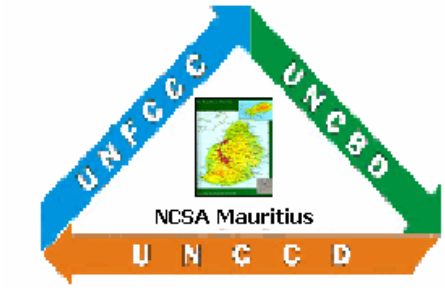
National Capacity Needs Self Assessment for Global Environmental Management - Republic of Mauritius



Final NCSA Report

Ministry of Finance and Economic Development and
Ministry of Environment and National Development Unit
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Abbreviations and Acronyms

ACP	African, Caribbean and Pacific
AFRC	Albion Fisheries Research Centre
AGOA	African Growth and Opportunity Act
AREU	Agricultural Research and Extension Unit
AS	Agricultural Services
BD	Biodiversity
BEPD	Bagasse Energy Development Programme
BRGNP	Black River Georges National Park
CC	Climate Change
CCAP	Climate Change Action Plan
CBOs	Community Based Organisations
CEB	Central Electricity Board
CMA	Conservation Management Area
CO2	Carbon Dioxide
CoP	Conference of Parties
CSO	Central Statistics Office
CWA	Central Water Authority
DBM	Development Bank of Mauritius
DMIS	Data Management and Information System
DMS	Disaster Management System
DSM	Demand-Side Management
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EIA	Environment Impact Assessment
EIS	Environmental Information System
EPZ	Export Processing Zone
ERP	Electronic Road Pricing
ESA	Environmental Sensitive Areas
EU	European Union
FAD	Fish Aggregating Devices
FAO	Food and Agricultural Organisation
FARC	Food and Agricultural Research Council
FiTEC	Fisheries Training and Extension Centre
FMIS	Forest Management Information System
FRTU	Fisheries Research and Training Unit
FS	Forestry Service
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIS	Geographic Information System
GMO	Genetically Modified Organism
GoC	Government On Line Cantre
GoM	Government of Mauritius
IAS	Invasive Alien Species
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
INC	Initial National Communication
INTSS	Integrated National Transport Strategy Study
IOC	Indian Ocean Commission
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Right
IUCN	International Union for the Conservation of Nature

LIS	Land Information System
LMO	Living Modified Organism
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
MABI	Mauritius Agricultural Biotechnology Institute
MEAs	Multilateral Environmental Agreements
MMS	Mauritius Meteorological Services
MoE&NDU	Ministry of Environment and National Development Unit
MOI	Mauritius Oceanography Institute
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MRC	Mauritius Research Council
MSIRI	Mauritius Sugar Industry Research Institute
MTS	Mass Transit Systems
MWF	Mauritian Wildlife Foundation
NBSAP	National Biodiversity Strategy and Action Plan
NCSA	National Capacity Needs Self-Assessment
NDS	National Development Strategy
NES	National Environmental Strategies
NGO	Non Governmental Organisation
NIASC	National Invasive Alien Species Committee
NODC	National Oceanographic Data Centre
NPCS	National Parks and Conservation Service
NTNPC	National Threatened Native Plants Committee
OTEC	Ocean Thermal Energy Conversion
PGR	Plant Genetic Resources
PMO	Prime Minister's Office
PPF	Project Preparation Facility
PV	Photovoltaic
R & D	Research and Development
RRA	Rodrigues Regional Assembly
RD & D	Research Development and Demonstration
SADC	Southern Africa Development Corporation
SGP	Small Grant Programme
SIDS	Small Island Developing States
SLM	Sustainable Land Management
SLR	Sea Level Rise
SME	Small and Medium Enterprise
SPGRC	SADC Plant Genetic Resource Centre
SSR	Sir Seewoosagar Ramgoolam
TCMs	Transportation Control Measures
TDP	Tourism Development Plan
TMRSU	Traffic Management and Road Safety Unit
TNA	Technology Needs Assessment
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
UoM	University of Mauritius
USCSP	United States Country Studies Programme
VMS	Vessel Monitoring System
WCP	World Climate Programme

WMA	Wastewater Management Authority
WMO	World Meteorological Organisation
WRU	Water Resources Unit
WSSD	World Summit for Sustainable Development

Chapter I
Introduction

1. Introduction

The NCSA report for the Republic of Mauritius is one of the key outputs from the government/ GEF/ UNEP funded project, namely, '*National Capacity Needs Self-Assessment for Global Environmental Management* (NCSA)'. The primary objective of the NCSA project is to identify national priorities and capacity building needed to address national as well as global environmental issues, in particular, to enhance the capacity of Mauritius to meet its commitments under the three Rio Conventions, namely, the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Convention on Biological Diversity (UNCBD).

This study is also intended to catalyze national and internationally assisted actions to meet capacity building needs in a coordinated and planned fashion desired for an appropriate environmental management and sustainable development promotion.

The NCSA process was initiated in July 2004 and involved nation wide stakeholders' participation thereby emphasizing national ownership. The valuable contributions from all concerned stakeholders, members of the steering committee and working groups are thankfully acknowledged.

A number of national reports including those on environment, biodiversity, climate change and land degradation were consulted. The GEF/ UNITAR NCSA guideline (September 2003), the signed project document and the UNCBD, UNFCCC and UNCCD Conferences of Parties decisions and documents also constituted the key reference documents.

This NCSA report presents the findings made under the thematic areas of biodiversity, climate change and land degradation for the Republic of Mauritius as follows:

I. *Identified Thematic Priority Issues*
II. *Capacity Constraints and Opportunities for Capacity Building*
III. *Opportunities for Synergistic and Cross-cutting Capacity Building*
IV. *Strategic Recommendations for Capacity Building to Protect the National and Global Environment*
V. *Way Forward*

Eight thematic assessment reports (5 for Mauritius and 3 for Rodrigues), which were prepared as part of this project, have been extensively cited. These reports should be referred to for further details and are given as Appendices 1-8 to this main NCSA Report.

Appendix 1: *Agro-Biodiversity and Biotechnology Thematic Assessment Report – Mauritius*
Appendix 2: *Terrestrial, Fresh Water, Coastal and Marine Biodiversity Thematic Assessment Report – Mauritius*
Appendix 3: *Climate Change: Science, Responses and Mitigation Thematic Assessment Report – Mauritius and Rodrigues*

Appendix 4: *Climate Change: Vulnerability and Adaptation Thematic Assessment Report - Mauritius*
Appendix 5: *Land Degradation Thematic Assessment Report – Mauritius*
Appendix 6: *Biodiversity Thematic Assessment Report – Rodrigues*
Appendix 7: *Climate Change: Vulnerability and Adaptation Thematic Assessment Report - Rodrigues*
Appendix 8: *Land Degradation Thematic Report – Rodrigues*

1.1 Background

Geographical

The Republic of Mauritius comprises the main tropical island of Mauritius (1,865 km^2) together with Rodrigues (108 km^2), its second largest tropical island, and a number of smaller islets giving a total land area of 2,040 km^2 and an Exclusive Economic Zone (EEZ) of 1.9 million km^2.

Socio-economic

Mauritius has developed from a low-income economy to a middle-income economy over the past three decades with a per capita income of US $ 5078 (for Jan to Oct 2004)[1]. This growth was sustained by four main economic pillars, namely agriculture, manufacturing, tourism and financial services. Other emerging sectors are the Information and Communication Technology (ICT), the seafood hub and knowledge hub.

The growth rate for the economy for the period 1996-2000 was around 6% compared to 4% in the period 2001-2005[2]. In 2005[3], the economy is expected to grow by 3.8% and the sugar sector (sugar cane and sugar milling) is expected to register a rate of growth of -3.9% compared to +6.5% in 2004. Proposed reforms to the Sugar Protocol, aimed at reducing the price of sugar by 39% for the African, Caribbean and Pacific (ACP) countries are expected to have a negative effect on sugar exports and the whole of the sector as from 2006. To minimize this impact, a road map for the accelerated reform of the sugar sector has been launched in order to enable the industry to stay competitive and remain cost effective supplier to the EU market. To further diversify the economy, government is encouraging investment in the area of aquaculture.

The future of the EPZ sector is rather bleak with the expiry in January 2005 of the Agreement on Textiles and Clothing and surge of exports from China and other Asian countries. In 2005, the expected rate of growth for the EPZ sector is -8.0 %. Measures are being taken to uplift the Small and Medium Enterprise (SME) sector and for the exports to be eligible gain preferential access from African Growth and Opportunity Act (AGOA) to the US textiles market

[1] Minister of Finance and Economic Development Website
[2] Statement by Hon. R. Sithanen, DPM and Minister of Finance and Economic Development on 30 August 2005 – Setting the stage for Robust Growth
[3] National Accounts Estimates CSO June 2005 Issue No. 514

In the immediate term, tourism industry is expected to boost up the national economy and generate employment. The real growth rate in the tourism industry is expected to be 4.8% for 2005.

On account of the changing economic situations and rapid permutations affecting the global trade, which are impacting Mauritius, government has taken strong commitments to introduce reforms in a number of critical sectors including education and training, agriculture and tourism to enable Mauritius to meet its challenges towards ensuring that any economic decisions taken are in line with the set environmental objectives to achieve sustainable development. The NCSA findings and the implementation of the recommendations made will to large extent facilitate a sound and successful coalition among economic, social and environmental dimensions.

In furtherance to certain timely policy decisions taken in early 90s and also following signatures to the Multilateral Environmental Agreements (MEAs), improvements in the environmental scene have been noted. The Table 1.1 given below displays the key environment indicators for 1995 and 2004 (CSO, 2005). As it can be noted, there has been successful attempts in terms of increase in land protected areas from 11,125 ha in 1995 to 13,973.0 ha in 2004 and the marine protected areas cover a surface of 7,216 ha demonstrating the government's commitment to promote conservation, protection and management, and also sustainable use of the natural resources and general environment.

However, statistics still show a decrease in forest coverage, decline in total fish catch over the past decade, and a general increase in the following indicators:-

- total carbon dioxide emission and per capita carbon dioxide emission
- annual fresh water abstraction
- daily per capita domestic water consumption
- daily per capita solid waste generated
- total energy generated and per capita final energy consumption

Table 1.1: Main environment indicators for 1995 and 2004

Indicator	Units	1995	2004
1. Total land area	000 ha	186.5	186.5
2. Irrigated land	Ha	17,306.0	21,417.0
3. Forest area (as a % of total land area)	%	30.6	23.8
4. Land protected areas	Ha	11,125.0	13,973.0
5. Marine protected areas	Ha	7,190.0	7,216.0
6. Threatened plant species (IUCN Red List)	Number	…	87
7. Threatened animal species (IUCN Red List)	Number	…	60
8. Total fish catch	Tons	16,029.0	9,431.0
9. Mean catch per fisherman day	Kg	4.8	4.2
10. Total carbon dioxide emission	000 tons	1,738.4	2,795.7
11. Per capita carbon dioxide emission	Gg	1.6	2.3
12. Mean annual rainfall, hydrological year 1995/96 and 2004/05, respectively	Mm	2565	2205
13. Annual fresh water abstraction	Mm^3	650.0	662.0
14. Daily per capita domestic water consumption	Litres	154.8	160.0
15. Daily per capita solid waste generated (estimate)	Kg	0.6	0.9
16. Total electricity generated	GWh	1,165.5	2,165.0
17. Per capita primary energy requirement	Toe	0.8	1.0

18. Per capita final energy consumption	Toe Toe per Rs	0.6	0.7
19. Energy intensity	100,000 GDP	1.8	1.6

Source: Environment Statistics 2004, CSO, Issue No. 518, Republic of Mauritius

1.2 Rationale of the NCSA

All the national reports pertaining to the environment and related sectors prepared so far also identify capacity constraints at the systemic, institutional and individual levels amongst the most prominent issues. The reports consulted, including the *National Environmental Strategies* (NES, 1999), *National Development Strategy* (NDS, 2003), *Tourism Development Plan* (TDP, 2002), Climate Change Action Plan (CCAP, 1998), *Technology Needs Assessment and the Maintenance and Enhancement of Capacities for Climate Change Activities* (2004) and the *National Biodiversity Strategy and Action Plan* (Draft Final NBSAP, 2001) confirmed that the appropriate capacity building would be the requisite for a more effective resource management and sound environmental governance.

In the Mauritius' report '*Meeting the Challenges of Sustainable Development*' presented at the World Summit for Sustainable Development (WSSD) in 2002, it has been recognized that the environment is under threat in Mauritius in a number of different ways. Amongst the most common threats include:

- Rising populations, of both residents and tourists, putting pressure on space bringing problems of congestion and waste disposal;
- Increasing use of agro-chemicals resulting in land degradation and water pollution mainly as a result of agricultural development ;
- Tourism development putting pressure on scarce land in the coastal zone and on the fragile ecology of the lagoons; and
- Burning of oil, gas and coal for energy exacerbates the current situation of atmospheric pollution and adds to the emissions of GHG.

The Government of Mauritius, in its report presented at the SIDS International Meeting in January 2005[4] recognises that one of the priorities to consider in pursuing sustainable development is a strengthening of national institutions and administrative capacities.

It is being realized that for national development to be meaningful, it needs to strike the right balance among the economy, the environment and human development. Such development should be able to relate to the global economy and environmental context. The ecological balance will not happen by itself. It needs vision, planning, consultation and consensus among the various partners. The authorities are determined to strengthen or build such partnership in order to attain the goal of sustainable development.

The NCSA has been a useful process by bringing the relevant stakeholders of both public and private institutions, NGOs and academia on a common platform to analyse factors and recommend measures that would ensure effective implementation of the national priorities in line with the biodiversity, climate change and land degradation conventions within the long-term economic development strategy for the Republic of Mauritius.

[4] Mauritius Staking Out the Future (Ministry of Environment and NDU, 2005)

1.3 Overview of Participation and Preparation Process

Around 60 representatives from 10 ministries, 15 statutory bodies, 5 private organisations and 5 non-governmental organisations participated and contributed actively in the NCSA project. The sectors involved are as follows:

- Environment
- Climate and climate change components
- Forestry
- Agriculture
- Fisheries
- Water Resources
- National Parks and Conservation Service
- Health and Quality of life
- Energy
- Transport
- Public Infrastructure
- Housing and Lands
- Tourism
- Research and Development
- Finance and Economic Development
- Local Government
- Education and Human Resources

A participatory approach was adopted whereby stakeholders were convened for working sessions. Discussions were focussed on past achievements, lessons and weaknesses, capacity constraints, issues and gaps as well as potential corrective and mitigating measures and future works. In all 22 working sessions, including 5 from the National Workshop in Mauritius were held under various sub-thematic areas. Where the thematic issues were complex, individual interviews instead of systematic brainstorming sessions were arranged to allow for an in depth discussion of the subject. Also several working sessions and a 2-day workshop were held on Rodrigues Island.

The working groups were chaired by the designated national focal points in Mauritius while the meeting in Rodrigues was carried out under the chairmanship of the Departmental Head responsible for environment and also by other nominated representatives. The Table 1.2 below indicates the stages followed in conducting the NCSA process.

Table 1.2: Stages in conducting the NCSA for the Republic of Mauritius

Tasks	Status
Establishment of Coordinating mechanism, Steering committee and working groups	✓
Workshops to launch and initiate consultative processes	✓
Stock taking and gaps identification	✓
National workshops (Rodrigues and Mauritius)	✓
Identification of a group of local resource persons to assist in thematic assessment	✓
Undertaking thematic assessment and preparation of thematic reports	✓
Identification of potential synergies and cross cutting analysis	✓
Development of capacity building strategy	✓
Drafting of NCSA Report	✓
Circulation of Draft NCSA Report for comments /Presentations through 3 workshops	✓
Finalisation of the NCSA Report for the Republic of Mauritius	✓
Cabinet Approval of NCSA Report	☺
Submission of the NCSA report to UNEP	☺

☺ Expected

Chapter II
Identified Thematic Priority Issues

2. Identified Thematic Priority Issues

Issues related to the implementation of the three Rio conventions of UNFCCC, UNCBD and UNCCD and of relevance to the national general environment which were identified following a comprehensive consultative process with the relevant stakeholders comprising of public, statutory and private organisations, research institutions, academics, and NGOs have been reported in this chapter.

Prioritisation of the issues for action was essential as without a focus on priorities the number and type of issues to be addressed in the NCSA were likely to expand beyond any ability to handle them. The prioritisation process was carried out mainly in working groups during a national workshop in Mauritius and also a local workshop in Rodrigues. The methodology used[5] reflected the following 3 criteria that were further elaborated through a set of general guiding questions:

- Scale of problem: Is the issue of national and/or global importance and significance
- Level of concern: what is the level of concern nationally about the issue
- Urgency: How urgent is it to tackle the issue and do we have the ability to adequately address the issue

The working groups were devised as follows:

Mauritius

Group 1	Biodiversity 1: – Terrestrial and Forest Biodiversity; Freshwater, Coastal and Marine Biodiversity
Group 2	Biodiversity 2:– Agro-biodiversity and Biotechnology
Group 3	Climate Change 1:– Science & Variability and Responses- Mitigation
Group 4	Climate Change 2:– Vulnerability and Adaptation
Group 5	Land Degradation

Rodrigues

Group 1	Land Degradation
Group 2	Climate Change (Responses- Mitigation, Science & Variability and Vulnerability and Adaptation)
Group 3	Biodiversity (Terrestrial and Forest BD, Agricultural BD, Biotechnology and Fresh Water, Coastal and Marine BD)

2.1 Biodiversity - Summary Overview

Mauritius is amongst the first countries to have ratified the UNCBD in 1992. The biodiversity in the Republic of Mauritius has developed a high degree of endemism due to its age and isolation of the main islands. The high level of endemism and species diversity per unit area has resulted in the Mascarenes being identified as a Centre of Plant

[5] GEF and UNITAR (September , 2001) – A Guide for Self Assessment of Country Capacity Needs for Global Environmental Management

Diversity by the IUCN (World Conservation Union). However, the unique biodiversity has been stressed and suffered devastation by the action of people and the many species introduced since first settlement about 400 years ago. Much of the remainder is internationally recognised as threatened and vulnerable. As such, Mauritius has been ranked by the IUCN as having the third most endangered terrestrial flora in the world. Marine biodiversity in Mauritian waters is also very rich with some 1,656 known species so far though endemism levels are low compared with those on land. The national inventory process is still incomplete and severely limited by the lack of resources. Freshwater biodiversity has never been high but it has been further impoverished by the actions of invasive species and reduction in habitat quality. The majority of agricultural biodiversity in Mauritius and Rodrigues constitutes crop varieties and farm animal genetic resources that have been introduced since the start of agriculture. Biotechnology is still at its preliminary stage of development.

With the biodiversity heritage the country possesses, and although substantial progress has been made in terms of institutional and regulatory frameworks in place, conservation and management of genetic resources and other successfully implemented activities, terrestrial and islets national parks (13,926.0 ha) and 11 CMAs (45 ha) established, marine protected areas (7,216.0 ha) established, partnerships and joint initiatives by the actors in certain of the sub-sectors, there is still a long way to go towards a proper understanding, appreciation of environmental benefits as they relate to biodiversity conservation, efficient conservation, protection and management of biodiversity resources in the Republic of Mauritius.

Following the national workshops and subsequent working groups' meetings, the prioritised issues under the biodiversity thematic area and its various sub sectors for Mauritius and Rodrigues are given in the **Table 2.1** below.

Table 2.1: Prioritised issues under the Biodiversity thematic area

Biodiversity thematic area	Mainland Mauritius	Rodrigues
Terrestrial and Forest	• Limited area under protection and inadequate conservation management of native ecosystems • Invasive Alien Species • Lack of training of Mauritians • Incomplete inventory • Habitat fragmentation • Limited inter-institutional communication and collaboration • Limited research • Limited awareness of the population at large	• Invasive Alien Species (IAS) • Management of Protected Areas/ Nature Reserve/Caves • Lack of data and absence of data base • Past deforestation • Endangered native fauna and flora
Freshwater, Coastal and Marine	• Incomplete inventory • Ecosystem degradation • Illegal fishing and poaching (in outer islands) • Over fishing (lagoon) • Limited area under protection and inadequate conservation management • Invasive alien species (IAS) • Lack of training	• Unsustainable exploitation of the marine resources • Development of off lagoon fishery • Setting and Management of Marine Protected Areas • Stock assessment of lagoon and off lagoon resources/Preservation and Marketing strategy fishery
Agro biodiversity	• Need for a comprehensive and integrated policy (non sugar sector) • Inadequate Genetic Conservation and Utilisation/ Exploitation Activities • Absence of regulatory framework to promote research for development • Medicinal Plants & traditional knowledge neglected • Limited Research on Agro-biodiversity	• Decline in crop production • Absence of gene bank • Phytosanitary Control • Slow animal growth • No Rotational Grazing • Degeneration and loss of certain breeds • Insufficient veterinary services
Biotechnology	• Lack of a comprehensive policy in biotechnology (with particular reference to non-sugar sector) • Specialized Training • Enactment of legal framework and enforcement • Lack of co-ordination among institutions • A misunderstood Science (Limited awareness campaign)	

2.2 Climate Change – Summary Overview

In June 1992 Mauritius signed the United Nations Framework Convention on Climate Change. Mauritius is an active member in a number of international bodies, including the IPCC, World Climate Programme of the World Meteorological Organisation (WMO/WCP) and UNFCCC. Mauritius also fulfilled its obligations under the UNFCCC, notably the preparation and submission of its Initial National Communication (INC) in 1999. The INC was prepared by a local team following some specific training received within the framework of the United States Country Studies Programme (USCSP) in 1995-97 and also following some hands on training received in the context of a study on the Economics of Greenhouse Gas Limitation Phase I: Establishment of a Methodological Framework of climate change sponsored by UNEP/Riso National Laboratory Denmark.

The INC included a national inventory of greenhouse gas for the year 1995, analyses of vulnerability and adaptation of various socio-economic sectors to climate change, namely the coastal zone, agriculture and water resources among others. Emphasis was also laid on the collection of data, archiving and systemic monitoring; research, education, training and building public awareness, projections, suggestions of policies and measures and mitigation and adaptation options.

Under the USCSP, the scientists benefited from training in specific areas of climate change namely, in GHG inventory preparation, conducting of vulnerability and adaptation studies, and identifying appropriate strategies for future adaptation. Many of them subsequently contributed towards the preparation of the Climate Change Action Plan in 1998 which provides a number of possible actions with constraints or challenges identified in the agriculture, coastal zone, energy, transportation, fisheries, forestry, waste management and water resources sectors.

The Central Statistics Office (CSO) personnel have also been trained in the preparation of GHG inventories to enable them to carry out the exercise on an annual basis.

Despite local human capacity enhancement, amongst the most striking observations made is that the key national institutions dealing with climate change is either facing severe shortage of trained staff and/or lack of fund shortage coupled with prohibitive technologies and inadequate logistic for conducting research studies. The trained staff have either retired or shifted into other ministries/ departments. The recent study on the 'Technology Needs Assessments and Maintenance and Enhancement of Capacities for Climate Change' (September, 2004) also confirmed this fact.

Amongst the key factors that also came out following consultation with the key stakeholders, mainstreaming of climate change and related issues in long term development plans, policies and strategies is still inadequate while institutional synergies need development and existing possibilities need optimisation. Data collection, management, access and dissemination of research finding, monitoring, optimising linkages, development of new tools, sensitisation and applied research to bridge knowledge gaps and new development were amongst the most prominent factors noted.

The prioritised issues under the climate change thematic area and its various sub sectors for Mauritius and Rodrigues following the national workshops and subsequent working groups' meetings are given in the **Table 2.2** below.

Table 2.2: Prioritised issues under Climate Change thematic area

Climate Change thematic area	Mainland Mauritius and Rodrigues
Science & Variability	• Need for a complete picture of a warming world and other changes in the climate system • Projections of future climate and sea level rise (SLR) with focus at regional level • Limitations with Data Management and Information System • Linkages • Research & Development on Impacts of Climate Change (CC) on different sectors
Responses-Mitigation: Energy	• Inadequate use of Low Emission/ Renewable Energy Technologies • Inadequate use of Energy Efficiency Technologies • Distributed Power Generation • Energy Management • Energy Demand Outlook • Data Management and Information System • Research and Development, Future Technology, and Technology Export
Responses – Mitigation: Transport	• Emission Transport Technologies • Congestion-Free Systems • Transportation Control Measures (TCMs) • Data Management and Information System (DMIS) • Research and Development, Future Technology, and Technology Export
Vulnerability and Adaptation	➢ Coastal sector • Beach erosion, land loss, damage to infrastructure • Degradation of lagoon water quality • Coral degradation • Salt-water intrusion in coastal aquifers • Loss of native biodiversity ➢ Agricultural sector • Decline in cane quality and yield • Change in yield and quality of other crops in different microclimate • Change in cropping patterns • Change in land use • Crop productivity likely to be affected by salinity in the East and Southeast coast • Unusual incidence of pest and disease • Land degradation ➢ Water sector • Insufficient fresh water • Expected decrease in fresh water • Salt water intrusion in coastal aquifers • Deterioration in water quality ➢ Health sector • Heat fatigue and Heat stroke

	• Increase risk of vector-borne, water-borne and food-borne diseases (malaria, chikungunya, etc.) • Air pollution • Increase respiratory disease • Contamination of potable water ➢ Tourism sector • Damage to coastal hotel infrastructure • High maintenance cost • Decrease in number of tourist from northern hemisphere countries • Mauritius likely to become less attractive ➢ Fisheries sector • Mortality of juvenile • Decrease in coastal fish production

2.3 Land Degradation – Summary Overview

Mauritius signed the United Nations Convention on Desertification in June 1992. Its relevance to Republic is mainly through its provisions on land degradation.

The UNCCD defines Land Degradation as "*reduction or loss of biological or economic productivity and complexity of rainfed cropland, irrigated cropland, pasture, forest and woodlands resulting from land uses or from process or combination processes, including processes arising from human activities and habitation patterns.*

Land degradation as broadly defined under the 'GEF Operational Program 15 on Sustainable Land Management' (2003) refers to "… *any form of deterioration of the natural potential of land that affects ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience*".

However, past land planning weaknesses coupled with inadequate control of development have led to the admixture of incompatible development, encroachment onto environmentally sensitive areas including wetlands, forest areas, and prime agricultural land.

In 2003, Government commissioned the National Development Strategy, which is a revised version of the National Physical Development Plan. It provides amongst others policy guidance for the agricultural and forest sectors. It also provides a basis for the revision of all local land use plans and defines ESAs and recommends their identification, mapping and verification.

The following strategic priorities with regard to the environment have been identified and recommended:

- Safeguarding valued elements of the natural and built up environment
- Using national resources in a sustainable manner
- Ensuring that development makes a positive contribution to the environment

As key enabling measures, the implementations of a number of policy recommendations under the following reports have been initiated.

- The Non Sugar Sector Strategic Plan (2003 - 2007)
- The Sugar Sector Strategic Plan (2001 - 2005)
- National Environmental Strategies for the Republic of Mauritius – National Environmental Action Plan for the Next Decade (1999)

The promotion of sustainable agriculture is spearheaded by the Ministry of Agro-Industry and Fisheries through Agricultural Services (AS), Agricultural Research and Extension Unit (AREU) and the Mauritius Sugar Research Industry Research Institute (MSIRI). While the Food and Agricultural Research Council with institutions such as the University of Mauritius are promoting sustainable agriculture through promoting research and development on the use of organic wastes (composting).

For the mainland of Mauritius, land degradation on agricultural land is in general restricted to a few regions where vegetables and crops other than sugar cane are grown (e.g. pine apples, palms amongst others) on steep slopes. Hydro chemical studies and monitoring on borehole water samples are conducted by the MSIRI and the Central Water Authority on an ongoing basis. A 4-year project was implemented by MSIRI in collaboration with the Queensland Department of Natural Resources in 1997, with inputs from CWA and WRU, to measure and predict the movement of agrochemicals under cane. That work has concluded that run off were very negligible. Current work is focused on the effect of sugar cane cultivation on soil quality, particularly with respect to land preparation and mechanized harvesting. Results will probably be available in 2006.

However, degradation of agricultural lands is a serious problem in Rodrigues as a result of past deforestation, unsustainable agricultural practices and overgrazing by cattle, sheep and goats. The island hilly topography coupled with the climatic events is also considered among the most negative factor that has contributed towards the loss of fertile topsoil. A government/ EU funded anti-erosion project has been operating in Rodrigues for over ten years. Under this work programme several activities have been carried out such as reafforestation, planting of windbreaks and rationalization of livestock management however with varying degrees of success and sustainability.

While the state-owned forests are rather sustainably managed, the private forests have been gradually cleared for other land uses mostly agriculture, deer ranching and parcelling for housing development. It is estimated that around 9000 ha out of about 34000 ha of privately owned forest lands have been deforested in the past 15-20 years. Native forests under private ownership are still being cleared for pastures in deer ranching projects. As a result, accelerated erosion and soil degradation have been observed at some sites. Management, control and enforcement are being constrained by the limited tools, inadequate legislation and shrinking national funding.

Most of the shoreline of Mauritius especially the sandy shores is exposed to erosion. However there are many sites where the natural dynamic system has been disturbed or seriously degraded by direct or indirect human activities resulting in loss of significant beach areas. Alarming evidence of irreversible erosion in several sites has been reported in a study commissioned by the government in 2003.

The prioritised issues under land degradation thematic area for Mauritius and Rodrigues following the national workshops and subsequent working groups' meetings are given in the **Table 2.3** below.

Table 2.3: Prioritised issues under land degradation thematic area

Mainland Mauritius	Rodrigues
• Deforestation o Clearing for pasture on deer ranches o Clearing/ conversion on privately owned and state owned land o Clearing for settlements and cross cutting issues • Unsustainable agricultural practices • Severe degradation from fire on steep mountain slopes in dry region • Loss of wetlands • Land Drainage/ Erosion in 'sensitive' and other developed areas • Coastal erosion (due to anthropogenic causes)	• Unsustainable agricultural practices • Overgrazing due to unsustainable livestock production system • Unsustainable management of forest lands and nature reserves • Coastal zone degradation due to erosion • Inadequate management of land resources

Chapter III
Capacity Constraints and Opportunities for Capacity Building

3. Capacity Constraints and Opportunities for Capacity Building

The identification of capacity constraints (root causes) was carried out through a detailed causality analysis of the prioritised issues and involved establishing the "cause and effects" relationships between the existing issues. The 'problem tree' approach was favoured as it represents a comprehensive picture of the existing issues that require attention and it is also a useful tool in developing the causes occurring at various level including identification of the underlying root causes.

Problems were identified for a number of levels using both top bottom and bottom up approaches. Relevant stakeholders from the various working groups were presented the analysis and contributions made were incorporated. The detailed findings made under the various sub thematic areas and presented in the form of root cause matrices are given in the respective thematic assessment reports.

The presentation of the information in the root cause matrices have been made under the following columns:

- Issues
- Biophysical and other impacts (impacts likely to result in case the issues are not attended/ addressed)
- Root causes (particular focus on the capacity constraints)
- Potential mitigative and corrective measures
- Ongoing and planned activities (including past recommendation). The purpose has been to capture the ongoing or planned activities' outputs which are not visible yet. The benefits of doing so would be avoidance of any duplication in terms of project ideas and potential mitigative/ corrective measures.

Further analysis has enabled a grouping of the capacity constraints identified into categories along the concepts of individual, institutional and systemic capacity constraints. It is important to assess and group the capacity constraints, as the level at which the capacity constraints occurs would influence the type of capacity building required.

The findings are presented in summary form in the given adapted tables below in this section of the report. Tables 3.1 to 3.11 provide an overview of the capacity constraints (root causes) and the opportunities as potential mitigative and correctives measures. In working out the opportunities, ongoing and future planned activities have also been considered.

The Tables, 3.1 to 3.4 and 3.9 (for Mauritius) and 3.10 to 3.11 (for Rodrigues) have been kept separated (except for the climate change thematic area) so as to reflect the different baseline and specificities diagnosed. These summary information reflect the priorities identified by the groups of stakeholders. For the climate change thematic area, the analysis carried out is considered to be relevant to the entire Republic of Mauritius.

The adapted tables under the various thematic areas have been presented in Annex 1 of this report:

These are as follows:

Biodiversity (mainland Mauritius)

- **Table 3.1**: Adapted Root Cause Matrix on Biodiversity: Terrestrial/Forest Biodiversity
- **Table 3.2**: Adapted Root Cause Matrix on Biodiversity: Inland Water, Coastal and Marine Aquatic Biodiversity
- **Table 3.3**: Adapted Agro-biodiversity Root Cause Matrix
- **Table 3.4** : Adapted Biotechnology Root Cause Matrix

Climate Change (Mauritius and Rodrigues)

- **Table 3.5**: Adapted Root Cause Matrix for Climate Change: Science and Variability
- **Table 3.6** : Adapted Root Cause Matrix for Climate Change: Response and Mitigation: Energy
- **Table 3.7** : Adapted Root Cause Matrix for Climate Change : Response and Mitigation: Transport
- **Table 3.8** : Adapted Root Cause Matrix for Climate Change: Vulnerability and Adaptation

Land Degradation ((mainland Mauritius)

- **Table 3.9** : Adapted Root Cause Matrix for Land Degradation

Biodiversity (Rodrigues)

- **Table 3.10 a**: Adapted Root Cause Matrix – Terrestrial and Forest Biodiversity in Rodrigues
- **Table 3.10 b**: Adapted Root Cause Matrix – Agro-biodiversity and Biotechnology in Rodrigues
- **Table 3.10 c**: Adapted Root Cause Matrix – Fresh water, coastal and Marine Biodiversity in Rodrigues

Land Degradation (Rodrigues)

- **Table 3.11**: Adapted Root Cause Matrix –Land Degradation in Rodrigues

Detailed mitigative/ corrective measures meant to address all prioritised issues under each sub-thematic areas are presented in the Thematic Assessment Reports as Appendices. The findings from this stage constitute the basis for the development of potential synergies for cross-cutting elements and also in the formulation of stategic recommendations for capacity building under the various sub-thematic areas as further developed in the Chapters IV and V of this report.

Chapter IV

Opportunities for Synergistic and Cross-Cutting Capacity Building

4. Opportunities for Synergistic and Cross-cutting Capacity Building

Synergy can be defined as "*a combined effect...that exceeds the sum of individual effects*"[6]. Identifying cross-cutting synergies relevant for capacity building needs under the Rio Conventions and environmental management in general can therefore be an effective way to ensure effectiveness and efficiency in implementing activities at the national level.

An assessment of guidance from the three Rio Conventions shows a notable similarity across the conventions[7]. The Table 4.1 shows the overlapping requirements of Parties to the three Rio agreements which are of direct relevance to the NCSA project.

Table 4.1 - Overlapping Requirements of Parties to the Rio Agreements

	Climate Change	Biological Diversity	Desertification
National Inventories	Article 4(b)		
National & Regional Action Plans	Article 4(b)	"strategies" Article 6(a), (b)	Articles 9, 10
Identification & Monitoring		Article 8	Article 16
Develop Protected Areas		Article 8	
Legislation	Preamble	Article 8(k)	Article 5(e),
Research	Article 5	Article 12(b)	Articles 17, 19(b)
Public Education	Article 6	Article 13	Articles 5(d), 19, 6
Environmental Assessment	Impact Article 4(i)(d)	Article 14	
Clearinghouse for technical information		Article 18	Article 18
Public Participation	Article 6(i)(a)(iii)	Article 9	Article 19(4)
Conference of Parties (COP) / regular reviews	Article 7		
Exchange Information	Article 7	Article 17	Article 16
Training	Article 6	Article 12(a)	Article 19
Reports	Article 12	Article 26	
Data Collection			Article 16
Examine obligations-Assess implementation	Article 7(e)	Article 23	
Report Steps to COP	Article 12	Article 26	Article 26

[6] Concise Oxford Dictionary, 7th Edition
[7] GEF, (GEF/C.17/6/Rev.1), Elements of Strategic Collaboration and a Framework for GEF Action for Capacity Building for the Global Environment

As parts of obligations towards the three Rio agreements, Mauritius, just like any other party is required to take a number of similar actions for each instrument. Countries can generally carry out these obligations in ways that greatly leverage their participation by reducing costs, by relieving the burden of multiple reports and other requirements, and in general by producing greater effectiveness and efficiency. In sum, these sustainable development instruments can be more effectively implemented through a greater understanding of the commonalities and the overlaps between them, by favouring a coordinated and harmonised approach to their implementation at the local and national levels.

4.1 Scientific and Technical Linkages

Fundamentally, numerous international studies and assessments[8] have established many linkages between biodiversity protection, mitigation of climate change, preventing desertification and land degradation, and the sustainable management of forests.

One common example of multi-linkages is the interaction between change in forests, lands, biodiversity and climate change. Widespread deforestation converts forest into carbon dioxide and reduces the vegetative cover for CO_2 sink. By removing this cover, deforestation reduces the water retention capacity of the soil and increases soil erosion. This, in turn, can lead to changes in the weather patterns of surrounding areas, and to the potential for warming of the climate on a global scale. Thus, the sustainable management and use of forests could, among other things, help also limit global warming.

The array of impacts of climate on land and the implications of degraded land surface for the climate system are many. Changes in weather patterns and climate can negatively affect tree species which are both important biological resources and home to a great percentage of the world's biodiversity. And, should the sea level rise as a result of global warming — as the IPCC *Special Report on Emission Scenarios* (SRES) predict — the atmospheric general circulation pattern, oceanic currents and regions of upwelling could shift, affecting fish and other marine life. Climate change could also impact the productivity of grasses in ecosystem habitats, thus affecting wildlife biodiversity, especially of large animals. Increased surface temperature could result in

[8] Assessments include an estimate of the socio-economic implications of climate change, biodiversity loss, desertification, and deforestation. They are a summary of extensive experimental, theoretical (modelling work, for example), and observational studies carried out by research groups, individual scientists, and international research programmes.

reduction in land vegetation cover which would affect soil microbial diversity due to enhanced exposure to higher temperatures.

Because of the inextricable scientific and technical linkages between the three thematic areas considered by the Rio instruments, actions taken in furtherance of the objectives of each of the agreements can be beneficial to the purposes of the others. The linkages between the thematic areas therefore provide important synergy opportunities.

4.2 Barriers to Achieving Synergy

The key barriers to achieving synergy as identified in the case of Mauritius comprises the fragmentation in the responsibilities for achieving the goals of the agreements distributed among various ministries and other partners that are operating within their respective institutional and regulatory frameworks. The level of priorities and attention accorded to the issues in some of the cases differ while some of the executing institutions are running on inadequate financial, human and technical resources.

Government is also obligated under the 3 Rio Agreements to develop national action plans, policies, and strategies that can provide the framework for increased efforts. The agreements specify training of government decision-makers, managers, and others to strengthen their skills in taking appropriate and necessary actions.

In the face of this major barrier, there is a need to develop and enhance synergies at the national as well as orientation towards the regional and global levels. In many cases, synergies and integrated approaches to issues already exist and can be built upon. In other cases, including at the international level, new efforts are needed to stimulate collaboration, cooperation, and greater harmonization in order to catalyse integrated approaches toward the implementation of relevant measures.

4.3 Synergies at the National Level

Through a number of actions the government has promulgated revised legislation, regulations, and policies. One such key example is the use of environmental impact assessment, as an effective tool which is being used to

avoid or minimize the effects of proposed activities on the economy, on public health, on the quality of the environment, on biological diversity, on forests, and so forth. Implementation of a number of other strategic recommendations and measures, namely, the National Development Strategy, Tourism Development Plan, Sugar Sector and Non Sugar Sector Strategic Plans, development of Integrated Coastal Zone Management Plan amongst others have somehow strengthened collaborative links between the various national players. However, synergies at the national level remain one of the key challenges.

4.3.1 Institutional Requirement

The Rio instruments call for integration of environmental concerns into other areas of policy, but they leave it to country parties to determine the policy and institutional framework for implementation. The instruments do not, for example, require the establishment of particular institutions at the national level. This is for each Party to decide.

While there exists the Ministry of Environment and NDU (MoE) with the overall responsibility for environmental issues, a number of activities associated with the Rio agreements also fall within the mandates of other ministries. Thus, coordinated implementation of the agreements is likely to require horizontal inter-ministerial consultation and cooperation involving other stakeholders.

The Figure 4.1 shows the lead actors as well as other partners involved in the implementation of the various measures of relevance to the 3 Rio instruments. Whilst the national focal points have been designated and approved at the level of the Cabinet of Ministers, formal mechanism involving all stakeholders for the consultation on issues and matters related to the three Rio Conventions is generally inadequate.

Some of the weaknesses with such approach include:

- Serious gap in information flow (such as COPs decision/ SBSTTA recommendations and others important documents not discussed or circulated nationally) OR a communication lag. Thus stakeholders are

not fully aware about the decisions taken and its implications. Sharing and dissemination is inadequate.

- Uncoordinated implementation of measures
- With the autonomy status of Rodrigues, further decentralization needed to cater and measures to be implemented in Rodrigues.
- Stakeholders not aware about the positions taken in the COPs and technical meetings
- Team work and team building inadequate thereby threatening sustainability in terms of participation in the international meetings. Opportunities to be also given to other senior members.

To address the above weaknesses and gaps, the recommended institutional mechanism which was presented and discussed with all stakeholders concerned during the last national working session is given at the Figure 4.2. This further decentralized mechanism would have the benefits of avoiding an unhealthy centralization of control and power over environmental and sustainable development policies and programmes. This approach would foster a democratized participation while at the same time it optimizes the cross fertilization in approach, efficiencies and existing synergies. This mechanism also caters for participation by the RRA and also for the implementation of measures relevant for Rodrigues.

The proposed institutional mechanism would also function as an inter-institutional coordination committee, bringing together key participants (focal points, nominated coordinators for the various sub thematic areas etc) promoting inter-institutional exchanges to take place regularly, while synergies are generated at the level of implementation, including the line ministries and other actors.

Important to its success is an enabling environment, including appropriate legislation framework, delegation of authority, and leadership at the highest levels. The involvement and inputs from all the stakeholders could be effectively harnessed in a timely manner through the use available ICT and internet facilities.

A closer coordination by the Ministry of Environment and NDU would be essential to ensure effective implementation of programmes and plans for the entire Republic of Mauritius.

Figure 4.1: Institutional structure showing only lead agencies versus relevant stakeholders involved in the implementation of the 3 Rio instruments

Please note that Figure 4.1 is in the Microsoft Excel document

Figure 4.2: Revised institutional mechanism that would function as an Inter Institutional Coordination committee

Please note that Figure 4.2 is in the Microsoft Excel document

The Inter-Institutional Coordination committee would be a policy-making structure. It would deal with national policy issues, strategic planning, implementation, and legislative requirements for successful implementation of the instruments and other related initiatives. It would bring together the various departments and ministries, statutory bodies, academics and NGOs, including the focal points for each convention as well as may co-opt other members as required. To function effectively, the proposed committee would require the following:

- To be vested with authority, including a legal and policy mandate
- Has an efficient local conventions secretariat function which would pull together a diverse group of participants and the development of an local information and knowledge network
- Establishment of convention desks at the relevant line ministries preferably with a small team of staff involved and trained
- Includes all key stakeholders at the highest appropriate levels
- Retains policy recommendation responsibilities
- Delegates operational responsibilities to the line ministries and other programme implementors rather than becomes an implementing institution in its own right.
- Forms subcommittees/ taskforce/ adhoc committees to address technical matters, specific crosscutting initiatives, or issues with a particular thematic focus and which are of national importance.

This proposed inter-ministerial committee would also constitute a platform

- To oversee the elaboration of national reports under the various conventions
- For the dissemination of COPs decisions and the internalization of the relevant ones.
- For the dissemination of training and other material by beneficiaries to all relevant stakeholders
- To enable discussion and consensus building on cross sectoral issues and targets

4.3.2 Activities around which institutions can work synergistically

Within the overall framework of policy-making, planning, and implementation of the Rio instruments and other sustainable development-related conventions, there are several core activities for which capacity limitation exist and which are particularly amenable to the search for institutional synergies. Most of the thematic assessment reports confirmed the capacity limitations under the following commonalities. These include

- Education and awareness-raising
- Data management, Information access and networking (include data collection, quality control and archiving)
- Training and re-training
- Joint Research Programmes

Possible synergies under the above referred cross cutting issues have been further elaborated in the sub section that follows.

4.3.2.1 Education and Public outreach

Raising awareness of the three conventions at the national level can be achieved through media, fact sheets, public relations materials, video, radio programming, and other means. Such initiatives can be carried out jointly by a team comprising representatives from the key stakeholders and the local media. A number of environmental events such as the World Environment Day, World Biodiversity Day, World Wetland Day, World Water Day, World Meteorological Day, Drought and Desertification Day etc. are celebrated every year by key stakeholders. Such events can also be used to promote the 3 Rio Conventions.

The Ministry of Education and the Mauritius Institute of Education in collaboration with other key stakeholders undertake curriculum development programme for the primary and secondary level (Form I to III) for the Republic of Mauritius. For the tertiary level, the curriculum is devised by the institutions concerned in collaboration with their respective partners. The various curriculum formulation teams may also consider the development or adaptation of existing curriculum at all academic levels of issues addressed by the three instruments (for example, expanded curricula in environmental studies and science, biology, chemistry, physics, forestry, climatology and science of climate change, environmental law, policy analysis, and other allied fields reflecting requirements under the conventions). However, for such synergy to happen, it would require technical inputs by the executing agencies to curriculum developers as well as capacity building for the awareness raising and education specialists.

Education on global environment issues can promote the development of an increased awareness and understanding of the impact of local deforestation, desertification and drought, land and ecosystem degradation, and climate change on sustainable development.

4.3.2.2 Data Management, Information Access and Net working

Data and information gathering, analysis, and dissemination are at the heart of the three Rio instruments. Information is essential to know what the problems are, how big they are, whether and how they are changing, and where the priorities are for action. Accordingly, the UNCBD, for example, calls for assessment of the status and trends of: “components of biodiversity” (ecosystems and habitats, species and communities, and genomes and genes); threats to the components; and sustainable use of the components. It also requires assessment of whether the benefits of using biodiversity are shared fairly and equitably, as well as of measures to implement the UNCBD. Similarly, the UNCCD calls for systematic observation of land degradation and the processes and effects of drought, as well as monitoring and evaluation of implementation measures and their effectiveness. The UNFCCC requires

reporting on greenhouse gas inventories, land use, forests, projections on emissions and sequestration, in addition to activities related to implementation of the Convention.

Information technology and the capacity to use it to respond to the Rio conventions' reporting requirement is construed key to sustainable development. Integrating capacity building and technology transfer programmes across the instruments will greatly enhance synergy and cost-effectiveness. Synergy in information systems, data management, and reporting will help ensure that investments in information management build a reusable infrastructure.

- In the case of Mauritius, in furtherance to the recommendation made in the NES (1999), the government started implementation of "the *Setting up of an Environmental Information Systems for Mauritius* (EIS)" project in March 2002 and its completion is expected around December 2005.

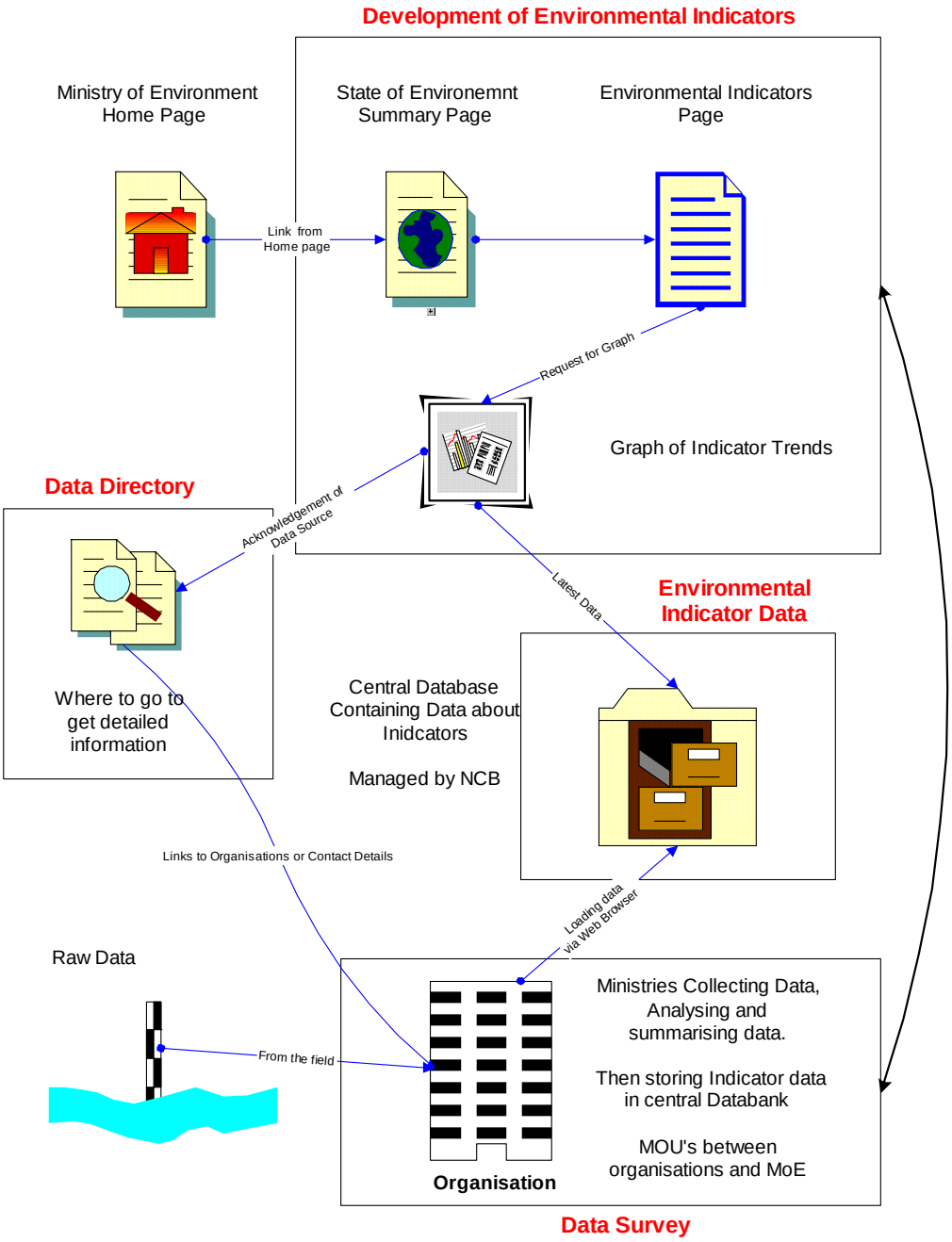

Figure 4.3: Concept of the Mauritius EIS (Source: Ministry of Environment)

The CSO, in close collaboration with the MoE & NDU, publishes an annual digest of Environment Statistics since 2003. There are various environmental indicators included in the report and it is expected that new ones, such as indicators of sustainable development and environmental accounting, will be incorporated therein. The publication is available on the Government web portal and hence it may supplement the EIS project.

The EIS being established (concept is given in Figure 4.3) consists of two main components:

- Development of a core set of environmental indicators for Mauritius and;
- Development of a computer-based environmental information system, or EIS, that makes maximum use of information technology for strategic management of the environment.

The computer-based EIS will gather and display environmental information on 32 indicators (under six areas, namely, Atmosphere, Fresh Water, Biodiversity, Quality of life; Marine Resources and Coastal Pollution, and Land and Soil) and help consolidate environmental data collected by some 28 ministries and organisations including NGOs. The stakeholders list also includes those involved implementing measures under the three Rio Conventions.

Nine critical success factors that are most important for the long-term success of the EIS have been identified and reported.

Also since a critical component of the project is to access information (in a continuous flow) from different government agencies, international organizations, foreign governments, and private business enterprises, inter-institutional cooperation is essential to the EIS project's success. Without the cooperation of these agencies and organizations, the achievements of the project will be decreased. To cater for data sharing, a data sharing Memorandum of Understanding has been developed and would be signed on a bilateral basis between the MoE and various the data custodians.

Possibilities exist for the use of the IT infrastructure (under the EIS) and also the IT facilities provided by the Government on Line Centre (GoC) for the creation of a centralized data base. With the materialization of the data sharing protocol and signatures of the memorandum of under the EIS, the data accessibility and free dissemination would become a reality.

However, one of the barriers that remain to be addressed is that there is no data exchange policy that has been developed yet. A national data policy that pays close attention to the concerns of custodians would have helped to reassure custodians that their data would not be abused or misdirected, and ensure smooth data flow. Key elements of such a policy could include issues of data accessibility, accuracy, IPR, pricing, a determination of which data sets should be supported by public investment, and minimum standards of data exchange.

Other synergy possibility that may be explored would be in terms of data and information free sharing among the existing Data Centres such as the NODC, UoM, MOI and so on. However, appropriate memorandum of agreements would be required.

4.3.2.3 Training and Re-Training

Training and re-training came out as one of the key issues in most of the thematic and sub thematic areas.

In supporting more effective implementation of the Rio agreements, capacity building would enable the development of capabilities of individuals, groups, organisations, and institutions to address environmental issues as a part of a range of efforts to promote sustainable development. The capacity needs assessment showed that capabilities which include technical and scientific knowledge, practical knowledge of resource management skills, data and information management, training on GIS, communication, technical empowerment, financial management, institutional development, leadership and management, policy development and analysis, environmental auditing and reporting, evaluation of projects and programmes, and other areas of activities would require enhancement through training to ensure efficient and harmonised implementation of activities pertaining to the general environment and also for the three Rio agreements at the national level. Any capacity building programme / activities should also include relevant partners and stakeholders to ensure the effectiveness of their participation in policies, plans, and processes affecting them.

Because there are many opportunities for synergy in joint capacity strengthening and building around the three Rio instruments, it would be difficult to justify an approach in which each instrument acts in isolation, either from the other agreements or from larger national capacity building needs and efforts. Seeking greater synergy can make the capacity building and strengthening process easier while helping ensure the development of enduring national capacities.

At the national level, adapted capacity enhancement programme could be developed on the basis of core competencies developed at the tertiary level institutions, in particular, through the two national universities. Also as is the case presently, the other local research organizations, such as MSIRI, AREU among others, even private sector organization as well as UN regional center such as the Dryland Centre can also be requested to provide courses in technical areas relevant to the three instruments to targeted audiences.

Another training tool could be course materials for technical professionals on issues relevant to the three instruments and the synergies, complementarities, and areas of overlap that exist and which can be used in structured courses, workshops, and seminars. The materials and workshops initially meant for 'Trainers' Trainings' could also be modeled on the **CC: Train**, the Climate Change Convention Training and Capacity Building Programme that produces multilingual training and information modules in

regional and national seminars and workshops on climate change and the implementation of the Climate Change Convention.

Tool such as joint exchange programmes for professionals at the national, regional and international levels on the implementation of activities under the different instruments could also be undertaken on a bilateral basis with advanced Research and Scientific centres from the developing and developed countries, thereby promoting knowledge transfer, technology transfer, knowledge hybridization while promoting either a general south- south or north-south cooperation. With such programme the 'train the trainer' approach could also be favoured. Training possibilities with research organizations need to be explored.

Some of the semi-specialized areas for which national and international capacity building supports would be required to undertake multi-institutional capacity enhancement include the following:

Biodiversity:

- Training of personnel in scientific methodology, taxonomy and biodiversity censuses
- Capacity building on invasive alien species risk assessment and management
- Training of Custom Officers to ensure control at entry points to reduce risk of introduction of new IAS. In Mauritius, Veterinary Officers and officers from Pathology Division could play an important role in controlling introduction of IAS.
- Strengthen capacity for coast guards to effectively enforce environment and biodiversity related legislations in lagoons and on islets
- Creation of field courses in ecology and conservation (terrestrial and marine)
- Training on development of improved control methods for already established IAS
- Capacity enhancement in techniques of rescuing endangered species of fauna and flora
- Training in drafting of management plan for reserves, preparing project write-ups and report writing
- Capacity enhancement in management of reserves

Climate Change:

- Capacity enhancement at relevant organizations on CC impacts, deployment of latest technologies and in the identification of vulnerable areas and mitigation analysis

- Capacity enhancement in CC Science, trend analysis, forecasting, handling existing climate models (including GCM) and downscaling from regional scale to island scale, scenarios building, GHG inventory and use of climate models with the appropriate spatial details
- Development of relevant climate change indicators and make projections of future climate (including forecasting climate hazards and climate extremes) and sea level rise
- Capacity enhancement for the development and implementation of a national mechanism for carrying out Energy Audit or Assessment and Review (including best management practices)
- Capacity enhancement to assess the effectiveness and appropriateness of the alternate transport technologies and also other options such as decentralisation
- Development and mapping of vulnerable areas of coastal zone (vulnerability atlas) on the basis of CC scenarios
- Capacity enhancement in developing and using environment friendly technology such as renewable energy sources

Land Degradation:

- Training on integrated coastal zone management, coastal zone planning, coastal erosion assessment and abatement techniques
- Training of farmers on sustainable agricultural practices (high relevance for Rodrigues, may be in terms of vocational training - type courses)
- Raising awareness among farmers on erosion control methods
- Inclusion of module in 'Soil erosion and conservation' in BSc/ and/or MSc courses related to Agriculture/ Environment
- Capacity building in the development of strategies for controlling and/or mitigating land degradation, with inputs from foreign experts
- Training of private sector people on Sustainable Forestry

4.3.2.4 Research

Research and development in the form of research and systematic observation (article 5 of the UNFCCC), research and training (article 12 of the UNCBD) and research (article 17 of the UNCCD) also lie at the centre of the three Rio conventions.

Support to targeted research along with development of new models of partnership and cooperation in order to strengthen capacity building in the fields of scientific research and development, information collection and dissemination is essential to enable stakeholders to bridge the knowledge gaps as well as ensure sound implementation of relevant measures and activities in line with the requirement of the three Rio conventions.

Presently, most of the institutions having the responsibility for the implementation of the various measures pertaining to the 3 Rio instruments do conduct research and related activities that are in line with their institutional mandate. However, these efforts are not necessarily addressing the relevant cross cutting requirements. One obvious example is

that climate related data, bio and physico-chemical fisheries data or even socio economic data, etc., are all collected and analysed with hardly any appropriate inter sectoral correlation established. Cross sectoral correlation of data for the various thematic areas is much needed especially as part of the adaptation response strategy to climate change.

According to the IPCC[9], there is high probability that recent regional changes in climate, particularly increases in temperature, have already affected many physical and biological systems around the world. Examples of observed global changes include shrinkages of glaciers, thawing of permafrost, later freezing and earlier break up of ice in rivers and lakes, lengthening of mid latitude of growing seasons, declines of some animal and plant populations, and earlier flowering of trees, emergence of insects and egg-laying in birds. Moreover, there are preliminary indications of socio-economic impacts due to recent changes in climate that have resulted in increased frequency of floods and droughts as well as deterioration of ecosystems on which people depend for their livelihood. At the local level, a number of observations made indicate that climate change is already happening namely, increase in fish (juvenile) mortality, insect pest attack to endemic plant in the BRGNP and upper Plaines Wilhems a couple of years ago, a rise in average air temperature of the order of 0.5°C during the last decade, a reduction trend in annual rainfall since the mid eighties, an increase in the number of storms reaching tropical cyclone strength and an increase in the frequency of extreme climate/ weather events.

While the magnitude of adverse effects from climate change remains uncertain, Mauritius just like other SIDS developing countries is generally perceived to be at greater risk. These impacts would add to the many other stresses that are already being faced.

Projected adverse impacts of climate change may include reduced crop yields, a decrease in water availability in already water scarce regions (higher risk of saline intrusion in coastal areas), an increase in the number of people exposed to vector-borne diseases (e.g. malaria and chikungunia) and water-borne diseases, an increase in the risk of flooding and other natural disasters from both heavy precipitation events and sea-level rise, and an increase energy demand for space cooling due to higher summer temperatures. Moreover, the rate of climatic warming may exceed the rate of shifts in certain species ranges, resulting in irreversible damage to or loss of these species if they are unable to adapt.
While ecosystems can, to a certain extent only, adapt naturally to changing climate conditions, the capacities required for assessing the extent of impacts and capacities in terms of technology and tools to implement the effective options would be required. Jointly undertaken research would be much needed to establish cross sectoral correlation Such targeted research programme and national efforts can generate a number of both direct benefits and secondary ones while avoiding duplication of efforts. Likewise, existing facilities and laboratories can be optimized and the shrinking fund can also be judiciously used to generate results that would be beneficial on a wider scale. Jointly undertaken research efforts just like integrated cross sectoral policies and programme, can reduce pressure on resources, improve management of long and short term environmental risks, as well as enhance adaptive capacity.

Areas for which possible joint targeted research of relevance to all 3 Rio Conventions could be undertaken include:

[9] IPCC. 2001Climate Change 2001: Impacts, Adaptation and Vulnerability- Report of the IPCC Working Group II

Climate Change *related ones are:*

i. Formulation a national research plan to undertake research and development on climate change impacts (while adopting an integrated approach and compliant with our commitments under the Rio conventions) with aims such as development of climate change indicators, projections of future climate changes and sea level rise and vulnerability assessment for the vital economic sectors
ii. Research on the relationship of global warming and tropical cyclone intensity in the South West Indian Ocean. Study of any shift in the regions of cyclogenesis and any increase in the number of tropical storms
iii. Research studies of the migration of tuna in the Indian Ocean in the event of a change in the sea surface temperature and sea level rise

Energy *related ones are:*

i. Breeding of sugar cane for producing new varieties with higher fibre content to generate more bagasse and/or for ethanol production
ii. Biomass and bio-diesel production
iii. In depth research and studies from a technical, economic and financial point of view of promising low-emission technologies focusing on renewable energy (solar, hydro, wind, and marine-based energies)

Vulnerability and Adaptation *related ones are:*

i. Further research to understand the potential impacts of climate change on coastal ecosystem and marine resources

ii. Further joint studies/research on the impacts of climate change on the hydrological cycle and on the fresh water availability including groundwater in coastal aquifers

iii. Targeted research to establish information systems, simulation and modeling to build up predictive capability to improve environmental management (e.g. using climate change models to improve value- added benefits of coastal zone planning)

iv. Further research to quantify vulnerability and adaptation of sugar cane and other crops (non-sugar crops) to climate change. Research should also be done to evaluate and quantify the change in yield

v. Further research on diffusion of agrochemicals and other nutrients

vi. Research to improve understanding of the response to global warming, climate change and climate variability and establish links to human health

vii. Further study and research on the reciprocal impacts between tourism and climate change. Such studies should be carried out in collaboration with public and private sector, academics, research institutions, NGOs, local people, and associations of hotels.

viii. Research studies on the impact of lagoon water warming on coastal fisheries

ix. Research studies on the impacts of loss of wetlands on fisheries

x. Modeling of lagoon dynamics with different climate change scenarios and sea level rise.

xi. Targeted research to identify and assess impacts of natural ecological disturbances and effects of human stresses

xii. Further studies/research on the impact of global warming on fish population

xiii. Targeted research to identify and assess impacts of IAS on natural ecological ecosystems (managed and non-managed)

xiv. Development of a national network of protected areas and buffer zones to allow natural ecosystem adaptation

Land Degradation:

i. Long term studies and research on the vulnerable beaches (including sediment dynamics, beach profile and so on)
ii. Long term studies on soil erosion on the major soil types and microclimates of Mauritius and Rodrigues, under different land uses and different crops or cropping systems
iii. Development and experimentation on strategies for controlling/ mitigating soil erosion and other related problems, such as soil quality degradation, nutrient losses, pollution of water courses, etc.
iv. Use of data collected in the above studies for the calibration and validation of soil erosion models, with the ultimate goal of using the calibrated models for scenario modeling
v. Long term studies on native forest degradation and ecosystem restoration (including wetlands)

Chapter V
Strategic Recommendations for Capacity Building to Protect the National and Global Environment

5.1 Policy Context

Since the first National Environment Policy for the Republic of Mauritius was defined in 1991, Mauritius has made considerable progress towards achieving sustainable development through the safeguarding of health and welfare, conservation and management of environment and natural resources in general and upgrading of the quality of life for all people.

By making sustainability an integral element in many policies, it has been possible to bring some changes in the general public behaviour, keep the air and water clean, protect the biodiversity, preserve sensitive ecosystem, and make a contribution to world environmental quality by energy conservation and the development of local renewable sources of energy.

A number of environment and the Rio Agreements related measures have been implemented by national executing agencies in collaboration with national actors as well as with international technical and financial assistance. However, implementation of other strategic recommendations and measures made under the following national reports and for which capacity building at the systemic, institutional and individual levels lies at the centre of the strategic reports and recommendations, such as, in the National Environmental Strategies, the National Development Strategy, the Tourism Development Plan, the Sugar Sector and Non Sugar Sector Strategic Plans, the Technology Needs Assessment, the draft final National Biodiversity Strategy and Action Plan, and the Integrated Electricity Plan, amongst others still remains.

Funding and capacity building remain amongst the two key limiting factors.

5.2 Systems and Institutional Framework

Although environmental policy statements continue to demonstrate a high level commitment to maintaining environmental quality, in practice, many environment related initiatives which are generally implemented by some 20 directly responsible organisations have met with varying degrees of success.

The most common causes for not having full satisfaction with implementation and enforcement measures and which need to be addressed include:

- Insufficient staff numbers, shortage of qualified and experienced staff in the executing agencies with responsibility for policy formulation, management and enforcement.

- Inadequate tools, equipment and logistic facilities to sustain or implement field works pertaining to management of general environment and sectors related to the three Rio Conventions.

- High turnover rate of trained staff in certain sectors

- Inadequate information and knowledge sharing

- Absence of long term human resource development plan at the key executing agencies

Under a '*business as usual*' scenario with the likely growth in the various socio-economic sectors, namely, housing, industry, transport, tourism amongst others to continue, without appropriate capacity enhancement programme to manage the environment, then quality of available limited resources would come under serious pressure.

The National Environmental Strategies recognises that overall failure to strengthen environmental management could lead to economic losses of over Rs. 3 billion/ year with deterioration in the coastal zone and marine ecosystem being among the most dominating factor. Similarly, in a '*do nothing*' scenario, the value of the terrestrial biodiversity resources could be reduced by 50% by the year 2010.

Long term and dynamic capacity building approach would be essential for institutional as well as human resource sustainability. Long term Human Resource Development plans would be required for the various thematic areas.

Implementation of the various strategic recommendations under this NCSA report would be complementary to the already existing capacity building initiatives. The following institutional arrangement would be required for the implementation of the recommendations:

Setting up of a local conventions secretariat at the Ministry of Environment and NDU, to enable the Ministry to fulfil its responsibility as lead agency for environmental management in the Republic of Mauritius. The secretariat would require staffing with 3 officers. The conventions secretariat would be required to act as a secretariat for the Inter - Institutional Coordination Committee recommended (*refer to Section 4.3.1 and Figure 4.2*) and it would be primarily responsible for the monitoring and coordination of measures implemented at the national level and also act as a network facilitator in the creation of a national information and knowledge network for the dissemination of relevant COPs decisions, SBSTTA recommendations, UN Conventions' Secretariat communications and guidance notes and other relevant documents for the three Rio Conventions in the first instance to all stakeholders. The Secretariat would operate on a fast track mode to ensure fast information flow to ease a rapid decision making process at the national level. The local secretariat would also require IT and internet facilities.

- In the line Ministries and organisation having the key executing role, the establishment of relevant convention desk. Such desk would be also responsible for internal coordination and reporting of measures pertaining to their specific areas of activity. The desk would also be required to explore synergies at field implementation and grass root levels in line with the recommendations made in this report.

- Sub thematic coordinators for the 9 sub thematic areas to be elected from the actors involved in the respective thematic areas. The sub thematic coordinators would have the responsibility to chair sub thematic consultations being convened to discuss issues pertaining to the relevant Rio Conventions.

- The three UN Conventions Secretariat and also the government be requested to consider as appropriate, the support of more than one participant to attend technical and COPs meetings to enable effective participation as relevant issues are often discussed concurrently. Government needs also to consider the participation of one RRA representative in such meeting as this would ensure capacity building and facilitate implementation of measures in Rodrigues.

Concerning the regulatory obligations pertaining to general environment and the three Rio Conventions, achieving full compliance should go beyond command and control mechanisms. A range of approaches can be adopted, including, voluntary agreements, incentives and support to initiatives through pilot programmes and demonstration projects. Such approach should draw in private organisations, NGOs, Research organisations, academics and individual as well as the core organisations.

5.3 Synergy Opportunities for Cross Cutting Activities

The Republic of Mauritius can take advantages of the complementary provisions of the Rio Conventions while reducing any potential conflicts. The environment related measures can be implemented in ways that can improve cost effectiveness by achieving the same or greater results with fewer or the same resources.

The synergy process does not need to end with the Rio instruments and can be extended to other international agreements such as the Ramsar, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on the Conservation of Migratory Species (CMS), the African Eurasian Waterbird Agreement (AEWA), the Montreal Protocol, and the Law of the Sea conventions amongst others.

However, the two requisite conditions strongly needed to take advantage of these overlaps and development of synergies, would be strong political will and the change in attitude for a smooth information flow, sharing and dissemination.

In terms of institutional synergies, a strong coordination and leadership would be required by the Ministry of Environment and NDU. The proposed institutional mechanism offers a number of benefits and would also eliminate the weaknesses identified earlier. It would bring both vertical as well as horizontal synergies at the national level. The setting up of the Inter-Institutional Coordination Committee would add further democratisation in terms of participation, cross fertilisation in the management approach and last but not least, add the sustainability and transparency dimensions in the national coordination process.

For the various activities around which synergies can be developed by optimising the available resources and facilities, it proposed that the Inter-Institutional Coordination Committee assigned three independent adhoc committees or task forces to come up with priority measures to be implemented as part of national capacity building programme. The three areas concerned would be:

i. Public outreach and education
ii. Training, Re training and skill enhancement
iii. Joint targeted research programme

5.4 Biodiversity

It is being increasingly recognized that mankind is living in an unprecedented period of mass extinction driven by the actions of humans on their environment. Species extinction rate is today at least 1000 times higher than the natural rate due to human-caused habitat destruction, fragmentation and degradation along with overexploitation, introduction of alien species and spread of diseases (Primack, 1998).

Mauritius has initiated and implemented a number of bold measures meant to at least reduce the loss in biodiversity. In a number of cases, biodiversity rescue missions were carried out with the support of international agencies and in partnerships with local NGOs. These initiatives have allowed a number of endangered species to be saved from the brink of extinction. However, biodiversity still remains one of the national priorities (NES, 1999 and Draft final NBSAP, 2003) and capacity strengthening at the individual, institutional and systemic levels remains the key challenges towards reversing the habitat degradation and loss of biodiversity resources in the Republic of Mauritius.

The approach for capacity building under the four sub thematic areas relevant for Mauritius is discussed below.

5.4.1 Forest/ Terrestrial Biodiversity

On mainland Mauritius, the native terrestrial biodiversity is today mainly confined to marginal lands of low suitability to agriculture such as steep mountain and valley slopes or to marshy and rocky soils where the land is relatively flat. The largest such area occurs in and around the Black River Gorges National Park in the South West, followed by the Bambou Mountain Range in the South East and the Moka-Port Louis Ranges in the North West. A few isolated mountain peaks also harbour remnants of native forest, for example, Mt Blanche, Corps de Garde, Trois Mamelles and Le Morne Brabant. Several lagoon and offshore islets also has important biodiversity value, although all has suffered from human activities. Most of these areas, with the exception of private forest land, benefits from the management by the Forestry Services (for mainland nature reserve) while the National Parks and most offshore islets Nature Reserves benefit from management by the NPCS. Ile aux Aigrettes Nature Reserve is leased for management to the Mauritian Wildlife Foundation (NGO) whilst the Rivulet Terre Rouge Estuary Bird Sanctuary (wetland) has been declared as the first Ramsar site.

Management Plans for some of these areas exist while for the rest, they are being developed. Whilst the investment in this management has paid off in many ways, there is still room for further improvement in the area of terrestrial biodiversity resource management and promotion of its sustainable use.

Strategy elements to bridge the capacity gaps and weaknesses identified at the systemic, institutional and individual levels are given below:

Systemic Level

- Strengthening the management of remnant native forest, of which only 2% is currently being managed for conservation (0.04% of Mauritius). Large scale in-situ biodiversity conservation is a must if Mauritius is to minimize costly hence unsustainable species-targeted conservation. Adaptive management plans for existing protected areas would need constant development and fast implementation approach adopted. CMAs would need also to encompass a larger array of vegetation types and different regions than the south west in order to better conserve all existing community types as well as intra-specific (genetic level) diversity. Larger scale restoration (which could also include job creation) including new areas to be protected and managed for conservation, such as biodiversity rich mountain reserves and dry lowland forest; creation of habitat corridors between isolated fragments and implementing new concept of micromanagement as recommended by National Threatened Native Plant Committee.

- Harmonisation of institutional mandates in the area of terrestrial biodiversity conservation. In Mauritius, the conservation activities appear to be too heavily influenced by organisations working within their particular field of expertise. The need to work within an overall national framework is very vital and each and

everyone's roles have to be clearly defined. Improved legislation is required to harmonise management of National Parks and Nature Reserves which ideally should be performed in such a way to optimize on core competences through enhanced collaboration of the agencies involved and thereby avoid duplication of efforts and minimize wastage of resources. Creation and maintenance of inter institutional committees and streamlining of bureaucratic procedures where possible to improve fruitful collaboration.

- Invasive alien species (IAS) currently constitute the single most important threat to Mauritian native terrestrial biodiversity. There is an urgent need to exert tighter control over entry of further potential pests in the country and to control pests already established. There is a need to pass an adequate IAS law in the country to provide provisions for preventing entry of new pests and to control/eradicate pests already present and raise public awareness about negative impacts of IAS on native biodiversity. Experimentation of new potentially cheaper weed control measures and contractual mechanisms (as recommended by Wildlife & National Park Advisory Council) need to be pursued while capacity building for customs officers, officers of Plant Pathology and Veterinary Divisions is a must.

- Inadequate forest legislation for protecting biodiversity on privately owned forest land. There is a suspected important loss of biodiversity in unprotected privately owned forests. Proportionally substantial areas have and are still being cleared to make way for pastoral development, hunting scheme, and agriculture. The legislation should also enable surveys to be undertaken for biodiversity resources of privately owned land to assess their biodiversity values for eventual conservation prioritisation and whilst devising incentives to encourage private land owners to conserve biodiversity on their land.

- Legal protection to be extended to many more threatened species in the ecosystems and penalties increased for law contraventions

- Improvement in museum infrastructure and curation facilities as required whilst strengthening of links with the Natural History Museum is also essential

- Promote and support *ex-situ* propagation/breeding mainly as a tool for *in-situ* conservation

- Explore and develop ways by which ecotourism can benefit native species conservation on Mauritius.

- More institutions to develop a biodiversity research oriented component with increased institutional collaborative research to avoid duplication

- Encourage partnership of international NGOs with local organizations involved in biodiversity conservation and thereby benefit in terms of international expertise and local capacity building. This approach would also increase prospects for careers in conservation related jobs (both technical and managerial).

- There is insufficient data collection and research on the forest ecosystem to inform on adaptive management. There is a major need for more data to facilitate decision making and these are seriously lacking.

- Need for a comprehensive inventory on all aspects of Research and Development undertaken by all concerned organisations

- A national biodiversity inventory will have to be initiated/ undertaken especially on privately owned lands where access is traditionally difficult, and consequently poorly known

Institutional and individual levels

- There is an imperative need for specialised training. Very few local actors in ecology and conservation have received specific postgraduate training in these fields. This results in an unfortunate heavy dependence on external expertise. More competence is particularly required in the following fields: taxonomy (particularly marine and invertebrate), soil biodiversity, conservation biology, and restoration ecology. Improvement of local capacity through creation of courses in ecology and conservation for professionals (including training of personnel in taxonomy), setting up general elective module on native biodiversity and conservation at the relevant tertiary institutions would be essential. Training must be extended to NGOs.

- Training of NPCS and FS staff as well as other involved stakeholders in the drafting of management plans for Reserves and the terrestrial/ forest ecosystem.

- Promote research within the FS and NPCS. Research in taxonomy, ecology, ecological restoration and conservation biology should be carried out. Scientific research based on sound and rigorous techniques and adequate interpretation of the data generated is essential in improving output. Further institutional strategies with skilled technicians and researchers would be required. The creation of Research Unit within the Forestry Service and the NPCS would be strongly recommended.

- There currently exists a generally low public awareness on the importance of biodiversity and the need to conserve it. This in turn can undermine political will while being directly detrimental to biodiversity itself. Involvement of volunteers in conservation work (as discussed on Wildlife & National Parks Advisory Committee) and development of community based conservation projects need to be pursued.

5.4.2 Inland Water, Coastal and Marine Biodiversity

Fresh Water Biodiversity

The freshwater biodiversity of Mauritius is mainly contained within some 90 rivers and rivulets for Mauritius and 43 for Rodrigues and also in several man-made reservoirs like

La Ferme and Mare aux Vacoas, natural lakes such as Bassin Blanc Crater lake, as well as ponds and marshy areas.

Eight endemic Vacoas species (*Pandanus* spp.) survive out of the ten known that grow in marshes and streams or are restricted to wet places or very close to rivers. All the eight surviving endemic *Pandanus* spp. are present with half of them maintaining world populations estimated at 200 or less, including *P. palustris* with only about 30 known individuals (Bosser and Guého 2003).

According to the Flore des Mascareignes (1974 onwards), there are also an additional 24 native higher plant species from 14 families that is strongly associated with freshwater ecosystems (excluding the Cyperaceae). Of the 24 species mentioned above, only three are endemic to Mauritius, including one, which appears to be extinct (*Eriocaulon johnstoni*). Another species is endemic to Mauritius and Réunion.

For the vertebrates, in contrast with the terrestrial vertebrates, the freshwater vertebrate fauna of Mauritius is markedly low in diversity and endemism. Of the 18 fish species found, none of the remaining 13 native fish species found is endemic to Mauritius. However, two are Mascarene endemics and another two are endemic to the Mascarene-Madagascar region. The others are of much of wider geographic distribution. It is interesting to note that a genetic study is underway to determine whether one of the Mascarene endemic fish species could not in fact comprise two species, one endemic to each of Mauritius and Réunion.

Regarding population densities, an alarming trend was revealed whereby most native fish species occur in far lower numbers in Mauritius than in corresponding habitat types on nearby Réunion. This situation seems attributable to a greater extent of habitat degradation on Mauritius caused by domestic, industrial and agricultural pollutions as well as other activities like the use of river water for irrigation or to produce hydroelectric power, which decrease both the area and quality of habitat.

In the case of invertebrates, three species out of ten macrocrustaceans belonging to two families (the Atyidae, with six Caridina spp. and one Atyoida) and the Palaemonidae (with two Macrobrachium and one Palaemon are endemic to Mauritius, and one to the Mascarenes while the rest are from of Indo-Pacific distribution. Most of these species occur at higher densities than in corresponding habitats on Réunion, which bodes well for their future. However, the edible 'Camaron' (Macrobrachium lar) is now rather rare as a result of its exploitation.

Regarding fresh water molluscs[10], *as at date*, 18 species of freshwater and one of brackish water snails are known from Mauritius. This includes seven introduced and one cryptogenic species. One of these alien species (the Golden Mystery Snail *Pomacea bridgesi*) appears to have naturalised recently having been first recorded in the wild in 1999. The case of *P. bridgesi* is a strong signal that adequate control on importation of aquarium and pet species is currently still lacking. Only one of the ten native species (the planorbid *Gyraulus mauritianus*) may be endemic to Mauritius. Rodrigues has a poorer freshwater malacofauna consisting of six native species of which one (*Afrogyrus rodriguezensis*) is endemic to the island. The rest are all common and widespread

[10] The information presented in this section is based on unpublished data from Griffiths and Florens (in prep.).

species. Three freshwater snail species have been introduced and are now naturalised in Rodrigues' rivers.

With the exception of wetlands, the fresh water biodiversity suffers a complete absence of an appropriate policy, institutional and regulatory frameworks for its protection and conservation of its living resources. On noticeable observation that could be noticed is that no institution has been mandated so far to address fresh water living biodiversity resources. The full biological and economic potential for this sector still remain to be fully assessed and optimized. On the other hand, there is a number of legislations pertaining to the management, use and control of fresh water bodies.

The strategy recommendations for the fresh water ecosystem include:

- Creation of a desk or preferably a Unit within the AFRC in collaboration with other key stakeholders to manage and come up with a fresh water aquatic resources conservation and management plan

- A legislative review would be needed to give clear mandate to the AFRC of the Ministry of Agro-Industry and Fisheries for the conservation and management of fresh water biodiversity resources.

- Capacity buildings in term of technologies needed and training of Officers working in the Unit dealing with fresh water biodiversity. Possibilities can be explored through bilateral technical cooperation with Indian and East Asian countries.

- Development of a programme for a comprehensive fresh water biodiversity resources assessment in Mauritius and Rodrigues

- Development and implementation of a targeted research and management plan for the sensitive fresh water ecosystem, including inland wetlands.

Coastal and Marine Aquatic Biodiversity

To date, only 1700 marine species have been recorded around Mauritius including 786 fish of which about 5% are of commercial value (42 species). Seven species of shrimps of the genus *Penaid* are known next to Mauritian shores and two inhabit deeper waters. There is also one endemic species of oyster (*Crassostrea edulis*) recorded so far.

Sea turtles which used to come to lay their eggs on Mauritian beaches in large numbers have suffered intense hunting pressures and depredation by alien animals and have virtually vanished (Cheke, 1987). Some turtles breeding on other islands of the region (e.g. St Brandon, Europa) do forage in Mauritian waters. There is however one encouraging recent record of turtle laying eggs in Mauritius. Both the Green Turtle (*Chelonia midas)* and the Hawksbill Turtle (*Eretmochelys imbricate)* have been re-declared protected species under the Fisheries and Marine Resources Act of 1998.

The primary mechanism for conservation of biodiversity and maintaining ecological functions is the establishment and management of protected areas. There is only 2 Marine Parks (none in Rodrigues) covering an area of 838 ha. There are also six fishing reserves around Mauritius, covering an approximate area of about 60 km^2. A long-term

monitoring of corals, benthos and fish population and water quality in the two marine parks has been established.

On the enforcement side, a Unified Enforcement Unit has been established since June 2004 for the Blue Bay Marine Park. The unit works on a 24 hourly basis and it comprises of the Fisheries Protection Service, Police de L'Environnment, Police du Tourisme, and the National Coast Guard (NCG). However, the Balaclava Marine Parks also requires a strengthened enforcement.

Seawater quality is also being monitored in fourteen sites around Mauritius while monitoring of coral growth and recruitment are activities carried out at eight dedicated sites in Mauritius.

In terms of new institutions created to support this sector, an ICZM Division was set up at the MoE in 2000 and an ICZM committee was constituted in 2002 further to the promulgation of the EPA 2002. While in 2005 a Coastal Zone Management (CZM) Division has also been created at the AFRC, Ministry of Agro-Industry and Fisheries.

The marine and coastal aquatic biodiversity sub-thematic area still faces a number of capacity constraints. In this sub-thematic area, conservation and management of the biodiversity resources is seriously limited on account of the relative complexity as compared to other terrestrial conservation measures, inadequate funding resources and also inadequate professional staff. Other noticeable weaknesses that were noted included inadequate collaboration in the area of conservation and research. So far it is the sustainable use aspect of marine resources that have been rightly holding greater priority.

The strategy to address the issues and weaknesses at the various levels has been discussed below.

A. Promote conservation and management of marine biodiversity resources

- Development of a framework for the establishment and legal protection for new protected areas including marine site of high ecological and global importance, wetland sites, river and lake (freshwater ecosystem)
- Improve management of MPAs through appropriate training and logistic supports to undertake field works
- Preparation and implementation of the Marine Parks Management Plans coupled with provision of logistics and equipment for their management
- Development of partnership management approach with all stakeholders concerned, namely fishers, hotels, divers etc.
- For newly declared Islet National Parks which also include management of 1 km aquatic area from the shore, development of conservation and management programme
- Harmonise management of islets with marine component
- Institutional strengthening required as 'ageing' workforce at key institution such as Albion Fisheries Research Centre is already visible.

B. Completion of inventory for the aquatic biodiversity

The lagoon has algae and crustacean of high quality which are not exploited. Appropriate survey needs to be done to know the species diversity and their potential for exploitation. Such possibilities may exist for other potential resources.

The recommendations are:

- Development and prioritisation of a long term and well coordinated inventory programme
- Encourage community participation and enroll traditional knowledge
- Technical and financial support to continue systematic inventory with particular attention to poorly studied groups
- Improved museum infrastructure together with appropriate training for improved curation
- Strengthening of links among inventory stakeholders, including Natural History Museum, MOI, NGOs, Min. of Fisheries, Mauritius Herbarium, UoM, knowledgeable individuals.

C. Capacity strengthening to mitigate ecosystem degradation

Systemic

- Development of alternative fisheries, including the development of mariculture further to a full assessment of its impacts and potential. Studies to identify other diversification possibilities towards other form of aquaculture (shrimps and octopus) and also commercial algae production to be pursued.
- Regulation to control activities that damage marine life, e.g. ski lanes, undersea walk and other water sports activities
- Strengthen enforcement to allow for an integrated abatement of industrial and domestic pollution through provision of training and equipment
- Protection of threatened species and habitat restoration/management (rivers, wetlands, lagoons). Legal protection extended to many more threatened species and increased penalties for law contraventions.
- Creation of more environment friendly mooring points in the lagoon and outer reef areas
- Zoning and maintenance of areas of high ecological importance for various uses
- Development of a wetland restoration plan (including mangroves)
- Re-vegetation of coastal areas with appropriate native species
- Continue creation and monitoring of artificial reefs as part of a long term programme
- Bridging knowledge gaps on ecosystem through training to allow better assessment and rehabilitation

- Promote sensitisation and awareness for the various decision makers, promoters and aquatic users including tourists. Promote protection and restoration of aquatic ecosystems (fresh water and coastal) through a variety of means including education

D. Strengthening enforcement to combat illegal fishing in outer islets

Systemic

- Develop and implement conservation programme for the outer islets
- Establish monitoring programme for the outer islands together with provision of *in situ* facilities, equipment and trained manpower
- Increased penalties to truly discourage illegal fishing and poaching
- Strengthen capacity for coast guards to enforce laws in lagoons and on islets
- Sensitization campaign for fishermen and community at large
- Enhanced collaboration with neighboring countries to achieve effective EEZ surveillance
- For leased islets, to include marine conservation measures in lease agreement.

E. Invasive Alien Species

The risk of introduction of IAS is very high, with many species deliberately introduced for example for the aquarium trade without prior assessment of their potential invasiveness. Monitoring for IAS appears inadequate. On the marine side, the risk of introduction is mainly through ballast water discharge. A committee on this subject has been set up in 2003 under the aegis of the Ministry of Shipping.

The recommendations at the ***systemic level*** are:

- Establishment of a dedicated team to assess and monitor IAS (marine). This team maybe called upon to raise public awareness about negative impacts of IAS
- Passing of an adequate IAS law in the country and provide provisions for control/eradication of already present pests
- Control commercialization and use of potential IAS (only allow for those whose risk have been assessed)
- Legal blacklisting to prevent entry in the country of species likely to pose serious threats to native biodiversity
- Effective control at airport and seaport to reduce risks of introduction of new IAS including training of customs officers
- Development of a mechanism to enable detection of new pest
- Provision to have the appropriate technologies (e.g. scanner) at the airport and seaport to detect IAS

F. Capacity building through specialized training

Mauritius has benefited a number of technical cooperation programmes from JICA as well as other organisations with regards to the marine sector. However consultations revealed limited expertise still prevailing in a number of specialised fields.

Areas where expertise as well as knowledge is limited include:

- Taxonomy (coral, fish and algae)
- Coral, mangrove, seaweed, sea-grass and other ecosystems
- Habitat Restoration
- Coral Reef Management
- Integrated Marine and Coastal Areas Management
- Mariculture in the open sea
- Framework for establishment of MPAs
- Wetlands Management
- Development of Indicators and benchmarking
- Sampling techniques for verification of compliance of ship with ballast water exchange controls
- Techniques for detection of potential invasive species in ballast water
- Techniques for treatment of ballast water
- Training on exogenous factors such as oil spill and others that can impact on marine biodiversity

G. Targeted Research

The formulation and implementation of a long term targeted research plan is recommended. Some of the areas could be to be covered include

- Establishment of bioregions of national / global importance and also corridors for whale and dolphins
- Ecosystem restoration (including coral transplant)
- Population dynamics
- Impacts of mariculture (need for research on associated impacts concerning antibiotics, hormones, and eutrophication).
- Invasive Alien Species
- Long term monitoring of ballast water
- Establishment of bio-indicators for the monitoring of the state of health of marine ecosystems

5.4.3 Agricultural Biodiversity

Agro-biodiversity is mainly dominated by sugarcane and to a varying extent by species belonging to plants, and farm animals that were introduced as food crop and agriculture.

The agricultural biodiversity in Mauritius is managed mainly by the Plant Genetic Resources (PGR) Unit of the Ministry of Agro Industry and Fisheries (Agricultural Services) in collaboration with other relevant national actors. Genetic materials, both wild and cultivated species are collected, characterized and stored in a Seed Gene Bank at Curepipe Experiment Station affiliated to the SADC Plant Genetic Resources Centre

for sustainable use. The PGR unit also undertakes rescue missions of endangered species through both conventional and biotechnological means. The unit has field gene-banks of clonal propagated species together with a collection of medicinal plants that are awaiting documentation in the expectation of the adoption of rights as specified in the Treaty of Access to Plant Genetic Resources 2001. The Quarantine Service of the Ministry of Agro- Industry is also responsible for bio-security including controls on the accidental and deliberate importation of alien species through sea and airports whilst an inter ministerial committee under the aegis of Ministry of Shipping is currently working on ballast water standards.

However, the NCSA process confirmed that capacity enhancement as recommended under the Non Sugar Sector Strategy Plan, would be essential for a sound management and sustainable use of the agro biodiversity resources for the Republic of Mauritius. The causality analysis also identified a number of capacity constraints and weaknesses that has been addressed as part of the strategy for this sector.

Also, funding came out as a prime concern, as no specific funding provision on agro biodiversity is made in most of the institutions concerned. Expenses are incurred as a side issue from the main programme. It was concurred by the key stakeholders that unless financial assistance is provided, it would not be possible to make a full fledge program on agro biodiversity which would include collection, evaluation, multiplication, regeneration, storage and sustainable use.

The strategy recommendations which are presented below reflect the various discussions held with the key stakeholders.

A. Formulation of a National Integrated Policy and Long Term Planning for Agro-biodiversity (Sugar, Non Sugar and Livestock Sectors)

A number of institutions are involved in agro biodiversity activities, namely, the MSIRI, Agricultural Services, AREU and UoM. Each one has its own programme of work that suits their mandate while the Agricultural Services is responsible for managing the local germplasm.

A clear mandate for the key institutions dealing with agro biodiversity would resolve any conflicting and unclear issues pertaining to the collection, maintenance, regeneration and storage of genetic material. At the same time the records pertaining to history of introduced species can be documented and stored.

In response to the fragmentation in the approach, the need for a comprehensive policy for the non sugar sector agro-biodiversity resources that would also serve as a policy for long term planning was strongly felt.

The following measures have been recommended:

Systemic level

- Review of the existing policy on agro-biodiversity
- Creation of an agro-biodiversity secretariat to perform the role of dissemination the decision pertaining to agro-biodiversity

- Need for comprehensive and 'consistent' long term planning for agro-biodiversity conservation and sustainable use
- Setting up of appropriate coordination mechanism to bring stakeholders towards a common platform (establish a National Agro-Biodiversity Committee (NABC))
- Means to implement activities and measures identified in the Non Sugar Sector Strategy Plan with M & E programme in place
- Develop synergy between public, private, NGOs, farmers amongst others.
- Institutional roles of key actors made clear

B. ***Genetic Conservation and Utilisation/ Exploitation Activities***

Funding, appropriate infrastructure and trained staff are amongst the key determinants for genetic conservation and utilization/ exploitation activities. For Mauritius, genetic conservation and utilisation programme have been hampered by limited funds. The limited funds allocated to agro biodiversity programmes have impacted and restricted the recruitment of staff at the level of relevant institutions. As a result, various collection, conservation and exploitation activities became difficult while it has also been noted that due to limited number of qualified staff the animal genetic resources collection could not be implemented.

Genetic conservations activities also require logistics support including space, technical and financial support, human and access to information. These ingredients being inadequate in some of the concerned institutions are thus causing a delay in the desired and quick take-off required for this sector.

To enhance the conservation measures and promote sustainable use of the genetic resources, the following recommendations were made for the crop and animal sub-sectors:

Crop

Systemic level

- New breeding programme to be initiated in a number of specified crops
- Sustainable use of genetic material for improving genetic potential
- Activities to be co-ordinated with applied agriculture
- Complete inventory of agro-BD resources
- Need for special funding for projects on agro-biodiversity

Institutional level

- Increase in qualified human staff
- More funding for conservation and required infrastructures
- Dissemination and publication of research results/ data
- Specific assignments or commitments in R& D
- Improvement of facilities and infrastructure (e.g. of the crop musuem maintained by the Faculty of Agriculture of the UoM for over 40 years now)

Individual level

- Training in the following specialised areas: Ecology, Plant Breeding and Genetics, Plant Genetic Resource Management, soil biodiversity
- Providing a consistent and clear career opportunities to staff hence capitalizing on capacity building and knowledge accumulation
- Researching on problematic areas and delegate responsibilities
- Encourage networking among scientists of various institutions

Animal

Systemic level

- Comprehensive policy and strategy for the Livestock sector to be redefined and implemented
- Develop a comprehensive programme of work with time schedule
- Increase funding

Institutional level

- Clarify institutional responsibilities – Needs for clear mandate to be spelt out for various relevant institutions
- Provide appropriate infrastructure and allocate adequate fund
- Increase in number of qualified staff in institutions concerned

C. Strengthening of Regulatory Framework

Serious limitations include the absence of an Intellectual Property Right (IPR) Bill, absence of exchange germplasm mechanism and also strong need to enhance the concerted effort in producing novel seeds or agricultural practice. The regulatory framework has been further detailed under the sub section dealing with *'Enactment of legal framework and enforcement'* under section dealing with biotechnology.

The recommendations for capacity building at the *systemic level* are:

- Complete the enactment of the Seed Bill, Intellectual Property Right Bill, Farmers Breeders' Rights Bill to enable the exchange, utilisation and exploitation of germplasm
- Improve co-ordination among research institutions by reviewing and empowering the FARC in its coordination roles

D. Organisms with Medicinal Properties & Traditional Knowledge

Organisms with medicinal properties (including pesticidal properties as well), wild species and traditional knowledge are those facets of agro-biodiversity that are claimed to be neglected or not exploited to its full potential. It is also recognized that this neglect may in the long run lead to economic loss, slow loss of plants and loss of traditional knowledge which are valuable asset to the country whilst also giving rise to occurrence of bio-piracy.

The potential of organisms with medicinal properties is immense and need to be harnessed while recognizing that with the advent of modern technology valuable genetic materials are fast disappearing.

For organisms with medicinal properties and the traditional knowledge, a number of measures were concurred to address the root causes identified. These include

Systemic level

- Complementary assessment of potential organisms with medicinal properties to avoid bio-piracy
- Survey & collection of information/ knowledge from older generation before it disappears to consolidate claim property rights.
- Research intensification for practical use
- Enhance legal protection and conservation
- Inculcate values to new generation (to be backed by research) by including a topic on 'Organisms with medicinal properties and traditional knowledge' in the curriculum of primary and lower secondary schools
- Participation of private sectors
- International collaboration

E. ***Promote Targeted Research on Agro-biodiversity***

In the absence of a comprehensive research program on agro biodiversity, aspects of ecology and habitat studies which are fundamental to agro biodiversity are completely neglected.

Also educational interest on agro biodiversity is low and data collected so far are sparse and scattered.

To enable a good planning, reliable and documented data and their accessibility are crucial.

Capacities needed at the various levels are as follows:

Systemic Level

- Development of long term research plan
- Development and implementaion of education and awareness programme
- Funds to undertake targeted research

- Agrobiodiversity as part of a subject included in school curricula
- Development of guidelines and incentive mechanism to encourage conservation and management of agrobiodiversity
- Dissemination of results and easy access to a centralised data base.

Institutional Level

- Increase research capacities both in terms of infrastructures at relevant institutions dealing with crop and animal agrobiodiversity resources

5.4.4 Biotechnology

The Government recognizes that science and technology have made significant breakthroughs in agriculture, such that it would be unwise not to take advantage of their benefits. In this context, in the Non Sugar Sector Strategic Plan much emphasis is laid onto the promotion of modern technology applications in agricultural activities, one of which is biotechnology.

In order to strengthen its technology base in agriculture, the Government is coming up with a new institution, the Mauritius Agricultural Biotechnological Institute (MABI). This institute will provide a sophisticated infrastructural and strong scientific skill-base that will cater for high-caliber, applied research in agricultural biotechnology. It will focus on optimizing agricultural productivity in the non-sugar sector agricultural sector, including livestock, through the efficient application of biotechnology. With the primary objectives being to address issues of national priorities which include protection of the endemic biological diversity of Mauritius, the Institute should emerge as a 'Centre of Excellence', assuming a leading role as a service provider and know-how disseminator in agricultural biotechnology.

The need to strengthen research and development to support non sugar agricultural sector and restructure existing ones has also been stressed.

Application of biotechnology in the safeguarding of native endangered species, such as *in vitro*, tissue culture and cyropreservation techniques is presently at experimental stage. One example is the experiment on embryo culture for the last individual of the endemic palm *Hyophorbe amaricaulis*. Propagation of some endangered species are also being undertaken at the level of the Ministry of Agro-Industry.

Biosafety legislation, namely, 'Genetically Modified Organism (GMO) Act' has been enacted in November 2004 and only few section of the GMO Act came into force, i.e., the entry, transit and labeling of GMOs. Issues pertaining to the execution of the GMO Act, such as infrastructure, human and financial resources, development of guidelines and necessary training of staff (in terms of risk assessment and risk management) still need to be implemented.

The FARC has also recently (2004) came up with a research programs on Biotechnology on issues pertaining to practicing local agriculture. The initiative is noted to be very positive, however, the execution and the financing of the project still need to be finalized.

Further to the causality analysis and consultation with stakeholders, a number of issues were identified and assessed. The strategy elements required to address the capacity constraints and weaknesses have been discussed below.

A. Need for a Comprehensive National Policy on Biotechnology (with particular reference to sugar, non-sugar sector and livestock)

Amongst the key concerns noted, the absence of national policy on biotechnology, in particular on the non sugar sector, poor coordination among institutions, lack of funds, isolated research program were the prominent ones.

The need for a comprehensive policy that would provide for a long term vision for the biotechnology sector in Mauritius is strongly felt.

Also as fund is scarce and research capital extensive, it was agreed that it would be wise to provide direction to the sector through the national policy based on priorities. Hence, the need for a comprehensive policy for the biotechnology, in particular for the non sugar sector, came out as the key recommendation at the at the *Systemic level*.

B. Need for Specialised Training

With the necessary shift from passive management towards a more dynamic, proactive and interactive agro-biodiversity management and biotechnology including training in basic sciences such as bio-informatics, specialized training in the fields of agro-biodiversity/ biotechnology are strongly felt. The thrust is more so in biotechnology where a probing mind is essential. It is also essential to have a strong base in genetics, microbiology, plant and animal pathology, plant and animal breeding, and biology before biotechnology can be tackled. Therefore, these sciences as well must be emphasized.

It has also been observed that technical staff mobility in the field of agro-biodiversity/ biotechnology tend to be high and this makes the effort of capacity building stressful and less productive.

To resolve the issue it is important that long term and comprehensive approached is adopted with continuous training programme established such that a solid legacy can created.

The recommendations include:

Institutional level

- Need for specialised training to enable relevant advanced research on molecular biology, gene transfer, DNA analysis.
- International assistance to support the ongoing specialized training

Individual level

- Incentive mechanism to be developed with appropriate career path for staff (to enable staff retention and to reap from the investment on staff training)
- Collaborative net-working among scientists of various institutions

C. Enactment of legal framework and enforcement

To keep in line with requirements of the CBD, the Cartagena Protocol, the international treaty of Plant Genetic Resources and TRIPS (Trade Related Instrument to Property Rights System), Mauritius needs immediate attention to the enactment and implementation of laws regarding IPR, conservation and exchange of germplasm, and other related aspect of agriculture pertaining to trade. In the absence of these laws various institutions are handicapped in their developmental research where IPR restricts the flow of germplasm and also for other facets of research procedures. Indeed, the Property Right regimes over biological resources and associated knowledge constitute the main theme of regulation both at international and national level.
Some draft legal texts such as the Breeder's Rights with the inclusion of transfer and management of PGR, Plant's Quarantine and Seeds Bill have been worked out. Care has been taken to include international, regional and local obligations. As an example Breeders Rights Bill has taken into account UPOV 1978 and 1992 model, African model legislation amongst others. These draft legislations are presently at the State Law Office for vetting, revisions and eventually for enactment through the Parliament.

However, the greatest concern that these pieces of legislations pose is their enforcement, networking and training of staff with appropriate career prospect and accountability.

The recommendations for the various levels are as follows

Systemic level

- Capacity building to enable an efficient enforcement of the GMO Act 2004.
- Education and sensitisation of the public in general on the GMO Act/ biotechnology
- Capacity to develop norms and guidelines according to international norms
- Funding for infrastructure improvement

Institutional level

- Training for staff on EIA, biosafety, risk assessment and risk management, GMO testing

D. Enhance Co-ordination among institutions

The poor coordination among institutions is resulting in isolated research programmes being run at the key institutions. An enhanced coordination would provide for efficient and optimal resource use especially as fund is scarce.

The recommendations at the ***systemic level*** include

- Empowering FARC or instituting of a central body for co-ordinating research work and set research priorities.
- Financing mechanism development for long term project
- Coordinating body established and with monitoring and evaluations programme developed and implemented.

E. Promote Awareness and Sensitization Campaign

Biotechnology is still a science which is misunderstood by the public, whose concept is perceived to go only to the production of LMOs / GMOs. This perception needs to be revised altogether through appropriate sensitization and awareness campaigns.

The recommendations at the ***systemic level*** include

- Needs for a national sensitisation strategy (Proper education / sensitisation should be introduced at early stage in schools and also carried out for the public in general).
- Proper assessment of relevant and appropriate biotechnology tools, their limitations and potentials required.

5.5 Climate Change

Like all other SIDS, Mauritius is highly vulnerable to climate variability and climate change. In fact, trends in recent weather pattern call for an increasing urgency to deal with in climate related issues and disasters. The importance of greater adaptive efforts to respond to the risks of climate change is being increasingly felt.

The phenomenon of sea level and temperature rise, and precipitation patterns, as a result of the "greenhouse effect", has found broad acceptance in the scientific community. There is no doubt that the climate is changing. Evidence is gathering that man-made greenhouse gas emissions are responsible for the changing earth's climate (IPCC, 2001).

The ten hottest years on record have all occurred within the last two decades. Current climate models predict that global temperatures will rise by a further 1.4 to 5.8° C by the end of the 21st century whilst the global mean sea levels are predicted to rise by 9 to 88 cm by 2100 as a result of thermal expansion of the oceans. Climate change will also impact on man's health, such as thermal stress, rise in the incidence of skin cancer due to sun exposure, and increase in respiratory diseases such as asthma. Such rapid rate of change will leave the ecosystems little time to adapt, making them more vulnerable to the phenomenon of climate change. Extreme weather events such as very intense tropical cyclones, flash floods, severe drought, heat and cold waves are becoming more frequent around the world.

In the case of the Republic of Mauritius, even though the contribution to global emissions of greenhouse gas (GHG) is very insignificant (that is, the emission by NAI total less than 1% globally) and the islands are amongst the least responsible countries for global warming and climate change, yet small islands are amongst the most vulnerable ones to the impacts of climate change, climate variability and sea-level rise (SLR).

Effective and result oriented measures are required. The strategy to address capacity constraints and weaknesses for the various sub sectors is given below.

5.5.1 Science and Variability

Although a broad understanding of climate processes does exist today, scientists are eager to get a complete picture of a warming world and other changes in the climate system, to make solid projections of future climate and sea level based upon emission scenarios, and to study the impacts of climate change.

Further research is essential to improve the ability to detect, attribute and understand climate processes and climate change, to reduce uncertainties and to project future climate changes. In particular, there is a need for additional systematic and sustained observations, modeling and process studies. Various institutions, in particular, the Mauritius Meteorological Service has highlighted the need for further investigation, research and analysis as well as technical training and transfer of environmentally friendly technologies from developed countries to implement the UNFCCC provisions. Although Mauritius is aware of global warming and its sectoral impacts, for reason of limited funding little is being implemented in its anticipation. The recommendations are given below.

A. Need for a complete picture of a warming world and other changes in the climate system

- Enhancement of the level of understanding of the climate processes through appropriate trainings. Such training should also aim at building capacities in organizations managing and using natural resources
- Reduction in uncertainties through improvement in detection techniques, data processing techniques, analytical methods, spatial sampling, observational networks, data coverage to include current climate and palaeoclimates, quality-control of data, inter-comparisons, modeling and on attribution and quantification
- Explore international assistance through bilateral technical cooperation for latest technology & equipment and support to carry out research in basic science on climate;
- Strengthen national and international co-operation and co-ordination whilst undertaking collaborative efforts and building linkages in order to optimize utilization of scientific, computational and observational resources. Linkage would also be essential to allow free exchange of data among scientists while a special need is to increase the observational and research capacities in many regions, particularly in Indian Ocean
- Setting up of a virtual **Centre of Energy and Environment** (preferably at an existing institution with an initial infrastructure and capacity) to promote advanced R&D, undertake data management, postgraduate teaching programmes and be active in sensitising the public, decision and policy makers. The proposed centre may be called upon to develop data sharing protocol to allow free exchange of data, information and research findings

B. Improvement in projections of future climate and sea level rise (SLR) with focus at regional level.

The following approach would be advised:

- Capacity enhancement through training in CC Science, trend analysis, forecasting, modeling (incl. GCMs), scenario building, GHG inventory and use of climate models with the appropriate spatial details
- Develop relevant climate change indicators and make projections of future climate (including forecasting climate hazards and climate extremes) and sea level rise
- Enhance GHG inventory and development of a national mechanism for carrying out Energy Audit
- Continue support and participation in global data collection efforts
- Improvement in data acquisition towards better estimates of GHGs (CO_2 and non-CO_2)
- Development of Disaster Evacuation plan with accompanying response strategies including public outreach programmes such as appraisal of hazard level, evacuation plans, amongst others

C. Data Management and Information System

- Development of a coordinated collection strategy for relevant data needed for projections and mitigation analyses
- Seek foreign technical assistance and funding for the upgrading of existing system and complementary databases such as CSO, DMS, MMS, NODC (including software development and logistics, and training)

D. Support to Research & Development on Impacts of Climate Change (CC) on different sectors

- Develop a national research plan to undertake R&D on CC impacts, adopting an integrated approach and compliant with our commitments under various conventions, to develop climate change indicators, and to make projections of future climate changes and sea level rise with appropriate mitigation analyses
- International assistance for latest technology & equipment and support targeted research
- National Capacity enhancement at relevant organizations on CC Impacts, deployment of latest technologies, trend analysis, forecasting, modeling and scenario building, in the identification of vulnerable areas
- Review of existing policies, reinforce regulations and strengthen enforcement (Environmental Police)
- Establish protocol for data sharing; free exchange of data, information and research findings

E. Advanced Training

- Advanced Meteorology to include scientific understanding of complex climate processes and climate impacts
- Advanced Instrumentation Methods in Meteorology/Energy/Transport to include automated systems, and latest gadgets (such as ARGO floats, seismic monitoring), maintenance and repairs of energy-efficient equipment, etc.
- Advanced Signal and Data Processing – advanced analytical techniques in signal analysis including spatial sampling, measurement uncertainties, quality control, analysis of extremes, etc.

5.5.2 Response and Mitigation: Energy Sector

Over the last ten years, the energy sector has witnessed sustained increase in primary energy, used mainly for transport, industrial, commercial and domestic sectors; energy consumption being for the respective sectors (percentage-wise) 51:25:7:16. The

electricity demand has risen sharply due to, amongst others, sustained economic growth and a general improvement in the standard of living. In 2003, 77% of the total energy requirement for the Republic of Mauritius was met from imported fuels, while the remaining 23% was supplied from indigenous sources, hydro and bagasse principally. It is projected that the total electricity demand will increase from 1627 GWh energy consumed in 2003 to 2690 GWh by 2012, representing a mean annual growth of 6% over the next ten years. The GHG emitted from this sector has increased from 1185.4 Gg in the year 2000 to 1418.3 Gg in the year 2003. The trend is likely to be maintained in the years to come.

Mauritius faces a rapidly changing and vulnerable electricity future. The energy sector is also vulnerable to climate change. Programmes for expanding renewable energy sources are not keeping pace with increasing demand.

The capacity building strategies for the energy sector is discussed below.

A. Promotion of Low GHG Emission/ Renewable Energy Technologies

The Government is quite keen in promoting the use of renewable energy in an effort to reduce GHG emissions to sustain utilisation of local energy resources and to further reduce the dependence of Mauritius on imported energy. Although the major environment and economic benefits accruing in the long-term is attractive, the initial capital investments required are high thus acting as a structural barrier to investment in renewable technologies.

The exploitation of indigenous sources of energy is limited to wind, hydro, solar and biomass mainly. A number of technologies that are worth considering include solar, wind, wave, ocean, tidal, OTEC, fuel cell, advanced batteries, natural gas, combined-cycle gas turbines, coal/biogas gasification, biogas (from landfills/waste treatment plants), micro-scale hydro (suited for off-grid applications), pumped storage hydro, small micro-turbines, amongst others. Improved power storage would also increase the use of electricity from solar and wind power. The use of bio-engineered crops (e.g. sugarcane) for fuels by the genetic revolution will permit cultivation of crops to produce fuels such as ethanol. Mauritius with its vast EEZ may have a huge potential for methane hydrate crystal mining. These rich deposits of frozen natural gas crystals reserve on the ocean bottom would be a notable leap in our ability to provide energy for the future.

However, not all these technologies are readily available for exploitation. Further studies and research would be essential.

The recommendations include

- Promote clean power technologies
- Request international support and assistance to carry out an in depth socio-economic and technical feasibility studies of all the renewable energy technologies options with due considerations, amongst others, to quality and reliability, environmental impacts, development, marketability, social acceptability, capacity, sustainability, and policy implications.

- Determine technical capability of electric utility systems to use intermittent renewable energy
- Enhance and support the development of cost-competitive technologies and systems [e.g. hydrogen and alcohol]
- Development of **grant programmes** with national and international technical and financial support for **Research, Development and Demonstration (RD&D)** on low-emission/ renewable energy technologies, *fuel-switching*, in the development and deployment of *distributed* energy resources, *efficiency* studies, etc.
- Further encourage renewable energy use through tax credits and soft loans
- Continue efforts to **restructure electric utilities** and simultaneously establishing a Renewable Energy Portfolio Standard and set maximum greenhouse gas emission standards
- Advanced Training on Energy Technologies – low emission, renewable and co-generation technologies, their effectiveness and appropriateness as well as economic appraisals

B. Capacity building for energy efficiency and energy conservation

A number of efforts have already been undertaken to promote energy efficient devices. Of significance is the promotion of energy saving lamps by the Government with the support of the CEB. Efforts to modify existing building (housing unit) structures are also envisaged by the MRC and Ministry of Public Utilities.

There is plenty of room for improvement in the efficiency of energy utilisation in the various sectors of the economy – industrial, hotels, transportation, residential and commercial. The culture of energy management to improve energy efficiency must be widely encouraged and vigorously pursued. A number of issues of strategic importance should also be addressed in line with sustainable consumption patterns. These include energy planning, energy audit in the public and private sector to increase energy efficiency, efficiency of energy utilisation in all economic sectors, reform of transportation and physical movements to reduce energy use and pollution, and establishment of performance indices, guidelines and regulations to optimize energy use in new and in old buildings, and carbon credit.

A number of appliances are also classed as energy efficient, some with specially labeled such as energy star. Sensitisation with respect to the latter is still low. On the industrial scale, the latest technologies have plenty to offer with respect to energy efficient equipment whilst sustaining quality, reliability and performance characteristics. In the construction sector, new designs of residential, commercial and industrial buildings are expected to bring down energy related costs – and hence, GHG emissions (be it in terms of lighting, heating, air conditioning, and use of other appliances).

The strategic recommendations are as follows:

Systemic level

- Development of programme for a comprehensive energy audits or assessments and reviews in the public, private and economic sectors to improve productivity, energy efficiency, reduce waste and save energy
- Increase sensitisation and promote use of energy efficient products and technologies and best management practices whilst sustaining quality, reliability and performance characteristics. Encourage and vigorously pursue a culture of energy management to improve energy efficiency
- Develop efficiency standards for household appliances
- Promote use of new and innovative designs (e.g. eco-school, eco-house, eco-farm, eco-village) appropriate to local climate in the construction sector to bring down energy costs
- Update building codes; adopt, maintain and extend Model Energy Code; develop software program to ensure Model Energy Code compliance; establish performance indices, guidelines and regulations to optimize energy use in new and in old buildings
- Capacity building through advanced training for technical know-how
- Provide market-based incentives and tax credits; Remove market barriers to penetration of cleaner, more efficient energy supply further to study on the economic costs and implication of the policy
- Consider the possibility of banning high power consuming devices following a full cost and benefit analysis
- Build local capacity to enhance local production, maintenance and repairs of energy efficient appliances
- Develop **grant programmes** and initiatives (MRC, etc.) to support national and community assistance efforts
- Continue and enhance **participation** in local/foreign sponsored energy efficiency programs; enhance utility participation in energy savings/climate programmes

C. *Distributed Power Generation*

The economic cost of a power disruption in information-driven business is extremely high. Major blackouts due to thunderstorms, cyclones and overloading of the grid would require appropriate attention basically in terms of power decentralisation.

Already in Mauritius, bagasse is providing a remarkable opportunity to decentralize power generation (at sugar factories – instead of being focused near the seaport). Decentralized power sources would have the benefits to be extensive, affordable, and environmentally clean. New, high-power, distributed energy systems would provide backup if not primary energy sources for appliances, homes, and vehicles. Line losses would thus decrease substantially.

The recommendations include

- Pursue decentralization and diversify future power stations as per spatial and economic needs with emphasis on the potential of low emission/renewable technologies penetration
- Development and implementation of new, high-power, distributed energy systems as backup
- Increase usage of IT in mapping distribution systems such as power plants and transmission lines and scenario buildings
- Develop programmes in the development and deployment of distributed energy resources

D. Energy Management

Energy management covers energy supply and energy demand. Supply-side management is proving to be very costly to sustain, to consumers and to the environment. CEB is seriously considering demand-side management (DSM) that involves the participation of consumers with the electricity utility in meeting their needs by managing both the level and timing of their demand.

The strategic recommendations are as follows:

- Assess and review island-wise energy planning strategies
- Promote energy management systems
- Enhance capacity through training in DSM with the aim to continue and expand electric utility DSM programmes
- Promote consumer partnership with the electricity utility in meeting their needs by managing both the level and timing of their demand
- Investment in technologies as required
- Explore other measures to alleviate heavy load shedding include time-of-use or spot pricing and special off-peak tariffs to consumers
- Awareness raising and sensitisation programmes for the private and public sectors and the public in general
- Encourage energy intensive industries to carry out and report actions to reduce greenhouse gas emissions

E. Energy Demand Outlook

Compared to the residential consumers the commercial is expected to expand more to enhance their productivity and competitiveness. Less electricity-intensive future industrial growth is expected to be

geared towards value-added production and efficient use of primary resources production processes.

Overall, future increase in energy production is expected to grow by ~ 4.3%. The CEB's 2003 IEP has earmarked coal and/or bagasse as principal fuel options of the near future.

The recommendations include:

- Enhance capacity in forecasting models on energy demand outlook, modeling scenarios and use of GIS
- GDP tracked down and used as an indicator for electricity demand
- Energy Conservation sensitization programmes

F. Data Management and Information System

Gathering and analysing information for the preparation and updating of demand forecasts has only just begun. Annual forecast is expected to reflect a more detailed analysis of the different drivers of demand in each market segment, with explicit consideration of uncertainties.

The strategic recommendations include:

- Formulation of data collection strategy for useful data needed for energy / emission projections and mitigation analyses
- Capacity building for information management and information exchange
- Development of a system for compiling a national 'cadastre' of GHGs by sources and sinks

G. Research and Development

The already proposed virtual *Centre of Energy and Environment* can be called upon to play very active role in coordinating targeted and advanced R&D. The setting up of a R & D group with the involvement of key institutions would be needed.

The recommended Research and Development areas to include, *inter alia*,

Distributed Power Generation

- Assess the feasibility of importing power DC to remote islands of the Republic using submarine high voltage DC system (which is claimed to be more economical than AC for distances exceeding ~ 800 Km)
- The feasibility of using wave/ocean/solar/wind energy – Mauritius and Outer Islands
- Investigation of possibilities of Micro turbines in Mauritius

- Investigation of possibilities of dual-fuel combustion – Mauritius and Outer Islands
- The Feasibility of locating a major power station next to Mahebourg – the old seaport of Mauritius

Low GHG Emission/ Renewable Energy Technologies

- Biomass and adoption of more efficient technology such as gasification
- Environmental impacts of different energy resources
- Air quality monitoring and modeling

Energy Efficiency/Conservation

- Efficient alcohol technologies (for production and use as fuel including for vehicles)
- Energy efficiency & Energy savings in Sugar/Textile/Process/etc. Industries
- Energy audit assessments and future scenarios (manufacturing, process, hotels, hospitals, etc.)
- Assessing the co-generation potential in Mauritian industries
- Enhancing bagasse energy co-generation efficiency
- Clean and reliable use of heavy fuel in small boilers
- Energy efficient appliances for households
- Developing public awareness and requisite capacity in the efficient utilisation of energy resources
- Investigating the relationship between tailpipe emissions and air quality

Energy Management/Planning/Policy

- Electricity Costs and Tariffs
- Forecasting models on energy demand outlook
- Energy supply and demand analysis with emphasis on the possibilities of fuel substitution
- Risk management strategies in order to save on imported fuel (hedging, reserves, etc.)
- Development of guidelines, performance indices and regulations of novel energy technologies
- Development of economic appraisal methods of novel energy technologies
- Assess the feasibility of using voltage lower than 240 V in the residential sector
- In depth studies from a technical, economic and financial point of view of promising low-emission technologies focussing on renewable energy (solar, hydro, wind, and marine-based energies)
- Study of the socio-economic and environmental impacts of the climate change on energy/energy technologies

5.5.3 Response and Mitigation: Transport

Today, land transportation in Mauritius is dominated by passenger transportation, commercial transportation, and agricultural transportation. Motorisation rates in

Mauritius (~230) are higher than on the African continent (~20) but much below that of Western Europe (~415) or the United States (~750). The average annual rate of growth stems around 5.5%; the ensuing economic, social and environmental impacts of this growth of vehicles are important considerations of the future.

The transport sector is also the heaviest energy consumer, accounting for 48% of total energy imports. Transportation and its subsequent demand and usage of energy have progressed dramatically over the past decades with the massive importation of Japanese and European vehicles. The increase in vehicles implies increase in CO_2 emissions, more traffic congestion and longer travel times. In 2004, for example, the fleet of motor vehicles stood at 291,600 compared to 180,884 in 1994, representing an increase of 35%. With the total road network of 2015 km, there are 148 vehicles for each kilometre of road, i.e., 6.76 meters of road per vehicle.

The Government is seriously considering an integrated transport system for Mauritius with a Light Rail Transit system (LRT) between Curepipe and Port Louis main corridor, to serve the mobility needs in our densely populated conurbation. Concurrently other possibilities such as decentralization are also being considered.

The strategic recommendations for transport sector are given below:

- Carry out reforms of transportation and physical movements to reduce energy use and pollution; Encourage more efficient engine capacities of vehicles on the road

A. Promotion of Low-Emission Alternative Transport Technologies

Alternative technologies in the transport sector include Electric Vehicles (EV), Bi-Fuel Vehicles (BFVs), Air Car, Hybrid Electric Vehicles, Flexible-Fuelled Vehicles. Although some effort has been made in identifying possible alternate technologies, only few incentives have been given to encourage the use of same. At the moment only the Bi-Fuel vehicles are in operations using on LPG and gasoline; with some 3% of cars now converted. Major impediments to adoption of BFVs are the high costs for conversion kits, inadequate trained labour/facilities, and availability of only a few retail points. There is also the need to assess the effectiveness and appropriateness of the alternate technologies and to introduce formal policies to govern or to adopt the alternate technologies.

The recommendations include:

- Review and refine existing policies and introduce formal policies to govern or to adopt lower emission transport technologies (consider limiting engine capacities of road vehicles; Consider barrier removal - to encourage import of fuel efficient vehicles)
- Capacity enhancement through advanced training to assess the effectiveness and appropriateness of the alternate transport technologies
- Develop and publicize incentive mechanisms to encourage entrepreneurs (local and foreign) to invest in potential for alternate fuel vehicles and technologies; Aggressive market-based incentives (e.g. lower customs fees and import duties for

import of fuel efficient vehicles); Encourage vehicle manufacturers to offer electric vehicles for sale; Introduce in-built conversion options in new vehicle purchases

- Setting up of special funds that may be used for transit services, pedestrian improvements, bikeways, ride-sharing programmes, alternative fuel projects, traffic flow improvements, and other transportation-demand-management projects, as well as system improvements on the road network
- Encourage use of low or no emission technologies such as LPG-based technologies, ethanol-based technologies and early deployment of electric vehicles
- Undertake R&D of technology and fuel that would reduce consumption of petroleum--based fuel and reduce carbon emissions associated with cars, light trucks and heavy vehicles: on Bio-fuels (such as bio-ethanol and bio-diesel), encourage its use with the aim to promote the large-scale use of environmentally sound, cost-competitive, biomass-based transportation fuels and to provide biomass for energy production

Conduct studies on economical fuel switching (e.g. ethanol and other bio fuel)

Public outreach programmes such as on the visibility of driving costs, on the use of an Environmental Impact Information Sheet to increase awareness of the environmental costs of vehicle use

Adopt operating measures for fuel efficiency; Be alert to possible fuel substitution opportunities; and re-equip or encourage use of fuel-efficient modes of transportation by air and sea, esp. both inter-island routes and Mauritius to mainland routes

B. Toward Congestion-Free Roads

Mauritius is facing serious congestion problems. The Light Rail Transit (LRT) system is being considered as the preferred solution to the transport and congestion problems in the Port Louis - Curepipe corridor. The LRT project has a high initial cost investment requiring major capacities. Since the LRT system will not by itself reduce traffic congestion, an Electronic Road Pricing (ERP) scheme is envisaged to be concurrently implemented to make drivers pay a toll for using scarce road capacity and thus discourage people from driving unnecessarily during peak hours. With the assistance of the World Bank, Government is implementing a Project Preparation Facility on the LRT project and its associated works.

The recommendations for this sector are as follows:

- Pending policy decision taken at the level of the government to EITHER undertake a thorough assessment of decentralization efforts from the capital and other key areas though proper planning strategies taking account future developments and orientations (including mobilizing of the stakeholders to consider shifting their establishments fully or partly) OR build capacity that will enable exploration of avenues for Mass Transit Systems (MTS) (including LRT) and their integration with all existing modes of transport
- Develop a smart road network – Enhance land use planning to explore new road networks to reduce congestions and the need for transportation and Upgrade road networks through models and scenarios for traffic flow
- Develop a campaign for a coordinated flexitime adoption across capital-based offices and services (government and other labour intensive ones) towards

promoting a coherent traffic flow. The concept of 'core' office hours can be studied as a potential flexitime alternative

- Introduce deterrent measures for use of private vehicles through review of existing legislation
- Better traffic management in and around seaport and airport

C. Introduce Regulatory and Traffic Management Measures

It is very clear that the road infrastructure would not be able to bear the increasing volume of traffic competing for space thereon and our possibility to extend its capacity is limited by land use and financial considerations. The LRT is one solution but requiring an initial sizable capital investment with adequate capacity building.

Measures favoring public transport are therefore most plausible means to solve existing transport problems. The following capacity enhancement measures are therefore recommended.

Develop public outreach programmes e.g. driving at optimum speed, proper maintenance of vehicles, carpooling, estimation of energy- and emission- saving effectiveness of TCMs, traveling at optimum speeds (for optimised fuel consumption and hence decreased GHG emissions), etc.

- Investment in traffic equipment (synchronous traffic lights/count/speed/ camera/signs/GIS/GPS/etc)
- Introduce incentives (e.g. carpooling and special parking and use of fast traffic lane for carpoolers, shuttle service provision from major transport hubs or car parks, etc);
- Introduce deterrent measures (restricted/no driving zones, car restraints, bus priority schemes, electronic road pricing, car parking with different tariffs at different times)
- Reinforce vehicle examination centres (and provision of an adequate number of emission measuring meters if fines or penalties are to be applicable), Environmental Police and road traffic regulations such banning visible emissions of fumes by initiating a "Clean Air Act" and introducing fine for slow vehicles
- Upgrade road networks through models and scenarios for traffic flow, replacement busy roundabouts/intersections by flyovers, conversion of 2-way lanes into one-way, restricted access to major roads and highways, provision of special lanes for non-motorised mode of transportation
- Incentive for transport companies to use real time information; Use of electronic navigational aids (GPS, changeable message signs, etc), special traffic radio/TV channels
- Capacity enhancement in modeling, scenario building, GIS and technical know how
- Road accidents studies with remedial recommendations for improvements of road conditions where applicable

D. Data Management and Information System (DMIS)

In the transport sector, data gaps include categorisation of vehicles in terms of in use, energy use, freight/passenger statistics, payload capacity, licensed/unlicensed, projections

of traffic volumes by vehicle category, total vehicles-km, fuel use intensity, fuel type consumed, and vehicle ownership by type.

The recommendation is therefore to:

Develop a DMIS for the transport sector. Along the same line, improve collection strategy for useful data needed for land/ air/marine transport demand / emission projections and for mitigation analyses

E. Research and Development

In addition to the joint research programme proposed as part of synergy opportunities, the following areas are recommended for further Research and Development.

- Develop vehicular technology (ethanol, LPG hydrogen, and others) and fuel that will reduce consumption of petroleum-based fuel and reduce carbon emissions
- Advanced targeted RD&D with regard to air quality monitoring and modelling
- Develop models and scenarios for passenger forecasting - detailed analysis of the different drivers of demand in each market segment, with explicit consideration of uncertainties
- Develop models and scenarios for traffic flow for better traffic management
- Enhanced carbon technologies: carbon sequestration under changing land use practices; carbon sequestration from fossil fuel combustion; road surface carbon sequestration by the bitumen dressing on road surfaces
- Impact on performance on air/sea/land operations due to climate hazards
- Decentralisation study for Mauritius; decentralization versus LRT
- Feasibility of re-opening Mahebourg seaport

5.5.4 Vulnerability and Adaptation

Adaptation to climate change and the adaptive capacity enhancement came out as a prime challenge resulting from impacts of CC and sea-level rise. The thematic assessment exercise showed that climate change although perceived as being amongst the national priorities; the issue of climate change adaptation still requires integration in long term development plans and strategic planning framework. Follow up and implementation of climate related activities are generally still being considered from a sectoral perspective while a certain number of proactive and adaptive measures have been implemented with varying degrees of success. Capacity limitations at different levels to effectively plan and implement desired adaptive measures and the subsequent follow-up were also noted.

In some cases, priority is focused on the utilisation of the resources and due to funding limitation less attention is being given to the adaptive measures and capacities given the complexity of the issue and the knowledge gaps.

Because of the complex interaction between and within the natural and anthropogenic activities coupled with the involvement of some 20 key national actors (including, public,

private, parastatals, academics, research institutions and NGOs), the issue of vulnerability and adaptation to climate change require an integrated multi-sectoral approach when designing sound adaptation policies, strategies and programmes. Establishment of a climate change desk in the key organisations together with a desk set up at the MMS for instance to coordinate CC activities would largely facilitate follow up and coordination.

The recommendations pertaining to six most vulnerable sectors made further to the assessment of issues for the entire Republic of Mauritius are discussed in the paragraphs below.

- Coastal Zone
- Agriculture
- Water Resources
- Human Health
- Tourism
- Fisheries

A. Coastal Zone

The coastal zone and in particular, the coastline of Mauritius is undergoing morphological changes as a result of natural causes and anthropogenic activities. The natural phenomena include tropical cyclones, tidal waves, and tsunamis. The anthropogenic activities include haphazard construction of ill-designed jetties and groynes, past lagoonal sand removal, increasing infrastructural development, pollution from point and non point sources, and degradation of coral reefs. The major impacts of sea-level rise in Mauritius are land loss, erosion of beaches, damage to coastal infrastructure, damage to coastal ecosystems including degradation of coral reefs and loss of wetlands. Rising sea levels may also be especially threatening to coastal aquifers (causing saline intrusion) and to coastal resorts. The following strategic measures have been recommended at the following levels.

Systemic level

- Integration of CC and related issues in forthcoming ICZM policies and plans, urban development plans with new adapted guidelines developed.
- Development and mapping of vulnerable areas of coastal zone (vulnerability atlas) on the basis of CC scenarios
- Development of joint research programme on impacts of global warming on marine resources
- Funding for the replication of the geospatial information project from mapping the marine habitat and resource for coastal areas of Mauritius, Rodrigues and Outer Islands

Institutional level

- Monitoring of beach profile and further research on hydrodynamics of beach
- Have beach nourishment programme where necessary
- Build sustained awareness programme fostering participatory approach
- Maintain reforestation of coastal zone with native vegetation

- Institutional strengthening and stringent enforcement of laws on setback distance and adapted construction guidelines

B. Agriculture

Global warming is likely to alter the productivity zones of some crops from the lowland areas to regions of higher altitudes. Sugar cane cultivation will become more profitable in the super humid zone and will compete with other crops and forestry. While in the sub-humid zone, there is a distinct possibility that sugarcane land will become economically non-productive as a result of higher rates of evapotranspiration. Vegetable crops cultivated in the highlands, bulks within a short temperature range, beyond which it might become less productive.

The magnitude and frequency of drought periods and heat stress could also be of direct concern. Irrigation might have to be adopted in or extended to these areas. Higher evapotranspiration demands of the forests used for grazing may cause this land to become less productive and result in lower carrying capacities. The duration of some crops will shorten with concurrent reductions in yield. Cropping calendars, flowering and productivity of some fruits and vegetables will be affected. Pastures that are actually in the low-lying dry areas may support fewer animals as a result of lower grazing potential. Livestock will be under higher stress and poultry production may decrease because of higher mortality rates. Temperature increases will also alter the geographical range of some insect pests and diseases. The magnitude of change in the different climatic parameters will determine the vulnerability of our agricultural production and how many adaptive measures need be taken to maintain productivity.

The following measures have been proposed.

Systemic level

- Promote the application of efficient irrigation, (e.g. Drip or center pivot)
- Further research on cultivars requiring less water ; Development and Promotion of alternative such as hydroponics and protected cultivation
- Application of Early Warning System at field level for efficient water use
- Improvement in Crop management and Pest control techniques
- Research to Identify adaptive crops tolerant to salinity.

- Develop suitable salinity management practices such as efficient drainage, use of acidifying and organic fertilizer.
- Establish a programme of continued training in handling simulation models, interpreting simulation outputs and downscaling GCM products to island scale.

C. Water Resources

Climate change represents an additional stress on the availability of freshwater. Climate change is expected to perturb the hydrological cycle with the following projected results

- a reduction of the water supply since less water will be captured due to expected decrease in rainfall
- an increase of the saltwater intrusion into coastal aquifers as a consequence of the projected SLR
- more intense downpours as suggested by several models, with increased runoff and a reduction of the ability of water to infiltrate the soil.
- reduction in hydropower

The following measures have been proposed at the ***Systemic level***

- Review of policy for sustainable management of ground water including coastal aquifers
- Bridging knowledge gap with respect to ground water model in line with SLR scenarios.
- Sustained effort to minimize leakage and losses in water transmission systems
- Application of Climate Early Warning in Water resources management
- Sustained awareness campaign on water savings
- Studies for development of water resources inclusive of construction of new dams on rivers to increase surface water storage capacity and to recharge aquifers
- Policy development and promotion of re-use of treated waste water
- Optimize use of river off-takes
- Systematic monitoring of quantity and quality of surface and groundwater resources and effluent

D. Human Health

Climate change is expected to have a negative impact on human health in Mauritius. It is therefore important to consider human health and well being under a climate change scenario.

Climate change and variability will influence the biology and impact on the health of the human populations directly since human physiological adaptive activities such as sweating and the degree of comfort, and indirectly, on the environment (food, disease agents and vectors, ecosystems, water resources, air and air pollution, humidity amongst others) will be impacted.

It was also argued that until and unless good quality data from long term monitoring is available, it would be not so obvious to establish linkages between climate change and human health.
The following proposals have been made:

Systemic level:

- Development of a long term monitoring programme to assess the impact of CC and variability on human health and well being.
- Further studies on the impact of CC on the spread of diseases

Institutional level:

- Planting of trees in residential areas and greening of urban areas
- Promote awareness campaign adequate sanitation level
- Monitoring and spraying of vector borne disease affected areas
- Proper drainage system to evacuate stagnant water
- Creation of more health walk track away from dense traffics
- Extension of sewer collection system to coastal and other potentially sensitive areas in the long term
- Rodent control and other pest programmes in market places, urban and rural areas.

E. Tourism

Mauritius with an important and fast-growing tourism sector is even more vulnerable to climate change and is linked to other vulnerable sectors. A strong case for synergistic action arises for Mauritius, as well as for identifying the impact that climate change will have on the tourism sector and reinforcing national capacities to deal with the consequences. Climate prediction is becoming an important tool for ensuring the viability of the tourist industry and the correct planning of tourist activities.

The following measures have been proposed:

Systemic level

- Development of Joint studies and Research programmes to investigate the reciprocal impacts between tourism industry and CC
- Integration of CC and related concern into long term tourism development plan
- Encourage construction of hotels inland
- Diversify existing tourism market as well as create informed tourism industry
- Promote use of clean technologies and optimisation of renewable energy technologies e.g. solar water heaters

Institutional level

- Develop appropriate alert system for Hotels and Tourism industry
- Development of emergency response plan for coastal hotels and resorts.

Individual level

- Capacity building of hotels employees by incorporating CC concepts in hotel training programme.

F. Fisheries

Fish habitat and behaviour are directly related to climate. Climate change and variability directly impact on the fish behaviour, the aquatic food cycle and eventually on the entire ecosystem.

In Mauritius, sustainable utilisation and a reasonable degree of fisheries management have remained the focus for many years. However, the fisheries sector monitoring still require the integration of climate parameters from a more coherent resources and environment perspective.

The following measures have been proposed.

Systemic level

- Use satellite technology to monitor fish population.

Institutional level

- Ongoing plantation of mangrove programme
- Monitoring of lagoon for water quality taking into consideration other indicators
- Enforcement of existing laws of effluent discharge
- Encourage fishing in the outer lagoon so as to allow reef to recover
- Encourage cage-culture, mari-culture and “barachois”
- Development of a sustained awareness programme on the marine environment

5.6 Land Degradation

Land degradation in Mauritius is in general confined to the following sectors:

- Degraded hill slopes in privately owned agricultural and forest land (native forest remnants not managed)
- Beach erosion
- Loss of top soil as a result of unsustainable agricultural practice (for certain non-sugar crops and in certain specific areas)
- Loss of grass cover by wildfire (Port Louis area)

Whilst in Rodrigues, land degradation is a more serious problem. The key issues that retained attention of the stakeholders include:

- Soil erosion (ending up in lagoon siltation)
- Unsustainable agricultural practices
- Overgrazing

Causality analysis of the issues revealed a number of capacity constraints and weaknesses at the systemic, institutional and individual levels. Sound management, protection and enforcement are all constrained by outdated policies, limitation in tools to effectively manage resources in sensitive areas, inadequate legislation, shrinking funds as well as limited human resources (e.g. ageing of workforce at the Forestry Service).

As a number key actors are already active in the forestry, agricultural and coastal zone management and that land degradation is one of issues pertaining to these sectors, the need to have a coordinated approach to the issue of LD mitigation is highly desirable.

The following recommendations complement those presented under the potential mitigative responses to the LD issues identified.

Mainland Mauritius

- ***At the Systemic level***

a. Mainstreaming of UNCCD obligations

There is a need to mainstream the UNCCD obligations into national policies and legislations. Sectoral policies need to be formulated to specifically address the question of rehabilitation of degraded lands.

b. Integrated Strategy and Action Programme

No integrated Strategy and Action Plan has yet been formulated to deal with land degradation issues in Mauritius including droughts mitigation effects. This is one of our major obligations under the UNCCD and the deadline for submission of the National Action Plan is 31st December 2005.
The comprehensive strategy could also cater for LD issues such as, forest management systems, development of economic mechanism and tools to promote

Private Public Partnerships for SLM, enforcement capacity, characterization and management of ESAs (wetlands and private forests of high biodiversity importance – sensitive ones), beach erosion abatement and restoration using native species (low cost technologies and also stressing on preventive approaches), forest fire prevention and control, and national awareness raising and sensitization campaigns.

Specific and new regulatory measures would be required concerning issues such as forest clearing and wetland management.

c. Establishment of a National Committee to address issues on LD

Land degradation is being addressed in a fragmented manner. There is a logical need to take a holistic approach to address the issue of land degradation. There is a need to establish a National Committee, identify priority actions, set targets and monitor progress of implementation.

d. Data Management and Monitoring for an informed decision making process and efficient Enforcement

Absence of an appropriate land data management and monitoring system call for an urgent need to create a central Land Information System and a data bank at the Ministry of Housing and Lands, which can be accessed by potential users and also enable an informed decision making process.

The setting up of a Forest Information system at the Forestry Service and a special unit for monitoring land degradation and loss of forest cover

Use of latest and affordable technologies such as latest satellite images for the preparation of digitized maps of the various land based sectors, especially the agriculture, forestry, fisheries sectors (incl. wetlands) amongst others strongly felt.

e. Need for Capacity Building in the Private Sector

Sensitisation and awareness raising

There is a need to "educate and inform" the owners of privately lands and farmers on the importance of Sustainable Land Management and 'impress' on them the long term negative impacts of deforestation and soil erosion e.g. loss of soil fertility, loss of biodiversity, siltation of the lagoons.

Public Private Partnership

There is a need to develop a public private sector partnership to practice a non-consumptive use of the forest especially in sensitive areas. Other activities e.g. recreational or ecotourism may bring the same (or more) revenue to promoters. There is a need to sensitize and train private forests owners.

'Acquisition' of very sensitive areas (could be by the Government, NGOs and private sectors) e.g. biodiversity rich areas, steep slopes, landscape value and so on. Environmental sponsorship and stewardship could also be considered.

Other means of protection against private forest loss

Developing capacity to identify, assess and develop incentive mechanism to enable adequate protection and sustainable management of private forest lands through appropriate mechanism and measures such as:

- Grant for rehabilitation, through re-afforestation programme
- Tax rebate on expenses incurred
- Compensation for restricted use of lands
- Free issue of plants, technical guidance.

f. **Targeted research and dissemination of findings and best practices**

Develop and Sustain an ongoing and new targeted researches to facilitate the refinement and adoption of sustainable land management practices and technologies, including early warning and monitoring systems to improve and sustain the preservation/ restoration of ecosystem stability, functions and services.

At the Institutional level

A. Forestry Service and National Remote Sensing Unit

Infrastructural requirements for sustained field interventions in degraded areas
There is a need to increase the capacity of the Forestry Service (Mauritius) and (Rodrigues) in the following:-

a. Vehicles and Equipment to sustain field works and enforcement

- Lorries for transport of materials and seedlings to degraded sites
- Lorries with water tanks for irrigation
- 4 x 4 vehicles for off road transports
- Irrigation systems, comprising of water tanks, drip irrigation network, to support reafforestation works in rain deficient months.
- Fire fighting equipments – e.g. watch towers, communication equipments, fire bats, motorized water sprayers.
- Fencing materials e.g. treated poles, metallic fencing, and barbed wire.
- Motorised sprayers for herbicides.

b. Human Resources

- There is a general discreet downsizing of personnel in the organization responsible for field interventions (Forestry Service). There is a need to increase the work force or alternatively financial supports to be made available for contracting out priority works.

- Limited staff and training are also being perceived as a severe constraint in organization such as the National Remote Sensing Unit of the Ministry of Agro-Industry and Fisheries. However, human resources will not suffice as Satellite Imagery is very expensive. The possibilities to explore synergy between different institutions (e.g. Ministry of Housing and

Lands) as well as bilateral co-operation with countries like India as in the past need to be considered. It is taken note that the University of Mauritius is planning to run a BSc course in Agriculture with specialization in Forestry.

- Absorptive capacity: It has been noted that the capacity of private contractors in this particular area, is often limited thereby the extent that can be contracted out in a particular year is restricted. Also contracting out, very often is not cost-effective due to high overheads, inflated costs or lack of competition among bidders.

- Ageing of workforce and decline in productivity. The average age of the workforce of the Forestry Service is around 50 years and their productivity is on the decline. Workers are reluctant to operate motorized equipments.

B. Integrated Coastal Zone Management Division of the Ministry of Environment

In line with the recent study on Beach Erosion commissioned by the Ministry of Environment and NDU (2003), the following relevant capacity needs for Coastal Zone Management have been recommended.

Monitoring of Beach, Reef and Lagoon Ecosystem: The setting up of a specialized team within the ICZM division equipped with the latest state of the art technology and to work in collaboration of other concerned institutions and monitor the beach, health of the coastal/ reef/lagoon ecosystem through indicator species. Creation of effective networks amongst the concerned institutions would be very important from a capacity building point of view.

Enhance the basic capacity required of the staff of the ICZM Division in terms of skills and knowledge (in areas of coastal zone planning, coastal engineering, resource management, modeling, assessment of beach erosion and development of appropriate soft and hard measures, etc.) and equipment (such as man power, boats, and basic logistics including software) to enable effective forward planning, enforcement of the EPA 2002, the Fisheries and Marine Resources Act (98) and other regulations and guidelines.

Setting up of a task force for the development of guidelines to regulate activities on the coastal zone and lagoons.

Additional human capacity to undertake long term monitoring (physical as well as bio-chemical) and survey works to better understand beach and hydro dynamics.

Dynamic beach zone restoration: the restoration of the original coastal indigenous and endemic vegetation and the gradual removal of the exotic species, especially *Casuarinas* trees, from all the public beaches. While this is a commendable proposal, its implementation would have important implication in terms of capacity. Indigenous and endemic vegetation are generally very slow growing and propagating materials are not readily available. Such projects have a longer time frame as they cannot be executed

over vast areas, in view of the heavy pressure in the beach. The following would be the *sine qua non* to the realization of the restoration project:

- Creation of forest nurseries in the proximity of coastal areas
- Fencing of project areas against trampling by pedestrian, vehicles
- Irrigation facilities round the year for watering of young seedlings
- Either provision of additional manpower to implement the project, or financial resources to contract out.

C. Land Use Division (Agricultural Services, Ministry of Agro- Industry and Fisheries)

To enable this Division to fully implement its required tasks which include also promoting sustainable agricultural practices and to be able to undertake collaborative research in various areas of SLM, a dedicated team/ unit would be required. The Unit should reasonably be staffed with

- One (1) Senior Research and Development Officer (SRDO)
- Two (2) Research and Development Officer (RDO)
- Four (4) Technical Officers (TO)

D. Agricultural Research and Extension Unit

AREU plays an important role with regard to research and extension works for the non sugar crops. They are actively in training farmers and in the promotion of sustainable agricultural practices. However, long term sustainability in their programme is limited by funding resources and also need for additional infrastructure, logistics and training of the resource persons/ trainers. The following would be therefore essential:

- Infrastructural support and logistics e.g. vehicles and research equipment
- Capacity enhancement through training in the following specialised areas: bio-technology, soil dynamics, hydroponics, soil-less culture, etc.
- Need of additional human resources (3 Post Graduates to carry out research in Land Resources Management)

At the Individual Level

Skill and knowledge enhancement of staff would be required under the following areas:

- Soil conservation measure
- Fire management
- G.I.S application
- Training of non-scientific officers working in the following sectors e.g. Economic Planning, State Law Office Municipalities, District Councils, etc on the importance of Sustainable Land Management, with a view to obtaining their support for field interventions.
- ICZM

Development of expertise in the following areas that are directly/indirectly related to beach erosion include:

- Creation and closure of natural passes
- Coastal Management including monitoring
- Protection and restoration of corals and associated communities of the lagoon
- Assessing physical damage to lagoon corals by large nets and basket trap fishing
- To assess lagoon sediment production capacity and examine sediment pathways / movements.

5.7 Capacity Building Strategy for Rodrigues

In addition to the recommendations made for Mauritius which are also applicable for Rodirigues, the following recommendations are meant to reflect the Rodriguan specificities and to address capacity weaknesses under the biodiversity and land degradation thematic areas.

5.7.1 Biodiversity

5.7.1.1 Terrestrial Biodiversity in Rodrigues

A total of 134 species of native plants have been listed for Rodrigues (Strahm 1993). Around 39 of these species are being closely monitored and propagated.

An intensive programme for the production of seedlings of native plants, some threatened with extinction, is ongoing. A number of species have been successfully propagated such as *Ramosmania rodriguesii* (Café marron), known only a unique sterile plant, which successfully propagation obtained after trials at the Royal Botanical Gardens, Kew (UK).

The successful partnership between the communities, local NGO and the Forestry Service in Rodrigues has allowed implementation of conservation measures towards restoration of the remnant native forests. Community forests have been developed on about 200 ha of lands in five villages. Beneficiaries were also trained in forest nurseries and management.

An intensive programme for the production of juvenile native plants that were once threatened of extinction is ongoing and a number of plants have been successfully propagated to the example of *Ramosmania rodriguesii* (Café Maron) of which only a unique sterile plant was left. Following a number of trials at Kew Garden in England has the successful propagation been possible.

The forest cover has been digitalized and a Forest Management Information System (FMIS) established. The officers have been trained in the manipulation of the FMIS software and in Arc View Geographical Information System in 2004.

However, the conservation facilities need enhancement and staff trained to effectively manage the fauna, establishment of protected areas as well as management of sensitive areas. The recommendations are as follows:

A. Management of Protected Areas/ Nature Reserve/Caves

- *Systemic level*

- Development of management plans for all Protected Areas, Nature Reserves and Caves
- Development an inventory programme for the caves
- Need to establish more PAs with relevant training needs
- Continue with sustain restoration programme of native flora and fauna

- Capacity building CBOs and NGOs in terms of project formulation and write up, project management, monitoring and evaluation.
- Development of best management practices and dissemination

Institutional level

- Training of scientific staff and key stakeholders in management of Pas, reserves and caves

B. Endangered Native Fauna

Systemic level

- Initiate of conservation and rescue programme for the endangered species
- International assistance to support studies on the native fauna species
- Development of programme aimed at elimination of potential predators

C. Invasive Alien Species (IAS)

Systemic level

- Development of management plan for control of IAS
- Harness Community participatory approach in the control of IAS and propagating endemics
- Awareness raising of population in general through preparation and dissemination of outreach material.

Institutional level

- Training of staff of relevant institutions to enable enforcement and appropriate phytosanitary control at immigration level. Also, training needs to be extended to NGOs

D. Lack of data and absence of data base

Systemic level

- Support for the setting up of a data base including procurement of logistics and software
- Formulation of a data collection programme and data sharing protocol.
- MoU to be developed for data sharing between RRA and EIS project
- Capacity building through training of staff in data management

5.7.1.2 Fresh Water, Coastal and Marine Biodiversity in Rodrigues

Rodrigues has a lagoon which is twice the land surface area and which contains a diverse marine ecosystem. Conservation efforts at the level of the RRA have been hindered by

severe lacks of technical and financial resources. The pressures on the lagoon are rather visible and studies have confirmed a decreasing trend in terms fish and octopus catch reduction. The decline in the amount of lagoon resources has been attributed to unsustainable fishing practices, pollution, and siltation of the lagoon in general.

There are presently 5 Fishing Reserves proclaimed under the Fisheries (Reserve Area) Regulation 1984 for Rodrigues and the creation of the first Marine Park in the southern region at Mourouk would be materialized through a Government/ GEF funded "Partnerships for Marine Protected Areas" project. Under this project appropriate management strategies will be developed and tested to ensure the following:

- The maintenance of ecological diversity
- To maintain sample ecosystem
- To provide for education, research and tourism
- Multiple use in regulated ways

As at to date, there are some 1971 registered fishermen involved in the fisheries sector whereby most of them operate within the confinement of the lagoon. There is also a significant number of 'part time' fishermen that are involved in lagoon fishing.

On the other hand, a limited number of about 250 fishermen practice off lagoon fishing. The timid exploitation of the off lagoon resource is primarily due to the lack of expertise and lack of appropriate boats to venture off lagoon because of the rough sea that exists in Rodrigues (around 150 Bad Weather days/year).

In an attempt to reduce pressure on the lagoon, efforts have been initiated to sensitize and train fishers for off lagoon and fishing around FAD.

The mangrove ecosystem is being established in areas such as Diamant, Baie Malgache, Mourouk, and Anse Pansia. To date some 40 ha of mangroves have been planted in the several bays to control soil sedimentation of the lagoon. The major species being propagated is *Rhizophora mucronata.*

Regarding fresh water ecosystem, there is only a few wetlands in Rodrigues. However no monitoring/ inventory have been carried out so far.

In order to address the capacity gaps and weaknesses, the following recommendations have been made:

A. Promotion of sustainable exploitation of the marine resources

- *Systemic level*

- Development of further incentives mechanism to encourage off lagoon fishing (e.g. Loan at concessionary rate to purchase boat and engine of greater capacity).
- To undertake research and development of alternative techniques together with provision of appropriate facilities
- Strengthen enforcement of the law through provision of logistics and training

- Raise awareness of fisher through sensitization and training
- Encourage community participation to step down fraud
- Survey of number of unregistered or part time fishers

Institutional level

- Institutional strengthening of the Fisheries, Research and Training Unit
- Training of staff on the ecological importance and management of wetland

A. Setting and Management of Marine Protected Areas

Systemic level

- Development of a framework for the creation of PAs with partnership management
- International assistance for the implementation of the necessary infrastructure
- Capacity through training for an effective and sound management of resources

B. Stock assessment of lagoon and off lagoon resources

Systemic level

- Capacity building through training for the stock assessment of lagoon and off lagoon resources
- Support for the establishment of data base and also for the develop new software
- Development of set of Indicators and benchmarking
- Training of FRTU and NGOS staff on stock assessment and monitoring

C. Preservation and marketing strategy for fishery products

Systemic level

- Support for the implementation of preservation facilities
- Training on handling and preservation of catch
- Sensitization on sanitary measures to be adopted
- Marketing strategy to be developed

5.7.1.3 Agro-biodiversity and Biotechnology

Agriculture is the key economic sector of Rodrigues. The production system is mainly traditional and numerous farmers continue to operate subsistence agriculture. Adoption of novel techniques is very low and most farmers continue to produce without addition of fertilizers.

In line with the NSSSP for Rodrigues, the Agricultural Services has worked out a strategic plan for the development of five key products in 2003; namely:

- Honey

- Pork
- Rodriguan Lime
- Local Red Bean
- Rodriguan Small Chilli

The Rodrigues Regional Assembly has also introduced the item 'Incentive to Farmers' in the budget 2004/2005 to assist farmers in professionalizing their enterprise. The sum of Rs 1.8 M of the budget has been increased in the 2005/2006 budget to Rs 2.5 M.

Further more, the RRA is promoting irrigation facilities to farmers where irrigation infrastructures are being promoted.

Specific recommendations to address the capacity constraints and weaknesses pertaining to the Agro biodiversity sector include:

A. Enhance Crop production

Systemic level

- Encourage utilization of appropriate irrigation system
- Training of farmers to adopt novel techniques of crop production
- Institutional Strengthening of the Extension Unit
- Development of an appropriate marketing channel for the agricultural products
- Support targeted collaborative research and development programme with MoAI&F, AREU, MSIRI, UoM, etc.

B. Support towards genetic conservation

Systemic level

- Policy development to promote genetic resources conservation
- Develop facilities for sperm genebank
- Control import of species susceptible to cross with local species

Institutional level

- Training of staff in genetic conservation

C. Strengthen phytosanitary control

Systemic level

- Strengthen bio-control measures with stricter phytosanitary control at point of entry and compulsory import permit for all agricultural products.
- Sensitization campaign

Institutional level

- Training of personnel

D. Promote sound livestock production

Systemic level

- Promote semi-intensive production system on improved pasture
- Development of farmers training programme on proper production system with the aim to improve animal health
- Capacity building of local personnel as veterinary officers (to promote preventive rather than curative) with the provision of appropriate infrastructural facilities
- Establishment of a proper network amongst the farmers
- Training of farmers on Rotational Grazing
- Set on-farm trials on rotational grazing
- Promote participatory approach system for pasture setup and management

5.7.2 Land Degradation

A. Sustainable Land Management

The inherent topographic features and adverse climatic conditions make it conditional that judicious land management prevails in Rodrigues, in order to preserve the soil cover and arable lands.

The constraints to efficient land management; identified to-date are: the existing land tenure system, the inexistence of a coherent land database and human induced erosion.

The recommendations at the various levels include:

Systemic Level

- Enforcement of land lease clauses which stipulate that lessee is bound to maintain anti erosive works on the plot of land allocated to him.
- To adopt and regulate the National Development Strategy on land use and planning and recommended policies for zoning and clustering of areas.
- To replicate pilot project on Area Action Plan of La Ferme
- To consider replication of Anti Erosion Program pilot activity, which consisted in providing incentives to land lease holders for rehabilitation of soil protection infrastructures
- The decentralised management of agricultural leases should be promoted to accelerate delivery period of permits and leases

Institutional Level

- A detailed outline scheme is required for Rodrigues
- Land Information System to be finalized
- Recruitment /Contracting out of private surveyors to eliminate backlog of land applications

- Application of technology on Remote sensing, Photogrametry and Satellite Imagery should be introduced to aid in land management

Individual Level

- Training of staff in Remote sensing, Photogrametry and Satellite Imagery technology
- There is need for training in land management and administration
- An agricultural engineer should be recruited or trained to assist in topography and terrace management, hydroponics, irrigation, livestock housing designs, among others.

B. Sustainable Agricultural Systems

The key sub issues addressed are the abandonment of agricultural lands, decline in soil fertility and overgrazing.

The abandonment of arable lands, and overgrazing by uncontrolled livestock are pertinent causes to land degradation. Moreover, the recurrent drought periods coupled with limited availability of irrigation represent high risks agricultural enterprises with the result that more people are deterred from this activity.

The limited availability of fodder is presently detrimental to the environment and result in overgrazing, ending up in having exposed soils which is prone to erosion.

The recommendations include:

Systemic level

- The Livestock (Cattlewalks) regulations should be revised and appropriate environment created to enhance its sustainable enforcement.
- To devise appropriate Incentives and Crop insurance to compensate for high risk levels
- To facilitate access to agricultural lands and create awareness about credit facilities
- To create legislative framework to boost and support the agro-processing sector
- Support to future implementation of Soil and Water Conservation Decentralised EDF Project

Institutional level

Crop Sector:

- To finalize Registration of farmers
- Mechanisation sector needs to be developed
- Vulgarisation of novel technologies (e.g. protected cultures, mini tunnels, greenhouses, etc.)
- Development of orchard production
- To promote agricultural diversification

- Control should be exerted over the marketing of fake or adulterated "Rodriguan" food products e.g. honey, red beans, dry octopus, etc

Livestock Sector:

- Additional fodder reserves should be created.
- Replacement of rusted fencing and introduction of live fence is recommended
- Rotational grazing should be promoted
- Sylvopastoral activities to be introduced in cattlewalk areas
- Meat processing sector to be developed
- Need for improved husbandry practices (shelter, control of parasites, etc).
- Need for Assessment of Economics of livestock and fodder production and hence promote cut and carry system by farmers.

Improve Soil Fertility:

- Need for the set up of an elementary laboratory to conduct basic soil tests in view of recommending remedial measures.

Individual level

- Training and adoption of Dry Land farming systems
- Need for training and research on animal nutrition and animal feeds.
- Human resource capacity for fodder management and conservation should be developed
- Need for training and assessment of economics of livestock and fodder production and hence promote cut and carry system by farmers.
- Refresher courses on agricultural extension should be provided to Agricultural staff
- Training is needed in Statistics and Biometrics to analyse data and develop experimental designs

C. Management of Forest lands and nature reserves.

Noticeable achievements have been accomplished by the Forestry Service to improve and exert effective control over forest cover of the island.

However, two issues were identified to be dealt with; i.e. proliferation of IAS and absence of forest cover in the cattlewalk areas.

Measures below were recommended address the principal associated capacity constraints of lack of trained human resources and insufficient labour force.

Systemic level

- Additional nature reserves should be declared
- To create appropriate environment for the sustainable enforcement of revised Livestock (Cattlewalks) regulations
- Appropriate legislative framework should be developed for the establishment of community forests

- *Institutional level*

  - Sylvopastoral development to be initiated in cattlewalk areas
  - Deployment of labour force from other institutions

- *Individual level*

  - Training in forest, islet and biodiversity management needed
  - Training on Remote sensing and Satellite Imagery for efficient forest management and identification of tree species.

D. Coastal Degradation

Coastal degradation has been identified as a phenomenon localised to certain parts of the shoreline. Human interventions in terms of lagoonal sand extraction, infrastructural development, e.g. construction of walls and other structures have been the main reason attributed.

The recommendations made by earlier studies still hold good. These include

- *Systemic level*

  - Implementation of the recommendations made for the sustainable management of beaches, construction and set back distance from the beach and appropriateness of existing anti erosive measures on Coastal Erosion (Cazes-Duvat, 2003),
  - The setting up of a defensible setback policy based on the physical processes of flooding, and land and beach erosion (Bairds *et al.*, 2003).

- *Institutional level*

  - Establishment of a dedicated team to monitor beach erosion with the development of erosion profile to control beach erosion.
  - Protocols should be established to monitor reef- lagoon habitat (Bairds *et al.*, 2003)

- *Individual level*

  - To build up capacity through training in Integrated Coastal Zone Management

Chapter VI
Way Forward

6. Way Forward

1. ***High level political support and strong coordination*** would be essential for the successful implementation of the NCSA recommendations. A revised institutional mechanism in the form of an ***Inter-Institutional Coordination Committee*** has been recommended. ***Three independent task forces*** would be needed to carry forward the implementation of activities around which synergies can be built and achieved, namely, for the ***education and public outreach, training and re-training, and joint research programmes***. For the implementation of recommendations under the sub thematic areas, the key executing agencies would be required to take the lead role.

2. The strategic recommendations for capacity building made under this NCSA report can best be implemented within a series of capacity building programmes and led by the key executing agencies concerned. The capacity building process should be seen as a dynamic process requiring appropriate evaluation and necessary re-engineering in line with national and global challenges. ***Monitoring and evaluation*** has to be inbuilt in the ***capacity building programmes***.

3. The scheduling of the recommended activities would be subject to availability of funds and in general, upon logical ordering requirements with the systemic capacity building recommendations implemented either prior or concurrently with measures pertaining to institutional and individual levels.

4. Funding being one of the key limiting factors, the capacity building measures can be formulated into a ***Medium Sized Project*** and submitted for ***GEF funding*** through the relevant Implementing Agency.

5. Integration of the recommended research areas in the national priority list as well as ***financial support / grant*** to undertake such research activities to be further considered by existing agencies such as the Mauritius Research Council and others.

6. Capacity building can also be achieved through ***bilateral technical cooperation with technology advanced countries***.

7. Priority should be to promote the ***use of relevant local expertise*** for capability and skill enhancement for the various training areas identified including the specialised training. Only in the event that the required training facilities/ trainers are not available locally, international expertise is to be solicited. In such case, ***'train the trainer' approach*** should be given preference and the beneficiaries to be in turn called upon to carry out local training.

Annex 1

Table 3.1: Adapted Root Cause Matrix on Biodiversity: Terrestrial/Forest Biodiversity

Issue	Root causes	Potential corrective/mitigating measures	Ongoing activities/past recommendations
Limited area under protection and inadequate conservation management of native ecosystems	***Systemic*** • Proportionally too much emphasis placed on species approach conservation apparently due to low appeal of ecosystem approach	• Larger scale restoration (also include job creation) • Improved management plans	• Complete/improve, and implement sound management plans for conservation areas
	• Limited realisation of importance of ecosystem approach to sustainable long term conservation	• Development of cheaper alien control and maintenance methods • Development of cheaper contractual mechanism for conservation management	• Experiment new potentially cheaper weed control measures and contractual mechanisms (as recommended by Wildlife & National Park Advisory Committee) • Implementation of new concept of micromanagement as recommended by NTNPC
	• Currently prohibitive cost of large scale conservation management and low current level of conservation management research	• Legal protection extended to far more threatened species	
	• Some areas not adequately protected by law (biodiversity rich private land)	• Incentives for Private land owners to manage their land for conservation	• Carry out survey of privately own land to assess their biodiversity values for eventual prioritisation
	• Conservation being a comparatively low priority for Government	• Prioritise and earmark new areas to be protected and place under conservation management, including particularly biodiversity rich, mountain reserve and dry lowland forest	
	• Relevant laws not fully implemented	• Enforcement of existing laws • Increase penalties for law contraventions	• Increasing area on mainland and offshore islets being managed or restored
	• Alternative land use • Land use incompatible with biodiversity	• Legal protection extended to far more threatened species	

	conversation • Virtually inexistent monitoring	• Create centralised biological database/ mapping system to allow efficient monitoring	
Invasive alien species (IAS)	***Systemic*** • Ongoing introduction of alien species (deliberate and accidental) • Very limited public awareness and understanding of severity of threats posed by IAS • Quarantine not efficient • Lack of legislation to regulate entry of IAS potentially deleterious to biodiversity • Lack of coordinated effort to fight IAS already established	• Decrease commercialisation and use of IAS/Increase availability of native species and its use for landscaping • Raise public awareness about negative impacts of IAS • Development of improved control methods for already established IAS and new IAS • Passing of an adequate IAS law in the country and provide provisions for control/eradication of already present pests • Legal blacklisting to prevent entry in the country of species likely to pose serious threats to native biodiversity • More effective border control to reduce risks of introduction of new IAS • Good monitoring system to detect new pest outbreak • Development of improved control methods for already established IAS and new IAS	• National IAS Committee (NIASC) set up (but still seeking greater leverage) • Possible inclusion on the Plant Act, which is in revision, of a Black List of worst invasive weeds to be prevented of entry in Mauritius, as recommend by NIASC • Controlled scientific research into improved cost-effective ways of controlling established IAS • Small scale action: areas of forest being weeded, trapping and poisoning
Lack of training	***Systemic*** • Limited interest in conservation • Few conservationist jobs available • Limited financial resources (biodiversity is a low priority for the	• Increase incentives for careers in biodiversity conservation • Increase prospects of conservation related jobs (both technical and managerial)	• Set up University course Programme for conservation biologists • Creation of field courses in ecology and conservation • Increasing number of graduates with

	country) • Limited ongoing training of personnel • Lack of locally available course for ecologist and conservation biologist (students and professionals)		conservation and fieldwork background (University of Mauritius has recently increased its ecology related courses from 2 to 7 modules)
Incomplete inventory	***Systemic*** • Inadequate conditions for storage and maintenance of specimens of several groups • Information not always accessible/lack of communication within institutions ***Institutional*** • Lack of local taxonomic expertise • Poorly staffed and equipped Natural History Museum	• Strengthening of links with Natural History Museum • Create centralised biological database for easy and efficient access to information • Training of personnel in taxonomy • Improved museum infrastructure and curation	• Ongoing Darwin Initiative on native insects • Botanical survey on private land being planned
Habitat fragmentation	***Systemic*** • Past extensive deforestation • Continued forest degradation due to lack of management • Current continuing deforestation and infrastructure development (e.g. SE Highway project)	• Increase protected areas and their adequate conservation management to slow down/reverse further fragmentation • Create habitat corridors between isolated fragments • Conduct reintroduction programs where suitable	
Limited inter-institutional communication and collaboration	***Systemic*** • High level of bureaucracy • Information not always accessible/lack of communication within institutions	• Streamlining of bureaucratic procedures improving collaboration • Amendment of legislation for non-duplication and harmonisation (e.g. Nature Reserve Act and Wildlife & National Park Act) • Creation and maintenance of inter institutional committees	• Committees created (NIASC) or reactivated (NTNPC) encouraging inter institutional collaboration

	Institutional • Serious limitation in infrastructure (office, space)	• Improve infrastructure	
Limited research	***Institutional*** • Too few institutions involved in such research • Limited technical training available to conservation stakeholders • Limited researcher positions within institutions carrying out research • Limited resources available to researchers • Limited financial resources (biodiversity is a low priority for the country)	• More institutions to have a research oriented component of quality • Staff training • Encourage institutional collaborative research • Coordination of research to avoid duplication	• MoU between UoM and NPCS to include synergies in research
Limited awareness of the population at large	***Systemic*** • Limited knowledge of native biodiversity • Inadequate presence of need to conserve biodiversity in school curriculum	• Involvement of volunteers in conservation work (ex students, youth groups) • Community based restoration programmes • School curriculum adopting teaching of native biodiversity and its conservation • Recycling of school teachers/Development of specific country oriented school resources	• General elective module on native biodiversity and its conservation planned at UoM • Planned further involvement of volunteers in conservation work (as discussed on Wildlife & National Park Advisory Committee) • UoM students club willing to be given opportunity to help during their holidays

Table 3.2: Adapted Root Cause Matrix on Biodiversity: Inland Water, Coastal and Marine Aquatic Biodiversity

Issue	Root causes	Potential corrective/mitigating measures	Ongoing activities/past recommendations
Incomplete inventory	***Systemic*** • Information gaps • Limited funds to continue expensive exploration/ inventory works ***Institutional*** • Lack of local taxonomic expertise and incentives in that field • Lack of communication within institutions • Poorly staffed and equipped Natural History Museum • Inadequate facilities for storage and maintenance of specimens of several groups	• Create either a uniform database for easy storage and retrieval of information on marine and fresh water biodiversity • Development and prioritisation of a long term and well coordinated inventory programme • Provision of funds to continue systematic inventory with particular attention to poorly studied groups • Encourage community participation and enrol traditional knowledge • Training of personnel in taxonomy • Strengthening of links among inventory stakeholders, including Natural History Museum, MOI, NGOs, Ministry of Fisheries, Mauritius Herbarium, UoM, knowledgeable individuals • Improved museum infrastructure and curation together with appropriate training	• Inventory of freshwater fish and macrocrustaceans • Inventory of the coral fauna of Mauritius initiated by the MOI • Bio-prospecting of Mauritius waters by the MOI • Creation of a widely accessible database of marine organisms by the MOI • Undertake sensitisation work
Ecosystem degradation	***Systemic*** • Rapid development of coastal zone • Knowledge gaps that have resulted in	• Zoning and maintenance of areas of high ecological importance for various uses • Bridging knowledge gaps on ecosystem through	• Preparation of ICZM and Beach Management Plan • Removal or relocation of facilities to set back line

	certain inappropriate ecosystem degradation • Past damaging activities (e.g. deforestation, sand extractions, coastal constructions like jetties and piers) • Water pollution from mainly non point sources resulting in eutrophication, siltation and ecosystem damage (Due to illegal release of untreated effluent, and agricultural and industrial pollutants) • Coastal wetlands disruptions and filling • Destruction of mangroves and sea grass beds • Coral trampling, anchor and boat pole damage etc. • Alien species invasion • Global climate change causing coral bleaching • No clear mandate for fresh water	training to allow better assessment and rehabilitation • Strengthen enforcement to allow for an efficient monitoring regarding abatement of industrial and domestic pollution through provision of training and equipment • Development of a wetland restoration plan (including mangroves) • Re-vegetation of coastal areas with appropriate species • Protection and restoration of aquatic ecosystems (fresh water and coastal) through a variety of means including education • Strengthen monitoring programme in new vulnerable areas including inland water courses • Regulation of activities that damage marine life, e.g. ski lanes, undersea walk and other water sports activities • Creation of more environment friendly mooring points in the lagoon and outer reef areas • Promote sensitisation and awareness for the various decision makers, promoters and aquatic users including tourists • Continue creation and monitoring of artificial reefs as part of a long-term programme	• Strategy being devised to improve water quality in coastal waters • New Sewerage Plant to reduce marine pollution (Baie du Tombeau) • Restoration of native coastal vegetation • Replanting of mangroves • Ship sinking for reef building • Coral Reef Monitoring Project ongoing • Mapping of marine habitats of the South-East coast of Mauritius • Mooring buoy project to reduce anchor damage • Lagoon and Reef Watch Movement of the MOI • Sensitisation campaigns by Government and NGOs • Coral restoration as pilot project in Flic en Flac

	biodiversity • Lack of information on fresh water biodiversity	• Creation for a special desk or unit for fresh water biodiversity	
Illegal fishing and poaching (in outer islands)	***Systemic*** • Poorly enforced laws by relevant institutions ***Institutional*** • Limited awareness of fishermen and poachers • Community support and low awareness (e.g. purchasing of turtle parts) • Huge size of Mauritian EEZ greatly limits its effective surveillance • Inadequate staff and equipment for patrolling • Absence of conservation programme and management plans for outer islands	• Increased penalties to truly discourage illegal fishing and poaching • Strengthen capacity for coast guards to enforce laws in lagoons and on islets • Develop and implement conservation programme • Sensitization campaign for fishermen and community at large • Establish monitoring programme for the outer islands together with provision of in situ facilities, equipment and trained manpower • Collaboration with neighbouring countries to achieve effective EEZ surveillance • For leased islets, to include marine conservation measures in lease agreement	• Amend laws to increase penalties • Provide an enabling environment for coast guards to enforce laws • Set up and run sensitization campaign • A Vessel Monitoring System is planned for implementing effective surveillance of Mauritian EEZ
Over fishing (lagoon and fresh water)	***Systemic*** • Increasing demands coupled with decreasing yields of fish • Illegal fishing • Poor enforcement of laws • Bad weather allowance increased	• Development of alternative fisheries • Development of mariculture (Assessment of potential is required on a national scale) • Studies to identify diversification possibilities towards other form of aquaculture (shrimps and octopus) and also commercial algae production • Improved surveillance through logistics and	• Off lagoon fisheries being encouraged • Fisheries Protection Services and National Coast Guard are stepping up surveillance intensity • Running of the

	fishermen pressure • Resistance on the part of fishermen for recycling • Reduced habitat quality for marine life • Gaps in knowledge	facilities • Sensitisation and training • Limited number of fisherman licences delivered • Habitat rehabilitation (fund to conduct studies meant for bridging knowledge gaps)	Fisheries Training and Extension Centre (Pointe aux Sables) • Mangrove restoration program ongoing
Limited area under protection and inadequate conservation management	***Systemic*** • 2 Marine Parks, 6 fishing reserves and other areas not adequately managed for conservation • Marine areas inventories still deficient • Limited logistic support • Competing alternative area uses • Conservation is a priority for Government, however funding limited • Need for enforcement of regulations for various MPAs users	• Development of MPAs' management plan for the 2 marine parks and implementation • Harmonise management of islets with marine component • For newly declared Islet National Parks which also include management of 1 km aquatic area from the shore, development of conservation and management programme • Improve management of MPAs through appropriate training and logistic supports to undertake field works • Development of a framework for the establishment and legal protection of new/ additional protected including wetland sites, river and lake (freshwater ecosystem) • Development of partnership management approach with all concerned stakeholders concerned	• Strategy and Management Plan of islets National Park being finalised • Virginia Conservation Area project being set up to restore and conserve mainland coastal biodiversity • Demarcation of the 2 MPAs
Invasive alien species (IAS)	***Systemic*** • Ongoing introduction of alien species (deliberated and accidental) • Lack of legislation to	• Passing of an adequate IAS law in the country and provide provisions for control/eradication of already present pests	• National IAS Committee (NIASC) set up (but still seeking greater leverage) • Proposal on

	regulate entry of IAS potentially deleterious to biodiversity • Limitation at the Quarantine level concerning aquatic species • Very limited public awareness and understanding of severity of threats posed by IAS • Lack of coordinated effort to fight IAS already established	• Legal blacklisting to prevent entry in the country of species likely to pose serious threats to native biodiversity • More effective border control to reduce risks of introduction of new IAS • Limit commercialisation and use of potential IAS (only allow for those whose risk assessed) • Good monitoring system to detect new pest outbreak • Capacity building on IAS risk assessment and management • Development of improved control methods for already established IAS • Control commercialisation and use of potential IAS (only allow for those whose risk have been assessed) • Raise public awareness about negative impacts of IAS • Establishment of a dedicated team to assess and monitor IAS (marine)	development of a pest control strategy is ready. Funding not yet secured • A Task Force on the monitoring of Ballast Water has been set up by the Ministry of Public Infrastructure, Land Transport and Shipping
Lack of training	***Systemic*** • Complexity of the marine environment ***Institutional*** • Limited ongoing training of personnel • Lack of locally available course for ecologist and conservation biologist (students and professionals)	• Seek local fund as well as international assistance to bridge knowledge gap and for training in specialised areas (taxonomy – corals, species; ecology; reef management; mariculture, MPA management) • Conduct a training assessment and development of a training plan • Development of train the trainer programme • Develop linkages amongst local institutions for the development of tailor	• Increasing number of graduates with conservation and fieldwork background • Set up University course Programme for conservation and marine biologists • Creation of field courses in ecology and conservation

		made programme	

Table 3.3: Adapted Agro-biodiversity Root Cause Matrix (mainland Mauritius)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	Ongoing activities/past recommendations
`or a ehensive and ıted policy ıgar sector)	***Systemic*** • Although priority is given to the sector, implementation is inadequate (e.g. due to limited funding) • Lack of forward planning • Absence of a comprehensive baseline document • Absence of data in certain areas • Data that are available are kept in a fragmented manner • Inaccessibility of existing data • Absence of a National Agro-Biodiversity Committee (NABC)	• Implementation of identified measures and activities with Monitoring and Evaluation programme in place • Policy review and recommendation • Need for comprehensive and 'consistent' long term planning • National Integrated Planning on Agrobiodiversity • Creation of a biodiversity secretariat • Setting up of appropriate coordination mechanism • Establish a National Agro-Biodiversity Committee (NABC) • Develop synergy between public, private, NGOs amongst others	• Recommendations made under the Sugar Sector Strategic Plan • Recommendations made in the Su Sector Plan • FARC: Strategic Plan • Botanical Garden as a Conservatio Centre (*in- situ* and mostly *ex- situ*
dequate netic nservation *l Utilisation/* *ploitation* tivities:	***Systemic*** • Very costly and fiscal return is not immediate • No proper weightage given in terms of Government priorities • Limited funding • Poor co-ordination among institutions • Absence of regulating mechanism pertaining to PGR • No dissemination of research results in some sectors ***Institutional*** • Lack of Human and Infrastructural capacity in various institutions	• More funding for conservation and required infrastructures • Provide special funding for projects on agro-biodiversity • Activities to be co-ordinated with applied agriculture • Specific assignments or commitments in Research and Development program of research institutions • Sustainable use of genetic material for improving genetic potential • New breeding programme to be initiated in a number of specified crops Dissemination and publication of research results/ data • New breeding programme to be initiated in a number of specified crops • Increase *in qualified* Staff	• Implementation of the Non-Sugar Strategic Plan • SPGRC financed some projects • Creation of a basic seed station • Specific training on multiplication/ regeneration conservation
l	***Systemic*** • Conflict on institutional	• Sort out institutional responsibilities –	• Collection initiated by both AR

	responsibilities	Needs for clear mandate to be spelt out for relevant institutions	Agricultural Services
	• Lack of vision for livestock sector • Low priority to local breed • *No* strategy for research	• Develop a comprehensive programme of work with time schedule • Comprehensive policy and strategy for the livestock sector to be redefined and implemented	• Provision made in Non-Sugar Stra Plan
	Institutional • Limited qualified staff • Lack of Human and Infrastructural capacity	• Provide qualified staff in institutions concerned • Provide appropriate infrastructure • Increase funding	
ce of tory vork to te research for pment.	***Systemic*** • IPR Bill absent • Lack of concerted effort in producing novel seeds or agricultural practice • Absence of exchange germplasm mechanism	• Enact bills on seed, Breeder's Right and exchange of germplasm including IPR Bill	• Draft Bills (Seed Bill, IPR Bill, Pl Protection Bill) have already beer prepared • FARC has already worked on a promising area for food as biotech
	• Inadequate coordination among research institutions	• Improve co-ordination among research institutions • FARC's role in coordination should be enhanced	
inal Plants & onal edge ted	***Systemic*** • Easy access to modern drugs • Conflict between traditional and modern medicine	• Inculcate traditional values to new generation (to be backed by research) and the use of medicinal plants • Participation of private sectors, NGOs and CBOs	• Few publications on medicinal pla available
	• Limited capacity to undertake research	• Involvement of international collaboration	
	• Lack of consolidated information	• Research intensification for practical use	• Research effort has been initiated medicinal plants through MRC fu (for the last 5 years or so)
	• Neglect of traditional values and medicinal plants	• Immediate assessment of potential medicinal plants • Survey & collection of information/ knowledge from older generation before they disappear • Protection and conservation under law	
d Research on biodiversity	***Systemic*** • Little attention given to biodiversity research	• Mainstreaming of agro-biodiversity into national policies	
	• Capital intensive and does not bring immediate gain	• Proper incentive be given to encourage conservation and management of biodiversity	
	• Limited funding	• Funds be made available	
	Instituional • Lack of institutional capacity	• Increase research capacities • Provide incentives for project funding by MRC	Few academic research are being car

	Individual Lack of competency (knowledge, skills and aptitudes)	• Training and awareness	

Table 3.4 : Adapted Biotechnology Root Cause Matrix (mainland Mauritius)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	Ongoing activities/past recommendations
f a ehensive in nology (with lar reference sugar sector)	***Systemic*** • Absence of policy • Absence of guidelines and a long term vision for biotech in Mauritius	• Need for a comprehensive and consistent national policy • Set norms, according to international convention	• FARC has work on an elaborate Programme on biotechnology, in 2005)
lized ıg	***Systemic*** • Very costly training • Limited number of scientists that have mastered specialised and sophisticated training • Expensive technology	• Funding to be made available for continous training and retention of staff • Need for specialised training to enable relevant advanced research • International assistence to be sought from donor agencies through IAs such as UNEP, FAO	• On-going research/training at Uo MSIRI • Training needs analysis undertak the Ministry of Agro-Industry an Fisheries
ıent of legal ork and ement	***Institional*** • Limited trained technical staff for implementation of GMO regulations • No proper administrative facilities yet in place	• Training for staff on EIA, risk assessment and risk management • International assistence to be sought from donor agencies through IAs such as UNEP, FAO. • Strengthen enforcement of the GMO Act 2004	• GMO Act passed in parliament ir • Part of GMO Act is now being er
f co- ion among ions	**Systemic** • Absence of co-ordinating body to direct research	• Instituting of a central body for co-ordinating work & set research priorities • Financing long term project and set task to facilitate implementation	• Mauritius Agricultural Biotechno Institute (MABI) is being set up
nderstood e (Limited ess gn)	***Systemic*** • Media inflate on the pro's & con's • No proper introduction of the subject and sectors of novel finding are being emphasised	• Proper assessment of relevant and appropriate biotechnology tools, their limitations and potentials required • Educating the public on the GMO Act • Needs for a national sensitisation strategy (Proper education / sensitisation should be introduced at early stage in schools and also carried out for the public in general)	

Table 3.5: Adapted Root Cause Matrix for Climate Change: Science and Variability (Mauritius and Rodrigues)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Need for a complete picture of a warming world and other changes in the climate system	**Systemic** ▪ **Knowledge gap** in our understanding of the climate processes	• Enhance our **understanding** of the climate processes through R & D	• Ml • R un
	▪ **Uncertainties** due to ❖*Limitations* with detection techniques; analytical methods; data processing techniques; techniques adopted for spatial sampling; observational networks; data availability (both current and palaeo-climates); quality-control of data; inter-comparisons among data from different sources; models that simulate changes with observed recordings; ❖*Attribution difficulties* due to complexity of the systems (e.g. internal vs external factors, +/- radiative forces, ❖*Quantification difficulties* due to dynamic changes (e.g. aerosols – compared to GHGs);	• Reduction on uncertainties through improvements in detection techniques, in data processing techniques, in analytical methods, in spatial sampling; in observational networks; in data coverage to include current climate and palaeoclimates; in quality-control of data; in inter-comparisons; in modelling; on attribution and quantification • Establish protocol for data **sharing**; Free exchange of data, information and research findings;	• Ml va • CC Uc
	▪ Scarcity of funds for research; ▪ Limited Capacity and expertise;	• International assistance for the setting up of a Virtual ***Centre of Energy and Environment*** *(preferably at an existing institution with an initial infrastructure and capacity)* to promote advanced R&D, undertake data management, postgraduate teaching programmes and be active in sensitising the public, decision and policy makers	▪ Lo de ▪ Ma ma IP UN

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Projections of future climate and sea level rise (SLR) with focus at regional level	**Systemic** ▪ Knowledge gap on making future climate and SLR projections ▪ Know how and insufficient local expertise • Limitations' with acquisition of appropriate data ▪ Scarce funding as CC is generally regarded as an area of low priority; ▪ Research in basic science on climate is scarce ▪ Handling of data ▪ Climate models lack the spatial detail required (e.g., very small-scale phenomena such as thunderstorms, tornadoes, hail and lightning)	• Capacity enhancement in CC Science, trend analysis, forecasting, modeling (incl. GCMs), scenario building, GHG inventory and use of climate models with the appropriate spatial details • Development of Disaster Evacuation plan • Enhance GHG inventory and development of a national mechanism for carrying out Energy Audit; • Continue participation in global data collection efforts; • Improve data acquisition towards better estimates of GHGs (CO_2 and non-CO_2) • Free exchange of data, information and research findings at national as well as the regional level • Develop relevant climate change indicators and make projections of future climate (including forecasting climate hazards and climate extremes) and sea level rise	• • Ma ma SA • Ml – s co Of • Re for ex im
Limitations with Data Management and Information System	**Systemic** ▪ Lack of latest technology and equipment; ▪ Absence of an appropriate protocol for data sharing; ▪ Little research ▪ Inadequate sensitisation	▪ Development of a collection strategy for relevant data needed for projections and mitigation analyses ▪ Foreign assistance and funding required for the development of an information system (including software development and logistics, and training) ▪ The already proposed Virtual ***Centre of Energy and Environment*** may also undertake data management, establish protocol for data sharing, free exchange of data, and ventilation of information and research findings ▪ Update existing complementary databases such as CSO, DMS, MMS, NODC ▪ Public outreach programmes such as appraisal of hazard level, evacuation plans, amongst others	• MM rela ▪ CC UoM ▪ PM(Syst drou othe ▪ CS(eco

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Linkages	**Systemic** ▪ Limited interactions and inter institutional linkages amongst relevant institutions • CC to be considered and included under the regional agenda	▪ Strengthen national and international co-operation to undertake collaborative efforts and building linkages in order to better utilize scientific, computational and observational resources; The already proposed virtual ***Centre of Energy and Environment*** may be mandated to play a key role here nationally, regionally and internationally ▪ Promote the free exchange of data and information ***amongst institutions*** ▪ Increase the observational and research capacities Foreign assistance and funding to undertake collaborative initiatives at the regional and international	• Con out ▪ For prep com ▪ T
Research & Development on Impacts of Climate Change (CC) on different sectors	**Systemic** ▪ Knowledge gap on the understanding of CC impacts and extreme events (*viz*, cyclones, droughts, floods and inundations, heat waves, cold chills, wind, ozone, etc); ▪ Research on CC impacts (including forecasting climate hazards, climate extremes and SLR) is isolated and scarce due to various limitations and is not focused on an integrated sectoral platform; • Know how, insufficient local expertise and little incentives for officers to work on this issue; ▪ Unavailability of the latest technology and equipment ▪ Lack of precise and appropriate data and information, especially at local level ▪ Limited awareness on CC and its impacts • No deterrent measures for illegal practices;	iv. Develop a national research plan to undertake R&D on CC impacts, adopting an integrated approach and compliant with our commitments under various conventions, to develop climate change indicators, and to make projections of future climate changes and sea level rise with appropriate mitigation analyses • Synergy and interlinkages development amongst projects • National Capacity enhancement at relevant organizations on CC Impacts, deployment of latest technologies, trend analysis, forecasting, modelling and scenario building, in the identification of vulnerable areas • International assistance for latest technology & equipment and support targeted research • Establish protocol for data sharing; **f**ree exchange of data, information and research findings v. Review of existing policies, reinforce regulations and strengthen enforcement (Environmental Police);	• Na at • Ml va • Re Ml • Pu • Ml sta • Av Uc • CS ec sec

Table 3.6: Adapted Root Cause Matrix -CC: Response and Mitigation: Energy (Mauritius and Rodrigues)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Inadequate use of Low Emission/ Renewable Energy Technologies	**Systemic** ▪ Knowledge gap ▪ Not all these technologies are readily available for exploitation - some hazardous, some still at early stages of their development and others requiring high capital investments ▪ Know-how ▪ Little RD&D	• **Coal though is an option, its future use** for the energy sector to be re assessed (Coal being the largest emitter of CO_2) ▪ Development of **grant programmes** with national and international technical and financial support for **RD&D** on low-emission/ renewable energy technologies, *fuel-switching*, in the development and deployment of *distributed* energy resources, *efficiency* studies, etc.	• The Pers cou mak 202 mea
	▪ Lower efficiencies of power generation	• **Technology updating** aimed at improving **efficiencies of power plants** including cogeneration plants	
	▪ Under-exploitation of indigenous energy sources	• Consider technology options (substituting, hybrid or complementing) with emphasis on green energy with low emissions, use of local energy resources [with emphasis on renewables: wind, wave, hydro, solar, biomass, biodiesel and bioethanol and non-renewables such as ocean methane hydrate crystals*]* and geographical/ economic considerations to reduce our dependence on imported energy • Enhance and support the development of cost-competitive technologies and systems [e.g. hydrogen and alcohol] • Encourage renewable energy use through tax credits and soft loans	• Gov rene • BEI to th ener effi enc usin • 125 unit and • A at th • The runs hou wat • OTI • 3 'V inst ▪ The con poss was
	▪ Inappropriate tariff policy in the energy sector	▪ Studies and appropriate **removal of market barriers** to enable penetration of cleaner, more efficient energy supply ▪ Improve energy **tariff** policy	
	▪ Limited capacity to assess and evaluate the effectiveness of alternative energy technologies ▪ Technology constraints	• • Determine technical capability of electric utility systems to use intermittent renewable energy • Continue efforts to restructure electric utilities and simultaneously establishing a Renewable Energy Portfolio Standard and set maximum greenhouse gas emission standards	
Inadequate promotion of Energy Efficiency practices	**Systemic** ▪ Energy efficient devices / appliances / equipment are not especially labelled (with green labelling tools such as energy star)	▪ Develop **efficiency standards** for household appliances; **More efficient** engine capacities of vehicles on the road	• Gov proc effi ener air c • Gov Ene use equi

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	▪ Inadequate sensitisation and public education programmes with respect to energy efficient devices / appliances	• Increase sensitisation and promote use of energy efficient products and technologies and best management practices whilst sustaining quality, reliability and performance characteristics; carry out reforms of transportation and physical movements to reduce energy use and pollution; ▪ Encourage and vigorously **pursue a culture** of energy management to improve energy efficiency	• Of s ener fluo som the SGI
	▪ Market-based incentives not aggressive enough	• Provide market-based incentives and tax credits; Remove market barriers to penetration of cleaner, more efficient energy supply further to study on the economic costs and implication of the policy; Ban high power consuming devices ▪ Organise **local production**, maintenance and repairs of energy efficient appliances • Develop grant programmes and initiatives (MRC, etc.) to support national and community assistance efforts ▪ Continue and enhance **participation** in local/foreign sponsored energy efficiency programs; Enhance utility participation in energy savings/climate programmes	• Bud to p givi savi dim appl loss cons fluo wat
	▪ Absence of energy audits or assessments and reviews	▪ Conduct comprehensive **energy audits or assessments and reviews** in the public, private and economic sectors to improve productivity, energy efficiency, reduce waste and save energy	• Dev Mec Effi Buil
	▪ Building codes and regulations do not incorporate energy efficiency and conservation aspects in designs and construction	• Promote use of new and innovative designs appropriate to local climate in the construction sector to bring down energy costs • Update building codes; Adopt, maintain and extend Model Energy Code; Develop software program to ensure Model Energy Code compliance; Establish performance indices, guidelines and regulations to optimize energy use in new and in old buildings	
	Institutional ▪ Limited know-how	▪ **Capacity building** for technical know-how ▪ **More RD&D efforts**; Use of computers in increasing efficiency of energy production	
Distributed Power Generation	• Extreme weather events ▪ Grid overloading	• **Decentralize and diversify** future power stations as per spatial and economic needs with emphasis on the potential of low emission/renewable technologies penetration • New, high-power, distributed energy systems as **backup** • Increase usage of IT in mapping distribution systems such as power plants and transmission lines and scenario buildings	• Ba op ge of
	• Leakage in distribution network	• Develop programmes in the development and deployment of distributed energy resources	
Energy Management	▪ Knowledge gap in CC impacts on energy and energy management	▪ Assess and review island-wise energy **planning strategies**	▪

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	▪ Limited capacity	▪ **Capacity building** through training in DSM	
	▪ Non-adoption of cleaner technologies due to high instalment/maintenance costs	▪ **Investment** in technologies required	▪
	▪ Risk management undertaking	▪ **Risk management strategies** in order to save on imported fuel (hedging, reserves, etc)	
	▪ Strategy for Demand-side management to reduce electricity consumption	▪ Invite **consumers to participate** with the electricity utility in meeting their needs by managing both the level and timing of their demand ▪ Explore other **measures to alleviate heavy load shedding** include time-of-use or spot pricing and special off-peak tariffs to consumers ▪ **Awareness** raising and Sensitisation programmes for the private and public sectors and the public in general • Continue and expand electric utility DSM programmes ▪ Encourage energy intensive industries to carry out and **report actions** to reduce greenhouse gas emissions	▪ ▪ ▪
Energy Demand Outlook	• technologies • know-how • Models needs refinements • Uncertainties of the different drivers of demand in each market segment; estimates of residential and commercial needs projections; uncertainties in electricity-intensive industrial growth	• Forecasting models on energy demand outlook • Capacity building in forecasting, modelling scenarios and GIS • GDP tracked down and used as an indicator for electricity demand	• CE gat the for
	• Inadequate energy conservation measures	• Energy Conservation sensitization programmes	• out savi
Data Management and Information System	**Systemic** ▪ Inadequate funding ▪ Need for latest technologies and equipment ▪ Need for know-how ▪ Limited capacity	▪ Data collection strategy for useful data needed for energy / emission projections and mitigation analyses ▪ Information management and Information exchange ▪ Consideration to be given to network modifications to address system losses, tariff adjustments and DSM options ▪ Already proposed Virtual **Centre of Energy and Environment** could also undertake data management ▪ Develop a system for compiling a national 'cadastre' of GHGs by sources and sinks	▪ for g for th dema

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Research and Development, Future Technology, and Technology Export	▪ Limited capacity	▪ Already proposed Virtual ***Centre of Energy and Environment*** can be called upon to play very active role in targeted and advanced R &D ▪ Set up R &D groups with key institutions concerned	
	▪ Lack of funding	• Emphasize sustainable development projects supporting reduction of greenhouse gas emissions	
	▪ Need for latest state of art technologies and equipment	▪ Promote export to Mauritius and support for increased commercial technologies, expertise, and services that reduce or mitigate greenhouse gas emissions especially to the world	
	▪ There are many isolated research between a few institutions in Mauritius – and generally there is a lack of focus;	**Research and Development areas include:** • Bio-engineering sugar cane for producing new varieties with higher fibre content to generate more bagasse and/or for ethanol production • Biomass and bio-diesel production • In depth studies from a technical, economic and financial point of view of promising low-emission technologies focusing on renewable energy (solar, hydro, wind, and marine-based energies) • Development of guidelines, performance indices and regulations of novel energy technologies • Development of economic appraisal methods of novel energy technologies • Efficient hydrogen and ethanol technologies (for production and use in vehicles) • Air quality monitoring and modelling • Assess the feasibility of importing power DC to remote islands of the Republic using submarine high voltage DC system (which is claimed to be more economical than AC for distances exceeding ~ 800 Km) • Renewable energy • Building efficiency through R &D • Clean energy and transportation energy efficiency • Electricity system efficiency and clean energy for electricity generation	

Table 3.7: Adapted Root Cause Matrix -CC: Response and Mitigation: Transport Sector (Mauritius and Rodrigues)

Issues	Physical Impacts	Root Causes	Potential Corrective/ Mitigating Measures	C
High Emission Transport Technologies	▪ Environmental Pollution; ▪ Health impacts; ▪ Economical impacts due to soaring fuel price	▪ **Policy** decision on low emission technologies needs reinforcement; ▪ Initial capital **investments** required is normally high and high costs for conversion kits; ▪ Limited local **capacity** to assess feasibility of an alternative modes of transport; ▪ Inadequate trained labour/facilities; Inadequate retail points for Liquid Petroleum Gas natural gas; ▪ Inadequate market-based **incentives** (e.g. lower customs fees and import duties on fuel efficient vehicles); ▪ **R&D** for economical fuel switching not initiated for ethanol and other biofuels; ▪ Inadequate **sensitization**;	▪ Review and refine existing **policies** and introduce formal policies to govern or to adopt lower emission transport technologies (*consider limiting engine capacities of road vehicles; Consider barrier removal - to encourage import of fuel efficient vehicles*); ▪ **Capacity enhancement** to assess the effectiveness and appropriateness of the alternate transport technologies; ▪ Develop and publicize **incentive** mechanisms to encourage entrepreneurs (local and foreign) to invest in potential for alternate fuel vehicles and technologies; Aggressive market-based incentives (e.g. lower customs fees and import duties for import of fuel efficient vehicles); Encourage vehicle manufacturers to offer electric vehicles for sale; Introduce in-built conversion options in new vehicle purchases; ▪ Setting up of **special funds** that may be used for transit services, pedestrian improvements, bikeways, ride-sharing programmes, alternative fuel projects, traffic flow improvements, and other transportation-demand-management projects, as well as system improvements on the road network (programmes to include GHGs reduction directly or as an ancillary benefit); ▪ **Encourage use of low or no emission technologies** such as LPG-based technologies, ethanol-based technologies and early deployment of electric vehicles; ▪ Undertake **R&D** of technology and fuel that will reduce consumption of petroleum--based fuel and reduce carbon emissions associated with cars, light trucks and heavy vehicles: ▪ On Bio-fuels (such as bio-ethanol and bio-diesel) with the aim to encourage the large-scale use of environmentally sound, cost-competitive, biomass-based transportation fuels and to provide biomass for energy production; Increase local production of ethanol from sugar by-products and encourage early use of ethanol-blend gasoline; ▪ Economical **fuel switching** (e.g. ethanol and other bio fuel); ▪ Public **outreach programmes** such as on the visibility of driving costs, on the use of an	▪ ▪ ▪ ▪ ▪

Issues	Physical Impacts	Root Causes	Potential Corrective/ Mitigating Measures	C
			Environmental Impact Information Sheet to increase awareness of the environmental costs of vehicle use; ▪ Adopt **operating measures** for fuel efficiency; Be alert to possible fuel substitution opportunities; and re-equip or encourage use of fuel-efficient modes of transportation by air and sea, esp. both inter-island routes and Mauritius to mainland routes; ▪	
Congestion-Free Systems	• Congestion Problems; • Subjected to high prices on imported fuel; ▪ Loss of Productivity; ▪ Environmental pollution; • Health impacts; ▪ Stress;	▪ No detailed studies discriminating between the two most plausible options exist: **the integrated plan for the LRT** <u>on one hand</u> and **Decentralization** <u>on the other</u>; ▪ *The LRT system would require a high initial investment and capacity building; The system would operate optimally when integrated to all other modes of transport - a challenge. The LRT would necessitate public and private policy support as well as urban planning;* ▪ *The Electronic Road Pricing (ERP) scheme or other deterrent measures for cars to enter the city (proposed to run in parallel with LRT) would need public support;* • Reluctance of the working class to shift to public transportation; No Incentives to shift; ▪ Sensitization rate low; ▪ Shortage of efficient public transport services;	▪ **Pending policy decision taken at the level of the government** to **<u>EITHER</u>** undertake a thorough assessment of **decentralization** efforts from the capital and other key areas though proper planning strategies taking account future developments and orientations (including mobilizing of the stakeholders to consider shifting their establishments fully or partly) **<u>OR</u>** build capacity that will enable exploration of avenues for Mass Transit Systems (**MTS**) (including LRT) and their integration with all existing modes of transport; ▪ Develop a **smart road network** – Enhance land use planning to explore new road networks to reduce congestions and the need for transportation and Upgrade road networks **through models and scenarios** for traffic flow; ▪ Develop a campaign for a coordinated flexitime adoption across capital-based offices and services (government and other labour intensive ones) towards promoting a coherent traffic flow. The concept of 'core' office hours can be studied as a potential flexitime alternative; ▪ Develop/introduce incentives to encourage use of- / shift from Private to- Public mode of transportation; ▪ Introduce deterrent measures for use of private vehicles through review of existing: ▪ Policies with regards to vehicles at the service of the public; ▪ 'Duty-free' schemes; ▪ Public outreach programmes in favour of public transport e.g. "Ride the Bus", Carpool, Flexitime;	▪ ▪ ▪ ▪

Issues	Physical Impacts	Root Causes	Potential Corrective/ Mitigating Measures	C
		▪ Planning/ strategies often does not adequately address future developments and orientations;	▪ Better traffic management in and around seaport and airport; ▪ Examine ways to **increase load factors** and to maintain high load factors, especially on both inter-island routes and Mauritius to Mainland routes; ▪ See *also* ***Transportation Control Measures*** *issue below***;**	▪ ▪ ▪ ▪
Transportation Control Measures (TCMs)	▪ Congestion; ▪ Loss of Productivity; ▪ Poor land use planning; ▪ Environmental pollution; ▪ Health impacts; ▪ Accidents;	▪ Know how; need capacity building – at all levels, specially modeling, equipment use and transport economics; ▪ Inadequate sensitization; ▪ Limited funding; ▪ Little research; ▪ Insufficient number of emission measuring meters if fines or penalties are to be applicable; ▪ Road conditions needs to be enhanced; ▪ Deterrent measures not applied strictly; ▪ Capacity limitation to assess and evaluate deterrent schemes;	▪ Public **outreach programmes** e.g. driving at optimum speed, proper maintenance of vehicles, carpooling, estimation of energy- and emission-saving effectiveness of TCMs, travelling at optimum speeds (for optimised fuel consumption and hence decreased GHG emissions), etc.; ▪ Investment in **traffic equipment** (synchronous traffic lights/count/speed/ camera/signs/GIS/GPS/etc); ▪ Introduce **incentives** (e.g. carpooling and special parking and use of fast traffic lane for carpoolers, shuttle service provision from major transport hubs or car parks, etc); ▪ Introduce **deterrent measures** (restricted/no driving zones, car restraints, bus priority schemes, electronic road pricing, car parking with different tariffs at different times); ▪ **Reinforce** vehicle examination centres (*and provision of an adequate number of emission measuring meters if fines or penalties are to be applicable*), Environmental Police and road traffic regulations such banning visible emissions of fumes by initiating a "Clean Air	▪ ▪ ▪

Issues	Physical Impacts	Root Causes	Potential Corrective/ Mitigating Measures	C
		▪ Unchecked speed of vehicles; ▪ Policy for fining slow drivers missing;	Act" and introducing fine for slow vehicles; ▪ **Upgrade road networks** through models and scenarios for traffic flow, replacement busy roundabouts/intersections by flyovers, conversion of 2-way lanes into one-way, restricted access to major roads and highways, provision of special lanes for non-motorised mode of transportation; ▪ **Real time information**; Use of electronic navigational aids (GPS, changeable message signs, etc), special traffic radio/TV channels; ▪ **Capacity enhancement** in modelling, scenario building, GIS and technical know how; ▪ Road accidents **studies** with remedial recommendations for improvements of road conditions where applicable; ▪	▪
Data Management and Information System (DMIS)	▪ Limitation in the long term planning as a result of poor inventory of relevant parameters; ▪ Weak strategies ▪ Impact on decisions and economical sustainability	▪ Inadequate funding; ▪ Need for latest technologies and equipment;; ▪ Need for know-how; ▪ Limited capacity;	▪ Improve **collection strategy** for useful data needed for land/ air/marine transport demand / emission projections and for mitigation analyses; ▪ Development of **DMIS** for the transport sector; The proposed ***Centre of Energy and Environment*** may be also be called upon to undertake data management, establish protocol for data sharing, free exchange of data, and ventilation of information and research findings; ▪	▪ ▪ .
Research and Development, Future Technology, and Technology Export	• Productivity Loss; • Economic development suffers; • Barrier to Sustainable Development;	• Knowledge gap on climate change and its impacts on transport; • know-how and capacity; • funding; • Need for latest equipment and technologies; • Uncertainties in transport mode; Constraints proper modelling and scenarios; •	▪ Establishment of a Proposed ***Centre of Energy and Environment***; ▪ Training and sensitization of technicians, engineers, scientists, managers and policy makers on CC and impacts on transport; • Develop **models and scenarios**: ❖ for passenger forecasting – with detailed analysis of the different drivers of demand in each market segment, with explicit consideration of uncertainties; ❖ for traffic flow for better traffic management; • **Capacity** enhancement in forecasting, modelling scenarios and GIS; • Development of guidelines, performance indices and regulations of novel technologies; ▪ Development of technical, economic and financial appraisal methods of promising	▪

Issues	Physical Impacts	Root Causes	Potential Corrective/ Mitigating Measures	C
			low-emission technologies; Advanced targeted RD&D wrt: • Air quality monitoring and modelling; ▪ Bio-engineering sugar cane for producing new varieties with higher fibre content to generate more bagasse and/or for ethanol production; ▪ Bio-diesel production; ▪ Clean energy and transportation energy efficiency to reduce Mauritius's overdependence on oil; ▪ Develop vehicular technology (ethanol, LPG hydrogen, and others) and fuel that will reduce consumption of petroleum-based fuel and reduce carbon emissions; • Impact on performance on air/sea/land operations due to climate hazards; ▪ Carbon sequestration; ▪ Emphasize sustainable development projects supporting reduction of GHGs; ▪ Promote and support increased commercial exports from Mauritius of technologies, expertise, and services that reduce or mitigate GHGs, especially to the world; •	

Table 3.8: Adapted Root Cause Matrix Climate Change: Vulnerability and Adaptation (Mauritius and Rodrigues)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating measures	Ongoing Activities/ Past Recommendations
Coastal Zone Beach erosion, land loss and damage to infrastructure on the coast	***Systemic*** • Clearing of protective native coastal vegetation and exotic species • Effects of past lagoon sand mining • Removal of coral	• Reforestation of coastal zone with native vegetation • Monitoring of beach profile and further	• Propagation of mangrove • Monitoring of those areas where coral sand extraction have been

	rubbles • Creation of artificial passes in the reef • Construction of structures, e.g. groins, jetties, breakwaters, and sea walls • Illegal filling of wetlands • Damage to coral as result of certain unsustainable marine activities • Limited funding • Natural causes e.g. cyclone and other extreme weather events	research on hydrodynamics of beach • Have beach nourishment programme where necessary • Enforcement of more stringent laws on setback distance and construction guidelines • Earmark resource (finance and human) to finalize formulation of ICZM plan and its implementation • Build sustained awareness programme among local population for the need of preservation of the environment • Integration of CC and related issues in national policies and development plans	banned • Beach replenishment from off-shore sand as a mitigating measure of coastal erosion • Monitoring of coral reefs at several sites by AFRC • Marine Parks at Blue Bay and Balaclava and six fishing reserves declared as MPA • Research related to the coastal zone is being done by various institutions e.g AFRC, MOI, UoM • Some studies on current patterns in lagoon at specific sites done at AFRC
Coastal Zone Degradation of lagoon water quality and coral degradation	***Systemic*** • Illegal discharge of effluent agrochemicals/nutrients in runoff water • Lack of state of the art equipments	• Enforcement of existing laws on waste management • Further research on diffusion of agrochemicals and other nutrients • Mapping of vulnerable areas of coastal zone (vulnerability atlas)	• Monitoring of water quality in the lagoon by WMA • Development of a Geospatial Information System for mapping marine habitat and ecological richness of the South Eastern coastal zone
Coastal Zone Salt-water intrusion in coastal aquifers	***Systemic*** • Knowledge gap in assessing the extent of salt water intrusion with respect to SLR • Lack of National Water Policy for integrated sustainable water resources management including groundwater • Past unsustainable management of groundwater	• Bridging knowledge gap with respect to groundwater model in line with scenarios for SLR • Further studies in harnessing water capabilities • Systematic monitoring of water quality • Policy for sustainable management of ground water including coastal aquifers	• Study on Coastal Erosion in Mauritius by Bairds Associates • Rehabilitation works on coastal zones in Flic-en-Flac, Bambous Virieux and Riviere des Gallets. (Tenders floated and Bids invited) • Monitoring of sea level by Meteorological services • Control on amount of water extracted in coastal aquifers by the

		• Construction of surface water storage uplands	WRU & CWA
Marine Resources Loss of marine biodiversity	***Systemic*** • Lack of understanding of the impacts of Climate Change on biodiversity • Rise in lagoon water temperature • Lack of funding for further research	• Further research on the impacts of global warming on marine resources	• MOI has been set up to foster research and development in the marine environment
Agricultural Sector Decline in cane quality, decrease in cane yield, change in yield and quality of other crops in different microclimate and Change in cropping patterns	***Systemic*** • Inadequate water for irrigation • Lack of funding for irrigation • Knowledge gap on the impacts of global warming on sugar cane crop and non-sugar cane crops	• Increase water storage capacity • Further research on cultivars requiring less water • Develop hydroponics and under cover culture • Additional application of efficient irrigation, (e.g. Drip or center pivot) • Further studies on impacts of CC on sugar cane • Application of Early Warning System at field level for efficient water use • Improvement in systems management	• Implementation of Sugar Sector Strategic Plan is ongoing • Implementation of Non-Sugar Sector Strategic Plan is also ongoing • Diversification policies underway, such as hydroponics village • Drip and center pivot irrigation have been adopted at several sites • Hydroponics culture and greenhouse culture are being encouraged • Incentive mechanisms in place for planters by DBM • Research on sugar crop done at MSIRI for crop tolerant varieties and genotypes
Land Change in land use	• Land degradation due to recurrent drought, stray animals causing damage to crops (Rodrigues) • Abandoned land (Rodrigues)	• Change to endemic plants and trees thus increasing forest areas • Development of incentive mechanism for adaptation	
Agricultural Sector Crop productivity likely to be affected by salinity in the East and Southeast coast	***Systemic*** • Coastal areas becoming unproductive due to lack of water • Knowledge in soil water movement and leaching requirement	• Identify adaptive crops tolerant to salinity • Develop suitable salinity management practices such as efficient drainage, use of acidifying and organic fertilizer • Determination of leaching requirements	

		in the mentioned areas	
Agricultural Sector Unusual incidence of pest and disease	***Systemic*** • Extreme temperature and humidity • Other favourable conditions of proliferation	• Research on crop disease and their control	
Agricultural Sector Land degradation	***Systemic*** • Land remain bare • Improper use of agrochemicals • Runoff at times of heavy rains • Lack of fund among small planters	• Trash blanketing • Use of compost • Terracing of steep slopes • Development of incentive mechanism for adoption of best practices	
Water Resources Insufficient fresh water Expected decrease in fresh water	***Systemic*** • Inadequate storage capacity • Leakage in water distribution networks • Insufficient awareness campaign on water savings • Knowledge gap on the impacts of CC on the hydrological cycle and extent of impact due to SLR on coastal aquifers	• Increase water storage capacity • Optimize use of river off-takes • Use of more efficient irrigation system for agriculture • Further studies for better water harnessing • Sustained effort to minimize leakage and losses in water transmission systems • Sustained awareness campaign on water savings • Encouraged use of recycled water • Further studies/research on the impacts of CC on the hydrological cycle • Application of Climate Early Warning in Water resources management	• WRU integrated Plan to meet water requirements up to 2040 • Rehabilitation of dams and feeder canals • Hydro-geological studies to harness ground water are ongoing • Efforts to minimize leakage and losses in water transmission systems
Water Resources Deterioration of fresh water quality	***Systemic*** • Contamination with agrochemicals/nutrients and mud in run-off • Lack of fund	• Systematic monitoring of quantity and quality of surface and groundwater resources and effluents	• Monitoring of water quality done at CWA and WRU • Development and promulgation of standards and issue of effluent discharge permit regulations by MoE & NDU
Water Resources Contamination of potable water	***Systemic*** • Poor sanitation in soak-away system for toilet and pit latrines	• Extend sewer collection system to whole country ideally in the long term	• Extension of sewage system networks as an ongoing process

	• Agrochemicals in runoff water • Intrusion of salt water into coastal aquifers • Lack of state of the art technology • Lack of fund	• Further research in flow of agrochemicals during heavy precipitation, and modeling of same • Monitoring of water quality	• Standards on the quality of potable water by MoE & NDU
Human Health Heat fatigue and heat stroke	***Systemic*** • Exposure to high temperature • Air conditioning still expensive • Dehydration • Poor understanding of physiological response of human to rise in temperature	• Review of building design to minimize cost of air conditioning • Planting of trees in residential areas • Drink adequate potable water • Further studies and research • Promote awareness campaign	• White Paper on health has set goals to achieve better health • Free public health service • Education of population on several aspects of health and nutrition through sustained programme of awareness
Human Health Increase risk of vector-borne, water-borne and food-borne diseases (malaria, chikungunya, etc.)	***Systemic*** • Stagnant water provides breeding ground • Inadequate sanitation in residential quarters • Poor food preservation techniques • Lack of awareness • Insufficient environmental and civic education • Lack of fund for environmental upkeep	• Monitoring and spraying affected areas • Proper drainage system to evacuate stagnant water • Education to maintain adequate sanitation level • Further studies on the impact of CC on the spread of diseases	
Human Health Air pollution Increase respiratory disease	***Systemic*** • Trapping of dust, industrial particles and similar aerosol in the lower atmosphere • Sugar cane burning fly-ash • Emission vehicle and industrial gases • Agglomeration of industrial zone near residential area	• Enforcement of laws on vehicle exhaust fumes • Greening of urban areas • Create more health walk track away from dense traffics	• Monitoring of vehicular emission done • Health walk track in other residential areas are under way and becoming popular

Tourism Sector Damage to coastal hotel infrastructure High maintenance cost Decrease in number of tourist from Europe Mauritius likely to become less attractive	***Systemic*** • Hotel infrastructure within HWM or too close to HWM • Change in hydrodynamics of lagoon • Extensive beach erosion and inundation • Knowledge gap • Excess heat and reduction of potable water	• Encourage construction of hotels inland • Built other attraction in replacement of those along the coast • Diversify tourism market as well as create informed tourism industry • Develop appropriate alert system • Further studies on the impacts of CC • Capacity building of hotels employees by incorporating these concepts in hotel training programme • Use of renewable energy	• Eco-tourism are being encouraged • Implementation of Tourism Development Plan is underway • Tourism Environment Charter has set standards in tourism facilities • Diversification of tourism market is ongoing • A Thematic Working Group paper on Energy and Energy Efficiency that included hotels and industries was published by MRC. • Use of low energy fluorescent lamp and solar power for water heating are gaining ground
Fisheries Mortality of juvenile Decrease in coastal fish production	***Systemic*** • Loss of coastal wetlands • Mangrove uplands • Degradation of water quality (agrochemical/nutrients contamination) • Discharge of industrial effluents • Decrease in dissolve oxygen amount • Lack of knowledge on the impact of CC on fisheries in the coastal waters • Coral reef degradation • Over-exploitation in the lagoon	• Encourage cage-culture, mari-culture and "barachois" • Plantation of mangrove programme to be pursued • Enforcement of existing laws of effluent discharge • Monitoring of lagoon for water quality taking into consideration other indicators • Further studies/research on the impact of global warming on fish population • Use satellite technology to monitor fish population • Encourage fishing in the outer lagoon as to allow	• Fisheries and Marine Resources Act defines policies and measures for management of marine resources Conserve fish habitat and also as nursery of juvenile fish • AFRC acts as facilitator for aquaculture • Mangrove propagation programme ongoing • Fishing reserves have been set up to protect and sustain fisheries • Various studies are underway at the level of AFRC • FAD set up to provide

	Decrease in salinity Lack of funding	reef to recover • Sustained awareness programme on the marine environment	better grounds for fishermen • FiTEC provides training need of fishermen

Table 3.9 : Adapted Land Degradation Root Cause Matrix (mainland Mauritius)

Issues	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating measures	
1. Deforestation a. Clearing for pasture on deer ranches (Mauritius only)	**Systemic** **On State land leased for deer ranching** • No system for monitoring forest clearing for pastures • No up-to-date accurate maps of leased lands (Lack of capacity for survey) • Lack of capacity for enforcement **On privately owned forest land** • Clearing for deer pastures or other uses is unregulated • Lack of incentives to private sector to protect sensitive areas and re-afforest degraded lands • Lack of trained Forest Managers • Lack of awareness and the need for correct attitudes	• Develop remote-sensing based system for monitoring loss of forest cover • Develop Forest Service capacity for enforcement of regulations on pasture clearing on lease land • Develop forest management systems that combine pasture clearing with reforestation systems • Develop regulations governing forest clearing on private land • Development of incentives to private forest owners to promote re-afforestation • Development of joint ventures e.g. Public/Private sector partnerships • Dissemination of monitoring results to general public and decision makers • Awareness raising on forest loss	• *Devel monit* • *Traini in the* • *Traini applic Minis* • *Recru enforc* • *Revie sensiti* • *Integr Fores* • *Traini (i) to manag (ii) to sustai* (iii)t and develo degradation • *BSc C UoM*
b. Clearing/ conversion on privately owned and state owned land	**Systemic** • Clearing of forest land and conversion to other land uses, especially agriculture, is largely unregulated in Mauritius • Lack of information and data (accurate forest cover maps, or forest information system or monitoring capacity for privately owned forest lands) • Lack of awareness of general public/decision makers • Encroachment on state forest lands	• Assessment of the sustainability and environmental impacts of the alternative land uses • Participatory Development of appropriate regulations where needed • Reviewing and up-dating of existing legislation • Assessment of the extent of the problem using remote sensing/GIS • Awareness raising • Field checks by forest officers • More efficient enforcement	• *Prepa Remot* • *Acqui*
c. Clearing for settlements and cross cutting issues	• Clearing for settlements Clearing for housing Clearing by squatters	• Development of land information system to support land use planning • Strengthening enforcement of legislation relevant to land use • Increased transparency in the land allocation/ permitting systems	• *NDS f* • *Pilot s*
2. Land degradation due to unsustainable Agricultural practices	**Systemic** • Some small planters and estate planters still burn residues and plough to replant, leaving soil exposed to heavy rains • Sharecroppers ('metayeurs') have little incentive to invest in soil conservation/sustainable agricultural practices • Cultivation right up to river banks • Improper use of agro-chemicals	• Development of SLM practices and integration into cultivation practices	• *Aware*

	• Mechanization and heavy equipment may cause soil compaction	• Development of mechanism / Incentives for adoption of best practices	• Farm mecha erosio
	• **Inadequate logistics, tools, staff and infrastructure to carry out monitoring and to support field interventions and enforcement**	• Development of a Land Information System for the non-sugar agricultural sector. Use of GIS will be required. • Need for setting up of a monitoring and information system on land degradation (later extended to cover all the issues) • **Logistical support like vehicle and equipment tc carry out field intervention**	
	• Knowledge gap at farmers level • Limited dissemination of results and findings on good agricultural practices.	• Training of farmers on sustainable agricultural practices, may be in terms of Vocational Training - type courses.	• Disse agricu FARC
	• Ecological sustainability is dependent on the financial system. • Uncoordinated targeted research on LD. • Limited long term targeted research (other issues take priority over LD research).	• Identifying and addressing the underlying causes of land degradation on farmlands. • Assessing and monitoring of land qualities and degradation at farm levels. • Analysis of impacts of mechanization and development of strategies to minimize negative impacts. • Identification of alternative land uses and analysis of the ecological, economic/financial and social sustainability of each in order to identify the SLM practices to be encouraged through policy, regulations and incentives. • Sustain long term targeted research .	
3. Severe degradation from fire on steep mountain slopes in dry region	**Systemic** • Use of fire as the principal cause of the past. degradation of these sites from forest to grassland or savannah grasslands. Also fire is the principal .impediment at present preventing the reforestation of these areas. • Slopes were once commonly burned by herders to obtain succulent re-growth from perennial grasses for goats/livestock during the dry season (the importance of this factor has diminished as goat herding has diminished). • Other reasons for burning – including criminal burning • Land tenure – when land is owned by the state, local populations have little incentive to protect	• Development of multi-disciplinary, participatory, inter-sectoral approaches including civil society groups (development of community-based programmes for fire fighting) • Development of adaptive management approaches for monitoring fire risk management and reforestation options tested and for modifying techniques accordingly • Identification and testing of innovative options for minimizing frequency and intensity of wildfires – such as grazing by deer or sheep to reduce grass cover and fire danger or use of very early, light, patchy, partial controlled burns to minimize dry season wildfires • Program on sensitisation and awareness raising, fire prevention and control to be carried out on a continuous basis.	***As part of Managem*** • *Identi minim exam (deer/* • *Identi* • *Creati towers* • *Traini* ***Other proj*** • *Neem mount*
	• Limited budget/resources to allow for a sound forest land management; • No economically viable, proven models/techniques/models for restoring these sites to full, evergreen forest cover and for sustainable management of the restored forest (expertise is available internally; however, funding is the limiting factor).	• Economic/financial analyses to identify the most cost effective management of such areas	
	• Squatters established illegally at the base of these mountains	• Enforcement to prevent settlement by squatters	
4. Loss of wetlands	**Systemic** • Strong pressures for development of these economically high value sites	• Awareness raising on importance of wetlands	• *Creati*
	• Condition/loss of wetlands is not being monitored systematically • Absence of monitoring system • Limited enforcement • Many wetlands are on private lands rendering access and ground monitoring difficult	• Integration of wetlands into land information system • Development of wetlands monitoring system using satellite imagery and ground visits and linked with clear enforcement capabilities.	• *Integr* • *Elabo* •
	• Institutional responsibilities and regulations for wetlands conservation are fragmented and unclear.	• Development of a wetlands conservation strategy and management framework (with definition of	• *Devel*

		clear institutional responsibilities and definition of site-specific priorities amongst others)	
	• Absence of comprehensive policy and management framework for coastal wetlands	• Development of wetland management plan for existing 2 reserves (wetland)	• *RTRE Reser*
5. Land Drainage/ Erosion in 'sensitive' and other developed areas	**Systemic** • Drains in settled areas are sometimes inexistent and are often inadequately maintained • Construction on steep slopes without adequate engineering and soil protective measures • Construction of drains is capital intensive and hence funding is a serious limitation • Obstruction of existing drains with garbage or construction across drains	• Adequate investments in proper design, upgrading and maintenance of drainage systems • Development and enforcement of appropriate regulations minimizing risk of erosion from construction sites • Capacity at the level of the Land Drainage Unit to be enhanced	• Land • Study compl and ur
6. Coastal erosion (mainly anthropogenic origin considered)	**Systemic** • Past clearing of protective native coastal vegetation and plantation of exotic species • Construction of structures e.g. groins, jetties, breakwaters, sea walls (other hard structures) • Past and illegal removal of coral rubbles • Effects of past sand mining in the lagoon • Unauthorised opening of passes/ artificial passes in the reef • Damage to coral as a result of certain unsustainable marine activities/ practices • Trampling by pedestrians and heavy vehicles on the beach • Natural: Cyclone, global warming and Sea Level Rise **Institutional** • Limited knowledge + data on sediments dynamics and lagoonal hydrodynamics	• Restoration of degraded beach sites with indigenous and endemic vegetation • Formulation and strict implementations of construction guidelines • Implementation of set back policy • Sensitisation and awareness raising • Special parking zone and restriction of vehicular access to sensitive spots on the public beaches • Need for long term studies and research on the vulnerable beaches (including sediment dynamics, beach profile and so on) • Building capacity/ training of the ICZM Division (MoE), CZM Division of Ministry of Fisheries, and Beach Authority	• Study 2003. • Imple operat • Tende works Bamb • Speci • ICZM startin

Table 3.10 a: Adapted Root Cause Matrix – Terrestrial and Forest Biodiversity in Rodrigues

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Invasive Alien Species (IAS)	***Systemic*** • Uncontrolled introduction of exotics • Inadequate enforcement at the immigration level • No programme in place for the control and monitoring of IAS • Limited population awareness	• Enforcement and appropriate phytosanitary control at immigration level • Proper management plan for control of IAS • Training of staff of relevant institutions • Harness Community participatory approach in the control of IAS and planting of endemics • Awareness raising of population and other relevant institutions and schools	• Regul Servic • Rodrig Progra and at

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	• High economic value as timber (Eucalyptus)	• Propagation of most endangered endemics	• Refore FS and • Refore endem one (C
Management of Protected Areas/ Nature Reserve/Caves	***Systemic*** • Absence of proper Project Write up and Management plan • Absence of long term research plan • Excessive Deforestation (in the 70s) ***Institutional*** • Limited capacities for project write up and therefore monitoring • Lack of trained scientific staff Insufficient collaboration between relevant institutions	• Management plan for all Protected Areas, Reserves and Caves • Development of best management practices and dissemination • More Explorations of the caves • Need to establish more PAs with relevant training needs • Restoration of native flora and fauna • Control of exotics/ IAS species • Capacity building for project write up • Training of scientific staff	• Manag (in pip • Establ the pla • Manag pipelir • Trainir draftin • Involv in the p proper
Lack of data and absence of data base	***Systemic*** • Lack of funding • Absence of MoU for data sharing bet relevant institution • Absence of an Environmental Information System for Rodrigues • Limited trainings on data collection , processing and data management • Lack of know how	• Resources- funding mobilization from relevant funding agencies • MoU to be developed for data sharing and EIS for Rodrigues • Capacity building through training of staff	• The for Forest M establis
Past deforestation	***Systemic*** • No intensive programme of livestock management • Stray animal • Little or insufficient reforestation on coastal slopes and littoral areas	• Enforcement for cattle regulation • Programme for elimination of stray animal to be continuous • Intensive reforestation of coastal slopes and littoral areas • Intensive Cultivation of coastal arable land • Continue Mangrove planting in bays and estuaries to prevent inland sediments from reaching the coral areas. • Sustainable terracing	• Cattle implen • Forest • Goverr produc

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	• Drought • No education and or sensitization programme	• Provide irrigation water • Create awareness	• Rehabi • Dam c • Constr • Comm
Endangered Native Fauna	***Systemic*** • Degradation and loss of native forest habitat • Lack of food • Low level of management and conservation of the species • Predation (stray cats, agama lizards, mice etc.) • Few local expertise for efficient management	• Restoration of forest habitat • Management lead to production more food • More studies to be conducted on the native species • Elimination of potential predators (Mice control programme on Coco islet)	• Forest • Refore • Eradic Sables • Educat

Table 3.10 b: Adapted Root Cause Matrix – Agrobiodiversity and Biotechnology in Rodrigues

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Decline in crop production	***Systemic*** • Severe Drought • Lack of qualified labour source • Subsistent production system • Poor marketing strategy	• Appropriate irrigation system • Training of farmers • Adopt commercial production system • Development of an appropriate marketing channel	• Rehabi • Promot • Soil wa • Crop r
Absence of gene bank	***Systemic*** • Absence of appropriate policy to preserve landrace plant species • Deliberate Crossing with other imported varieties (meant to increase yield) • No successful improvement of local varieties • No adequate facilities for sperm bank • No control of importation of plant species	• Devise a clear cut policy for genetic conservation • Train staff in genetic conservation • Develop facilities for sperm bank • Control import of species susceptible to cross with local species	• Institut and ap
Phytosanitary Control	***Systemic*** • Insufficient phytosanitary control • Import permit not compulsory for animal and plant products (Quarantine) • Unawareness of the public • Insufficient trained staff • Poor field sanitation and lots of flies breeding sites Insufficient participation of farmers in flies control	• Stricter phytosanitary control at point of entry • Render the import permit compulsory for all imports • Sensitization campaign • Training of personnel • Strengthen bio-control measures	• Phytos
Slow animal growth	***Systemic*** Production system is extensive hence absence of improved pasture Improper treatment of animal parasites resulting in slow growing animal	Promote semi-intensive production system on improved pasture Train farmers on proper production system to improve animal health	Training
No Rotational Grazing	• Rotational grazing is not practiced at farmers level • Concept and reason for rotational grazing is not well understood by farmers	• Training of farmers • Set on-farm trials on rotational grazing, • Promote participatory approach system for pasture setup and management	

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Degeneration and loss of certain breeds	***Systemic*** • Improper management of herds during mating period • Non selection of males for breeding • Absence of proper conservation policy for the breeds • No gene bank for sperm conservation • Introduction of exotic varieties resulting in cross breeding (chillies) ***Institutional*** • No trained personnel in animal breeding	• Training of farmers on management of heat period • Castration of unwanted males and separation of males from herd • Devise a clear cut policy for conservation of landrace breeds • Setting-up of a small gene bank for sperm • Restore and maintain purity of variety	• Trainir preserv • Trainir manag • Resear (chilly) • Trainir
Insufficient veterinary services	***Systemic*** • Poor extension link with farmers ***Institutional*** • Only one Veterinary Officer • Centralize Veterinary laboratory	• Establish proper connection with farmers • Capacity building of local personnel as veterinary officers • Provide appropriate infrastructural facilities	• Greate • Recruit veterin

Table 3.10 c: Adapted Root Cause Matrix – Fresh Water, Coastal and Marine Biodiversity in Rodrigues

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
Unsustainable exploitation of the marine resources	*Systemic* • Soil erosion resulting in siltation of lagoon • High fishing pressure/including part time fisher • High number of fishers as a result of incentive such as Bad Weather allowance • Bad fishing practices • Undersize capture (octopus) • Poverty • Unwillingness to adopt new techniques • Very limited studies to inventory and determined maximum sustainable yield in lagoon carried out	• Apply soil erosion control measures • Reduce the number of fishermen operating in the lagoon • Creation of MPAs • Encourage off lagoon fishing by creating incentives • To undertake research for development of alternative techniques to the harmful fishery, inventory and offshore fisheries potentials	• Alterna • Plantin • Setting Marine • Investr • Maricu (Seawe • Vessel lagoon • Buy ba • Trial o • Poverty

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	• Limited Research on offshore fisheries potentials • High rate of illegal fishing • Lack of enforcement by relevant institutions • Limited sensitization and awareness of fishermen community • Lack of community participation to step down fraud • Lack of know-how • Too many part time fishermen and whose number is not known (unsustainable exploitation) • Reclamation of marshes and other wetlands ***Institutional*** • Lack of staff and equipment in relevant institutions • Lack of coordination and communication between relevant institutions	• Better enforcement of the law • Raise awareness of fisher through sensitization and training • Encourage community participation to step down fraud • Survey of number of unregistered or part time fishers • Better management of wetland • Increase Man Power of relevant institution for the betterment of the situation	• Contro • Sensiti lagoon • Trainir village • Survey Fisheri • Sensiti popula
Development of off lagoon fishery	***Systemic*** • Lack of knowledge in the off lagoon fishery • Lack of appropriate fishing boats and vessels (> 27 ft recommended) • Lack of appropriate fishing equipment on the local market/ expensive or scarce • Poverty within the fishermen community • Limited financial assistance for proper investment • Rough sea condition in the outer lagoon	• Training and sensitization of fishers for off lagoon fishing • Availability of fishing equipment and ice on local market at affordable prices • Incentives for purchase of boats and engines (greater capacity) • Bank Loans at concessionary rates	• Fishers associat • Soft loa • No fixe • Assist tl • Registra • Sick Le • Scholar • FAD Fi
Setting and Management of Marine Protected Areas	***Systemic*** • Infrastructure • Lack of funding • Lack of knowhow and training • Lack of knowledge on how to assess the MPAs • Incomplete inventories • Lack of monitoring	• Develop the necessary infrastructure • Seek funding from overseas funding agencies • Implementation of MPA projects • Better management of resources	• Funding UNDP/ • Setting (GoM/U • Setting of the is • Better p such as
Stock assessment of lagoon and off lagoon resources /Preservation and Marketing strategy fishery	***Systemic*** • No appropriate ice making and cold storage facilities	• Provide ice making and cold storage facilities	• To prov rooms f • Constru Station • Rehabil providi and oth

Issue	Capacity Constraints (Root Causes)	Potential Corrective/ Mitigating Measures	
	• Low awareness of the importance of catch preservation • Limited knowledge on preservation ***Institutional*** • Limited trained personnel in the research institutions • Limited software application for data analysis	• Training on handling and preservation of catch • Sensitization on sanitary measures to be adopted • Marketing strategy to be developed **(long term)** • Training of personnel • Develop new software	• Trainin by FRT • Exchan Researc •

Table 3.11: Adapted Root Cause Matrix –Land Degradation in Rodrigues

Issues	Capacity Constraints (Root Causes)	Potential corrective/ mitigating measur
Land Resources Unsustainable Land Management Poor enforcement and implementation of anti erosive measures.	***Systemic*** • About 90% lands are state owned • Lack of security and motivation for maintenance of anti erosive infrastructures	• Enforcement of land lease clauses which stipulate tha to maintain anti erosive works on the plot of land allo • To consider replication of Anti Erosion Program pilot consisted in providing incentives to land lease holder rehabilitation of soil protection infrastructures
	Institutional • Inexistence of a coherent Land Information System due to lack of Human Resource for land surveying • Limited funding	• Cadastral Unit has been equipped with soft and hardw Erosion Programme 1999-2004) • The Land Management software (GIS) has been intro 2004 and 15 officers trained. • The Land Information System to be finalised. • Recruitment /Contracting out of private surveyors • Introduction and training on Remote sensing, Photogr Satellite Imagery to complement the GIS • Need for training in land management and administra
	Systemic • Dispersed mode of settlement on vulnerable and sloppy areas result in human induced erosion.	• A detailed outline scheme is required for Rodrigues • To adopt and regulate the National Development Stra and planning and recommended policies for zoning ar areas. • Applicants are encouraged to apply for residential lea built-in areas • To replicate Area Action Plan of La Ferme
	Institutional • Lack of human capacity in the control of soil erosion and maintenance of anti erosive infrastructures • Lack of funds	• Training in agricultural engineering is needed (topogr management, hydroponics, irrigation, livestock housi • Decentralised management of agricultural leases
Land Resources Overgrazing Unsustainable Livestock production system	***Systemic*** • Limited availability and quality of fodder resources due to encroachment of residential development onto grazing areas (Cattlewalks) • Rusted and damaged fencing of fodder reserves need replacement to prevent grazing inside. • Limited fodder and long rearing periods exacerbate grazing pressure and results into overstocking and production of livestock with poor conformation and limited marketing prospects • Limited fodder resources refrain enforcement of Livestock Regulations	• Additional fodder reserves should be created. • Need for training and research on animal nutrition an • Human resource capacity for fodder management and should be developed • Replacement of rusted fencing and introduction of liv recommended • Rotational grazing is being initiated. • Need for Assessment of Economics of livestock and f production and hence promote cut and carry system b Sylvopastoral activities to be introduced in cattlewalk • The Survey of remaining cattlewalk areas by Cadastr completed • The Livestock (Cattlewalks) regulations should be re appropriate environment created to enhance its sustai enforcement. • Meat processing sector to be developed

	Institutional • Poor husbandry practices and irregular supplies of inputs eg.animal feeds, medicines,etc • Inadequate sanitary and health care (control of endo- and ectoparasites)	• Destocking Programme carried out in 2001-2002 • Need for improved husbandry practices (shelter, cont etc). • Future implementation of Soil and Water Conservatic EDF Project to address the issue
Agriculture Unsustainable Cropping Practices Fallow agricultural lands	***Systemic*** • Agriculture is part time activity • Lack of security for land tenure and lack of motivation for maintenance of anti erosive infrastructures • High-risk level and uncertainty of harvest due to frequent droughts.	• To finalize Registration of farmers • To devise appropriate Incentives and Crop insurance for high risk levels
	Systemic • Stray livestock feed on farmers' crops	• The Livestock (Cattlewalks) regulations should be re appropriate environment created to enhance its sustai enforcement
	• Very limited access to irrigation (Rainfed systems) • Adverse climatic conditions (Frequent droughts and cyclones	• Trials were conducted on drought tolerant crops (Anti Programme) • Training and adoption of Dry Land farming systems i • 3 Water Harvesting Structures are established • An Irrigation reservoir was built at Cascade Victoire • An Irrigation Unit has been set up under the Commis Agriculture
	Systemic • Expensive labour (deviation from Agriculture + effect of globalization) • Labour unavailability	• Mechanisation sector to be developed
	Individual • The existing crop production system is not appealing to the younger generations	• Vulgarisation of novel technologies (eg protected cult tunnels, greenhouses, etc) • Development of orchard production • To facilitate access to land and create awareness abou • To promote agricultural diversification • The logo for Rodrigues Label has been created • To boost and support the agroprocessing sector • Control should be exerted over the marketing of fake "Rodriguan" food products e.g. honey, red beans, dry
Agriculture Unsustainable Cropping Practices Decline in Soil Fertility	***Systemic*** • Limited inputs of soil amendments (chemical or organic additives) • (Crop rotation and mulching are not always adopted. Thus natural mineral recycling does not occur,) Land is ploughed and exposed for long periods, to soil erosion by strong precipitation, in the expectation of the rainy season. • Low adoption rate by farmers • Lack of funding	• Vulgarisation and training on the use of compost und Environment Unit and financed by Anti Erosion 2002 • 100 composting units were distributed to trained farm • Refresher courses on agricultural extension should be Agricultural staff • Preliminary consultancy study conducted by MSIRI f a soil fertility and suitability map for agrarian areas (2
	Institutional • Insufficient Research and logistic facilities • Lack of funding	• Training is needed in Statistics and Biometrics to ana develop experimental designs • Need for the set up of an elementary laboratory to cor • (Consultancy Proposal was made by the MSIRI for th laboratory for soil analysis under the Anti Erosion Pro
Forests	***Instituional***	

Unsustainable management of forest lands and nature reserves Proliferation of invasives e.g. Acacia nilotica	• Lack of trained human resources in forest lands, biodiversity and islet management; management and control of invasives; and research • Insufficient labour force	• Training in forest, islet and biodiversity management • Tests were carried out on removal of Acacia nilotica l Programme • Additional nature reserves should be declared • Introduction and training on Remote sensing and Sate efficient forest management and identification of tree
Forests Degraded cattlewalk areas Absence of forest cover in Cattlewalk areas	***Systemic*** • Limited and seasonal fodder production in cattlewalk areas • Deforestation in past centuries	• Sylvopastoral development to be initiated in cattlewal • To create appropriate environment for the sustainable revised Livestock (Cattlewalks) regulations
	Systemic • Absence of community participation in development and management of forest areas	• Villagers were trained in establishment of forest nurs sylvicultural practices under Anti Erosion Programme • Appropriate legislative framework should be develop establishment of community forests • Distribution of endemic plants
Coastal zone degradation Beaches are generally highly vulnerable to erosion The exposed South East beaches are eroded	***Systemic*** • Heavy engineering works along the coast enhance beach erosion (impermeable jetties, walls,etc) • The high hydrodynamism on the South East coast • Degradation of surrounding lagoon and reefs due to siltation and intense fishing (Bairds, 2003)	• To build up capacity in Coastal Zone Management • To implement proposed recommendations for the sus management of beaches, construction distance from t appropriateness of existing anti erosive measures on ((Cazes-Duvat, 2003), • The Beach Authority was set up in 2002 with the obj ensuring better control and management of public bea Mauritius and Rodrigues. • Coastal rehabilitation project was conducted by MWI by the Anti Erosion Programme. • The set up of a defensible setback policy based on the processes of flooding, and land and beach erosion is r Bairds, 2003. • An erosion profile station should be established to co erosion and carry out surveys • Protocols should be established to monitor reef- lagoo (Bairds, 2003)

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UNCBD Conferences of Parties decisions

UNCCD Conferences of Parties decisions

UNFCCC Conferences of Parties decisions