of rainwater by using rooftops as catchment areas can help reduce the use of treated water for secondary purposes, thus preserving water resources destined for primary purposes (e.g. drinking water).</td></tr>
<tr><td colspan="2">Logical Framework</td></tr>
<tr><td>Goals
i. Conservation of water resources
ii. Raising awareness of the need to conserve water</td><td>Objectives
i. At least 5 enterprises should be able to install rainwater harvesting systems in the first year of the project</td></tr>
<tr><td>Inputs
i. Source or offer rainwater collection systems suitable for residential, commercial and industrial buildings.
ii. Demonstrate the effectiveness of the system
iii. Promote the commercialisation of the technology</td><td>Outputs
i. Small scale enterprises should offer the systems and installation service
ii. Awareness of the national benefit is raised</td></tr>
<tr><td colspan="2">Estimated costs
MUR 2,000,000 – for installations only</td></tr>
<tr><td>Proposed timeframe
2 YEARS (primarily to stimulate market uptake)</td><td>Executive bodies
Ministry of Energy and Public Utilities</td></tr>
<tr><td>Cost-benefit analysis
Potential volume that can be collected = 62.5Mm^3 per year as compared with the total annual potable water harnessed for use which is 212 Mm^3 per year.</td><td>Risks
□ Reluctance to retrofitting existing water systems</td></tr>
<tr><td colspan="2">Experts required</td></tr>
<tr><td>Profile
Local expertise in water systems usage and dissemination.</td><td>Key tasks
□ Identify critical areas for, and facilitate participatory workshops
□ Identify adequate media to reach the different targeted groups</td></tr>
</table>

AGRICULTURE SAMPLE PROJECT SHEET: The Forest Development Plan (ref[108])

Project description

The project aims at the planting of 1 million trees in the next 30 years. This will be achieved by planting of trees by schools (students), women groups and youth groups, in addition to afforestation and reforestation by the authorities. Each school will be supplied with water tank, to support the establishment and management of tree nurseries and tree seedlings. In addition, large scale owners of land will be encouraged to construct dams for water harvesting and storage in order to support establishment of irrigated private forests.

Logical Framework

Goals:	**Objectives:**
i. To reduce net GHG emissions ii. To enhance carbon sequestration iii. To reduce climate change impacts iv. To prevent soil erosion v. To encourage tree planting in order to prevent soil erosion	i. At least 5% reduction in GHG emissions by the end of first year ii. Reduce climate change impacts iii. Reduce soil erosion by at least 10 % by end of first year of project initiation iv. Awareness on planting trees created on at least 10% of the targeted groups by end first year of project initiation.
Inputs	**Outputs**
i. Introduction of tree species with high carbon sequestration ability, estimated through research ii. On farm demonstrations of tree planting and management and demonstration in schools and colleges iii. Measuring of impacts of trees on climate change parameters and soil erosion by research staff iv. Production of newsletters, radio and TV programs on tree planting and management v. Introduction and purchase of tree seedlings	i. Awareness created on tree planting and management in schools, colleges and communities ii. Reduction of climate change impacts iii. Forest cover increased by 30% by 2030

Estimated costs:

USD 930,000 or MUR 27,700,3000

Proposed timeframe	**Executive bodies:**
Initial 3 YEAR phase	Ministry of Agro-Industry and Food Security and its parastatal bodies
Cost-benefit analysis Avoided future costs: - Infrastructure repair or re-building costs as a result of land-slide or erosion, - Loss of agricultural production	**Risks** - Slow tree growth - Setback of efforts by cyclones and bad weather

Experts required

Profile	**Key tasks**
Experience in ecosystems based climate change adaptation, experience in tropical and sub-tropical climates, demonstrable knowledge of design for water and nutrient cycling.	- Identify critical areas for erosion prevention, - Identify and offer options and techniques that support agro-forestry and agriculture, - Define an afforestation and reforestation plan.

FISHERIES SAMPLE PROJECT SHEET: Audit of coastal marine resources (ref [117])

Project description

Carry out an audit of fish resources, corals, sea weeds and mangroves ecosystems to ensure their preservation and conservation.

Logical Framework

Goals	**Objectives**
iii. To establish clear knowledge of the coastal marine resources iv. Long term conservation of the marine resources and ecosystem	ii. A comprehensive, seasonal resource map is available at the end of the first year iii. Exploitation quotas and guidelines are established and follow-up surveys ascertain safety factors in the second year
Inputs	**Outputs**
iv. Conduct assessment of cost and lagoons v. Gather local knowledge through surveys and workshops vi. Research on regeneration of local resources/ecosystems	iii. Sensitization programme for the general public iv. Publication of posters/guidelines/brochures, etc. v. Reports to the Ministry of Fisheries on state of lagoons and exploitation quotas

Estimated costs

MUR 4,500,000

Proposed timeframe	**Executive bodies**
2 YEARS	Ministry of Fisheries and affiliated bodies
Cost-benefit analysis	**Risks**
An inventory of the coastal marine resources will enable the establishment of exploitation quotas and guidelines, enforcement to prevent over-exploitation, retention and increase of profitability of the beneficiary sectors (fisheries, tourism) in a sustainable manner.	□ Capture of actual seasonal data may be difficult □ The data acquired may not be representative of the mean condition of resources

Experts required

Profile	**Key tasks**
Proven experience in tropical and subtropical marine resources assessments, capacity to use existing data and collect field data, demonstrable capacity to provide resource use guidance based on scientific knowledge of local species, ecosystems and marine natural processes.	□ Collate all available data from local and international institutions and identify data gaps for a comprehensive resource map □ Collect field data with the assistance of local institutions and complete resource map □ From exploitation records, resource map and resource regeneration research, establish exploitation quotas and guidelines □ Calculate safety factors through follow-up data collection and analysis

TOURISM SAMPLE PROJECT SHEET: Climate change awareness in the tourism sector (ref [118])

Project description

Creation of climate change awareness amongst local communities and the tourism industry. This should create a better understanding among stakeholders of each other's needs and contribution to climate change impacts and adaptation.

Logical Framework

Goals	**Objectives**
i. To disseminate climate change information through media ii. To create awareness of climate in the Tourism Sector iii. To use other methods such as administrators to create awareness in their meetings with communities iv. To develop short courses on climate change	i. At least 10% of the targeted groups are reached by each of TV, radio and print media respectively by the end of first year of project initiation. ii. At least 10% of the targeted groups made aware by the Government administrators about climate change adaptation by end of first year of project.
Inputs	**Outputs**
i. Publishing climate change information in newspapers, reports and newsletters ii. Convene seminars and participatory workshops for information dissemination and exchange of local knowledge	At least 3 magazines and newsletters produced on climate change adaptation by the end of first year of project initiation.

Estimated costs

USD 60,000 or MUR 1,722,600

Proposed timeframe	**Executive bodies**
1 YEAR	Ministry of Tourism and Leisure, Ministry of Environment & Sustainable development
Cost-benefit analysis	**Risks**
The main avoided future cost is the loss of ecosystem diversity and health which would incur: - Loss of tourism attractiveness, - Loss of biological resources (crops, fisheries) - Loss of water quality (erosion, pollutants)	- Willingness of targeted groups to be trained - Reach of media

Experts required

Profile	**Key tasks**
Proven experience in stakeholder engagement for sustainable development and climate change, experience with ecosystems impacts from the tourism industry, rural and urban communities	- Identify critical areas for, and facilitate participatory workshops - Identify adequate media to reach the different targeted groups

Annex A: Methodology - development of an Integrated CC Adaptation Policy

A1. Incorporating climate change adaptation in national development planning

Adaptation to climate change is a continuous process. It is not expected that adaptation can be dealt with at one time. It is far more likely that, being cross-sectoral by nature, it will require regular revisiting of development policies, plans and projects as climate and socio-economic conditions change. This section briefly describes a generic four-step approach that decision makers can take to address adaptation to climate change (OECD, 2009) [122].

Policy processes can vary, and these steps can be modified or adopted in a different order depending on circumstances. This four-step approach is similar to a climate risk management approach, as it starts with the consideration of both current and future vulnerabilities and climate risks.

Step 1: Identify current and future vulnerabilities and climate risks

When addressing adaptation to climate change, the first step is to identify the vulnerability of the system of interest and the climate risks to that system (Smith, 1996; Smith and Lenhart, 1996)[123] [124]. These assessments can either be done quantitatively or more qualitatively through expert judgement. A simple rule of thumb is that, if an area or system is affected by climate variability (extreme events, variability in precipitation, extended periods of warm temperatures), it is therefore sensitive to climate change.

In addition to assessing current vulnerability and climate risks, an assessment of future vulnerability and future climate risks needs to be carried out. In order to understand possible future vulnerability, a qualitative understanding of the drivers of vulnerability needs to be developed. This step should also allow an assessment of the opportunities that may arise from climate change and potential ways to take advantage of these. The available literature on climate change impacts may yield important insights into whether and how a system may be affected.

Step 2: Identify adaptation measures

This next step involves the identification of a list of adaptation measures to be considered. These adaptation measures may be justified by considering the risks of climate change, and even without considering these risks.

Measures can be designed to provide net benefits regardless of climate change (these are known as “no regrets” or “low regrets” measures) or can, on the other hand, depend on projections of changes in climate to justify their benefits (known as “climate justified” measures).

No regrets or low regrets adaptations are justified under current (or historical) climate and are even more justified when climate change is taken into account. No regrets adaptations include removing or limiting maladaptation (again, ensuring that climate change is taken into account). Investments in development, particularly those that enhance the capacity of a society to adapt to climate change, are no regrets

[122] OECD (2009). *Integrating Climate Change Adaptation into Development Co- operation.* Policy Guidance. OECD Publishing, 196p.

[123] Smith, J. B. (1996), “Development of Adaptation Measures for Water Resources”, *Water Resources Development* 12(2): 151-163.

[124] Smith, J. B. and S. S. Lenhart. (1996), “Climate Change Adaptation Policy Options”, *Climate Research,* Vol. 6, pp.193-201.

adaptations. The category also includes other measures, such as reduced pollution and destruction of natural habitats, water conservation and enhanced public health systems.

Climate justified adaptations consist of measures taken specifically to anticipate climate change. Often these are changes made to long-lived investments. For example, a sea wall being built or rehabilitated might be built somewhat higher to account for sea- level rise. Climate justified adaptations can be changes to infrastructure design, but can also include changing land use (such as limiting development in areas that would be vulnerable to climate change), enhancing emergency response procedures, enabling standards to be updated on the basis of changed conditions, and so on.

In addition, the timing of adaptation measures should be considered (reactive *vs. anticipatory* measures). Reactive adaptations are made in response to observed climate change. Anticipatory adaptations plan for future climate change.

Step 3: Evaluate and select adaptation options

Having identified adaptation options, the next step may be to evaluate and select some for implementation. The following is a list of criteria that could be used to evaluate adaptation policy options (OECD, 2009) [125].

- *Effectiveness:* This criterion addresses the extent to which the adaptation policy reduces vulnerability and provides other benefits. Essentially, it compares vulnerability without adaptation to vulnerability with adaptation. Ancillary or co-benefits should explicitly be considered if the adaptation option provides benefits to other sectors or for other policy objectives.
- *Cost:* This criterion concerns whether an adaptation is relatively expensive or inexpensive. Typically, it includes the initial costs of implementing an adaptation policy. However, costs over time, such as operation and maintenance, administration and staffing, expected frequency of reconstruction and so forth, should also be considered. Further, costs of inaction should be analysed, as well as externalities and cross-sectoral ancillary benefits.
- *Feasibility:* This criterion addresses whether the action can be implemented. Do the necessary legal, administrative, financial, technical, and other resources exist, and are they available for use on this policy option?

Step 4: Evaluate "success" of adaptation

The final step in the process is to monitor and evaluate the success of the adaptation strategy implemented. Evaluating the success of a set of adaptation interventions is not a straightforward task and may take a long time because the benefits of some adaptation measures may not be realised until the climate changes significantly. For adaptation measures that were designed to reduce vulnerability to infrequent extreme events, their evaluation can only be carried out if and after those extreme events occur. If such events do not occur, it may be difficult to evaluate the success of the adaptation strategy. In addition, some adaptations may be developed to respond to long-term risks from climate change, in which case it will be even more difficult to evaluate the success of the strategy. For adaptation measures that have benefits if climate does not change (i.e. no regrets measures), their evaluation is facilitated, as the benefits should be seen in the near term.

Concluding, Evaluating the success of an adaptation should be based on measuring the benefits against the policy objectives used in the effectiveness analysis. Quantitative measures of success should be used when available (Smith and Lenhart, 1996).[126]

[125] OECD (2009). *Integrating Climate Change Adaptation into Development Co- operation.* Policy Guidance. OECD Publishing, 196p.

[126] Smith, J. B. and S. S. Lenhart. (1996), "Climate Change Adaptation Policy Options", *Climate Research,* Vol. 6, pp.193-201.

A2. Integrated Policymaking for Climate Change Adaptation

The need for integration in the case of climate change adaptation stems from the segmented nature of current policy frameworks that address parts of the economic-social-environmental system considered (in this case, the ROM). Hence, this section first provides a systems perspective to integrated policymaking (2.2.1), introduces stakeholder processes for capturing necessary knowledge from within the system (2.2.2) and describes the IP policy cycle (2.2.3). The implementation of policies is favoured by conducive enabling frameworks. The final section (2.2.4) discusses the elements of enabling conditions for climate change adaptation.

A.2.1. The systems approach to Integrated Policymaking

In order to design and evaluate national development policies the structure of the system analysed (e.g. social, economic and environmental) should be properly understood. Economic volatility, as well as natural disasters and other unexpected events, can have a considerable impact on the effectiveness of policies over time. For these reasons scenarios have to be defined, to reduce the uncertainty coupled with the analysis carried out. Policies would then be evaluated based on the structure of the system analysed as well as on a variety of possible scenarios. Policies are "shocks" to the system, which in turn responds to these changes. Hence, the system itself should be analysed focusing on feedbacks and causal relations, with a specific interest on medium to longer-term impacts (which go beyond the implementation delays of policies -i.e. inertia of the system-).

The understanding of the functioning mechanism of the system allows for the identification of medium to longer-term sectoral and cross-sectoral implications of policy implementation. These impacts have to be analysed with the understanding that different sectors are influenced by different key causes defining the success (or failure) of policies. In other words, a policy can have very positive impacts for certain sectors and create issues for others. Furthermore, successful policies in the longer term may have negative short-term impact, for which mitigating actions may be designed and implemented.

Simulation models exist which aim at understanding what the main drivers for the behaviour of the system are. In the case of System Dynamics, this implies identifying properties of real systems, such as feedback loops, nonlinearity and delays, via the selection and representation of causal relations existing within the system analysed. This is advantageous for integrated policymaking because, while optimization models are prescriptive and econometric models are heavily relying on the history of the system analysed, simulation models are descriptive and focus on the identification of causal relations influencing the creation and evolution of the issues being investigated.

A.2.2. Multi-stakeholder processes for climate change governance

It is widely acknowledged now that the knowledge required to articulate what would constitute sustainable development in any given context (i.e. country or sub-regions therein) is often dispersed within the system boundary (i.e. country and its sub-regions), which is why a multi-stakeholder approach is necessary for successful outcomes. In other words, the complex system of socio-economic conditions existing within the natural ecosystems characterising any given territory can only be seen collectively for the adequate response to the increasing demands for policy-relevant interventions. Multi-Stakeholder Processes (MSP) can also help ensure better coordination between

programmes and projects which may be overlapping, on top of ensuring that knowledge is combined and properly utilized by sharing common mental models.

Climate change impacts, vulnerability, adaptive capacity, and barriers to adaptation are location-specific and will change over time, but the processes needed for adaptation that supports all affected parties are similar. Bottom-up as well as top-down processes are key for adaptation, from community-level adaptation design and implementation, to access to information across all levels, to the enabling national-level processes to finance, build capacity, and integrate. The MSP is an appropriate model to achieve this.

The five sequential steps of a generic MSP are illustrated in Figure A1.[127] Each step involves specific actions to ensure maximum ownership of the process by the beneficiary stakeholders and ensuring them that climate change related actions are discussed through dialogue and consequently integrated in the national and local agenda. Briefly, the steps of the MSP are defined in generic terms while noting that the central issues are related to climate change:

1. Context – Setting the context is probably the most critical step in the process, and the 'one-size-fits-all' cannot be applied. After the key stakeholders have been identified based on principles of inclusiveness, diversity and size, they should be involved in every aspect of the design process to generate legitimacy, credibility and trust. This does not mean that conflicts will not arise, but that any conflicts may be better dealt with later on. In designing the process, it should be made very clear how the output of the dialogues will permeate the policy decision-making process. Productive dialogue can only take place when all participants share a common understanding of the agenda of the MSP. This requires a clear definition of what issues the MSP will address. Successful MSPs require facilitation and organizational back up, also implying the need for adequate financial resources.
2. Framing – MSPs need precisely defined issues before them. The questions to be addressed and the goals of the process need to be very clear to all the participants and agreed by them. Possible changes over the course of an on-going process also need to be agreed by the group, allowing for consultations within constituencies if necessary.
3. Inputs – In order to facilitate dialogues, several inputs must be in place or be made available to participants. First, all participants must have equitable access to all information, and they should be given sufficient preparation time. The ground rules for the purpose of dialogue must be agreed within the group, while noting that no one has all the answers but that the output required will be the collective wisdom and knowledge of the participants. Fundamental differences exist between stakeholders in such things as knowledge and information, communication skills, size, nature and the amount of resources that define significant power gaps and unfair distribution of bargaining and negotiating power. Care must therefore be taken to identify and address power gaps, and this is also a reason why facilitation of dialogues is critical. Bilateral meetings can be used where necessary to prepare participants for plenary sessions.
4. Dialogue – MSPs are about creating a space where dialogue can take place. An atmosphere that cultivates equity, respect, dignity, humility and hope will create a space where people can

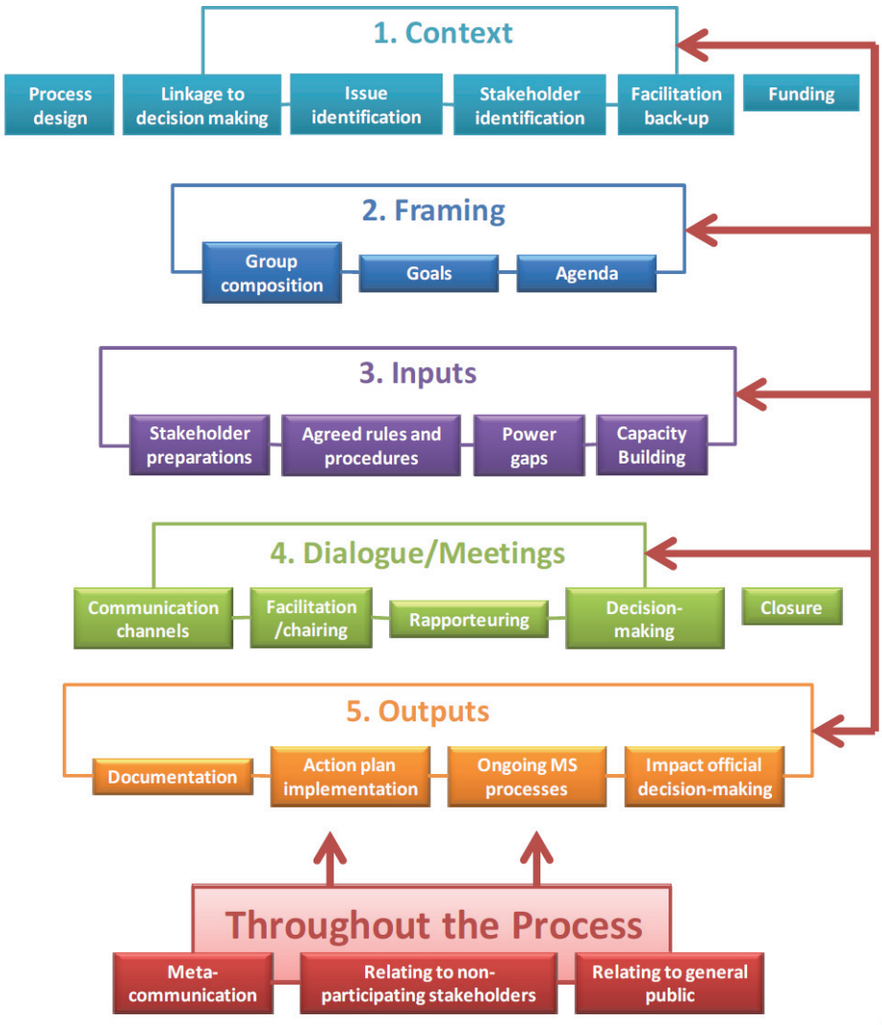
[127] M. Hemmati, Multi-Stakeholder Processes for Governance and Sustainability: Beyond Deadlock and Conflict (Earthscan, London, 2002).

interact in such a way that their differences and their commonalities become clear so that they can begin to explore possible ways forward.

5. Outputs – MSPs should be transparent all the way. So, they should not only publish and communicate their deliberations and outcomes but also keep record of their design. A critical aspect is to be able to demonstrate to stakeholders how the outcomes of their dialogues impacted policy decision-making.

MSP was adopted for the identification, prioritisation and barrier analysis of technological options, in the scope of the Mauritius Technology Needs Assessment (TNA – focused predominantly on adaptation to climate change).

Figure A1. The five sequential steps of a generic Multi-Stakeholder Process.

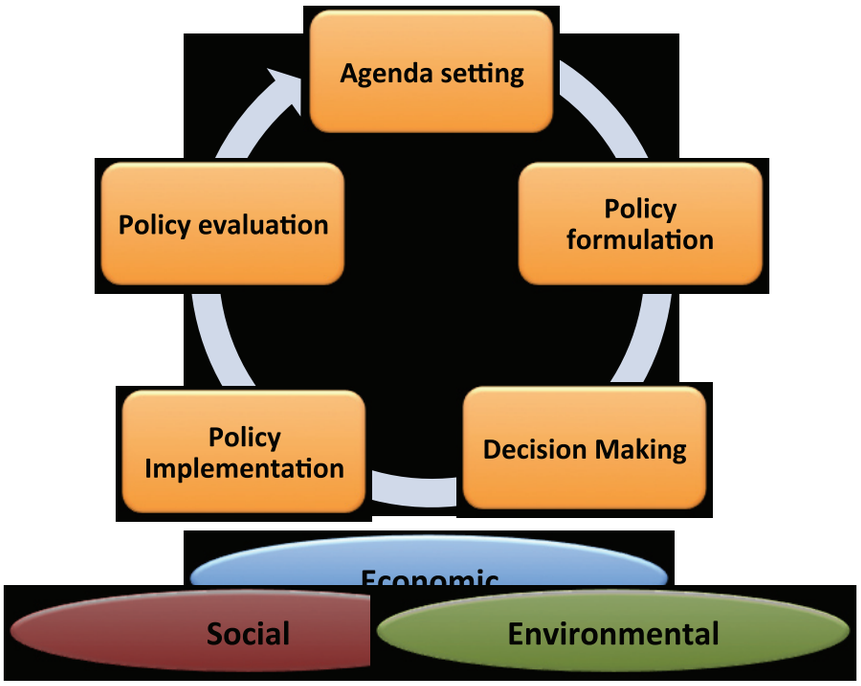


A.2.3. The Policy Cycle

With the systems approach and MSPs in mind, IP places possible solutions within a policy cycle that typically includes (1) the definition of issues (or agenda setting), (2) policy formulation, (3) decision-

making, (4) implementation, and (5) evaluation. This is done to ensure respectively that: (1) policy issues are appropriately defined, (2) potential solutions compared, (3) the solution that increases synergies and reduces trade-offs adopted, (4) and the adopted solution implemented, (5) monitored, and evaluated.

Figure A2. The main steps of the policy cycle, taking into account social, economic and environmental factors.



The present framework makes use of IP steps (1), (2) and (5):

- In the context of public policy, an agenda is a list of issues or problems (including potential opportunities, which may be missed without policy interventions) to which government officials, and people outside of the government closely associated with those officials, are paying some serious attention at any given time.
- Policy formulation is a process of generating policy options in response to a problem established on the agenda. This stage does not always follow suit the agenda setting phase. Nor is this stage the same as the decision-making stage, where a course of action is to be chosen from the available option.
- Integrated policy evaluation refers to the effort of monitoring and determining how a policy has fared during implementation. In the case of this document where policy options are proposed, it is important to provide appropriate indicators for the monitoring and evaluation of these policy options.

Decision Making and Policy Implementation – IP steps (3) and (4) pertain to the Strategy and Action Plan sections of this document (sections 4 and 5).

A.2.4 The Enabling Framework

Policies, strategies and action plans require the presence of factors conducive for their implementation. The enabling framework (also 'enabling environment') captures the country-specific circumstances including the entire range of institutional, regulatory, political, technological and socio-cultural conditions necessary to facilitate implementation of policies. Typically, lack of the enabling framework gives rise to barriers to policy and strategy implementation. The elements of the enabling framework are listed below, and the categorisation is related to the ability of government to either directly or indirectly configure the framework conditions to promote the implementation of climate adaptation policies.[128]

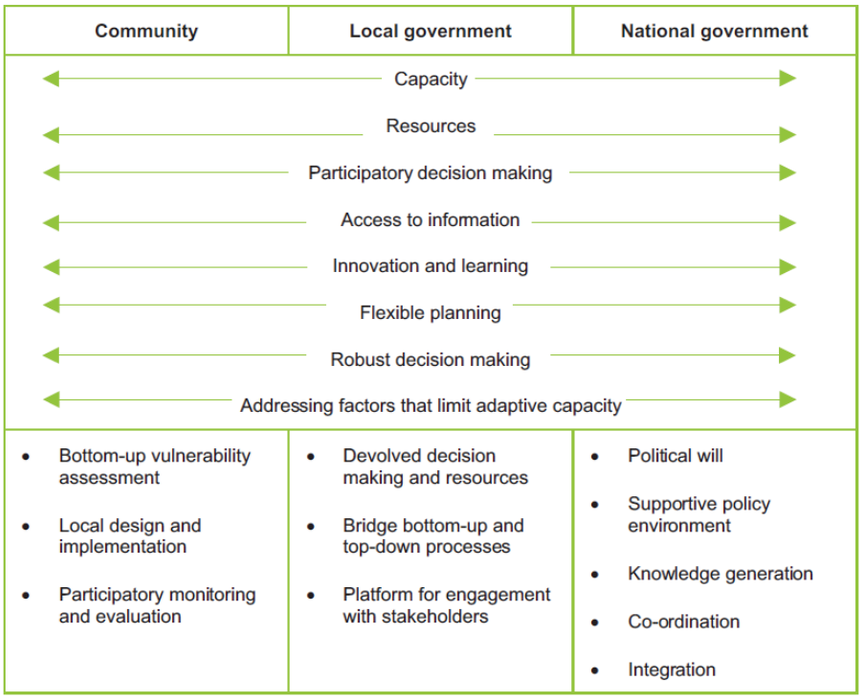
Table A1. Elements of enabling framework and barriers that they address.

Elements of enabling framework	Examples of areas of government's influence	Examples of barriers addressed
National macroeconomic conditions	□ Trade policies and laws □ Tax, subsidies, and tariff regime policies □ Regulation of financial sector institutions □ Public investment policies □ Commercial law and practices □ Monetary policy	□ Lack of adequate financing options e.g., high cost of capital and interest rates □ High inflation rate and high price fluctuations □ Balance of payment problems □ High import duties □ Unstable currency and uncertain exchange rates □ Low foreign direct investments □ Low level of adaptation technology transfer
Human, organisational, and institutional capacity	□ Capability building programmes of governmental agencies and institutions □ Initiatives to efficiency in government procedures and processes □ Promotion associations, networks, organisations and alliances	□ Lack of functioning legal institutions □ Lack of coordination between governmental agencies (national and sub-national) and between state and non-state actors □ Lack of stakeholder/community participation in adaptation □ Lack of specialised governmental climate change agencies
Research and technological capacity	□ Technical standards, certification, and codes □ Publicly funded research and development and training programmes on CC □ Support for testing and demonstration facilities (including training programs) □ Monitoring capacity enhancement programmes □ Property rights regimes policies	□ Lack of technology nurturing sites □ Limited capacity to install, implement, operate and maintain technology □ Insufficient specialised expertise in technology, practice, or organisational system □ Lack of institutions or initiatives to set standards or to benchmark best practices
Socio-cultural	□ Information dissemination, outreach and awareness-raising campaigns □ Targeted assistance to promote early adopters and technology front runners □ Promotion of public–private-partnerships □ Education policies	□ Limited awareness, trust, or acceptance in the suitability/reliability of adaptation policy, strategy, action, technology □ Community resistance to new practices □ Tradition, social esteem, pride, laziness and religious belief discouraging adoption of adaptation

[128] Adapted from Boldt, J., I. Nygaard, U. E. Hansen, S. Trærup (2012). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies. UNEP Risø Centre, Roskilde, Denmark, 2012

While the above table summarizes the broad enabling framework, it is also important to delineate the enabling conditions at the multiple levels at which decisions and planned adaptation actions are taken. Figure A3 shows the enabling elements at the national and local government levels, as well as the level of the community.[129] This framework is exemplified by the fact that it is ultimately communities that bear the impacts of climate change and climate vulnerability. Sub-national levels of government are vital for adaptation, given that it is the level of government closest to the communities vulnerable to the impacts of climate change.

Figure A3. Enabling elements for multi-scale interactions for successful adaptation.



A3. Tools for Climate Change Integrated Policymaking

A.3.1. Development Planning: three layers for sustainable development

In order to curb existing trends and progress towards a more climate resilient economy, an integrated approach that incorporates environmental, social and economic (ESE) implications of policy implementation is needed. Underlying this approach is the recognition that the algebra among the social, economic and environmental pillars of sustainable development (how the variables relate and affect one another in context; how they combine towards the equation of sustainable development) is more important than the arithmetic among them (added or subtracted as convenient) (EMG, 2011)[130].

[129] Catherine Pettengell (2010) Climate Change Adaptation – Enabling people living in poverty to adapt, Oxfam International, Great Britain, April 2010, p.24.

[130] United Nations Environment Management Group (EMG), *Working Towards a Balanced and Inclusive Green Economy, A United Nations System-wide Perspective* (2011).

Figure A4 indicates that policy formulation and evaluation need to be carried out in the context of scenarios (e.g. technological development, natural disasters), and policies (e.g. subsidies, incentives and/or mandates) have to be evaluated across a variety of indicators (social, economic and environmental) simultaneously. How these three levels are supported with solid and coherent information, and interact with each other, will greatly determine the success of any national development plan over the medium to longer term. This information is also crucial to truly understand the drivers of change and design policies that have the desired impacts, effectively.

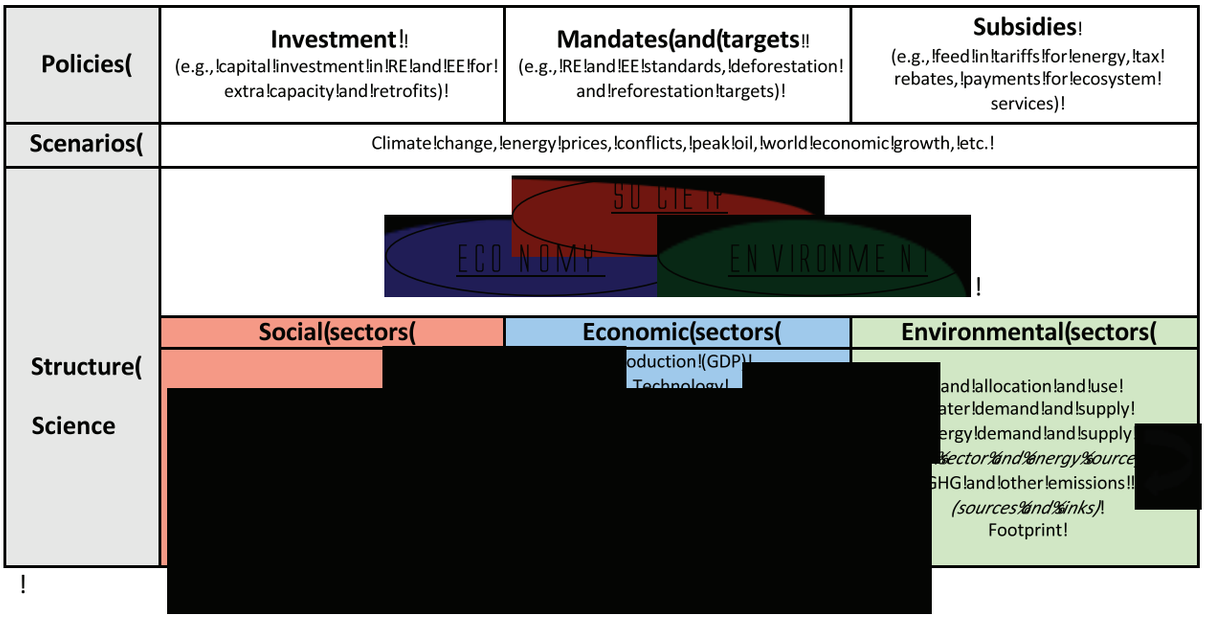
More specifically, firstly, in order to design and evaluate national development policies the structure of the system analysed (e.g. social, economic and environmental) should be properly analysed and understood. Using the example of the energy sector, this includes the investigation of the main drivers of demand, and how supply can respond to its needs; in the case of poverty reduction, this implies understanding what are the key factors influencing poverty and what are the main drivers for their behaviour. This is a broad investigation heavily relying on soft and hard data analysis, as we are in rapidly changing times and various cross-sectoral interdependencies are emerging.

Secondly, economic volatility, as well as climate impacts, natural disasters and other unexpected events, can have a considerable impact on the effectiveness of energy and environmental policies over time. For these reasons scenarios have to be defined, to reduce the uncertainty coupled with the analysis carried out. Policies would then be evaluated based on the structure of the system analysed as well on a variety of possible scenarios.

Thirdly, the implementation of policies for climate change adaptation, in the context of longer-term national development, should be tested. In order to do so effectively -and evaluate whether they create synergies, bottlenecks or side effects across sectors-, the impact of policies has to be evaluated for a variety of social, economic and environmental indicators. Policies are “shocks” to the system, which in turn responds to these changes. For this reason, the system itself should be analysed focusing on feedbacks and causal relations, with a specific interest on medium to longer-term impacts (which go beyond the implementation delays of policies -i.e. inertia of the system-).

To conclude, the understanding of the functioning mechanism of the system allows for the identification of medium to longer-term sectoral and cross-sectoral implications of policy implementation. These impacts have to be analysed with the understanding that different sectors are influenced by different key causes defining the success (or failure) of policies. In other words, a policy can have very positive impacts for certain sectors and create issues for others. Furthermore, successful policies in the longer term may have negative short-term impact, for which mitigating actions may be designed and implemented.

Figure A4. The three main layers for carrying out integrated policy formulation and evaluation: structure, scenarios and policies.



A.3.2. Policy Development: indicators for policy formulation and evaluation

From a policymaking perspective, selecting the correct set of indicators is particularly relevant for climate adaptation and sustainable development, being the former a vehicle for the latter, for at least four reasons (UNEP, 2009)[131]:

- Agenda Setting: An issue, becoming visible through an event and driven by potentially known trends, could be affected by several simultaneous and cross-sectoral systemic failures, all of which need to be identified. For example, climate change is driven by the carbon concentration in the atmosphere, simultaneously influenced by sources (e.g., burning of fossil fuels, energy consumption) and sinks of emissions (e.g., forests, or biomass more in general, and soils).

- Policy Formulation: Synergies among different issues exist and a policy intervention can be designed to achieve multiple benefits. For example, investing in ecological agriculture practices can increase agricultural yields, improving nutrition and reducing pressure on deforestation.

- Policy Evaluation: A policy that addresses one issue can lead to other issues, which may not be less important -also considering that stakeholders may have diverse values and interests that need to be harmonized. For example, fossil fuel subsidies to stimulate economic growth can contribute to the increase in energy consumption as well as emissions, and reduce the drive for innovation and energy efficiency.

To simplify the complexity of real world decision making while still providing a useful framework for analysis and eventually action, we consider a simplified model for IP to highlight the contribution that climate change adaptation and sustainable development indicators can provide throughout the

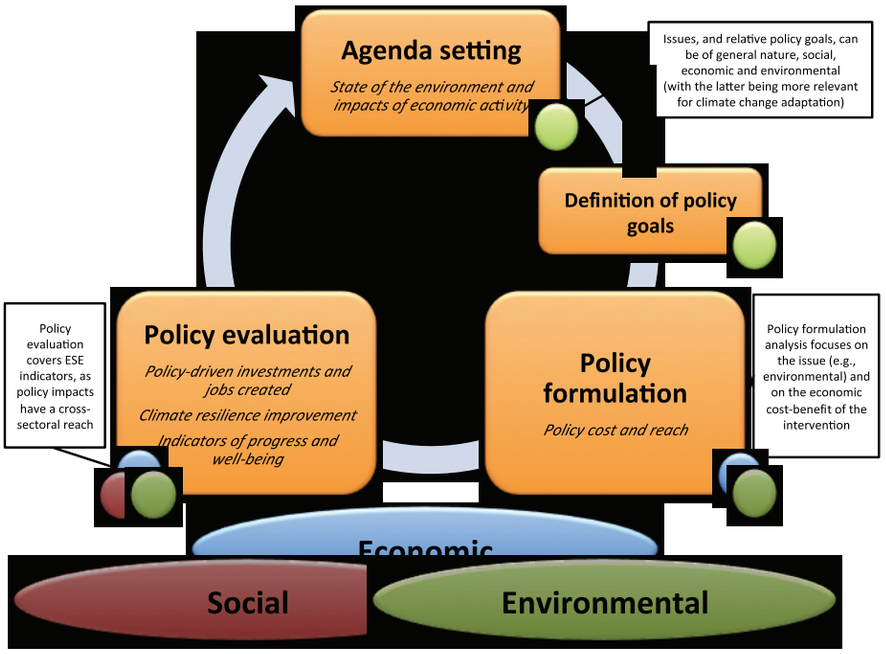
[131] United Nations Environment Programme (UNEP), *Integrated Policymaking for Sustainable Development, A Reference Manual* (2009).

process of IP. This framework focuses specifically on three key phases of IP as identified above: agenda setting (issue identification), policy formulation and policy evaluation.

Agenda setting	*Indicators contributing to a better identification of potentially harmful trends, existing or in the process of formation, created by policies that prioritize short-term gains vs. medium and longer-term resilience, within and across sectors. Indicators are selected and utilized to clearly detect the strength of various potential drivers of any specific issue, to better support the policy formulation phase.*
Policy formulation	*Indicators informing decision makers on the required effort needed to achieve stated goals and the adequacy of different intervention options. Of fundamental importance are indicators that measure the level of effort in implementing a climate change adaptation strategy.*
Policy evaluation	*Indicators allowing for a consistent and cross-sectoral monitoring and evaluation of the performance of the policies implemented to stimulate the green economy. This framework of indicators is broader in scope than the two categories above, being cross-sectoral and touching upon all ESE consequences of policy implementation. These indicators include information on the state of the environment, directly related to the issue and the intervention implemented, as well as indicators of socio-economic progress, such as employment and well-being, sectoral production and resource efficiency.*

While the conceptual framework of indicators proposed in this study (see Figure A5) could be generally applied to a variety of countries at different stage of development, the list of indicators utilized throughout the IP process presented here is customized to the local context of ROM. As different countries face various unique issues that are heavily influenced by their local context (agenda setting phase), the elaboration of how investments are to be undertaken or stimulated needs to be customized, depending on their political, economic and institutional circumstances (policy formulation phase). Similarly, impacts need to be defined and measured according to the local socio-economic and environmental context (policy evaluation phase).

Figure A5. Key indicators to support Integrated Policymaking in the context of climate change adaptation.

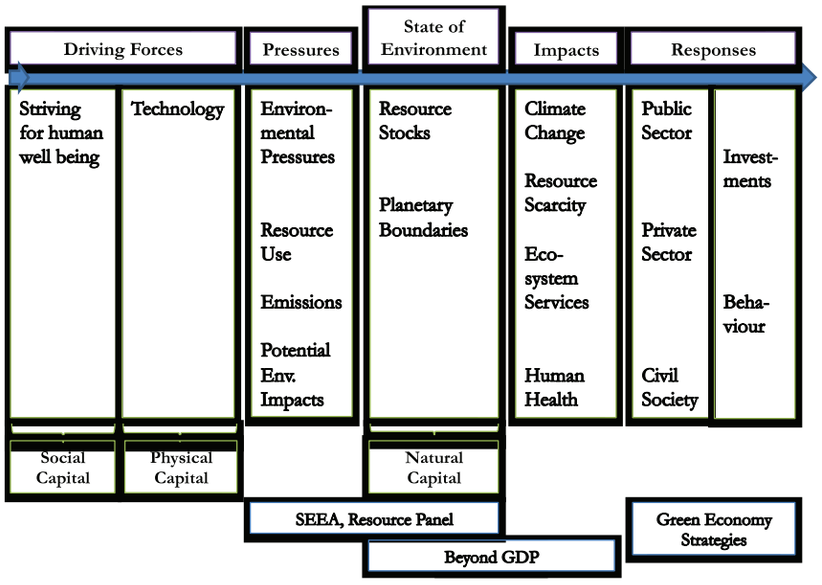


A.3.3. Strategy and Action Plan: DPSIR framework

The DPSIR framework is used to mainstream the environment, identifying key drivers (often social, also driving the economy), and impacts on the state of nature, finally supporting the identification of intervention options. The DPSIR framework is a rigorous approach being implemented at the international level to analyse environmental pressures, and, when coupled with IP and the use of cross sectoral indicators, becomes a very important tool for environmental (as well as climate change) mainstreaming. The DPSIR framework is presented in Figure A6.

For environmental assessments, the ***Drivers (D)*** in DPSIR describe the social, demographic and economic developments of societies that exert pressures on the environment. The primary driving forces are population growth and developments in the needs and activities of individuals, which result in changing levels of production and consumption. ***Pressures (P)*** are emissions of substances, release of physical and biological agents, (e.g. rate of CO_2 emissions) and the use of land and resources by humans. Pressures on the environment cause the ***State (S)*** of the environment to alter. State indicators describe the quantity and quality of physical phenomena (e.g. temperature), chemical phenomena (e.g. CO_2 levels in the atmosphere) or biological (e.g. community structure). Alteration of the environment ***Impacts (I)*** the functions of the environment. Impacts are changes in the environmental use functions (e.g. biodiversity loss, health impacts). ***Responses (R)*** are the policy, societal and technological responses by governments, groups and individuals to prevent, compensate, ameliorate or adapt to changes.

Figure A6. The DPSIR framework, as elaborated by UNEP in the context of the green economy.



The DPSIR distinguishes causal chains among driving forces, pressures, states, impacts and responses but the interactions may be non-linear both among elements in the DPSIR framework and within elements e.g. there may be several pressures driving a change in the state of the environment while reductions in pressures and drivers may occur from a mix of policy responses.[132]

[132] http://www.nccarf.edu.au/sites/default/files/attached_files_publications/iClimate_Report_April_2012.pdf

Annex B: Methodology – Water sector

This section outlines the methodology used in estimating future water availability factors: water demand, climate change, and climate variability, under two water utilisation scenarios:

A. Business As Usual (BAU), where current policies continue to apply in the water sector[133]. This is also considered a worst case scenario, as Mauritius is already a water-scarce country.

B. "No-regret" scenario where measures to reduce unaccounted-for water are fully implemented as per the ambition of the CWA to reduce unaccounted-for water by 25%. For the sake of this analysis, implementation is assumed to be achieved by 20% every 5 years from 2010 to 2035 (100% complete in 2035).

Water demand:

Analysis carried out in the Mauritius Environment Outlook (MEO, 2010) indicates that total water demand is projected at 1,200 Mm^3 per year by 2040 based solely on changes in population dynamics[134]. It is to be noted however, that the population and water demand, as shown in Figure B1 below, show a slower increase which appears to lead to lower demand than the above projection.

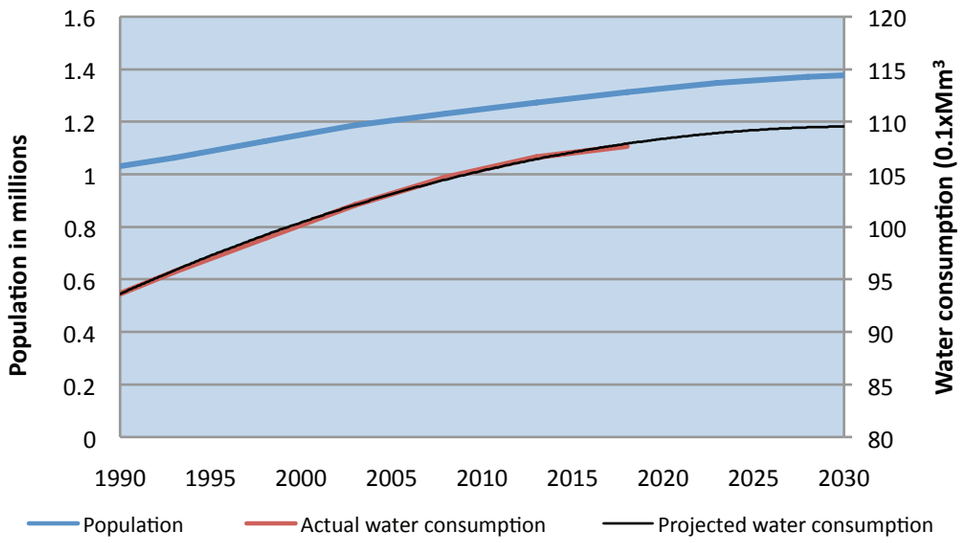


Figure B1 – Population and water use projections (Source – MEO, 2010)

Additionally, projections point to peaking population of 1.371 million in 2030, then declining to 1.306 million in 2050 (the Digest of Demographic Statistics, 2010, provides only the medium variant, which is considered most likely)[135]. Projecting a water demand stabilisation at 1,120Mm^3 as per Figure B1 is a reasonable assumption, as it assumes increased water use due to increased access, while improvements in water use efficiency can be expected to dampen this increase.

[133] An underlying assumption of this scenario is that the water system doesn't further depreciate, which would result in further losses.
[134] Mauritius Environment Outlook 2010, pg. 46.
[135] Central Statistics Office – Digest of Demographic Statistics, 2010, p185-186, reviewed at http://www.gov.mu/portal/goc/cso/report/natacc/demo10/demo10.pdf

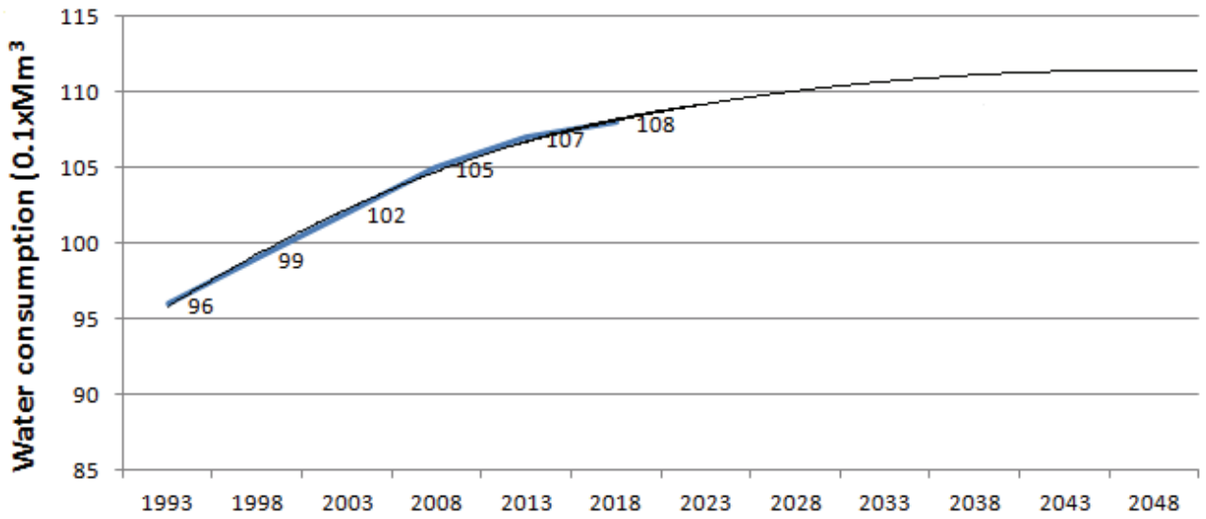


Figure B2 – Water demand projection to 2050

Scenario A: BAU - water availability under climate change and climate variability

Climate Change

In addition to water demand, projected changes in rainfall must be taken into account. These are presented in two variants in table B1, and are assumed to alter the utilisable renewable water potential in the same proportion.

Table B1: Projected Changes in utilisable renewable potential[136]

	2020	2030	2050
Low reduction variant	-5.41%	-6.9%	-9.19%
High reduction variant	-6.02%	-8.2%	-13.96%

Assuming that rainfall starts to decline from 2010, reduction in 2010 equals zero, and linear extrapolation is made to obtain the projected changes at intervals of 5 years: 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050. Change in rainfall is calculated from long-term mean values of rainfall, so as to avoid a baseline which is above or below the mean (for example, the 2010 rainfall represented 87% of the long term mean). Hence, the long term mean is taken as baseline (approx 3.87 billion m^3).

From here the percentages shown in Table B1 are subtracted from the total rainfall (long term mean) for the consecutive 5 year periods (the new value obtained is called W1 for future reference). It is known that 30% of rainwater is lost as evapotranspiration[137], hence 30% of W1 is subracted from W1, giving W2. Assuming that all remaining water is taken into the water system, it is known that

[136] Government of Mauritius (2010) Second National Communication under UNFCCC (Mauritius Meteorological Services, Vacoas, 2010)

[137] This percentage is assumed as constant as per the statistics provided by the Central Statistics office, however it must be noted that evapotranspiration increases with temperature.

47% of this water is lost, thus, 47% of W2 is subracted from W2, giving W3: the renewable water supply. This potential is however extremely hard to be totally exploited.

Due to high variability of supply, and because depletion of the renewable water potential is to be avoided, the assumption is made that a "safety margin" of 5% of annual rainfall can/should not be used (to provide a reference value, during the 2008 to 2010 period, on average 88% of total rainfall was utilised, leaving only 12% unutilized). Thus, 5% of W1 is subtracted from W3, giving W4, the usable water supply.

Following this methodology, calculations permitted to obtain *Figure 8: Demand and effect of mean climate change conditions on water availability*.

Climate variability

Year on year variations in precipitation must be taken into account in order to get a more realistic estimate of the potential economic impacts of climate variability in the water sector. In the past two decades, yearly variability in rainfall compared to the long-term mean has ranged between -45% (1999) and 22% (1995). For future variations, it is assumed that variability remains within the historical range observed since 1993. Here, year on year precipitation fluctuations have been randomly chosen to mimic changes within these historical limits, while following the overall projected rainfall change mean (climate change).

From this more fluctuating trend, the process of subtracting losses and "safety margin" is again applied and the trend is shown in *Figure 9: Example of climate variability effect, 2015 – 2050*.

Scenario B: No Regret - water availability under climate change and climate variability

Climate Change

As per the scenario description, implementation of measures to reduce unaccounted-for water (to 25%) is assumed to be achieved by 20% every 5 years from 2010 to 2035 (100% complete in 2035). Table B2 shows this reduction in losses over the 2010 – 2035 period. In this scenario, losses are expected not to increase after 2035.

Table B2: reduction of unaccounted-for water

2010	2015	2020	2025	2030	2035
47%	42.6%	38.2%	33.8%	29.4%	25%

Calculations are then performed as for scenario A, however the above percentages for W2 are subtracted from W2. New renewable water supply and usable water supply are therefore determined, from which *Figure 10: Water availability with losses reduction under mean climate change conditions* - is plotted.

Climate variability

As for scenario A, the same year on year precipitation changes are applied, and the new losses are subtracted, as well as evapotranspiration losses and "safety margin".

Annex C: Methodology – Agriculture sector

In section 4.1.2, the value added of food-crops and production costs are estimated for the 2015-2050 period, in two scenarios:

I. Business as Usual (BAU): Land is degraded by droughts and floods, and rehabilitated in a reactive manner in an effort to increase production after these climatic events.
II. No Regret: as sugar cane cultivation is decreasing under the MAAS[138], this scenario assumes that 5,000 Ha can be added to food-crop cultivation between 2015 and 2050[139].

Food-crops production

Production equals harvested area multiplied by yield. These two parameters are dependent on rainfall, temperature, the presence of pests and other factors. In the scope of this analysis, it is not possible to estimate future climate variability and the complex interaction of the aforementioned factors with food-crop productivity.

It is however possible to plot hypothetical harvested area and yield trends for the 2015-2050 period which are within historical range, and from these trends value added from food-crops and production costs can be calculated.

Value added

The baseline figure for food-crops value added was taken as the 2010 figure, a total of 2,193.4 million rupees. With production amounting to 114,844 tons that year, value added per ton is calculated at Rs 19,099[140].

Based on the harvested area and yield trends for 2015-2050 for both scenarios, annual value added is calculated as shown by Figure 11 and Table 10.

Cost of production

In this methodology, costs of production per hectare were assumed to be the same in both scenarios, and depend on harvested area only. The 2005 Agriculture Cost of Production Survey[141] provides cost of production per hectare for 11 food-crops[142], and is composed of *Intermediate consumption + Land preparation + Imputed cost of seeds/seedlings + Paid labour + Rent on land (Rent paid on leased land or rental value of owned land) + Interest on working capital + Depreciation of machinery and equipment + Imputed family labour*.

[138] Agreco Consortium, 2007, Implementation of the Multi-annual Adaptation Strategy for the Mauritian Sugarcane cluster (2006-2015), Strategic Environmental Assessment, pg. 43, 44.
[139] The land under sugar cane is to go down from 70 550 ha in 2005 to some 63 000 hectares by 2015. In 2005-2006 MSIRI identified 12,341 Ha of difficult lands where the abandonment of sugar cane will give rise to environmental, economic and social problems. Of this area 5000Ha would be converted to over uses specifically under the MAAS.
[140] Calculated from *Digest of agricultural statistics 2010*, Central Statistics Office.
[141] Calculated as average of production costs per hectare for selected food-crops, Central Statistics Office 2005, Agricultural Cost of Production Survey.
[142] Beans, brinjal, cabbage, carrot, cauliflower, chillies-long, cucumber, onion, potato, pumpkin and tomato.

The calculated average cost of production per hectare is Rs. 108, 889, and median cost Rs. 104,650. As the difference between these values is approximately 4%, the average value of cost per hectare is used to calculate total production costs for both scenarios.

Annex D: Indicators from the Climate Vulnerability Monitor

For the detailed references corresponding to the in-text references below, see the Climate Vulnerability Monitor, Second Edition (DARA and the Climate Vulnerable Forum 2012, Climate Vulnerability Monitor 2nd Edition – *A Guide to the Cold Calculus of a Hot Planet)*.

Environmental disasters

Drought:
The indicator measures the impact of climate change on drought, defined as a consecutive sequence of months with "anomalously low soil moisture". It measures the change in both disaster damages and depreciation of property due to soil subsidence damages. The change in the number of droughts expected to occur is estimated using an ensemble of eight climate models (Sheffield and Wood, 2008). Baseline data for disaster damages is derived from the main international disaster database, but is known to be incomplete (CRED/EM-DAT, 2012). Accelerated depreciation of infrastructure due to soil subsidence uses a model based on France and extrapolated based on GDP per capita and population density, but excluding arid countries where the effect is considered less relevant (Corti et al., 2009; Hoekstra et al., 2010). Limitations and uncertainties relate to difficulties in estimating rainfall change for certain regions, the simplistic 1:1 damage assumption implied and to the extrapolation used for the soil subsidence indicator.

Floods and landslides:
The indicator combines exposure to floods and landslides with modelled mortality risk for estimations of deaths with socio-economic adjustments. For economic losses, a combination of 20 years of disaster data from different sources is relied upon as a baseline. The indicator then estimates how the change in, or increases in the occurrence of, heavy precipitation events would alter the current picture of flood and landslide risk. Uncertainty regarding precipitation change in some areas is an impediment to reliable national-level estimates of these changes. Likewise, country-specific variation in the effects of increased heavy rainfall is not accounted for, except through the worsening of the pre-existing topography of risk, as reflected in historic and modeled disaster data. Although records of floods are unreliable, models of the effects of climate change on heavyprecipitation and observed rainfall changes do reveal the increasing trend (IPCC, 2007, IPCC, 2012a; Kharin et al.).

Storms:
Although the increasing severity of weather including tropical and extra-tropical cyclones is well established, the indicator is considered speculative because there is considerable disagreement among the models predicting change in cyclone intensity for different regions of the world. With the exception of the North Atlantic, where evidence of an increase in extreme weather is strongest, predictions of changes in cyclone activity in the Indian and Pacific oceans differ widely (Mendelsohn et al., 2011; IPCC, 2012a).

Habitat change

Biodiversity:
The indicator measures the proportion of species doomed to future extinction in different biomes around the world on account of the contraction of geographical climate-determined range size and future biome distribution due to climate change (Thomas et al., 2004). The exact time lag between threatened extinctions and their full realization varies and is not fully understood, although estimates exist (Brooks et al., 1999). Since the process of biodiversity loss due to climate change is continuous, in reality only a proportion of the estimated losses would be incurred at a date later than indicated. The indicator pairs biodiversity loss information and vegetation change with estimations of the lost economic value to determine a scale of economic losses in affected economies and the world (Mace et al. in Hassan et al. (eds.), 2005; US Forest Service, 2010; Costanza et al., 1997).

Desertification:
The indicator measures the value loss (or gain) in rapidly degraded (or improving) dryland agricultural zones resulting from an increase (or decrease) in aridity, due to temperature and rainfall changes brought about through global warming (Hansen et al., 2007). It is broadly indicative of how desertification is likely to unfold as a result of climate change. The amount of new agricultural lands accruing from deforestation is also accounted for. While projections of the key variable of rainfall

are uncertain, there scientists are virtually unanimous about the direction of change (wet or dry) for a number of the world's key dryland regions, such as the Mediterranean basin.

Heating and cooling:
The indicator maps residential/ non-residential heating demand changes. It is considered robust, given the certainty of the climate science community and model convergence on the main parameter of increasing heat, although humidity levels are also important (Wang et al., 2010). High quality energy consumption data gives a reasonable indication of the phenomenon's scale, but relies on the concept of heating and cooling degree-days, which are not fully accurate in terms of all demands, since wind, cloud cover, and humidity strongly influence heating and cooling behaviour (Baumert and Selman, 2003). While the same optimal temperature is assumed for different countries, it is argued that the optimal temperature varies by region, climate, and other conditions (Dear and Brager, 1998). Though the Indicator considers several dynamic variables, floor space size changes over time are not, though are understood to have a significant impact on future energy requirement estimates (Isaac et al., 2008; Clune et al., 2012).

Labour productivity:
Certainty about increasing temperature, the main climate variable at play, contributes to the robustness of the indicator, although humidity levels are another important determiner of thermal stress and are less certain (Wang et al., 2010).
The indicator relies on a lobal/ subregional scale model for estimating the loss of labour productivity, based on international labour standards and estimates of wet bulb globe temperature (WBGT) change for populations assumed to be acclimatized (Kjellstrom et al., 2009a). It takes into account both the productivity of outdoor and indoor workers, although the heaviest forms of labour are not considered. The changing structure of the workforce over time, in particular, the industrial shift of developing countries away from outdoor agriculture is also factored in. Productivity gains to countries in high latitudes that will experience a reduction in extreme cold were also accounted for, over and above the base model (Euskirchen et al., 2006).

Sea-level rise:
The indictor is deemed robust for several reasons: first, the science is firm on the increase in sea levels over time around the world, as recognized by the IPCC (IPCC, 2007). Second, there is relatively low uncertainty compared to other areas of climate change regarding the scale and rates of change between different models in the near term (Rahmstorf, 2009). Third, the indicator is built on a high-resolution global model (DIVA, 2003). Improvements in the estimation of the complex set of costs involved across countries and in the actual model resolution, now 75km segments, could nevertheless further improve the analysis going forward.

Water:
The indicator measures costs of changes in the re-supply of water resources due to temperature and precipitation changes caused by climate change (Nohara et al., 2006). It considers agricultural, domestic/municipal and industrial demand and country or region-specific marginal water costs (Rosengrant at al., 2002; McKinsey & Company, 2009). A key limitation not controlled for is that while climate change may increase water availability over a year, if it does not fall when water demand peaks in the absence of adequate catchment, reservoir and irrigation facilities, water scarcity may still increase. It has been estimated that around 20% of areas experiencing increased water could also experience an increase in water scarcity, including India, Northern China, and Europe (Yamamoto et al., 2012). Since the indicator is aggregating the country-level picture of change, it is possible that increases in water availability for some parts of a country are not compensating fully for decreases in water availability elsewhere.

Industry stress

Agriculture:
This Indicator relies on a recent and comprehensive global review of agricultural impacts of climate change that combines a wealth of experience from a range of methods and models (Cline, 2007). The difficulties in predicting rainfall accurately make some regions more uncertain about agriculture outcomes. Carbon fertilization or other effects related to atmospheric pollutants are not considered here. The Monitor accounts for the effect under Agriculture in the Carbon section of this report.

Fisheries:
The indicator relies on a global high resolution bio-climate study that maps the change in preferred water climates due to global warming for over a thousand key commercial species, as compared to their current habitats (Cheung et al., 2010). The main limitation is that the inland aspect of the indicator relies on a study carried out in one area (O'Reilly et al., 2003). Ocean temperature changes are fairly well studied and understood and the economic data from the UN Food and Agriculture Organization is comprehensive and accurate, all of which contributes to the robustness of the indicator (Domingues et al., 2008; FAOSTAT, 2012). Economic data on various segments of global fishery production could have been of a higher standard for the purpose of this analysis.

Health impact

Diarrheal infections:
The indicator is deemed robust, particularly because of its reliance on temperature—among the most

certain of climate effects—as the parameter for estimating a climate effect and because of the quality of the global health database compiled by the WHO on which the estimates are based (WHO BDD, 2011). Nevertheless, a number of improvements could be envisioned: for example, the WHO modelled the global effect on the basis of two detailed studies, which could benefit from further expansion into different areas, particularly detailed analysis of climate change effects on diarrhea in Africa (WHO, 2004). Moreover, the model does not take into account factors other than temperature, such as humidity and rainfall, nor does it take into account effects for developed countries which, while potentially low in terms of mortality, could be high in terms of the number of illnesses; one study identified a 9% increase in food poisoning causing diarrhea in the UK for every one degree increase in temperature (Bentham, 1997).

Heat and cold illnesses:
The indicator measures the impact of new heat or cold patterns on cardiovascular and respiratory diseases, skin cancer, and influenza-like illnesses (Curriero et al., 2002; Bharath and Turner, 2009; Hill et al., 2010; van Noort et al., 2012). Baseline mortality is drawn from World Health Organization disease data (WHO BDD, 2011). The indicator has corrected for the so-called "harvesting effect"— i.e., climate change merely shifts the timing of mortality, as opposed to triggering it, given the high share of morality in already high-risk groups. Baseline research from a wider set of countries studies would help improve the analysis, although the basic mechanisms of heat stress are understood to be broadly similar from country to country (Suchday et al., 2006). While the temperature effect is highly certain, other weather effects, such as humidity, which plays a key role, are more unpredictable. The complex interplay of disease and climate parameters for influenza-like illnesses is particularly difficult to map.

Hunger:
The indicator measures the risk for malnutrition and disease for which low-weight is a principal risk factor as a result of global climate change (WHO, 2004). It relies on the latest global health data updated by the World Health Organization (WHO BDD, 2011). Scientists and the IPCC have recognized the challenges of hunger in the context of climate change. In addition to socio-economic considerations, which add layers of complexity and potential error, the many uncertainties related to impacts on agriculture apply to hunger. Nevertheless, the scientific community is virtually unanimous that lower-income groups are profoundly affected by the impacts of climate change on agriculture (Loetze-Campen et al. in Edenhofer et al., 2012). The indicator could have benefitted from the use of updated emission scenarios than those upon which the base model is built. The base model includes carbon fertilization, which is otherwise considered a "carbon" issue in this report.

Meningitis:
The indicator is a simple model that relates the incidence of meningitis to the incidence of drought. Global changes in the frequency of drought were linked to a meningitis risk model and population density, the indicator being highly sensitive to the latter, since close human contact is a major vulnerability driver for meningitis outbreaks (Sheffield and Wood, 2007; Adamo et al., 2011). The indicator then draws on the main WHO database to estimate how the current burden of meningitis evolves as drought incidence changes (WHO, 2011; WHO BDD, 2011). Uncertainty in relation to the climate effect is present due to the unpredictability of future rainfall patterns, a determining factor of drought.