Ministry of Home Affairs, Environment, Transport and Energy
Government of Seychelles

Seychelles' Second National Communication

Under the United Nations Framework Convention on Climate Change

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Project Coordination, and Compilation and Editing of the SNC Document

Wills Agricole, UNFCCC National Focal Point

Daniel Confait, Project Manager

Maria Jeannie, Project Assistant

Antoine Marie Moustache, Proof Reader

National Circumstances

Wills Agricole

GHG Inventory

Terence Coopoosamy (Team Leader)

Andrew Jean-Louis

Mamy Ramanotosozy

Antoine Marie Moustache

Patrick Andre

Gulliy Moustache

GHG Mitigation

Terence Coopoosamy (Team Leader)

Andrew Jean-Louis, Mamy, Antoine Marie Moustache, Patrick Andre, Gulliy Moustache

Vulnerability and Adaptation

Antoine –Marie Moustache (Team Leader), Alain Decommarmond (Coastal Sector), Jan Robinson (Fisheries), Denis-Chang-seng (Climate Change Scenarios and Water Sector), Simon Julienne and Elvina Henriette (Health Sector), Antoine –Marie Moustache (Agriculture), Michelle Martin (Education)

Other Relevant Information

Wills Agricole

Gaps and Constraints and National Climate Change Strategy

Dr. Rolph Payet

Document Editing

Antoine –Marie Moustache

Technical Review of the whole SNC Document -International

Ms Gabriela Walker and her Team - National Communication Support Programme of UNDP.

Technical Review of Sectors - Local

Dr. Rolph Payet (GHG Inventory, Mitigation and Adaptation Sectors))

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Wills Agricole

UNFCCC National Focal Point

Second National Communication Project, Seychelles

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AAGR	Annual Average Growth Rate	CBS	Central Bank of Seychelles
AC	Alternative Current	CCGT	Combined Cycle Gas Turbine
A/C	Air conditioner	CCRU	Climate Centre Research Unit
ACD	Admiral Chart Datum	CDM	Clean Development Mechanism
A CP	African Caribbean Pacific	CES	Climate and Environmental Services
ADB	African Development Bank	CFL	Compact Fluorescent Lamp
ADS	Agricultural Development Strategy	CFTC	Commonwealth Fund for Technical Cooperation
ADSL	Asymmetric Digital Subscriber Line	CGE	Consultative Group of Experts
AG	Attorney General	CHM	Clearing-House Mechanism
AGOA	Africa Growth and Opportunity Act	CH_4	Methane
AIMS	Atlantic, Indian Ocean, Mediterranean and South China Seas	CHP	Combine Heat Process
AOSIS	Alliance of Small Island States	CIF	Cost Insurance and Freight
AEIN	African Environment Information Network	CITES	Convention on International Trade in Endangered Species of Wild Fauna & Flora
AFTN	Aeronautical Fixed Telecommunication Network	CNG	Compressed Natural Gas
AIACC	Assessment of Impacts and Adaptations to Climate Change	CNN	Cable Network News
AMESD	African Monitoring of Environment for Sustainable Development	CO_2	Carbon Dioxide
AMO	Atlantic Multi-Decadal Oscillation	CO	Carbon Monoxide
ARI	Average Recurrence Interval	COI	Commission de l’Océan Indien

Av Gas	Aviation Gasoline	COP	Conference of the Parties
CBD	Convention on Biological Diversity	COMESA	Common Market for East and Southern Africa
CBR	Central Bank Report	CORDIO	Coastal Oceans Research & Development–Indian Ocean
CPI	Consumer Price Index	EC	European Commission
CPUE	Catch-Per-Unit Effort	EE	Environmental Education
CVI	Commonwealth Vulnerability Index.	EES	Environmental Enginering Section
CWA	Community Works Attendant	EEZ	Exclusive Economic Zone
DA	District Administrators	EF	Emission Factor
DBS	Development Bank of Seychelles	EFDB	Emission Factor Database
DCD	Department of Community Development	EHO	Environmental Health Officer
DII	Department of Investments and Industries	EIA	Environment Impact Assessment
DJF	December, January, February	EIC	Education, Information & Communication
DMI	Dipole Mode Index	EIO	Eastern Indian Ocean
DOC	Degradable Organic Compound	EMPS	Environment Management Plan of Seychelles
DOE	Department of Environment	EMS	Environmental Management Systems
DOI	Department of Immigration	ENSO	El Niño Southern Oscillation
DONR	Department of Natural Resources	EP EIA	Environment Protection Impact Assessment Regulations
DOTT	Department of Tourism and Transport	EPA	Environment Protection Act, 1994
DP	Democratic Party	EPA	Economic Partnership Agreement
DJF	December, January and February	EU	European Union

DMS	Demand Management System	EWS	Early Warning System
DNR	Department of National Resources	FA	Fisheries Agreement
DRDM	Department of Risk and Disaster Management	FAR	Fourth Assessment Report
DWFN	Distant Water Fishing Nation	FAO	Food and Agriculture Organization
EAB	Energy Affairs Bureau	FBOA	Fishing Boat Owners Association
FCCC	Framework Convention on Climate Change	GoS	Government of Seychelles
FD	Intensity-Frequency-Duration	GOOS	Global Ocean Observing System
FDI	Foreign Direct Investment	GPS	Global Positioning Satellite
FPA	Fisheries Partnership Agreements	GSP	Generalised System of Preferences
FTA	Free Trade Area	g	Gramme
GAW	Global Atmospheric Watch	GSN	GCOS Surface Network
GCM	Global Climate Model	GST	Goods & Service Tax
GCOS	Global Climate Observation System	GUAN	GCOS Upper Air Network
GCRMN	Global Coral Reef Monitoring Network	GWh	Giga Watt Hour
GDP	Gross Domestic Product	GWP	Global Water Partnership
GEF	Global Environment Facility	HC	Hydro Carbon
Gg	Giga gramme	HSI	Harry Savy Insurance Company Ltd
GJ	Giga Joule	HDI	Human Development Index
GHGs	Greenhouse Gases	HDV	Heavy Duty Vehicle
GIS	Geographic Information System	HFC	Hybrid Fibre Coaxial Cable
GOP	Gainful Occupation Permit	HFC	Housing Finance Company

GOS	Government of Seychelles	HFC	Hydro-fluorocarbon
GPG	Good Practice Guidance	HFO	Heavy Fuel Oil
GSP	Generalised System of Preferences	HL	Hecto Litres
GST	Goods and services tax	HRDP	Human Resources Development Plan of Seychelles
GHGs	Greenhouse Gases	IAS	Invasive Alien Species
GIS	Geographical Information System	IBC	International Business Company
GLOSS	Global Sea Level Observing System	ICCS	International Conference Centre
ICS	Island Conservation Society	JJA	June, July, and August
ICRAN	International Coral Reef Action Network	Kl	Kilolitres
ICRC	International Committee of the Red Cross	Km	Kilometre
ICT	Information Communications Technologies	kV	Kilo Volt
ICZM	Integrated Coastal Zone Management	KWh	Kilowatt Hour
IDC	Island Development Company	KTOE	Kilo Tonne Oil Equivalent
IFRC	International Federation of the Red Cross and Red Crescent Societies	LDCs	Least Developed Countries
INC	Initial National Communications	LFO	Light Fuel Oil
IOC	Indian Ocean Commission	LNG	Liquefied Natural Gas
IODM	Indian Ocean Dipole Mode	LRT	Light Rail Transit

IO-GOOS	Indian Ocean -Global Oceanographic Observing System	LPG	Liquefied Petroleum Gas
IOI	Indian Ocean Index	LSAT	Land-surface Air Temperature
IOT	Indian Ocean Tuna Limited	LTD	Land Transport Division
IOTC	Indian Ocean Tuna Commission	LUCF	Land Use Change and Forestry
IPCC	Intergovernmental Panel on Climate Change	LUNGOS	Liaison Unit for Non-Governmental Organisations in Seychelles
ISO	International Standards Organisation	MCDYCS	Ministry of Community Develop, Youth, Culture and Sports
E	Internet Service Provider	MCSS	Marine Conservation Society of Seychelles
ITCZ	Inter Tropical Convergence Zone	MDG	Millennium Development Goal
ITZ	International Trade Zone	MENRT	Ministry of Environment, Natural Resources and Transport
ITU	International Telecommunication Union	MEPE	Ministry of Economic Planning and Employment
IUCN	World Conservation Union		
IUU	Illegal, Unregulated &Unreported		
MEFP	Memorandum of Economic and Financial Programme	MW	Mega Watt
MENRT	Ministry of Environment and Natural Resource and Transport	NA1	Non-Annex 1 (Parties)
MERP	Macro-Economic Reform Program	NLA	National Legislative Assembly
MEY	Ministry of Education and Youth	NAM	Non-aligned Movement
MFN	Most-Favoured-Nation	NAPA	National Adaptation Program of Action

MFA	Ministry of Foreign Affairs	NBSAP	National Biodiversity Strategy and Action Plan
MICs	Middle Income Countries	NC	National Circumstances
MISD	Management Information and Statistics Division	NCCC	National Climate Change Committee
MJO	Madden Julian Oscillation	NCSA	National Capacity Needs Self Assessment
MLUH	Ministry of Land Use and Habitat	NCV	Net Calorific Value
MMS	Multimedia Messages	NDC	National Disaster Committee
MNA	Member of the National Assembly	NDP	National Development Plan
MNP	Marine National Park	NEAC	National Environment Advisory Council
MoF	Ministry of Finance	NGO	Non-Governmental Organization
MoE	Ministry of Education	NHRDC	National Human Resources Development Council
MoH	Ministry of Health	NIC	National Interministerial Council
MOU	Memorandum of Understanding	NIE	National Institute of Education
MPA	Marine Protected Area / Marine Parks Authority	NMS	National Meteorological Services
MSP	Medium Sized Project	NIHSS	National Institute for Health and Social Services
MSW	Municipal Solid Waste	NMVOC	Non-Methane Volatile Organic Compound
MSY	Maximum Sustainable Yield	N_2O	Nitrous Oxide
MT	Metric Tonnes	NOx	Oxides of Nitrogen

NOAA	National Oceanic and Atmospheric Administration	PSMSL	Permanent Station for Monitoring Sea Level
NPOA	National Plans of Actions	PPS	Policy, Planning and Services
NPV	Net Present Value	PUC	Public Utilities Corporation
NS	Nature Seychelles	PV	Photo Voltaic
NSB	National Statistics Bureau	QBO	Quasi Biennial Oscillation
O18	Oxygen isotope	ReCoMaP	Regional Coastal Management Programme
OAU	Organization of African Unity,	RAF	Resource Allocation Framework
ODA	Overseas Development Assistance	RCI	Residential, Commercial & Institutional
ODINA	Ocean Data and Information Network for Africa	RCSS	Red Cross Society of Seychelles
PA	Planning Authority	R&D	Research & Development
PCA	Plant Conservation Action Group	RET	Renewable Energy Technology
PFC	Per-fluorocarbon	RFMO	Regional Fisheries Management Organisation
PIAC	Public Internet Access Centres	SF6	Sulphur Hexafluoride
PIROI	Platform d'Intervention Régional Océan Indien	S4S	Sustainability for Seychelles
PML	Probable Maximum Loss	SAA	Seychelles Agriculture Agency
ppm	Parts per million	SACL	State Assurance Company Limited
PPS	Policy Planning and Services	SACVAP	Seychelles Awareness, Communication and Visibility Action Plan
PRIDE	Integral Regional Programme for Development of Trade	SADC	Southern Africa Development Community
PSC	Project Steering Committee	SAFIF	Seychelles Agriculture & Fisheries

			Insurance Fund
PSIP	Public Sector Investment Programme	SAHTC	Seychelles Agricultural and Horticultural Training Centre
PSTN	Public Switched Telephone Network	SBA	Stand-By Arrangement
PUC	Public Utilities Corporation		
SBC	Seychelles Broadcasting Corporation	SINC	Seychelles Initial National Communication
SBL	Seychelles Breweries Ltd	SIT	Seychelles Institute of Technology
SBOA	Seychelles Boat Owner Association	SLA	Seychelles Licensing Authority
SBS	Seychelles Bureau of Standards	SLM	Sustainable Land Management
SCCI	Seychelles Chamber of Commerce and Industries	SLRF	Sea Level Rise Foundation
SCFHRF	Seychellois Charter of Fundamental Human Rights and Freedoms	SMB	Seychelles Marketing Board
SCMRT-MPA	Seychelles Centre for Marine Research and Technology – Marine Parks Authority	SNC	Second National Communications
SeyFa	Seychelles Farmers Association	SNCRN	Seychelles National Coral Reef Net
SEYMEMP	Seychelles Marine Ecosystem Management Project	SNDIS	Seychelles Natural Disaster Insurance Scheme
SEYPEC	Seychelles Petroleum Company	SNOC	Seychelles National Oil Company
SETS 21	Seychelles Eco-Tourism Strategy for the 21st century;	SOTN	Seychelles Ocean Temperature monitoring Network
SFA	Seychelles Fishing Authority	SPPF	Seychelles People's Progressive Front
SHTA	Seychelles Hospitality and	SPTC	Seychelles Public Transport

	Tourism Association		Corporation
SIA	Seychelles International Airport	SR	Seychelles Rupees
SIB	Seychelles Investment Bureau	SRES	Special Report on Emission Scenarios
SIBA	Seychelles International Business Authority	STA	Seychelles Tourism Academy
SIDA	Swedish International Development Agency	STB	Seychelles Tourism Board
SIDS	Small Island Developing States	STC	Seychelles Trading Company
SIDSnet	Small Island Developing States N et	SSF	Social Security Fund
SIF	Seychelles Island Foundation	SST	Sea Surface Temperature
SIM	Seychelles Institute of Management		
SUBIOS	Sub-Indian Ocean Seychelles (Annual Marine Festival)	UNEP	United Nations Environment Programme
SWAC	Solid Waste Agency	UNESCO	United Nations Educational, Scientific, and Cultural Organisation
SWDS	Solid Waste Disposal Site	UNFCCC	United Nations Framework Convention on Climate Change
SWH	Solar Water Seychelles	US$	United States Dollar
SWIO	Southwest Indian Ocean	VCP	Voluntary Cooperation Programme
TAR	Third Assessment Report	VTC	Vehicle Testing Centre
TC	Tropical Cyclone	W	Watt
TCPA	Town and Country Planning Act, 1972	WCS	Wildlife Clubs of Seychelles

TJ	Terra Joule	WHO	World Health Organization
TOE	Tonne of Oil Equivalent	WIOMAP	Western Indian Ocean Marine Application Programme
TOGA	Tropical Ocean Global Atmosphere programme	WTIO	Western Tropical Indian Ocean
TOR	Terms Of Reference	WTO	World Tourism Organisation; also: World Trade Organisation
3G	3rd Generation	WMO	World Meteorological Organization
UC	Utilities Committee		
UCPS	United Concrete Products Seychelles		
UHSLC	University of Hawaii Sea Level Centre		
UN	United Nations		
UNCTAD	United Nations Conference for Trade and Development		
UNDESA	United Nations Department of Economic and Social Affairs		
UNDP	United Nations Development Programme		

SECOND NATIONAL COMMUNICATION OF SEYCHELLES

Executive Summary

EXECUTIVE SUMMARY

Introduction

The Initial National Communication of Seychelles which was submitted to UNFCCC in October 2000 was important in bringing attention to climate change issues in Seychelles; it had nonetheless some limitations. It focused primarily on reporting under the Convention and that strategic opportunities for feeding into national development were not fully exploited and there was limited participation of stakeholders from public and private sectors. The Investigations were essentially academic in nature; hence of limited relevance to policy decision making, for instance the climate risk management issue.

By contrast, the Seychelles' Second National Communication is an opportunity in transforming the Initial National Communication from a mere reporting process to a strategic and policy support tool. This SNC is a vehicle to facilitate:

- Institutionalisation of climate change responses;
- Production of knowledge and information on the basis of national priorities;
- Mechanism of policy dialogue for effective actions;
- Public education and awareness for mainstreaming climate change concerns at different levels in society.

Therefore, the SNC seeks to facilitate policy changes by exploring ways to facilitate the mainstreaming of the National Communication process into the government agenda for environment sustainability.

The outcomes of the SNC process highlighted the policy strategies in the short and long terms by focusing more on adaptation in key sectors and the need to prepare a National Climate Change Strategy and Action Plan to address climate change and its adverse impacts**.**

Situation Analysis

Seychelles is a very small country with a population of approximately 88,113 (NSB Censor Report, 2010). Despite this, under stable socially-oriented governance, the country has made considerable advances in the socioeconomic and political contexts. The Seychelles consists of an archipelago of over 115 diverse islands, both granitic and coralline, some extending over 1000 kilometres from Mahé, the largest island, which is approximately 30 km by 5 km.

The potential effects of global warming remain a source of concern for the country. The vast majority of Seychelles infrastructure is located on the narrow coastal plains on the three main islands, and hence, is very much threatened by climate-related changes like sea level rise. Seychelles is facing a visible increase in dry periods and coastal erosion, problems that make climate change an apparent and immediate threat, which is bound to have effects on the coastal environment and that the country's capacity to adapt to such change is highly limited.

In Seychelles, the per capita budget per year allocated for direct environment management and protection is about USD 100. The pressure for increasing the present allocation will likely escalate in view of decreasing international funding possibilities and increased costs as a result of the El Nino and Southern Oscillation (ENSO) events and global warming.

Therefore, long-term policy responses are needed to address a wide range of issues pertinent to the specificities of Seychelles. These include mainstreaming land-use planning, coastal, agriculture, fisheries and water in the National Development Plan, enhancing monitoring, building institutional capacity, and capacity-building. Unfortunately, many of these actions would not be possible without significant financial and technical support. For example, it has been estimated that the marginal cost per capita to protect small island states from a 1 metre sea-level rise is over 10 times more than that for developed countries.

The extensive coral bleaching and death experienced in 1998 following the ENSO event highlighted the direct impact of climatic event on biodiversity and ecosystem function. Just as worrying, however, are the secondary effects of projected climate change on Seychelles' capacity to manage global environment issues. The vast majority of Seychelles infrastructure, habitation, the seat of Government and administrative agencies all reside on the narrow coastal plains of the three main developed islands. Projected sea level rise would place all these in jeopardy and severely undermine the country's capacity to manage environmental issues. Mitigating costs are exorbitant and would likely involve further encroachment in the biodiversity –rich mountainous areas bringing with it another host of environmental problems. Sea-level rise would undermine the economic and industrial base of the country likely causing much of society to resort to subsistence on direct exploitation of environmental resources. This will lead to further environment stresses which will be heightened and a clear increase in land degradation. In summary, climate change and its related projected sea-level rise threaten the very fabric of Seychelles' socioeconomic development.

The continuous efforts by the Government of Seychelles to conserve and protect the nation's natural heritage through a strong policy of sustainable development are well known and accepted internationally. The Government of Seychelles has pledged to continue to make significant investments in the conservation and sustainable use of the natural resources and related biodiversity and ecosystems. However, national resources are not sufficient to achieve effectiveness and sustainability in the long-term management and utilisation of natural resources, including the conservation of globally unique and threatened ecosystems and the management of the coastal resources. Whilst Seychelles may have one of the highest per capita investments in environmental management, there is still a great need for more participation by international agencies, donors, local private sector, NGOs and civil societies in environmental management.

Economy

Economic and Social Situation

Seychelles' economic growth has averaged 7.7% per annum over 2005-2007 (mostly explained by a buoyant tourism sector). However, in mid-2008, the petroleum and food price spike pushed Seychelles over the financial brink on which it had teetered for many years, due to unsustainable macroeconomic policies. Arrears to bilateral creditors had built-up, official reserves had been virtually exhausted, and foreign exchange shortages and extensive exchange restrictions were heavy constraints on economic activity. Growth was already negative in 2008 (-0.9%) due to the economic crisis in Seychelles and increasingly on account of the deteriorating global environment. In addition, heightened piracy activity in and around Seychelles' territorial waters was affecting the tuna industry.

A far reaching reform programme, supported by the IMF, took immediate bold steps, including the removal of all exchange restrictions, the floating of the currency, a large tightening of fiscal policy, and the introduction of a market-based monetary policy. Fiscal measures included the replacement of universal indirect product subsidies with a targeted social safety net, a large reduction in public sector employment, and removal of tax exemptions. The authorities also approached their external creditors seeking a restructuring of their unsustainable public external debt (156% of GDP), consistent with their limited payments capacity. From the beginning, there has been a high degree of ownership of the reform strategy and the programme has been implemented with diligence and determination. The programme has succeeded in rapidly stabilising the macroeconomic environment, with inflation reduced to the low single digits and the exchange rate appreciating from its lows after the float.

The international crisis hit the Seychelles as the reform programme was being launched and further seriously affected the whole economy: for tourism, the latest estimates show that tourism earnings should decline by 24% in 2009; Foreign Direct Investment (mainly tourism-related) is also expected to decline by 48%, and the financial crisis in developed countries limits the access of investors to credit. GDP is expected to contract by 11 percent in 2009. The external current account deficit widened sharply in 2008, reaching 46% of GDP, mainly reflecting a large surge in imports in the fourth quarter. External reserves already at low levels since 2006-2007 dropped to precarious levels under the combined impact of the global commodity price shocks and continued economic troubles. Finally, lower performance of the tourism sector and large reform of the public sector is leading to a sharp increase of unemployment, which in turn is fuelling a rise in social ills, including drug abuse, prostitution and robberies.

The impact on poverty remains difficult to ascertain, although the most recent household expenditure survey data indicates around 13% of Seychellois are living below a SR 50 (approximately US$ 3.5) per day poverty line. The number of applicants to the newly created Social Welfare Agency has sharply increased reaching 3,154 end of June (3.9% of the population) multiplying by four the payment of social allowances (base November 2008). Unemployment has also increased and is partly compensated by the departure of expatriate workers (estim. 2.000 out of 10.000).

As a small island developing state highly dependent on imports and exports' revenues, Seychelles is highly vulnerable to external shocks. Despite the comprehensive reforms, including the Seychelles Rupee float, and IMF disbursements, the level of international reserves is expected to reach only 1.3 months of sustained imports in 2009.

Moreover, despite a tight and comprehensive fiscal policy (with far-reaching measures to curb public expenditure) and taking into account the good-faith negotiations Government is carrying out for debt rescheduling, the IMF forecasts a residual fiscal financing gap of USD 12 million for 2009 (and USD 10 million in 2010). The original financing gaps were to be closed by the external debt restructuring, but on account of the international crisis, higher gaps for 2009 and 2010 require new and additional external support. In the light of recent developments, a main challenge for Government is to secure sufficient resources for the social sectors and also to mitigate an eventual rise in social ills.

National Development / Cooperation Policy and Strategy

In March 2007, the Government of Seychelles (GoS) formulated a ten-year National Development Programme (Seychelles Strategy 2017). Government has also formulated, in November 2008, a macroeconomic and financial reform programme to rebalance the economy, which is detailed in the Memorandum of Economic and Financial Policies (MEFP) 2008-2009. The latter is the basis on which the IMF has designed its ongoing Stand-By Arrangement (SBA). Implementation of the GoS's reform programme is coordinated by the Ministry of Finance. Moreover, progress on the reform agenda is reviewed by the IMF on the basis of quantitative performance indicators and structural benchmarks related to the macroeconomic framework and PFM. The National Development Programme should be revised accordingly to address the new economic challenges.

Cooperation-related Policy and Strategy of Beneficiary Country

The GoS has formulated a ten-year National Development Programme (Seychelles Strategy 2017). The global national strategy is to double GDP by 2017 mainly through fisheries and tourism expansion, and the development of financial services industry. This growth is to be achieved while generating the maximum level of local participation, enhancing Seychelles' human resource capacity, securing high environmental protection and standards, creating efficient and transparent governance and fostering strategic national and international partnerships.

The national economic reform strategy, which was supported by EC financed Seychelles Economic Reform Program (SERP) programme, was detailed in a comprehensive and credible macroeconomic and financial reform programme launched in 2008 (MEFP 2008-2009), aiming at restoring internal and external imbalances while also having a social focus to ensure that the needs of the most vulnerable people were catered for. The Government of Seychelles replaced its extensive welfare system with a safety net targeted at the neediest people and devised a package to retrain people leaving the public sector in the framework of the Voluntary Departure Scheme. In spite of its expenditure control policy, GoS maintained free education and health services. Government had prepared a medium-term (2010-2012) economic programme for which it was requesting a 3 year Extended Fund Facility (EFF) from the IMF (2010-2012) and further support from other donors.

The Seychelles national climate change strategy drafted in 2009 aims at supporting sustainable development through mitigation and adaptation policies to climate change, with concerted and proactive action at all levels of the society. It has five priority objectives:

- To advance understanding of climate change, its impacts and appropriate responses;
- To put in place measures to adapt, build resilience and minimise the country's vulnerability;
- To achieve sustainable energy security and to reduce greenhouse gas emissions;
- To mainstream climate change considerations into national policies, strategies and plans;
- To build capacity and social empowerment at all levels.

This strategy is guided by the principles laid down in the Seychelles Strategy 2017, notably maximum local participation, enhancing human resource capacity, high environmental protection standards, efficient and transparent governance, and fostering strategic national and international partnerships. It is also based on Seychelles Initial National Communication (2001) under the United Nations Framework

Convention on Climate Change (UNFCCC), and on the Second National Communication (final report expected in January 2011).

Climate Change Threats

The National Communications of the UNFCCC identify the likely Climate Change threats to the country's economy and population. Ninety percent of the population and development, concentrated on the coastal plateaux, will suffer increased flooding and erosions from sea level rise and increased tropical storms/cyclones intensity. Rising sea surface temperature and changes in ocean chemistry will negatively impact on the health of coral reef systems, a natural protective barrier for the coastal plateaux, a major tourist attraction, and essential to the islands fisheries and conservation of biodiversity. The economy will also be impacted by worsened water shortages resulting from dryer south east monsoons and by the high risk of climate sensitive diseases (Chikungunya, leptospirosis and dengue) during the wetter north-west monsoons.

In support to the national economic reform programme which aims to correct structural imbalances, open the economy, reform the public sector, and create an environment conducive to more private sector and Seychelles Civil Society participation, Government has developed strategic tools for the sustainability of its development and reforms through: a) the third Seychelles Environment Management Plan (EMPS 2011-2020 which is in preparation), and b) Seychelles National Climate Change Strategy (SNCCS), which is being finalised.

National Capacity Self-Assessment 2005

The objective of the NCSA project is to determine the priority needs, and a plan of action, for developing Seychelles' capacity to meet its commitments to global environmental management. The project focussed on capacity needs for each convention and on capacities that are needed in common across the conventions. The NCSA assessed the capacities needed to address the Conventions in a synergistic fashion, including needs associated with strengthening existing institutional mechanisms and developing networks. In addition the project aims to strengthen the dialogue, information exchange and cooperation amongst all stakeholders.

The NCSA Action Plan will identify and develop key actions to address priority capacity needs as identified in the assessment. The action plan would be implemented by 1] informing capacity strengthening activities supported under the various GEF projects under implementation and preparation; reorienting public sector financing to address priority capacity needs in a cost effective manner; and securing new funding and technical assistance, including from non-traditional sources.

Greenhouse Gas Inventory

Introduction

The second Greenhouse Gas Inventory of Seychelles was prepared as per the requirements of the Guidelines issued by the Decision 17/CP.8 of the Conference of the Parties (COP 8, 2002). The Annex of the Guidelines states the following:

- Each Non-Annex I Party shall, in accordance with Article 4, paragraph 1 (a), and Article 12, paragraph 1(a) of the Convention, communicate to the Conference of the Parties a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, to the extent its capacities permit, following the provisions in these guidelines;
- For the Second National Communication, Non-Annex I Parties shall estimate national GHG inventories for the year 2000;
- Non-Annex I Parties should use the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, hereinafter referred to as the IPCC Guidelines, for estimating and reporting their national GHG inventories;
- Non-Annex I Parties are encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved;
- Each Non-Annex I Party shall, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass (metric tonne), estimates of anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) by sources and removals by sinks.

Compiling a national greenhouse gas (GHG) inventory requires a fairly lengthy and interconnected series of tasks, including collecting emission factors and activity data, selecting appropriate methods, estimating GHG emissions and removals, implementing uncertainty assessment and quality assurance/quality control procedures, reporting the results and documenting and archiving all relevant data and procedures.

This work requires fundamental decisions about data and methods, the establishment of a network of contacts for accessing data and reviewing results and the design of a system for data management, quality assurance, quality control, documentation and archiving. The inventory process should be planned, operated and managed to ensure optimal quality and efficiency, given available resources.

In addition to meeting national UNFCCC reporting obligations, the preparation and the reporting of national GHG inventories can provide a number of other benefits to a country. These include:

- Providing information useful to economic development assessment and planning, such as: information on the supply and utilisation of natural resources (e.g., croplands, forests, energy resources) and information on industrial demand and production;
- Providing information useful for addressing other environmental issues (e.g., air quality, land use, waste management, etc.);
- Clarifying national data gaps that, if filled, may be beneficial for other reasons, e.g., vehicle fleet data;
- Evaluating GHG mitigation options.

Quality of the National GHG Inventory

Improving the quality of the national GHG inventory can also be beneficial. More accurate inventories enable a country to identify major sources and sinks of GHGs with greater confidence, and thus allows it to make more informed policy decisions with respect to appropriate response measures. For example, a technically defensible GHG inventory can serve as the foundation for public policy as it relates to air quality issues. Formulation of appropriate control strategies requires a reliable base of accurate emissions estimates. If the data used to derive control strategies are flawed, the public policy resulting from the strategy may also be in error. These errors can be costly to the public being exposed, the industries or economic sectors that are being controlled and to the environment.

Results of the GHG Inventory for the Year 2000

Energy

The overall performance of the economy of Seychelles is heavily dependent on the import and the consumption of refined petroleum products to meet the domestic energy needs, and also for the international bunker fuels, which accounted for around 72 % of the total import of fuel in 2000.

In 2000, the domestic consumption of fuels was 83,164 tonnes and this represented an increase of 37 % over the 1995 consumption level. The domestic consumption of fuels by sector in 2000 was as follows: Public Electricity – 56 %, Transport – 26 %, Manufacturing, Commercial & Institutional – 16 %, and Residential – 2 %. The international marine and aviation bunker fuels accounted for 72 % of the total import of fuel. The main types of fuel imported were: Fuel Oil, Gas Oil, Gasoline, Av Gas, Jet Kerosene, LPG and Kerosene.

The contribution of alternative and renewable energy sources are limited to the use of solar water heaters for bathing, and some biomass (wood) for heat production for drying of food products.

The Public Utilities Company (PUC) is the sole producer and distributor of public electricity and it operates two power stations on Mahe and one on Praslin. The distribution systems on Mahe feed some of the inner islands via sub-marine cable, and that of Praslin feeds La Digue also via sub-marine cable. Electricity is generated using internal combustion engines running on fuel and gas oil. The 2000 consumption of fuel oil was 30,347 tonnes and that of gas oil was 16,813 tonnes. The installed capacity was 88.5 MW, of which 83 MW were on Mahe, and 5.5 MW were on Praslin. The supply of electricity on the other islands is from small gas oil operating engines and this is the responsibility of the owners of the islands. Tourism activities (hotels) are the main consumers of electricity on these islands. There is no readily available data on the overall installed capacity on the other islands.

Since Seychelles is made up of 115 islands, both air and sea transport plays a vital role in the socio-economic development of the country. Air transport is vital for the tourism sector for transporting tourists to various hotels that are situated on different islands, and also as a mean of transport between Mahe and Praslin. The service is provided by small aircrafts and helicopters. Maritime transport is also very important and it facilitates the transport of passengers and cargo from Mahe to all the other islands, and also for the surveillance of the Exclusive Economic Zone (EEZ). Gas oil is the main fuel consumed.

The manufacturing and construction sector consumed mainly public electricity, but some gas oil is consumed for electricity generation and heat production in the manufacturing sector, whilst in the construction sector gas oil is used for plant operation.

The commercial and institutional sector depends heavily on public electricity, but gas oil is used to produce electricity for the hotels that are situated on the outer lying islands, and LPG is used for cooking in all hotels, guest houses and restaurants. There are a lot more hotels on the outlying islands now compared to 1995. The tourism arrival figure in 2000 was 130,046 compared to 120,716 in 1995, representing an increase of 8 %.

The residential sector was made up of 20,270 households in 2002 compared to 16,808 in 1994, representing an increase of 21 %. Electricity is the main form of energy consumed, but LPG is widely used for cooking. Nearly all the houses are connected to the electricity grid.

Fishery is the second most important sector of the economy after tourism. In 2000, 391 tonnes of gas oil were consumed by various fishing activities.

Data gaps for GHG inventories

In the Seychelles' Initial National Communication, data gaps for GHG inventories were highlighted as one of the areas for capacity building. It was recommended that a system for data collection, analysis, storage, and dissemination be set up to facilitate the preparation and the reporting of future GHG inventories as per the requirements of the IPCC. This has not been fully implemented, and as such there are still certain constraints to get data for certain sectors, such as road, navigation, manufacturing and construction, commercial and institutional sectors, etc. The required energy data were obtained from the main data holders, especially SEPEC, PUC and EAB/MoI.

Methodology

The TIER 1 method has been used for the calculation of the GHGs. This method concentrates on estimating the emissions from the carbon content of fuels supplied to the country as a whole (Reference Approach) or to the main fuel combustion activities (Source Categories). The TIER 1 method has been applied as follows:

- CO_2 emissions using both the reference approach and the source categories;
- Non-CO_2 emissions from fuel combustion by source categories.

Results

The total CO_2 emission for energy in 2000 was 260.640 Gg or 260,640 tonnes, compared to 194.342 Gg or 194,342 tonnes in 1995. This represents an increase of 34 %. In 1995, the CO_2 emission from the combustion of gas oil was nearly 71 %, but this had decreased to around 44 % in 2000. This was as a result of the increase in consumption of fuel oil for public electricity generation, especially at Power Station C. The emission of CO_2 from fuel oil combustion was around 37 % in 2000, compared to only 1.5 % in 1995. There has been a decrease in CO_2 emission from kerosene and an increase for LPG, as a result of fuel switching in the residential sector. LPG has replaced kerosene for cooking in the residential sector.

In 2000, public electricity production (56 %) and road transport (19 %) were still the main sources of CO_2 emission, followed by the commercial & institutional sector (11 %). It is to be noted that around 8 % of the emission from the commercial sector was for electricity production from hotels where public electricity is not available. Therefore, the total emission for electricity production was around 64 % while from the transport sector (road, aviation & navigation) it was around 25 %. The total emission for cooking was around 6 %.

The total CO_2 emission in 2000 was 260 Gg or 260,000 tonnes, compared to 179 Gg or 179,000 tonnes in 1995. This represented an increase of 45 %. It is to be noted that the domestic fuel consumption in 2005 was around 8 % higher than that in 2000, therefore it was expected that the CO_2 emission in 2005 would have been around 8 % higher than in 2000. As a result of ongoing development in the tourism and housing sector, it is expected that the CO_2 emission will continue to increase.

Industrial Processes

The industrial sector consists mainly of light to medium industries involved in manufacturing and construction activities. There are relatively very few large manufacturing industries in Seychelles. The Seychelles relies heavily on imported goods to meet local demand.

In Seychelles there is no manufacturing of mineral products (cement or lime), chemical industry or metal production. As such, there are no significant emissions of CO_2 from this sector. Only food and drink production along with the consumption of HFCs are considered as relevant sources for emissions of GHGs. The main GHG emission from this sector comes from food processing, namely beer, meat & meat products, fish & fish products, poultry & poultry products, animal feed and bakery. HFC is emitted from the use of refrigerants for cooling and also from the use of fire extinguishers. Most of the data were obtained from the Department of Natural Resources and the National Statistics Bureau (NSB).

Methodology

The simplified approach (Tier 1) was used to estimate the emissions of NMVOC from food processing and production. The Tier 1a method was used to estimate the emissions of Halocarbons from the consumption of halocarbons in refrigeration and air-conditioning systems and the use of fire *extinguishers.*

Results

The total emissions of NMVOC were 0.051 Gg and the potential bulk Halocarbon emissions were 0.014 Gg.

When the First GHG Inventory was prepared in 1997, it was not possible to estimate GHG emissions for Industrial Processes, since emissions factors were not readily available. For the present inventory, it has been possible to estimate the GHG emissions, since the default emission factors given in the IPCC Reference Manual were used. The GHG emissions that were of relevance were NMVOC and HFC, and the amounts of emissions were quite low. It is not expected that there will be a significant increase in GHG emissions from this sector in the future.

Agriculture

The main sources of emission were from enteric fermentation, manure management and agriculture soils. The main GHG emission was CH_4 from domestic livestock as result of enteric fermentation and manure management. N_2O emissions from agricultural soils were not estimated since the amount of fertilisers used was quite small. The data were obtained from the Department of Natural Resources and the NSB.

Methodology

The Tier 1 methodology was used as the livestock population was quite small. The emissions of CH_4 amounted to 0.21 Gg (212 tonnes).

Results

The results confirm those of the first GHG Inventories and show that emissions of CH_4 from the agriculture sector are negligible, since the amount of livestock is quite small. There is no indication at present that this situation will change; therefore it might not be necessary to calculate GHG emissions from the agriculture sector in the future.

Land Use, Land Use Change and Forestry (LULUCF)

The Seychelles archipelago has a total land area of 45,500 hectares (see Table ES-1) of which 54% are granitic islands and the rest are coral islands. About 50 % of the total land area is protected in the form of national reserves or parks. The land is about 88.9 % vegetated with a mixture of different types of forest, with primary forest cover making up only 5% of the total forest area. The table below gives details of the land and forest areas.

	Granite	**Coral**	**Total**
Land Area (ha)	24,500	21,000	45,500
Forest Area (ha)	21,781	18,669	40,450
National Park (ha)	3,630	14,810	18,440

Table ES-1:The total amount of biomass harvested for commercial purpose per year was 8,000 m^3

At the time of preparation of this inventory, data for the total forest area converted for infrastructure development were not available.

Methodology

The methodology used for the estimation of the removal capacity and emissions of CO_2 is based on the fact that forest of Seychelles is considered to be tropical and made up of mixed fast growing hardwood.

The primary forest is only 5 % of the forest area. It is assumed that all forest areas of Seychelles are in the managed forest category.

Results

The Table ES-2 below gives the results of the estimate of CO_2 removal capacity and emissions, of which the net removal capacity of CO_2 is 821.74 Giga gramme.

Removal/Emissions in the year 2000	**Amount (Giga gramme)**
Total removal capacity of vegetated area	-834.28
Emission from commercial use of biomass	12.54
Net removal capacity	-821.74

Table ES-2: Estimate of CO_2 removal capacity and emissions

Waste

In the late 1990s, significant advances were made in the effective management of solid wastes in the Seychelles. Two major initiatives which contributed to these advances were the establishment of a dedicated waste management authority (SWAC) and the award of a major contract for the collection, treatment and disposal of solid waste to a specialist contractor (STAR). SWAC was primarily responsible for the enforcement of legislation and the minimisation of the environmental impact of waste management, whilst ensuring that appropriate facilities and operational activities are provided. The role and responsibilities of SWAC has now been incorporated within the Department of Environment. STAR continues to manage the solid waste disposal sites and the collection of wastes.

The majority of waste is managed by STAR under a number of contracts overseen by the Department of Environment. This includes waste collection, treatment and disposal. On Mahe, most solid waste is disposed of at the Providence solid waste disposal site (SWDS). On Praslin, the majority of waste is disposed of at the SWDS at Amitie. On La Digue there is a SWDS at L'Union Estate.

CH_4 emission from the SWDS was considered as the main GHG emission for the waste sector. CH_4 emission from waste water treatment plant has not been considered since the main plant is operated on an aerobic process.

Methodology

The default methodology which is based on a mass balance approach that involves estimating the degradable organic compound (DOC) content of the solid waste was used for estimating the amount of

CH_4 that can be generated by the waste. The Fraction of DOC of the MSW of Seychelles was calculated to be 0.11 Gg. The CH4 emission from the SWDS was 2.51 Gg.

Results

The total CO_2 emissions for the year 2000 was 273.146 Gg and the total CO_2 removal capacity was 837.380 Gg. This meant that Seychelles was a net sink for CO_2 to the tune of 564.232 Gg and this represents 3 times the amount of emissions. The amount of emissions for the other greenhouse gases was quite low. CH_4 was 2.743 Gg and NOx was only 1.150 Gg. It is to be noted that the global warming potential of CO_2 is 1, that of CH_4 is 21, and that of N_2O is 310.

Conclusion

The base year for the second GHG inventory was 2000 and the main GHG emitted was CO_2. The inventory indicated that the national total of CO_2 emissions in 2000 was 273.146 Gg (273,146 tonnes), of which 95 % came from the energy sector and 5 % were from the forestry sector. Some 57 % of the CO_2 emissions were from public electricity production, 25 % from the transport sector (19 % for land transport), 11 % from commercial and institutional sector, 3 % from the manufacturing and construction sector, 3 % from the residential sector, and 1 % from the other sectors. There has been a 46 % increase in CO_2 emission from the energy sector since 1995. Compared to 1995, in 2000 the CO_2 emission from public electricity production has increased by 41 % and similarly, for the transport sector this has increased by 20 %. The figure for the transport sector would have been much higher if foreign exchange constraints did not exist and also if government had not implemented a number of measures to regulate the import of vehicles. Figure ES-1 indicates the 2007 CO_2 Emissions from Fuel Combustion by Source Categories having a national total of 359,269 tonnes.

The Seychelles 2000 per capita CO_2 emission was 3.37 tonnes. The national total CO_2 removal capacity in 2000 was 837.380 Gg (837,380 tonnes), which was about 3 times the amount emitted.

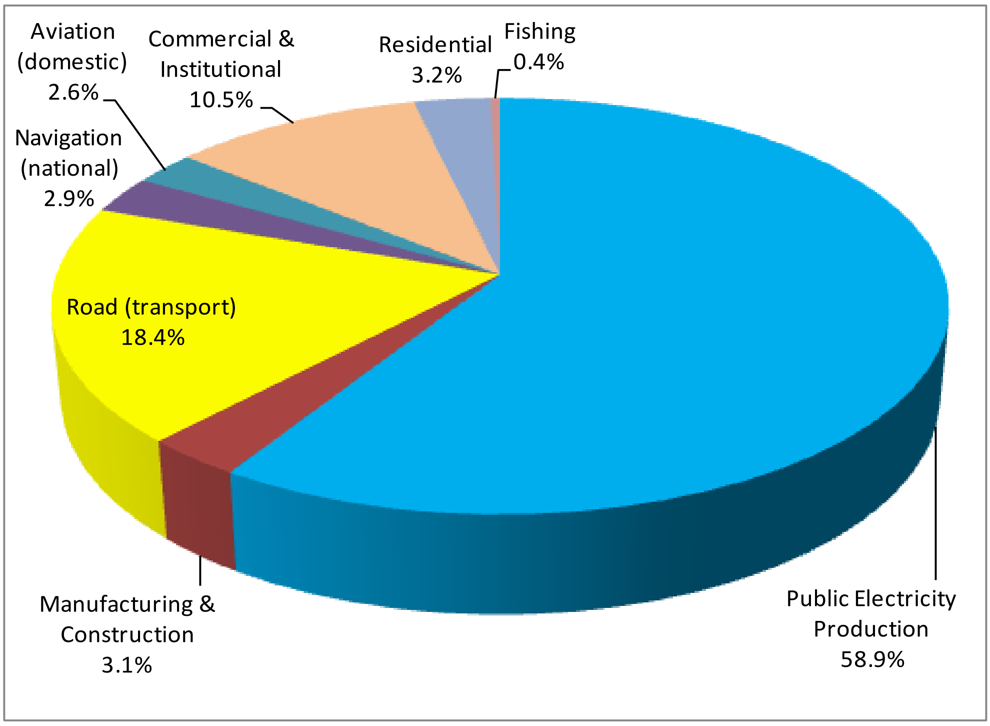

Figure ES-1: The 2007 CO_2 Emissions from Fuel Combustion Expressed in Percentage

Mitigation Measures

Introduction

Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC) requires Parties to the Convention to carry out assessment and prepare report on the technologies and the measures that can be used to limit and reduce GHG emission thereby contribute to mitigate the negative impact of climate change.

This study presents the assessment of the options for the mitigation of CO_2 emission for all the main energy consuming sectors, ie, Electricity Production, Road Transport, Industrial, Residential, Commercial and Institutional sectors. The options for mitigating GHG emissions and also for maintaining the sink capacity of the Forestry sector was also assessed and have been reported. The 'business as usual' approach has been used to formulate the baseline scenario. The mitigation scenario is based on options that are most practical and also on those that will bring maximum benefit if implemented.

Even though it is not binding for Seychelles as a Non-Annex 1 Party to implement GHG mitigation options, the country stands to benefit since it will lead to reduction in the growth of the energy demand of the country. Since the country is presently going through a rapid development process, both in the tourism, fisheries, construction, and residential sectors, it is expected that the demand for energy will increase steadily over the coming years. As a result of the present world economic crisis, the country is facing many challenges in terms of financing the cost of the national energy bill. The Seychelles has embarked on an IMF-backed economic reform proramme to alleviate its foreign debt burden. As part of the reform, the country's monetary framework has been changed from a fixed regime to a floating system, resulting in 95 % depreciation in the local currency. This has already pushed an already high inflation figure up to 60 %, putting pressure on all sectors of the economy and the population. Since virtually all the energy that is consumed nationally is imported as petroleum products, this has placed a considerable constraint on the government, as the sole importer of petroleum products, to find the necessary foreign exchange to import these products. Implementing the GHG mitigation options in the energy consuming sectors will assist toward limiting the demand for petroleum products and reduce the energy bill of the country. This will be an overall gain for the country.

Apart from implementing mitigation options to limit the growth in the demand for petroleum products, the country should seriously consider the options for increasing the use of renewable energy technologies, especially solar energy, for both solar water heating and photovoltaic system. Renewable energy technologies have a great potential in contributing significantly to the energy demand of the country. Implementing these mitigations options will show to the world the country's commitment to reduce GHG emissions and contribute to limit the impact of climate change.

Technologies and Measures

The recent worldwide energy crisis and the ongoing financial crisis in major economies, has also impacted heavily on the performance of the economy of Seychelles. As a small island developing state which has to continue its development process, there are many challenges ahead, especially, in the area of energy security to meet and sustain the energy need of the country. Sustaining the present energy bill of the country is a major challenge, since the country relies heavily on the importation of petroleum products. Therefore, this situation presents a perfect opportunity for the government to review the national energy policy and to make decision on how to reduce the country's dependency on petroleum products. The way forward is to increase the use of renewable energy technologies, especially solar and wind energy which has very good potential for application. At the same time, the use of technologies and measures to facilitate energy conservation should also form part of the strategy to address the country's future energy need. The implementation of strategies for reducing/limiting the amount of petroleum products that is consumed nationally will be in line with the GHG mitigation options that the country must implement as part of its commitment to the UNFCCC. This will be beneficial to the national economy and the global environment.

The technologies and measures proposed as GHG mitigation options in this report for the various sectors of the economy that consume petroleum products, are aimed at limiting the growth in consumption, thereby contributing to limit the growth of GHG emission. The main sectors to concentrate on are the public electricity production and the electricity end use sectors, such as industrial, commercial, institutional and residential sectors. This is obvious since demand in the end use sectors drive the production of electricity by PUC.

Public Electricity Production Sector

There is only one company that supplies public electricity in Seychelles, and that is the Public Utilities Corporation (PUC). Electricity is produced through the combustion of HFO and LFO in thermal engines that vary in size from 1 to 5 MW set. In June 2000, the new 45.5 MW Victoria C power station was inaugurated, and the Victoria A power station at Huteau Lane was decommissioned. The total generating capacity of PUC in 2008 was 66 MW.

In 2000, the CO_2 emission was 133,419 tonnes and in 2005 this has gone up to 156,378 tonnes. By 2010, the emission is expected to reach 203,851 tonnes and by 2020 it will increase to reach 332,355 tonnes.

As part of the mitigation options for public electricity production, PUC should increase the capacity of the waste heat recovery system/cogeneration system, since over 60 % of the energy consumed at the power stations is wasted as heat. The waste heat should be considered as an alternative source of energy. The PUC should also invest in projects that will reduce losses in the electricity distribution network. The use of renewable energy technologies, such as photovoltaic and wind turbine systems, that are GHG free, are considered as viable mitigation options. The implementation of these GHG mitigation options forms part of the mitigation scenario and are considered as those that will have the greatest impact on limiting the growth in GHG emission.

Commercial, Institutional & Residential Sector

The residential sector consisted of around 21,000 households in 2000 and this sector relied on LPG for cooking and electricity for lighting and for powering various domestic household appliances. In the commercial sector, the main energy consumers are the hotels, guesthouses, restaurants and commercial buildings. LPG is widely used for cooking, and electricity is used for air-conditioning, refrigeration, lighting, powering machineries and appliances. Gasoil is used to produce electricity for hotels that are situated on the outlying islands, which are not covered by the PUC electricity grid.

In 2005, 296,675 tonnes of CO_2 were emitted from this sector, and it is expected that in 2030 the CO_2 emission will reach 691,226 tonnes if the business as usual approach continues.

The GHG mitigation options proposed for the commercial, institutional and residential sectors are all aimed at increasing the use of solar energy technologies and energy conservation technologies. The use of these solar energy technologies will contribute to reduce the consumption of gasoil for electricity production in hotels that are situated on outlying islands. This will reduce the emission of GHG from this activity. There is a huge potential for the use of solar water heater in all these sectors and government should play a lead role to introduce the necessary measures and provide the appropriate incentives that will facilitate wide scale use of the solar water heater. The use of photovoltaic system to run lighting system in the commercial and institutional sectors is seen as a viable GHG mitigation option. The buildings in these sectors have large roof structures and use a lot of lighting. Replacing incandescent electric bulbs with compact fluorescent lamps is an option that is applicable in all these three sectors of the economy. There are also a number of measures that are needed to drive the use of these technologies and these include energy conservation awareness programmes, energy efficient building, reviewing taxes on incandescent bulbs, maintaining LPG at a low cost, annual energy audits and energy management systems for commercial and institutional enterprises. Maintaining LPG at a low cost is very essential for avoiding consumers switching back to electricity for cooking, as this will cause another big problem for PUC in meeting electricity demand. SEPEC and PUC should co-ordinate their pricing policies with regard to LPG and electricity. The use of the energy conservation technologies will contribute to lower the demand for electricity and thereby lower the production of electricity by PUC, and thereby reduce the amount of GHG emission.

Industrial Sector

The CO_2 comes from the combustion of HFO and LFO in boilers to produce steam and hot water for food processing. Electricity is also widely used to power plants, machineries, lighting, air-conditioning, refrigeration and other appliances. In 2005, the CO_2 emission was 41,498 tonnes and this is expected to reach 76,494 tonnes in 2030 if the business as usual approach is followed.

The mitigation options for the industrial sector also focus on the use of solar energy technologies and energy conservation technologies. The use of solar water heater in industries that relies on hot water for their production system is a viable mitigation options. There are a few of these industries and they consume quite a bit of petroleum products and electricity for producing hot water. These industries include IOT, Seybrew, Agro industries, abattoirs, etc. These same industries consume a lot of electricity for lighting purposes and they should be encouraged to utilise photovoltaic system. These industries have large roof systems that can be put to use to capture solar energy and to provide electricity for their lighting system. The use of solar energy technologies is GHG free and will contribute in limiting the growth of emission from this sector of the economy. The use of energy conservation technologies will assist to reduce the electricity demand in these industries and contribute to lower the production output of PUC, thereby reducing the emission of GHG. Measures should be introduced to ensure that industries conduct yearly energy audits and also to implement energy conservation system.

Road Transport Sector

The vehicle population has increased steadily since the early seventies and in 2005, there were 10,622 vehicles and this is expected to increase to reach around 20,000 vehicles in 2030. Gasoil and gasoline are the main type of fuels that are consumed. In 2005, 21,324 tonnes of fuel were consumed and this is expected to reach 53,620 tonnes in 2030. The CO_2 emission in 2005 was 66,525 tonnes and this is expected to increase to reach 167,087 tonnes by 2030.

The mitigation options proposed for the road transport vehicles will be more difficult to implement since these are more focused on measures than on technologies. The technologies proposed cover the use of a light electrical rail system that will reduce the pressure on the present bus system. This can contribute in transporting a larger number of passengers per trip and thereby reduce the number of buses that are needed for transporting the same number of passengers. This will lead to reduction of consumption of gasoil and the emission of GHGs. The road improvement programme, traffic management in Victoria to reduce congestion, and the vehicle maintenance programme will also contribute to lower demand for gasoline and gasoil. The road transport system is already heavily regulated and there are limited measures that can be introduced. Increasing on the level of the existing measures can have negative impact on the socio-economic development of the country. The price of fuel and the taxes are already very high, and there are a number of controls in place such as import restriction on used vehicles, control of the movement of heavy duty vehicles, mandatory vehicle inspection and testing etc., that are all contributing to limit emission of GHGs.

Forest Sector

The Seychelles is 90 % covered by vegetation and forests. In 2005, the CO_2 removal capacity was 813,780 tonnes and this is expected to decrease to reach 773,896 tonnes by 2030.

The protection of the forest areas is very important for maintaining the CO_2 removal capacity and for Seychelles to stay as a net sink. It is going to be difficult to avoid encroachment of forest areas, since in future land will be needed for all types of socio-economic development. As such, the CO_2 removal capacity is expected to decrease by 1 % every 5 years, but at the same time CO_2 emission will be increasing at a rate of 15 to 20 %. The technology options proposed for protecting forest areas are equipping government agencies with the necessary forest fire-fighting equipment and the use of more efficient timber preparation equipment. The measures proposed are varied and include: prevention of land degradation, prevention of forest fires, forest management & conservation, and enforcement of legislations. Reclaiming land from the sea has helped to avoid encroachment of forest areas, but this has proved to be too costly and has contributed to the country's present high debt burden.

Conclusion

In 2005, the total CO_2 emission was 310,816 tonnes and this is expected to increase to reach 911,985 tonnes in 2030, if the business as usual scenario is followed. The CO_2 removal capacity was 813,780 tonnes and is expected to decrease to reach 773,896 tonnes in 2030. As such, the Seychelles will become a net emitter of CO_2 by the year 2030. It is also very unlikely that the country will be able to sustain the growth in demand of petroleum products as per the business as usual scenario. It is therefore necessary that the mitigation option scenario is adopted and implemented. The mitigation scenario will contribute positively toward the planning and the management of the national energy need, and also ensure a certain level of energy security for the future. It will also facilitate the lowering of the amount of petroleum products that is consumed nationally, and hence reduce the emission of GHGs. The outcome of the implementation of the mitigation scenario will contribute to mitigate the effect of climate change as a result of global warming.

Adaptation Measures

Assessments of vulnerability in the Seychelles have been derived from three main studies – the preparation for the Initial National Communication (INC, 2001), the Assessments of Impacts and Adaptations to Climate Change (AIACC) Project (Payet, 2006) and preliminary outcome of the Second National Communication (SNC). The Initial National Communication (INC) outlines the vulnerability of the Seychelles in relation to its water resources, fisheries, agriculture, industry, human habitation, health and coastal zones. The AIACC project which focused on the impact of climate change on tourism, also considered issues such as coastal zones and coral reefs. The Second National Communication process is primarily focused on strengthening the technical and institutional capacities to mainstream the effect of climate change into national policies and development guidelines of Seychelles, and will study four major sectors -the Fisheries Sector, the Agricultural Sector, the Water Sector and the Coastal Zone Sector.

Climate change impacts in the Seychelles are very similar to those on many other small islands in the world. Characteristics such as narrow coastal zones and the concentration of development on the low-lying coastal areas make Seychelles extremely vulnerable to climate change and its associated impacts.

For example, in a study by Sheppard *et al.* (2005), it was suggested that mass coral mortality over the past decade at some sites in Seychelles has resulted in a reduction in the level of the fringing reef surface, a consequent rise in wave energy over the reef, and increased coastal erosion. Coastal erosion would have significant impacts on coastal infrastructure especially tourism and the road network.

Agriculture

Extreme rainfall has caused significant agricultural losses to crops in the last few years (Payet, 2005). The heavy rainfall experienced during the 1997–1998 El Nino and the 1998–2000 La Nina events have had profound impacts on the economy of the Seychelles. Fisheries suffered the greatest loss in monetary terms accounting for 45% of the total losses. This was followed by agriculture (28%), tourism (12%), industry (7%), construction (5%) and forestry (3%). The services providing support to these sectors were also affected. Food had to be imported to meet the shortfall on the local market and financial assistance was given to farmers. These impacts which are clearly climate related provide insights into the potential consequences of long-term climate change. Such damage to livelihoods can lead to further economic and political destabilisation in the affected areas. Coastal flooding and persistent heavy rainfall can destroy entire crops. With sea level changes, seawater can also cause salinisation of the soil.

Establishing an insurance scheme for the agricultural and fisheries sectors would require a series of studies into the sectors and would address on the one hand the inevitable periodic losses which the producers would succumb to as a result of the natural disasters brought on by climate change, and on the other hand provide the financial support to restart their activities subsequent to the natural disasters.

It would require an in-depth assessment of the agricultural sector with a view to assess the feasibility of establishing such a scheme on the basis of the characteristics of local producers, the nature of the threats and the local agricultural production. Hence the need to set up an insurance mechanism through a study for both farmers and fishermen to address losses and damages due to the adverse effects of climate change.

Seychelles Agriculture and Fisheries Insurance Fund (SAFIF)

A study was carried out to set up the Seychelles National Disaster Insurance Scheme as a Public-Private-Partnership as **Seychelles Agriculture & Fisheries Insurance Fund (SAFIF)**. It is an insurance mechanism to address loss and damage due to the adverse effects of climate change.

SAFIF should be operated, administered and underwritten by SACL and HIS jointly. The insurance companies would provide the legal basis for insurance/reinsurance and acting as policy issuing, premium collecting and loss paying entity; all insurance operations should be based on market principles.

Whilst SACL and HSI provide the legal and administrative back office platform for SAFIF insurance services, all field operations should be carried out by the Seychelles Agricultural Agency (SAA). Regarding risk and loss data management, SAA should cooperate with the Department of Risk & Disaster Management (DRDM) in order to use the GIS know-how and risk information already developed by DRDM and to avoid parallel operations.

SAA should be indemnified for its field services rendered *(individual client data collection, risk and loss assessment services, etc.)* on an agreed commercial basis, as usual in the local insurance industry.

The SAFIF is to be supervised by a board of directors, representing all stakeholders in the Seychelles Agriculture & Fisheries Insurance Fund comprising of the:

- Seychelles Government
  - Ministry of Finance
  - Ministry of Environment, Natural Resources & Transport
- State Assurance Company Ltd. (SACL)/H. Savy Insurance Company Ltd.(HSI)
- Seychelles Farmers Association (SeyFa)
- Seychelles Fisheries Authority (SFA)
- Seychelles Boat Owners Association (SBOA)

The **Seychelles Agriculture and Fisheries Insurance Fund** is considered as the ideal insurance platform for the suggested public-private-partnership approach, combining in a holistic way agricultural extension services, risk mitigation & management and last but not least insurance services for Seychelles farming and fishing sectors.

The suggested disaster risk management solution via SAFIF contains also elements of Mutual Insurance for the agriculture and fisheries industry *(e.g. grass root industry control, low cost, public and private sector solidarity, etc.).* The limited catastrophe insurance product range at the start of operations could gradually be developed into a full suite of specific insurance products tailored to the local risk exposure and insurance needs, as may be required by the farming and/or fishing sector.

Fisheries

'Climate change is likely to heavily impact coral reefs, fisheries and other marine-based resources (high confidence)' (IPCC, 2007; Mimura et al., 2007).

Fisheries are extremely sensitive to climate variability and change (Stenseth et al., 2005). In Seychelles, the fisheries sector constitutes the second major pillar of the economy and contributes significantly to food security, a level of reliance which confers high vulnerability to climate change (Allison et al., 2009).

Two studies were carried out in fisheries for adaptation to climate change as follows:

Study 1: Establishment of the Seychelles Ocean Temperature Monitoring Network (SOTN)

Through the establishment of the Seychelles Ocean Temperature monitoring Network (SOTN) the aim of this project was to develop capacity and collaboration for ocean temperature monitoring in order to improve knowledge of climate-driven changes in marine ecosystems and their implications for management.

<u>Objectives</u>

- To establish an operational network of national and international partners and programmes with a shared interest in collaborating on monitoring and sharing ocean temperature data;
- To facilitate sharing and use of ocean temperature data through the development of a national database linked to online access to metadata.

Website Design and Access to Metadata

A website was designed to provide information on the SOTN and to enable access by the partners to aggregated data. Ocean temperature metadata are available for different island groups within the Seychelles archipelago, namely the Inner Islands, the Amirantes, the Aldabra group, the Farquhar group and Coetivy. All of the island groups have graphic representation of the spatial distribution of installed temperature loggers together with basic metadata. As agreed upon by the partners during workshops, basic metadata that are available on the website include a brief description of where the data were gathered, information on the depth of the loggers, the time-period of data collection and contact details of the person responsible for the data. A website had to be designed and was published in February 2009 (see Figure ES-2).

Study 2: Determination of the Socio-economic Impacts of Climate Variability on Seychelles Industrial Tuna Fishery, with a View to identifying Management and Policy Strategies to adapt to Future Uncertainty and Change

Introduction

While the economic impacts of the strong 1997-1998 warm event have been estimated at a broad sector level (Payet, 2005; SFA, 1999), a thorough socio-economic analysis has not been conducted. Recognising this deficiency and its implications for adaptive management in the fisheries sector, this project was conceived under the Self-Assessment Exercise for the preparation of the Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC). The aims of the project were to assess the impacts (direct or indirect) of climate variability on the socio-economics of the tuna industry of Seychelles, and to assess the management measures and the policies for appropriate responses to aid adaptation under various scenarios of climate change.

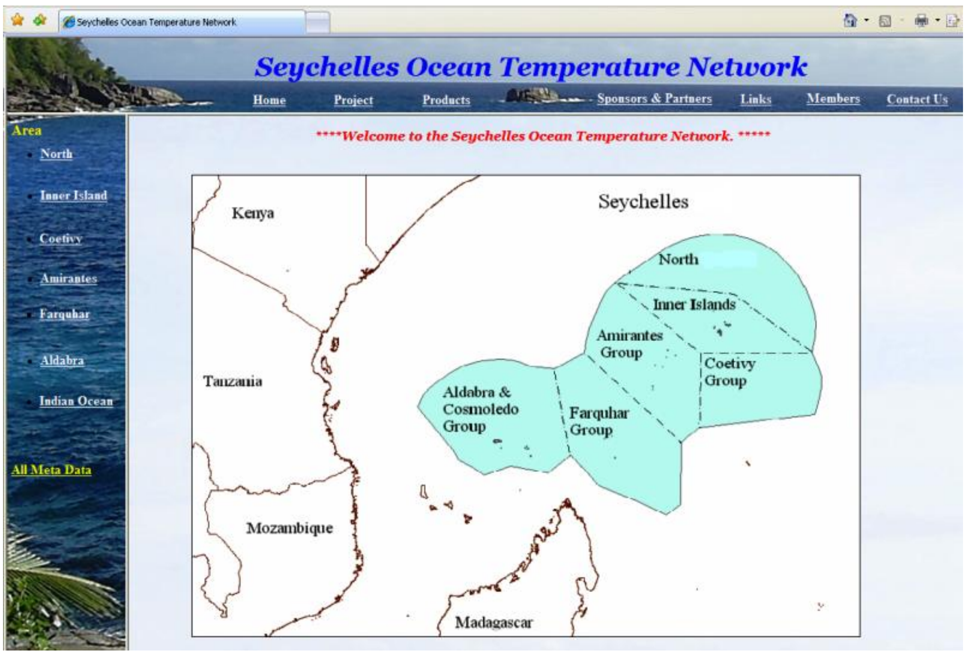

Figure ES-2: Homepage of the SOTN Website published early 2009

Discussion

The findings of this study are indicative of links between climate variability and the economy of a small island developing state. While it is recognised that causality has not been demonstrated, the coincidence in late 1997 and 1998 of a severe warming event and significant disruptions to the tuna purse seine fishery, acting in phase with a dramatic fall in revenues from the tuna industry, is compelling evidence for a climate effect.

Climate Change and the Seychelles Tuna Economy

Similar to other SIDS situated in productive tuna fishing zones, Seychelles has come to rely heavily on a 'tuna economy' as the world demand for tuna has grown steadily over recent decades (Campling *et al.,* 2007; Campling and Havice, 2007). The importance of the tuna economy for Seychelles was, for the first time, demonstrated using a multiplier approach. On average, SR 1 spent by the purse seine fleet in Port Victoria leads to a doubling of inflows for the economy through household, shareholder, State and private company expenditure. Given that the availability of tuna in the Seychelles area is at the core of competitiveness for the canning industry, it is easy to comprehend the multiplier impact that climate oscillations may have on the local economy. As evidence, the warming episode of 1998 resulted in major disruptions in production at IOT for several months.

Of paramount importance for assessment of vulnerability is the finding that climate oscillations of low to moderate intensity did not act strongly on the Seychelles' economy relative to the intense 1997-1998 warm event. Within the period corresponding to the expenditure dataset (1992-2008), there have been several warming events in the WIO, in addition to 1998, some moderate (2003 and 2004-2005) and some relatively strong (1994 and 2006-2007).

Conclusion

The last decade has witnessed pervasive impacts from climate variability on Seychelles' marine ecosystems and the fisheries they support. Both reef and pelagic ecosystems suffered extreme modification during the 1997-1998 warming event. The temporality of the modification and the corresponding impacts show important differences between the two ecosystems, with coral mortality and subsequent loss of structural complexity on reefs pointing to lag effects on reef fisheries that are not yet fully realised (Graham *et al.,* 2007). The pelagic ecosystems and tuna habitat were modified only for the duration of the climate oscillation (Ménard *et al.,* 2007). In the longer term, however, pelagic and reef ecosystems will potentially be subject to the effects of climate change, dually in terms of increasing frequency and severity of climate variability and through gradual shifts in physical dynamics of the marine environment and productivity regimes. Adaptive management of the specific risks posed by overfishing (anthropogenic), habitat degradation, trade distortions, local macro-economic constraints and regional competition are more tangible than direct adaptation to climate change. Adaptive strategies should not, however, be considered mutually exclusive and should be assessed holistically, at the widest sector and macro-economic policy levels, to promote resilience to climate change. As a small island state with an almost exclusive reliance on the marine environment for fisheries and tourism, the social, economic and cultural fabric of Seychelles is inextricably linked to climate change.

Human Health

'There is growing concern that global climate change is likely to impact human health, mostly in adverse ways (medium confidence)' (IPCC, 2007; Mimura et al., 2007).

Climate-related events that may affect health in Seychelles include the spread of certain diseases such as leptospirosis and Chikungunya, heat waves (uncommon) and respiratory ailments arising during extreme drought conditions. Leptospirosis is a bacterial infection that can cause death in both humans and animals. The infection is commonly transmitted through contamination of water, so it is usually prevalent during periods of rainfall. On the other hand, the Chikungunya fever is a result of an insect-borne virus transmitted by virus-carrying *Aedes* mosquitoes. Chikungunya manifests itself with a prolonged fever that affects the joints of the extremities. The acute febrile phase of the illness lasts only two to five days.

A study on the impact of climate change on the health sector was carried out. The focus of this study was on the impacts of climate change on vector-borne diseases especially those transmitted by mosquitoes in the Seychelles. Vector-borne diseases are infections transmitted by the bite of infected insects, such as mosquitoes, ticks, sandflies and blackflies (Confalonieri et al., 2007). Mosquitoes are the vectors responsible for the transmission of many vector-borne diseases (Sattenspiel, 2000).

<u>Discussion and Conclusion</u>

It is evident that change in climate is inevitable and that it will impact on human health in several different ways. Thus, there is the need to take a precautionary approach and to prepare for those impacts. The study revealed a very good correlation between the Chikungunya outbreaks and temperature variations (see Figure ES-3 and Figure ES-4).

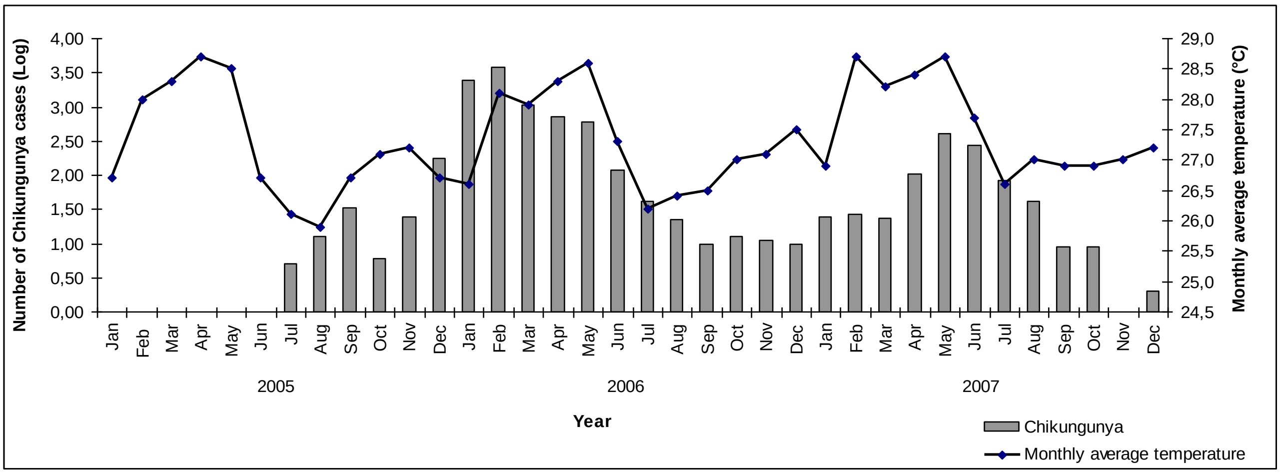

Figure ES-3: Atmospheric Temperature and Chikungunya Outbreaks 2005-2007

Warmer temperatures could have created the ideal conditions for the rise in the number of Chikungunya cases as it favoured an increase in mosquito abundance, higher biting rates and activity level, and increased exposure to mosquitoes (as people tended to stay outdoors during hotter weather). The 2005-2008 outbreak of Chikungunya resulted in an estimated USD 1.84 million in economic losses, against an estimated cost of less than USD 200,000 for disease control (which can be roughly assumed to be related to disease prevention).

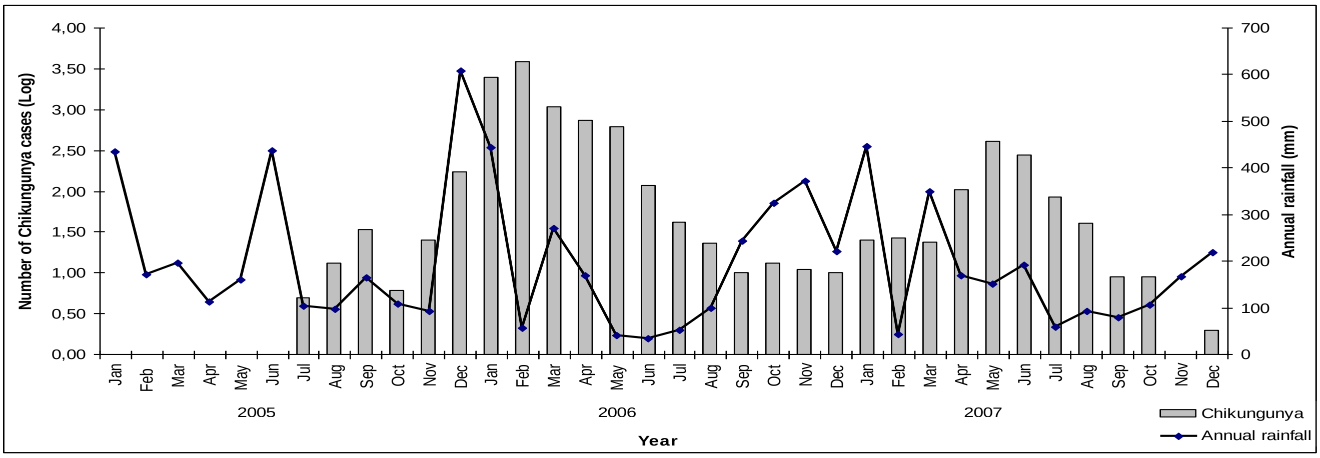

Figure ES-4: Rainfall and Chikungunya Outbreaks 2005-2007

In order to develop policies to mitigate and adapt to climate change-related health impacts, it is important to continuously understand and seek evidence of the ways climate change will affect the patterns of human health. Priority should be assigned to developing and implementing effective adaptation measures. These measures can be used effectively to greatly reduce many of the potential health impacts of climate change. The most important measure is to strengthen public health infrastructure and resources in addition to having adequate financial resources. Public health resources include public health training programmes, research to develop and implement more effective surveillance and emergency response systems, health education programmes, along with prevention and disease control programmes**.**

Water Resources

'There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised (very high confidence)' (IPCC, 2007; Mimura et al., 2007).

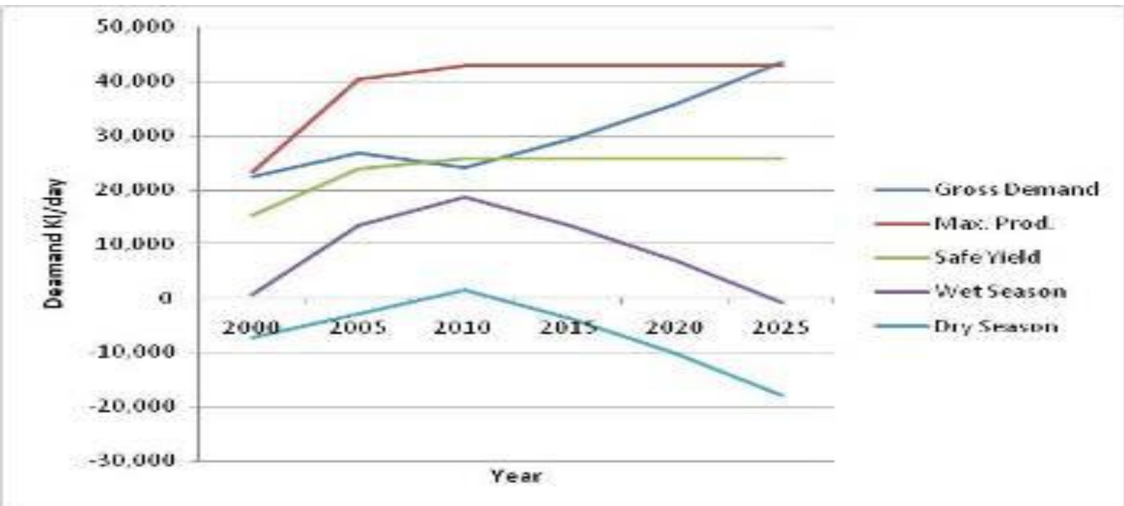

Figure ES-5: Mahé Projected Daily Water Demands, Yields & Shortfall in Supply - Revised October 2004 (PUC, 2004).

Water distribution on the three main islands is extensive, serving more than 87% of the population with treated water supply (NSB, 2007). Despite these efforts, the Seychelles will face serious water shortages in the near future (INC, 2000), primarily due to a lack of adequate resources to invest in appropriate reservoirs, and growing demand (see Figure ES-5).

Climate Change Impact and Adaptation in the Water Sector

The Climate Change Impact and Adaptation in the Water Sector study is the focus on four adaptation-oriented studies addressing: (1) integrated water resource evaluation, planning and management focusing on climate, socio-economic and technological change impacts on the water resources, (2) hydro-climate statistical prediction for better water resource planning and management (3) a study on the potential of rain water harvesting study in Victoria as a water conservation and flood control measure and (4) a national education and awareness programme on climate change in the water sector.

Achievement

One of the main achievements of this study is its fairly detailed analysis in terms of the integrated water resource evaluation planning and management focusing on the climate, socio-economic and technological change impact on the water resources using a new decision support tool. Demand and supply policy scenario strategies are simulated to provide a guide of how to mitigate or adapt to these likely expected stressors in the water sector. This approach essentially establishes the main difference with the Initial National Communication (1997-2000). Furthermore, the leading causes and mechanisms of droughts are uncovered while the multivariate statistical model is a predictive early warning tool for droughts, while the pilot rain harvesting study highlights potential water conservation strategies contributing to significant water demand reduction. Finally, the education and awareness activities have provided the benchmark for further initiatives, but have truly succeeded in mobilising both teachers and students throughout the country.

Recommendations of reducing the water sector vulnerability to climate change are proposed with the normative goal of achieving the constitutional water access right and sustainable development

Study 1: A Modeling Assessment of the Climate, Socio-Economic and Technological Change Impact on the Water Resources in the Seychelles

The Water Evaluation and Planning System (WEAP) software was used for integrated water resources planning. It provides a comprehensive, flexible and user-friendly framework for scientific and policy analysis. Operating on the basic principle of a water balance, WEAP is applicable to municipal and agricultural systems, single catchments or complex trans-boundary river systems. Moreover, WEAP can address a wide range of issues, e.g., sectoral demand analyses, water conservation, water rights and allocation priorities, groundwater and stream flow simulations, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements, vulnerability assessments, and project benefit-cost analyses.

Capacity Building of Water Evaluation, Planning and Distribution System

Seychelles lacks the required capacities to carry out such integrated water resource assessment. Therefore, the first and most critical component of the climate–water sector project of the Second National Communication (SNC) is to build the basic capacities in water evaluation, planning and management from an established international organisation. In this regard, the Stockholm Environment Institute (SEI) was contracted for conducting the basic WEAP software training in the Seychelles. SEI is the developer of the WEAP software tool. The WEAP software tool is also a free software available on the internet. The main objective of the training workshop was to develop capacities in using the WEAP 21 software. The basic WEAP training workshop was carried out for a period of four days between 12th - 15th June 2007 at the Adult Learning Distance Education Centre (ALDEC) at Mont Fleuri, Seychelles.

The training workshop was facilitated by Dr. Brian Joyce, a Senior Scientist at the Stockholm Environment Institute from the United States who trained 20 local participants. The training workshop equipped the participants with the general concepts of integrated water management and the use of the WEAP 21 software. Following the training workshop, a preliminary assessment of the climate, socio-economic and technological changes impact on the national water resources was proposed.

Specific Objectives

- To assess the climatic and socio-economic impact on the water resources on the main Island of Mahe;
- To provide policy-scenario options for better water resource management in the Seychelles;
- To make projections of the ‘’unmet’’ water demand through scenario modelling;
- To evaluate the impact of global warming climate change impact on a catchment and stream flow level.

Data and Methodology

The study area focused on the main island, Mahe, however, the results were nationally applicable. The water systems on the main island of Mahe is quite complex in terms of the number of streams, catchments, reservoirs, water treatment facilities, transmission and distribution links. For instance La Gogue catchment, located to the extreme north of Mahe, transmits water to Hermitage for treatment and for national distribution. On the other hand, Le Niol and Cascade water works carry out their own water treatment and distribution, particularly to cover north and east Mahe respectively. Overall, the water demand side is represented by the residential, tourism, fisheries and agricultural activities on the main island while the supply facilities are modeled simply as reservoirs or other supplies such as the desalination plants.

Results and Discussions

The results of the various scenarios are portrayed. It is highlighted that high population growth, climate variably, economic development are the water related stressors. Demand management here includes strategies such as technological efficient water saving devices for water conservation while supply management strategies simply are the methods by which supply of water can be increased. The following are deduced from the figures and tables.

The Reference Scenario

The reference scenario characterised by current socio-economic and technological conditions representing business as usual shows unmet water demands of 1317.8, 1429,8, 1577.7, 1738.3, 1958.7 and 2217.7 million litres for the 2006 base year and the projection years of 2010, 2015, 2020, 2025 and 2030 respectively as shown in Table ES- .

The Water Stress Scenarios

On the other hand, the 'what-if' scenarios such as a possible high population growth rate of 1.8% shows a sharp increase indicated by the steepness in the exponential curve in terms of the unmet demand. The unmet demands are 1487.3, 1717.6, 2047.8, 2549.7 and 3173.6 million litres for the years 2010, 2015, 2020, 2025 and 2030 respectively. The increase in unmet demands compared to the reference or business as usual scenario are 57.5, 139.9, 309.5, 591.0, and 955.9 million litres respectively.

The economic development sector scenario bears the largest contributing factor for increasing unmet demands. The unmet demands are 1582.9, 2001.5, 2677.2, 3549.2, and 4621.0 million litres for the respective years of 2010, 2015, 2020, 2025 and 2030 (see Table ES-). The increasing differences in unmet demands compared to the reference or business as usual scenario are 153.2, 423.8, 938.9, 1590.5 and 2403.4 million litres for the same sequential years. Therefore, the economic development sector contributes to a larger unmet demand compared to that of the high population scenario.

Table ES- 6: Unmet Water Demand under Economic Development, High Population Growth Scenarios and their Differences compared to the Reference Scenario for the Selected Years

	Year				
Scenario (million litres)	**2010**	**2015**	**2020**	**2025**	**2030**
High Population Growth	1487.29	1717.55	2047.81	2549.68	3173.55
Economic Development	1582.95	2001.51	2677.15	3549.19	4621.03
Climate Fluctuation	1808.88	1577.67	1426.49	1958.72	1770.41
Reference	1429.77	1577.67	1738.30	1958.72	2217.65
High Population Growth-Reference	57.51	139.88	309.51	590.95	955.90
Economic Development-Reference	153.18	423.83	938.853	1590.47	2403.38
Sum of Water Stressors (WS)	4879.10	5296.70	6151.50	8057.60	9565.00
Sum of Water Stressors (WS)-Ref	3449.40	3719.10	4413.20	6098.90	7347.40

If the climate fluctuation is factored in the analysis, the unmet demands are 1808.9, 1577.7, 1426.5, 1958.7 and 1770.4 million litres respectively for the years 2010, 2015, 2020, 2025 and 2030. One should note that the performances in some years are better or worse depending on the expected climate. During the relatively wet years the unmet demand is lower while it is higher in the projected dry years. For simplicity, climate fluctuation is considered as a stress because the perturbation added in this scenario is characterised by more consistent dry spells.

Integrated Water Scenario Analysis

This study is more concerned about how to adapt or mitigate some of the worst possible climate-socio-economic water related impacts rather than managing the reference or business as usual likely realities. Therefore, it is important to evaluate the difference between the proposed worse case scenarios to those of the demand and supply management measure scenarios.

Study 2: Hydro-Climate Statistical Prediction of the Extreme Dry Periods in the Seychelles

Discussion and Results

The hydro-climate dry years were 1978, 1979, 1981, 1984, 1998, 1999, 2000, 2001, 2002 and 2004. The wavelet power spectral analysis confirmed the biennial and decadal cycles of the hydro-climate time series index and was rather consistent with similar findings by Chang Seng (2007). The spatial composite analysis signals revealed that the La Nina signal in the Pacific Ocean along with alternating warming effects in the West African coast and North Atlantic Ocean were the background forces driving the dry hydro-climate years. Thermodynamic warming in the northern hemisphere coupled with high pressure anomalies over northeast India and south Indian Ocean were also linked with the low rainfall and stream flows.

One of the surprising results was the fact that during the peak of the dry season, dry and stable low level air mass swept across Seychelles from Sahara Desert. However, in the middle levels anomalous south-easterlies prevailed. The contrasting air mass characterises the trade wind inversion and wind shear effects which suppress rainfall in the south-west Indian Ocean. Upper level zonal winds at six months lead time were strongly westerly and centred over Seychelles in the South Western Indian Ocean (SWIO) while a core of easterlies remained fairly stable even at 3 months lead time in the Arabia region; in the north-western Indian Ocean. The deficit in rainfall was associated with a shift in the cyclonic vortices north-east wards. The oscillation of energy from the Indian monsoon to the south-east Asia monsoon influenced rainfall pattern in the south-west Indian Ocean. The in-season composite of surface precipitation rate, specific humidity and outgoing long wave radiation anomalies agreed with the presence of the dry hydro-climate years.

Multi-variate analysis has been used to develop the 3-month and the 6-month lead time predictive models. Two approaches have been employed namely the Multiple Linear Regression and the Principal Component Regression (PCR), which provided a useful supplement to the former due to its orthogonal property. The predictive model relates the hydro-climate (i.e. combination of extreme low rainfall and stream flows) index to the global predictors from a basket of potential predictors. Independent validation and verification procedures have revealed the usefulness of the forecast system across 12 years of data with training of 15 years using various accuracy measures. Moderate to high categorical forecast skill levels of 37-60% are achieved for the dry season forecast at both lead time, which suggested significant operational value. In general, both methods were feasible, however due to high co-linearity between predictors the stability of Multiple Linear Regression (MLR) approach is a concern. It is generally accepted in seasonal forecasting science that near normal conditions are the most difficult to forecast (Ward, 1998). Statistics have shown that algorithms could be used with high confidence in forecasting extreme events. Generally, the MLR performed better at 3 month lead time than PCR, which could be used as early indicators of likely outcomes with a higher chance of detection for the below normal category, followed closely by the above normal category.

The leading predictors of the dry season were the north-west Indian Ocean 200 hPa zonal wind, the Air Temperature at 925 hPa over Arabia and the Sea Level Pressure between India, China, and Russia. On the other hand, the six month lead time model have OLR-convection centred over central Africa, Sea Surface Temperature in the North Atlantic Ocean and the Specific Humidity at 500 hPa over central southern Africa between Botswana and Zimbabwe. Case study examples during two extreme years suggested that the El-Niño years were characterised by more frequent easterly propagating wave than during La Nina years, hence less extreme dry season was expected in El-Niño years. However, detailed analyses are required to make firm conclusions and to establish the wave dynamics.

Conclusion

The spatial composite analysis signals revealed that the La Nina signal in the Pacific Ocean with alternating warming effects in the West African coast and North Atlantic Ocean were the background forces driving the dry hydro-climate years. In addition, the combination of (1) atmospheric thermodynamic warming in the northern hemisphere, (2) inter-hemispheric anomalous high sub-tropical pressure, (3) dry and stable air mass of Sahara desert origin and, (4) the oscillation of energy between the Indian monsoon and the south-east Asia monsoon have profound impact causing the extreme low rainfall and stream flow over SWIO and the Seychelles.

Moderate to high categorical forecast skill levels of 37-60% could be achieved for the extreme dry season forecast at both lead times, which suggested significant operational value. In general, both methods were feasible, however due to some degree of co-linearity between predictors the stability of Multiple Linear Regression approach is a concern. The MLR performed better at 3 months lead time than PCR, which could be used as early indicators of likely outcomes with a higher chance of detection for the below normal category, followed closely by the above normal category.

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Study 3: A Case Study on Rain Water Harvesting Potential in Victoria, Mahe, Seychelles as an Adaptation Strategy to Climate Change

Discussions and Results

On average a small family house can capture 153,732.4 litres of rain water in the wet season and 76,873.7 litres of water in the dry season. This amounts to an average of 1708 litres per day during the rainy season and 854 litres per day during the drier season. The annual total potential rain harvested from a single average small roof size is 451,531.9 litres. The roof on an average 4-bedroom family home captures more than 100,000 litres of rainwater each year. This implies that the GIS estimation of rain harvesting seems to be overestimating the rain harvested. The main reason being that the GIS approach considers rain captured over the whole roof top which is not necessarily the case. Some roof tops cannot be employed for rain harvesting as discovered in the pilot project at Belonie School. Nevertheless the following were also found:

- The total rain harvested from all roof tops in Victoria, Mahe, Seychelles varies from 214.4 to 107.2 million litres in the wet and dry seasons respectively;
- The total rain harvested in Victoria, Mahe, Seychelles is close to 630 million litres annually;
- The deficit in Unmet Water Demand is predicted to be 6151 million litres annually by the year 2020 (Chang Seng, 2009). Rain harvesting in Victoria has the potential to reduce the total unmet demand (i.e. deficit in water demand) by 10.2% by the year 2020;
- The total small, medium, and large roof tops can contribute to 23%, 28% and 49% respectively of the rain harvested annually;
- Rain harvesting for medium to large buildings contributes to a total of 77% of the rain water captured in Victoria;
- Equation 2 characterised by the first flush and the pollution factor provides a more realistic picture of the practical processes. Comparison between Equations 1 and 2 (where Equation 2 caters for first flush and pollution factor) shows some notable differences, however, the percentage differences in rain harvested appear not to be significant;
- The estimated roof run off from the selected roof area at Belonie School is 32,766 litres of water for the period of April, May and June 2009 and is lower than its long term average, thus emphasising that the efficiency of rain water harvesting will itself be affected by the prevailing climate conditions;
- In the recent years (i.e. after the aerial survey of 1999), there has been an increase of large buildings in Victoria such as the MS Complex, the SACOS Tower, the Social Security Building, the Caravelle House, etc. This implies that with increased development there will be a greater ability to capture increased volumes of roof run off;
- On average droughts occur during the south-east monsoon especially in the JAS season. Therefore to manage such water problems, rain harvesting could be most useful some months prior to the dry season. It is denoted by the T-JAS season rain harvesting strategy where T is the lead time indicator;
- In Victoria, surface storage is the only practical solution due to limited space, and effects of sea water intrusion due to low elevation. However, bladder tanks can also be used to wrap around the building in user suited colours and taking up very limited space and acting as an above ground tank;
- The main concern regarding rain harvesting is water quality with heavy metals from roof paint, but can be it reduced if run-off is heavy and allowed to discharge initially. However, the input of heavy metals and feedback in the ocean biological systems and human system should not be underestimated;
- Based on supply-side approach, the recommended tank sizes for the small, medium and large roof tops for 20 days are 6000, 30,000 and 76,000 litres respectively. However, the tank sizes estimated are fairly big and will prove costly to buy, install and maintain. Therefore, using a more realistic approach based on demand (i.e. consumption) it is found that the tank sizes for a small, medium and large families with 4, 6 and 8 people are estimated to be 2000, 3000, and 4000 litres

respectively for a period of say 20 days. The results in these cases are realistic even for large families and for longer duration of storage;

- Water tanks' cost for small to large families may be from SR12, 000 to SR13, 500. The main cost can easily be recovered in less than 30 months;
- The Dual Top Up Approach can help in ensuring that a minimal demand load per capita per day is always present regardless if there is rain or not and this implies there is a likely reduction in the tank size and cost.

Conclusion

The study has shown that a single average roof top can capture 1708 and 854 litres per day during the wet and dry season respectively whilst the total water captured can contribute to about 214 million litres of water during the rainy season and 107 million litres in the relatively dry season of the year. The total rain water captured only in Victoria, Mahe, Seychelles is close to 630 million litres annually. This theoretically can contribute to 10% of the national water requirement by the year 2020. The GIS approach has provided useful ways at minimum cost to estimate rain harvesting; however there are important considerations to take into account such as the apparent overestimation. Therefore, it is important to consider employing a correction factor applied to all the values computed using the GIS approach. This implies considering a quarter of the value obtained (i.e 214/4 million of water during the rainy season; 107/4 during the dry season etc.).

However, such water may be used for domestic use such as washing cars, flushing toilets, general cleaning and washing due to water quality issues such as heavy metal composition. It is highlighted that medium to large buildings can catch up to 77 % of the total rain water in Victoria. This is encouraging as larger buildings are continuously being constructed on the main island of Mahe. Rain harvesting is an ideal management strategy some months prior to the dry season (i.e T-JAS rain harvesting strategy). Due to the increase in urban development and the natural geological setting, surface water storages would be most suitable for Victoria.

Full application of first flush and pollution issues into the usual rain harvesting equation provides a more realistic view of the process, however the percentage differences compared to the simpler method appear not to be significantly different (i.e < 2% difference). The pilot rain harvesting system at Belonie School captured an estimated 37,220 litres of water for the period of April, May and June 2009 and was lower than its long term average, highlighting the rain water harvesting efficiency will all suffer from prevailing climate conditions and there would be a need to consider even larger water storage tanks. Results from the supply-side approach show that the recommended tank sizes, especially for larger roof tops, are relatively too large and will prove to be a large investment. Using the demand approach, it is found that the tank sizes for small, medium and large families are estimated to be 2000, 3000, and 4000 litres respectively for a period of 20 days. In addition, the results proved to be realistic even for longer duration storage exceeding 2 months. Water tanks' cost for small to large families does not exceed SR15, 000 and can effortlessly be recovered in less than 30 months. The Dual Top Up Approach being explored in the Ministry of Environment, Natural Resources and Transport is promising and would help achieving a minimal demand load per capita per day though a likely persistent dry spell, and consistent cut off of the main water supply may prove to be of decreasing satisfaction and reliability.

Study 4: Education and Awareness on Climate Change and Adaptation in the Water Sector in the Seychelles

Results and Conclusion

The project activities have helped raise national awareness on climate change water related impacts and adaptation in the water sector through various activities which include the following: launching of the project at school level, integration of project activities in national science and technology fair, community survey, the installations of rainwater harvesting in a school and data collection and analysis, national exhibitions, water day school education campaign, awareness publication materials and capacity building. Most activities were well covered by the media for wider sensitisation of the community.

This initiative has motivated both teachers and students at many schools to educate themselves further on climate change, water and adaptation issues. It has attracted many people at exhibitions and has often been referred to in many meetings or workshops as an example of climate change adaptation. The project has also attracted private participation and contributions.

The survey carried out by students was done on a small sample of the community. Nevertheless, the results suggest that rain harvesting is not widely practised at household level but can be accepted by the people. It has great potential in Seychelles in contributing to economic benefits at the household level. It can help in water conservation during the dry season and it can be used as a mechanism to cope and adapt to the negative effects of climate change.

The project results suggest that with more awareness, sensitisation campaigns, commitment, coordination and funding the activities can be promoted more effectively at a national scale.

General input from meetings and workshops suggests that specific adaptation activities such as rain water harvesting can be incorporated in the different national environment, social and economic programmes or action plans to become rooted in the society. It is also recognised that more scientific based research is needed as well as the need to improve innovative design in the context of Seychelles. Project activity four has provided the momentum to the development of adaptive capacity and resilience associated with climate change in the water sector through education and awareness, however the initiative should not only be sustained, but widened to capture a range of other adaptation options.

Coastal Sector

'Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities (very high confidence)' (IPCC, 2007; Mimura et al., 2007).

The Mahe group, which consists of narrow coastal areas and steep mountain slopes, are highly vulnerable to floods and landslides. Short, intensive rainfall will however trigger landslides in severely deforested areas and zones cleared for construction. There are two specific cases of mass ground movements (at Vista do Mar and Quatres Bornes – both on Mahe) which were apparently caused by heavy rainfall. The coastal plateau on the granitic islands (of the Mahé region) is characterised by wetlands and marshes, which act as flood buffers. However, with increased development, modification of these water bodies and inadequate drainage the vulnerability to floods has increased in many areas. Land use planning, drainage plans and guidelines for development on both coastal and hilly slopes are lacking, and where present, poorly enforced (Decomarmond *et al.*, 2008).

The impact of climate change on coastal livelihoods as a result of sea level rise, storm and tidal surges, extreme sea-surface temperatures, and coastal flooding will have serious consequences for livelihoods on small islands, such as the Seychelles. In the Seychelles, more than 90% of the population and development are concentrated on the coastal plateau of the main granitic islands, which are themselves very narrow strips, no more than two km wide.

There is considerable evidence for historical accretion and erosion of beaches in the Seychelles, either through natural or man-made causes. Anse Kerlan, on Praslin, is a case where human interference has completely destabilised the beach to the point that one land owner is estimated to have lost over 10,000 m^2 of land in the last few years (Quatre, 2005). Extreme tide levels in the last few years have also served to destabilise the coastline. Climate change will exacerbate these problems and lead to further destabilisation of the coastline.

Coastal Flooding

Coastal flooding especially during spring tides and heavy rainfall has become common in Seychelles, however the problem is further compounded by the lack of appropriate drainage and high density developments. In May 2007, very high tides combined with heavy waves resulted in flooding up to 50m inland causing damage to roads, public infrastructure (De Comarmond, 2007). Hazard scenarios constructed by Chang-Seng and Guillande (2008) for the Mahe region, indicated that '24 Hours Probable Maximum Rainfall' (an important factor in determining severity of the hazard) exceeding 200 mm have a return period of at least 10 years. It is known that rainfall exceeding this threshold has caused significant damage in the Mahe region in the last 30 years. The 1997/1998 El Nino also caused serious flooding around the island of Mahe. Over a 24-hr period a maximum of 694.1 mm was recorded at the Pointe Larue Meteological Station on Mahe. This caused extensive damage to agriculture, and some residential areas were flooded.

Coastal Tourism

Tourism plays a role of unmatched importance in the economy of the Seychelles and any shocks that negatively impact the tourism industry are felt throughout the islands. A study undertaken in 2004 found that more than 65% of tourists choose to visit the Seychelles for the predominantly pristine nature of their coastal resources and the natural beauty in general (Cesar et al., 2004). Tourism now accounts for about 29% of foreign exchange earnings, 20% of GDP and one third of employment. Climate change will impact tourism through its effects on the resources (e.g beaches & coral reefs) and infrastructure (e.g hotels & guesthouses) that are critical to tourism services and on the climate-related amenities that tourists seek when visiting destinations such as the Seychelles (Payet, 2007). The effects of climate change on tourism in small islands are expected to be largely negative (Mimura et al., 2007). Sea-level rise, rising sea surface temperatures, increased tropical cyclones' intensity and changes in ocean chemistry from higher carbon dioxide concentrations are likely to negatively impact the health of coral reef systems; another major tourist attraction of the Seychelles and also important to the islands' fisheries and conservation of biodiversity. Increased coral mortality would also accelerate coastal erosion, as demonstrated by the effects of coral mortality over the past decade in the Seychelles (Sheppard *et al*., 2005).

Other Impacts

Forest Fires

Forest fires pose risks to human habitation, critical infrastructure and also to the unique biodiversity of the islands (GoS, 1998). Many of the islands of the Seychelles are host to a number of endemic species and with no migration corridors, forest fires present one of the highest threats to conservation. Forest fires are also the main cause of erosion and consequently land instability on Praslin. To reduce the risk of forest fires, burning permits are mandatory during certain periods of the year. Although fire contingency plans and other measures are in place, such as fire breaks, the lack of suitable early warning and fire control equipment hampers both prevention and response. It is expected that extended droughts may increase the likelihood of forest fires (Payet, 2005). The forest fires of 1998 caused an estimated USD 0.5 million in losses in terms of market value of wood but the loss of biodiversity-use values is yet to be accounted for (GoS, 2000). The cost of reforestation and fire prevention equipment has been estimated to exceed USD 1 million per year (GoS, 2000).

Forest fires are much more common on the islands of Praslin and Curieuse, than on other islands in the Seychelles. The risk of forest fires is linked to periods of little or no rainfall, type of vegetation, and involuntary or voluntary arson. The high incidence of forest fires on Praslin during the months of June to August relates to the dry season.

Constraints and Gaps, and related Financial and Technical and Capacity Needs

Different constraints and gaps and related financial technical and capacity needs were examined in the the preparation of the Second National Communication (SNC) and made proposal how to address them.

References were also made to the gaps, constraints and needs relating to human resources development to increase the local knowledge base, institutional and infrastructural capacity-building, access to and adequacy of methodologies and the promotion of information sharing and networking. It also includes the need to mobilise financial resources to conduct studies, implement adaptation and mitigation projects and strengthen the legislative and institutional framework.

The experience and lessons that Seychelles has learned in the preparation of this SNC will guide the National Climate Change Committee in the enhancement of successive National Communications. A case in point is that it became apparent during the collection of data and information for the preparation of this SNC, it was found necessary to set up a proper data and information collecting and recording procedures and frequently updated databases. As a result of this observation, it has prompted the authority to establish a clearing house mechanism and data sharing system.

The information provided on financial and technological constraints associated with the implementation of the Convention in various sections of the SNC has varying level of details.

In general, financial and technical assistance was requested to strengthen national institutional framework and coordination, enhance the capacity for policy development and planning, and improve infrastructure and equipment for data collecting and monitoring.

Others include the enhancement of analytical capacity of experts, policy-makers and decision-makers, promotion of participation of key stakeholders in climate change activities, promotion of public awareness campaigns, and incorporation of climate change in national educational systems.

In relation to the preparation of GHG inventories, this chapter expressed the need for assistance to ensure continuous collection and maintenance of activity data and improvement of the accuracy and reliability of data, especially in the land use and land-use change and forestry sector. Other needs relate to the enhancement of local technical capacity and expertise and the development of country-driven methodologies to estimate emission factors. The specific capacity needs relate to the energy, transportation, agriculture, and waste management sectors.

Financial assistance and access to appropriate technologies were identified as being crucial to the development of integrated mitigation strategies and policies. Specific needs included the promotion of renewable energies and achievement of energy efficiency, increase in sink capacities, research into sustainable agricultural practices, enhancement of national capacities for forest fire management, strengthening of national policies to manage solid and liquid wastes, and the promotion of the use of more energy efficient vehicles.

It also emphasised the need for improving its national capacities to prepare adaptation and mitigation projects for funding.

Chapter 1

NATIONAL CIRCUMSTANCES

CHAPTER 1 NATIONAL CIRCUMSTANCES

1.1 Introduction

The Seychelles Second National Communication to the Conference of the Parties of the UN Framework Convention on Climate Change consists of six chapters The activities within these chapters are a continuation and upgrade of the work done under the Initial National Communication (1997-2000) and the Enabling Activities Phase II (top-up; 2003-2005). The main components of the SNC are: a) Inventory of GHG Emissions b) assessment of potential impacts of climate change on the most vulnerable sectors, c) analysis of potential measures to abate increase of GHG emissions, d) National Action Plan to address climate change and its adverse impacts. The SNC further enhanced the national capacities and raised general knowledge on the climate change. It also contributed to putting climate change issues higher on the national agenda through strengthened cooperation and increased involvement of all relevant stakeholders in the process. In addition, it built national capacities for participation in the different mechanisms related to GHG mitigation and fulfilling other commitments to the UNFCCC.

In line with Paragraph 3 of the United Nations Framework Convention on Climate Change (UNFCCC), this chapter on the National Circumstances of Seychelles provides a description of the national development priorities, objectives and circumstances, on the basis of which it will address climate change and its adverse impacts. It also provides information on features of Seychelles geography, climate and economy which may affect Seychelles' ability to deal with mitigation and adaptation to climate change.

Thus as a Non-Annex I Party, Seychelles is providing an assessment of appropriate information concerning its National Circumstances in accordance with the principle of *common but differentiated responsibilities* enshrined in the Convention. The convention further recognises that each party is unique and therefore its climate change response strategy must be tailored to suit its particular circumstances.

1.2 Geographic Profile

The Seychelles is an island archipelago in the Western Indian Ocean located between 3 and 10 degrees south of the equator and between longitude 46 and 57 degrees east, (See Figure) and is about 1,600 kilometres east of Kenya. It has a total land mass of 455 square kilometres, and an Exclusive Economic Zone (EEZ) covering 1.374 million square kilometres. The archipelago consists of 155 islands, of which 42 are granitic and the rest are of coralline origin. The main granitic islands, also known as the inner islands, in descending order of size, are Mahé, Praslin, Silhouette and La Digue. The granitic group of islands is all within a 56-kilometre radius of the main island of Mahe. These islands are rocky, and most have a narrow coastal strip and a central range of hills rising as high as 914 metres. Mahe is the largest island being 9,142 square kilometres and is the site of Victoria, the capital. The coral islands are flat with elevated coral reefs at different stages of formation.

The main outer islands are, from north to south, Bird, Denis, the Amirantes group, Alphonse, Coetivy, and the Aldabra, Cosmoledo and Farquhar groups. Figure shows the physical location of the Seychelles archipelago, while Figure 1-2 shows the location of the granitic islands. Seychelles' vibrant but tranquil island society boasts one of the most pristine natural environment beauty on the planet with warm crystal clear waters and harbours flora and fauna so spectacular that almost 50% of land area has been set aside as natural reserves.

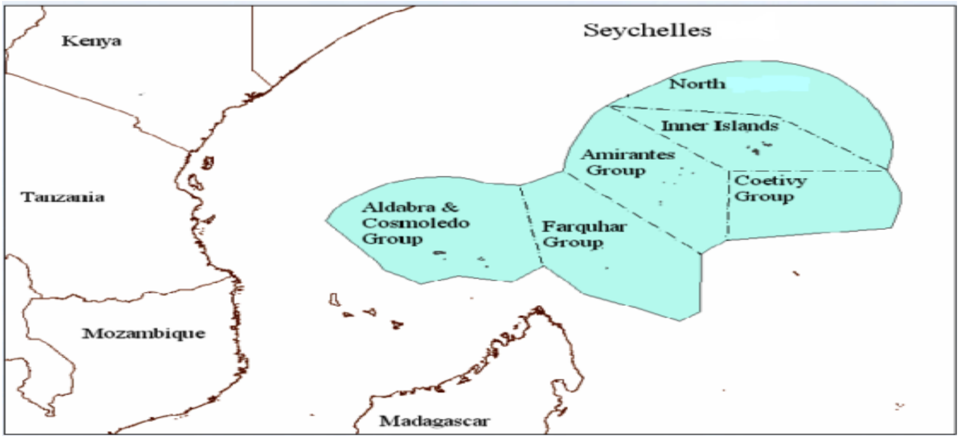


Figure 1-1: Physical Location of the Seychelles Archipelago (Source: SFA, 2007).

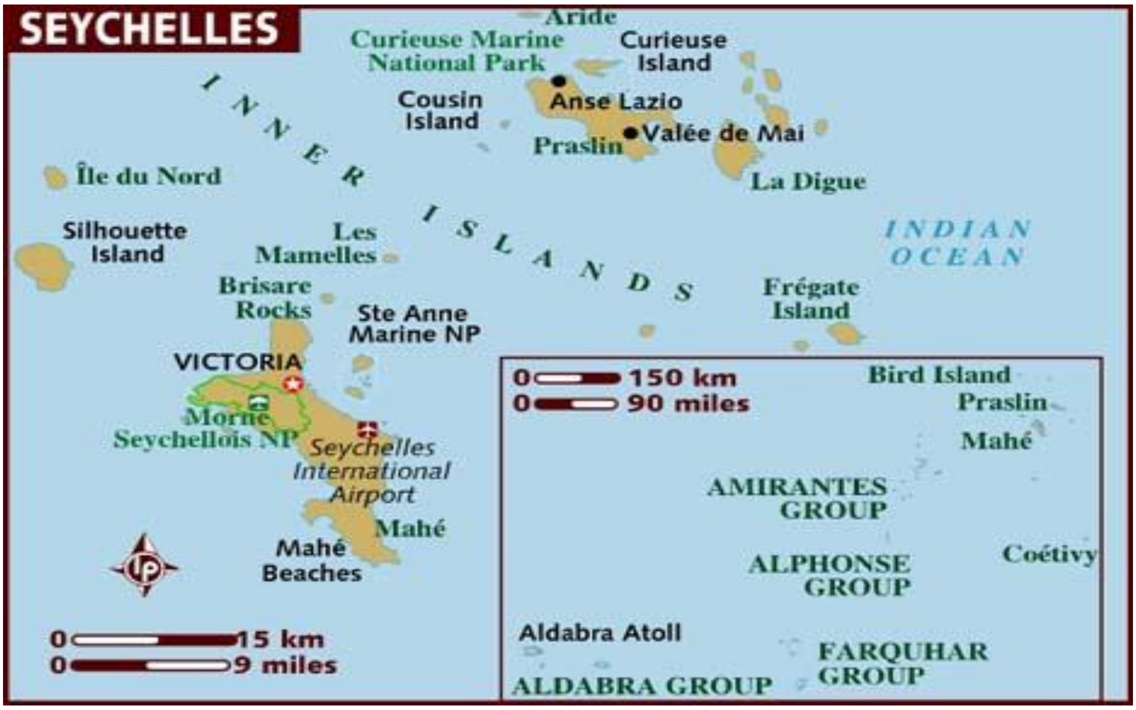


Figure 1-2: The Seychelles Archipelago showing the Granitic Inner Islands

1.3 Climate Profile

1.3.1 General

The climate of the Seychelles archipelago is strongly influenced by the ocean, especially through changes in monsoonal winds, ocean currents and sea surface temperature patterns, hence a tropical maritime climate. In Seychelles two distinct seasonal patterns associated with the wind regime dominate; the south-east monsoon which blows from May to September associated with the dry season and the north-west monsoon from November to March associated with the wet season and also the Tropical Cyclone Season over the Southwest Indian Ocean. Synoptically, the main systems which govern weather over these parts of the world are primarily the Inter-Tropical Convergence Zone. Hence, complex and highly interactive processes control the Seychelles climate system. The interactions among these various processes are indeed difficult to predict, not least because they may occur on widely differing temporal scales, but also because of the relatively microscopic size but extensive spatial distribution of the islands in the Seychelles archipelago.

Detailed observational data in Seychelles are available since the opening of the International Airport in July 1971, but rainfall data are available for more than 100 years. Paleo-climatological evidence from sea-bed cores of the last 20,000 years indicates that there may have been drastic climatic variations within the Seychelles region, mainly associated with changes in rainfall (Perlmutter et al., 1996).

1.3.2 Winds – South-East and North-West Monsoons

During the greater part of the year, trade winds blow from the south-east; they are steadier from May to September. The south-east trade winds keep the Seychelles cool during these months. Maximum winds between 100 to 120 km/hr are quite common during the south-east monsoon creating moderate to severe turbulence for aircrafts on landing. Localised convective clouds formation passes by harmlessly bringing only light to moderate rain and serving to clear the air after a spell of warm, dry weather. But the sea is normally moderate to rough.

In November to April, the winds are lighter and are from the north-west, periodically interrupted by convective activities associated with the season's *Rain Belt* known as the Inter Tropical Convergence Zone (ITCZ). The *Rain Belt* could be vigorous at times associated with the tail-end of a tropical cyclone thus generating heavy downpours and rough sea conditions along the coast albeit temporarily. Generally the sea is calm around this time of the year.

1.3.3 Rainfall

The topography of the Seychelles strongly influences rainfall patterns. The rainfall varies according to the height above sea level, and ranges from 76.2 mm in July to 404.8 mm in January. The mean annual rainfall total for Mahe is 2369.4 mm over the coastal areas but it is expected to exceed that amount over most of the hilly interiors. Rainfall also tends to be higher on the west facing slopes and ridges of La Misere, since most rainfall occurs during the Northwest monsoon. The heavy downpour normally occurs mainly from late December to the beginning of January.

Analysis of rainfall for January, the month of maximum rainfall, indicates marked variability (having the influence of global oscillations such as the ENSO) throughout the 36 years. It reveals three remarkable peaks in 1974, 1991 and 2005 respectively (see Figure 1-3) with 10 years of rainfall above the 400 mm average for that month. In contrast, July the month of lowest rainfall (see Figure 1-4) depicts a decreasing trend having 17 years of rainfall equal and below 50 mm. The analysis does clearly indicate that the ENSO phenomenon is just one of several factors influencing climate variability in the Seychelles.

Figure 6 shows the 36-Year Long Term Mean of monthly rainfall (R/F(mm) distribution over Mahe which clearly depicts the months of maximum and minimum rainfall respectively.

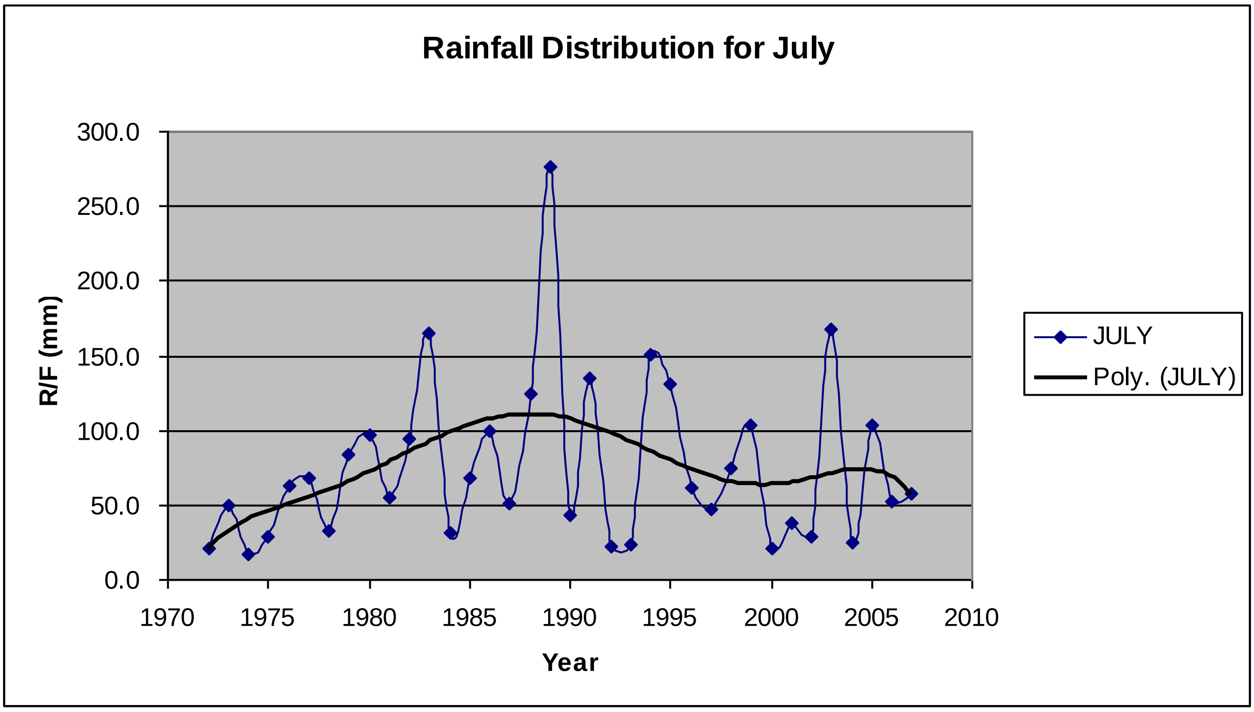


Figure 1-3: Annual Rainfall (R/F(mm) Distribution for January over Mahe (Source: NMS, 2008)

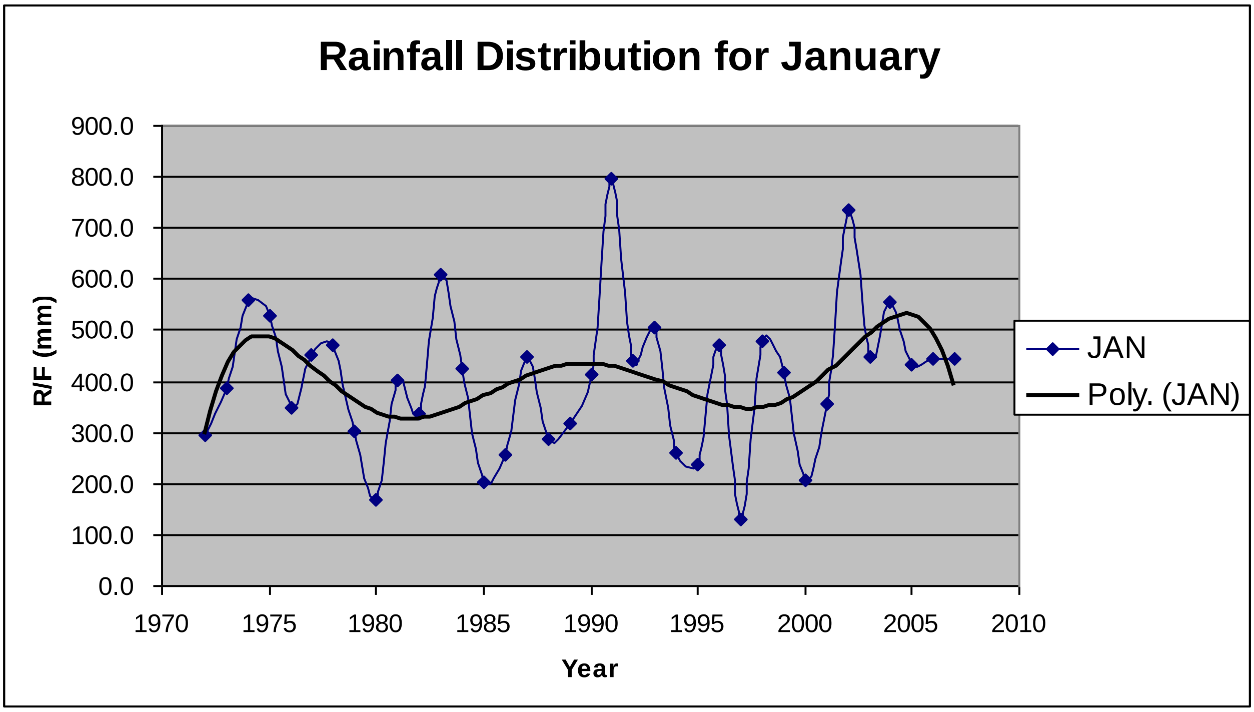


Figure 1-4: Annual Rainfall Distribution for July over Mahe (Source: NMS, 2008)

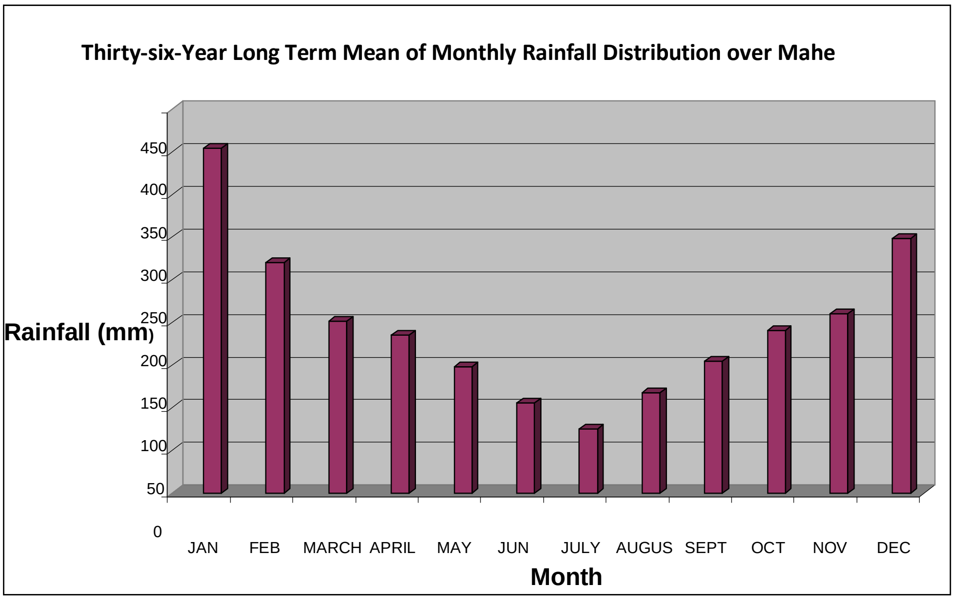


Figure 6: Thirty-six-Year Long Term Mean of Monthly Rainfall Distribution over Mahe (Source: NMS, 2008).

1.3.4 El Nino Southern Oscillation (ENSO) Events

The effects of the El Nino Southern Oscillation (ENSO) were also observed, in particular in 1997-1998 when it caused significant damage to the Seychelles economy (Payet, 2005) and mass coral bleaching in Seychelles. It is not yet clear whether climate change will increase the occurrence of ENSO conditions in the long-term.

However, analysis of ENSO records for the period 1880 till the 1950s indicated a periodicity of 2 to 4 years. But the periodicity of the ENSO had varied since the 1950s. In particular there had been a rather distinct change from 1976 to 1977, with more frequent El Nino episodes, with only rare incursions of La Nina. It has been shown that for the majority of the El Nino cases, an extreme weather event occurred over the Seychelles. However, there have been other extreme weather events, apart from these El Nino episodes.

Figure 7 reveals that there are about 20 years in which Seychelles has experienced below normal annual rainfall and only 16 years above normal, and most of the above rainfall occurred after 1990. It is worth to note that within the 1990s Seychelles experienced a series of ENSO events but the most remarkable one was the El Nino of 1997-1998 and the La Nina event of 1998-2001 which followed thereafter.

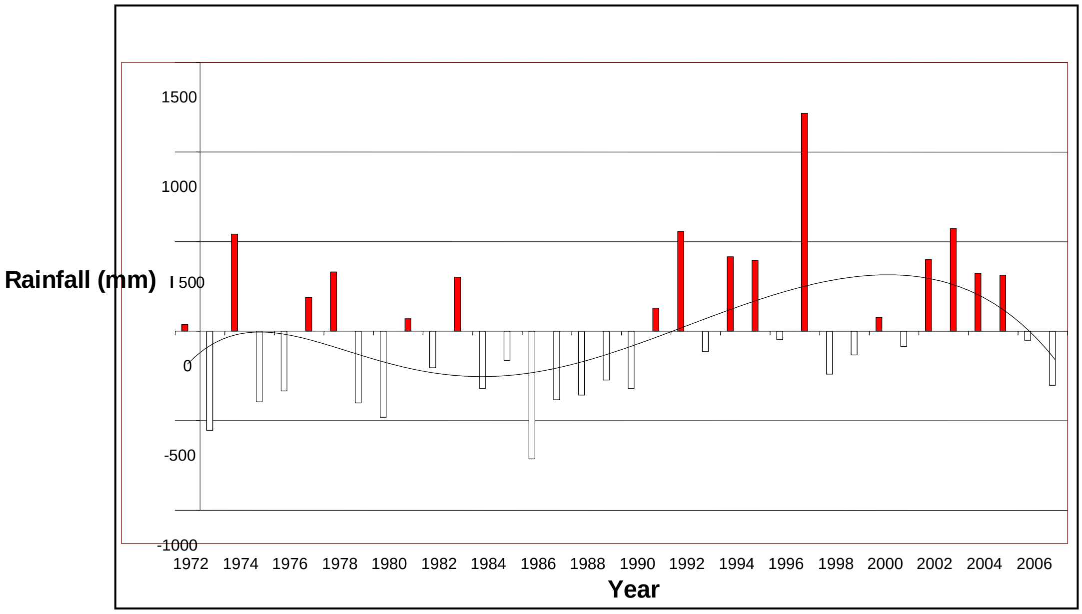


Figure 7: Annual Precipitation Anomaly for the Seychelles International Airport (Source: NMS, 2008). FIGURE TO CHANGE

1.3.5 Temperature

The temperature varies between 25°C and 26°C in July and August, and between 27°C and 28°C in March and April. Near sea-level, the maximum temperature is about 4°C higher than at higher altitude, reaching an average of 31°C at mid-day in April.

The warmer, wet season during north-west monsoon months of November to March produces prolonged sunshine with extreme maximum temperatures of up to 34°C on the coasts, and which may be broken by short heavy bursts of rainfall. From May to September, cooler and dry conditions are accompanied by extreme minimum temperatures of up to 19°C, with cooler nights and lower humidity particularly at high altitude. There is an average of seven hours of sunshine each day throughout the year. The average maximum temperature is 29.9^{0}C; average minimum of 24.6^{0}C with average humidity at 80% (see Table 1-1).

Table 1-1: Thirty-six-Year Monthly Climatic Means and Extremes (Source: NMS, 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MEAN
MAX (°C)	29.9	30.5	31.1	31.4	30.6	29.1	28.4	28.5	29.1	29.8	30.2	30.2	29.9
MIN (°C)	24.3	24.8	25	25.2	25.5	24.7	24.1	24	24.4	24.5	24.2	24.2	24.6
Highest MAX (°C)	33.2	33.4	33.5	34.1	33.5	32.6	31.1	31.4	31.3	32.4	34.4	34.4	
Year	2003	2007	1998	2003	2005	1982	1983	1992	1980	1998	1974	2003	
Lowest MIN (°C)	21.4	21.1	22.1	22.3	21.6	20.9	20.4	19.6	20.2	20.5	21.5	20	
Year	1973	1976	1979	1982	1984	1991	1984	1977	1974	1978	1995	1973	
Rainfall (mm)	404.8	270.2	199.1	185.7	148.5	105.7	76.2	117.9	161.6	191.1	209.9	298.6	2369.4
Highest Rainfall	798.2	611	465.8	463.2	558.9	528.6	276.9	694.1	456.8	564.7	441.2	606.9	
Year	1991	2001	2000	1992	1996	1992	1989	1997	2002	1974	1981	2005	
Lowest Rainfall	132	9.1	55	61.8	6.7	15.7	17.6	15	13	8.8	38.5	57.9	
Year	1997	1982	1984	1986	1974	1985	1974	1990	1986	2001	1976	1987	
Humidity (%)	83	80	80	80	79	79	80	80	79	79	80	82	80

1.4 Population Profile

There is some evidence that Seychelles islands were known and visited as long ago as the 8th and 9th centuries. In the 15th and 16th centuries, they were spasmodically inhabited by pirates but it was not until the middle of the 18th century that the first twenty-eight settlers were brought in to live on the island of St. Anne where they established themselves in 1770. The population originated primarily from French settlers, African plantation workers, British sailors, and traders from India, China and the Middle East. The population has subsequently grown and when the last census was conducted in 2002, there were 81,200 inhabitants. In 2007, the population of Seychelles stood at 85,000 (NSB, 2008) (see Table 1-2) and projected to reach 100,000 by 2020 (NSB, 2008). With a literacy rate of 97% and a high average life expectancy of 72 years, the Seychelles enjoys a high quality of life despite the challenges of being a small island developing state. Further to the census carried out in August 2010, the **population** of **Seychelles** is now 88,311 people, figures released by National Bureau of Statistics (NBS) on 6TH December 2010. The number is made up of 45,315 or 51.3% males and 42,996 or 48.7% females. About 22% of the population are below 15 years and 77.7% are 15 years or above. The labour force stands at 50,923 (57.7%) of whom 94.2% are in employment while 5.8% are unemployed.

Table 1-2: Main Characteristics of the Population of Seychelles as at 31st December 2007

Population	(Year)2003	2004	2005	2006	2007
Total Resident Population ('000)[1]	82.8	82.5	82.9	84.6	85.0

[1] Based on 2002 census data.

Male	40.9	40.7	41.2	41.9	39.5
Female	41.9	41.8	41.6	41.7	42.4
Geographical Distribution ('000)					
Mahe	72.4	72.1	72.4	73.9	74.2
Praslin	7.2	7.2	7.2	7.4	7.5
La Digue and Outer Islands	3.2	3.2	3.2	3.3	3.3
Age Composition (%)					
Under 15 years	26.8	25.3	23.2	21.6	25.4
15-44	46.5	45.3	44.9	45.0	46.0
45—64	17.9	20.1	22.0	23.1	22.5
65 years and over	8.8	9.3	9.9	10.3	6.1
Projected Population ('000)	**2008**	**2012**	**2016**	**2019**	
Male	43.7	47.6	49.3	50.1	
Female	44.5	48.9	50.9	51.9	
Total	**88.2**	**96.5**	**100.2**	**102.0**	
Life Expectancy at Birth (years)					
Both Sexes	70.9	72.6	71.9	72.2	73.1
Male	66.2	69.0	67.4	68.9	68.9
Female	76.1	76.4	77.1	75.7	77.7
Infant mortality Rate	16.0	11.8	9.8	9.5	10.7
Crude birth rate Per 1,000 population	18.1	17.4	18.5	17.3	17.6
Crude death rate	8.1	7.2	8.1	7.8	7.4

Source: MISD (2007) Population and Vital Statistics No. 2 of 2007

The bulk of the population, the economic activities and the other forms of development are concentrated mostly on the narrow coastal strips of the three main granitic islands of Mahe, Praslin and La Digue. Mahe, in particular, has about 87% of the total population, with some 40% located on the east coast in a belt of 7 km by 1 km to the south of the capital, Victoria. The population is projected to reach 100,000 by the year 2016.

To date, almost all of the coastal plains are heavily built or developed, and reclamation of mangrove areas for additional land is a practice, albeit not as common as before. Due to increased pressure for land for development, and in line with its policy for forest conservation, Seychelles has embarked on a series of land reclamation projects on the east coast of Mahe Island. These coastal reclamation projects already accommodate large amounts of residential areas, industrial areas and other facilities such as the central power station and other critical services.

The population density in Seychelles is 163 persons per square kilometre. On Mahé the density is very high, estimated to be about 434 persons per square kilometre. The most densely populated are those districts located on the outskirts of Victoria, with a density of about 3000 persons per square kilometre, as compared to about 100 in the more rural areas of the island. The urbanisation rate is estimated at 2.2 % per year. It was identified that there are three main forces that have driven internal migration over the last two decades: employment, education and housing. Consideration of international migration statistics shows an increase in migrants to the Seychelles.

1.5 Government Profile

The country is a democratic state with a straightforward administrative structure. The Constitution (1992) is the supreme law of Seychelles. It establishes clearly the separation of powers between the three arms of government: the Executive, the Legislature and the Judiciary. The Seychellois Charter of Fundamental Human Rights and Freedoms within the constitution guarantees to the citizen twenty five clearly defined rights which includes when it comes to environment, the right to a *clean, healthy and ecologically balanced environment*. The President of Seychelles is the Head of State, Head of Government and Commander-in-Chief of the Defense Forces of the Seychelles.

The general decision making process that operates for the establishment of national policies and legislation within the country is detailed as follows. In relation to policies, the relevant institution, in the case of environmental policy, legislation and climate change issues is the Ministry of Environment, Natural Resources and Transport (MENRT). Within MENRT is the Climate and Environmental Services Division (CESD), which has as its primary function to formulate plan for the development and coordination of all Climate Change issues in the country, relating to Adaptation and Mitigation Policies and related sector strategies and plans.

The Cabinet of Ministers, comprising not less than seven and not more than fourteen, is appointed by the President subject to the approval of a majority of the members of the National Assembly. For the environment sector, the development of policies and management of resources is given over to one ministry; the Ministry for Environment, Natural Resources and Transport.

The legislative power of Seychelles is vested in the National Assembly and is exercised subject to and in accordance with the Constitution. Presently, the National Assembly is made up of 25 directly elected members and up to 10 members elected by a scheme of proportional representation, based on the results of a general election held at least every five years. The elected legislature enacts legislation through the passing of Bills, which is made into law once given presidential assent. Judicial powers of Seychelles are vested in a Judiciary corpus comprising of the Court of Appeal, the Supreme Court and other subordinate courts or tribunals established under the Constitution. The concept of the separation of powers, as defined by the Constitution, guarantees the independence of the Judiciary. The Supreme Court has original jurisdiction in matters relating to the application, contravention, enforcement or interpretation of the Constitution as well as civil and criminal matters. The Supreme Court exercises supervisory jurisdiction over subordinate courts, tribunals and adjudicating authorities.

1.6 Economic Profile

Since Independence in 1976, Seychelles has developed from an agrarian-based economy into one based upon tourism and fisheries. In Africa, it has the second highest GDP per capita and is one of the six upper-middle-income countries. It ranked 50th in 2007, the highest in Africa, on the United Nations Development Programme (UNDP), Human Development Index, partly due to its stable political democratic system and high investments in education, health, housing and the environment. Overseas development assistance decreased significantly when Seychelles achieved middle-income status.

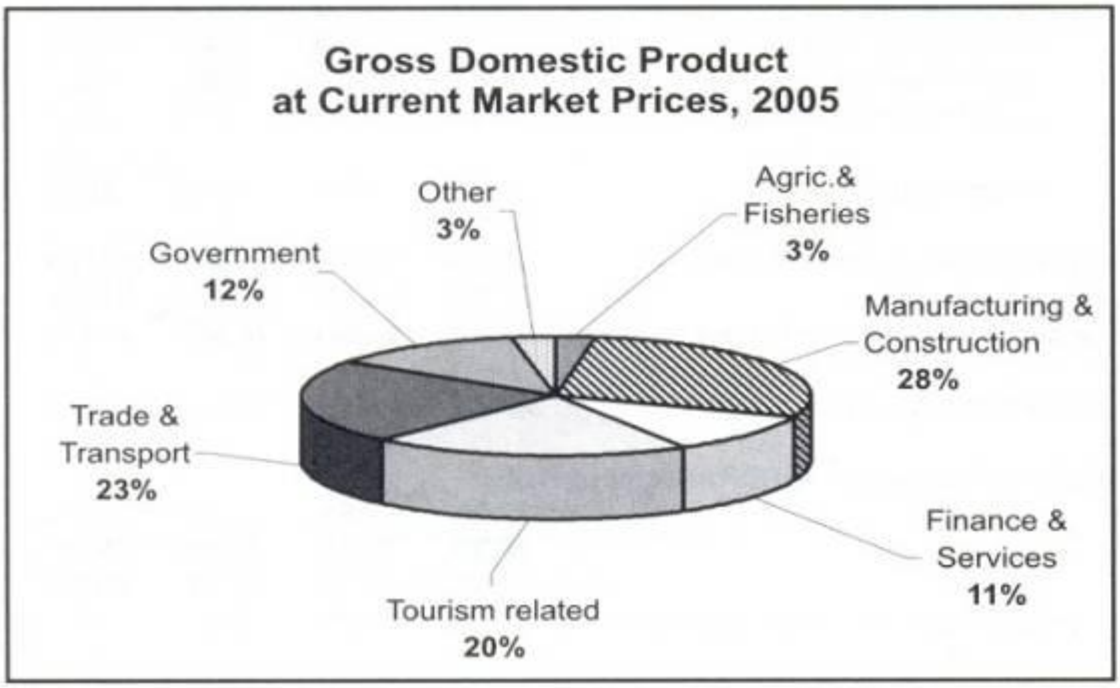


Figure 8: Gross Domestic Product (GDP) for 2005

However, since the early nineties, Seychelles, development strategy slowed down primarily due to external shocks and also to internal macro-economic imbalances, a relatively centralised economy and other longstanding structural issues. In response, Seychelles adopted a Macro-Economic Reform Programme in 2003 which resulted in the further liberalisation of the economy and reduction in debt.

However, these measures proved insufficient to address the macro-economic imbalances and the economic vulnerability of the country remained high. Persistent foreign exchange shortages resulted in shortages in basic items and inflation as well as external public debt, which in 2008 represented 98% of GDP (USD 808 million) of which USD 313 million were in arrears. Figure 8 shows the GDP for different sectors.

In 2007/2008 the global oil and food price shock seriously exhausted Seychelles' official external reserves causing the country to default on a private debt in mid-2008. In October 2008, government implemented an IMF-backed reform programme to completely liberalise the foreign exchange market and restore economic sustainability. Despite a rapid depreciation of the currency and a significant increase in inflation, peaking at 63.6%, the currency had stabilised by mid-2009 and in August 2009, inflation had reduced to 39.8%. According to the IMF (2008), the Seychelles real GDP will shrink by 0.5% in 2009 primarily due to a slowdown in the global economy. Although these measures indicate a stabilisation of the economy, the vulnerability of the Seychelles to global shocks cannot be underestimated as shown. In view of heavy foreign direct investment in the tourism sector, Seychelles has a very low rate of unemployment. Unemployment rate is estimated at around 5.4%.

1.7 Tourism

Tourism plays a role of unmatched importance in the economy of the Seychelles and any shocks that negatively impact the tourism industry are felt throughout the islands. A study undertaken in 2004 found that more than 65% of tourists choose to visit the Seychelles for the predominantly pristine nature of their coastal resources and the natural beauty in general (Cesar et al., 2004). Tourism now accounts for about 29% of foreign exchange earnings, 20% of GDP and one third of employment. Tourism impacts on all Seychelles citizens, irrespective of whether they earn a living directly from it or not.

Seychelles' tourism industry is being commended for its *concerted effort* that has secured the sector as one of the three pillars of the country's economy. The actions being engaged in the sector forms part of the goals set by the Seychelles' Strategy 2017, which was launched in 2006. Tourism is a major stakeholder in Seychelles' efforts to double the country's GDP per capita by 2017 and increase its contribution to GDP by 1.5% a year over the period of the plan. Signs of encouragement are being shown as it continues to attract interest from both local and foreign investors in Seychelles' tourism industry, thus highlighting the potential of this industry as the engine for economic growth.

For the second consecutive year, the tourism industry posted an unprecedented growth in visitor arrivals. At 161,273 visitors, (seeTable 1-3) the total number for 2007 represented a 15% annual increase compared to 9.3% recorded in the preceding year. Consistent with the higher arrivals and a depreciated rupee, tourism earnings rose to R1.9 billion in 2007, a 52% growth relative to the earnings in 2006. The ripple effects of a surging tourism industry were strongly felt in other peripheral and downstream sectors of the economy as well as in national employment. In 2007, employment in the industry increased by 8.6% and remained in a major way, short-staffed with numerous vacancies unfilled. Tourism related activities (see Figure 9 and Table 1-3), which represent some 21% of the GDP, have thus contributed greatly to the increase in economic activity during 2007. For yet another year, European visitors stayed atop of the market, making up 79% of total arrivals growing by 12% over 2006.

Table 1-3: Tourism Statistics

Year	2003	2004	2005	2006	2007
Visitors Arrivals	122,038	120,765	128,653	140,627	161,273
Average Length of Stay (Nights)	10.15	10.04	9.69	9.82	10.20
Tourism Foreign Exchange Earnings (SR Million)	918	938	1,051	1,251	1,901
Average Expenditure Per Diem – SR	741.1	773.5	842.9	906.2	1,155.8
Hotel Bed Occupancy Rate (%)	44	46	49	57	60

Sources:National Statistics Bureau (expected tourism foreign exchange earnings which are from Central Bank data)

Figure 9: Tourists enjoying the Beau-Vallon Beach (Source: The People).

1.8 Fisheries

The fisheries sector is the second pillar of the Seychelles' economy after tourism. It is significantly vital for both guarantying food security and economic development. Although industrial fisheries constitute a major source of foreign exchange earnings for the Government, it is the artisanal fisheries that remain of great importance in terms of assuring food security to communities, generating local employment and cultural identity. This sector employs nearly 1800 people mainly within hand line fisheries (see Figure 10). The state of demersal resources, in particular, in inshore waters for the various types of artisanal fisheries, is considered to have nearly reached optimum level of sustainable exploitation. The total landings for the artisanal fishery have remained fairly constant for the last 20 years with approximately 4000 tonnes of fish landed annually. This catch supplies the local market demand, including hotels and restaurants.

Mixed results were observed in the fisheries sector during the year 2007, relative to the preceding year. This was reflected in both production indicators and revenue flows. In the artisanal domain, the level of catch increased by 4.0% to reach 4,211 tonnes in 2007 (seeTable 1-4).

Table 1-4: Estimates of Fish Landed (tonnes)

Type	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Artisanal method (tonnes)	3,334	4,842	4,764	4,290	4,914	3,852	4,374	4,583	4,050	4,211
Semi-industrial (longline) (tonnes)	308	457	290	238	190	76	111	251	260	270
Industrial method										
- caught	252,595	331,424	330,340		296,141	378,027	408,366	389,256	389,936	214,464
- Transhipped (tonnes)	151,592	257,447	269,673	255,551	335,549	359,379	300,937	338,271	371,087	212,000

Source: Seychelles Fishing Authority

Nonetheless, this remained below the 4,583 tonnes landed in 2005. As such, the price of fish during the year remained at a high level, with the fish component of the CPI showing a year on year rise of 16%. The improved catch levels permitted an increase in the production of certain fish products. In particular, smoked fish production reached a record level of 29,413 kg, representing a 17% growth compared to 2006. As regards to industrial tuna fishing activity, this experienced a lower performance in 2007 due to warm seawater conditions, often forcing the tuna biomass to cooler depths beyond the operational threshold of the fishing nets. Notwithstanding the considerable decrease in tuna catches, the Indian Ocean Tuna (IOT) canning factory did not report much of a decline in export revenue in foreign exchange terms. At USD 184 million, exports were a mere 1.9% lower than in 2006, an outcome associated with positive currency developments as well as value-additions from improved by-product management mainly in the production of fish meal. While the volume of fresh and frozen fish (excluding canned tuna), including dried sea-cucumber and shark fins declined by some 13% to 370 tonnes, an increase of approximately 12% in value was recorded, taking total revenue to SR18 million.

The authorities, through agencies such as the Seychelles Fishing Authority (SFA), initiated discussions and engaged in various fora to discuss the sustainable use of the country’s fisheries resources in the light of scientific evidence of possible overexploitation of certain marine species. This was set against a backdrop of increasing global awareness of the danger of exploitation of fisheries resources beyond sustainable levels.

Of particular interest to Seychelles is the restoration and management of certain depleted stocks, notably groupers as well as snappers and other reef fishes. The same year saw the implementation of National Plans of Actions (NPOA) covering shark fisheries and Illegal, Unregulated and Unreported (IUU) fishing in the country's Exclusive Economic Zone (EEZ). As part of Strategy 2017, the fisheries sector is to further implement an operational management plan for each of the country's major fisheries. First steps were taken in 2008 with a demersal line fishing action plan as well as a Sea Cucumber Management Plan. Also provided for in the Strategy 2017's framework is the improvement and diversification of port services to provide better infrastructural and logistical support to both artisanal and industrial fisheries with a new modern fishing port.

Whilst the prevailing situation of insecurity in international waters off Somalia is of grave concern to the international community, it is of graver concern to Seychelles, the Exclusive Economic Zone of which borders this maritime zone of hazard. In the middle of September 2008, some forty European fishing vessels laid idle in Port Victoria as a result of an act of piracy on one of their tuna vessels by the Somalian pirates. Such acts could seriously impact on the lifeline of the second pillar of the Seychelles' economy at a time when Seychelles is engaging itself in a process of economic reforms.

Figure 10: Local Fishing Boats at Victoria Fishing Port (Source: The People).

Figure 11: The Indian Ocean Tuna (IOT) Company is confident Tuna Catches will recover soon after falling for the Past Two Years (Source: Seychelles Nation).

1.8.1 IOT Cannery Direct Contribution to the Economy

Besides giving employment to workers, who fluctuate between 2,000 and 2,600, IOT also provides a significant level of indirect employment for up to 1,000 other people through related port and other activities. The IOT direct contribution to the local economy in 2007 was Euros €42 million and which represented 18% of Seychelles' GNP. The factory's current daily output volume is 300 tonnes with the capacity to go to 400 tonnes of tuna, and IOT's current daily output volume is 1.2 million cans (see Figure 12).

Figure 12: The Indian Ocean Tuna (IOT) Cannery contributed Euros €42 million to the Seychelles' Economy in 2007 (Source: Seychelles Nation)

During 2006 and 2007, IOT has been processing about 70,000 tonnes of fish a year but added that this is lower (Figure 11 and Figure 12) than the average of 85,000 tonnes for the last five years because of the terrible 40% drop in catches in the Indian Ocean due to El Niño and similar phenomena. The El Nino effect during the peak fish season of September-December 2007 resulted in abnormally warm temperatures which forced planktons to move deeper into the sea, and with them the fish that fed on the planktons, hence pushing the whole chain deeper – from about 250 m where purse seiners could reach the fish to 400 m, which was too deep for purse seiners. This resulted in a shortage of supply which forced the plant to reduce production. The IOT represents around 95% of Seychelles' exports and 46% of its imports with 3,200 outbound and 2,200 inbound containers respectively.

1.9 Petroleum and Tanker - Fourth Pillar of Seychelles Economy

The Seychelles Petroleum Company (SEPEC), one of Seychelles' most successful parastatals, is responsible for the import and redistribution of petroleum products in the country. Its re-export business and the returns from the tanker operations are helping Seychelles to cushion the costs of fuel and electricity in Seychelles, despite record prices on the world market in 2008. The *Seychelles Pride* (built in June 2002), the *Seychelles Pioneer* (built in April 2005) and the *Seychelles Progress* (built in August 2005 are all registered in Port Victoria and fly the Seychelles' flag (see Figure 13). The *Seychelles Pioneer* and the *Seychelles Progress* were, for easier access to loans and cheaper servicing of the borrowings, initially registered in the Isle of Man. The Financial Supervision Commission in the Isle of Man also allowed for the parallel registration of the ships in Port Victoria and the flying of the Seychelles' flag.

Figure 13: Two modern tankers: The Seychelles Pioneer and the Seychelles Progress in Lindenau Shipyard Kiel, Germany (Source: Seychelles Nation).

The modern double-hull tankers SEPEC has built for Seychelles' future economic development are being publicised worldwide as environment friendly and commercially viable ships. The *Seychelles Pioneer* is SEPEC's second tanker which was delivered early in 2005. The 185-metre MT *Seychelles Pioneer* which is described as ultra-modern *is exceptionally ecological*. Apart from its double hull, the ship's other environment friendly facilities include waste water treatment and fire control system. Lindenau charged

USD 46.684 million and USD 47.031 million respectively for the construction in 2007 of the 45,000 dwt *Seychelles Prelude* and the *Seychelles Patriot*. The investments in these tankers will be of long-term benefits to the country.

The success of the tanker operation, coupled with the company's fuel re-exports operations, has put SEPEC on track for a near USD 20million profit per year and has become the fourth pillar of the economy.

1.10 Energy Profile

The issue of energy is one that is critical for Seychelles, and for its future. The amount of petroleum products Seychelles is consuming now is not sustainable in the long term. This has prompted the Government to draft an energy policy that will look at radical solutions. Hence a special energy commission was set up to lead this exercise by looking for innovative ways to conserve energy. Using energy more efficiently makes a great deal of sense to many industries and to the country in general, both economically and environmentally.

The Seychelles depends heavily on the import of refined petroleum products to meet the domestic energy needs as well as for international bunker fuels, which can account to around 75 % of the total amount of the import of fuels. In 2005, the domestic consumption of fuels was 91,986 tonnes, which amounted to USD 38.5 million and also around 6 % of the GDP. This represented an increase of nearly 10 % over the 2001 domestic consumption. The contribution of alternative/renewable energy sources is quite low. The most common renewable energy source used is solar panel for solar water heating for bathing. Some biomass (wood) is used to produce heat for drying of food products.

1.11 Energy Demand

Seychelles depends upon imported petroleum products for its energy needs. Use of renewable energy forms is virtually non-existent, except for solar water heaters. Seychelles consumed 83,164 TOE (Tonne of Oil Equivalent) of fuel in 2000 (Coopoosamy & Jean-Louis, 2008), an increase of up to 37% above the 1995 consumption levels. In 2007, Seychelles primary energy consumption reached 115,000 TOE (see Figure 14). This rapid growth is attributed to recent economic expansion, in particular, in the tourism sector in the last 5 years (see Figure 15).

The transport sector consumed 42% of energy in 2005 (see Figure 15) and the fuel imports was 22% of the GDP in the same year, and the Seychelles energy import bill rose from USD 6 million in 1998 to approximately USD 84 million in 2008. However, Seychelles only consumes one-third of what is imported; the remainder is exported as international bunker. Coupled with increased consumption and the price of fuel, Seychelles suffered economically over the period of the July 2008 oil price peak.

Seychelles is an archipelago and depends upon air and sea transport to connect it to the rest of the world. Since the tourism and fisheries industries are heavily dependent upon those forms of transportation, historical changes in airlines and shipping have affected the economy of Seychelles. Notable examples include the gulf war which affected airline travel to the Seychelles, and the recent attacks of piracy in the northern Indian Ocean which caused increase in shipping costs and insurance.

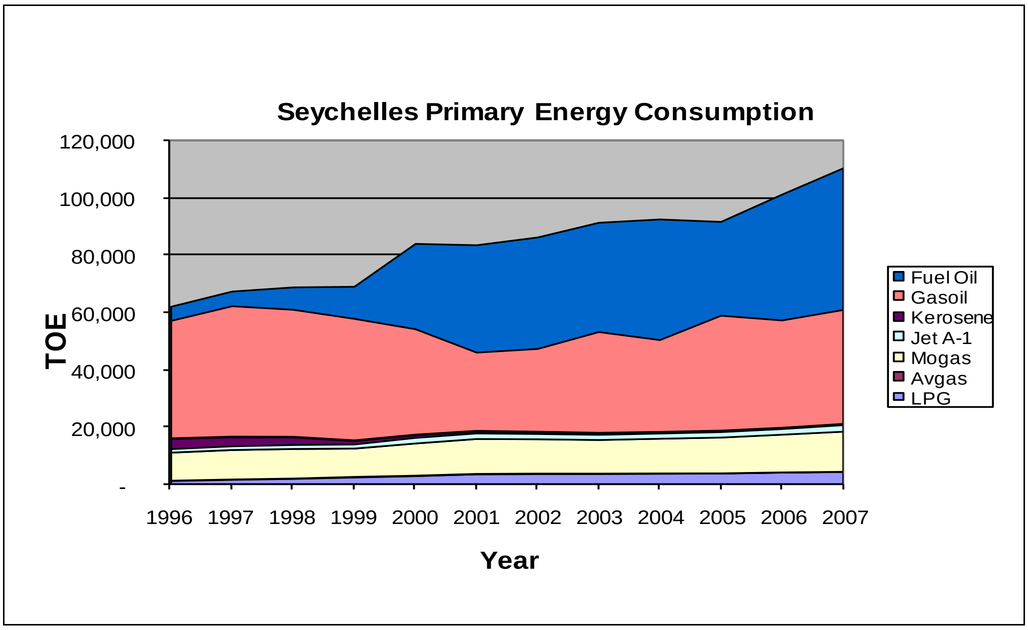


Figure 14: Trends in Primary Energy Consumption (GoS, 2008).

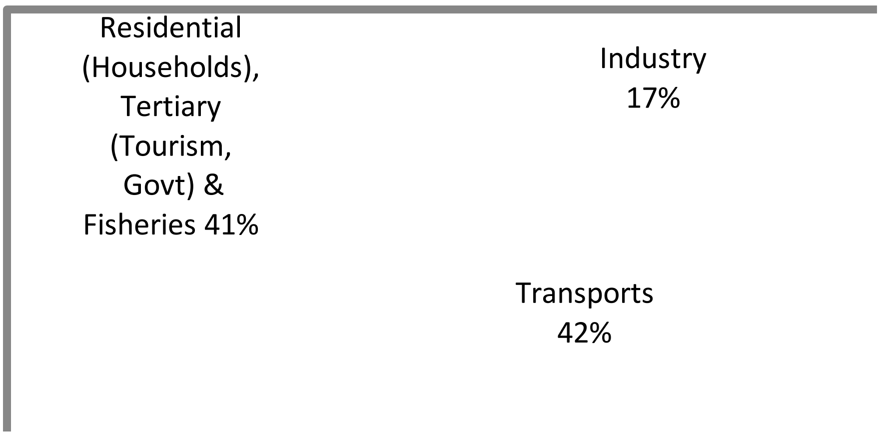


Figure 15: Consumption of Energy by Sector 2005

Virtually no mitigation projects have been implemented in Seychelles since it ratified the UNFCCC. In January 2009, an MOU was signed between Seychelles and MASDAR (a renewable zero-carbon initiative by the United Arab Emirates; www.masdar.ae) for the establishment of an 18 MW wind energy farm on Mahe, the most densely inhabited island. Detailed feasibility studies for the wind turbines are ongoing and other options such as solar photovoltaic farms are being explored.

1.12 Transport Sector

The vehicle population has increased steadily since the early seventies and in 2007, there were 14,097 vehicles and this is expected to increase to reach around 36,640 vehicles in 2030. Gasoil and gasoline are the main types of fuels that are consumed. In 2007, 21,324 tonnes of fuel were consumed and this is expected to reach 53,620 tonnes in 2030. The two primary fuels used are motor gasoline and gas oil. Unleaded gasoline was introduced for the first time in 1999. In general there is more traffic on the East Coast of Mahe than in other parts of the island.

1.13 Water Sector

Water supply in Seychelles is primarily from river sources, combined with groundwater extraction and desalination plants in some locations. Whilst river water is abundant, the steep topography and low retention of the soil and rock, the flow in these streams is erratic and falls to very low values during prolonged periods of drought. Groundwater extractions have not been successful in view of the narrow coastal plateau. Desalination plants have been installed to meet shortfall in demand during the dry season. Water distribution on the three main islands is extensive, serving more than 87% of the population with treated water supply (NSB, 2007). Despite these efforts, the Seychelles will face serious water shortages in the near future (INC, 2000); primarily due to a lack of adequate resources to invest in appropriate reservoirs and growing demand (PUC, 2004). Figure 16 shows Mahé's projected daily water demands, yields and shortfall in supply.

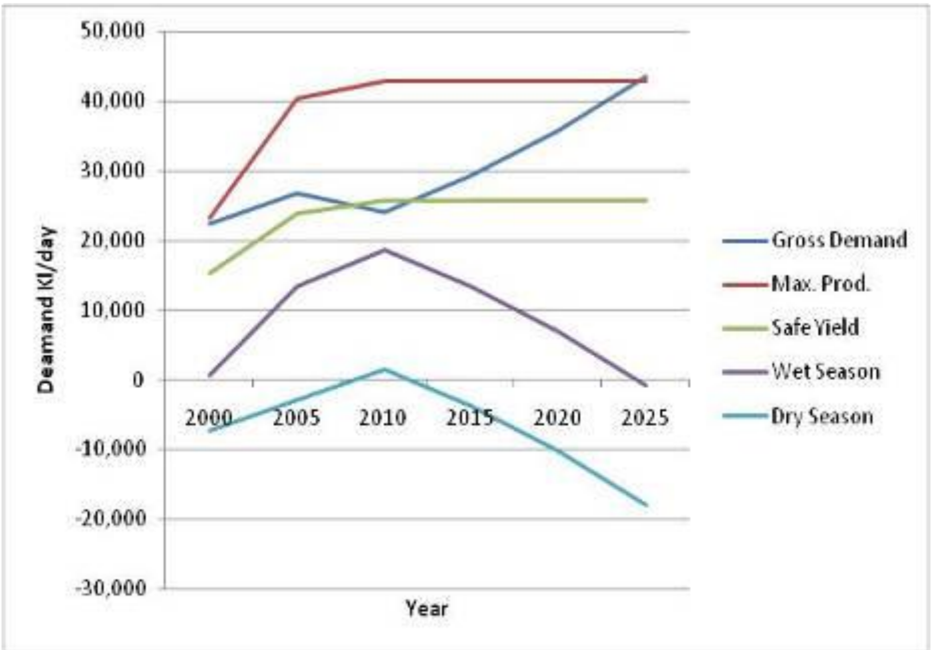


Figure 16: Mahé Projected Daily Water Demands, Yields & Shortfall in Supply - Revised October 2004 (PUC, 2004).

Furthermore, recent studies suggest that changes in long-term rainfall patterns and temperature changes will have adverse consequences for the water sector (Payet & Agricole, 2006). Results from four global circulation models indicate that climate change is expected to increase the severity of water shortages on Mahé, Praslin and La Digue because of the following factors: (i) decreases in rainfall during the dry southeast monsoon which will reduce stream flow, groundwater recharge and therefore water supply; (ii) increases in surface air temperatures which will increase rates of evapo-transpiration and consequently reduce stream flow, ground water recharge and further exacerbate the water supply problem; and (iii) increases in rainfall intensity which will result in greater surface runoff and reduced water capture in existing storage facilities. Payet and Agricole (2006) also noted that a warmer and wetter climate for the Seychelles will not necessarily translate into a greater availability of water. Dry spells are likely to be longer, and precipitation events more intense. These predicted changes will affect water supply adversely because of greater variation in stream flows.

1.14 Agriculture Sector

General

In 2007 the Seychelles Gross Domestic Product (GDP) was estimated at USD 728 million, of which agriculture accounted for approximately 3 percent but with the recent global food crisis, the issue of national food security has taken the highest priority in Seychelles.

Agriculture in Seychelles is characterised by a relatively large number of small farms with an average size of 0.5 hectare and rarely exceeding 2 hectares, employing various levels of technology and management.

Crop Production

Currently on all islands approximately 600 hectares are under some form of agricultural production and/or agriculture use. Only about 300 hectares are however under intensive cultivation .

Some 416 farms were registered for farming in 2007 out of which 310 farms were based on the main Island of Mahe, 96 were located on Praslin and 10 were on La Digue. In addition to the registered farms, a relatively high number *(exact number is unknown)* of small scale, subsistence farmer exist, farming mainly for home consumption and/or to supplement income. *(The number of registered farms can vary from year to year and during the February 2009 meeting with personnel of the Seychelles Agricultural Agency there were 580 registered farms).*

Registration of a farm is important because only registered farmers are eligible to receive public benefits according to the Agriculture and Fisheries (Incentives) Act, 2005.

The total area equipped with irrigation is estimated to be some 260 ha, out of which approximately 20 ha are surface irrigated, 40 ha sprinkler irrigated and 200 ha drip irrigated. Surface water is used for irrigation and all irrigation schemes are medium-scale schemes (2−70 ha) and state-owned. The main irrigated crops are vegetables like cabbage, pumpkin, beans, tomatoes, eggplant, cucumber, lettuce, spring onion, cocoyam, capsicum, okra, spices and flowers.

Crops such as sweet potatoes, cassava, plantains, sugar cane, bananas and citrus fruits are rain fed but irrigated at the planting stage.

The cultivation and exploitation of traditional crops like cinnamon and coconuts along with patchouli and vanilla have dropped considerably during the last decade and contribute as of today insignificantly to the sector.

The annual value of crop production in the Seychelles is estimated at approximately SR 210 million or USD 14 million (SAA, 2007) with banana representing about one third of the total annual crop value.

Extreme rainfall has caused significant agricultural losses to crops in the last few years (Payet, 2005). The heavy rainfall experienced during the 1997–1998 El Nino and the 1998–2000 La Nina events have had profound impacts on the economy of the Seychelles. Fisheries suffered the greatest loss in monetary terms accounting for 45% of the total losses. This was followed by agriculture (28%), tourism (12%), industry (7%), construction (5%) and forestry (3%). The services providing support to these sectors were also affected. Food had to be imported to meet the shortfall on the local market and financial assistance was given to farmers.

Livestock Production

Livestock farming in the Seychelles consists predominantly of pig and poultry farming. Because of the limited land available, cattle are farmed to a very limited extent only (see Table 1-5).

From the total of 416 registered farms, 148 farms are engaged in sole livestock farming and/or mixed crop and livestock farming activities out of which some 108 farms are registered for pig production (fattening & breeding). Registered pig farms represent farms with an annual production of 25 head or more. Most registered pig farms (99 out of 108) are based on Mahe, whilst 7 pig farms are on Praslin and 2 are on La Digue.

Table 1-5: Number and Type of Livestock Farms in the Seychelles

Name of Island	Number of Livestock Farm	Type of Livestock Farm	Number of Livestock
Mahe	134	99 Pig Fattening & Breeding 23 Poultry – Layer 12Poultry – Broiler	7844 92000 16000
Praslin	11	7 Pig Fattening & Breeding 4 Poultry – Layer 1 Poultry – Broiler	490 7200 16000
La Digue	3	2 Pig fattening & Breeding 3 Poultry – Layer	6800 560

Source: Livestock Section, Seychelles Agricultural Agency (SAA), 2008

Chapter 2

National Greenhouse Gas Inventory

CHAPTER 2 NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

The first Greenhouse Gas Inventory of the Seychelles was published in July 1997. This was followed by the publication of the Technologies and Measures for the Mitigation of Greenhouse Gases in Seychelles in October 1998. The Seychelles Initial National Communication was published in October 2000 and submitted to the UNFCCC in November 2000. The second Greenhouse Gas Inventory of Seychelles has been prepared as per the requirements of the Guidelines issued by the Decision 17/CP.8 of the Conference of the Parties (COP 8, 2002). The Annex of the Guidelines states the following:

For the Second National Communication, Non-Annex I Parties shall estimate national GHG inventories for the year 2000; and the methodology used to develop the inventory is based on the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Good Practice Guidance) prepared by the Intergovernmental Panel on Climate Change (IPCC) and the Good Practice Guidance for Land Use, Land-Use Change, and Forestry, which further expanded upon the methodologies in the Revised 1996 IPCC Guidelines.

This chapter therefore, presents estimates of Seychelles' national anthropogenic greenhouse gas emissions and sinks for the year 2000. The inventory includes five categories: energy, industrial, agriculture, land use-land use change and forestry (LULUCF) and waste . Worksheets and data tables are found in the annex 1.

2.2 Summary of Total National GHG Emissions

A summary of Seychelles' GHG emissions and removal for the base-year 2000 is presented in Table . The total CO_2 emissions were 273.148 Gg and the total CO_2 removal capacity was 837.380 Gg. This meant that Seychelles was a net sink for CO_2 to the tune of 564.232 Gg and this represented 3 times the amount of emissions. The amount of emissions for the other greenhouse gases was quite low. CH_4 was 2.743 Gg and NOx was only 1.150 Gg. It is to be noted that the global warming potential of CO_2 is 1, that of CH_4 is 21, and that of N_2O is 310.

About 95 % of the emissions of CO_2 were from fuel combustion, whilst 5 % were from changes in forest and other woody biomass stocks. Some 57 % of the CO_2 emissions from fuel combustions were from public electricity production, 25 % were from transport (19 % from road transport), 11 % were from the commercial and institutional sector, 3 % were from manufacturing and construction, 3 % were from residential sector, and 1 % from other sectors.

Table 2-1: Summary Report - National Greenhouse Gas Inventories for the Year 2000 (all values in Gg)

Greenhouse Gas Source & Sink Categories	**CO_2 Emission**	**CO_2 Removal**	**CH_4**	**N_20**	**NOx**	**CO**	**NMVOC**	**HFC**
1. **Energy (Fuel**	260.608	0	0.023	0.002	1.150	4.217	0.804	0

Combustion)								
2. Industrial Processes	0	0	0	0	0	0	0.051	0.014
3. Agriculture	0	0	0.210	0.036	0	0	0	0
4. Land Use Change & Forestry	12.540	-837.380	0	0	0	0	0	0
5. Waste		0	2.510	0	0	0	0	0
Total National Emission	**273.148**	**-837.380**	**2.743**	**0.038**	**1.150**	**4.217**	**0.855**	**0.014**
Net Sink		**-564.232**						

2.3 GHG Emission Comparison by Sectors for 1995 and 2000

Table 2-2 gives the comparison of GHG emissions by sectors for the year 1995 and 2000. There has been a 46 % increase in CO_2 emissions from the energy (fuel combustion) sector. CO_2 emission from public electricity production has increased by 41 %. From the manufacturing & construction sector, there has been an increase of 53 %, as a result of better data. CO_2 emissions from the transport sector has increased by 20 % and this could have been higher if there were none of the existing constraints and controls on import of new vehicles, since the vehicle population could have been higher, leading to a higher consumption of fuel. As can be seen, the road transport emission of CO_2 has increased by only 9 %, but for navigation this was 50 % and domestic aviation it was a 40 % increase.

The large percentage increase of CO_2 emission in the commercial & institutional sector was mainly due to the availability of more accurate data for the year 2000 compared to that of 1995. The decrease of emission of CO_2 by 18 % in the residential sector was mainly due to fuel switching, ie, kerosene to LPG for cooking. The decrease of emissions of CO_2 by 20 % in the fishing sector was mainly due to more accurate data for the year 2000. There could have been some double accounting in 1995.

Table 2-2: Emissions of GHG by Sectors (all values in Gg) for the Years 1995 and 2000

Greenhouse Gas Source & Sink Categories	Greenhouse Gas	Year (1995)	Year (2000)	% increase
1. Energy (Fuel Combustion)	CO_2	178.736	260.608	+46
i) Public Electricity Production	CO_2	103.951	147.151	+41
ii) Manufacturing & Construction	CO_2	5.528	8.452	+53

iii) Transport (Total)	CO_2	55.354	65.996	+20
a) Road	CO_2	46.561	50.732	+9
b) Navigation	CO_2	4.081	7.982	+50
c) Aviation	CO_2	4.713	7.282	+40
iv) Commercial & Institutional	CO_2	1.563	28.985	+xxxx
v) Residential	CO_2	10.838	8.781	-18
vi) Fishing	CO_2	1.500	1.243	-20
2. Industrial Processes				
i) Food & Drinks	NMVOC	NE	0.051	
ii) Refrigeration, Air-conditioning & Fire Extinguishers	HFC	NE	0.014	
3. Agriculture				
i) Enteric Fermentation	CH_4	0.202	0.210	+5
ii) Manure Management	CH_4			
iii) Agricultural Soils	N_2O	0.075	0.036	
4. Land Use Change & Forestry				
i) Changes in Forest & other Woody Biomass Stocks	CO_2 Emission CO_2 Removal	12.542 -845.310	12.542 -837.380	0 -1
ii) Forest & Grassland Conversion				
iii) Abandonment of Managed Lands		0.002		
5. Waste				
i) Solid Waste Disposal Sites	CH_4	2.050	2.510	+25
6. International Bunker				
i) Aviation	CO_2	132.360	89.745	-32
ii) Marine	CO_2	246.780	584.599	+137

Table 2-3 gives the comparison of emissions for the main greenhouses gases for the years 1995 and 2000. The overall CO_2 emissions have increased by 43 % and the removal capacity has decreased by 1 % only. As per the GHG Mitigation Report published in 1997, the CO_2 emissions were projected to increase from 191.378 Gg in 1995 to 232.747 Gg in 2000 (22 % increase), but this had reached 273.148 Gg in 2000, or a 43 % increase. This could have been due to the rapid development of the country and also a lack of implementation of mitigation projects between 1995 and 2000. This growth also reminded us of the exponential growth scenario when using the econometric projection model.

As for the CO_2 removal capacity, the Mitigation Report assumed that this would remain the same in 2000 as in 1995, but there has been a 1 % decrease only. The emission of CH_4 has increased by 7 %, which was directly linked to better collection and disposal of solid waste. The emissions of the other GHG in 2000 remained quite low as in 1995.

Table 2-3: Emissions of main GHGs for the Years 1995 and 2000

Greenhouse Gas	Year (1995)	Year (2000)	% increase/decrease
CO_2 Emission	191.378	273.148	+43
CO_2 Removal	-845.310	-837.380	-1
CH_4	2.563	2.743	+7
N_2O	0.077	0.036	-53
NOx	0.059	1.150	+95
CO	5.126	4.217	-18
NMVOC	0.594	0.855	+44
HFC	NE	0.014	

2.4 Energy Sector

2.4.1 Introduction

The energy (fuel combustion) sector remained the most significant source of GHG emissions, especially CO_2. Figure 17 below shows that the distribution of CO_2 emissions for each fuel type in the year 2000 and Figure 18 shows the same for the year 1995. As can be seen, the emissions from fuel oil consumption have increased from 1.5 % in 1995 to 36.78 % in 2000, and for gas oil, this has decreased from 70.82 % in 1995 to 43.68 % in 2000. Therefore, consumption of fuel oil contributed the most to CO_2 emission. Fuel oil was mainly used for public electricity production. There was no significant change in emission of CO_2 from gasoline. Emission from LPG had increased from 1.08 % in 1995 to 2.74 % in 2000. That for kerosene had decreased from 4.82 % in 1995 to 1.01 % in 2000. This was directly due to fuel switching from kerosene to LPG for cooking.

Figure 19 and Figure 20 show the percentage distribution of CO_2 emission by sector in the years 2000 and 1995 respectively. The share for CO_2 emission from public electricity production remained about the same; that is at an average of 57 %. The increase in the share from the commercial & institutional sector (0.87 % in 1995 to 11.12 % in 2000) was mainly due to the fact that the CO_2 emission for fuel combustion for electricity production for hotels on outlying islands was accounted for under this sector in 2000, whereas in 1995, the same was accounted for under the auto production.

The share for road transport had decreased from 26.05 % in 1995 to 19.47 % in 2000, as a result of better accounting/estimation for the other sectors. The drop in the share for the residential sector (6.06 % in 1995 to 3.77 % in 2000) is directly linked to the switching to less carbon intensive fuel (kerosene to LPG) for cooking.

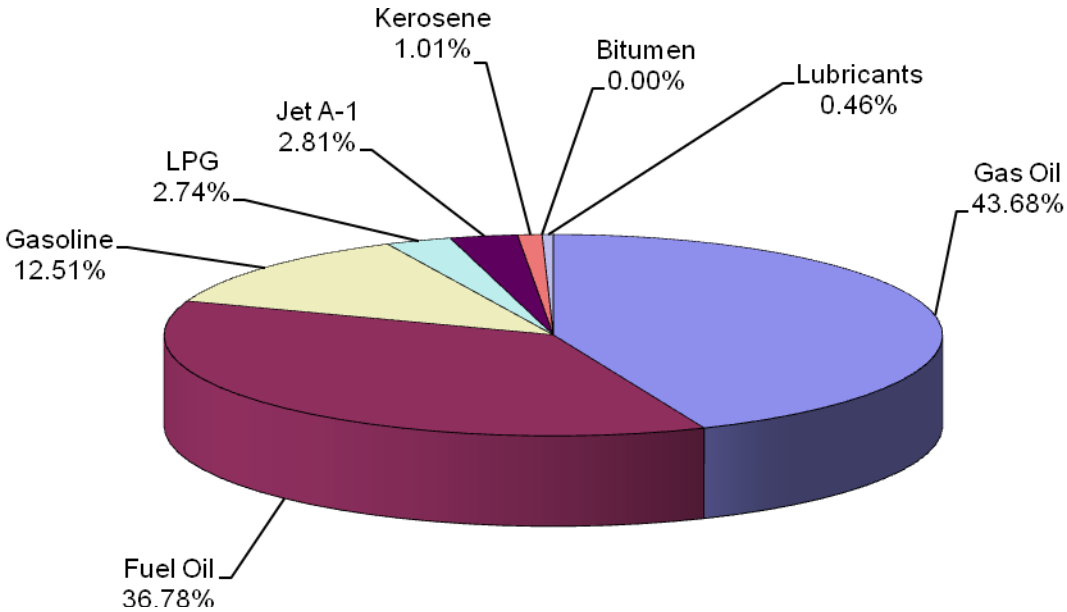


Figure 17: CO_2 Emissions for each Fuel Type in 2000

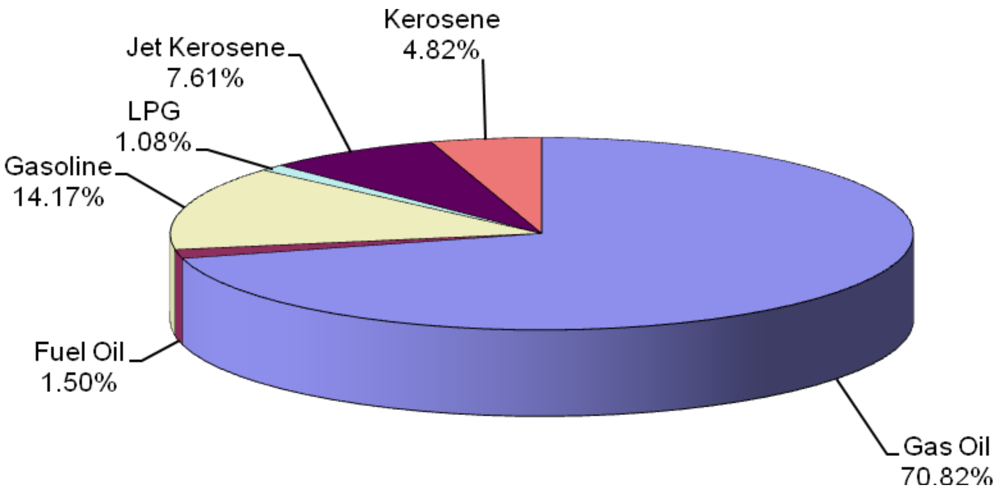


Figure 18: CO_2 Emissions for each Fuel Type in 1995

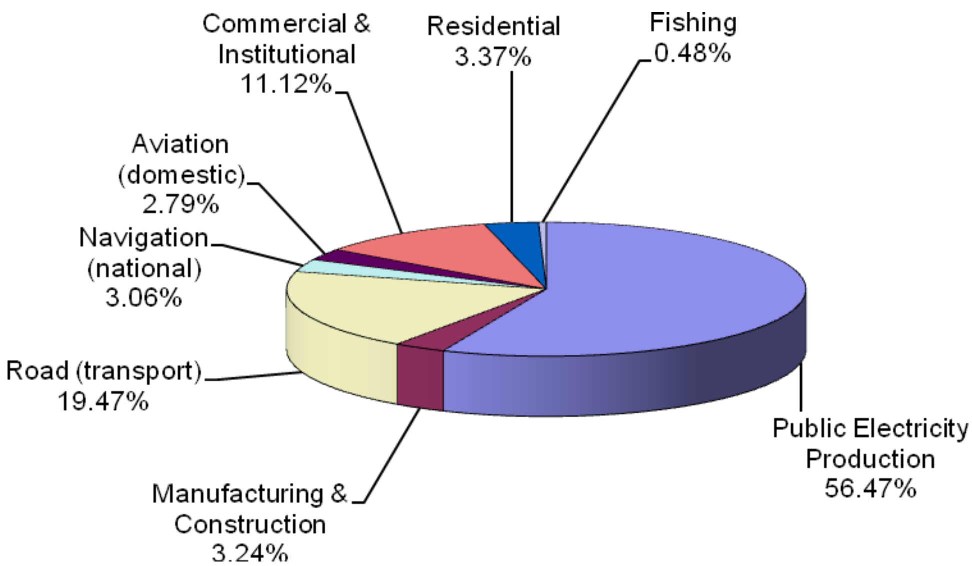


Figure 19: CO_2 Emissions by Sector in the Year 2000

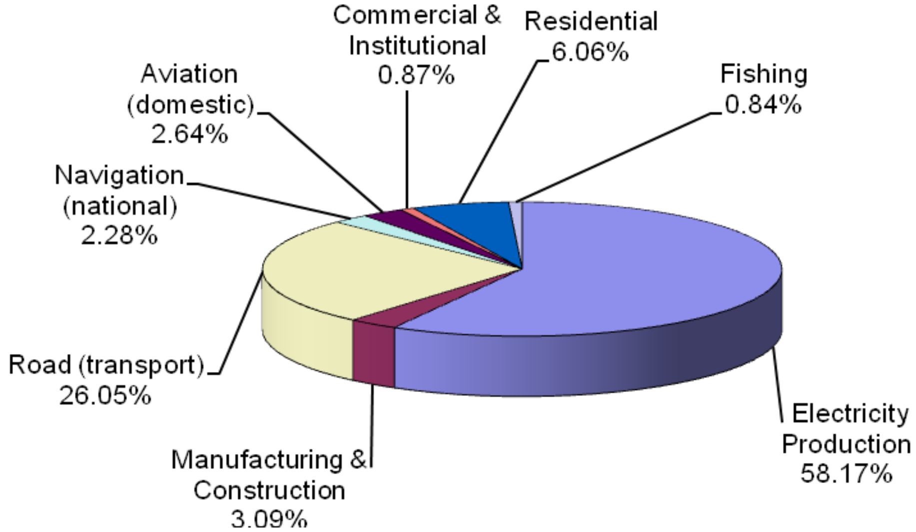


Figure 20: CO_2 Emissions by Sector in the Year 1995

2.4.2 Methodology

The TIER 1 method has been used for the calculation of the GHGs. This method concentrated on estimating the emissions from the carbon content of fuels supplied to the country as a whole (Reference Approach) or to the main fuel combustion activities (Source Categories). The TIER 1 method has been applied as follows:

- CO_2 emissions - Reference Approach
- By main source categories - Non-CO_2 emissions from fuel combustion by source categories

2.4.3 Results For Year 2000 CO_2 Emissions

The total CO_2 emission from Fuels Consumed (Reference Approach) for the year 2000 was 260.640 Gg or 260,640 tonnes (see Table2-4) , compared to 194.342 Gg or 194,342 tonnes in 1995. This represents an increase of 34 % over the year 2000 value. In 1995, the CO_2 emission from the combustion of gas oil was nearly 71 %, but this had decreased to around 44 % in 2000. This was as a result of the increase in consumption of fuel oil for public electricity generation, especially at Power Station C. The emission of CO_2 from fuel oil combustion was around 37 % in 2000, compared to only 1.5 % in 1995. There has been a decrease in CO_2 emission from kerosene and an increase for LPG as a result of fuel switching in the residential sector. LPG has replaced kerosene for cooking in the residential sector.

Table 1: CO_2 Emissions from Fuels Consumed (Reference Approach) for the Year 2000

Fuel Type	Quantity (Gg CO_2)	%
Gas Oil	113.857	43.68
Fuel Oil	95.861	36.78
Gasoline	32.619	12.51
LPG	7.146	2.74
Jet Kerosene	7.329	2.81
Kerosene	2.629	1.01
Bitumen	0.000	0.00
Lubricants	1.199	0.46
Total	**260.640**	

Table 2: CO_2 Emissions from International Bunkers for the Year 2000

Fuel Type	Quantity (Gg CO_2)	%
Gas Oil (Marine)	584.599	86.69
Jet Kerosene (Aviation)	89.745	13.31
Total	674.344	

The total CO_2 emission from international bunkers in 2000 was 674.344 Gg or 674,344 tonnes, compared to 365.028 Gg or 365,028 tonnes in 1995 (see Table 2-5). This represented an increase of 85 %.

Table 3: CO_2 Emissions from Fuel Combustion by Source Categories for the Year 2000

Source Category	Quantity (Gg CO_2)	% of National Total
Public Electricity Production	147.151	56.46
Manufacturing & Construction	8.452	3.24
Road (transport)	50.732	19.47
Navigation (national)	7.982	3.06

Aviation (domestic)	7.282	2.79
Commercial & Institutional	28.985	11.12
Residential	8.781	3.37
Fishing	1.243	0.48
National Total	**260.608**	
International Marine Bunker Fuel	584.599	
International Aviation Bunker Fuel	89.745	

In the year 2000 (see Figure 2-5), public electricity production (56 %) and road transport (19 %) were still the main sources of CO_2 emission, followed by the commercial & the institutional sector (11 %). It is to be noted that around 8 % of the emission from the commercial sector was for electricity production from hotels where public electricity was not available. Therefore, the total emission for electricity production was around 64 % while 25 % came from the transport sector (road, aviation & navigation). The total emission for cooking was around 6 %.

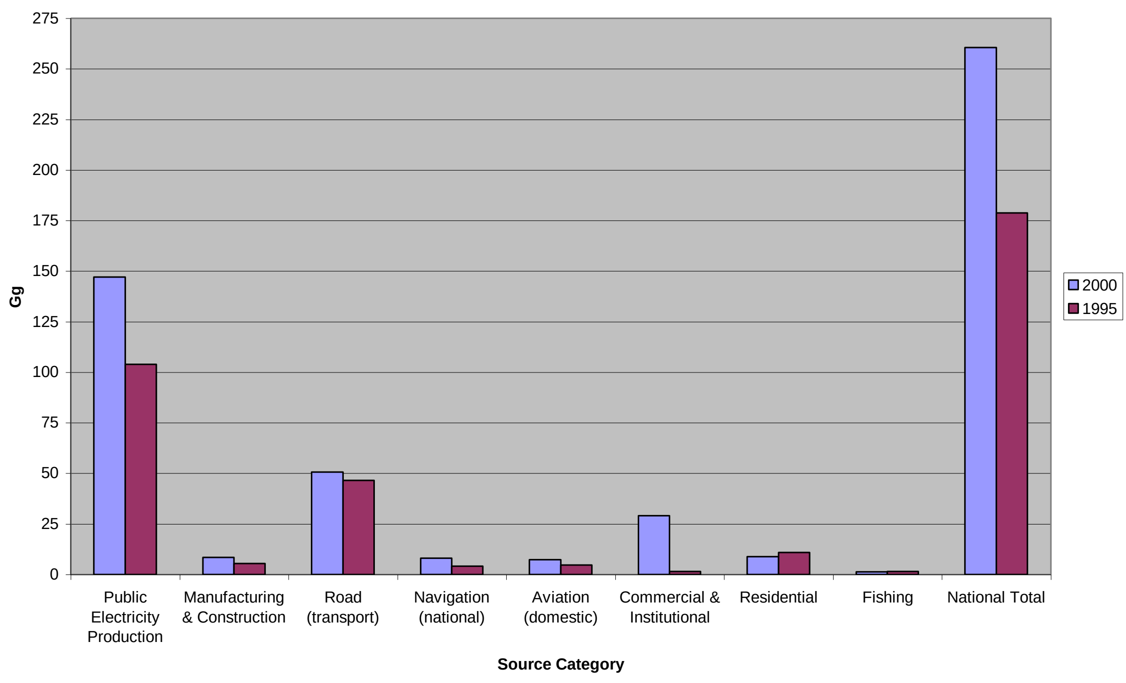


Figure 2-5: CO_2 Emissions for the Years 1995 and 2000

2.4.4 Non-CO2 Emissions

Table 4: Non-CO_2 Emissions from Fuel Combustion by Source Categories for the Year 2000

	Emission (Gg)				
Source Category	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**
Public Electricity	5.87×10^{-3}	1.17×10^{-3}	0.391	0.029	0.010
Manufacturing & Construction	0.23×10^{-3}	0.07×10^{-3}	0.023	0.001	0.001
Transport					
Aviation	0.05×10^{-3}	0.21×10^{-3}	0.031	0.010	0.005
Road	10.74×10^{-3}	0.43×10^{-3}	0.483	4.050	0.763
Navigation	0.49×10^{-3}	0.05×10^{-3}	0.146	0.098	0.020
Commercial/Institutional	4.20×10^{-3}	0.25×10^{-3}	0.042	0.008	0.002
Residential	1.36×10^{-3}	0.08×10^{-3}	0.014	0.003	0.001
Fishing	0.085×10^{-3}	0.01×10^{-3}	0.020	0.017	0.003
Total	**0.023**	**0.002**	**1.150**	**4.217**	**0.804**

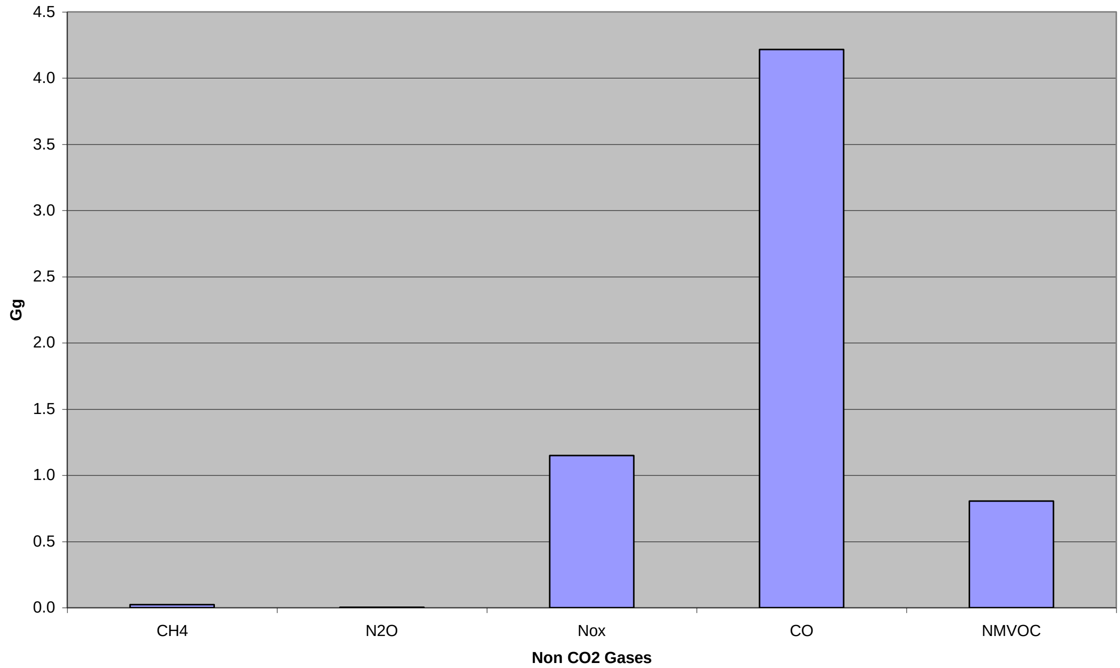


Figure 2-6: Emissions of Non-CO_2 Gases for the Year 2000

From Table 2-7 and Figure 2-6, they show the total amount of CH_4 emission was 0.023 Gg or 23 tonnes, and most of the emission was from the transport sector and public electricity generation. In the same manner the total amount of N_2O emission was 0.002 Gg or 2 tonnes, and most of the emission was from public electricity generation and the transport sector. The total amount of NOx emission was 1.15 Gg or 1150 tonnes, and most of the emission was from the transport sector and public electricity generation. The total amount of CO emission was 4.217 Gg or 4217 tonnes, and most of the emission was from the transport sector. The total amount of NMVOC emission was 0.804 Gg or 804 tonnes, and most of the emission was from the transport sector. The emission of Non-CO_2 gases were mainly from the transport sector.

2.4.5 Data Gaps and Uncertainties

All raw data are available from SEPEC, apart from data for public electricity production, the rest of the data are not processed and are kept in the classification of source category as per the requirements of the IPCC for GHG inventory. Therefore, the NCCC should make a request to SEPEC to obtain the data to the requirements of the source category of IPCC. This will facilitate the inventory process, eliminate data gaps and minimise uncertainties.

2.4.6 Conclusion

The total CO_2 emission in the year 2000 by source category was 260.608 Gg or 260,608 tonnes (see Table 2-6), compared to 179 Gg or 179,000 tonnes in 1995. This represented an increase of 45 %. It is to be noted that the domestic fuel consumption in 2005 was around 8 % higher than that in 2000, therefore it was expected that the CO_2 emission in 2005 would have been around 8 % higher than in

2000. As a result of ongoing development in the tourism and housing sector, it is expected that the CO_2 emission will continue to increase.

2.5 Industrial Processes Sector

2.5.1 Introduction

The industrial sector consists mainly of light to medium industries involved in manufacturing and construction activities. There are relatively very few large manufacturing industries in the Seychelles. The Seychelles relies heavily on imported goods to meet local demand.

In Seychelles, there is no manufacturing of mineral products (cement or lime), chemical industry or metal production. As such, there are no significant emissions of CO_2 from this sector. Only food and drink production along with the consumption of HFCs are considered as relevant sources for emissions of GHGs. The main GHG emission from this sector comes from food processing, namely beer, meat & meat products, fish & fish products, poultry & poultry products, animal feed and bakery. HFC is emitted from the use of refrigerants for cooling and also from the use of fire extinguishers. Most of the data were obtained from the Department of Natural Resources and the National Statistics Bureau (NSB).

2.5.2 Methodology

The simplified approach (Tier 1) was used to estimate the emissions of NMVOC from food processing and production. The Tier 1a method was used to estimate the emissions of Halocarbons from the consumption of halocarbons in refrigeration and air-conditioning systems and the use of fire extinguishers.

2.5.3 Results For Year 2000 CO_2 Emissions

The overall emissions of NMVOC and HFC from industrial processes are tabulated in Table 5. The total emissions of NMVOC were 0.051 Gg and the potential bulk Halocarbon emissions were 0.014 Gg.

Table 5: Emissions of NMVOC and HFC by Source Category

Source Category	GHG Emission	Quantity emitted
Alcoholic Beverage Production		
- Beer	NMVOC	0.002 Gg
Bread & Other Food Production		
- Meat, Fish & Poultry	NMVOC	0.009 Gg
- Animal Feed	NMVOC	0.015 Gg

- Bread	NMVOC	0.027 Gg
Total		0.051 Gg
Refrigerants/Fire Extinguishers	HFC	0.014 Gg

2.5.4 Data Gaps and Uncertainties

There was no major data gap, except for the actual amount of flour that was used for bread production. For this inventory, all the flour imported was considered to have been used for bread production. Therefore, there was a certain amount of uncertainty in the estimated amount of NMVOC from bread production, but since the overall emissions were quite low, the uncertainty was not assessed.

2.5.5 Conclusion

When the First GHG Inventory was prepared in 1997, it was not possible to estimate GHG emissions for Industrial Processes, since emissions factors were not readily available. For this inventory, it has been possible to estimate the GHG emissions, since the default emission factors given in the IPCC Reference Manual were used. The GHG emissions that were of relevance were NMVOC and HFC, and the amounts of emissions were quite low. It is not expected that there will be a significant increase in GHG emissions from this sector in the future. For the industrial processes, the availability of data for the year 2000 has resulted in the improvement in the estimation of emissions of NMVOC and HFC, but the overall total amount of emissions was very low as a result of the size of this sector and the activities that were not directly linked to emissions of GHGs.

2.6 Agriculture sector

2.6.1 Introduction

Agricultural activities contribute directly to emissions of greenhouse gases through a variety of different processes. There are four greenhouse gas-emitting activities and the gases are CH_4, N_2O, CO, and NOx. There have been very little changes in emissions of GHG, and the total amount remains very low.

The emission factors used in the estimation of CH4 emission are given in the Table 6.

Table 6: Emission Factors for estimation of CH4 emission

Typeof Livestock	**Fermentation (kg/head/yr)**	**Manure Management (kg/head/yr)**
Cattle	44	2
Pigs	1.5	7
Chicken	0	0.023

Source: IPCC, 1996; GL manual, Table 4.4.

2.6.2 Methodology

CH_4 emissions from enteric fermentation in domestic livestock

The methodology used is the *Tier 1* as the livestock population is quite small. The result from the 1st GHG inventory shows that the contribution of enteric fermentation from livestock is quite small and its significance on a national scale is also small. Therefore, the use of higher tiers would not yield more relevant result. It is clear that the number of cattle has decreased; hence the emissions will be low.

2.6.3 Results For Year 2000 GHG Emissions

The results for the year 2000 GHG emissions (see Table 7) confirmed those of the first GHG Inventories and showed that emissions of CH_4 and N_2O from the agricultural sector were negligible, since the amount of livestock was quite small. There is no indication at present that this situation will change; therefore it might not be necessary to calculate GHG emissions from the agriculture sector in the future. The emissions of CH_4 amounted to 0.21 Gg (212 tonnes) and N_2O was 0.036 Gg (36 tonnes).

Table 7: GHG emissions from Agriculture

GHG Emissions	Quantity (Gg) For the year 2000	Quantity (Gg) For the year 1995
CH_4 Emissions from Livestock	0.210	0.202

2.6.4 Data Gaps and Uncertainty

The data received were of good quality and there were no major data gaps. The primary data received by the Department of Natural Resources were very accurate, since the livestock population was quite small. The NSB received data directly from the Import Division. The availability of data for this inventory was fairly good in general. The quality of data seemed to have been pretty good when cross referenced with those of the NSB.

2.6.5 Conclusion

When the First GHG Inventory was prepared in 1997, it was not possible to estimate GHG emissions for Industrial Processes, since emissions factors were not readily available. For this inventory, it has been possible to estimate the GHG emissions, since the default emission factors given in the IPCC Reference Manual were used. The GHG emissions that were of relevance were NMVOC and HFC, and the amounts of emissions were quite low. It is not expected that there will be a significant increase in GHG emissions from this sector in the future.

2.7 Land Use-Land, Use Change And Forestry (LULUCF)

2.7.1 Introduction

The fundamental basis for the inventory methodology for the LULUCF sector rests upon two linked assumptions: i) the flux of CO_2 to/from the atmosphere is equal to changes in carbon stocks in the existing biomass and soils, and ii) changes in carbon stocks can be estimated by first establishing the rates of change in land-use and the practice used to bring about the change (example burning, clear-cutting, selective cutting, change in management practice, etc.). This requires estimating the land-use in the inventory year, conversion of forests or grasslands, and the stocks of carbon in the land-use categories (those that are subjected to change and those that are not).

The IPCC Revised 1996 Guidelines provides a default approach, a methodology and default data for GHG inventory in the LULUCF sector.

For the land use, land use change & forestry sector, the CO_2 removal capacity has decreased by 1 % only, since most of the infrastructure development had taken place on the reclamation land. As such, there was very little deforestation or conversion of forest land. The CO_2 emissions remained the same in the year 2000, since the yearly quota for logging of hardwood for commercial purpose was maintained at 8,000 m^3 per year.

2.7.2 Methodology

The methodology used was those given in the workbook (IPCC 1996 GL). The forest of Seychelles is considered to be tropical and made of mixed, fast growing hardwood. The process involved the collection of the required data and multiplying these by a given factor. The calculations were done by using the information as required in section 5.2, of the IPCC 1996 GL and from there these were entered appropriately in Worksheets 5-1.

The simple methodology was chosen as a result of Seychelles' simple forestry system and the fact that it was found in one climate zone. The forest was small with also a small removal capacity. Its impact on the global scale was quite small, although it was quite significant through its contribution to the removal of CO_2 from the atmosphere.

2.7.3 Results For Year 2000 GHG Emissions

The result for the LULUCF setor (see Table 8) shows that the total CO_2 removal capacity of the Seychelles has gone down by about 1.32 % from 832.77 Gg in 1995 to 821.74 Gg in 2000. The graph below shows the trend between the two base years (1st inventory). It shows an expected decrease in the removal capacity of the forest. This trend is expected to continue with the increasing pressure for land use for development projects.

Table 8: GHG removal/emissions from LULUCF (Gg)

Removal/Emissions in Gg	Year 2000
Total removal capacity of vegetated area	**-834.28**
Emission from commercial use of biomass	12.54
Net removal capacity	**-821.74**

2.7.4 Data Gaps and Uncertainty

It was difficult to get access to information for abandonment of managed land for the last 20 - 100 years, as usable land is used mainly for agricultural purposes and development. The country has a total land area of approximately 450 square kilometres, of which around half is protected areas.

The amount of timber used was a figure that the Forestry Section of the ministry responsible for environment provided, as per the record that was kept in order to control timber harvesting. There could have been the possibility that there was illegal harvesting of timber, but according to the Forestry Section, this could have ranged from insignificant to reasonable, but it should not have been too problematic given the difficult terrain where this activity occurred.

The areas covered by mangrove on the main island of Mahe, Praslin and La Digue, and in the other granitic islands of Seychelles were assumed to be insignificant. Whereas there were some mangroves in some of the outer lying islands, namely Aldabra and Cosmoledo, these were accounted for in the vegetation of the coralline islands and hence contributed to the removal capacity of the forest.

2.7.5 Conclusion

The total CO_2 removal capacity of the Seychelles has gone down by about 1.32 % from 832.77 Gg in 1995 to 821.74 Gg in 2000. The graph below shows the trend between the two base years (1st inventory). It shows an expected decrease in the removal capacity of the forest. This trend is expected to continue with the increasing pressure for land use for development projects.

2.8 Waste Sector

2.8.1 Introduction

Methane is the most important GHG emission from landfill or solid waste disposal sites (SWDS). Methane is produced as a result of anaerobic decomposition of waste. Methanogenic bacteria break down organic matter in waste to produce methane. Methane can migrate from solid waste disposal sites either laterally or by venting to atmosphere, causing vegetation damage and unpleasant odours at low concentration, while at concentration of 5-15 % in air, the gas may form explosive mixtures.

Changes to waste management affect mainly the CH_4 emissions. The contribution of waste sector to global CH_4 emission was estimated to have been around 90 tonnes annually, during the 1990s. Solid waste is a major source of methane from the waste sector. The contribution of other gases is usually smaller and these include N_2O, CO_2 and NMVOCs. The sector has seen an increase of 25 % of CH_4 emissions from solid waste disposal sites. There were more accurate data in 2000, and there could have been some under estimation in 1995.

2.8.2 Methodology

The methodology chosen for the estimation of methane emissions from Solid Waste Disposal Sites was based on the default methodology of the IPCC 1996 Revised Guidelines. The default methodology is a mass balance approach that involves estimating the Degradable Organic Compound (DOC) content of the solid waste, i.e the organic carbon that is accessible to biochemical decomposition, and using this estimate to calculate the amount of CH_4 that can be generated by the waste.

2.8.3 Estimating the Degradable Organic Carbon (DOC)

Degradable Organic Carbon (DOC) content is based on the composition of waste, and can be calculated from a weighted average of the carbon content of various components of the waste stream. The IPCC 1996 Revised Guidelines provides default DOC values for different waste streams so that countries can calculate the DOC content of their waste, rather than relying on single default values. Country/region default data for DOC, where available, are given in the IPCC Manual (in general, these values are for wet waste). For example, in the Africa region, fraction of DOC of Municipal Solid Waste (MSW) for Nigeria is given as 0.11 and that for Egypt is 0.21. It is highly recommended, however, for countries where the composition of the fractions in the waste stream are known, that these be combined with a knowledge of the carbon content of these various fractions to produce a country-specific value for DOC. It is critical that the DOC value corresponds to the waste generation/disposal rate on which the CH_4 estimate is based. For example, a country that includes industrial waste in its MSW estimate should ensure that the DOC value used reflects this component of the waste stream.

To assist countries to calculate the DOC of waste streams, a set of default DOC values for different waste types is given in Table 2-12. Note that these values are for wet (or fresh) waste.

Table 2-12: Default DOC Values

Default DOC Values for Major Waste Streams	
Waste Stream	**Per cent DOC (by weight)**
A. Paper and textiles	40
B. Garden and park waste, and other (non-food) organic putrescibles	17
C. Food waste	15
D. Wood and straw waste	30

Table 9: Composition of Municipal Solid Waste on Mahé in the Years 2003 and 1995

Waste Component	Scott Wilson, 2003			ITW, 1995		
	Min	Average	Max	Min	Average	Max
	%	%	%	%	%	%
Green & kitchen	47.3	48.5	49.7	16.5	43.9	54.5
Miscellaneous combustible	7.9	11.1	14.3	3.0	7.2	12.6
Miscellaneous non-combustible	5.5	11.1	16.8	0.0	1.1	2.0
Plastics	7.9	9.9	11.8	6.8	9.2	12.1
Card & Paper	4.9	5.9	6.9	6.3	16.7	42.0
Glass	3.0	5.2	7.4	1.1	7.2	12.9
Metal	3.1	4.5	6.0	3.1	9.5	19.7
Textiles	2.3	3.3	4.3	3.7	4.6	5.5
Batteries	0.1	0.1	0.1	0.0	0.1	0.3
Hazardous waste	0.0	0.1	0.2	0.0	0.1	0.4
Liquids	0.3	0.3	0.3	n/d	n/d	n/d

2.8.4 Data Gaps and Uncertainty Estimation

On Mahe, there was no data gap since all the wastes collected were disposed of at the SWDS at Providence and there was a reliable and accurate measurement system (weighbridge) in place (see Table). The weighbridge was calibrated yearly by SBS. On Praslin and La Digue, there were no measurement systems in place at the SWDS, so the data were estimated based on visual observation of volume of solid waste.

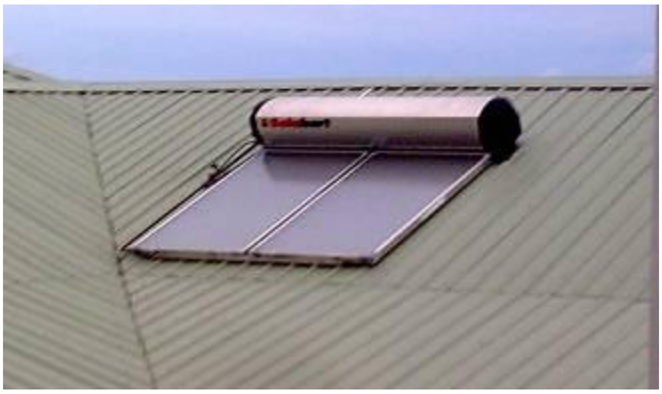
Uncertainty in estimation of CH_4 from solid waste disposal site was directly linked to the fact that the amount of solid waste deposited in the solid waste disposal site on Praslin and La Digue was estimated based on visual observation of the volume of solid waste, rather than from direct measurement like on Mahe. The accuraccy of this process of measurement has not been calculated or documented. It is to be noted that the total amount of solid waste for Praslin and La Digue was equivalent to 8 % of the total solid waste disposed off in solid waste disposal sites.

2.8.5 Results and Conclusion

In 2000, emissions of CH_4 from SWDS amounted to 2.510 Gg, compared to 2.080 Gg in 1995. This represented a 21 % increase in emissions of CH_4.

Chapter 3

Mitigation Measures of GHGs



CHAPTER 3 MITIGATION MEASURES OF GREENHOUSE GASES

3.1 Introduction

The world has been emitting greenhouse gases at extremely high rates and has shown only small signs of reducing emissions. The ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) *"is to achieve … stabilisation of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"* (Article 2). After the 1997 Kyoto Protocol, the world has finally taken the first step in reducing emissions. The assessment of the GHG emissions mitigation is based on the detailed analysis of GHG emissions in 2000 detailed in Chapter 2.

3.2 Mitigation of GHG in the Energy Sector

3.2.1 Trends and Projections of Primary Energy Consumption

Seychelles' primary energy consumption (see Figure 3-1 and Table 3-1) was increasing at an average growth rate of 5.4% per year between 1996 and 2007. Primary energy for Seychelles includes mainly all the petroleum fuels that are consumed locally. It does not include electricity or the fuel used by international aviation and marine bunkers. Consumption reached 84,817 Toe in 2000, a figure that is close to the population of Seychelles in that year (81,202) and indicated that the per capita primary energy consumption was nearly 1.04 Toe/capita.

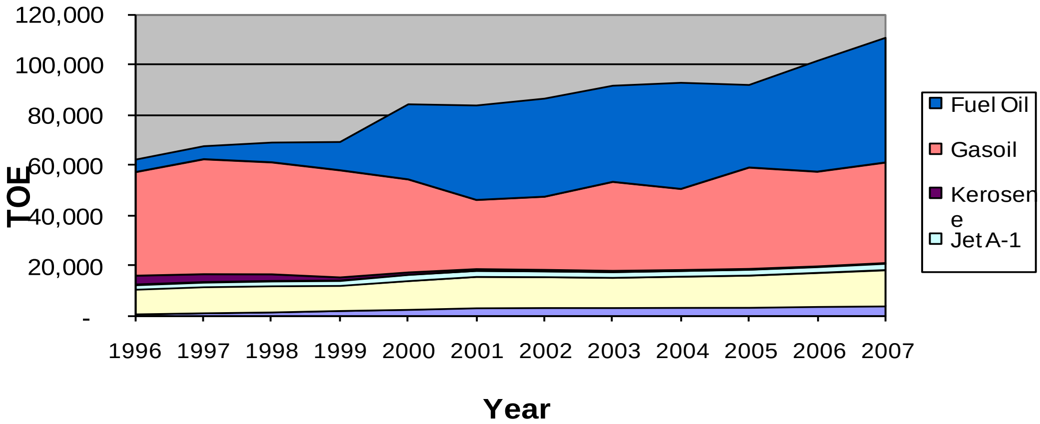


Figure 3-1: Seychelles Primary Energy Consumption

Table 10: Percentage Annual Average Growth of Fuel Consumption between 1996 and 2007

Period	1996-1999	1999-2000	2000-2005	2005-2007
AAGR	**3.6%**	**22%**	**1.8%**	**9.7%**
		Surge in Fuel Oil consumption due to the launching of the new Victoria C power station	Slow/ normal growth Rising oil price from USD 20 to USD 40/brl	Possibly due to increased demand in new housing and hotels and other development projects

3.2.2 Forecast of Fuel Consumption for Electricity Production

Heavy Fuel Oil (HFO) has been the main fuel used by PUC for electricity generation. The new and also largest power station, Victoria C, runs on 80% of Heavy Fuel Oil and on 20% of Light Fuel Oil or gas oil and utilises two-stroke diesel engines to drive alternators. Fuel consumption and electricity are directly related to the specific fuel consumption. Figure and

Table 11 show forecast of fuel consumption in Electricity production using an econometric model

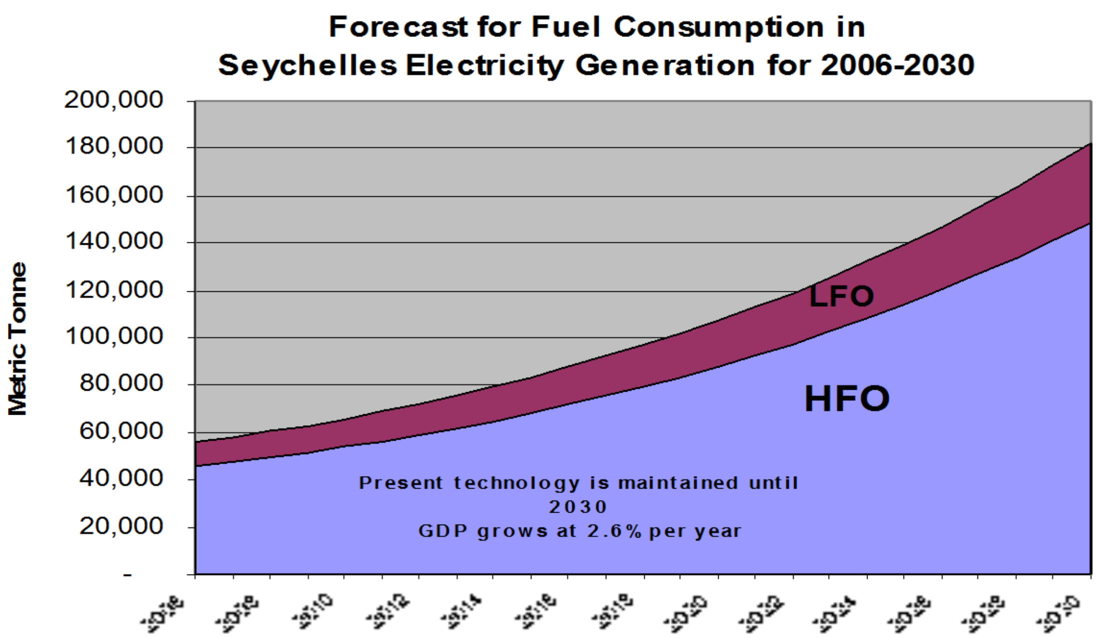


Figure 3-2: Forecast of Fuel Consumption for Electricity Generation between 2006 and 2030

Table 11: Projection of HFO & LFO Consumption

Year	2006	2010	2015	2020	2025	2030
HFO required in tonnes	45,577	53,812	68,119	87,735	114,038	148,944
LFO required in tonnes	10,184	12,024	15,220	19,603	25,480	33,279

3.2.3 Forecast of Electricity Production

Table 12 infers that electricity production increases exponentially with time, revealing that the demand is quite high year by year.From 297 GWh in 2010 to 630 GWh in 2025 - more than double the amount.

Table 12: Projection of Electricity Production

Year	2006	2010	2015	2020	2025	2030
Electricity production in GWh	252	297	377	485	630	823

3.2.4 Trends and Projection of CO_2 Emission

CO_2 emissions from electricity generation are related to the amount of fuel consumed in the power stations. Emissions are estimated using the IPCC method. The data presented (see Table 13) have been used to calculate the emission of CO_2 from the consumption of HFO and LFO.

Table 13: Data used to calculate the Emission of CO_2 from the Consumption of HFO and LFO

	Unit	HFO	LFO
Fraction of carbon stored (FCS)	-	0	0
Fraction of carbon oxidised (FCO)	-	0.99	0.99
Carbon emission Factor (CEF)	t C/TJ	21.1	20.2
Net Calorific Value (NCV)	TJ/1000 t	40.19	43.33
Carbon dioxide emission factor	t_{CO2}/TJ	76.593	73.326

3.2.5 Specific Carbon Dioxide Emission (SCDE) of PUC in g CO_2/kWh

Specific Carbon Dioxide Emission SCDE is the carbon dioxide emission per unit of electricity generated. Table 14 shows a detailed accounting of carbon dioxide emissions from the PUC power stations on Mahe and Praslin, from 1990 to 2007, based on the company's electricity generation statistics and the emission factors and Net Calorific Value (NCV) given above. The last column shows the Specific Carbon Dioxide Emission (SCDE) in g CO_2/kWh generated. The average for PUC for the period from 2000 to 2007 is **698 g CO_2/kWh**, and for comparison, it is above the 400 g CO_2/kWh average in Europe.

Table 14: Estimates of CO_2 Emissions from Power Stations from 2000 to 2007

	Fuel and Lub. Consumption in tonnes			CO_2 Emissions in tonnes				Total Elec. generated	SCDE
Year	**HFO**	**LFO**	**Lub Oil**	**CO_{2HFO}**	**CO_{2LFO}**	**$CO_{2LubeOil}$**	**Total CO_2**	**kWh**	**g CO_2/kWh**
2000	27,467	15,279	221	84,552	48,546	321	133,419	189,457,725	704.22
2001	37,299	6,572	132	114,816	20,882	191	135,889	201,169,178	675.50
2002	39,555	7,961	203	121,763	25,292	294	147,349	218,785,281	673.49
2003	38,602	10,779	187	118,829	34,246	272	153,347	223,783,829	685.25
2004	40,554	9,827	220	124,837	31,222	319	156,378	225,986,864	691.98
2005	37,406	14,409	268	115,145	45,782	390	161,316	232,985,210	692.39
2006	46,735	10,120	182	143,862	32,152	265	176,280	251,938,337	699.69
2007	49,463	10,875		152,259	34,552		186,811	270,583,843	690.40

Based on the projection of HFO and LFO consumption for the production of electricity as given in

Table 11, the corresponding CO_2 emissions are presented in Figure 21 and Table 15. It has been assumed that the present technology for electricity production is kept until 2030.

Table 15: Projected CO_2 Emission from Electricity Generation

Year	2006	2010	2015	2020	2025	2030
Total CO_2 (tonnes)	172,655	203,851	258,045	332,355	431,996	564,226

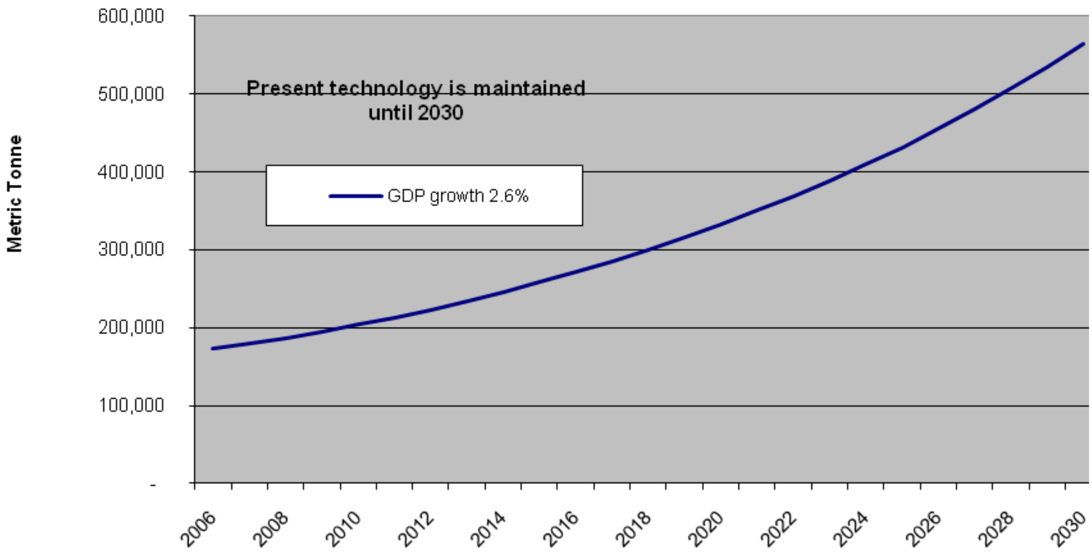


Figure 21: Forecasts for Seychelles CO_2 Emissions from Electricity Generation for 2006 - 2010

3.2.6 Technologies for Mitigation of CO_2 Emission

It is evident that the Public Utilities Corporation (PUC) will have to look at more efficient ways to generate electricity in the future as a result of lessons learned from the recent fluctuation in prices of petroleum products, the devaluation of the local currency and the shortage of foreign currency. The present overall efficiency of the Victoria C power station is 40-41%, which is higher than for Victoria B station, which is about 30 %. Still a large proportion of the energy in the fuel, 59-60% of fuel energy is lost in the form of heat, mainly through the exhaust gases. At the same time it is understood that it is not possible to convert 100% of the fuel energy into another form of energy, such as electricity (according to the second law of thermodynamics); loss of energy always takes place during the conversion. However, the heat from the exhaust gases can be partly recovered using a heat recovery system.

It is also unlikely that PUC will shift to a new and efficient technology for electricity generation immediately or in the short term because the Victoria C power station has been in operation for only 8 years. Moreover, two additional Wartsila generators were planned for commissioning during the year 2008 but the funding has not been secured yet.

The following technology options are proposed for the mitigation of carbon dioxide emissions in the public electricity supply system of Seychelles.

3.2.6.1 Cogeneration

This technology allows the production of heat in the form of hot water or saturated steam, from the exhaust gases at high temperatures (340-400 °C) from the power stations. This allows for the provision of processed heat to industries in the vicinity of the power station in the future. The main equipment required for this technology includes waste heat boilers, pumps and accessories. There are two main constraints for the implementation of this cogeneration project:

1st Constraint: The site of the industry that requires hot water has to be in the vicinity of the power station as it is difficult to transport heat over long distances. Long insulated pipes are costly and heat loss is unavoidable. Potential users would have to be either some offshore industries at SIBA or another small/medium industry such as a laundry to be built in the future in the area but the land available for that is limited. Another possible user is the PUC water division, which may want to supply hot water to its consumers in the region of Victoria, but it will have to promote the availability of hot water.

2nd Constraint: The demand for heat has to match the supply.

3.2.6.2 Combined Cycle Gas Turbine (CCGT)

This technology can be considered only for the future power station on Mahe to supply electricity for the base load. In a Combined Cycle Gas Turbine (CCGT) plant, a gas turbine generator produces electricity and the waste heat is used to produce steam to generate additional electricity via a steam turbine; this last step increases the efficiency of electricity generation. Combined cycle refers to the combination of gas cycle (in the gas turbine) and the steam cycle (in the steam turbine). The temperature of a gas turbine's fuel gas should be high enough to make steam for a second steam cycle with a live steam temperature of between 420 and 580 °C.

It is very likely that Seychelles will have to adopt a more efficient technology such as a CCGT for the next power station in 10 to15 years due to the uncertainty in the cost of fuel, and the need to make electricity generation economically viable, and electricity more affordable to consumers. It is also likely that Heavy Fuel Oil and Light Fuel Oil will continue to be used in the CCGT as the storage facilities for these fuels are already available and experience on their handling and treatment has also already been developed. In 2007, PUC generated 270,583,843 kWh of electricity. If this amount were generated with a CCGT, the energy input required would have been only:

270,583,843 kWh x 3600 kJ/kWh x 10^{-9}/ 58%= 1,679.5 TJ instead of 2,459 TJ with the existing system.

The fuel saving with a CCGT would have been: 2,459 – 1,679.5 = 779.5 TJ

The CO_2 emission which would have been avoided with a CCGT was:

40% x 779.5 TJ x 10^{9}/ 3600 kJ/kWh = 86,611,111 kWh (electricity avoided)

690.4 g CO_2/kWh x 86,611,111 kWh = <u>59,796 tonnes CO_2</u> (CO_2 emission avoided)

which represented 59,796 /186,811 = 32% reduction of total CO_2 emission from PUC during the year 2007.

The SCDE for a CCGT will be: (1-0.32) x 186,811 MT/ 270,583,843 kWh = **470 g/kWh**

This can be further reduced if Natural Gas is used instead of heavy fuel oil and gas oil.

Hopefully, this technology would be adopted for power station by 2015.

Assuming that 50% of all electricity generated by power stations in Seychelles is from CCGT as from 2015, the avoided CO_2 emission would be as follows (see Table 16) =87,444 in 2016 to 107,179 tonnes in 2020

Table 16: CO_2 mitigated from the Operation of CCGT

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CO_2 avoided with CCGT (tonnes)	0	0	0	0	83,216	87,444	91,942	96,721	101,796	107,179

3.2.6.2 Solar Roofs

Solar roofs refer to large scale solar photovoltaic installations on large roofs and connected to the electricity grid after conversion to AC and transformation to the standard 240V voltage. There are several potential solar roofs on Mahe and Praslin, such as the STC warehouse at the Bois de Rose earmarked for the Carrefour supermarket, the SIBA buildings, the IOT building, schools, hospitals, airports, bus terminals, stadiums, etc.

Seychelles has a high level of solar radiation. The annual average daily global energy received on the horizontal surface is 4.8 kWh/m^2 based on the measurements at the airport by the meteorology office in 1987-1989.

Considering a typical size solar roof of 1000 m^2 (50 m x 20 m) at an inclination angle of 20 degrees, the estimation of the annual electrical energy output and the subsequent removal of CO_2 is as follows:

- Annual global solar energy input:

4.8 kWh/m^2.day x 365 days x 1000 m^2 x cos(20 degrees) = 1,646,341 kWh/yr

- Annual total electrical energy output: η_{trans} x η_{inv} x η_{pv} x energy input

0.8 x 0.9 x 0.08 x 1,646,341 kWh/yr = 94,829 kWh/yr

η_{pv} : efficiency of the PV panels based on polycrystalline silicon solar cells

η_{inv}: efficiency of the (sine wave) inverter inverting the DC current to AC

η_{trans}: efficiency of the transformer which step up the voltage to match the voltage of the grid

- Annual amount of CO_2 emissions avoided or removed

If this amount of electrical energy were to be produced by the existing PUC electricity generation system, the CO_2 emissions generated would be:

698 g CO_2/kWh x 94,829 kWh/yr = 66 tonnes CO_2/yr

Each 1000 m^2 of solar roof can roughly remove 66 tonnes of CO_2 per year (Table 3-8).

Several projects of solar roofs have already been implemented in the island of Reunion during the last 5 years. A few foreign investors have shown interest in solar roofs projects in the Seychelles provided that they can operate as IPP (independent power producers) or PUC accepts to buy the electricity produced from such systems.

Assuming that a solar roof project of 1000 m^2 is implemented every 2 years by a private investor starting from 2010, then Table 17 gives a rough estimate of the total CO_2 emissions avoided by the PUC power stations every year through solar roofs.

Table 17: CO_2 mitigated from Operation of Solar Roofs

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Solar roof project 1 (1000 m^2)	66	66	66	66	66	66	66	66	66	66	66
Solar roof project 2 (1000 m^2)			66	66	66	66	66	66	66	66	66
Solar roof project 3 (1000 m^2)					66	66	66	66	66	66	66
Solar roof project 4 (1000 m^2)							66	66	66	66	66
Solar roof project 5 (1000 m^2)									66	66	66
Total CO_2 avoided in tonnes/yr	**66**	**66**	**132**	**132**	**198**	**198**	**264**	**264**	**330**	**330**	**330**

3.2.6.3 Wind Turbines

Although the wind regime in Seychelles that suits wind turbine operation is limited to about five months a year during the South East Monsoon, a period spanning from June to October, experience of the two wind generators project on Sainte Anne Island in 1987-1988 has shown that the wind speed is sufficient to generate electricity during that period.

Due to the recent oil price hikes, Seychelles is presently (2008) looking at different options for reducing its dependence on oil, including wind energy. Two consultants from the LAHMEYER INTERNATIONAL visited Seychelles in October 2008 for data collection, site identification and a feasibility study of wind turbines on Mahe. The wind turbines would have a rated power of 1 MW each. Three potential sites with highest wind speed in the central and southern parts of Mahe are being considered. The wind turbines will be connected to the PUC grid.

The hub height would be 50 to 60 m above the ground, the average wind speed at the hub height may be at least 5 m/s, and the rotor diameter would be about 40 m.

The annual energy output of one wind turbine of 1 MW installed in each site is calculated as follows: 1 MW x CF x 8760 hr/yr:

where, CF is the Capacity Factor equal to the ratio of the actual energy output to the maximum energy output at the rated power for one year. Assuming the CF is low and equal to 0.20, the annual energy output for one wind turbine would be roughly:

1000 kW x 0.20 x 8760 hr = 1,752,000 kWh

The corresponding avoided CO_2 emission by PUC for this amount of electricity is:

698 g CO_2/kWh x 1,752,000 kWh = 1,223 tonnes CO_2.

Each wind turbine of 1 MW rated power can roughly remove 1,223 tonnes of CO_2 per year from PUC's electricity generating activity (Table 3-9).

Table 18: CO_2 mitigated from the Use of Wind Turbine

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wind turbine project 1 (1 MW)	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223
Wind turbine project 2 (1 MW)		1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223
Wind turbine project 3 (1 MW)			1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223
Total CO_2 avoided in tonnes/yr	**1,223**	**2,446**	**3,669**	**3,669**	**3,669**	**3,669**	**3,669**	**3,669**	**3,669**	**3,669**	**3,669**

3.2.6.4 Reduction in Electricity Supply System Losses

The present line-losses are relatively high, reaching over 12 % of the total electricity generated. Therefore, all possible options should be implemented to maintain the losses in the transmission and distribution line to an acceptable level. These losses are mainly due to heat produced in the electrical lines and in the transformers when current is passing through them. As the current is higher on the low voltage lines than on those of the high voltage, there are more losses in the low voltage lines. Investments will consist of installing new high voltage line along the east coast of Mahe. In particular, PUC has planned the two following projects:

- A 33 kV high voltage line to the south of Mahe following the east coast starting from Victoria to the airport, then to Anse aux Pins, to Anse Royale, to Takamaka, etc.;
- Another 33 kV high voltage line from to the north of Mahe following the east coast starting from Victoria to Anse Etoile, to North East Point, to Glacis, to Beau Vallon, etc.

These projects have already been tendered out and are likely to be completed before 2010.

By reducing the supply transmission losses, fuel for generating electricity is saved and the emission of GHG is reduced. Assuming that the two projects will reduce the losses by 1% of the electricity generated, the avoided CO_2 emissions for 2010 would be:

1% x 296 000 000 kWh/yr x 698 g CO_2/kWh = 2,066 tonnes CO_2/yr

3.2.7 Mitigation Measures of CO_2 Emission in the Energy Sector

3.2.7.1 Use of Light Fuel Oil instead of Heavy Fuel Oil

The carbon content of Light Fuel Oil or gas oil is slightly less than that of Heavy Fuel Oil. The carbon dioxide emission factor for LFO is 73.326 t_{CO2}/TJ and that of HFO is 76.593 t_{CO2}/TJ. A reduction of carbon dioxide emission by 4.2% is expected if heavy fuel oil is replaced by light fuel oil (gas oil). This can be significant when considering the large amount of HFO used by PUC for electricity generation; from 27,400 tonnes in 2000 to 45,000 tonnes in 2006. However, the cost of HFO has always been lower than that of LFO, so there is no sufficient motivation or incentive for PUC to shift to LFO (see Figure 3-4).

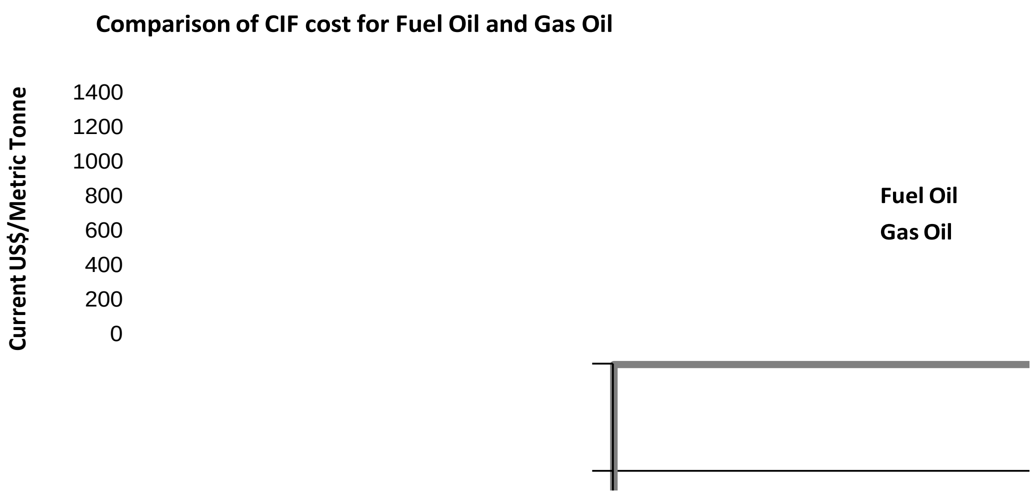


Figure 22: Comparison of CIF Cost for Fuel Oil and Gas Oil (*Source: SEPEC)*

3.2.7.2 Promotion of Foreign Direct Investments for Renewable Energy Projects

By promoting foreign direct investments in renewable energy projects such as solar power stations in the range of 1 to 2 MW (installed on large roofs) or wind turbine farm of 2 to 3 MW, electricity can be generated without any GHG emission. However, electricity generated needs to be supplied to the existing grid and sold to consumers. This requires an agreement with PUC and an amendment of the electricity market regulations to open it up to Independent Private Producers (IPPs). There are IPPs who are interested to invest in Seychelles such as AEROWAT for solar and VERGNET for wind. The Seychelles' Investment Bureau has the mission to promote FDIs in Seychelles. This measure requires a policy change on electricity generation and distribution and therefore has to be decided at high level of government. This can be expected in 2010 when the study on energy policy for Seychelles in completed.

3.2.7.3 Public Sensitisation and Education on Electricity Conservation.

This has always been part of government policy and programme but needs only to be well organised, intensified and coordinated. Efforts have been made in the past to hire a UNIDO consultant to prepare an energy conservation programme for Seychelles, to produce brochures for dissemination to the public, and later to sensitise the public through the media. The programme covered a wide range of subjects such as air-conditioning/ cooling, refrigeration, building thermal insulation, solar energy, electricity, heat, international standards for energy efficient appliances etc. The main issue was the insufficient manpower to deal with the range of subjects. At the same time, the staff level of the Energy Affairs section in the Ministry of National Development has been decreasing over time. A capacity building programme was developed consisting of reviewing and reorganising the national energy conservation programme. In 2010, the new energy policy came into forced and the new regulatory framework for energy set up. PUC could be involved and would be interested in Demand Side Managemen (DSM) programme which consists of reducing the load/power demand especially during the peak hours. An efficient DSM programme would allow PUC to delay investments in new generators by a few years.

3.2.8 Baseline and Mitigation Scenarios

3.2.8.1 Baseline Scenario

The Baseline scenario is a set of conditions that portrays the present situation and that is assumed to remain in the future. It can be also called 'Business as Usual Scenario'. The following features describe the baseline scenario:

- No mitigation/abatement of CO_2 emissions will be made in the Power Stations in the future;
- Electricity will continue to be generated with diesel engines in the future;
- Victoria C power station will continue to run on Heavy Fuel Oil and Light Fuel Oil in the same proportion as is presently used;
- National consumption of electricity will grow at a rate of 5.9 % per year (corresponding to the annual average growth rate of Seychelles electricity consumption over the last 16 years i.e. from 1990 to 2006);
- GDP will grow at a rate of 2.6% per year (corresponding to the annual average growth rate of Seychelles GDP over the last 16 years i.e. from 1990 to 2006);
- No significant power plants based on renewable energy (Wind energy or Solar Photovoltaic) will be installed or commissioned in the future;
- Population will grow at the normal average rate of 1% per year.

3.2.8.2 Mitigation Scenario

The mitigation scenario is based on the assumption that the mitigation options that have been proposed will be implemented along with the conditions mentioned below:

- The electricity generation technology mix will be as shown in the load duration chart below (see Figure 3-5), with Wind, PV and CCGT providing for the base load;
- The existing PUC diesel power stations will continue to run with the same fuels and at the same proportions as are presently used; however they will supply only for the medium and peak load;
- Cogeneration is used in Victoria C power station for the provision of industrial process heat;
- National consumption of electricity will grow according to the validated model described above;

- GDP will grow at a rate of 2.6% per year (corresponding the annual average growth rate of Seychelles' GDP over the last 16 years i.e. from 1990 to 2006);
- Population will grow at the normal average rate of 1% per year.

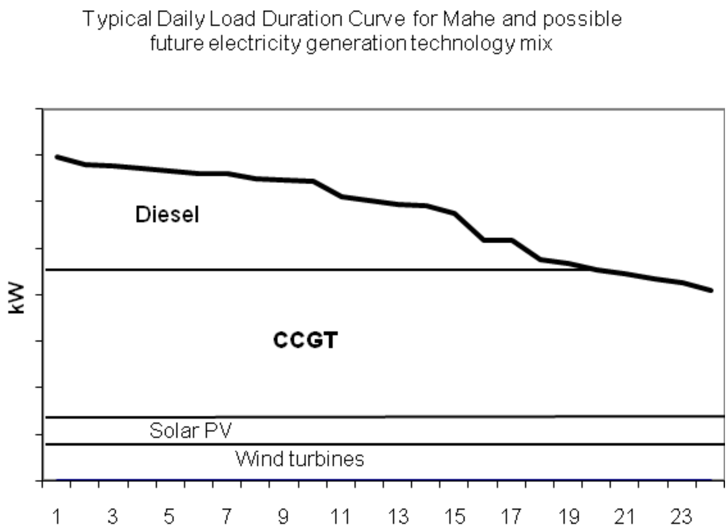


Figure 23: Typical Daily Load Curation Curve for Mahe and Possible Future Electricity Generation Technology Mix

Table 19: CO_2 avoided in Tonnes by implementing the Proposed Mitigation Technologies

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Technology Options											
Cogeneration in Victoria C	16,620	16,620	16,620	16,620	16,620	16,620	16,620	16,620	16,620	16,620	16,620
3 MW Wind Turbines	1,223	2,446	3,669	3,669	3,669	3,669	3,669	3,669	3,669	3,669	3,669
5000 m^2 solar roofs	66	66	132	132	198	198	264	264	330	330	330
CCGT generating 50% of total electricity						41,608	43,722	45,971	48,361	50,898	53,590
New 33kV line along East Coast of Mahe	2,076	2,172	2,275	2,385	2,503	2,628	2,762	2,904	3,055	3,215	3,385
Total CO_2 avoided in tonnes	19,985	21,304	22,696	22,806	22,990	64,723	67,037	69,428	72,035	74,732	77,594

The Table 19, Figure 23 and Figure 24 depict the base line and mitigation scenarios for the proposed mitigation technologies.

Figure 3.4: Forecast of future electricity generation Technology mix

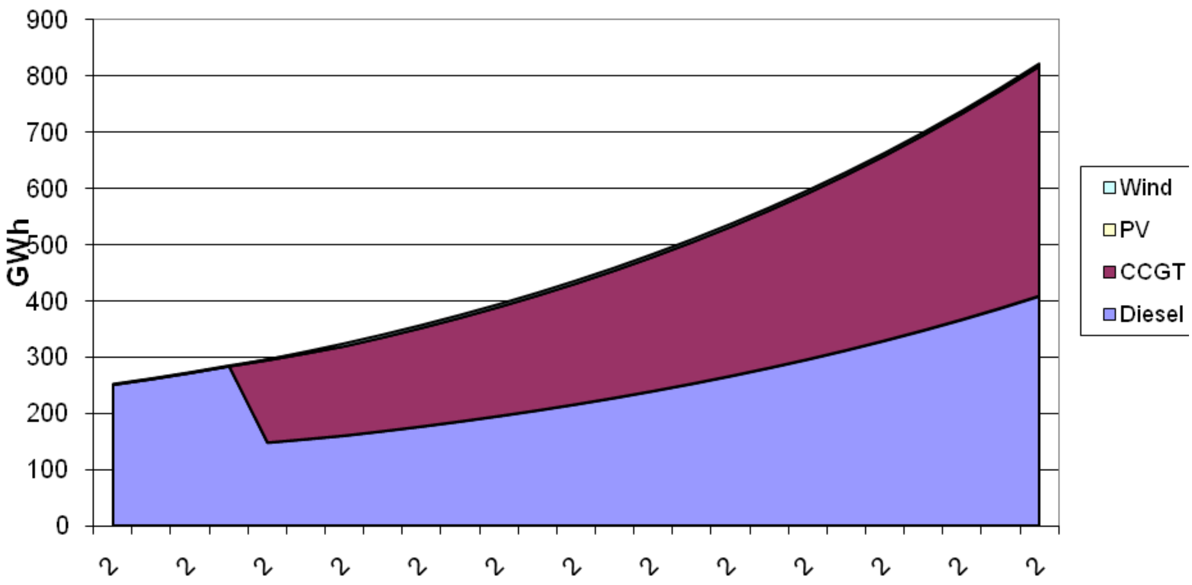


Figure 24: Forecast of Future Electricty Generation Technology Mix

Figure 3-7 shows two possible CO_2 emission patterns: 1) without mitigation options for Baseline scenario and 2) with the mitigation technologies for Mitigation scenario.

Scenarios for CO_2 emissions from Electricity Generation

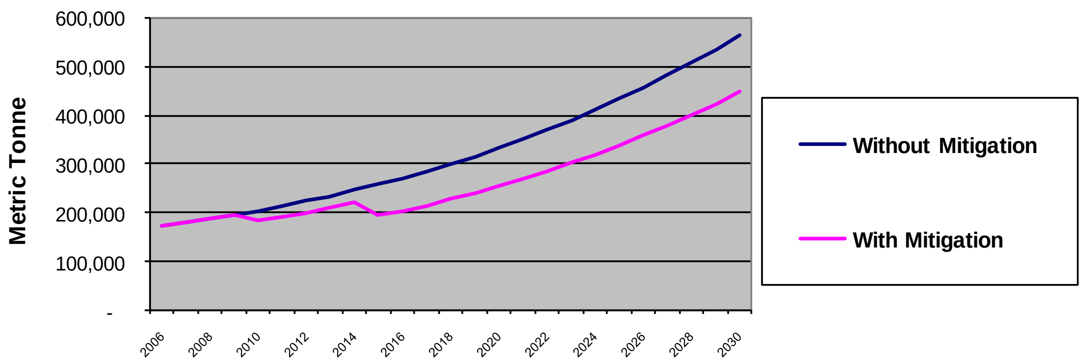


Figure 25: Scenarios for CO2 Emissions from Electricity Generation

3.2.9 Costs and Benefits of the Mitigation Options in the Energy Sector

The recent increase in oil prices to a high value of USD 147/ barrel has made most countries including Seychelles more conscious of the urgent need to conserve energy and to look for alternative sources of energy in order to sustain the energy need of the country. In Seychelles, the true cost of electricity was not passed to consumers. Government has subsidised the cost of production of electricity for various sectors of the economy so that they could operate effectively and also to make electricity affordable to the general public. The electricity tariff was revised in July 2008 to a level that allowed PUC to recover some of its operating costs. Since all the fuel needed to produce public electricity is imported, all options targeted to reduce consumption and GHG emissions will be beneficial the country.

Table 20 gives a quick assessment of the technology options and measures in terms of cost and benefit i.e. efficacy in the removal/ reduction of CO_2 emission.

Table 20: Costs and Benefits of the Mitigation Options

Mitigation Option	**Cost**	**Benefit**
Technology		
Cogeneration	High	Fuel savings in the range of 10 to 35% per year. Limit CO_2 emission by 16,620 tonnes/year.
Combined Cycle Gas Turbine (CCGT)	High	Very efficient system, can remove a large amount of CO_2 but only in the framework of the new power station. Limit CO_2 emissions by around 50,000 tonnes by 2020.
Solar Roofs	High	Potential is limited to the area of large roofs available in the country, possible not exceeding 10 MW in 20 years. Limit CO_2 emission by 330 tonnes by 2020.
Reduction in electricity supply system losses	Medium	Systems losses can be reduced slightly. Limit CO_2 emission by 2,000 tonnes per year.
Wind Turbines	High	Potential is limited to the 5 months of south-east monsoon, possibly not exceeding 10 MW in 20 years. Limit CO_2 emission by 3000 tonnes per year.
Measures		
Use of Light Fuel Oil instead of Heavy Fuel Oil	Low	Lower cost of maintenance. Reduction of GHG emissions by 4 %.
Promotion of Foreign Direct Investments for Renewable Energy	Low	Other source of funding and use of GHG free technologies.

projects		
Public sensitisation and education on electricity conservation.	Low	Electricity conservation conscious public. Lower use of electricity.
Declare emission standards	Low	Benchmark for assessment
Implementation of ISO 14064 by PUC- Electricity Division	Medium	Best practice

3.2.10 Conclusion

The present trend and forecast for energy consumption clearly indicates that demand will increase at a higher rate in the future. Subsequently, emissions of GHGs from the energy supply sector, particularly from electricity generation, will also increase in the future following the same trend, if low or no emission technologies are introduced in a large proportion in the electricity generation technology mix.

It appears that there was an insufficient level of commitment from the part of the stakeholders to implement the mitigation options outlined in the Initial National Communication. This may be due to the insufficient number of technology options proposed in the INC or to the lack of incentives and interests for implementing the options or measures. At the present, with the advent of high fuel prices, the economic reform programme and the global financial crisis create circumstances that can change the situation as individuals and companies have to save and become more efficient.

The mitigation options proposed in this Second National Communication (SNC) focus on what is realistic and feasible based on long-term observations in Seychelles. As investors are a key player in the implementation of the technology options, foreign investment regulations need to be improved accordingly. It should be noted that there are other benefits to be derived than only a reduction of GHG emissions, and as such will mean energy savings which directly translate into financial savings.

The most cost-effective technology options for mitigating CO_2 emissions in the energy supply sector are Cogeneration, CCGT and wind turbines. Solar PV is still an expensive option.

3.3 Mitigation of GHG in the Transport Sector

3.3.1 Introduction

The road transport sector of Seychelles remains as a major contributor to GHG emission as reported in the national GHG inventory reports for the years 1995 and 2000. The transport sector is proven around the world to be a significant contributor of GHG emissions. As a result of this situation, the impact on global warming and climate change is significant and, as such, all effort must be taken to mitigate the emission of GHGs from this sector. Since the pollutants from vehicle exhaust emission are released at ground level, these have a direct effect on the quality of air that we breathe and they are also very dangerous to human health. The effect of sea level rise will impact directly on the road infrastructure, since Seychelles is a small island developing state and most of the major roads are situated along the coast line. Therefore, it is in the national interest for the country to adopt and implement GHG mitigation options for the road transport sector.

3.3.2 Why Mitigate Emissions of GHGs and Benefits of Mitigations

The main GHG emitted in the road transport sector is carbon dioxide. Pollution from vehicles exhausts also include discharges like carbon monoxide (CO), unburned hydrocarbons (HC), lead (Pb) compounds, nitrogen oxides (NO), soot and aldehydes, among others. Apart from directly affecting humans by causing various human health problems, GHGs, mainly carbon dioxide, contribute to greenhouse warming resulting in climate change on a global basis. In Seychelles, there is the need to be concerned about the adverse effects that vehicular pollution may cause since it can affect the population. Even though the Seychelles Islands contribute to an insignificant level of GHG emissions on a global scale, it must still find ways to effectively mitigate the release of these gases, since this will benefit both human health and the state of the environment.

It is therefore expected that mitigating GHG emission would lead to significant benefits, but the benefits would not be accrued free of costs, as any abatement measure would entail significant level of costs. The GHG mitigation options could bring about certain economic benefits to the country or could cause inconveniences to other related parties, especially with respect to the issue of high taxes on fuel, road taxes, import restriction of used cars, etc. High taxes on gasoline or scrapping old vehicles may lead to economic costs to people; phasing leaded petrol can involve people shelling out large sum to retrofit the carburetor engine to fuel-injection system; retrofitting CNG (Compressed Natural Gas) engines may force people to change their consumption behaviour. The costs could be numerous but studies have argued that a more favourable ratio of benefits to costs would be expected in countries that are early with their pollution abatement efforts, especially the developing countries and economies in transition.

Reduction in GHG emission will involve a similar reduction in fuel consumption in the transport sector, and this will benefit the country which relies heavily on imported petroleum products, ie, gasoil and gasoline as well as in terms of managing the national energy demand.

3.3.3 Mitigation Options Technology For Transport Sector

The various mitigation technology options that could be considered for the road transport sector of Seychelles are highlighted below. Some of these options were proposed in the INC and have been proposed again, since these have not been implemented yet.

3.3.3.1 Use of other Types of Fuels

SEPEC has conducted a pilot project on the use of LPG in cars with successful results and presently there are two such vehicles being used on Seychelles roads. However, the results of the study have not been made public and SEPEC has not promoted the use of such fuel for vehicular use. The study should be made available to the general public to encourage them to move to such an alternative technology and fuel. There is also the potential for use of hybrid vehicles and also the use of biodiesel. The use of biodiesel could help to revive the coconut industry.

3.3.3.2 Use of Solar Energy to charge for Electric Buggies

Large hotels, especially those on the outer islands, are being encouraged to use solar buggies. This could lead to a reduction of CO_2 by 42 tonnes for 15 such vehicles. The Fregate Island Resort, have replaced 10 buggies with 14 solar buggies, this has reduced fuel consumption by about 4,752 gallons per year which has resulted in a saving of 41.677 tonnes of CO_2 emission a year (based on the UK Department for Environment guidelines). Government should make this a requirement for all large hotel resorts, especially those on the outlying island, to reduce the transportation and use of fuel.

3.3.3.3 Operation of an LRT/Electric Train/Tram System

A feasibility study has been carried out through a research thesis by an MSc student. Government is now moving towards implementing such a project for an Light Rail Train (LRT) system and the private sector is being requested to tender their intent. The light rail project concept is to be located along the north, east and south corridor (in fact north-south corridor), starting from La Retraite to Anse Royale passing through the reclaimed area and through the airport. The best economic system for the Seychelles' situation will be a monorail system which is fully electric as it will integrate very well with vehicular traffic. The one being proposed by the promoter and which is being encouraged by Government will have a capacity of 200 passengers. Such a system should be operating in parallel with the public bus service. The impact that this will have is that it will reduce the demand on SPTC buses, reduce in fuel and GHG emission. It will leave SPTC to concentrate more on the secondary routes and cross island traffic.

The LRT system can contribute to reduce the number of trips that are provided by the SPTC buses, since a larger number of passengers can be transported in one trip. This will contribute to reduce the amount of fuel consumed by the buses and also more commuters will use the LRT system, since it will be a much improved system as compared to the journey on the bus. The way the project has been presented on television has led to a lot of commuters looking forward to such a service.

3.3.3.4 Road Improvement Programme

The road improvement programme must continue, especially now that there is the issue of degradation of the existing road infrastructure by heavy duty vehicles that are being used to transport construction materials and containers. The by-pass roads for Victoria are much needed to reduce congestion in the town centre and to also reduce fuel consumption. New roads are to be constructed to serve the development on the newly reclaimed land. The extension of the dual carriage road from Providence to Anse Etoile is also to be considered. There are also much needed improvements on most of the secondary roads to facilitate the need of the public transport system.

3.3.3.5 Integrated Land-Use and Transport Planning

This entails the use of policies to ensure that urban structure, building forms, land-use locations, development designs, subdivision and street layouts help achieve the following planning objectives:

- To improve accessibility to housing, employment and services by walking, cycling, and public transport;
- To improve the choice of transport and reducing the dependence solely on cars for travel purposes;

- To moderate growth in the demand for travel and the distances travelled, mainly by cars.
- To support the efficient and viable operation of public transport services;
- To Provide for efficient movement of freight.

In Seychelles, the concept of integrated land-use and transport planning has not always been followed. Therefore, there is a need for Government to be more attentive when new housing projects are being planned to incorporate transport planning within it. The aim is to bring all the services residents need closer to their home in order to minimise the need for travel. Recently, with the creation of Ile Perseverance Housing Estates, the concept of land-use integration has been well used since the two newly created districts on Ile Perseverance will have their own shopping mall, schools, clinics, churches etc. There is also a hotel project that will even create employment opportunities for the residence. All of these infrastructure will prevent residents from travelling to the city centre, hence reduce the need to travel. There is also a good road network on Ile perseverance with bus stops not further than 400 metres from the furthest houses to allow efficient use of public transport when necessary.

3.3.3.6 Traffic Management in Victoria

A study for traffic management in Victoria was completed in early 2007 and the recommendations are being implemented. The study assessed the current and future traffic demand patterns as well as the analysis of the safety of road users in Victoria and its surroundings. From the report it was clear that the existing level of congestion is one of great concern, and several roads and junctions had already reached their capacity and if a ‘do nothing situation’ is adopted traffic in Victoria will grind to a halt. With an estimated 50% increase in the level of traffic over the next 10-15 years, several proposals were made with the aim to improve safety, circulation of traffic and improve the capacity of several junctions. A by-pass road has been included as a recommendation and the detailed design is being prepared.

The projects that have been proposed in the study are:

- Increasing traffic lanes on several roads e.g. Independence Avenue; Olivier Maradan; Albert Street, Francis Rachel St.; 5th June Avenue;
- Increasing the capacity of roundabouts;
- Installation of traffic lights at major junctions, e.g. Palm St.; Manglier St; Bel Air Junction; Bel Eau Junction;
- Construction of roundabouts at Union Vale and Bois De Rose;
- Construction of a by-pass road to connect the south to the north;
- Implementing segregation of pedestrian/vehicular traffic;
- Construction of footpaths/overhead footbridges;
- Constructing a by-pass road between Mont Fleuri and Bois De Rose.

3.3.3.7 Vehicle Maintenance Programme

Vehicle maintenance is a key area in reducing GHGs in vehicles. In order to achieve this, it is being proposed to sensitise vehicle owners, drivers, Vehicle Testing Station (VTS) and garages. This can be done by introducing the following:

- Prepare literature on the best practices on maintaining a vehicle which will be distributed to vehicle owners and garages;
- Transmit such information through the media, ie., television, radio and newspapers;

- Conduct training programmes with garages so that they can become more conscious on such matters;
- Prepare a grading programme for mechanics and garages so that they can become more professional in service delivery;
- Upgrade the vehicle testing station and train the staff to become conversant with new technology and deliver a better service;
- Sensitise the vehicle owners to use qualified and reputable garages for servicing their vehicles.

The technologies used by vehicles have changed quite rapidly over the years. In order to ensure that vehicles remain within their required operating condition at all times, it is proposed that a study be carried out to come up with an action plan to cover for the following:

- Upgrading of infrastructure, equipment, and resources used by garages;
- Upgrading the knowledge and skill of mechanics;
- Grading of garages and the mechanics;
- Upgrading of services provided by garages;
- Controls of activities and services provided by garages;
- Vehicle owner education programme.

3.3.4 Proposed Mitigation Measures

There is a need to define policies that have the potential to stabilise and reduce transport related CO_2 emissions, and in the case of land transport, the policies related to the reduction in fuel consumption have been adequately defined. The measures to be implemented to attain the objectives set out from the policies must be politically and socially feasible. The GHG mitigation measures must be fully justified by other policy objectives. In principle, the most economically efficient measure is the introduction of pricing mechanisms that reflect the full social and environmental costs of transport, but this could be difficult to implement for technical and also socio-economic reasons. Since the publication of the INC, Government and the Land Transport Division (LTD) has implemented a number of measures aimed at reducing the amount of fuel consumed in the transport sector to a sustainable level. These measures should be maintained to ensure the type and number of vehicle are being controlled, and that fuel consumption by vehicles remains sustainable. The measures are listed below:

3.3.4.1 Measures affecting Light-Duty Road Vehicles

Long-term management of GHG emissions for light-duty vehicles is likely to depend on implementing wide-ranging strategies involving several areas of policy making and levels of government. The strategies might involve a variety of measures: fuel economy standards, fuel taxes, incentives for alternative fuel use, measures to reduce vehicle use. The relative effectiveness of policies depends on national circumstances, including existing institutions and policies, and on the underlying technology trends. Measures to reduce GHG emissions from cars are normally appropriate for other light-duty vehicles such as light trucks, vans, minibuses and sport utility vehicles. These vehicle types increasingly are being used as personal vehicles, leading to higher GHG emissions. This increasing use could be encouraged if such vehicles are not subjected to the same measures as cars.

3.3.4.2 Maintaining High Fuel Prices

Higher fuel prices can act as an incentive to the purchase of fuel-efficient cars, or simply drive less. Fuel taxes can be a powerful tool in influencing the overall driver behaviour, thereby help to reduce traffic congestion and vehicle emissions. From the economic standpoint, fuel taxes are often described as the most effective means of reducing consumption of fuel. The political feasibility of sizeable tax hikes is an issue, as well, given that substantial price hikes may lead to public resistance. One way to avoid this might be to attenuate the impact of higher prices through a gradual and progressive rise in real fuel prices. In this way, consumers can gradually adapt to the price changes. Avoiding tax-related distortions by reducing taxation in other areas is also important to assure the overall efficiency of the market.

Since in Seychelles the tax on fuel is already high, making fuel expensive, any further increase in fuel tax must be carefully examined before introduction. The revenue collected from an increase in fuel tax could be used to implement other measures for the mitigation of GHGs. It has previously been observed that increase in fuel price has not generally led to reduction in fuel consumption; in fact there has been a gradual increase in the vehicle population, resulting in a gradual increase in gasoline and gasoil consumption. Therefore, this is not always considered as a suitable mitigation option, since vehicle owners have the need to travel and therefore quickly adjust to the price increase. It must be noted that the prices of gasoline and gas oil have been increased significantly since the beginning of the 2008 due to increase in fuel prices on the world market and also as a result of the devaluation of the local currency

3.3.4.3 Promote the Use of Public Transport System

Whilst there has been improvement in the public transport service, the bus fares have remained very nominal. Government has been subsidising the SPTC bus services over the years. The number of passengers has increased from 1.4 million in 1977 to over 12 million in 2000. The SPTC transport an average of 37,000 passengers daily, not including the 4,000 students for which there are special bus services. Due to present economic difficulties that the country is facing, Government has been finding it difficult to continue subsidising the SPTC. Government has decided to privatise the contract services and is also studying the possibility of privatising certain routes which are being serviced by the SPTC. Private sector participation is essential to ensure availability of fund to maintain investment in the public transport system and to keep the service to an acceptable level. Government should continue to provide support to the SPTC so that it can support its programme to make public transport available to all users at an affordable price, as well as maintain an acceptable level of comfort and safety for the passengers. Government should consider introducing a reduction in the price of gasoil purchased by the SPTC for its buses. This could be in the form of a refund in the trades tax paid on gasoil. It must be noted that this might create precedence as Government has allowed the private sector to operate contract bus service in direct competition with SPTC.

3.3.4.4 Road Taxes

Government should maintain and revise the existing road taxes, which stand at R 1/cc for Light Duty Vehicle (LDV) and R 0.5/kg for Heavy Duty Vehicle (HDV). The rate for HDV should be revised to reflect the costs of road repairs. The revenue collected should be used to implement road maintenance programmes. A proposal has been prepared to be submitted to Government for consideration and it proposes a tax due to the damage that such vehicles caused to the roads. However, such a tax if adopted will have consequences to the consumers of such a service, since the service provider will pass on the cost to the customers.

3.3.4.5 Lower Taxes for Fuel-efficient Vehicles

Government should introduce trades tax reduction for fuel-efficient vehicles and increase trades tax on fuel-inefficient vehicles.

3.3.4.6 Carbon or CO_2 Tax

This could be introduced from measurements obtained from the Vehicle Testing Centre for the emissions of CO and HC, or from odometer readings (kilometres travelled) to compute energy consumption/emissions of CO_2. This could be technically difficult to introduce in Seychelles. More research must be done to ascertain the best way to implement such a proposal. Experience from countries or states which have implemented such a measure must be obtained and analysed.

3.3.4.7 Emission standards and mandatory vehicle inspection/testing

Emission standards for CO and HC have been developed and declared, and are being implemented by the Vehicle Testing Centre (VTC). It is mandatory for all vehicles to be inspected and tested annually by the VTC for issue of road permit before a road license is issued by the Licensing Authority. The VTC measures emission levels for compliance to the emission standards and pronounces on the road worthiness of vehicles after a thorough inspection and checks. This has helped to increase vehicle engine performance and to control emissions. It has also helped to sensitise vehicle owners on efficient operation of vehicle. Of late, the equipment for measuring emission has not been functioning. This should be rectified at the earliest so that vehicles can be tested correctly. There should be more regular check on older vehicles and this should also cover spot check on the road. There is the need to revise the vehicle emission standards to bring them up to date to appropriate limits of emission.

3.3.4.8 Import Restriction for Used Vehicles

A new policy and regulation on the importation of vehicles came into force since 2006 which further reinforces the ban on importation of second hand vehicles, except for returning residents and graduates as their personnel belongings, and also on trucks/pick-up trucks and plants for commercial activities only. This restriction should be maintained, but the duty and levy on new cars should be re-looked at to ensure that vehicle owners can replace their old and inefficient vehicles.

3.3.4.9 Control of Movement of Heavy Duty Vehicles

The present restriction on the movement of HDV such as cranes, container carriers and other heavy plants should be maintained and properly enforced.

3.3.5 Baseline and Mitigation Options Scenario

The baseline scenario assumes that the business as usual approach will be maintained up to 2030, and that existing conditions and measures within the road transport sector will remain unchanged. This could well be the case in future since the use of technology for mitigation of GHG emission in this sector is very limited, and the most viable mitigation options will be to maintain the existing measures that have assisted to limit the growth of fuel consumption in this sector. The mitigation scenario is based on the proposed mitigation options as per details given above. It is well known that the consumption of fuel in the road transport sector will continue to grow as a result of ongoing economic development and also as the standard of living is improved. Therefore, the implementation of mitigation measures is vital in order to limit the growth in fuel consumption and subsequent growth in GHG emission. It is proposed that the mitigation options be implemented as of now, so that by 2010 there will be a 5 % reduction of GHG emission compared to if the business as usual approach is maintained. The target for the years ahead should be set as follows: 10 % reduction in GHG emission by 2015; 20 % by 2020; 25 % by 2025 and thereafter maintain the target at 25 % (see Table 3-12 and Figure 3-8).

Table 21: CO_2 Emission (tonnes) for the Baseline and Mitigation Scenarios

	1990	1995	2000	2005	2010	2015	2020	2025	2030
Baseline	41,186	46,068	57,921	66,525	80,754	96,390	117,310	139,998	167,087
Mitigation Scenario					76,716 **(5%)**	86,751 **(10%)**	93,848 **(20%)**	104,999 **(25%)**	125,315 **(25%)**

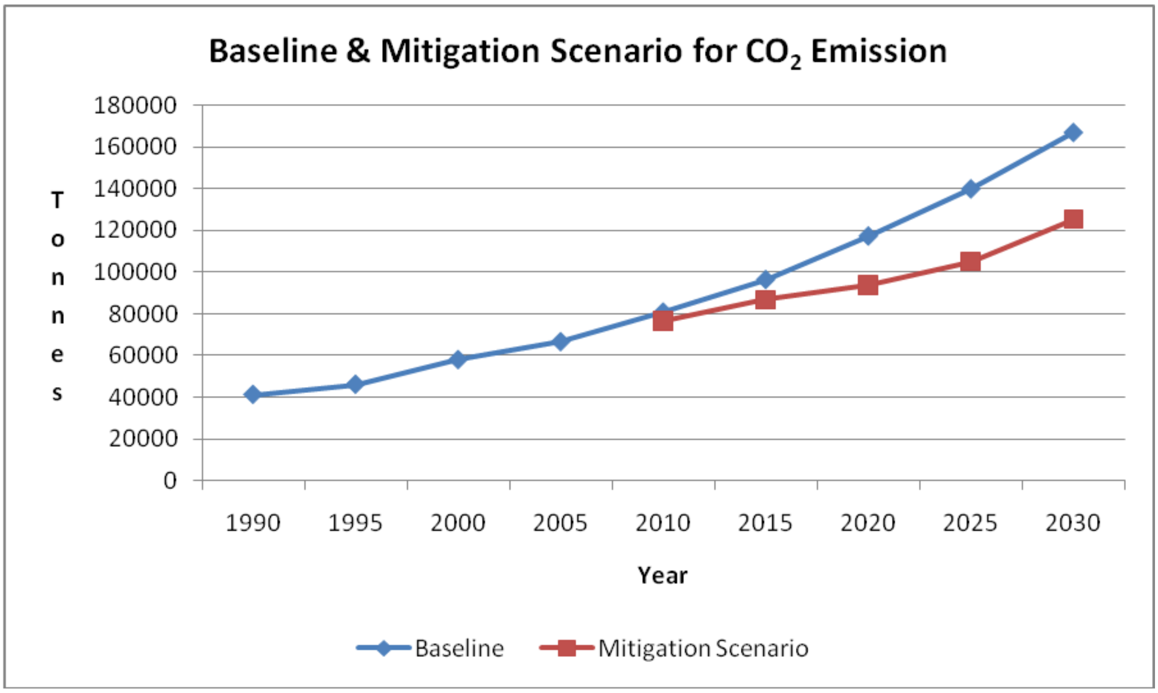


Figure 26: Trend and Projection for CO_2 Emission from 1990 to 2030

3.3.6 Costs and Benefits of Mitigation Options

The Table 22 below summarises the costs and benefits of mitigation technology options for the transport sector.

Table 22: Costs and Benefits of Mitigation Options

Mitigation Options	Cost	Benefits
Technology		
Use of other types of Fuels	High	Lowered emission
Use of Solar Energy to charge Electric Buggies	Low	Lowered emission
Operation of an LRT/Electric Train/Tram System	High	Improved public transport system. Increased number of commuters. Lowered use of private vehicles. Reduced use of buses. Reduced fuel consumption & GHG emission.
Road Improvement Programme	Medium	Reduced maintenance costs. Reduced fuel consumption and GHG emission.
Integrated Land-Use and Transport Planning	Low	Housing estate served with public transport system. Reduced use of private vehicles. Reduced fuel consumption and GHG emission.
Traffic Management in Victoria	Medium	Reduced traffic congestion. Reduced fuel consumption and GHG emission.
Vehicle Maintenance Programme	Low	Vehicles operating efficiently. Reduced fuel consumption and GHG emission.
Use of solar street lights	Medium	Reduced consumption of electricity and GHG emission.
Measures		
Measures for Light Duty vehicles	Low	Reduced emission of GHGs
Maintaining High Fuel Prices	Low But at the expense of	Reduced emission of GHGs

	increasing the cost of living and doing business.	
Encourage and Promote the use of Public Transport	Low	Reduced emission of GHGs
Road Taxes	Low	Tax collected could finance GHG mitigation projects.
Lower taxes for fuel efficient vehicles	Low	Reduced emission of GHGs
Carbon/CO_2 Tax	Low	Tax collected could finance GHG mitigation projects
Emission standards and mandatory vehicle inspection/testing	Low	Reduced emission of GHGs
Import restriction for used vehicles	Low	Reduced emission of GHGs
Control of movement of Heavy Duty Vehicles	Low	Improved traffic flow. Reduced emission of GHGs

3.3.7 Recommendations

The goal of implementing the GHG mitigation options in the road transport sector is to contribute to reduce the adverse effects on the global climate as a result of global warming caused by GHGs. Even though the road transport sector of Seychelles contributes marginally to the overall amount of GHG emissions and on the effect of global warming and climate change, there is still a need to find ways to effectively mitigate the release of GHGs in this sector. This is because there is a need to protect the well-being of our citizens and to form part of the global mitigation process for reducing GHGs for mitigating the effect of climate change that is going to affect small island states such as Seychelles.

In Seychelles, the land transportation sector is one of the main contributors in the release of GHGs in the atmosphere. This study has shown that the amount of GHG emission will continue to rise as a result of the ongoing development process, the rise in the standard of living and the present state of the public transport system.

In 2005, the vehicle population was 10,622 and this is expected to rise to around 20,000 by the year 2020. As a result of the expected growth in the vehicle population, there will be the inevitable increase in fuel consumption and the subsequent increase in the amount of GHG emission. In 2005, the amount of fuel consumed was 22.45 KTOE (15,992 tonnes) and the amount of CO_2 emission was 57,921 tonnes. By 2015, the fuel consumption is projected to reach 32.61 KTOE (30,920 tonnes) and the CO_2 emission will be 96,390 tonnes. By 2025, the fuel consumption is projected to reach 47.39 KTOE (44,920 tonnes) and the CO_2 emission will be 139,998 tonnes. These figures are alarming for a small country like the Seychelles, but this can be prevented from happening by introducing effective mitigation options for GHG emission. The business as usual scenario should not be allowed to continue and greater effort must be placed on the implementation of the proposed mitigation options.

If the proposed mitigation options are implemented, it will limit the growth rate of fuel consumption and the emission of GHGs as indicated in the business as usual approach. It is proposed that the reduction target should be set as follows: 5 % by 2010; 10 % by 2015; 20 % by 2020 and 25 % by 2025 and thereafter maintain the target at 25 %.

Therefore, Government must prioritise the mitigation options in order to achieve the reduction target that has been set. These targets are achievable because the mitigation measures can be accomplished. The reduction of GHG emission will be both beneficial in terms of promoting a cleaner ambient air for our citizens to breathe and at the same time contribute to the global reduction of GHG emission. This is important globally to prevent any further deterioration in the global climate that can affect the world, including small island states like Seychelles.

3.4 Mitigation of GHG in the Residential, Commercial and Institutional (RCI) Sectors

3.4.1 Introduction

Greenhouse Gas (GHG) emissions from the residential, commercial and institutional (RCI) sectors are as a result of both direct combustion of fuel and indirectly through the consumption of electricity. As per the Second National GHG Inventories of Greenhouse Gases, 2,084 tonnes of LPG were consumed in the residential sector in 2000. This represented around 4 % of the total energy consumption of the country. This resulted in the emission of 5,375 tonnes of CO_2, which represented around 0.7% of the CO_2 emission from energy consumption. The commercial & institutional sector consumed 12,887 tonnes of gas oil and 336 tonnes of LPG respectively in 2000.

As the consumption pattern of energy in the residential sector is different from the commercial and institutional sectors, these have been treated separately. Mitigating GHG emission in the RCI sectors through energy conservation measures will bring benefits both to that sector and to the environment. Any energy conservation measures will lead to a reduction in the energy bill thus a saving for the consumers of residential, commercial and institutional sectors.

3.4.2 Overview of the Residential, Commercial & Institutional Sectors

3.4.2.1 Residential Sector

The Seychelles' population stood at 88,311 (NSB, 2010) according to the latest census carried out in August 2010 and the number of households was 24,142. The Ministry of National Development (MND) has the portfolio responsibility for the development of the housing sector. Government's policy is to ensure adequate supply of housing and basic services for all. Government's policy is also to make available land, material and financial resources to families who aspire to own their own homes. As per the present National Development Plan, Government aims to build an average of 1000 houses every year.

The overall performance of the economy of Seychelles is heavily dependent on the importation of refined petroleum products to meet the national energy needs and for the international bunker fuels. In the residential sector, fuel is used directly in the form of liquid petroleum gas (LPG) mainly for cooking purposes. It was Government's policy to replace kerosene by LPG for cooking for social and economic reasons. A programme for replacing kerosene stove with LPG stove started in 1998, and by 2000, there was a complete switch from kerosene to LPG for domestic cooking. Electricity is the other main source of energy consumed in this sector. Electricity is produced by PUC using internal combustion engines that run mainly on heavy fuel oil (HFO) and as a result greenhouse gases are emitted into the atmosphere.

3.4.2.2 Commercial & Institutional Sectors

The commercial and institutional sectors comprise of hotels, guest houses, restaurants, take away vendors, retailers, government buildings, schools, hospitals, etc. These sectors are almost entirely dependent on electricity, gas oil and LPG as the main energy sources. Gas oil is used to produce electricity for hotels that are situated on outlying islands where the PUC electricity grid is not available. LPG is mainly used for cooking. In hotels and guesthouses, electricity is used to operate air-conditioning and refrigeration appliances, water heating for bathing, lighting, and for running other plants and machineries. In the institutional sector, electricity is used mainly to operate the air-conditioning system, lighting and office appliances. CO_2 is the main GHG emitted from this sector.

3.4.2.3 Future Plan for the RCI Sectors

Significant investment has been made in line with the economic development in the RCI sectors. Government's plan is to encourage the development of a commercial sector and business ventures that have some comparative advantages and have minimum adverse impact on energy consumption of Seychelles. Government promotes socially and environmentally sustainable housing development programmes to address satisfactorily the housing demand and to improve the living conditions of all Seychellois. Government encourages foreign investors to invest in the tourism industry. Government's policy is to make better use of renewable energy as an alternative source of energy in these sectors to reduce the dependency on petroleum products.

In the residential sector there are more housing development projects being undertaken, such as the Ile Perseverance housing project, with a total of 2056 housing units. A significant numbers of tourism establishments are being constructed and thus there is a need to take action in terms of carbon emission reduction as there is more pressure on the energy demand to meet the requirements of these developments. A programme of Demand Side Management (DSM) needs to be put into place, aiming at reducing the demand for electricity. A programme of energy conservation measures and the use of renewable energy technologies should be put into place to cater for future development, since the energy demand from this sector will continue to grow. Thus it is very important for Government to formulate and start implementing energy conservation measures that will contribute to the mitigation of GHG emission from this sector.

3.4.2.4 Data Collection and Analysis

The main constraint encountered while doing this mitigation exercise was with data collection. However, most of the data were available at the Energy Section of MND, at the SEPEC and at the PUC. Request was sent to the respective organisations and data were supplied accordingly but not in the time frame needed. There were a lot of inconsistencies in data reporting from the sources. Most of the commercial and institutional data were given separately. Therefore, the data for residential, commercial and institutional consumers had to be sorted out amongst other data in the consumer's list data that were supplied by SEPEC. As for the electricity data for the commercial and institutional sectors, these had to be partitioned by a ratio of 65%/35 % between the commercial and the industrial sectors.

PUC acknowledged that it cannot separate data from the commercial and industrial sector's data list because these fall under the same tariff and therefore are under the same category. Not all data requested were in the format needed. Conversions of data received had to be made in some cases such as litres into tonnes, and into ktoe. The NCCC should work in liaison with the NSB to set up a framework for energy data collection and archiving. The system for data collection, analysis, storage and dissemination need to be set up to facilitate the preparation and reporting of future GHG mitigation options to meet the country's obligation to the UNFCCC.

3.4.3 Energy Consumption in the RCI Sectors

3.4.3.1 Residential Sector

The Table 3-14 shows the energy consumption in the Residential Sector from 1997-2007 to be increasing.

Table 23: Energy Consumption in the Residential Sector from 1997 to 2007

Year	LPG (tonnes)	LPG (ktoe)	Electricity (GWh)	Electricity (ktoe)	Total (ktoe)
1997	560	0.63	42.7	3.67	4.31
1998	1,200	1.36	43.6	3.75	5.11
1999	1,759	1.99	48.9	4.21	6.19
2000	2,084	2.35	52.2	4.49	6.84
2001	2,350	2.66	54.9	4.72	7.38
2002	2,697	3.05	58.6	5.04	8.09
2003	2,707	3.06	62.6	5.38	8.44
2004	2,725	3.08	64.8	5.57	8.65

2005	2,712	3.06	67.1	5.77	8.84
2006	2,903	3.28	70.8	6.09	9.37
2007	2,971	3.36	77.6	6.67	10.03

Source: SEPEC actual sales report

3.4.4 Commercial and Institutional Sectors

The Table 3-15 shows the energy consumption in the the Commercial & Institutional Sectors from 1997 to 2007 to be increasing.

Table 24: Energy Consumption in the Commercial & Institutional Sectors from 1997 to 2007

Year	LPG (tonnes)	LPG (ktoe)	Gas Oil (tonnes)	Gas Oil (ktoe)	Electricity (GWh)	Electricity (ktoe)	Total (ktoe)
1997	187	0.21	4,089	4.23	63.1	5.43	9.87
1998	210	0.24	8,500	8.80	68.6	5.90	14.94
1999	253	0.29	8,679	8.98	77.9	6.70	15.97
2000	336	0.38	12,887	13.34	87.9	7.56	21.28
2001	243	0.39	12,075	12.50	89.7	7.71	20.60
2002	350	0.40	12,731	13.18	93.1	8.01	21.59
2003	389	0.44	12,036	12.46	102.2	8.79	21.69
2004	430	0.49	11,682	12.09	99.8	8.58	21.16
2005	502	0.57	12,480	12.92	104.2	8.96	22.45
2006	609	0.69	14,081	14.57	118.5	10.19	25.45
2007	721	0.81	14825	15.34	119.4	10.27	26.42

Source: SEPEC actual sales report

3.4.4.1 Trend and Projection of Energy Consumption

Projection of energy consumption in the residential sector is based on the linear model which looks at the past performance of the consumption of energy in this sector and determines the growth rate. The least square method approach has been used to find the best line fit and forecasts the value in the RCI sector.

3.4.5 Residential Sector

The Table 3-16 shows the energy consumption in the Residential Sector from 2000-2030 to be significantly increasing

Table 25: Projection of Energy Consumption in the Residential Sector from 2000 to 2030

	2000	2005	2010	2015	2020	2025	2030
Electricity (ktoe)	4.49	5.77	6.93	8.31	9.69	11.06	12.44
LPG(ktoe)	2.35	3.06	4.44	5.76	7.09	8.41	9.74

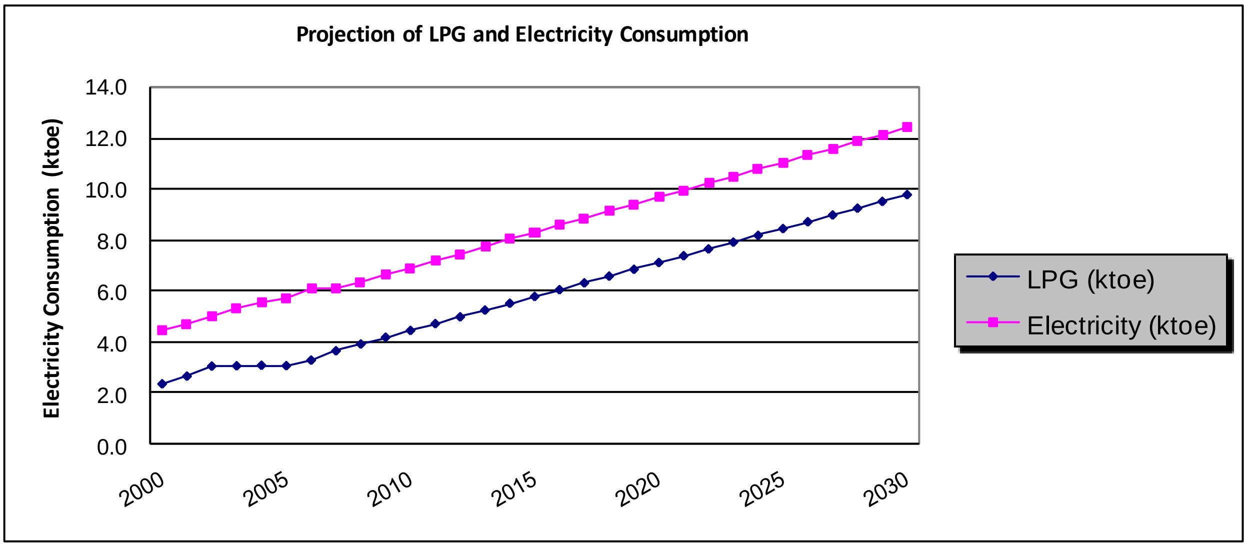


Figure 27: Projection of LPG and Electricity Consumption (ktoe) yearly

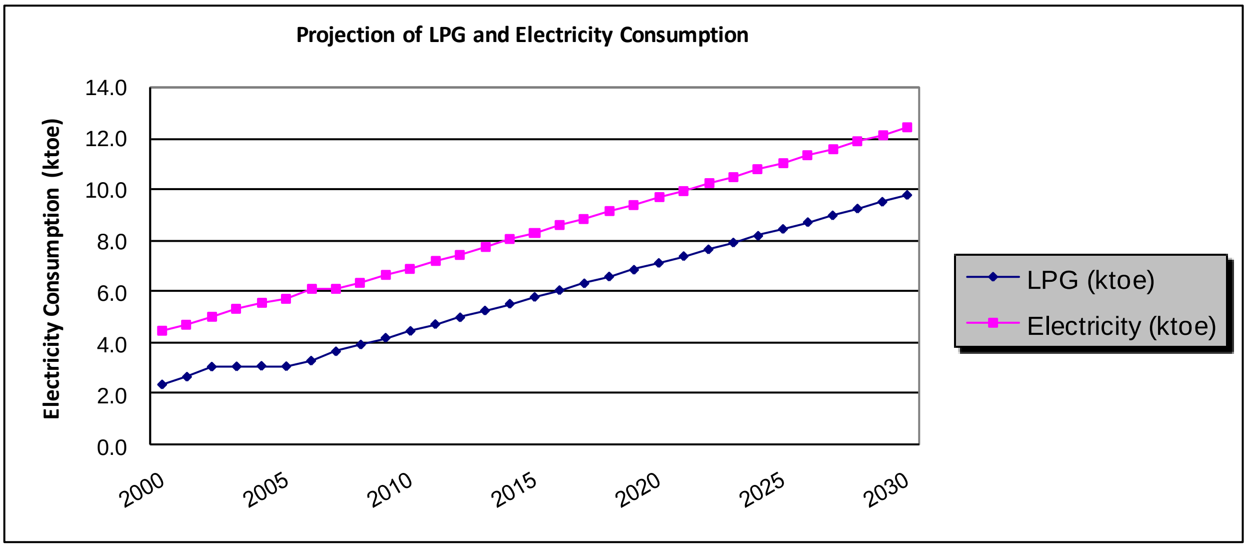


Figure 27 shows the trend of electricity consumption in kilotonnes of oil equivalent (ktoe) with an average growth rate by 3.5 % annually and that for LPG, which is primarily used for cooking, shows an average growth rate of 4.9 % annually. It is to be noted that the consumption for kerosene and LPG was combined in the first mitigation option report. The projection of electricity was higher, with an AAGR of 5.8% compared to the 3.5 % now.

3.4.6 Commercial and Institutional Sectors

The Table 3-17 shows the energy consumption in the Commercial & Institutional Sectors from 2000 to 2030 to be increasing significantly when comparing the period 1997-2007.

	2000	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Electricity (ktoe)	7.56	8.96	7.21	8.59	9.96	11.34	12.71
Gasoil (ktoe)	13.34	12.92	18.30	22.40	26.51	30.62	34.75
LPG (ktoe)	0.38	0.57	0.81	1.05	1.29	1.52	1.76

Table 26: Projection of Energy Consumption in the Commercial & Institutional Sectors from 2000 to 2030

3.4.7 Total Energy Consumption

The Table 3-18 and Figure 3-10 show the total energy consumption in the Residential, Commercial & Institutional Sectors from 2000 to 2030 to be increasing significantly when comparing to the period 1997-2007.

Table 27: Projection of Total Energy Consumption from Residential, Commercial and Institutional Sectors from 2000 to 2030

Sectors with values in ktoe	2000	2005	2010	2015	2020	2025	2030
Residential	6.84	8.83	11.37	14.07	16.78	19.47	22.18
Commercial & Institutional	21.28	24.45	26.32	32.04	37.76	43.48	49.22
Total	28.12	31.28	37.69	46.11	54.54	62.95	71.4

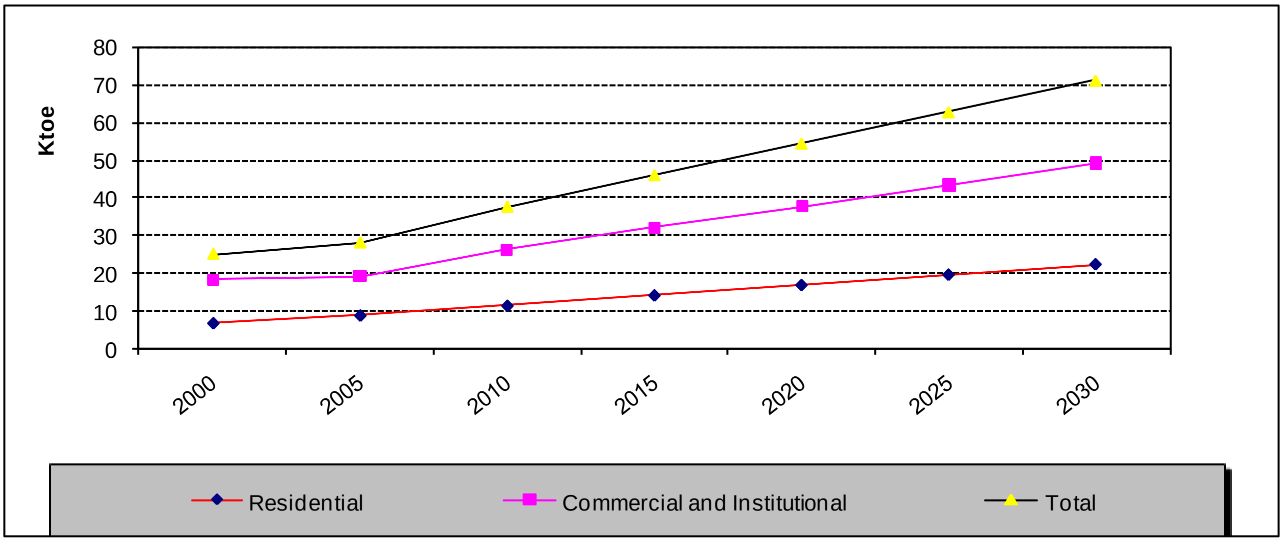


Figure 28: Projection of Total Energy Consumption from Residential, Commercial and Institutional Sectors from 2000 to 2030

3.4.8 Trend and Projection of CO_2 emission in the Residential, Commercial and Institutional Sectors

The estimation of emissions of GHGs from fuel combustion in the residential, commercial and institutional sectors has been calculated using the IPCC methodology and as per the details given in the GHG inventories report. Only CO_2 has been considered, since it is the most significant GHG released from fuel combustion. The Table 3-19 below shows thevalue of emission factors for all fuel type being used in Seychelles.

Table 28: Emission Factors for Fuel Type

Fuel Type	Net Calorific Value	Emission Factor
Gasoil	43.33	73.326
Fuel oil	40.19	76.593
Kerosene	44.75	71.148
LPG	41.31	62.436

Table 29: Projection of CO_2 Emission in the Residential Sector

Year	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Direct (tonnes)	6,156	8,010	11,016	14,153	17,290	20,427	23,564
Indirect (tonnes)	75,461	101,850	115,210	138,423	161,636	184,849	208,062

The direct carbon dioxide emission shown in

Table 29 and Figure 3-11 is obtained from the use of LPG mostly for cooking in the residential sector. The indirect emission is a result of electricity consumption since electricity is produced by the thermal power station. Electricity is used to operate various electrical appliances in this sector. The annual average growth rate from the direct and indirect emissions is projected to be 4.5 % and 3.4 % respectively.

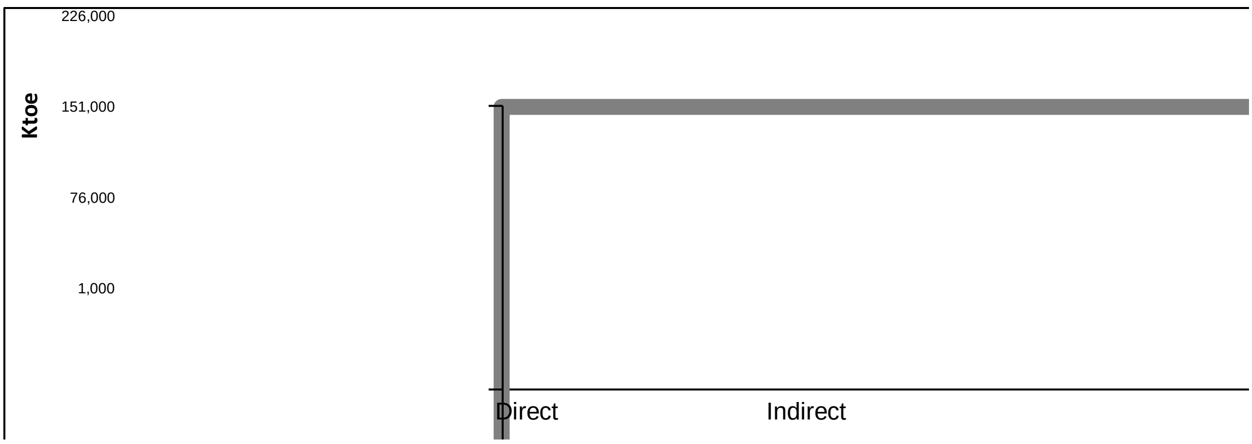


Figure 29: Projection of CO_2 Emission in the Residential Sector

From Table 3-21 and Figure 3-12 reveal the projection of CO_2 Emission in the Commercial and Institutional Sectors till 2030. As shown in the Figure 30, the emission of CO_2 is expected to increase to 106,393 tonnes in 2030 compared to 41,937 tonnes in 2000. The annual average growth rate from the direct and indirect emissions is projected to be 3.2 % and 3.5 % respectively.

Table 30: Projection of CO_2 Emission in the Commercial & Institutional Sector

Year	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Direct (tonnes)	41,937	41,135	54,955	67,814	80,674	93,533	106,393
Indirect (tonnes)	127,051	145,680	195,527	234,947	274,367	313,787	353,207

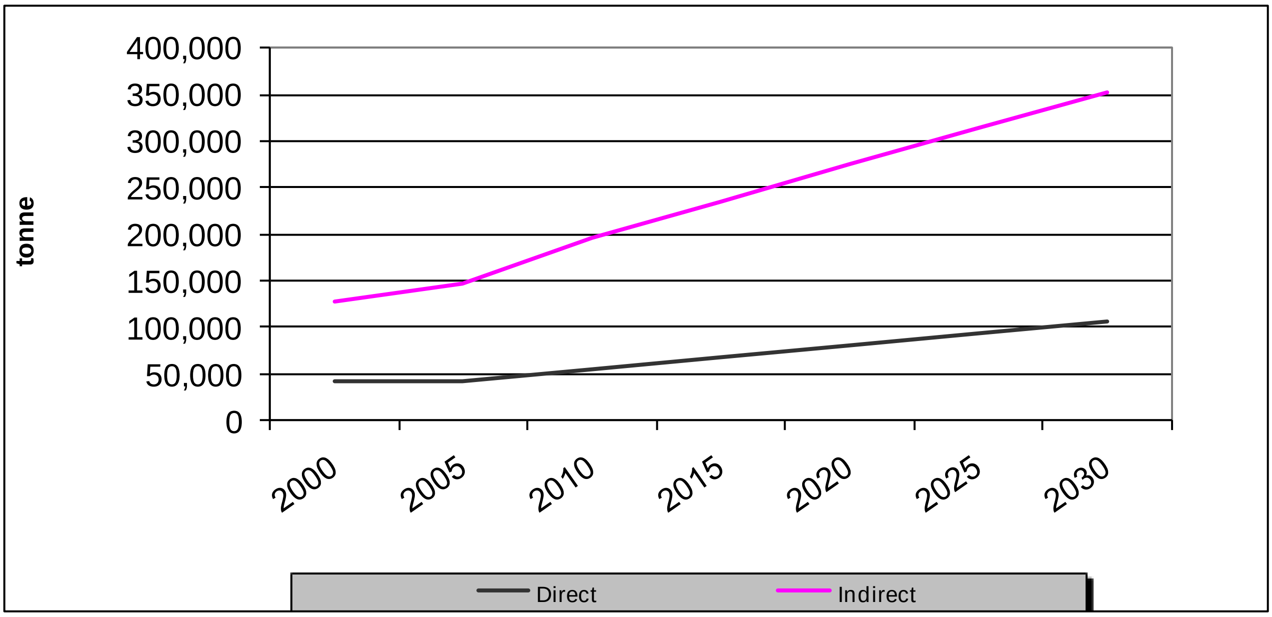


Figure 30: Projection of CO_2 Emission in the Commercial & Institutional Sectors

Whereas Table 3-22 and Figure 3-13 show the Projection of Total CO_2 Emission from Residential, Commercial and Institutional Sectors from 2000 to 2030.

Table 31: Projection of Total CO_2 Emission from Residential, Commercial and Institutional Sectors from 2000 to 2030

	2000	2005	2010	2015	2020	2025	2030
Total direct CO_2 (tonnes)	48,093	49,145	65,971	81,967	97,964	113,960	129,957
Total indirect CO_2 (tonnes)	202,512	247,530	310,737	373,370	436,003	498,636	561,269
Total CO_2 emission (tonnes)	250,605	296,675	376,708	455,337	533,967	612,596	691,226

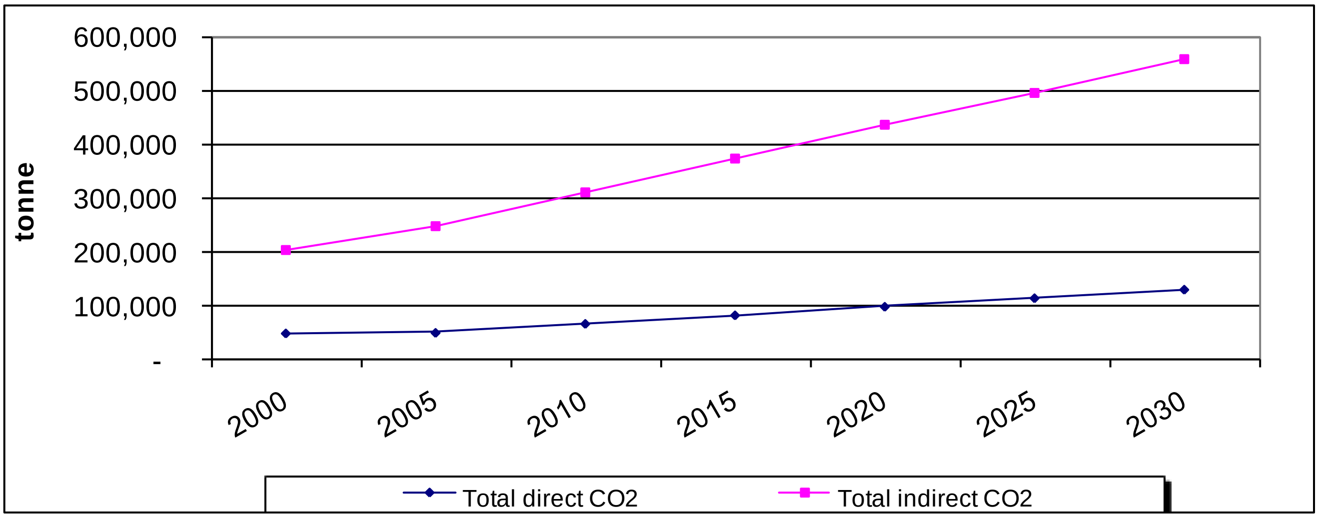


Figure 31: Projection of Total CO_2 Emission

Table 32: Projection of CO_2 Emission from Residential, Commercial and Institutional Sectors from 2000 to 2030

Year		**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Direct (tonnes)	Residential	6,156	8,010	11,016	14,153	17,290	20,427	23,564
	Commercial & Institutional	41,937	41,135	54,955	67,814	80,674	93,533	106,393

Total (tonnes)		48,093	49,145	65,971	81,967	97,964	113,960	129,957
Indirect (tonnes)								
	Residential	75,461	101,850	115,210	138,423	161,636	184,849	208,062
	Commercial & Institutional	127,051	145,680	195,527	234,947	274,367	313,787	353,207
Total (tonnes)		202,512	247,530	310,737	373,370	436,003	498,636	561,269

Table 32 above shows the direct and indirect carbon dioxide emissions in the residential, commercial and institutional sectors. The direct emission is as a result of fuel combustion to produce heat or electricity. The energy used is either in the form of LPG for cooking or diesel consumed by boilers and generators for producing hot water and electricity in hotels. The indirect GHG emission of CO_2 results from the use of electricity (produced by thermal power station) to operate various types of electrical appliances and equipment used in the RCI sectors.

3.4.9 Technologies and Measures for reducing GHG Emissions in the RCI Sector

The possible mitigation options presented below consist of a number of projects which if implemented in the short and medium terms will bring some benefits in term of energy conservation and thus limit emission of GHGs in the country. Capacity building in those areas is also very important to ensure sustainability of the mitigation option implemented.

3.4.9.1 Short Term Strategies

There are a number of low-cost, easy to implement methods that can be applied in the residential sector in order to decrease energy use and GHG emission indirectly in each dwelling. These are:

- Replace electric water heater with solar water heater;
- Replace incandescent bulb with CFL;
- Use most energy efficient appliances where appropriate;
- Use gas cooker instead electric cooker.

3.4.9.2 Technologies Options for the Residential Sector

Replacing Electric Water Heater with Solar Water Heater

In 2007, only 175 solar water heaters (SWH) were imported into the country compared to 810 electric water heaters. The average price of a solar water heater today is approximately SR 20,000 while compared to an electric one at SR 1500. This shows that the costs of non-electric water heaters are still high when compared to an electric one. Since 14.3% of households are owned by government, solar or gas water heater should be introduced in those as a lead example with a view to introduce these energy saving projects. There should be a national programme for replacing electric water heater with SWH. This should be coordinated by EAB/MND, PUC & SEYPEC.

There are still many households using electric water heaters for domestic use. By replacing these electric heaters with efficient solar water heater significant benefit could be achieved, and that would reduce the energy consumption and also help in the reduction of CO_2 emission in that sector. Government should promote the use of solar water heater in the domestic sector as follows:

- Sufficient incentives, including financial mechanism to invest in modern efficient technologies (SWH);
- Removal of GST on efficient solar water heater imported in the country;
- There is a need to have policy /regulation that helps stronger enforcement in the implementation of SWH in new housing development.

Replacing Incandescent Bulb with CFL

Electricity demand through lighting energy use can be reduced by 50% by the use of CFL which would also help in the reduction of GHG emission. Private sector and NGOs should be involved in the dissemination of information on energy project such as efficient lighting.

Some proposed options that can be explored to introduce the use of efficient lights in the country are:

- National programmes that aim to replace incandescent bulbs in households and workplaces nationwide with the energy efficient compact florescent lamps (CFLs) should put in place;
- The use CFL instead of incandescent lamp where appropriate;
- Make use of daylight (natural light) and daylight sensor to dim and switch off electric lighting;
- Use the most efficient lighting device available on the market;
- Subsidise the cost of CFL and other efficient lamps imported in the country;
- Tax removal on such appliances;
- Raise awareness campaign on the use of these efficient lamps.
- A national programme should implemented involving the participation of related government department or parastatal organisations such as PUC & SEPEC. It is proposed that PUC orders a stock of CFL and distributes to consumers. The consumers can then trade in their incandescent bulb for a CFL at a reduced price. PUC should then monitor whether the CFL bulbs are being used.

Use most Energy Efficient Appliances where appropriate

Refrigerators and freezers are appliances that use more energy to operate, and this contributes significantly to the electricity energy consumption in the domestic sector. Other appliances such as washing machines, electric irons and electronic appliances contribute significantly to energy consumption. It is therefore very important that these appliances are energy efficient. Appliances with high energy wattage such as the electric iron, electric heater, cooker, and kettle need to be used in an efficient manner. Change in life style and behaviour pattern of using these appliances will contribute to an energy saving. Energy conservation practices must be applied in homes to reduce their energy consumption. All appliances imported in the country should be energy rated using the star system. Regulations need to be put in place and these appliances should be compliant with the regulations. Dissemination of information on efficient energy appliances should be put in place either through the media to enable customers to be well informed on the usage of these appliances. There should be yearly survey of electrical appliances to assess their compliance to the energy efficiency rating.

Use of Gas Cooker instead of Electric Cooker

As per the 2002 census carried out by the NSB, there are 87 % of households in Seychelles that were using LPG for cooking, 2.1 % were still using kerosene and 7.4 % were using electricity. It is expected that with the increase in price of kerosene, those households that were using kerosene would have started to use LPG. For those households that are still using electricity for cooking, Government should put in place a mechanism for replacing their electric cooker with an LPG cooker. With the latest increase in electricity tariff, it is expected that these households will definitely see the advantage of making the shift. This will bring added benefit to the electricity production system since it will assist to reduce the electricity demand, especially at peak hours. This will mean that less fuel will be needed with less emission of GHGs.

3.4.9.3 Technologies Options for the Commercial and Institutional Sectors

The mitigation options considered are as follows:

- Use of solar water heater;
- Use of compact fluorescent lamp;
- Use of energy efficient appliances;
- Use of photovoltaic system for lighting;
- Use of efficient air-conditioning system.

Use of Solar Water Heater

Presently, a large number of hotels and guest houses are still using the electric water heater. Some of the large hotels are using industrial boilers that consume gasoil or fuel oil to produce hot water. So water heating contributes to high energy cost, and the amount of energy needed is quite high as the new electricity tariff has increased by 132% for units consumed below 500 kWh and by 161% for units consumed above 500 kWh. Some of these tourism establishments are situated on the outer islands, and as such, fuel need to be transported in bulk to meet their energy needs. However, mitigation measures need to be implemented to limit the GHG emission in this sector. Gas or solar water heater should replace electric water heater in the commercial buildings. The developer in the tourism sector should incorporate solar water heater and other rational use of renewable energy in the project memorandum. Large scale solar water heater projects should be implemented on the outer islands to reduce the fuel usage/ transportation to generate electricity for the hotels. This requirement should form part of the conditions for planning approval; any project that relies solely on electric water heater should be rejected, and the developer should be requested to include solar water system in the design.

Use of Compact Fluorescent Lamp (CFL)

There are commercial and institutional buildings that are still using incandescent bulbs and tube lights as their main lighting sources. These bulbs are being used as security lights and are not really efficient and consume lots of energy. The use of energy efficiency compact fluorescent lamp instead of incandescent bulb, in the commercial and institutional buildings, could help in reducing their cost of energy consumption. Central lighting in buildings will be more practical and efficient in terms of energy conservation. Light equipment fitted with timers or sensors should be encouraged for use in security lighting system.

Use of Energy Efficiency Appliances

The commercial and institutional sectors are the third largest energy consumer in the country. It is in these sectors that there is significant use of inefficient energy appliances. These appliances range from office equipment, food services equipment to laundry equipment, etc. By replacing these equipment with more energy efficient technologies it would help to reduce the energy consumption and have significant GHG emission reduction. Energy audit should be conducted to identify the energy inefficient equipment and advice should be given on how to access energy efficient appliances.

Use of Photovoltaic System for Lighting

This option is to be considered for all hotels, especially those on outer islands. Big buildings that have large roofs should also use PV for lighting, especially for security lights. Government needs to provide necessary advice and incentives to facilitate adoption of this technology.

Efficient Air-conditioning System

All commercial and institutional establishments are using air-conditioning system to cool their buildings and this consumes a large proportion of their electricity usage, and is also responsible for a large share of the electricity load demand. It is therefore necessary to promote the use of efficient air-conditioners in this sector so that electricity is used efficiently, and the load is managed properly. The technology that could be used include air-conditioning systems cooling recovery, use of centralised air-conditioning system instead of split units, use of air conditioning system enhancer which will increase the overall delivered efficiency. This will increase the efficiency of the air- conditioning with savings on the electric bill.

Some the strategies to adopt to encourage the use of efficient air-conditioning system include:

- Guideline should be established on how to select between central air-conditioning system or individual system based on the size of the building;
- New criteria with respect to energy conservation measures shall be added in the approval process for new commercial & institutional building applications by the Planning Authority;
- Provision must be made to have roof with adequate gradient along with well-ventilated roof void;
- Glass louvers must not be used if an air-conditioning system is installed;
- Make use of new efficient air–conditioning system with temperature sensor.
- Improve on the placement of appliances (eg. place them in a shaded area);
- Automatic air-conditioning control system must be installed.

3.4.9.4 Measures for the Residential Sector

Voluntary Agreements

- Energy education programmes and energy conservation practice can have significant impact on the amount of energy consumed in the residential sector;
- Incentive on energy efficiency appliance, renewable energy and mechanism should be put in place to achieve these objectives;
- Government should put in place system for voluntary replacement of electric water heater with SWH, and incandescent bulbs with Compact Fluorescent Lamp (CFL);
- A national energy efficiency programme should be developed with the objective of promoting the efficient use of energy throughout the country.

Regulatory Measures

- Mandatory energy efficiency standards for imported energy consuming appliances can ensure that the consumers will have the choice and the quality of appliances and this could benefit the consumers in their energy bill;
- Strengthen the policy regarding energy efficiency programme in the residential building;
- Re-evaluate the prices of CLF on the market. Pricing resources at their true cost to the consumers ensuring that the users know the true value. High prices of energy efficiency lamps encourage consumers to buy low cost inefficient bulbs and impede the introduction of energy efficiency technology (CFL);
- The electricity tariffs should be reviewed and this should be reflected in the monthly bill of the consumers who make sufficient energy savings;
- Mechanism should be set up to ensure that changes in foreign exchange costs of energy are reflected in the tariffs at regular interval. The current tariffs have generally not been sending the correct signals on the issue of the cost of supply of energy;
- Consumers should be well versed on the need to increase tariffs prices and how to use electricity wisely;
- The plumbing system in household should be incorporated with points for solar water heaters installation;
- The price of LPG should be maintained at optimum cost to encourage consumers using this type of fuel for cooking;
- Tax on the incandescent bulb has to be raised from 0% to 150% to discourage it use.

3.4.9.5 Measures for the Commercial and Institutional Sectors

The Incorporation of Energy Efficient Measures and Standards in Building Design

Building design and orientation sometimes does not take into consideration how various energy end-use activities will be implemented. Inefficient use of lighting and air-conditioning systems is sometime a direct result of bad design and orientation of the building. It is quite common to find an air-conditioning system which does not match the space to be cooled, windows that are not properly sealed, direct sunlight entering the rooms, inadequate temperature control, etc. Proper design and orientation of buildings would contribute towards the reduction of energy consumption and emission of GHGs. Government, through the Planning Authority, should introduce energy efficiency measures and standard designs, and designers should put these standards into practice. Government should introduce legislation to make it conditional for hotels on outer islands to incorporate solar water heater and photovoltaic system in their design, and to also incorporate design based on natural ventilation system.

Energy Audits for Commercial and Institutional Buildings

There should be regulatory requirements for these establishments to carry out regular energy audit and put in place energy management plan. Energy audit would need to be undertaken within the scope of an energy management plan to ensure sustainable and efficient use of energy. This would be an effective method for the introduction of energy efficient use and conservation measures, which could result in conservation of energy and reduction in emission of GHGs. The energy audit could identify areas where there is energy wastage, and action could be undertaken to limit these wastages and reduce energy consumption. Government should put in place measures for energy audits in commercial and institutional buildings which should be undertaken on yearly basis. This should be carried out by private sector consultants that have the necessary expertise in energy audit, and the audit findings are to be submitted to the appropriate government body for evaluation and monitoring of the recommendations. These institutions should be encouraged to introduce and operate under an environment management system and government should facilitate this process. This would benefit these institutions in terms of capital and energy savings, and also the country in term of management of the environment and the reduction in GHG emission.

Energy Efficiency Regulation

Government should consider the introduction of energy efficiency regulations to ensure that organisations are complying with energy standards. This will encompass the organisations being audited regularly to see if they are complying with the regulations. Awareness and guideline on energy conservation should be put into place in the entire commercial and institutional establishments.

Some energy regulations to be considered are:

- Importation of **energy star rated products** should be compulsory and make them affordable in the country;
- **Energy management plan** to ensure that energy wastage in the commercial & institutional buildings are kept at a minimum level. Monitoring system to check the performance of the energy management plan should be put in place;
- **Building regulation** to ensure that the buildings are energy efficient in term of air-conditioning load;
- **Tax incentive** for commercial businesses should be given so that they can apply energy management and make use of energy efficient appliance in buildings. Loan programme should be affordable to any business providing energy efficient appliances to the market;
- Commercial buildings e.g (hotels) installing solar water heaters for hot water use or photovoltaic for generating electricity should be eligible for **tax credit;**
- **Economic incentive** strategy to promote clean and efficient technologies eg: energy efficient appliances such CFL, air-condition, office equipment in the commercial and institutional buildings;
- Encourage wide use of Photovoltaic cells, through **demonstration projects** such as the installation of PV panels on rooftops of public buildings to generate electricity;
- Mechanisms and incentives should be put into place to encourage **foreign and local investors** to invest in projects for alternative sources of energy.

3.4.9.6 Cost and Benefit Analysis for the Mitigation Options

Despite significant advances in the technology, solar collectors still make a very modest contribution to the total energy consumption for water heating purposes. One of the major factors explaining this is that relevant investment decisions are based on market prices which do not reflect positive environmental impacts and other benefits associated with the exploitation of solar energy. Table 33 below provides the social benefits of the solar water heater compared to an electric water heater.

Table 33: Comparison between the Cost of Installing Solar and Electric Water Heater

Type of system	Initial cost (SR)	Installation cost (SR)	Capital Cost (SR)	Energy required (kWh/d)
Solar	20,000	1000	21,000	0
Electric	1,600	1000	2,600	7.33

With the newly revised electricity tariff, the amount of energy required from an electric water heater per day for each household is approximately 7.33kWh which averages SR 21 per day. This is in comparison to a solar water heater the energy cost of which is zero. A number of guest houses and hotels are still using eclectic water heater and industrial boiler fuelled by gasoil or fuel oil to produce hot water. As the price of electricity in the commercial sector has increased by 132% below 500 kWh and 161% above 500 kWh measures should be taken as a means to reduce their energy consumption in terms of hot water use and hence limit the indirect emissions. The mitigation options to be considered are given in Table 34.

Table 34: Mitigation Options for the RCI Sectors

Mitigation Option	Cost	Benefit
Technology Options		
Replacing electric water heater with solar water heater	Medium	Reduction in electricity demand, electricity bill, energy consumption and GHG emission.
Replacing incandescent bulb with CFL	Low	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Use of energy efficient appliances	Low for residential, Medium for commercial & institutional building	Less maintenance costs. Reduction in electricity demand, electricity bill, energy consumption and GHG emission

Replacing electric cooker with LPG cooker	Low	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Use of photovoltaic system for lighting	High	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Use of efficient air-conditioning system	High	Lowers maintenance costs. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Measures		
Introduction of energy efficiency regulations	Low	Appliances with longer running life and less maintenance costs. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Revision of tax on incandescent bulbs	Low	Encourages consumers to use CFL. Reduces the need for regular replacement of bulbs. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Revision of electricity tariff	Low	Lowers consumption
Incorporation of solar water plumbing system in building design	Low	Facilitates consumers to use solar water heater. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Incorporation of energy efficient standards in building design	Medium	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Energy audits for commercial and institutional buildings	Medium	Availability of data for good decision making by management. Reduction in electricity demand, electricity bill, energy consumption and GHG emission

3.4.9.7 Baseline and Mitigation Scenario

Table 35 and Figure 32 below illustrate the CO_2 emission pattern for business as usual and for the mitigation scenario. The baseline scenario is based on the doing nothing approach and that the CO_2 emission will continue to rise as per past trend. The mitigation scenario is based on the implementation of the most practical and feasible mitigation options in the next five years and the other options to be implemented after 2015. If the three sectors (RCI) could make substantial effort to implement the mitigation options over the next 5 years, the amount of expected CO_2 emission in 2015 could be reduced by 10 %.

The implementation of the proposed mitigation options is expected to have significant impact on the reduction of CO_2, and it is expected that in 2015 a reduction of 10 % (45,534 tonnes) can achieved and that by 2020 an overall reduction of 20 % (106,793 tonnes) can be achieved. After 2020, the reduction is expected to stabilise at 25 % (153,149 tonnes).

Table 35: CO_2 Emission for the Business as Usual and for the Mitigation Scenario

Year	2000	2005	2010	2015	2020	2025	2030
CO_2 emission – Business as Usual Scenario (tonnes)	250,605	296,675	376,708	455,337	533,967	612,596	691,226
CO_2 emission – Mitigation Scenario (tonnes)			376,708	409,174	427,174	459,447	518,420

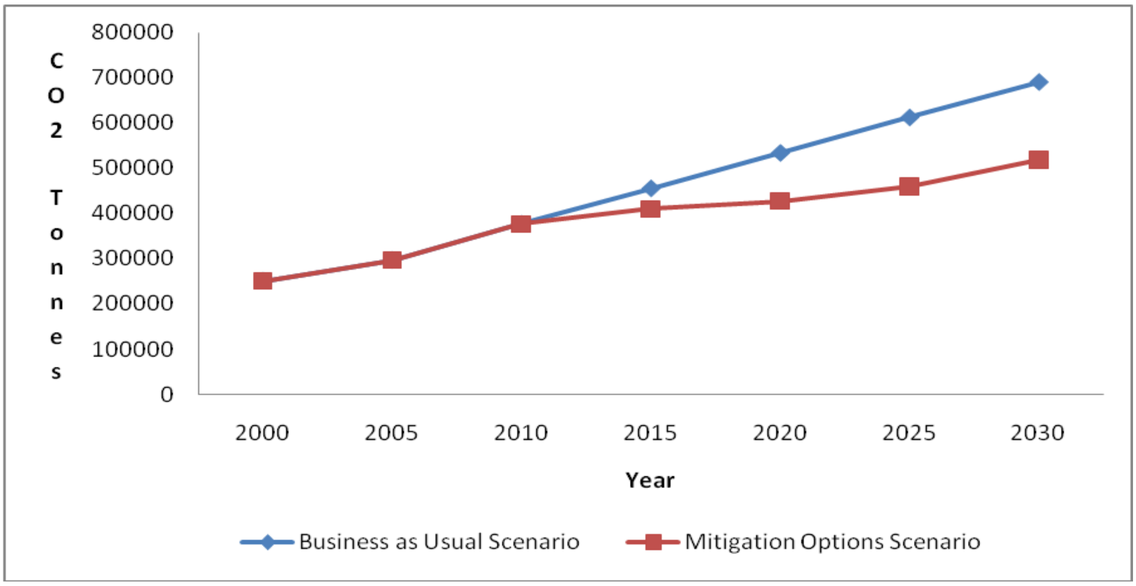


Figure 32: Projection of CO_2 Emission for the Business as Usual and for the Mitigation Options Scenario

3.4.9.8 Recommendations

The amount the GHG emitted from the RCI sectors has continued to increase as per the business as usual scenario. Most of the mitigation options proposed in the INC as part of the mitigation scenario have not been implemented. It is then expected that the energy consumption in the RCI sectors will continue to grow as a result of the ongoing development in these sectors and this will result in the continuous increase in the GHG emission. In 2005, 296,675 tonnes of CO_2 were released into the atmosphere from the RCI sectors. As forecast, in 2030 the emission of CO_2 is expected to reach 691,226 tonnes if the business as usual approach is to continue.

The mitigation options that have been proposed for the RCI sectors will definitely assist to limit the growth of energy consumption and thus limit the growth of CO_2 emission. If the mitigation scenario is adopted and put into practice, it will also help the country to limit the overall energy consumption and help to reduce the overall energy bill. The residential, commercial and institutional sectors should be encouraged to apply conservation practices and make use of all mitigation options that have been proposed to get the maximum benefit in terms of reduction of their energy bill, which in turn will limit the amount of CO_2 emission. There is a need to build and strengthen the capacity in the RCI sectors in order to ensure successful implementation of the proposed mitigation options. Enhancing information and data management is likewise considered to be very important to facilitate the preparation of good and sound project proposals and thereby assist the decision-making process. An energy balance sheet should be drawn up on a yearly basis by the organisation responsible for energy affairs and this will facilitate the implementation of any energy related projects in the future. Government, through the National Climate Change Committee, should increase its effort in facilitating the promotion and implementation of the mitigation scenario for the RCI sectors.

3.5 Mitigation of GHG in the Industrial Sector

3.5.1 Introduction

The industrial sector consists mainly of light and medium industries involved in manufacturing and construction. It is the second largest consumer of energy in the country. "The government's policy vis-à-vis the industrial development is to keep Seychelles free of heavy industries which may destroy the fragile and pristine environment. Emphasis is placed on viable light industries which are aimed at import substitution and exports and creation of employment." Mitigating GHG emission in the industrial sector through energy conservation measures will bring benefits both to the industries and for the environment. Any energy conservation measures will lead to a reduction in the energy bill, thus a saving for that particular industry or company.

3.5.2 The Energy Consumption in the Industrial Sector

Table 36 shows consumption of energy for the manufacturing and contruction processes within the industrial sector and please note the following:

Note 1: Unit: Tonnes of Oil Equivalent (TOE) and (tonnes); Note 2: Data for the years before 1997 have been reported in the first mitigation report which was published in 1998. Note 3: Factors used for converting tonnes to KTOE are as follows: Fuel Oil – 0.96, Gas Oil – 1.07, Electricity – 1 GWh = 86 KTOE

Table 36: Energy consumed in the Industrial Sector (Manufacturing and Construction Processes only)

Year	Fuel oil (tonnes)	Fuel oil (TOE)	Gas oil (tonnes)	Gas oil (TOE)	Electricity (GWh)	Electricity (TOE)
1997	507.23	486.94	4,329.19	4,480.72	22.35	1922.4268
1998	773.58	742.64	4,216.58	4,364.16	23.95	2059.6828

1999	1,108.83	1,064.48	4,033.85	4,175.03	24.59	2114.3745
2000	2,950.12	2,832.12	3,502.44	3,625.03	26.43	2273.3326
2001	3,712.05	3,563.57	2,605.47	2,696.66	25.44	2187.4272
2002	3,854.37	3,700.20	2,754.80	2,851.22	27.10	2330.8236
2003	3,777.62	3,626.52	3,349.69	3,466.93	28.11	2417.6922
2004	4,170.10	4,003.30	3,053.27	3,160.14	28.23	2427.8660
2005	3,242.06	3,112.38	3,817.52	3,951.13	28.69	2467.0863
2006	4731.03	4541.79	3559.57	3684.15	27.26	2344.2780

3.5.3 Trends and Projections of Energy Consumption and Projections CO_2 Emission from the Industrial Sector

Figure 33 shows the trends and projections of energy within the industrial sector whereas Figure 34 reveals the gas oil and fuel oil consumption. It also shows that between 1997 and 2000 most that were using gas oil as fuel for boilers switched to fuel oil. Whereas the projection of energy consumption in the industrial sector is based on linear model, which determines a linear growth rate, the Least Square Method approach has been used to find the best-fit line.

Table 37, Table 38,Table 3-30 and Table 3-31 show the projection of energy consumption in the industrial sector from 1997 to 2030. Whereas Figure 35 shows the results of the exercise in determining the future projections for CO2 emission by the industrial sector.

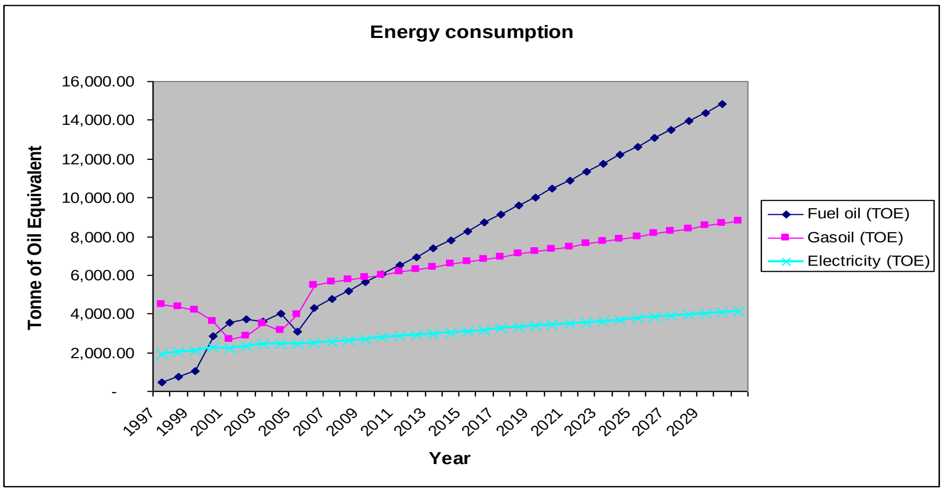


Figure 33: Trends and Projections of Gas Oil, Fuel Oil and Electricity Consumption in the Industrial Sector

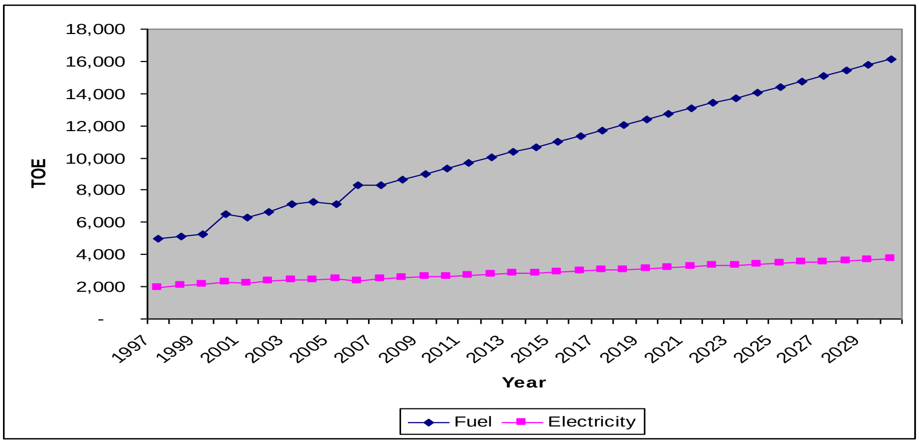


Figure 34: Trends and Projections of Fuel & Electricity Consumption in the Industrial Sector

Table 37: Projection of Energy Consumption in the Industrial Sector from 1997 to 2030

Energy Consumption	1997	2000	2005	2010	2015	2020	2025	2030
Electricity (KTOE)	1.92	2.27	2.47	2.65	2.90	3.19	3.45	3.72
Fuel (kTOE)	5	6.51	7.14	9.34	11.03	12.72	14.41	16.1

Table 38: Projection of Total Energy Consumption in the Industrial Sector from 1997 to 2030

Energy Consumption	1997	2000	2005	2010	2015	2020	2025	2030
Total Energy Consumption (KTOE)	6.92	8.79	9.60	20.00	13.95	15.91	17.86	19.82

Note: 1KTOE=42TJ

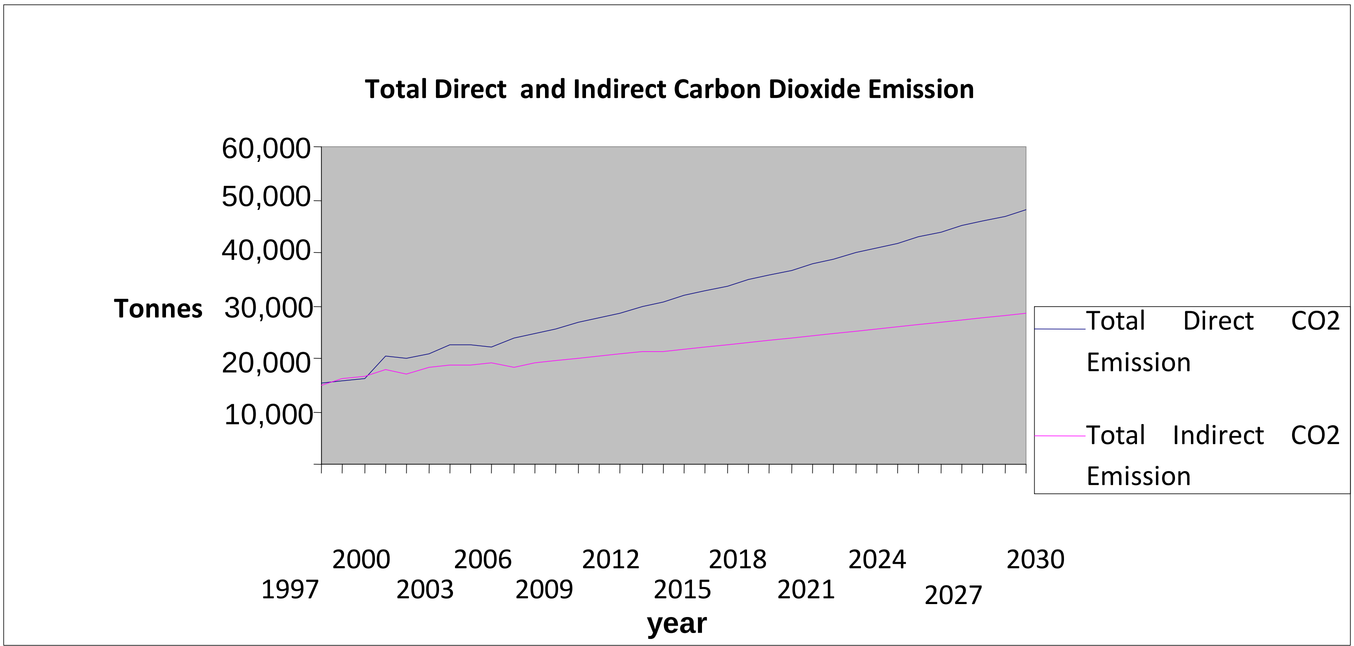


Figure 35: Trends and Projections of CO_2 Emission from the Industrial Sector

Table 3-30: Total CO_2 Emission from the Industrial Sector from 1997 to 2030

Year	**1997**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Total CO_2 released (tonnes)	30,354	38,044	41,498	47,921	55,064	62,208	69,351	76,494

Table 3-31: Technologies for reducing GHG Emissions, particularly Carbon Dioxide, in the Industrial Sector

Fuel Type	**Carbon Emission Factor**	**Net Calorific Value**	**Emission Factor - CO_2**
Gas Oil	20.2	43.33	73.326
Fuel Oil	21.1	40.19	76.593
Gasoline	18.9	44.80	68.607
LPG	17.2	47.31	62.436
Jet Kerosene	19.5	44.59	70.785
Kerosene	19.6	44.75	71.148

3.5.4 Technologies for reducing GHG Emissions, particularly Carbon Dioxide, in the Industrial Sector

3.5.4.1 Initiating New Technologies and Processes (Cleaner Production)

The driving forces for initiating new technologies and processes will vary according to the challenges and the characteristics of the existing situation in the industrial sector.

The main drivers will include:

- the need to maintain a leadership in the market and enhance competitiveness;
- the need to develop and assimilate new knowledge and technologies to evolve towards cleaner production;
- the need to reconcile different policy objectives with a view to a sustainable development of the industrial sector;
- the need to support development of new technologies by replacing ailing technologies in the industry sector.

Expected impacts of initiating new technologies and processes should:

- Reduce the overall energy consumption, wastage and GHG emissions while maintaining or raising the overall production output.

The Government of Seychelles should:

- Develop mechanisms for the introduction of efficient technologies and processes in the industrial sector;
- Identify and address obstacles for deployment and facilitate/ accelerate the market penetration of efficient technologies. The technology demonstration process will be an important element to facilitate the removal of inefficient technologies;
- Contribute to achieving a coherent and consistent policy and regulatory framework, taking into account both risks and benefits;
- Continue to increase public awareness, understanding and acceptance of the technologies concerned and the policy choices necessary to maximize benefits;
- Encourage financial institutions to grant assistance to industries interested in efficiency improvement;
- Recognise that products without markets are a waste of resources at all levels and should not be given the same priority as for well established marketed products.

3.5.4.2 Switching to less Carbon Intensive Industrial Fuel

Less carbon intensive fuel can bring great benefits through the reduction of carbon dioxide emission in the industrial sector, and Government should make Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) available to the industrial consumers so that they can replace existing technology such as boilers which run on diesel fuel with those that can run on natural gas. Though it is not cost effective to the Seychelles Petroleum Company (SEYPEC) in the short term, Government should be more involved in the reduction GHG emission and help industries acquire those alternative fuels.

3.5.4.3 Cogeneration

Industries are advised to install cogeneration equipment if they are auto-producers of electricity. Cogeneration has always been seen as a highly efficient means of generating heat and electric power simultaneously from the same energy source. The heat that would normally be wasted in the process of power generation can be re-used efficiently. Through the utilisation of the heat, the efficiency of cogeneration plant can reach 90% or more. Cogeneration therefore offers energy savings ranging between 15-40% when compared to the supply of electricity and heat from conventional power stations and boilers. Cogeneration can make use of the excess heat, usually in the form of relatively low-temperature steam exhausted from the power generation turbines. Such steam is suitable for a wide range of heating applications. The heat produced can be collected to pre-heat the boiler so that the amount of fuel needed to heat the boiler to the required temperature can be reduced significantly.

3.5.4.4 Cogeneration Benefits

Cogeneration is the most effective and efficient form of power generation. It allows for:

- Lowered emissions to the environment, in particular of CO_2, the main greenhouse gas;
- Large cost savings, providing additional competitiveness for industrial users;
- An opportunity to diversify generation plant and provide competition in generation. Cogeneration provides one of the most important vehicles for promoting liberalisation in energy markets;
- Increased employment. A number of studies by experts in this field have now concluded that the development of Combine Heat Process (CHP) systems is a generator of jobs.
- Improved local and general security of supply - local generation through cogeneration can reduce the risk that consumers are left without supplies of electricity. In addition, the reduced fuel need which cogeneration provides reduces import dependency.

3.5.4.5 Renewable Energy

With appropriate mechanisms in place many medium industries can adopt Renewable Energy Technologies (RET). Full scale application of RET in the industrial sector is still years to come due to its high investment cost and no local market availability. Seychelles has good solar radiation for the application of solar technologies (photovoltaic). Many industries in the Seychelles are encouraged to use solar water heaters for their production of hot water or to pre-heat water in boilers and make use of PV system to help minimise CO_2 from the main power station. The bureau responsible for energy issues of the country, should foster the adoption of variable RETS and seek international funding for pilot projects so that industries interested in RETS can have the opportunity to familiarise themselves and understand the technologies before they take the initiative of investing in them.

3.5.4.6 Measures for reducing Greenhouse Gas Emission in the Industrial Sector

Incentives

Government should ensure that the industrial sector is encouraged to conserve energy and adopt energy efficiency through various financial incentives or measures such as:

- ***Monetary incentives***: Cash grants for the purpose of conducting comprehensive energy audits and implementing corresponding measures to improve efficiency or to conserve energy or purchase replacement or retrofit equipment that is more energy efficient;

- ***Tax incentives:*** Refundable tax credit should be provided for the purchase of equipment or other capital expenditures that will result in quantifiable energy savings;
- ***Loan programme:*** Creation of an energy efficiency loan programme to offer low-interest loans for large capital expenditures to reduce energy consumption.

Tariff Structure

Tariff charges for the industrial sector are divided into two categories: the single-phase (tariff 210-220) and the three-phase (tariff 310-320). This has been revised early in 2008 due to the sudden increase in the oil price market. Government has taken the decision to revise the tariff every six months and the value of the new tariff will be determined by the situation of the oil price market during revision. The six month revision is too long and has to be reduced to one of at least three months. This is because SEPEC buys fuels and sells to PUC every three months and during that time the oil market could have gone up or down. In reality consumers are not paying what they should.

Carbon Tax

Seychelles has not implemented any carbon taxes but in the future when this would be well implemented it could play a significant role in the reduction of the total carbon dioxide emission annually. For the time being this subject should be left pending until the industrial sector is more energy conscious, willing to accept recommendations and to take on any challenges for a better Seychelles.

Emission Standards and Offset

Emission standards and offset have to be determined by the Seychelles' Bureau of Standards in collaboration with the Department of Environment to suit the current situation. A committee will need to be set up comprising of various stakeholders, hence this issue will be dealt with in greater depth. Many aspects have to be taken into consideration when determining the above such as economical, social and environmental aspects.

Voluntary Agreement

Voluntary agreement is recognised as an approach that is suitable to achieve a reduction in CO_2 in the industries. This can be implemented by each entrepreneur by developing an energy conservation plan or better known as an energy management programme that outlines the steps needed to reach targets that they would have set.

Energy Auditing

Energy auditing can be used to identify areas where there are energy wastages and losses in the industrial sector. It is a good tool for all companies in terms of energy savings and money savings. Conducting an energy audit will increase awareness of energy issues among personnel, making them more knowledgeable about proper practices that will make them more productive. Energy auditing can be performed by any industry at least every 2-3 years.

Research, Development and Demonstration Programme

Improving on the quality of products can help reduce cost and improve productivity. By doing so it reduces the amount of green house gases released in the atmosphere. It is important for industries to invest in research, development and demonstration programmes to improve the quality of their products. Every company is advised to take the initiative to research and develop new ways to improve their processes.

3.5.4.7 Baseline and Mitigation Scenarios

Figure 36 illustrates the CO_2 emission pattern for business as usual and the mitigation scenarios. The baseline scenario is based on the doing nothing approach and that the CO_2 emission will continue to rise as per past trend. The mitigation scenario is based on the implementation of the most practical and feasible mitigation options in the next five years and the other options are to be implemented after 2015. If the stakeholders of the industrial sector could make substantial effort to implement the mitigation options over the next 5 years, the amount of expected CO_2 emission in 2015 could be reduced by 15 %.

The implementation of the proposed mitigation options is expected to have significant impact on the reduction of CO_2 and it is expected that in 2015 a reduction of 15 % can be achieved and sustained to that level for the years to come.

Figure 36 shows how CO_2 emission will be reduced if 15% of carbon dioxide emission is eliminated each year from the projected emission output. The cost analysis below shows that if every company in the industrial sector replaces the incandescent bulb with the compact fluorescent bulb, then a decrease in electrical consumption of 15% will be achievable in that sector.

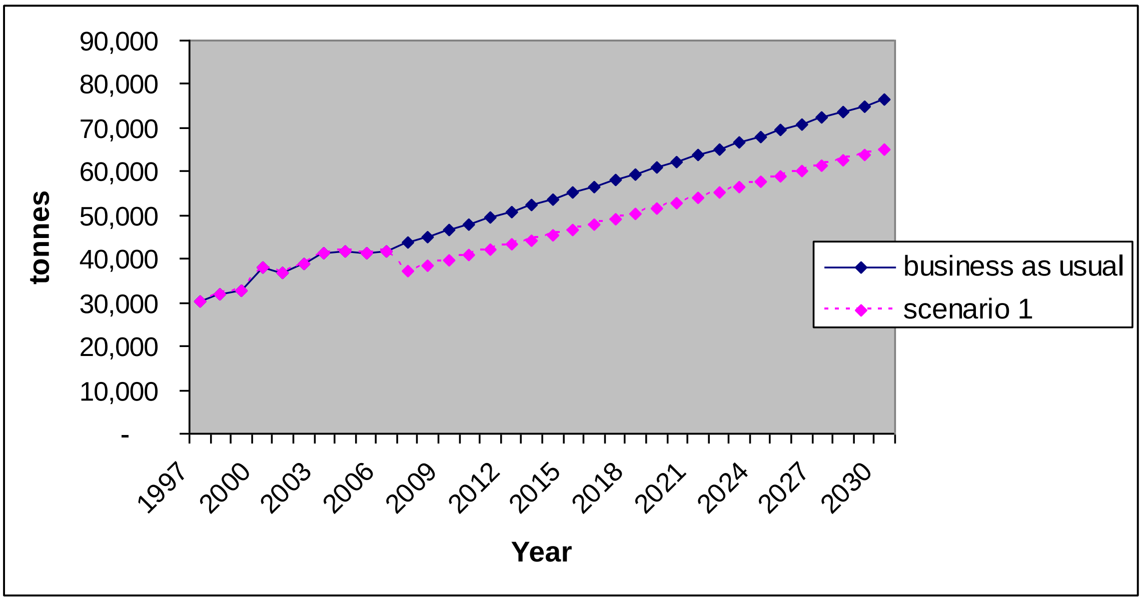


Figure 36: Trend and Projection of CO_2 Emission for the Baseline & Mitigation Scenarios

3.5.4.8 Cost and Benefit for the Mitigation Options

The adoption of new technologies and measures can significantly bring about potential benefits to the industrial sector and to the nation as a whole. If measures such as material recycling and substitution, incentives and awareness campaign are taken into consideration in the industrial sector, it will mean a reduction in GHG emission, production cost, and wastage. It will also improve the air quality, the socio-economic situation of the nation, health care, and create more wealth for the nation.

If solar water heaters were to re-heat water in boilers in the production of food and beverages in the industrial sector, then thousands of dollars could be saved from that sector. The Indian Ocean Tuna (IOT) being the largest consumer of fuel in the industrial sector spends around USD 2 million on fuel oil to heat boilers for the production of canned tuna. If IOT introduces solar water heaters to pre-heat water, then around 2000 litres (15%) of fuel could be saved per day. That is 730 kilolitres of fuel could be saved per year. This means a saving of USD 314,000 per year. The capital cost of solar water heaters is high but the payback period is expected to be short. So, if every industry pre-heats water with solar energy, then the energy consumption and production cost should be reduced by some 15-20%. Therefore, a total savings of 15 to 20% of GHG emission can be achieved in the industrial sector.

Again, if CFL were to completely replace the incandescent light bulb in the industries, then thousands of rupees could be saved in terms of electricity production. If each company in the Seychelles could replace five 40 watt incandescent lamps called the normal bulb with five 9 watt Compact Fluorescent Lamps called the CFL, then a saving of SR156.5 per year could be achieved per company for only five lamps.

3.5.4.9 Benefits

With 50,000 incandescent lights in operation for a period of four hours, it would cost the country around SR1.85 million or USD 232,000 in a year to generate the required electricity (see Table 39).

In comparison, it will cost the country around SR333,000 in a year to generate electricity for 50,000 9W CFL lights. That is by replacing 50,000 incandescent lights with 50,000 CFL, the country will benefit around SR1.5 million on production (see Table 403).

Table 39: Summary 1 - Industrial Benefits (Company Level)

Incandescent Lamp		**Compact Fluorescent Lamp**		
Power Rating (Watt)	Running Cost per year (SR)	Power Rating (Watt)	Running Cost per year (SR Million)	**Savings per year (SR Million)**
40W	40.2	9W	9.1	**31.1**
60W	60.45	13W	13.10	**47.35**

75W	75.55	18W	18.13	**57.42**
100W	100.75	25W	25.18	**75.57**

Table 40: Summary 2 - Production Benefits (PUC Level)

Incandescent Lamp		**Compact Fluorescent Lamp**		
Power Rating (Watt)	Production Cost per year (SR million)	Power Rating (Watt)	Production Cost per year (SR million)	**Savings per year (SR million)**
40W (5)	1.85	9W (5)	0.33	**1.5**

Note: Five bulbs are used to compare. All costing are done using existing tariff.

3.5.4.10 Fuel Switching

Switching to less carbon intensive fuel will mean a reduction in greenhouse gas (GHG) emissions. Indirectly, it will also mean an improvement in health care cost. The cost benefit to replace less carbon intensive fuel in the industrial sector of Seychelles will depend on the retail price of such fuel.

Natural gas is the preferred fuel to replace diesel for boilers but the facility for making natural gas available in Seychelles could be a big constraint. It involves a huge investment cost and it is not cost effective for the petroleum company in Seychelles.

3.5.4.11 Summary of Mitigation Options for the Industrial Sector

Table 41 outlines the cost and benefits of mitigation options for the industrial sector and its meadures.

Table 41: Cost and Benefit of Mitigation Options for the Industrial Sector

Mitigation Options	**Cost**	**Benefits**
Technology		
Use of new technologies and processes	High	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Switching to less carbon intensive fuels	Medium	Lowered maintenance cost. Reduction in energy consumption and GHG emission
Cogeneration	High	Utilisation of waste heat. Reduction in electricity demand, electricity bill, energy consumption and

		GHG emission
Use of renewable energy technology	High	Lowered maintenance cost. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Process improvement	High	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Material substitution	High	Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Measures		
Financial incentives	Low	Encouragement & recognition for energy conservation and environment management
Revision of tariff structure	Low	Better use of electricity. Reduction in electricity demand, electricity bill, energy consumption and GHG emission
Carbon tax	Low	Lowered emission of GHGs
Emission standards	Low	Lowered emission of GHGs
Energy audits	Low	Better management of energy use and data for decision making on energy conservation

3.5.4.12 Conclusion

Seychelles in the last ten years has not been able to reduce its CO_2 emission; in fact it has seen a continued increase in its emission. Not many of the options listed in the INC were implemented. The national consumption of energy has continued to rise due to the increasing development in the economic sector. Most of the new mitigation options highlighted above will have great potential benefits to the industrial sector in the coming years in terms of reduction in greenhouse gas emission and energy savings. Energy savings in an industry means lowering the cost of doing business, increases in competitiveness, productivity and profitability. If every industry in Seychelles makes significant contribution, the national greenhouse gas emission can be reduced by 15% in the next 20 years; particularly the CO_2 emission. This can be achieved by continued increase in the use of cleaner production technologies, adoption or implementation of energy conservation measures and the use energy efficient equipment and appliances.

3.6 Mitigation Of GHGs In The Land Use, Land Use Change and Forestry Sector

3.6.1 Introduction

The forestry sector remains the greatest national asset in the mitigation of CO_2 and other greenhouse gases. In the Initial National Communication, it was reported that the forests ensure that the Seychelles contributes towards removal of CO_2.

In the light of deterioration in the global environment, the Seychelles must ensure a strong policy for sustainable development, coupled with maintaining or upgrading current environment legislation. In the past, focus was only on forest related legislation to protect the forests, but there is a need to further explore how to better integrate sustainable development measures in the mitigation of climate change.

Sustainable lifestyle is an important aspect of mitigation of GHG emissions. This would provide opportunities to reduce impacts on already developed areas.

Proper management and utilisation of forest resources could further reduce national GHG emissions. An assessment will have to be carried out to find out an amount of biomass which could be sustainably harvested to substitute imported oil. Burning of biomass constitutes a closed CO_2 cycle.

3.6.2 Description of the Land Use, Land Use Change & Forestry Sector

3.6.2.1 Forest Area

In the 2001 Forestry Outlook Study (FOSA), Seychelles' total forest area was estimated to be about 40,600 ha, or 90% of the total land area of the archipelago. This estimate was based on aerial photo interpretation and some field validation. It should be noted that no comprehensive forest inventory has been conducted since 1976 and thus this data is somewhat imprecise. In the FOSA report, about 10% of the forest area was considered to be plantation (including casuarinas forests), with the remainder being considered "natural".

However, according to the INDUFOR study in 1993, natural forests no longer exist in Seychelles except as relict vegetation at high altitudes. According to this report:

- 63% of the forests are secondary, mostly consisting of invasive species;
- 17% of forested land consists of invasive bush vegetation;
- 1% of forest lands are actually deforested, as a result of fire;
- 12% consist of plantations, mostly casuarina on outer islands, and some mahogany on the granite islands;
- 7% consist of coconut plantations.

More than 45% of total forest cover is found within the boundaries of the national parks and the nature reserves.

3.6.2.2 Forest Policy of Seychelles

In Seychelles, the Forestry Section under the Department of Environment, is responsible for forest management, conservation and planning, and is guided by several policy documents. While there is at present no actual forest policy document, a comprehensive but now outdated Forest Management Plan was produced in 1993 (GOS & UNDP, 2007). Otherwise, strategies related to forest management are derived from the Environmental Management Plan for Seychelles (EMPS) (1990-2000, and 2000-2010), and the National Land Use Plan. The EMPS 2000-2010 is divided into ten thematic areas, one of which focuses on Biodiversity, Forestry and Agriculture and includes a Forestry Action Plan.

Other relevant local documents that influence forestry policy include:

- The National Biodiversity Strategy and Action Plan (NBSAP, 1997);
- The National Strategy for Plant Conservation (2005), spearheaded by the local NGO Plant Conservation Action;
- The Draft National Policy on Disaster Management (2006).

The Forestry Section has a Forest Fire Contingency Plan which defines responsibilities for forest fire fighting, but this is outdated (GOS & UNDP, 2008). Because of Seychelles' limited land area and reliance on tourism rather than forest products and harvesting as a source of foreign exchange, forest policies in Seychelles are guided by conservation management and maintenance factors.

The Government of Seychelles has recognised the need for a comprehensive new Forest Policy document based on sustainable land management principles, and is planning to develop it as part of a UNDP-GEF Targeted Portfolio Project, "Capacity Development for Sustainable Land Management" (GOS & UNDP, 2007).

3.6.2.3 Forest Management

Forests on government land are managed by the National Parks & Forestry Section under the Nature Conservation Division in the Department of Environment of the Ministry of Environment, Natural Resources and Transport. The National Parks & Forestry Section has the mandate to manage, protect and exploit the forests and forest plantations on Seychelles Government's land (GOS-UNDP, 2007). Its activities are guided by a Forest Management Plan dating back to 1993, which is in need of revision.

Some of the key management issues for Seychelles' forests specifically relevant to climate change mitigation strategies include:

- Maintenance of forest plantations;
- Sustainable harvesting of forest products;
- Forest fire prevention, detection and control;
- Regeneration of burned forested areas and erosion control;
- Control of alien invasive species, particularly creepers which smother and kill forest trees;
- Protecting coastal vegetation from beach erosion;
- Removal of vegetation for housing, agriculture, roads and other infrastructure;
- Disease control.

All of these issues have a direct bearing on the maintenance or improvement of current levels of forest cover functioning as a sink for CO_2 emissions. The following issues are of particular relevance and concern:

3.6.2.4 Forest Fires

Deforestation by fire is currently the most severe and widespread form of land degradation in Seychelles (GOS-UNDP, 2007). Most fires are started accidentally by people clearing and burning leaves near their homes. While Government has made some efforts to regenerate burned and eroded state land on Praslin and Curieuse, much of the degraded land is privately owned and private land owners are not obliged to undertake rehabilitation or provide access for the government to do so(GOS-UNDP, 2007).

Some 210 km^2 or 47% of Seychelles' land area is protected through a system of national parks and special reserves and this remains unchanged since the Initial National Communication.

3.6.2.5 Forest and Sustainable Development

As part of sustainable development practices, it is important to have measures to ensure sustainable management of both natural forest and plantations. Forests have an important role to play in our day to day life. They form the basis of life on earth, and provide shelter for a significant portion of the earth's biodiversity, of which many species are vulnerable to changes in the climatic condition. Forests also provide us with food and shelter and for many indigenous communities world-wide, their entire livelihood depends on the health of the forests. Their entire way of life and culture are at risk because of unsustainable development practices. Proper management of forests (worldwide) will lead to the stabilisation of GHGs in the atmosphere. It is very important to include this in the national forest policies.

In Seychelles, forests provide us with wood and leaves used in the construction industry. This is harvested manually or with the limited use of technology. There is some monitoring of these activities by the ministry responsible of environment and forestry. The local forest is also subject to pressure for infrastructural development, although some steps have been taken to ensure that minimum damage is done. It is important to be vigilant as the implementation of legislation is weak.

It has been suggested that with proper sustainable management, Seychelles could reduce its reliance on imported timber and develop an efficient and self-sufficient supply of local timber. The Plant Conservation Strategy for Seychelles suggests harvesting invasive Albizzia species to supply timber for the construction industry, thus contributing to the control of an invasive species, reducing the reliance on imported wood and more efficient use of a local natural resource. Open areas where trees have been selectively harvested should be replanted with native species to prevent re-growth of alien invasive species.

3.6.2.6 Trends and Projection of Forest Coverage

There has been a slight decrease in the total forest coverage since 1990, and in view of current environmental and forest management policies and practices, the decrease in coverage will not be too significant between now and 2030. This is clearly shown in the graph in the next section. Forest fire is one of the main threats to forest cover, however it is estimated that only about 1% of forest area has been affected by deforestation due to forest fire. The Ministry of Environment, Natural Resources and

Transport has an active Forest Fire Contingency Plan to oversee the prevention of forest fires and guide actions in case of forest fire.

3.6.2.7 Trends and Projections of CO_2 Emission/Removal (1990 to 2030)

The Department of Environment (DoE) has maintained the 8,000 m^3 of biomass harvest per year quota which has ensured that the forest is not being over exploited. This represents an emission of 12,540 tonnes of CO_2 per year. This should remain more or less constant, but Government should look more seriously at agro-forestry as a more sustainable approach to wood harvest for construction purposes. If this trend is maintained, then the overall removal capacity should decrease slightly every year, which would be equivalent to an increase in GHG emission in the LUCF sector of 2.21Gg per year (*LULUCF GHG Inventory 2000*). As per the GHG Inventory for the year 2000, there was a 1 % decrease in the removal capacity from 1995 to 2000. If this trend should continue, it is expected that there will be a 1 % decrease in the removal capacity every 5 years (see Figure 37).

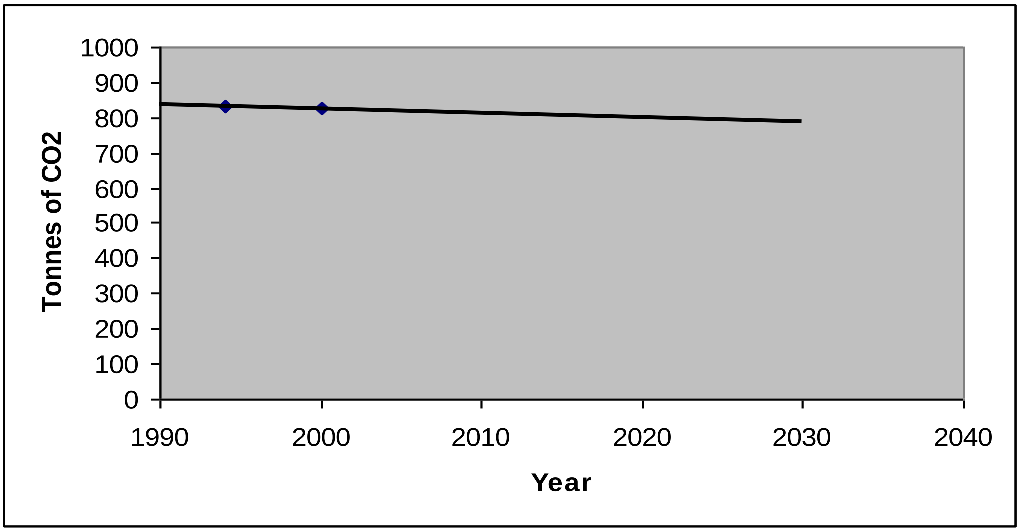


Figure 37: Trends and Projections of Emission and Removal Capacity of CO_2

3.6.2.8 Technologies for Mitigating CO2 Emission/Maintaining the Removal Capacity

<u>Forest Fire-Fighting Equipment</u>

There currently exists some equipment for fighting forest fires, especially on Praslin. There is however limited technical knowhow on the full use of these equipment. Hence there is a need for a broader capacity building and technical knowledge transfer in order to be able to fight forest fires more effectively. There needs to be more equipment in place on Mahe and Silhouette, given the difficult terrain that exists on those islands.

<u>Technical Capabilities</u>

There is limited knowledge that exists locally in the field of using technology to mitigate CO_2 emissions. There are various ways and means that exists worldwide and there is a need to expand local capabilities to ensure maximum effectiveness in mitigating GHGs.

Efficient Sawmills

Currently, there is quite a bit of unnecessary waste being generated from the harvest of wood for use in the construction industry. The current technology being used in this area is the chainsaw. Because of the thickness of the blades, a significant portion of the wood ends up as waste. Efficient sawmills (some of which are portable) can significantly reduce the amount of waste produced.

3.6.2.9 Measures for Mitigating CO_2 Emission/Maintaining the Removal Capacity

Prevention of Land Degradation

Land degradation is a major form of forest depletion. This is especially important given the topography of the main granitic islands, and soil degradation would easily expose the fertile topsoil that will easily erode to the sea, causing secondary pollution and degradation of the coral reefs. Severely degraded lands, such as in some areas of Praslin and Curieuse, are extremely difficult to re-vegetate. Policies and legislation should be put in place so as to ensure the protection of the soil against degradation. This is a cross sectoral issue that has to be addressed together with the ministries responsible for agriculture and land use.

Prevention and Control of Forest Fire

Fires could pose a serious threat to the forests locally. The damage caused by forest fires is still visible on the islands of Praslin and Curieuse, where the vegetation regeneration has been painfully slow. There has been serious degradation of the land which has helped to slow down the re-growth of plants. Forest fire is also a way for invasive alien plants to spread in the regeneration process.

Government needs to ensure that capacity exists to implement legislation to prevent and control forest fires. There needs to be in place a more stringent legislation to deal with those responsible to start forest fires. This is especially the case for Valle de Mai, a world heritage site on Praslin.

Maintaining and Updating of Legislations

The Department of Environment should be better equipped, both in term of human resources and equipment, to enforce existing regulations for forest management and conservation. Reserves that are to be protected by the Forest Reserves Ordinance must be gazetted and in the same manner provisions must be made for private properties in cases where these are to be turned into reserves. There is also the need to review all existing regulations and to declare other regulations to ensure proper and effective protection of the forest areas. This work should be contracted out if the Department of Environment does not have qualified personnel.

Development of a Sustainable Development Master Plan

A Sustainable Development Master Plan (SDMP) will help reduce the risk of uncontrolled development and will provide Government with a tool to facilitate the process of development, and at the same time protect the forests. An SDMP is especially important for the Seychelles, given the fact that there is limited land for development. Uncontrolled development can have a devastating impact on the forests and can cause serious land degradation, and these could be easily avoided with this simple and appropriate tool.

The development of the SDMP should carry a national political weight in order for it to be effective, and it would require the setting up of an office that will be responsible to ensure the application of the SDMP, with required human resources and technology.

Proper Spatial Planning Capabilities

As part of the SDMP, special emphasis should be placed on spatial planning to ensure that all infrastructural development projects fall within the Planning Authority's purview. There needs to be a proper office set up to work with the Planning Authority, and it will assist with development projects through their entire life cycles.

Sustainable Lifestyles

While reducing the impact of human activities on forests has to be part of a SDMP led by Government, it is imperative that all citizens also begin to take responsibility for making efficient and environmentally sustainable use of existing land-based resources. Government and NGOs need to start to promote sustainable lifestyles that minimise the ecological footprint of every household, organisation and district. This should be done through an intensive public awareness campaign such as the national strategy for environmental education and awareness, recently developed in a workshop led by the Division of Environment (June 10-12, 2008), and which would involve the collaboration of a range of organisations and individuals. Such a campaign should harmonise initiatives to reduce greenhouse gas emissions and at the same time maximise CO_2 uptake in developed areas, ie through various activities such as opting for public transport, growing food at home, conserving electricity, planting shade trees, using solar energy for water heating and electricity, etc. The promotion of sustainable lifestyles would also entail the application of additional technology that would improve the effectiveness of already existing technologies such as intelligent control to switch off air conditioners when a room is unoccupied.

Forest Management and Conservation

There are various measures that are in place to ensure effective forest management and conservation. The Seychelles has 47% of the forest areas protected in National Parks. There are also various regulations in place such as the EPA (1995) to control deforestation, commercial biomass harvest and forest fires. The Government of Seychelles has an effective policy towards land use and natural resources utilisation. There needs to be a reinforcement of the Forestry Division with additional human resources and necessary equipment so as to ensure the effective implementation of the Forest Management Plan.

Enforcement of Existing Regulations

There should be increased capacities within the Department of Environment to better carry out the duty of enforcement, especially when it comes to the implementation of regulations to do with harvesting of forestry products, forest management and conservation. Reserves that are to be protected by the Forest Reserves Ordinance must be gazetted and in the same manner, provisions must be made for private lands in cases where these are to be turned into reserves. There is also the need to review all existing regulations and to declare other regulations to ensure proper and effective protection of the forest areas.

Reclamation

Land reclamation is an effective way to mitigate GHGs, and in the Seychelles it has effectively reduced the pressure to develop forest areas for infrastructure. In the past, several land reclamation projects took place and this helped to increase land area that can be used for housing, industries and roads. There is the need however, for a stronger emphasis on the application of a sustainable development strategy to develop current and future land reclamation projects. In the future, the reclamation should also take into account sea level rise.

Data Collection, Storage and Dissemination

Data availability is an important part of the National Communications and the lack of forestry and land use data has been a significant problem in providing good quality reports. There should be mechanisms in place to collect, process, store and disseminate data. These data would also be useful for policy and legislative purposes.

3.6.2.10 Baseline & Mitigation Scenario

The second national greenhouse gas inventory (2000) represented the baseline for the mitigation options. This was a comprehensive document detailing the contribution of GHG emission of all sectors of the economy that consumed petroleum products and the forest biomass.

The main contributions of GHGs in the land use and forestry sector are from unsustainable development activities, forest fires, land degradation, clearing of forest for infrastructural projects and commercial biomass harvest.

The CO_2 emission resulting from commercial biomass harvest was about 12,000 tonnes in 2000. The CO_2 removal capacity of the forest was 832,770 tonnes in 2000. It was estimated that 89 % (40,450 ha) of the total land area (45, 500 ha) were covered by forest in 2000.

The baseline scenario is based on past and current forest management practices, which have contributed to minimise the loss of forest areas. As per the GHG Inventory for the LULUCF sector for the year 2000, there has been only 1 % decrease of the CO_2 removal capacity. This has been mainly due to the fact that 47 % of the land is protected in nature reserves, most of the infrastructure development has taken place on the reclamation area, construction in forest areas are followed by re-forestation, and a number of major hotel projects have been built on previously built land.

The mitigation scenario is expected to be similar to the baseline, since the percentage of forest protected in national parks is expected to remain the same or increase slightly while similar effort will be undertaken to protect the forest areas as it has been done in the past. Most of the major infrastructure developments are to be undertaken on the reclaimed land, and this also covers housing projects. Forest policies and legislation are not expected to change and the country will continue the programme of biodiversity conservation, which is centred on the protection of forest areas.

3.6.2.11 Cost & Benefit of the Mitigation Options

The cost effectiveness of the mitigation options in the land use and forestry sector needs further attention (see Table 42). This is especially the case where some of the mitigating options will bring significant benefits to the country. The costing exercise for the mitigation options is not very well understood here because of the limited capacity and human resources available. Mechanisms that will allow the country to make full use of the benefits need to be put into place. Government should put emphasis on the setting up of a unit and equipping it with the necessary resources so that it can fully take into account the local needs and accurately calculate the cost-benefit of the mitigation options.

Table 42: Cost and Benefit of Mitigation Options

Mitigation Options	Cost USD	Benefit
Technologies		
Forest Fire Fighting Equipment	30,000.00	More effective at fighting bush fires
Technical Capabilities	125,000.00	Sustainable harvesting & fire-fighting
Efficient Sawmills	5,000.00 (per unit)	Improved wood harvesting
Measures		
Prevention of Land Degradation	25,000.00	Policies, strategies, education & awareness
Prevention & Control of Forest Fire	100,000.00	Building observation towers, education & awareness
Maintaining & Updating of Legislation	5,000.00	More effective legislations.
Development of a Sustainable Development Master Plan	25,000.00	Keeping development in line with forest conservation
Proper Spatial Planning Capabilities	25,000.00	Ensure that development doesn’t come at the expense of forests.
Sustainable Lifestyles	30,000	Reducing impact of individual on forest
Forest Management & Conservation	75,000.00	Policies, strategies, appropriate technology, education & awareness
Enforcement of Existing Legislation	75,000.00	Appropriate technology, capacity building, education & awareness.

Reclamation	5,000,000.00	Reducing to a minimum the negative impact on forest as a result to increase development needs
Data Collection, Storage & Dissemination	50,000.00	Necessary human resources, acquisition of equipment to facilitate the drafting of national communications to the UNFCC (over 5 yrs)

3.7 Baseline and Mitigation Scenario Summary of Sectors

The baseline scenario or the business as usual scenario is based on the assumption that the existing trends in the consumption of petroleum products in the various sectors is allowed to continue without any action to limit the growth and reduce the demand. This can quite easily happen, since very few of the mitigation options proposed in the INC have been implemented and the present foreign exchange situation, along with the fact that Seychelles, as a middle income earning country, is receiving very little funding from donor agencies.

Table 43 and Table 3.38 give data for emission of CO_2 from the main sectors that consumed petroleum products from the year 1990 to 2005, and also the projected figures from 2010 to 2030 and proposed options measures to be undertaken plus measures forsSustaining the rorest removal capacity. The sum of the CO_2 emissions from these sectors gives the baseline scenario.

The mitigation scenario (see Figure 3-20) is based on the assumption that the proposed mitigation options will be implemented progressively from 2010 onward. For the mitigation options that have been proposed, an assessment of those that are most practical, viable and less costly should be short-listed for implementation in 2010. The other options can be considered for implementation by phases, depending on the availability of funding. A meaningful target for the reduction of emission based on the business as usual scenario should be established. It is proposed that by 2015 there should be a 10 % reduction of the business as usual emission figure, by 2020 the target should be 20 %, and by 2025 the target should be 25 %. After 2025, a target of 25 % reduction of the business as usual scenario should be maintained.

Table 43: CO_2 Emission from Combustion of Petroleum Products and Removal Capacity of Forest Areas

CO_2 emission and removal capacity (tonnes)	**Year**								
Sector	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Public Electricity	74,159	97,353	147,151	172,655	203,851	258,045	332,355	431,996	564,226

Production									
Land Transport	41,186	46,561	57,921	66,525	80,754	96,390	117,310	139,998	167,087
Industrial	5,102	15,750	20,507	22,491	29,421	34,745	40,068	45,392	50,715
Residential, Commercial & Institutional	9,343	12,401	48,093	49,145	65,971	81,967	97,964	113,960	129,957
Total CO_2 Emission as per the BAU Scenario	129,790	172065	273,672	310,816	379,997	471,147	587,697	731,346	911,985
Total CO_2 Emission as per Mitigation Scenario						424,032	470,158	548,510	683,989
CO_2 Removal Capacity	845,000	845,000	822,000	813,780	805,642	797,585	789,610	781,171	773,896

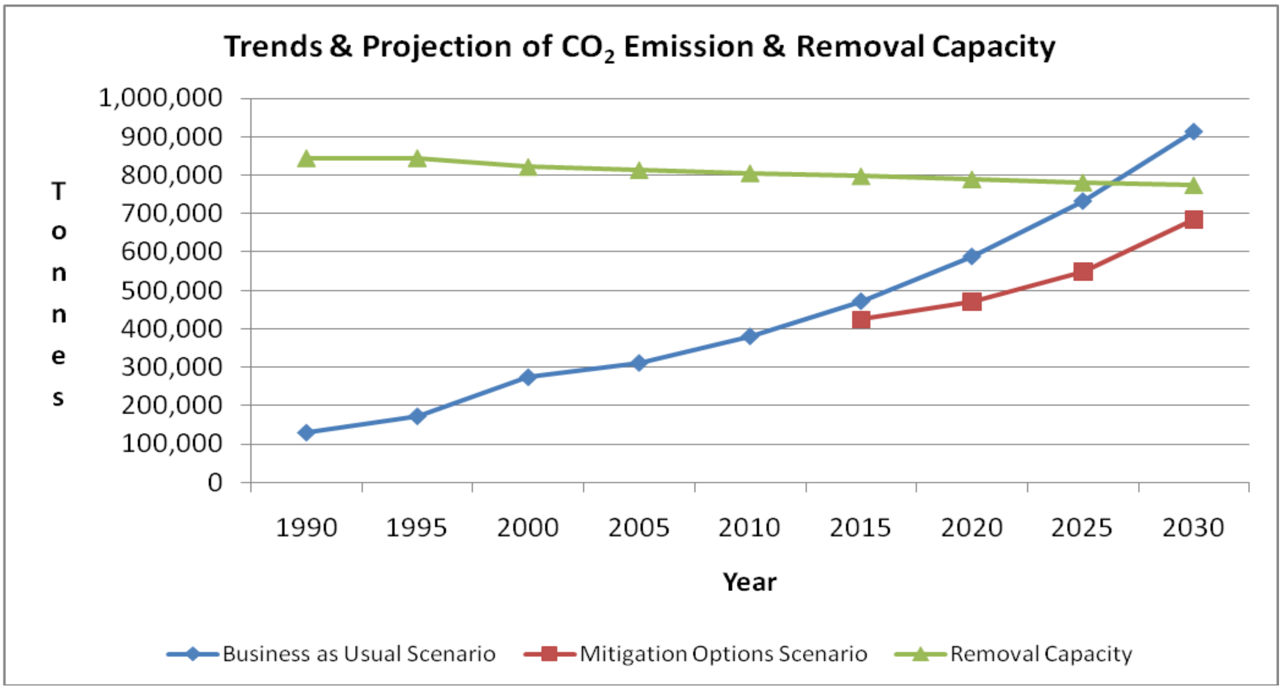


Figure 38: Trends and Projections of CO_2 Emission and Removal Capacity

The technologies and measures to be considered as mitigation options for those sectors that consume petroleum products are listed in Table 44.

Table 44: Technologies and Measures for the Sectors that consume Petroleum Products

Sector	Mitigation Options
Energy Supply (Public Electricity Production)	
Technology Options	Use of cogeneration system
	Reducing losses from the electricity distribution network
	Use of combine cycle gas turbine system
	Operation of solar roof system
	Operation of wind turbine system
Measures	Use of light fuel oil instead of heavy fuel oil
	Promotion of foreign direct investment for renewable energy projects
	Public awareness campaign for energy conservation
	Declaration of emission standards
	Implementation of ISO 14000 by PUC
Transport	
Technology	LRT/Electric Train/Tram
	Road Improvement Programme
	Traffic Management in Victoria
	Vehicle Maintenance
Measures	Improved public transport system
	Carbon or CO_2 tax
	Emission standard and mandatory vehicle inspection & testing
	Control of movements of HDV
	Integrated Land-Use and Transport Planning
Residential, Commercial & Institutional	
Technology	Replacing electric water heaters with solar water heaters
	Replacing incandescent bulbs with CFL

	Use of energy efficient appliances
	Use of gas cookers instead of electric cookers
	Use of photovoltaic system for lighting
	Use of efficient air-conditioning system
Measures	Implementation of energy conservation awareness programmes
	Plumbing system to incorporate piping for solar water heater
	Higher taxes on incandescent bulbs
	Lowering retail mark up on CFL
	Maintaining LPG at a very low cost
	Incorporation of energy efficient measures in building design
	Annual energy audits for commercial & institutional buildings
	Energy management plan for commercial & institutional buildings
	Tax incentives for energy efficient buildings
Industrial	
Technology	Use of cleaner production system
	Switching to less carbon intensive fuels for industrial boilers
	Use of cogeneration system
	Use of renewable energy technology
	Process improvement to minimise energy use
	Material substitution in production process
Measures	Monetary and tax incentives for energy conservation initiatives
	Revision of tariff structures
	Introduce carbon tax
	Declare emission standards
	Introduce mandatory energy audits

	Encourage the implementation of environment management

Table 45: Summary of Technologies and Measures for Sustaining the Forest Removal Capacity

	Mitigation Options
Technologies	Forest fire-fighting equipment
	Use of efficient saw mills
Measures	Developing technical capacity
	Prevention of land degradation and Prevention and control of forest fires
	Maintaining, updating and enforcing legislation
	Development of a sustainable development master plan
	Proper spatial planning capabilities and Sustainable lifestyles
	Forest management and conservation
	Reclamation for housing development

Chapter 4

Vulnerability and Adaptation Measures

CHAPTER 4 VULNERABILITY AND ADAPTATION MEASURES

4.1 Introduction

This chapter outlines Seychelles' climatic, environmental and socio-economic conditions that contribute to its vulnerability and its impact to climate change. It also includes measures taken to lessen Seychelles' vulnerability to current climatic variability and future climate change. The assessments of vulnerability in this chapter primarily focus on strengthening the technical and institutional capacities to mainstream the effect of climate change into national policies and development guidelines of the country. Five vulnerable sectors which are of utmost importance to the people of Seychelles, are the coastal zones, water resources, agriculture, fisheries and health sectors were studied. This chapter also includes an overview of current and planned adaptation activities, measures and programmes that can reduce Seychelles' vulnerability to current climatic variability and future climate change. Unless stated or referenced otherwise, all information in this chapter is derived from these studies.

4.2 Climate Variability and Trends

4.2.1 Air Temperatures

The warming in the Seychelles region, over the period 1972-1997, is estimated to be of the range of 0.25 ^{o}C (Payet & Agricole, 2006). Analysis by Lajoie (2004) indicated that the number of very warm days and nights is increasing dramatically, while the number of very cool days and nights are decreasing. The most significant warming trend is reflected in the minimum temperatures where there has been an increase in days of warm nights as compared to days of cool nights .Recent work by Chang-Seng (2007) confirms such a positive warming trend in the past 35 years. Maximum and minimum temperatures show a positive warming between +0.33 to +0.82°C respectively and are significantly warmer than previously assessed in the Initial National Communication. Figure 39 confirms the continued positive warming trend in the maximum temperature anomaly with rates of +0.0149, + 0.0032 and +0.0096°C per year for the December, January and February (DJF), June, July, August (JJA) and the annual temperature time series respectively. The annual maximum temperature warming in the past 34 years is estimated to be +0.33°C. The maximum temperature warming occurred during the southern summer season (DJF). The smoothed curve is a 5 -point moving average showing the upward warming in the maximum temperature with respect to the 1972-1990 period. Figure 40 shows the positive trends and warming of +0.0298, + 0.0135 and +0.0241°C per year in the DJF, JJA and annual minimum temperature respectively. The annual minimum temperature warming in the past 34 years is estimated to be +0.82°C. The smooth light grey curve (5 point moving average) also indicates the warming trend in the minimum temperature with respect to the 1972-1990 period. The average temperature warming in the last six years is +0.5°C with a peak of +0.7°C in 2006. The minimum temperature is at least twice warmer than the maximum temperature for the DJF, JJA and annual temperature trends respectively. The minimum temperature for the cooler southeast monsoon season (JJA) is found to be warming faster than the DJF season. The minimum temperature is warming faster than maximum temperature as a result of the 'urban heat island' effect and the warming is higher during the southeast monsoon. The minimum temperature trend is three times that of the maximum temperature trend (Figure 41 and Figure 42).

The 2007 monthly average maximum temperature observations show record warming of +1.7, +2.5 and +1.3°C for January, February and March respectively compared to the 1972-1990 period. The record warming in temperature is attributed to a number of factors such as the development of a moderate El Nino late in 2006, an active cyclone season to the northeast of Madagascar, a pronounced positive phase of the Madden Julian Oscillation (MJO) suppressing cloud development in the southwest Indian Ocean and the potential increasing background effect of the green house global warming. The ENSO influence on global rise in air temperature is complex and not clearly understood. The warming in air temperature is also reflected in the longer-term data sets.

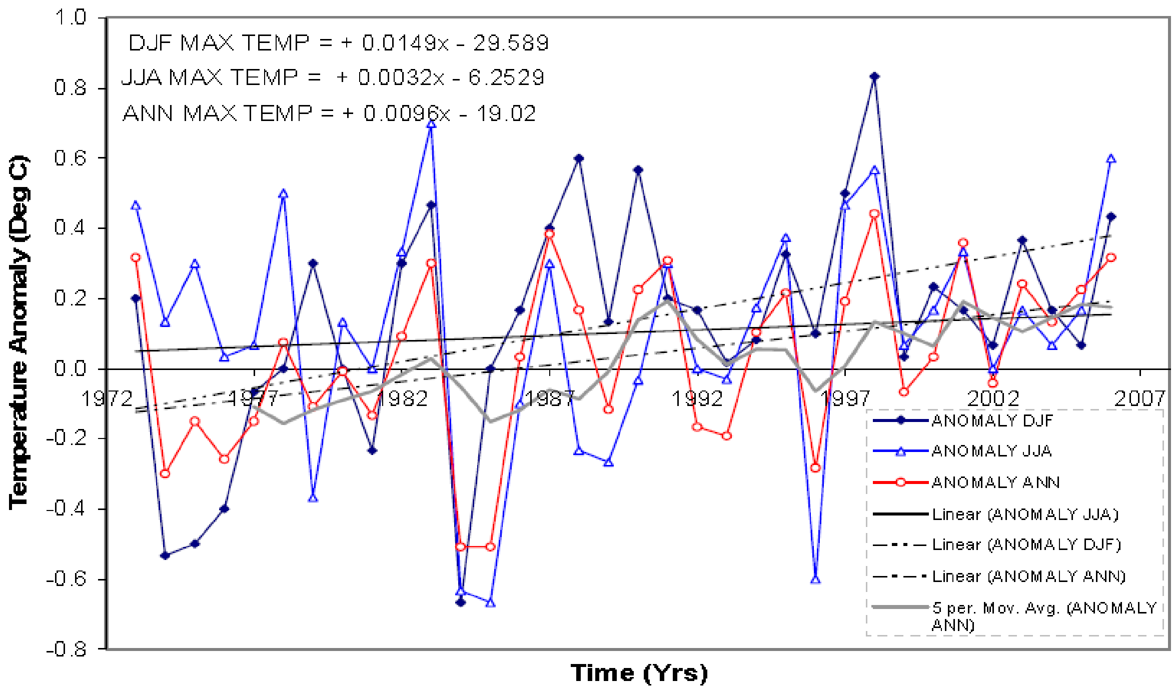


Figure 39: Seychelles International Airport DJF, JJA and Annual Maximum Temperature Anomalies with respect to the 1972-1990 Period with Linear and 5-point Moving Average Trends (Chang-Seng, 2007)

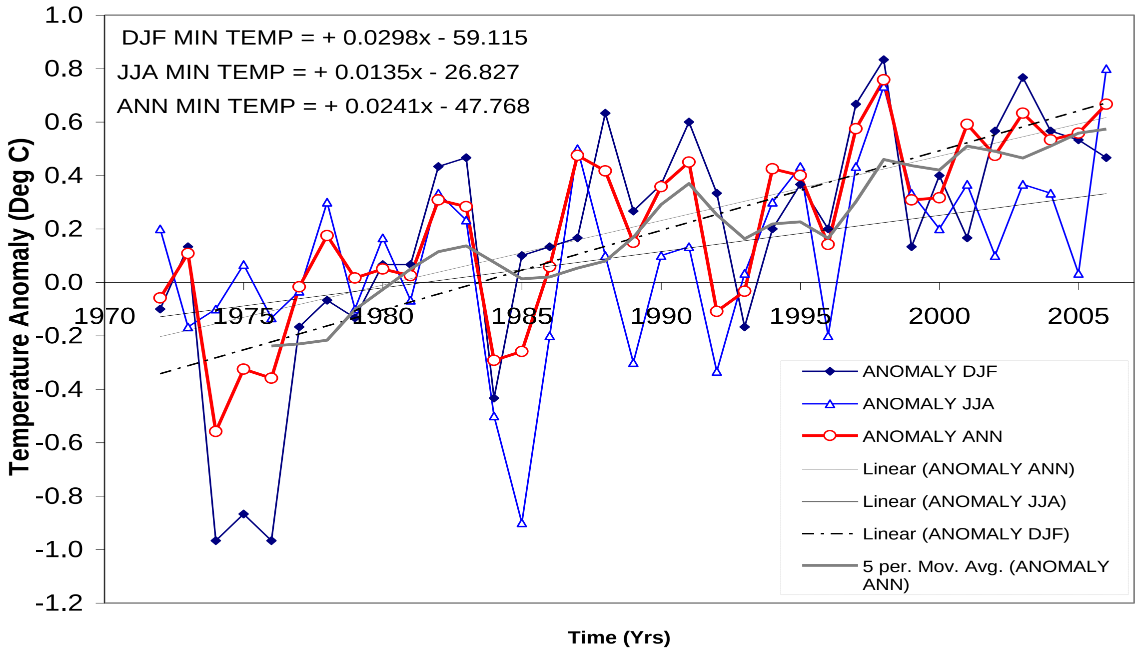


Figure 40: Seychelles International Airport DJF, JJA and Annual Minimum Temperature Anomalies Time Series with Reference to the 1972- 1990 Period with Linear and 5 Point Moving Average Trends (Chang-Seng,2007).

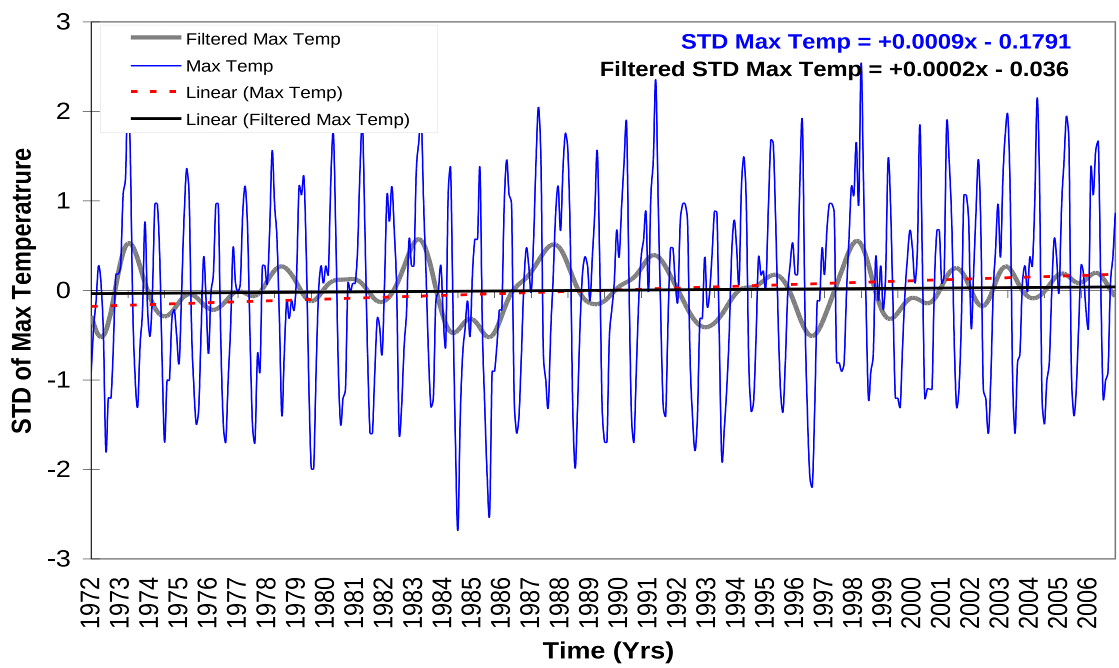


Figure 41: Standard Deviation of Monthly Maximum Temperature and its Low Band Pass Wavelet Filter (1.5-16 yrs)

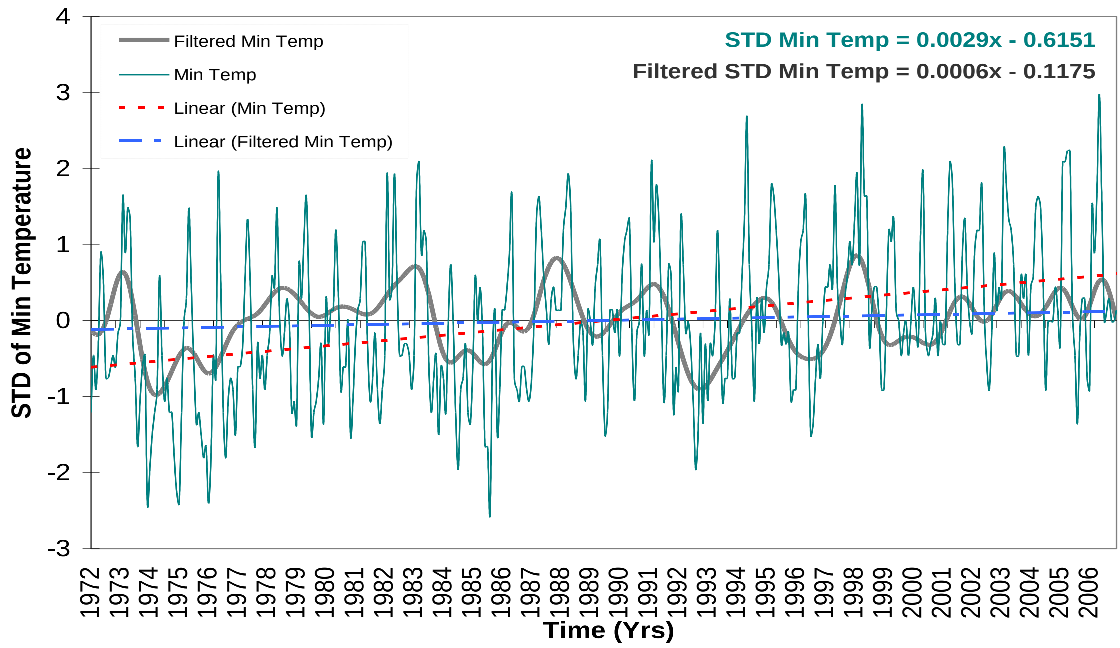


Figure 42: Standard Deviation of Monthly Minimum Temperature and its Low Band Pass Wavelet Filter (1.5-16 yrs)

4.2.2 Rainfall

The long term trend of a merged 119-year monthly rainfall data confirms strong rainfall variability over Mahe, Seychelles. It is characterised by distinct 2-4, 10 and 30-year cycles. The 2-4 year cycles are linked to the ENSO, biennial cyclone variability and the Quasi-Biennial Oscillation (QBO) (Chang-Seng, 2005). The decadal rainfall cycle is linked to the sunspot cycle (Marquerite, 2001) and the decadal variability in intense tropical cyclone (Chang-Seng, 2005).The 30-year cycle was detected and was characterised by periods of abnormally high and low rainfall trends operating as a background low climate signal. It is suggested that the 30-year natural cycle has gradual, but significant influence on the long term climate variability in the Seychelles. It is proposed that the 30-year cycle in rainfall is tele-connected to the Atlantic Multi-Decadal Oscillation in sea surface temperature through the ocean thermohaline circulation which distributes heat globally. Although the long term annual rainfall shows an upward trend in rainfall of +2mm per year, it is also clear that the upward trend is not consistent or maintained when the data is filtered further.

Temporal rainfall changes are analysed for DJF, JJA and the annual time series with respect to the 1972-2006 period at the Seychelles International Airport, Seychelles (Figure 43, Figure 44 and Figure 45). The linear seasonal and annual anomaly trends are +0.6423, + 2.0286 and +13.774 mm per year for DJF, JJA and annual time series respectively. The JJA upward trend is larger than the DJF trend. There are 14 cases in which rainfall has exceeded +50mm in the DJF season, while only 9 cases in which rainfall was at a deficit of -50mm. There are 9 cases for which the rainfall anomalies have exceeded the +50 mm anomaly for the DJF season. It is found that there is only one instance in the year 2000 when rainfall plummeted to a deficit of -50 mm during the strong 1999-2000 La Nina event.

Overall, the JJA dry season has larger upward trend (3 times that of the rainy season) and it is now characterised by wetter-like conditions compared to the 1972-90 period. The low band pass filter of rainfall reveals a surprising downward trend in rainfall (Figure 46).

Extreme precipitation and flooding is now of great concern. However, only few studies are available mainly because of an absence of a network of rainfall intensity observation instruments. The existing manual voluntary network of rain gauge only measures 24 hours rainfall. Nevertheless, one measure of extreme precipitation is the percentage of total precipitation due to events above the 95th percentile (R95p). Figure 47 shows the annual total precipitation when rainfall is greater than the 95th percentile or simply rainfall accounted for by extreme events. As indicated, a strong positive trend is evident (significant at the 5% level). This signifies that heavy rainfall events have been the major contributor to the increase in rainfall (Lajoie, 2004). However, further observations and rainfall intensity analysis are recommended to draw firm conclusions.

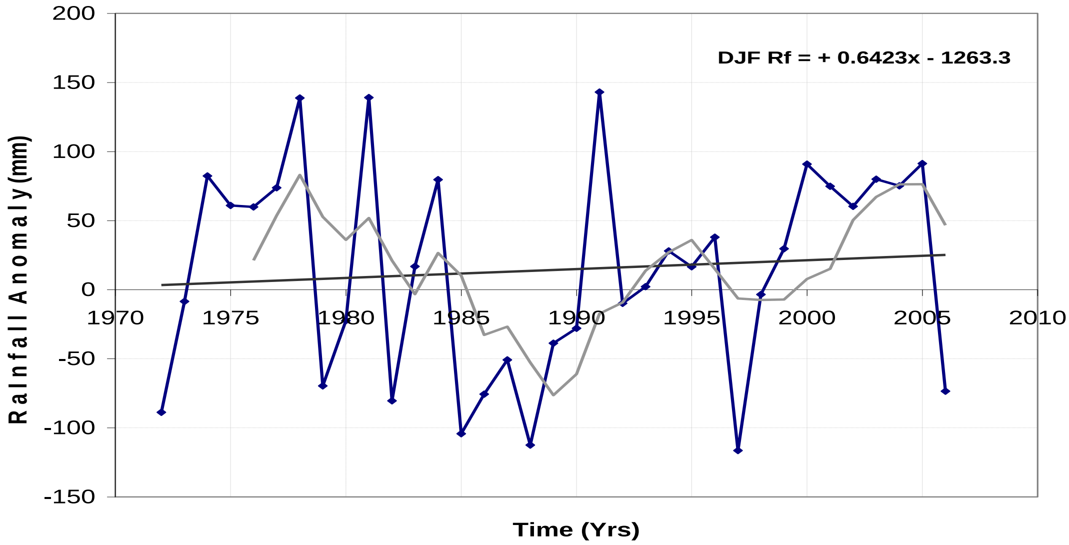


Figure 43: Time Series Anomaly of December, January and February DJF) Rainfall at the S.I.A

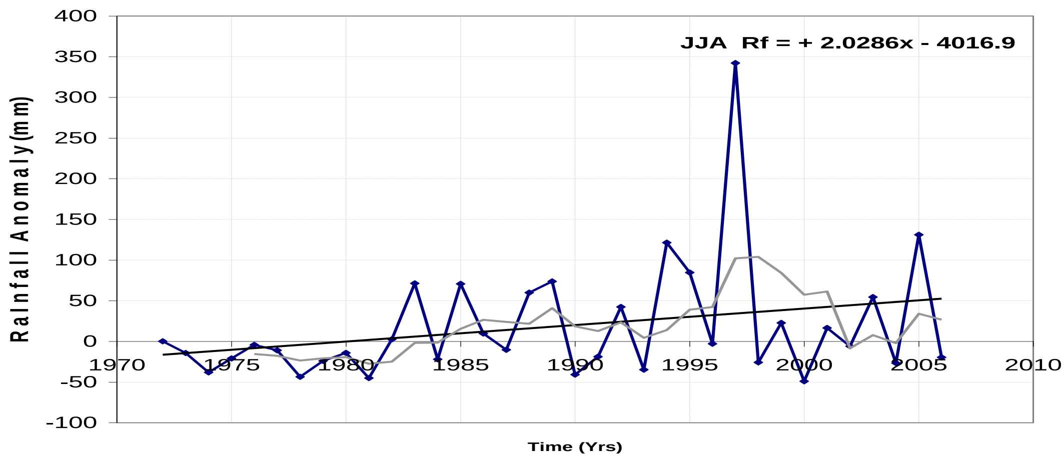


Figure 44: Time Series Anomaly of June, July and August (JJA) Rainfall at the Seychelles International Airport

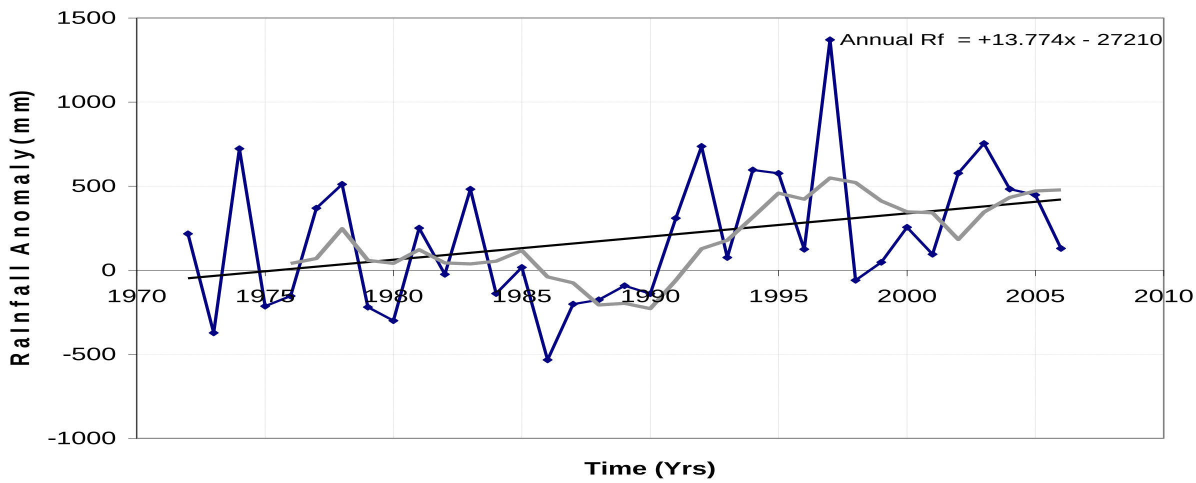


Figure 45: Time Series Anomaly of Annual Rainfall at the Seychelles International Airport

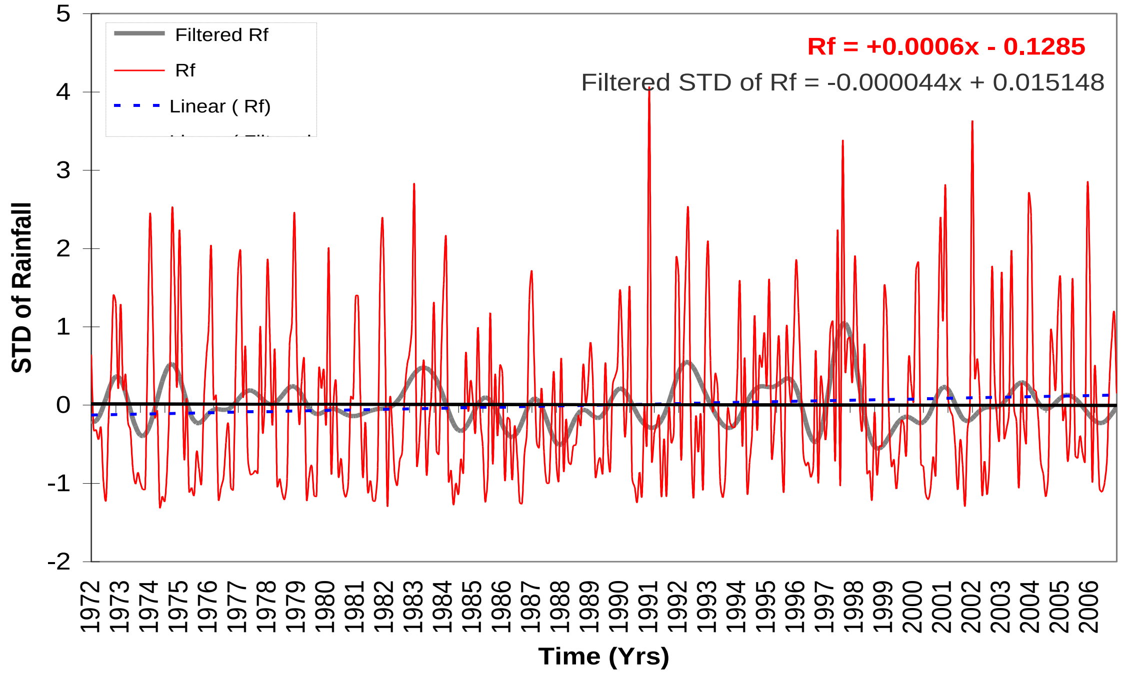


Figure 46: Standard Deviation of Monthly Rainfall at Seychelles International Airport and its Low Band Pass Wavelet Filter (1.5-16 yrs)

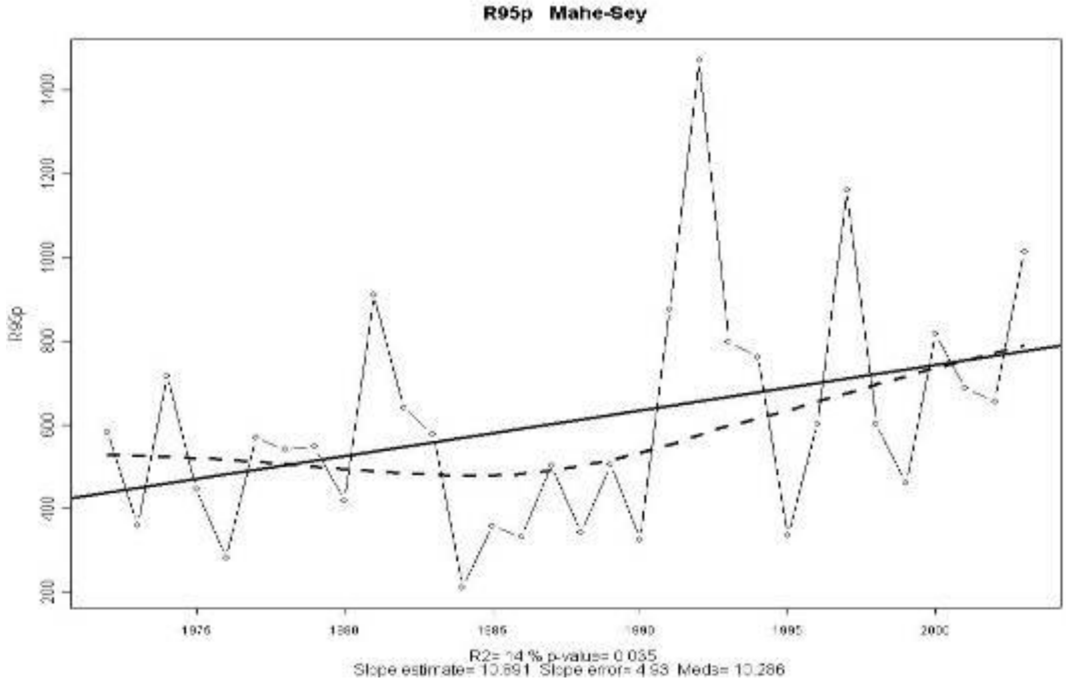


Figure 47: Annual Total Precipitation (mm) when RR>95p or Precipitation accounted for by Heavy Rainfall Events (Source: Lajoie, 2004).

4.2.3 Sea Surface Temperature (SST)

The sea surface temperature observations at the Seychelles International Airport, Pointe Larue, show that SST is characterised by two maxima and minima linked to the transition period associated with the reversal of the monsoon winds and the equatorial ocean currents (Figure 48). It is interesting to find that the secondary maxima occurs in November and then drops to secondary minima in December before peaking to another maximum in April. The extreme minimum occurs in August at a time when the southeast monsoon is at its peak with the sun in the northern hemisphere. The extreme minimum temperature dropped from 25.8°C in August 2000 to 24.9°C in August 2005. In contrast, the extreme maximum of SST in April 2000 has warmed up to a maximum of 30.1°C in April 2001 following the 1999-2000 La Nina event. Overall, the linear trend suggests a cooling in SST; however no firm conclusions can be drawn from such limited data set. Consequently, the Climate Research Unit (CRU) area monthly time series of SST data at a 2-degree grid size resolution around Mahe Island, Seychelles is analysed (Figure 39). The 5 and 10-years filtered data are also shown in the same graph. There is a consistent upward trend showing warming in SST after the 1960s. The result agrees well with earlier analysis of the Initial National Communication. The spatial regional scale variability of NOAA SST (1948-2006) relative to the 1960-1990 period shows cooling in the western Indian Ocean, while warming in the east-southeast with a peak of +0.04°C centered between 5-12° S / 55-67°E (Figure 50). The warming in the SST is closely related to the mean position of the ocean thermocline and the ITCZ in the Indian Ocean. The warm pool in SST in the east-southeastern Indian Ocean was found to be closely linked to the ocean Rossby wave propagation and the inter-annual variability of tropical cyclone and fish resource in the southwest

Indian Ocean (Chang-Seng, 2005) at inter-annual time scales. However, more detailed study is recommended to understand the warm pool pattern.

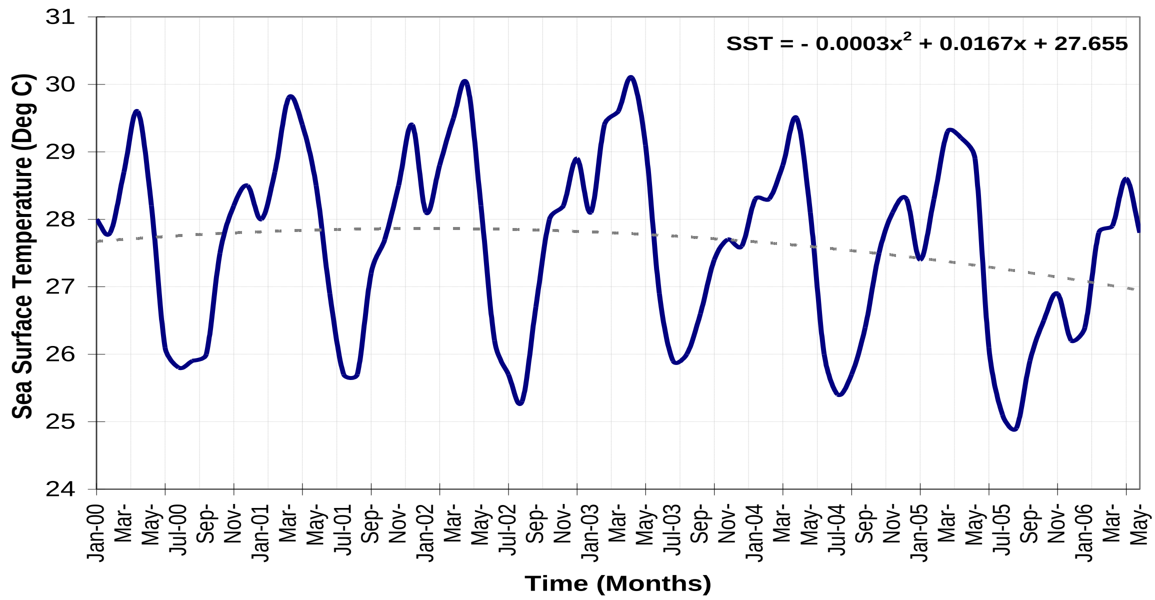


Figure 48: Sea Surface Temperature at Seychelles International Airport, Point Larue

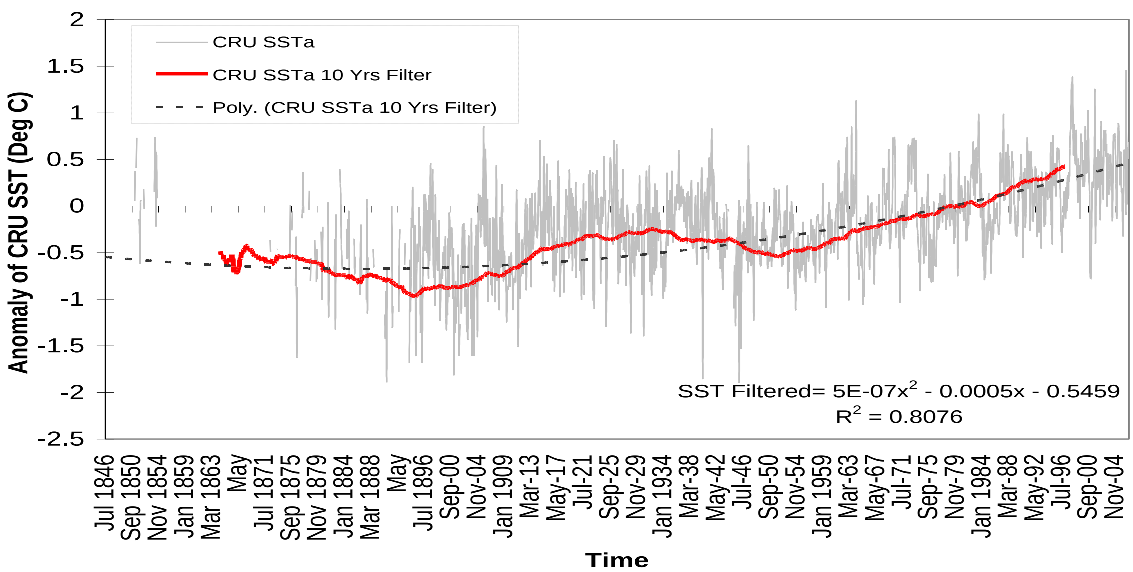


Figure 49: Area Time Series CRU SST in the Seychelles. The Smoothed Curve is the 10-year Filter with a Quadratic Trend

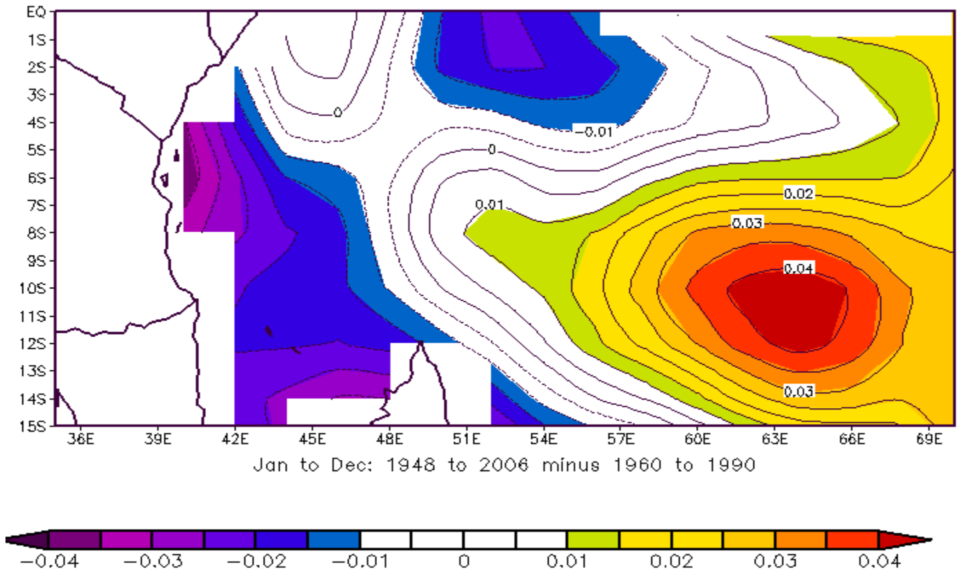


Figure 50: Spatial Change in SST from 1948-2006 relative to the 1960-1990 Period

4.2.4 Sea Level Rise (SLR)

There are several quality Global Sea Level Observing Systems (GLOSS) monitoring stations in the Southwest Indian Ocean (SWIO). Table 46 shows the details of the SWIO Permanent Station for Monitoring Sea Level (PSMSL) GLOSS station.

Currently, only the Pointe Larue Station which was installed in 1993 is monitoring quality sea level in the Seychelles waters (Figure 51).

Recently, there has been a notable increase in the gradient of the mean sea level slope as highlighted by an arrow on the sea level time series (Figure 51). From 2002 to 2006, there were 5 instances when sea level anomaly has exceeded +10 cm. Consequently, although not properly documented, there have been increased reports of coastal impacts. Figure 52 shows the annual sea level trend anomaly of +0.146 cm per year which is in close agreement with the trend computed by the PMEL in August 2005. It is important to note that the standard error in the case of the Pointe Larue Station is ± 2.11 mm per year. There is still a positive trend even after the high frequency signals are filtered out (Figure 53).

4.2.4.1 Spatial Changes in Sea Level

Figure 54 and Table 4-1 show the current sea level trends and its standard error in the Southwest Indian Ocean. Apart from three stations, most stations are reporting a small positive trend particularly in the Mauritius and Reunion area; however the standard error is also quite large (Figure 55). The results are consistent with the latest publication of Ragoonaden (2006) which concluded that most stations were reporting some rising trend while others had a negative trend. Figure 56 shows the negative sea level in the southwest Indian Ocean derived from the satellite altimetry of the TOPEX/Poseidon observation from 1993-2003 (Leuliette et al., 2004). Ragoonaden also concluded that there were no clear indications of enhanced or abnormal acceleration in the sea level rise. The local sea level trends are rather consistent with the global average sea level rise of an average rate of +1.8 mm (1.3 to 2.3 mm) per year over the 1961 to 2003 period. It is highlighted that the rate was faster over the 1993 to 2003 period, with about +3.1 mm (2.4 to 3.8 mm) per year. It is not clear if the faster rate is linked to decadal variability or to an increase in the longer-term trend.

The sea level variability in the last few years have also been influenced by extreme equatorial and mid-latitude generated storm surges and swells, as was the case with cyclone ''Bondo'' in December 2006 and the latest 'high wave'' event which unfolded between 13th-20th May 2007.

Table 46: PSMSL GLOSS Station, Number of Years of Data used to compute the Trend, Range of Years used, Trend and Standard Error in mm/year, Latitude and Longitude and Station Name (Source: PMEL, August 2005).

Station Name	Start	End	Trend (mm/yr)	Standard Error (mm/yr)	Latitude			Longitude		
MAPUTO, Mozambique	1961	2000	1.24	0.51	25	58	S	32	34	E
MOCAMBIQUE ISLAND	1963	1966	14.36	7.05	15	2	S	40	44	E
NOSY-BE , Madagascar	1959	1972	-3.54	2.84	13	24	S	48	17	E
PT. LA RUE, Seychelles	1994	2003	1.05	2.11	4	40	S	55	32	E
PORT LOUIS, Mauritius	1942	1965	2.98	0.94	20	9	S	57	30	E
PORT LOUIS II, Maurtius	1987	2003	-0.94	1.9	20	9	S	57	30	E
RODRIGUES, Mauritius	1991	2003	3.95	2.5	19	40	S	63	25	E
POINTE DES GALETS, Mautius	1979	1985	-1.58	4.59	20	56	S	55	18	E
DIEGO GARCIA-C	1989	2000	2.26	3.63	7	17	S	72	24	E
GAN II ,Maldives	1992	2003	5.76	1.71	0	41	S	73	9	E
MALE-B,HULUL Maldive	1993	2003	2.03	1.36	4	11	N	73	32	E
ZANZIBAR, Tanzania	1985	2003	-3.75	1.11	6	9	S	39	11	E
MOMBASA, Kenya	1989	1999	3.69	2.85	4	4	S	39	39	E

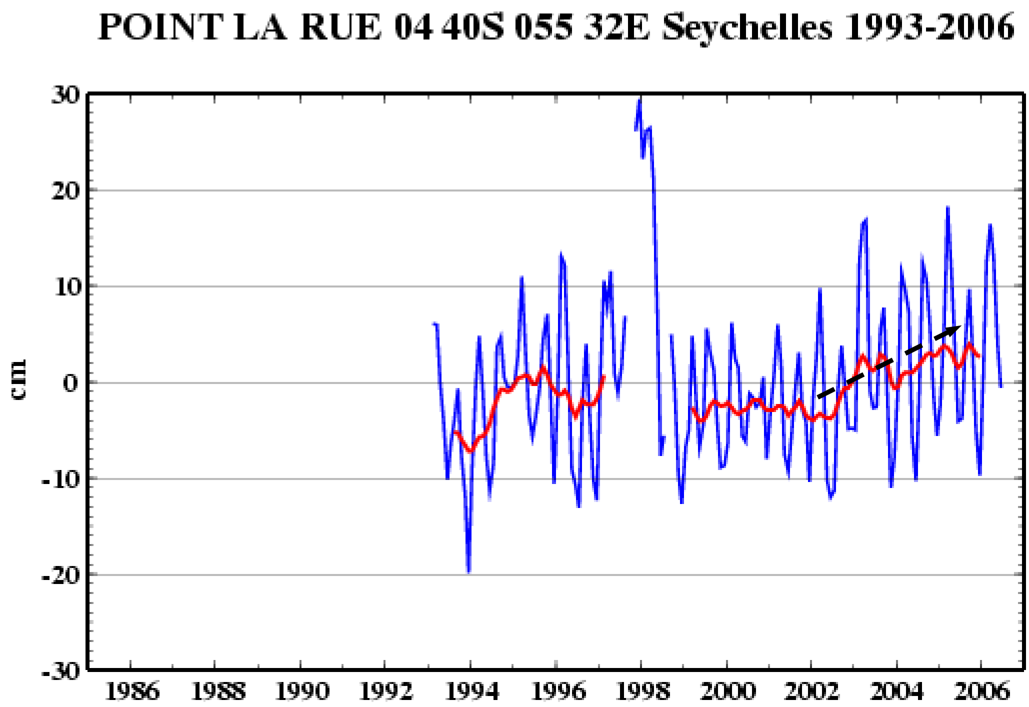


Figure 51: Time Series of Pointe Larue observed Monthly Sea Level Anomaly. Red Curve is Smooth Sea Level (Source: University of Hawaii).

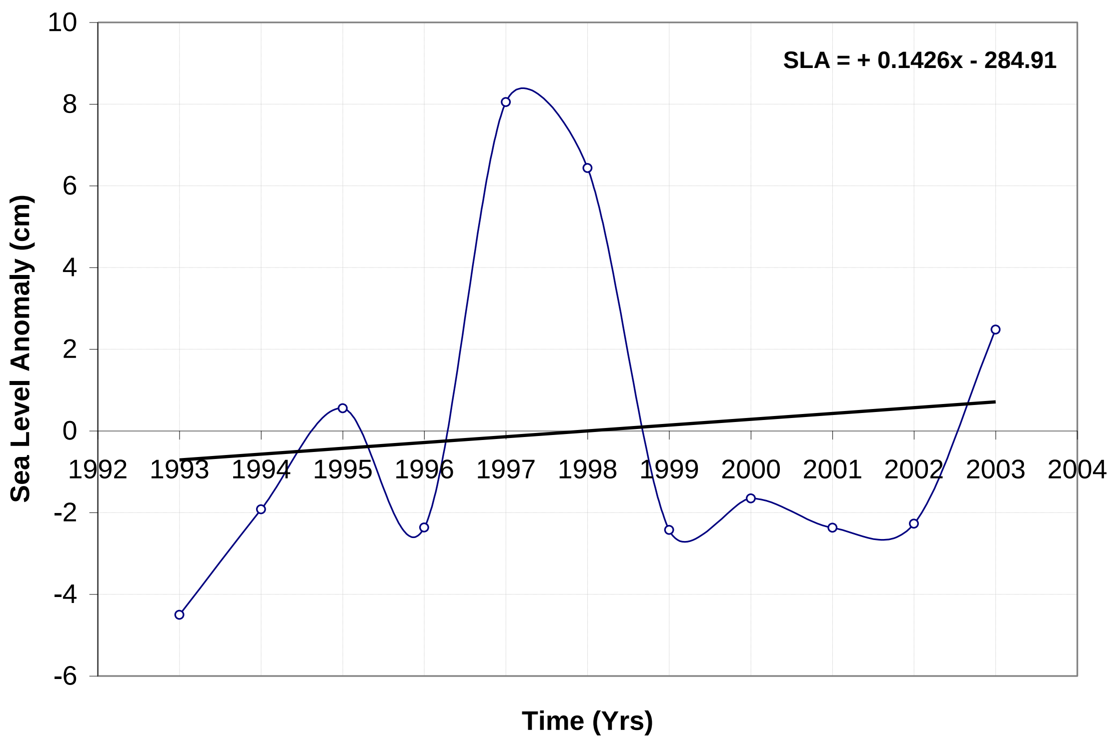


Figure 52: Time Series of Pointe Larue Monthly Sea Level Anomaly

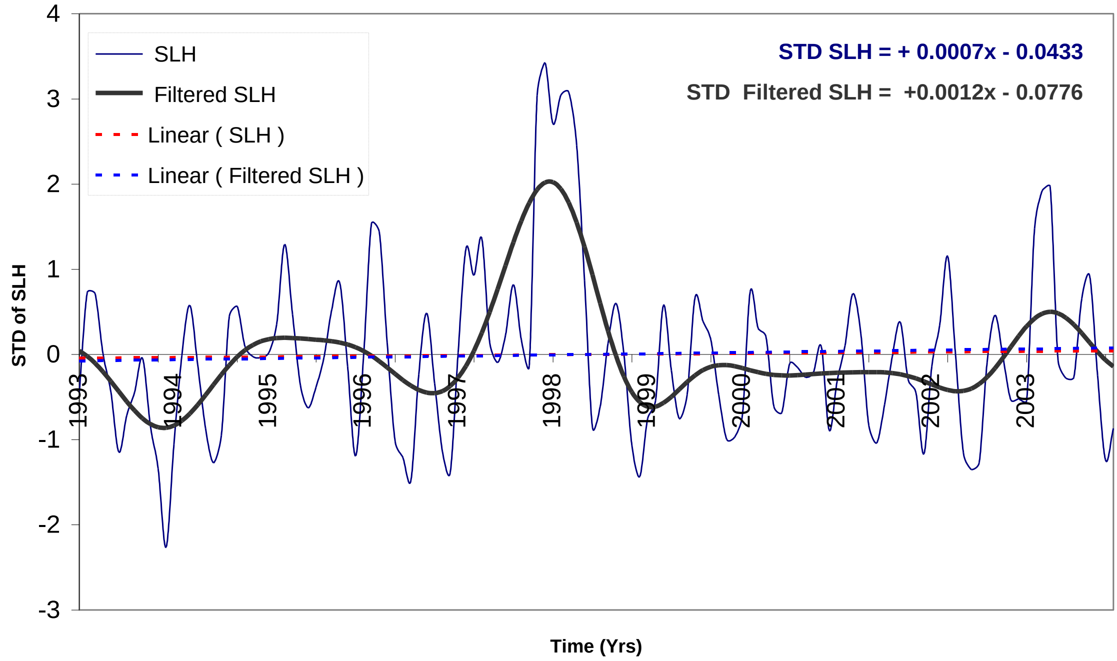


Figure 53: Standardised Monthly Sea Level at Pointe Larue and its Low Band Pass Filter

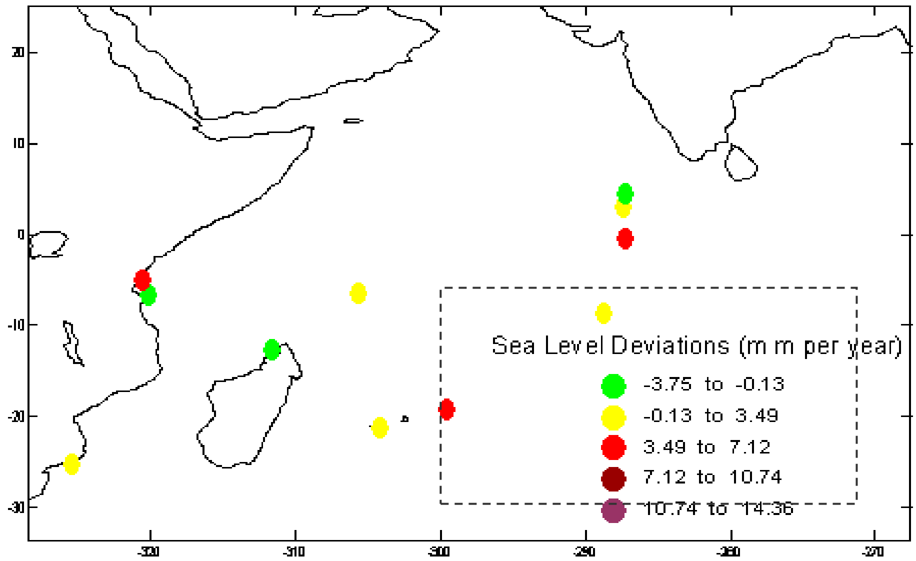


Figure 54: Sea Level Trend in mm per Year in the Southwest Indian Ocean

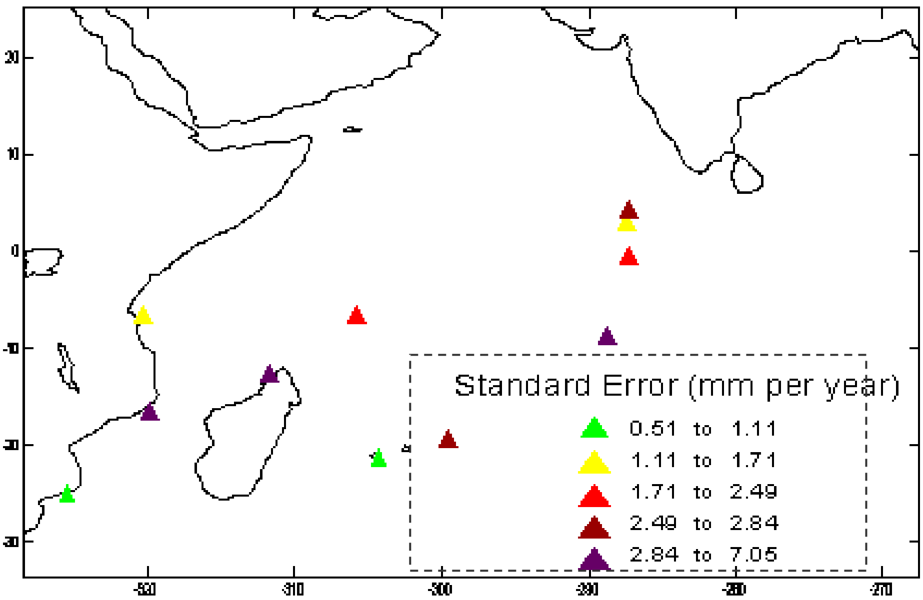


Figure 55: Standard Error in Sea Level Trend in mm per Year in the Southwest Indian Ocean

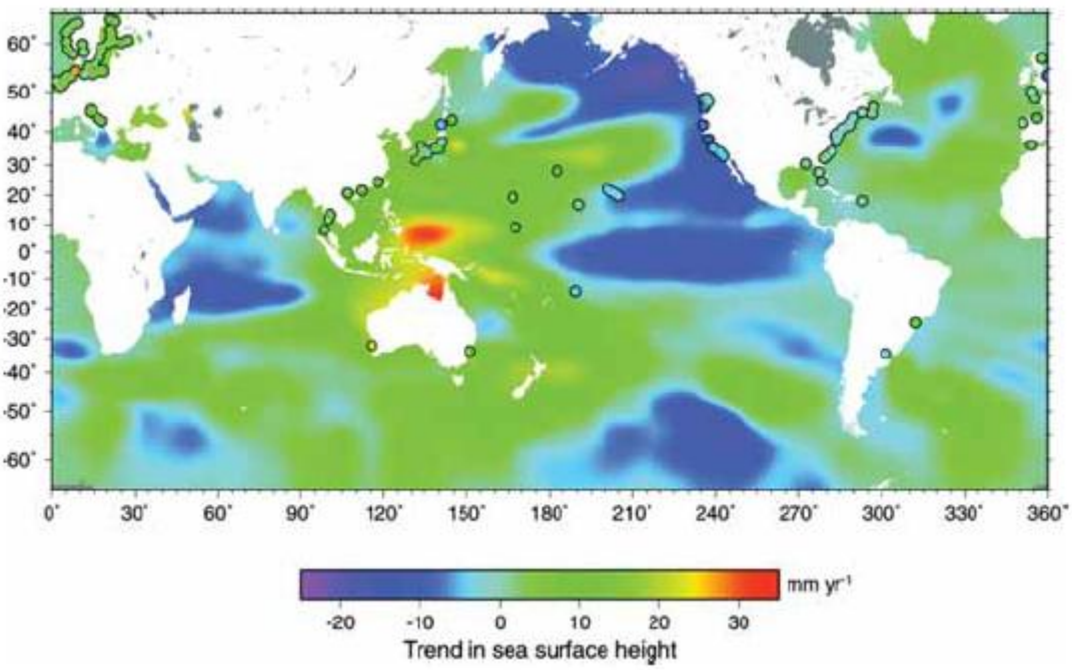


Figure 56: Altimetry-derived Sea Level Map for TOPEX/Poseidon Observation for the 1993-2003 Period (Source: Leuliette et al., 2004).

4.2.5 Extreme Weather Events

Nearly all extreme weather events in Seychelles are directly or indirectly associated with the Inter Tropical Convergence Zone (ITCZ), and tropical cyclones in the region. In fact, the Indian Ocean is the most prolific of all other oceans in generating tropical cyclones. However, tropical cyclone trajectories do not come close to those islands of the Seychelles located close to the equator, although there have been a few incursions. However, it is important to note that extreme rainfall and wave swells resulting from Indian Ocean tropical cyclones do affect the Seychelles and need to be taken into consideration. Since 1990, Seychelles has recorded an increase in off-season tropical storms which formed and moved near the granitic islands of Seychelles.

Three intense tropical depressions have affected the Seychelles in recent times; tropical depression 'Ikonjo' in May 1990 at 7.5°S with a maximum wind speed 96 km/hr affecting Desroches in the Amirantes, the tropical storm of the 9-12 September 2002 with a maximum wind speed of 120 km/hr in the form of a very local 'microburst' on the island of Praslin, and Cyclone Bondo in December 2006 with a maximum wind speed of 287 km/hr within the Farquhar island group (11.1°S). The last documented evidence of a cyclone hitting the Farquhar group was in 1956, exactly 50 years ago. The September 2002 storm caused exceptional damage in terms of the biodiversity, infrastructure and houses when it made landfall on Praslin. The total measurable direct and indirect losses were estimated to have been in the region of USD 86.7 million (Government of Seychelles, 2004). Whereas, intense tropical cyclone 'Bondo', the first category-5 storm to make landfall in 56 years in Seychelles, affected most of Seychelles southern islands namely; Providence, Cosmoledo and Farquhar, wreaking havoc to infrastructure, buildings and to the natural environment, with an estimation of damages worth in tens of millions USD.

4.3 Climate Change Scenario Projections in Seychelles

The MAGICC SCENGEN version 4.1 was used to construct two climate scenarios for Mahe and the Aldabra area based on the A1 high-range emission with a high climate sensitivity and the B2 mid-range emission with a mid climate sensitivity at seasonal and annual time scales. A range of seven General Circulation Models (GCMs) at 5° (~500 km) resolution were employed to assess the regional climate change patterns (Chang Seng, 2007) and models suggest the following:

4.3.1 Air Temperature

- Air temperature for both Mahe and Aldabra area is more likely than not to warm by +3.0°C;
- The relative warming will occur mainly during the cooler southeast monsoon;
- The warming ranges are from +0.4° to 0.7°, 0.9° to 1.4° and 1.8° to 2.9° C respectively for the years 2025, 2050 and 2100 (see Figure 4-19).

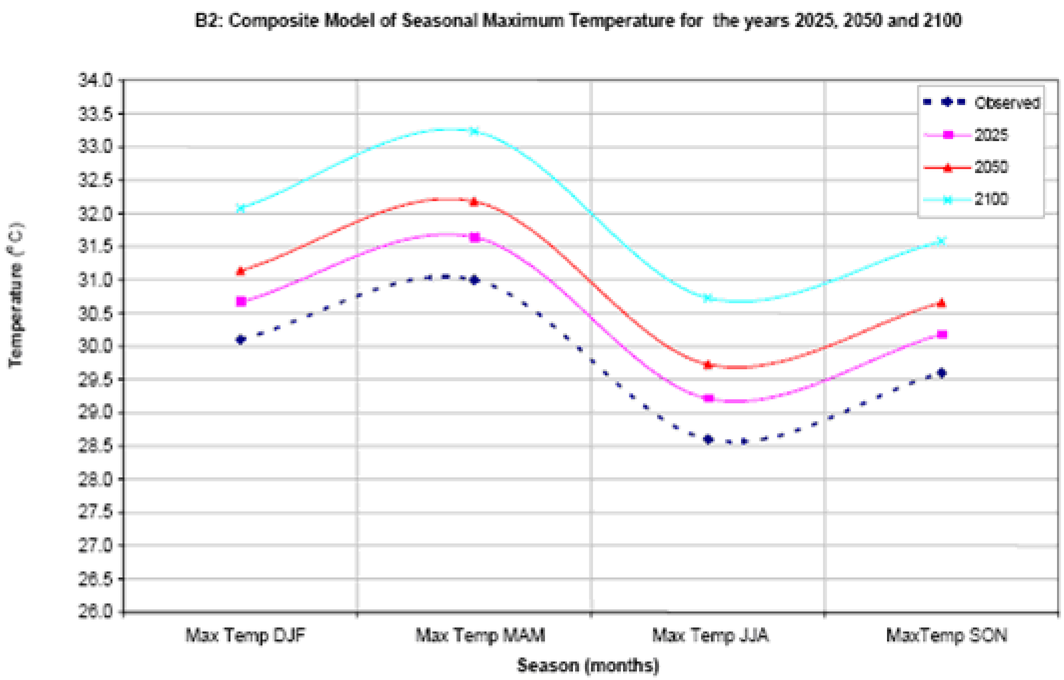


Figure 57: Observed (1972-1990) and Composite Model Scenarios for Average Maximum Temperature Values (˚C) for the Years 2025, 2050 and 2100 at the International Airport, Mahe, Seychelles for the B2 Mid-range Emission with Mid –range Climate Sensitivity (Source: Chang Seng, 2007).

4.3.2 Rainfall

The Figure 58 shows the standardised–average Global Circulation Models (GCMs) percentage rainfall projections at 5 degree resolution over Mahe Island.

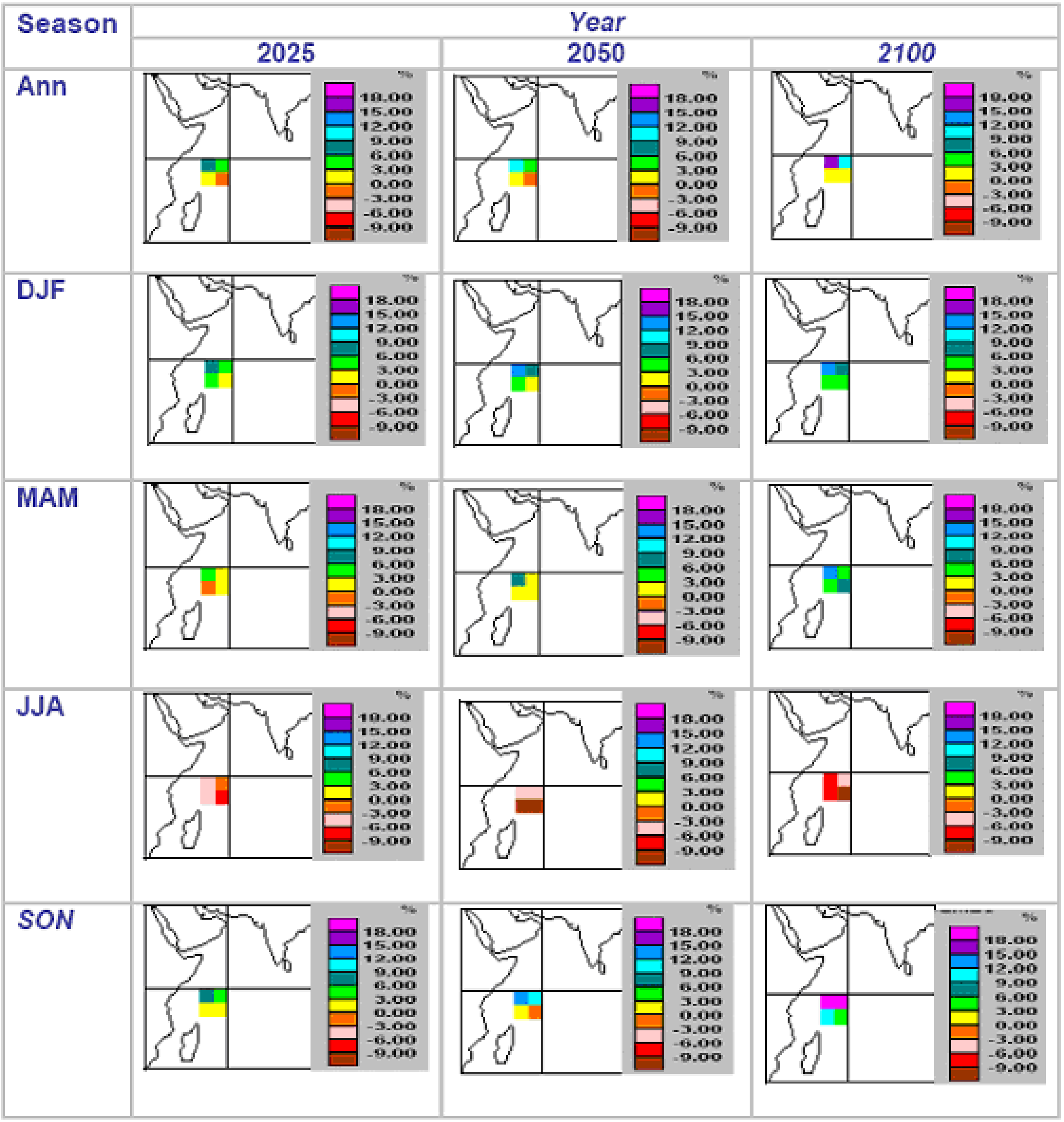


Figure 58: Standardised-Average GCMs (CMS, ECHS, ECH4, GFD, HAD2, HAD3, MODBAR) Percentage Change (%) in Rainfall Projections (for B2 Mid-range Emission with a Mid-range Climate Sensitivity at 5 –degree Grid Size Resolution) (Source: Chang Seng, 2007).

On the other hand, Figure 59 shows composite model scenarios of local seasonal predicted rainfall while Figure 60 shows annual rainfall projections for the years 2025, 2050 and 2100. Figure 61 shows the variability in individual Global Circulation Models (GCM) performance, highlighting the degree of uncertainty in model output.

Therefore, the following is summarised:

- Likely extremes of low rainfall in the dry season with a deficit of -12.7 % (-9.9 mm) in rainfall for the year 2025, and a decrease of -36.3 % (-31.1 mm) in the year 2100;
- In contrast, the likely extremes of wet conditions are likely to be characterised by an increase of +5.9 % (+19 mm) for the year 2025, +9.3 % (+25.4 mm) for the year 2050 and +12.4% (+38.6 mm) for the year 2100.

On the other hand, another independent regional climate change projection from Multi-Model Ensembles shows that on an annual basis it is 89 % likely that the rainfall rate will be greater and equal to +0.5 mm per day by theyear 2100. The certainty lowers to 45-50% that the seasonal rainfall will increase in the rainy season of up to +1.0 mm per day by the year 2100. This informs us that rainfall is more likely to increase in the southern summer and decrease during southern winter time.

Overall, it is projected that the climate can be characterised by more likely than not extreme dry (i.e. prolonged dry spells), wet (i.e. likely flooding) and hot episodes. The expected increase in dryness in the dry southeast monsoon is likely linked with the overall extreme warming in the northern hemisphere which would drive a stronger divergent southeast monsoon suppressing rainfall in the southwest Indian Ocean. However, it is important to note that the above recent studies target temperature and rainfall only. There is a need to elaborate on the impact of climate change on the water resources in an integrated process to enable the design of appropriate adaptation policies, mechanisms and responses.

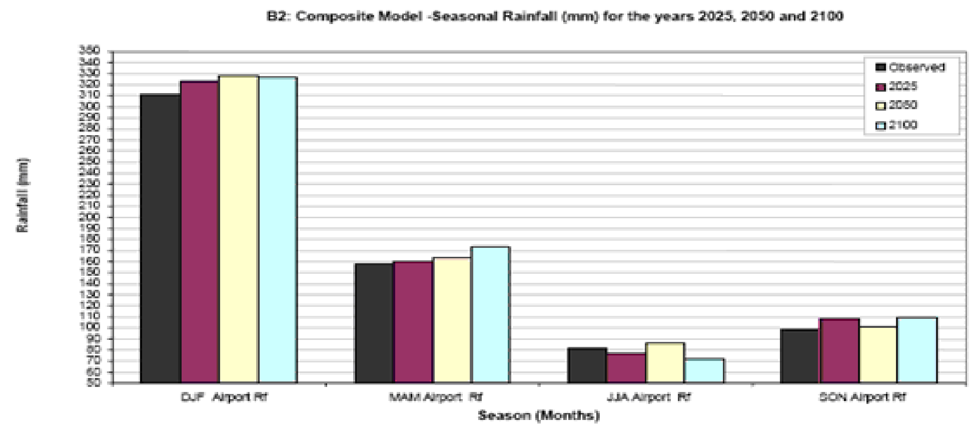


Figure 59: Observed (1972-1990-Grey Colour) and Composite Model Scenarios of the Seasonal Precipitation Values (mm) for the International Airport for the Years 2025, 2050, and 2100 for B2 Mid-range Emission with a Mid-range Climate Sensitivity (Source: Chang Seng, 2007).

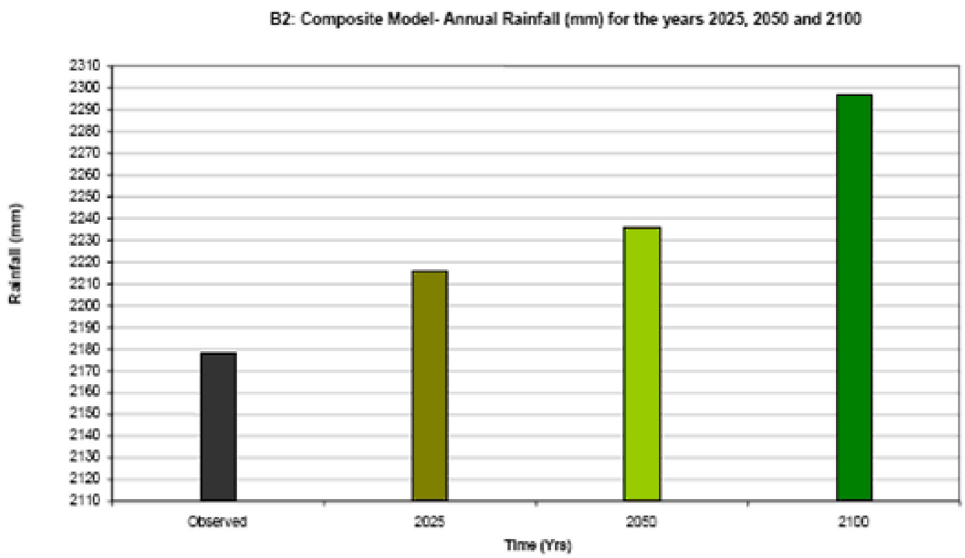


Figure 60: Observed (1972-1990-Grey Colour) and Composite Model Scenarios of the Annual Precipitation Values (mm) for the International Airport for the Years 2025, 2050, and 2100 for B2 Mid-range Emission and a Mid-range Climate Sensitivity (Source: Chang Seng, 2007).

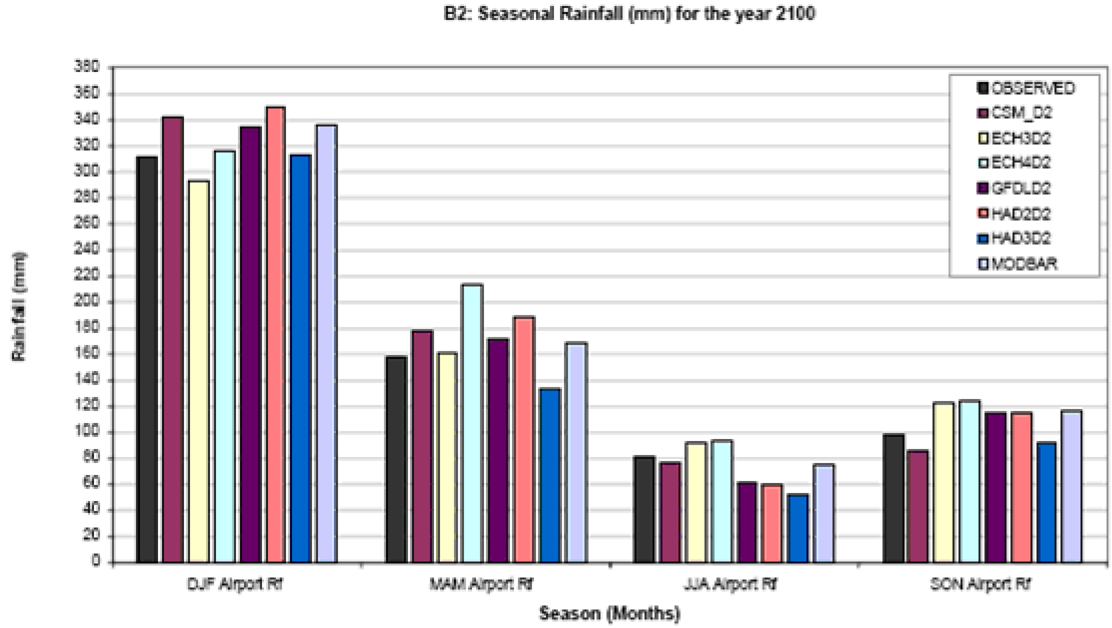


Figure 61: Observed (1972-1990-Grey Colour) and Scenarios of Seasonal Precipitation Values (mm) for the International Airport for B2 Mid-range Emission with a Mid-range Climate Sensitivity for the Year 2100 (Source: Chang Seng, 2007).

4.3.3 Sea Level Rise

The mean elevation of the coastal plateau of the granitic islands is 2-10 m, whereas the coral islands vary from 1.8 metres to 9 metres above sea level. Ste Pierre is the most uplifted reef in the Seychelles group, being surrounded by cliffs of up to 10 metres. Sea level monitoring data for the Seychelles is limited. Data is available from 1993 to present (Figure 62), and are not consistent.

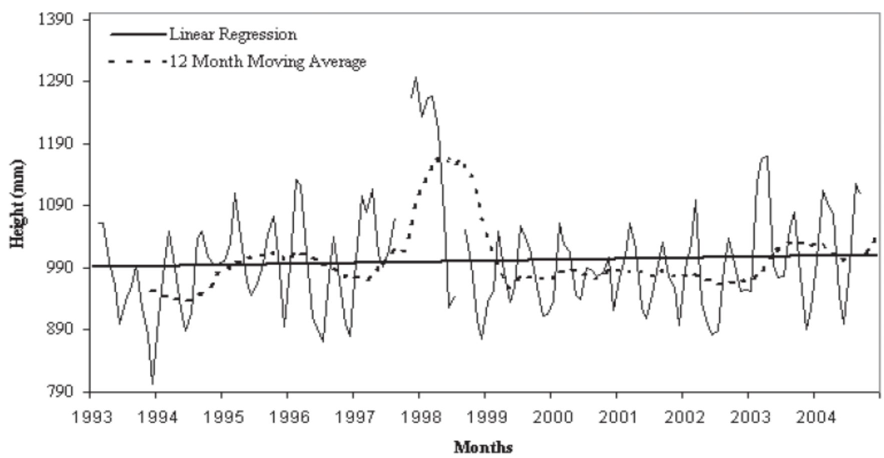


Figure 62: Time Series of Monthly Mean Sea Level at Pointe La Rue, Seychelles (Source: Hawaii Sea Level Monitoring Centre).

Furthermore, data on sea level rise in the Western Indian Ocean is limited to a short-term sea level gauge network in over 13 stations, including one in Seychelles, on Mahe Island. These gauges were installed on islands located between 06°N and 46°S and between the African coast and 80°E during the TOGA (Tropical Ocean Global Atmosphere) programme to monitor sea level. The data range from 1993 to 2004 which make any conclusive assessment difficult (see Figure 4-24).

Chang-Seng (2007) suggests an annual sea level trend anomaly of +1.46 mm (± 2.11 mm) per year on Mahe Island, which is very close to Ragoonaden's (2006) estimate of +1.69 mm/year. Church et al. (2006) using tide gauge data combined with TOPEX/Poseidon satellite altimetry data from 1950-2001 estimated the rate of relative sea-level rise of 0.5 ± 0.5 mm/yr for Pointe Larue, Mahé (Seychelles) as shown in Figure 4-25, which is lower than proposed earlier. Against the global mean sea level rise (1961 to 2003) of 1.8 ± 0.5 mm/year (Bindoff et al., 2007), these results appear in line with the global average increase in sea level.

Of concern, however, is the need to determine the increase in mean sea level rise. Over the period 2002-2006, there were 5 instances at which sea level anomaly exceeded +10 cm. These incidences, combined with extreme storm events, caused significant coastal damages, particularly to roads and other coastal infrastructure.

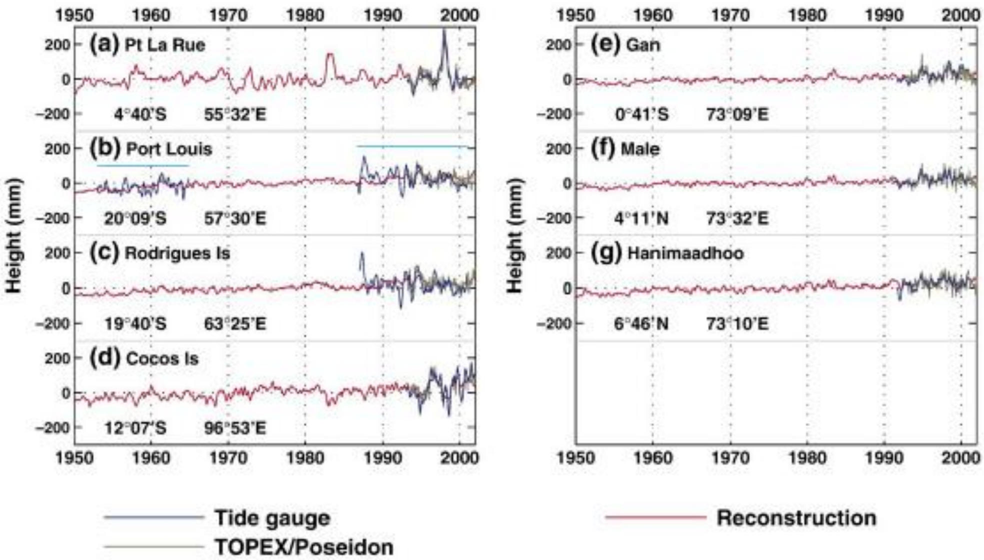


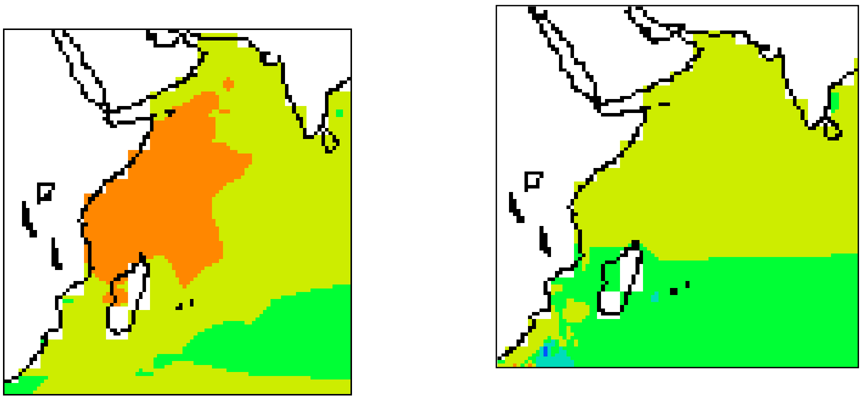
Figure 63: Time Series of Tide-gauge (blue), TOPEX/Poseidon (green) and Reconstructed Sea Level (red) for Indian Ocean Sites. The Light Blue Lines on Panel (b) show the Time Spans of the Two Separate Records for this Site (From Church et al., 2006).

4.3.4 Regional Sea Level

Sea level scenarios for specific region or location are not available in MAGICC SCENGEN. However, the Hadley Centre for Climate Prediction and Research has published the change in annual sea(Table 4-2) level from the 1960 to 1990 and from the 2070 to 2100 periods using the IS92 or P50 emission scenario . Sea level rise for the period 2070- 2100 is expected to be in the range of 0.5-0.6 metre for HadCM2 (Figure 63a), but it is 0.4 -0.5 metre for the HadCM3 model (Figure 63b).

Table 47: Summary of Global Carbon Dioxide (ppmv), Change in Average Global Temperature (° C) and Average Global Change in Sea Level (cm) Values for the Policy Range and Policy Best Guess for the B2 Mid-range Emission with Mid range Climate Sensitivity of 2.6 ° C and the A1 High-range Emission with High-range Climate Sensitivity of 4.6 ° C, abbreviated as BM and AH

	2025		2050		2100	
Climate Scenario	**BM**	**AH**	**BM**	**AH**	**BM**	**AH**
CO2 (Policy Range) **Policy Best Guess**	(420-440) 430	(425-450) 430	(460-500) 480	(500-550) 530	(580-650) 620	(690-800) 730
Temp (Policy Range) **(Policy Best Guess)** °C	(0.5-1.0) 0.7	(0.7-1.3) 0.8	(0.8-1.8) 1.3	(1.2-2.3) 1.7	(1.6-3.6) 2.5	(1.9-4.3) 3.0
Sea Level (Policy Range) **Policy Best Guess**	(3-12) 7	(4-13) 8	(7-27) 15	(8-29) 17	(14-62) 35	(17-70) 40



(a) (b)

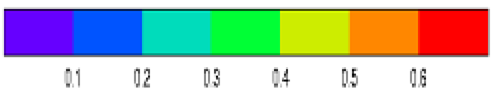


Figure 64: Regional Sea Level Projections for the Year 2100: (a) HadCM2; (b) HadCM3

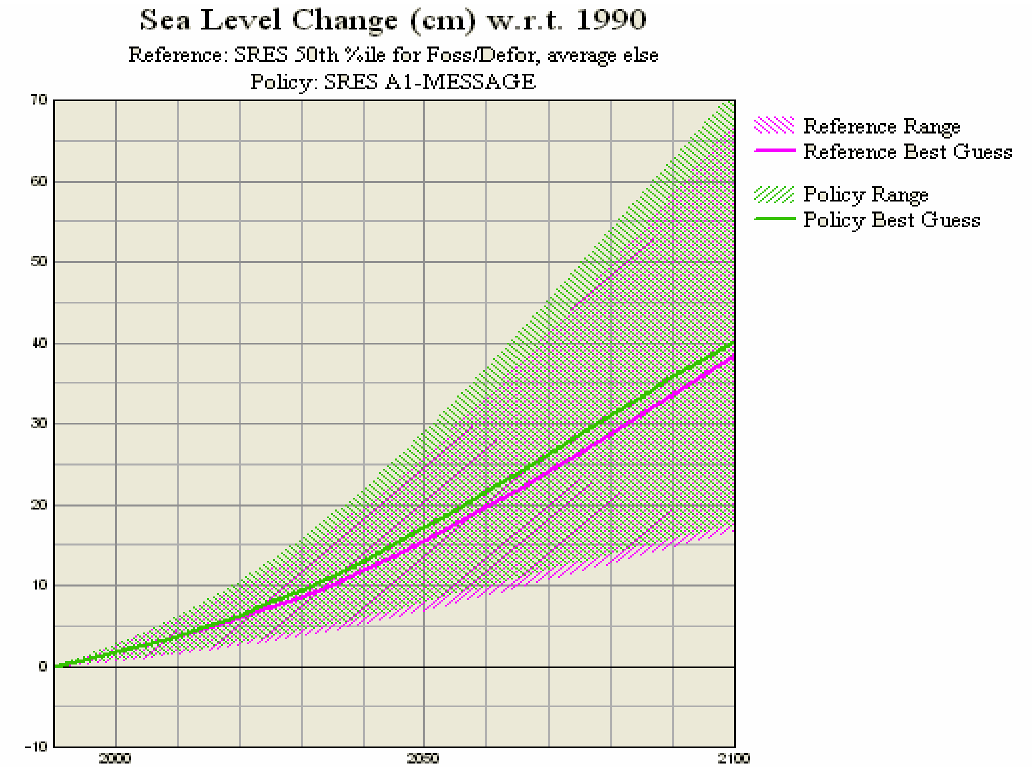


Figure 65: Global Mean Sea Level Change for the A1 Mid-range Emission with Mid-range Climate Sensitivity.

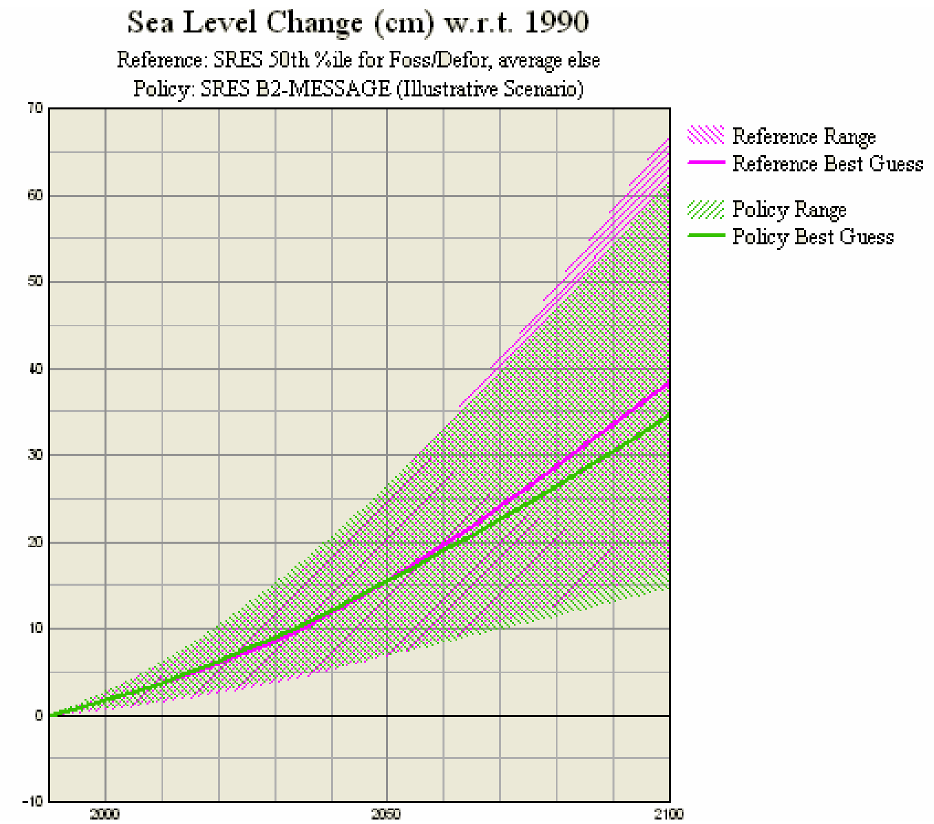


Figure 66: Global Mean Sea Level Change for the B2 Mid-range Emission with Mid-range Climate Sensitivity

4.3.5 Global Sea Level

Figure 65 and Figure 66 are the MAGICC output of the mean sea level changes (cm) derived from the two climate scenarios abbreviated as the policy best guess scenario BM and the policy best guess scenarios AH respectively.

Global sea level is expected to rise from +7-8, +15-17 to +35-40 cm according to the policy best guess scenario by the years 2025, 2050 and 2100 respectively. Regional sea level in the southwest Indian Ocean is expected to rise between +40 to +60 cm according to the UK Meteorological Office model. On the other hand, tropical cyclone scenario remains a major challenge, but recent modeling studies in the US, have suggested that peak winds may increase by 5 to 10 % and peak rainfall rates may rise by 20 to 30 %.

4.3.6 Recommendations

It is recommended that future climate change scenario assessment should consider higher resolution model to provide more skillful island-type of climate scenarios. It is also envisaged that climate downscaling can be applied to achieve far better results at a national level. Future work should also focus on verifying the 'critical' climate changes identified here in this assessment.

A detailed climate change–ecological-environment impact assessment should follow through in the case of the Aldabra area for possible mitigation and adaptation of the impacts.

4.4 Vulnerability and Adaptation for Coastal Zones

4.4.1 Introduction

The impacts of climate change on coastal livelihoods as a result of sea level rise, storm and tidal surges, extreme sea-surface temperatures, and coastal flooding will have serious consequences for livelihood on small islands, such as the Seychelles. In the Seychelles, more than 90% of the population and development are concentrated on the coastal plateau of the main granitic islands, which are themselves very narrow strips, no more than two km wide.

This section is aimed at assessing the state of the beaches and coastlines of the three main granitic islands of the Seychelles; that is Mahe, Praslin and La Digue. The three islands have been chosen as they are the most developed and inhabited islands of the archipelago and therefore most of the developments and activities take place along their coastal plains. It also considers and discusses the impacts of climate change on the Seychelles coastlines through:

- Providing an overview of the aspects of climate change in relation to Seychelles;
- Assessing the state of the beaches and coastlines through the use of chosen indicators;
- Mapping of the assessment results;
- Proposing possible future development strategies and adaptation options based on the assessment results.

There are different impacts associated with climate change which may affect the coastlines. These in turn create the need for the planning professionals of the country to incorporate all of those issues so as to achieve better adaptation measures and solutions, which will eventually lead to sustainable development of the Seychelles coastal zones.

4.4.2 Methodology

The methodology comprises of different components. Field assessment of different regions of Mahe and Praslin as well as of the island of La Digue were done over a period of approximately three months so as to collect the necessary data (Table 48). This included assessing the degree of erosion taking place at the beaches, recording human impacts on the beaches, analysing the characteristics of the beaches, profiling of the coastline, and outlining the management measures and adaptation strategies that currently exist, and if there is a need for future ones.

Table 48: Illustrating Field Assessment Dates

MAHE	**DATE**
Northern Region	02-03-07 to 04-03-07
Eastern Region	05-06-07
Southern Region	13-04-07 to 14-04-07
Western Region	18-05-07
PRASLIN	
Grand Anse	11-05-07 to 13005-07
Baie Ste Anne	09-03-07 to 11-03-07
La Digue	01-06-07 to 03-06-07

4.4.3 Impact of Climate Change On the Coastal Sector

4.4.3.1 Sea Level Rise

A rise in the sea level will affect almost all of the economic sectors of the Seychelles. Such sensitivity is further enhanced by the fact that the main granitic islands rise up to more than a thousand feet, have steep hill slopes which are prone to land slides, and have a very narrow strip of coastal plain. According to the IPCC Fourth Assessment Report, 2007, the average rate of sea-level rise is 1.6 mm/year. The same report goes on to state that it has been projected that the global average sea-level rise for the end of the 21st century (2090-2099) ranges from 0.19 to 0.58 cm. Payet (2006), states that there were a number of problems associated with local sea-level rise in the Seychelles but until now there has been no conclusive evidence to confirm such statement. It has been predicted that sea temperatures will continue to rise, as a result this will not only cause coral mortality but will increase the frequency of such happening (Sheppard et al., 2005). Repeat warming caused new recruitment of corals to set back. However, there are few quantitative data to prove that there will be further reduction of reef given continuous coral mortality.

Sea level rise is expected to affect Seychelles in the following ways:

- Destroy properties and infrastructure located on the coastal plains and reclaimed land;
- Inundate agricultural areas, wetlands and the lowlands;
- Cause several low-lying islands, especially the sand cays to disappear;
- Erode the shorelines and beaches;
- Enhance coastal flooding, especially during severe rainstorms and high tides;
- Increase salinity of mangrove swamps and raise groundwater level thus affecting plant growth;
- Threat groundwater aquifers and coral island fresh water lens;
- Alter tidal ranges in the rivers and bays;
- Alter sediment deposition patterns;
- Affect the coastal and the marine ecosystems (Lajoie; De Comarmond, 2004).

4.4.3.2 Coastal Erosion

Coastal erosion has led to a powerful battles between the land and sea, at several locations in Seychelles. It is evident that most of the exposed locations in Seychelles are being affected by coastal erosion. Coastal erosion maybe classified as a major problem especially to those properties, infrastructure and people situated on the coastal plains and shoreline.

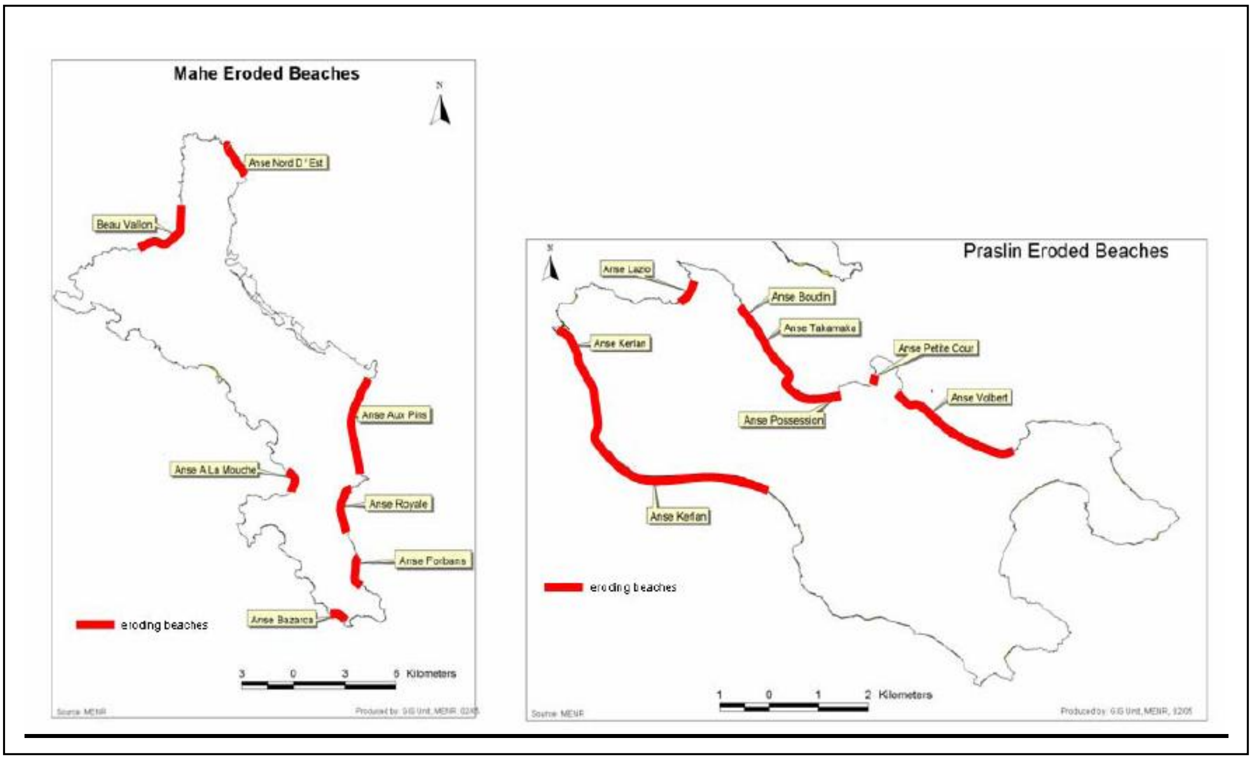


Figure 67: Eroded Beaches (Mahe and Praslin) after the 2004 Tsunami. Source: (Asian Tsunamis Disaster Taskforce, 2005).

According to several reports and observations made during the field assessments, the erosion issue is not a new one in Seychelles. Some coastlines have been retreating for a long time. At Anse Kerlan (Praslin) for instance, old resident's estimate that approximately 10,000 square metres of coastlines have been washed away. Erosion-sensitive sites on Mahe and Praslin are being lost at an average of between one and three metres per year (Tsunami Disaster Task Force, 2005; Seychelles Nation, 1998). Increased recession of the coastline also takes place because of the destabilising nature of the high tide levels.

Some beaches experience erosion during the South East Monsoon but it must be noted that this is a seasonal change scenario as the same beach may become more or less stable during the Northwest Monsoon. Seasonal fluctuations of the beach profile are normal processes as the coastline is always adjusting to its equilibrium. Noticeable changes in the wave energy reaching the shores have occurred during the past decade. Greater wave energy results in greater erosion of the beaches. The changes to come in the next decade are likely to double compared to recent past (Sheppard et al., 2005).

An overview of the main eroded beaches on Mahe and Praslin just after the December 2004 Tsunami is illustrated in Figure 67.

4.4.3.3 Flooding and Coral Bleaching

Flooding in the low lying areas becomes more pronounced with the occurrence of storms coinciding with the annual spring tides. Such was the case at North East Point during the month of May 2007 after the occurrence of the above-normal high tide whereby the coastline was inundated and flooded by tidal surges (Figure 68). The surges impacted mostly the narrow coastlines of less than 50 metres wide and were more prominent at exposed spots (De Comarmond, 2007). At some instances the surge reached approximately 50 metres inland. The occurrence of sea-water surges may result in widespread damages to the beaches, vegetation, coastal roads, properties and other infrastructure.

Figure 68: Pictures showing Situation at North East Point during the Month of May 2007

Another immediate and obvious hazard associated with climate change is the expected change in rainfall patterns. This period could lead to periods of very intense rainfall, leading to flash floods and landslides which end onto the beach and in the sea.

The Seychelles reefs suffered extensive coral bleaching and mortality from February to May 1998, after seawater temperature reached 34 ºC. Approximately 40-95% of corals bleached in irregular patterns across the archipelago, with mortality from 50-95%. Thus, many sites are now covered in rubble which will impede recovery (Status of Coral Reefs in the South West Indian Ocean Island, 2002).

4.4.4 Results

4.4.4.1 Introduction

In Seychelles, beaches differ in many ways; some have gentle and long profile such as the Beau Vallon beach others are characterised with steep profile. The sandy beaches of the three main islands are characterised mostly by very fine sand particles. Most of these beaches have gentle slopes and their profiles change depending on the season. Beaches are seen to predominate on the windward coast; that is those exposed to dominant South East Trade winds. All together approximately 190 beaches have been assessed. However, some beaches were not included due to inaccessibility and some exist as pocket beaches. GIS mapping has been utilised to illustrate the results.

Indicators used in the assessment have been divided into three main groups and they are:

1) Physical state of the beaches

- Degree of coastal erosion;
- Beach profile;
- Coastal vegetation.

2) Impacts

- Human (example sand extraction, coastal development);
- Natural/Physical processes (Wave regimes, tides, tsunamis and storm surges).

3) Adaptation strategies

- Mainstreamed into national policies and plans

4.4.4.2 Degree of Coastal Erosion

Coastal erosion have for the past few years been one of the most sensitive and alarming concerns of Seychelles, as a result of climatic change.

Field visits conducted showed that on Mahe the degree of erosion varies between the different regions. Some of the most eroded beaches include Anse Aux Pins, Anse Boileau and Au Cap (all of which are situated in the Eastern Region of the island). On Praslin, most of the eroded sites were more prominently found along the western side of the island. It is evident however that the majority of the eroded beaches on all islands are usually clearly visible, and the beaches are exposed; meaning having no reefs barrier to act as protection or any other natural or man-made forms of erosion protection barriers. Those beaches are exposed to wave actions and seasonal variations of gaining and losing of sand.

The occurrence of erosion is also evident along some of the beaches on La Digue Island. In certain areas, example at the Logan Hospital (La Digue) and Anse Kerlan (Lemuria Resort, Praslin), the erosion cliffs reaches up to 2 metres high.

On certain sites namely Anse Source D’argent on La Digue, breaks at intervals occur along the beaches. Of the sites assessed, it was obvious that there were two main causes of erosion, and they and were:

- Natural causes (topography of the area and marine hydrology, seasonal changes);

- Human activities (such as the construction of sea walls, groynes, reclamation, and ad-hoc developments, as well as irresponsible behaviours).

According to the results, the degree of erosion on the three main islands has been classified into three main categories namely severe, moderate or normal. The degree of erosion has been illustrated using different colours (as illustrated in the Table 4-4 below).

Table 49: Showing the Degree of Erosion and Colour Code

Degree of Erosion	**Colour Code**	**Remarks**
SEVERE	RED	Intense erosion, erosion cliffs up to 2 m, denuded roots of coastal vegetation Exposed beaches.
MODERATE	ORANGE	Shows signs of erosion but not alarming. Erosion cliffs up to 0.5 m. In some instances partly covered with coastal vegetated.
NORMAL	YELLOW	Normal seasonal gain and loose of sand. Reef barrier. Stable beach. Well vegetated.

Figure 69: Coastal Erosion at the Anse Kerlan Beach (April 2007).

If comparison is made between exposed beaches (no natural protection) and protected beaches, the latter are more tolerant to surges and the forces of waves. Thus, the resulting effect of erosion is moderate or normal implying that it occurs due to the natural beach dynamic processes. Whereas the more exposed beaches comprising of both reefs and vegetation for example at Anse Kerlan, Praslin are usually the ones eroding at an alarming rate, as shown in Figure 69 above. Thus, habitats of coastal living organisms are destroyed, properties and infrastructure are threatened and species survival is at great risks. With the threat of future sea level rise, the impact will surely increase. It is a fact that at certain eroded turtle nesting sites, hatchlings rarely make it to sea and at other times eggs are being washed by the sea. It is evident that as a result of seasonal changes such as spring tides, the severity of erosion intensifies, thus leading to species mortality.

Figure 70: Coastal Erosion at Anse Severe (La Digue) and the Grand Anse Beach (Lemuria Resort Praslin, April, 2007).

If a portion of the reef is dredged, then the large waves with high intensity can reach the shoreline thus, accelerate the degree of erosion. These vulnerable beaches are in most cases stressed out with the high human interference. Beach recovery has become very difficult in the Seychelles and most of the time these beaches do not recover completely albeit of the seasonal changes. The North East Point and Intendance beaches are good examples of those that have made significant recovery. These two beaches experienced severe erosion during both the 'Bondo' cyclone and Spring tides of the 15th to 16th of May, 2007.

Erosion along some of the coastlines have caused the roots of existing coastal vegetation to be denuded as is the case at Anse Sevère on La Digue (Figure 70), and as a result breaks at certain spots and beach cliffs are formed. The rates at which some of the beaches are retreating especially on the La Digue Island (Logan Hospital) are alarming and also on Praslin (see Figure 4-33 below).

Figure 71: Eroding Beach (Anse Georgette, Praslin), and Stable Beach (Amitie, Praslin)

4.4.4.3 Coastal Vegetation

On most of the sites assessed, the beach-fringed vegetation grows mainly above the high water mark. Though growing above the high water mark, the soil in which it grows contains both sand and organic matter. Most plant species found on the beach around the three islands are trees, creepers or bushes. These have low branches and extensive root systems enabling them to withstand the environment stress mostly caused by the combined effects of wind, high insulation and salt spray. During very high tides such as spring tides or storms, the vegetation is often squashed and affected by the sudden high salinity. Major changes during the North-West and South-East monsoons are responsible for the shifting of sand, both along and up the beach. The vegetation is very much affected by these seasonal changes, thus their adaptation to the exposed conditions of the beach edge is vital to enable beach stabilisation.

The plants are widely distributed forming a narrow strip of vegetation along the beach and they help in protecting the shoreline against coastal erosion. The coasts of Grand Anse (Praslin) and Petit Anse (La Digue) are good examples where there is very dense *vouloutier(Scaevola serica)*. It was found that some species may occur on rocky shores, example coconut, and patatran (*Ipomoea Pes-caprae)* just to name a few. Taller plants (coconut, bwa-de-roz) as at Anse Coco (La Digue) also act as a barrier by protecting the inland growing plants from the effects of salt spray.

The vegetation has been found bordering practically all of soft shores on the three islands. Much of the vegetation is a mix of indigenous and non-indigenous species. Some of the vegetation has been severely impacted at some locations; there are different reasons for such impact. The severity of the impacts is most apparent along narrow coastlines (example at Anse Sevère on La Digue (Figure 72), Anse Kerlan on Praslin and Anse Aux Pins on Mahe), which are usually those same coastlines being impacted by severe coastal erosion. On the other hand, coastal vegetation has been removed in certain areas to accommodate coastal developments, especially tourism establishments. It is therefore vitally important that tourism developers are made aware that the coastal areas are exposed to climate change risks whenever coastal vegatation are removed so that such practices are avoided in the future.

Figure 72: Coastal Vegetation on the La Digue Island

4.4.4.4 Beach Profile Monitoring

It is evident that the beaches along all three islands experience fluctuations in their beach profile. In some cases such fluctuations depend on the change of the seasons, or after extreme weather events. Beach profile fluctuation is evident after above-normal high tide exemplified during the month of May, 2007 when part of the North East Point beach was replenished, therefore creating a gentle profile along that coastline. Such profile indicates that the beach is continuously adjusting to the respective coastlines equilibrium. Regular beach monitoring along some of the beaches is currently being done. This method helps to indicate which of the beaches are receding or accreting or even recovering. Such programme will also help to provide a scientific basis on which adaptation measures can be taken to address the problem of coastal erosion at the local scale. It will enable the relevant authority to take proper decision against climate change risks such as sea level rise and storm surge. Data collected for beach monitoring may also help to detect the extent of climate change-induced coastal erosion in Seychelles, as it threatens very important economic sectors such as tourism. However, the programme needs to extend its coverage in ensuring maximum data on the coastline and beaches of Seychelles.

4.4.4.5 Human Impact

As is the case for many small islands states, Seychelles' beaches are under constant pressures either from human activities or from natural processes . The extent of erosion varies from slight to severe at some key beaches with high human interferences. Sand mining was once one of the main threats towards sand loss, therefore contributing to the recession of the beach. Coastal sand and coral mining in the Seychelles in the 1980s and 1990s enhanced the rate and degree of coastal erosion. However, these practices are now greatly reduced due to the enforcement of the Removal of Sand and Gravel Act (1991) and the Environment Protection Act (1994) (United Nations Environment Programme, 2005). It is vital that the enforcement of such regulations, policies and legislation are upheld and regularly reviewed to cater for climate change issues and risks.

4.4.4.6 Coastal Development

Most of the coastal development has been made in the past without taking into consideration sea-level rise and the possibility of any increase in the frequency and intensity of extreme natural events such as flooding and storm surges. This was probably due to the lack of awareness and understanding on the climate change risks.

Several properties along the coastline of the three islands are affected by wave splashing. This is so as the properties lack the necessary setback distance to the beach or is directly on the shoreline and on the sand dune. There are examples on Praslin where several hotel establishments are located on the shoreline or less than 25 metres from the High Water Mark (HWM). Therefore, these structures create obstruction to the natural sand movement and are at risk of inundation of water due to sea level rise. At the moment the Department of Environment has a setback policy of 25-30 metres from the high water mark for any coastal development. The setback line approach is one of the main tools currently in place regulating development and planning along the coastal zones. With future threats of sea level rise and storm surges, it is vital that coastal developments are setback as far as possible from the high water mark.

The types of developments found near the beach or on the dune land vary between the islands. On Mahe, for example, in the northern region, most particularly at Beau Vallon, tourism development such as hotel establishments dominate, thus creating ribbon development along that particular shoreline. On the other hand, in the southern region residential developments are the dominant type of coastal development. In contrast, the east coast region is characterised by land reclamation. Most hotels on Praslin are on the beachfront. La Digue Island, being the smallest island among the three assessed, has different types of developments along its coastal area and these include residential, tourism establishments and the jetty.

One of the main infrastructure found close to the shoreline on all of the three islands is the main road. Such infrastructure creates a type of obstruction to the wind blown sand. With a lack of dune land to retain the sand, the beach no longer receives the natural replenishment and is unable to establish its natural profile system. Many of such areas experience undercutting of the buildings and other infrastructure. Along many of the coastlines, sea-walls have been constructed so as to repair the damages to the coastal roads (examples are at North East Point and Au Cap on Mahe, and Baie Ste Anne on Praslin). Future coastal road construction and development should consider climate change threats; it should be considered that the future coastal road network should be located furthest inland as possible.

The use of vehicles and beach-bed dragging on the beach are now popular practices among beach users. Such actions help to further increase the rate of erosion by disturbing the beach profile and make the beach more vulnerable to the impacts of climate change.

4.4.4.7 Existing Adaptation Measures

A number of hard and soft structural technologies to protect the shoreline against coastal erosion as a consequence of sea-level rise have been adopted along some of the beaches and coastlines of the three islands. Such structures have been put in place so as to protect the shoreline, in particular the beaches from the impacts of erosion caused by wave action. De Comarmond (2004) states that most of the 'hard' options such as sea-walls, groynes and break-waters have been used in the past as a means of protection for the coastline against erosion on the islands of Mahe, Praslin and La Digue. It must be noted that these technologies are also used today for the same purpose stated above. The hard structural technologies that exist include:

Rock armouring; Sea-walls; Break-water/Piers and Groynes:

These structures have been used more in the past rather than the softer technologies (example of soft technologies are dune and/or berm restoration, coastal planting).

The presence of the hard structures in certain places has further aggravated the problem of shoreline erosion because of their ineffectiveness. For example the installation of break-waters in some places may deprive beaches of the required sand. Continued deposition of sand between the shore and the break-water may tie the latter to the shore. Such scenario is currently emerging on the La Digue Island whereby the beach in-front of the Tarosa Restaurant is accreting at a fast rate. Such situation affects boating movement and the activities of the jetty and thus requires regular dredging.

As for groynes, if they are not installed correctly, they will obstruct long-shore drift along one side of the structure, and as a result will deprive the beach of its required sand, while on the other side of the groyne sand may accumulate. This means that while they might help sand accumulation on one side, often there will be loss of sand on the other side of the structure. Anse Kerlan Beach on Praslin is a good example whereby groynes either obstruct or help towards sand accumulation. Groynes on this stretch of beach have been constructed since the early 90s when the beach was experiencing severe erosion. The construction of the last groyne was completed in the year 2006.

Sea-walls in some cases accelerate beach erosion as they impede the dissipation of wave energy and a negative energy is created leading to the eventual undermining of the walls.

Figure 73: Examples of Different Existing Adaptation Measures.

There are several sites on the three islands where the hard technologies have not worked properly. Such situation is apparent, especially along some of the shorelines, for example at Anse Aux Pins, Au Cap, Anse Kerlan and at La Passe (La Digue) (see Figure 4-35). Those same beaches are now experiencing coastal erosion at an alarming rate. In most of the cases the groynes have been in place for a very long time and are in need of proper maintenance, refilling and extension as they have been degraded by wave action with time. Maintenance of such structures is essential to enable them to withstand long-term climate change risks.

A number of these structures have been built or have been installed since the 1970s, 1980s or even in the 1990s. It was in the late 1980s and 1990s that the 'soft' options were seen as another solution to the coastal adaptation challenge. Examples of areas where softer technology measures have been used include Grand Anse, Mahe, Grand Anse, Praslin and at the Paradise Sun Hotel on Praslin (Figure 74). Such method includes planting, dune and berm restoration.

Figure 74: Existing Protection Measure on Praslin (Soft Technology)

4.4.4.8 Adaptation Options

For the adaptation options and the strategies to be most effective in Seychelles, they should be mainstreamed into policies in other areas such as Disaster Mitigation Plans and National Development Plans. Such plans should map the potential areas of the country that are most sensitive to natural disasters, especially those related to climate change impacts.

On the other hand, it is a fact that the existing land-use plans of Seychelles are outdated and thus the relevant authority must start to update those plans, consequently the authorities need to identify and establish the environmental baseline so as to be able to do the appropriate zoning, whilst bearing in mind the impacts of climate change along the sensitive areas. These plans must clearly indicate "the no development zones".

Adaptation options are best addressed when they are also mainstreamed into Integrated Coastal Management and Sustainable Development Plans. There is growing recognition in Seychelles of the need for researchers, policymakers, residents, managers and other key stakeholders to work together to establish a framework for adaptation that is mainstreamed into the current coastal management processes and practices, and take a broader view of the subject. A comprehensive legal framework incorporating all of the mentioned should be formed. Collaborative efforts of this kind can support a process of shared learning and joint problem solving, thereby allowing for better understanding, anticipation of, and response to climate change risks.

Integrated Coastal Zones Management Plans should be prepared for each of the main islands, especially the granitic islands (Mahe, Praslin and La Digue). Such plans should be prepared by taking into account the different aspects such as coastal processes and the uses of the coastal zones.

There is no legislation in Seychelles covering coastal zone management in its entirety; instead coastal zone management is covered by several legislations. On the other hand, the 25 metres setback is only a policy; it is recommended that this policy is given legal status even though one might argue that development should be treated on a case by case basis.

Climate change is already increasing hazards in all coastal zones and this is expected to continue. Many of the Small Island Developing States, including the Seychelles, neither have access to the latest appropriate adaptation technologies nor the knowledge or resources that are required to develop or implement these. It is essential that capacity is built nationally so as to better understand such technologies.

Successful coastal adaptation embraces more than just selecting one of the technical options to respond to sea-level rise; it is a more complex, combined and it is an interactive process with a combination of a series of policy approaches.

4.4.5 Recommendations

Seychelles as a Small Island Developing State (SIDS) should be prepared to adapt to changes in climate in view of the island's dependence on natural resources such as water, fisheries and coral reefs, to meet basic human needs. The IPCC (2001) defines adaptation as the adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It further states that adaptation refers to changes in processes, practices, and structures to moderate, potential damages or to benefit from opportunities associated with climate change. Limited size, proneness to natural hazards, and external shocks enhance the vulnerability of the island states to Climate Change (IPCC Fourth Assessment Report, 2007). Adaptation measures must therefore begin today so that Seychelles is better prepared to cope with future climate change risks.

Given the certainty of an accelerated climate change, there is a need for Seychelles to consider implementing adaptation measures, and such would include low-cost technology/technical measures as well as the implementation and the enforcement of regulatory as well as policy measures.

It is important to note that climate change impacts trigger off efforts for mitigation to remove or reduce the causes of the impacts. Climate-related changes represent potential, additional stresses on the country's coastal systems that are already under pressure. Therefore, climate change generally may contribute to aggravate the existing problems. At the same time, non-climate stresses can be an important cause to increase coastal vulnerability to climate change and variability.

4.4.6 Drainage and Flood Impact Mitigation and Management in the Seychelles

4.4.6.1 Introduction

The contents of this study attempts to evaluate the present onset and future impact of climate change, focusing on the Coastal Zone Sector, namely the effect on coastal flooding, which the country is currently highly vulnerable to and what mechanism, whether physical, policy or legal has to be put in place to meet the already-felt effect of global climatic shift. The study aims to evaluate the current hydrological status of the country, and balances these findings with climate scenarios assessment as well as models of climatic variability derived from the National Meteorological Services (NMS) and the World Meteorological Organisation (WMO). The end product of this assessment shall provide a clearer picture on how prepared Seychelles is in terms of drainage and flood impact mitigation.

4.4.6.2 Methodology

A series of field activities were carried out on the 3 main granitic islands of Seychelles, namely Mahe, Praslin and La Digue, whereby collection of information of existing hydrological features and the existing natural and man-made drainage infrastructurewere done (a brief description of the various districts covered is provided in Annex 2) . The report goes on to assess the discharge capacity of various watersheds per region, taking into account the hydrological parameters such as runoff coefficient, catchment areas and discharge capacities of outlets. The collected information was then compared with results of climate change scenarios acquired from the NMS, which provided an insight on how adequate are the islands' hydrological stance in relation to the degree of change forecast by these models.

The study not only provides physical recommendations based on the said analysis, but also provides the country's policy makers with a valuable tool for future formulation of guidelines and regulations on how to better manage, control and subsequently mitigate the adverse impact of flood and other related natural disasters in the Seychelles.

4.4.6.3 Results and Recommendations

The aims are to integrate climate change concerns into sustainable development planning for all socio-economic sectors, with special emphasis being put on integrated coastal zone management, including the protection of coastal areas from flooding and flood-related disasters. The integration of climate change into the coastal zone sector shall enable the planning and implementation of a comprehensive National Climate Change Action Plan, whereby the effects of climate change are catered for when planning, formulating, managing and establishing national guidelines and policies related to that particular sector. The followings are the results and recommendations:

Sound Information on Precipitation Trends

It is recommended that the NMS revise and update the Intensity-Frequency-Duration (IFD) curves to include a wider range of durations and frequencies/probabilities of storm events.

As demonstrated, the relief and topography of the three main granitic islands covered in the study depicts that rainfall intensity varies with altitude, specific locations and topographical characteristics of these islands, within any given storm event. In a similar argument, the result of the rainfall intensity derived from the recorder situated at the Seychelles International Airport (SIA) does not necessarily represent the rainfall intensity being experienced at La Misere or at Bel Ombre within the same storm event. The ENSO phenomenon, which triggers the torrential rain in 1997 in Seychelles, was recorded at the SIA weather station as being a storm of relatively moderate intensity, which was not the case in the northern regions of the Seychelles. In order to get around this and ensure a more accurate, localised rainfall pattern, it is vital for that the NMS considers the installation of the tilting siphon rain recorder on various parts of Mahe, Praslin and La Digue (Figure 75). In this way, the differences in intensities can be analysed separately for the various weather stations, with the ultimate goal of achieving a patterned cycle of intensity, frequencies and their durations (in other words, an accurate, updated IFD curve for various parts of the country.

Figure 75: Tilting Siphon Rain Recorder at NMS-Seychelles International Airport

Drainage Outlet Invert Levels

In formulating a set of guidelines for the Seychelles Drainage Design Strategy, thoughts were given to global warming and its effect on the then presumed sea level rise. The study recommends that in consideration of drainage design for storms of Average Recurrence Interval ARI of 10 years or less (which is more frequent but less intense in theory), the figure is revised to 0.3m above the designed invert level instead of the figure of 0.2m put forward by Paul Abbey in 1998.

For storms of ARI of 50-100 years, the report recommends that the figure is changed to 0.5m above the designed invert level instead of 0.3m

Catering for Run-Offs of Covered Surfaces and Catchments

- To recommend that the construction of any road accesses, driveways, yards and anything which covers the ground and affects the percolation of water into the ground, should cater for the water that will "otherwise run off" their surfaces (hence surface runoff) and channel this water conveniently into a natural water body or a connecting trunk drain;
- To recommend that any road accesses and main roads assume a **minimum** of 3-5% cross-fall or camber for ease of channeling water away from its surface and into its subsequent roadside drain;
- To recommend that man-made or natural main waterway that drains a catchment of known ground parameters should be adequate to take water from the whole of this catchment. The tricky part is how to get all the water from that catchment into this or these main waterways conveniently. This can be done via several means, such as drainage network, swales, berms, levees etc.;
- To recommend that the Seychelles' Government does away with the construction of road accesses without a proper drainage system, houses without a proper gutter and downpipe system, which in turns channels water into either a "relay" drain or a main watercourse.

Raising of Floor Levels and Terrains

- To agree that the whole islands of Mahe, Praslin and La Digue have a somewhat unique hydrological characteristic in that the 2 km strip of land where most development are situated is in the deltas of mini-streams and rivers, which has formed wetlands and marshes, as the flow velocity of small streams and rivers reduces upon reaching flat land. It is thus reasonable to say that most of these developments are very susceptible to local and general flooding in some particular storm events;
- To recommend that any new construction of buildings, houses and other erect structures that are susceptible to flooding must not only have their floor level raised, but also their surrounding terrain raised, making use of perimeter drains and swales to divert sheet flows and concentrated flows away from their establishments. The reality remains that as long as construction takes place within the 2 km strip of land of these islands, these developments will experience flooding to a certain degree. The strategy is to minimise the adverse effects of these existing water flows on the built environment.

Rainwater Harvesting

In the Seychelles, integrated water management can be adopted to a certain degree. The most recognised natural process that comes to light on this basis is the country's flood-drought cycle, which is closely related to the ENSO phenomenon. In recent years, the country has experienced some severe flooding events followed immediately by periods of moderate to severe droughts. A strategic Integrated Flood Management (IFM) approach in this case would be a programme or a project to make use of storage of all the water flowing into the sea to cover the period of droughts, such that there is a continuous supply of potable water to the community.

One promising approach to this strategy is the promotion of decentralised rainwater storage and rainwater harvesting practices on a district level, throughout the country. The Seychelles Public Utilities Corporation (PUC) has recently launched a project to install new pipelines in remote areas of the country, which is a good initiative. There have also been plans by this same institution to construct large-capacity dams for projected water demands. Although very welcoming initiatives, this report would go at full length to put emphasis on the IFM approach mentioned above. A storage device serving water within a community, with capacity to cater for projected growth of the community, is another very efficient approach of ensuring that this resource is maximised. It is believed that it would be more beneficial to have a number of relatively smaller water storage facilities serving a community instead of larger ones serving, say, half the population. The benefits will be observed in terms of costs savings, and being of minimum detriment to the Seychelles' fragile environment.

The Government of Seychelles (GoS) is presently implementing another very important approach in integrated water management nationally. With the ever-increasing number of hotels and other tourists' establishments, the demand for water is escalating faster than the predicted increases. This coupled with the country's small but growing industrial sector, the pressure on demand is even greater.

Seeing this fact, the GoS has taken the initiative to encourage these establishments to have their own water storage facilities, such that tapping into the domestic reserve is better controlled. This approach is fully encouraged and it is recommended that this practice is taken another notch further, by recognising and awarding the private institution.

The Environmental Impact Assessment (EIA), a most useful tool in Seychelles' control over developments, can make use of this regulation and insist that all hotels, industries and similar establishments having their own water storage facilities.

One such case, whereby the rain-water harvesting has been put to good use, can be found at the Cousine Island Hotel, which is on an inner, granitic island of the Seychelles' Archipelago. The resort has made use of an interlinked 400 000L water storage device, which is used to convey water to individual villas of the resort. A UV and sediment filter is used to purify the water for drinking and cooking.

One of the benefits of rain water collections to such resort is the reduction in soil erosion as all water runoff is collected and does not cause potential flooding of the surrounding areas.

4.4.6.4 Conclusion

The way forward for national adaptation to climate change is primarily to obtain sound information on the degree of climatic change over a projected period of time. These data are then weighed against the existing and known climatic stance of the country and region such that the degree of projected anomalies can be prepared for.

The study has attempted to provide a snapshot of the current physical drainage and flood control measures through field data amassed within the districts of the Seychelles, which have then been used to technically assess the degree of adequacy of the existing drainage infrastructure and to provide recommendations based on the findings. In addition, the report has also provided a glimpse of the current institutional approach to drainage and flood management nationally and has provided new recommendations on how these institutions can adjust their methodologies in order to meet the factor of climate change in the form of flood control.

It is again within the interest of every country to also compare the imminent impact of climate change with their various sectors such that the process of mainstreaming this event into their national policies, strategies and guidelines is effected in a way to ensure the continued well-being of the community.

Storm water management is a multi-task business. The recommendations set in the study outline a rather new path which the Seychelles can assume a more effective role in drainage and flood management, hence a drainage and flood impact mitigation, management and control in the Seychelles integrated flood management approach is recommended (Table 4-5).

A. National Meteorological Services

- Assimilate information on rainfall data and sea level variations.

B. Seychelles Planning Authority

- Act as the development control body by enforcing on the guidelines set by the Drainage Unit to other Ministries/Departments.
- Coordinate the liaison process of private developers with the Drainage Unit prior to them submitting any drainage and storm water management proposals.
- Assumes a monitoring unit to ensure that site practices are in line with recommendations on paper.
- Assumes a Utilities Committee to keep an eye on major drainage rehabilitation works, which shall also comprise of a representative from the Drainage Unit.

C. Department of Community Development

- Assumes an empowered coordinating unit for the proper maintenance of the drains.
- Assumes a comprehensive work program for the routine maintenance of drains.
- Liaises with the District Administrators for the proper implementation of the set maintenance programme.
- Leads a maintenance task force (CWA) through the DA's to be equipped with proper tools, machinery and equipment to ensure that the CWA carry out their duties efficiently.
- Ensures a proper liaison with the waterways task force for the maintenance of artificial waterways, marshes, rivers and any other watercourses, which might require an environmental input (such as existing eco-systems).
- Ensures a proper liaison with the Drainage Unit for the planning, designing and implementation of drainage infrastructure that fall under its jurisdiction.

D. Other Ministries, Departments and Parastatals

- Assume a clear role in whatever part they should be playing in the construction and rehabilitation of drainage and storm water proposals *(e.g. – LTD: Roadside drains; Housing, Habitat Department: Housing estate Drains; Department of community developments: drainage to private properties, public establishments, e.g. schools, churches, clinics etc.).*
- Coordinate with each other in terms of drainage proposals.
- Ensure a good liaison with the Drainage Unit to minimize the risk of breaching and also to allow this unit to upgrade its database of existing drainage infrastructures.
- Ensures the proper rehabilitation of their drainage infrastructures. Request necessary funds.

Table 76: The Integrated Flood Management Approach of the Seychelles

4.5 Vulnerability and Adaptation For Agricultural Sector

4.5.1 Introduction

With a rise in population and an increase in tourism, the consumption of food in the Seychelles will substantially increase over the next few years. Climate change might require a shift in contemporary national agricultural efforts, and a decrease in self-sufficiency would place more emphasis on imported agricultural products – leading to a negative impact on the economy's already strained balance of payments. The main direct effect will be through changes in temperature, rainfall and timing of extreme or critical threshold events related to crop development. A rise in sea-level level will contaminate coastal land and thus render the soil unsuitable for cultivation. Therefore, mainstreaming climate change in the agricultural sector is becoming crucial. As a result, it has prompted the sector to conduct two studies in the context of the Second National Communication namely:

- Study 1: Establish an insurance mechanism to protect crop and livestock producers and fishermen against natural disasters;
- Study 2: Seasonal Response of Lettuce to Weather Stresses and Implications of Climate Change on Crops in the Seychelles

4.5.2 Study 1: Establish an Insurance Mechanism to protect Crop and Livestock Producers and Fishermen against Natural Disasters

4.5.2.1 Introduction

The December 2004 national tsunami disaster together with excessive rain and strong winds following the tsunami event caused severe damage to agriculture and fisheries in the Seychelles, requiring the Government to respond with its National Disaster Fund to cater for the losses and damages.

As a consequence to the December 2004 event, the Government of Seychelles initiated research into private sector insurance solutions for the agriculture and fisheries sector.

A task force with members from the stakeholders of the private sector and the Government was set up to discuss and study the risks and the benefits of an insurance schemefor the agriculture and fisheries sectors.

After 2 years of study, the taskforce produced a working paper with the findings and proposed the establishment of an Agriculture & Fisheries Insurance Scheme for the Seychelles. No further follow-up had been done up till in February 2009 when an FAO agriculture insurance expert mission, arranged under Second National Communication project, carried out a pre-feasibility study mission to research and assess the possibilities for the implementation of a Disaster Insurance Scheme for the agriculture and fisheries sectors.

Meetings were held with the main stakeholders in the Seychelles' agriculture and fisheries industries and, with the kind assistance of Seychelles Agriculture Agency, selected crop and livestock farms on Mahe Island were visited for risk reviews.

The results of the work of the special taskforce (comprising of all the stakeholders in the Seychelles' agriculture and fisheries sectors), exploring in 2005/6 the establishment of an Agriculture and Fisheries Insurance Scheme for the Seychelles, were shared with the consultant and have been duly considered and taken into account during the preparation of this study.

4.5.2.2 Methodology

The preparation of model schemes of agriculture and fisheries insurance to cover livestock, crop farmers and fisheries comprised of:

- Establishing the objectives of crop and livestock insurance in the context of the macro economic reform programme;

- Defining the economic, financial and administrative implications of crop, livestock and fisheries insurance;
- Defining the organisational structure required at the administrative and field levels;
- Setting the criteria for selection of crops, livestock and location of farmers;
- Defining the funding assistance required in crop, livestock and fisheries insurance and who would provide it.
- The preparation of the underwriting guidelines:
    - i) Scoping the cover of the insurance;
    - ii) Defining how the sum insured would be calculated;
    - iii) Determining the premium rates;
    - iv) Stipulating how collection of full premium will be made before commencement of risk along with defining procedural details.
- The preparation of guidelines for claims handling:
    - i) Laying down provisions to determine the losses incurred, indemnities payable and defining procedures for claim settlement.
- Reinsurance requirement:
    - i) Determining the type and extent of reinsurance required as also the need for an automatic route for sanction of foreign exchange for remittance of reinsurance premium.
- Computerising the drafting of proposal policy, claims forms, internal records and procedures;
- Periodic review of performance: Considering an empowered mechanism for this constitution which may comprise of an expert committee to oversee the implementation of the insurance scheme on a continuous basis.

4.5.2.3 Public-Private-Partnership

The establishment of a viable national, market based agriculture and fisheries disaster insurance scheme for the Seychelles is possible, but full cooperation of the public and private sectors is required.

The establishment of a **Seychelles Agriculture & Fisheries Insurance Fund (SAFIF)** involving the agriculture sector, fisheries sector, insurance industry and the Government is recommended.

Private Sector

Private insurance sector ***(***State Assurance Company of Seychelles Ltd ***(SACL) and*** Harry Savy Insurance Company Ltd (***HIS))*** is in a position to provide the legal and operational SAFIF platform for policy issuing, premium collection and loss handling.

The Seychelles Farmers Association ***(SeyFa),*** the Seychelles Fishing Authority ***(SFA)*** and the Seychelles Boat Owner Association ***(SBOA)*** need to be actively involved, motivating their members for support of the envisaged Disaster Insurance Scheme for Agriculture and Fisheries.

4.5.2.4 Organisational Structure, the Seychelles Agriculture & Fisheries Insurance Fund

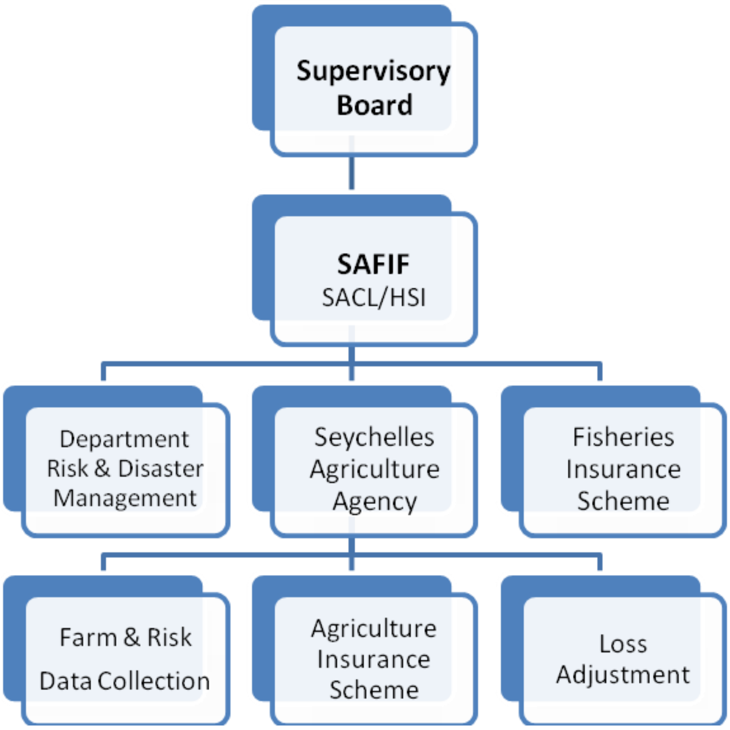


Table 4-6: Organisation structure of SAFIF Board

4.5.2.5 SAFIF Board

It is recommended to establish a Supervisory Board (Table4-6) comprising of 7 members, representing:

- Ministry of Environment and Natural Resources (2)
- Ministry of Finance (1)
- Insurance sector (1)
- Farmers' Association (1)
- Seychelles Fishing Authority (1)
- Boat Owners Association (1)

The Supervisory Board shall monitor SAFIF insurance operations carried out by the public-private partnership (SACL/HSI/SAA/DRDM) and ensure that the Agriculture and Fisheries Insurance Scheme is operated in a prudent, effective and efficient manner.

4.5.2.6 Government Institutional Support

Institutional public support is needed to create the necessary legal framework for the SAFIF operational basis and financial support.

In order to achieve effective disaster insurance coverage for agriculture and fisheries, the proposed scheme needs to be made compulsory whilst at the same time the current Seychelles National Disaster Fund should be discontinued for agriculture and fisheries.

It is suggested that all registered farmers and registered and/or licensed fishing vessel owners as defined in the Agriculture and Fisheries Incentive Act (2005) join SAFIF on a compulsory basis in order to ensure complete risk coverage and full solidarity within the agriculture and fisheries sector.

SAFIF operations also require Government's support regarding the services to be rendered by Seychelles Agricultural Agency and the Department of Risk & Disaster Management. However, these services should/could be remunerated based on market principles.

4.5.2.7 Government Financial Support

Premium subsidy support is required for the agriculture disaster insurance operations and is also recommended for the fisheries sector because of the large artisanal fishing part of the sector.

Premium subsidy of 50% with annual limit of Seychelles Rupees (SR) 20,000 per policy holder (farmer/fishing vessel owner) is recommended.

In addition to premium support, the exemption of SAFIF insurance policies from Goods and Services Tax (GST) and Trade Taxes on insurance premiums is recommended.

4.5.2.8 Insurance Products

The insurance policies suggested for the agriculture sector *(crop & livestock)* are designed as event and damage based, named perils policies covering losses due to excessive rain, flood, tsunami, windstorm and drought for crops and for livestock insurance, with additional coverage for heat stress and epidemics. In addition, standard group accident insurance is recommended for all farmers.

Insurance policies for the fisheries sector should be based on the already available standard marine hull policies for fishing boats, plus standard group accident policies for fishermen.

For all property policies, a minimum excess of at least SR 10,000 is recommended in order to underline the catastrophe character of the insurance products offered within the envisaged disaster insurance scheme.

4.5.2.9 Reinsurance of SAFIF

Since for all fisheries insurance products commercial reinsurance is readily available in the international market, international reinsurance capacity can easily be introduced and used right from the start by SACL/HSI for SAFIF's operations.

International reinsurance for agriculture insurance products is also available. However, due to the lack of experience data, reinsurance capacity will be rare and rather expensive. For this reason, it is suggested to operate the agricultural disaster insurance scheme for the first 3 years with limited catastrophe reinsurance only, or un-reinsured by SAFIF.

4.5.2.10 SAFIF - Operations

All policy issuing, premium collection and claims payment operations should be handled by SACL/HSI whilst all insurance field operations (establishment of detailed farm information/risk inspections/loss assessments and GIS based loss data bank management) should be carried out by Seychelles Agricultural Agency with support of the Risk & Disaster Management Department, regarding the GIS based loss data bank management.

The insurance scheme accounts for agriculture and fisheries should be handled separately by SAFIF for statistical and reinsurance purposes.

Standard insurance and reinsurance products are readily available for fisheries from private insurance and reinsurance markets, and no new or additional products and/or administrative handling procedures need to be established.

For agriculture, the situation is different since experience based actuarial insurance data, adapted insurance products for the local risk environment and particular operational handling processes to a large extent still need to be developed.

In addition, the traditional segmentation and specialisation within reinsurance companies in specific reinsurance departments e.g property, aviation, agriculture, marine, casualty, etc. requires that SAFIF operates the Fisheries Insurance Scheme separately from the Agriculture Disaster Insurance Scheme.

The two privately operated insurance companies in the Seychelles; State Assurance Company of Seychelles Ltd (SACL – *formerly SACOS*) and Harry Savy Insurance Company Ltd (HSI), are fully licensed and equipped to handle the administration of agriculture insurance products and/or a Seychelles National Agriculture and Fisheries Disaster Insurance Scheme.

4.5.2.11 Crop Insurance Products and Tariffs

Multi **P**eril **C**rop **I**nsurance (MPCI) is the most widely practiced form of crop yield insurance globally. However, this sophisticated form of crop insurance is difficult to operate, very costly, require comprehensive historical yield and/or loss data and is only viable with massive Government technical and premium subsidy support.

Because of the highly diversified crop production in the Seychelles, absence of actuarial yield and loss data, very high administrative cost and demanding operational requirements, traditional Multi Peril Crop Insurance (MPCI) does not represent a viable solution for the Seychelles.

The Crop Insurance Tariff should mirror the risk exposure of the insured crops at the insured location for the insured perils. However, for a proper calibration and differentiation of a premium tariff comprehensive loss experience data are needed. In absence of loss experience data, the classification of crops into exposure or vulnerability groups can assist to differentiate insurance rates for different crops.

In 2006, the Agricultural Extension Services Section of the Seychelles Agricultural Agency classified and grouped crops grown in the Seychelles into 4 different vulnerability groups regarding the perils of **rain**, **drought** and **wind.** The result of this work is shown in Table 50 below. In addition to the assessed vulnerability of the above named crops grown in the Seychelles regarding the perils of rain, wind and drought, the crop specific cultivation period, i.e the exposure time, needs to be considered to determine the final risk per crop type.

Although the work done by the Seychelles Agricultural Extension Services Section is comprehensive and solid, the vulnerability classification table for the crops alone is not sufficient to specify differentiated crop rates.

Also, the crop loss information available from the well documented December 2004 tsunami event – *as a one off event* - does not allow developing crop specific rates.

In addition to the difficulty to establish crop specific rates on limited loss data, the high diversity of agriculture crop production in conjunction with small farm units must be considered, which does – for practical operational and cost reasons – not allow for rate diversification of the envisaged Seychelles' catastrophe crop insurance scheme.

Risk Exposure - Location

In addition to the risk exposure regarding the peril and crop type, the risk exposure of the location is very important in the Seychelles. From a location point of view, we can divide crop production in the Seychelles into lowland farming and hill farming.

The Department of Risk & Disaster Management has comprehensively analysed the general risk exposure regarding rain, flood *(including tsunami)* and windstorm for all 25 districts of the Seychelles and has documented the results in detailed GIS based risk maps.

Setting of the Sum Insured per Farm

A simple and practical solution is needed for the Seychelles' agriculture insurance environment to establish a sum insured per farm.

4.5.2.12 Recommendation

- For the Seychelles, an easy manageable, less expensive, event and loss based Named Perils Catastrophe Insurance Policy is recommended offering coverage for rain/excessive rain, flood, tsunami, strong wind and drought;
- The district risk maps available from the Department of Risk & Disaster Management provide an ideal underwriting platform for agriculture insurance (crop & livestock) to locate individual farms in the Seychelles via GIS coordinates and allow – over time – also for a differentiated risk assessment, rating and underwriting approach**;**
- **iii.** It is suggested to start the proposed National Disaster Crop Insurance Scheme with a uniform rate as far as the crop type is concerned;
- iv. It is recommended to establish a per farm fixed sum insured which should represent the highest value of risk at any one time during the year;
- The establishment of the highest value at risk (sum insured) at any time during the year should form part of the annual insurance proposal form, which should contain all details about the registered farmer/farm and should be filled out and signed jointly by the farmer to be insured and the Seychelles Agricultural Agency.

Table 50: Crops of the Seychelles and their Vulnerability to Rain, Drought and Wind

Peril	Vulnerability **Least**	Vulnerability **Slightly**	Vulnerability **Moderate**	Vulnerability **High**
Rain	Alpina	Amaranth	Anthurium	Cabbage
	Banana	Bitter Gourd	Aster	Capsicum
	Breadfruit	Bottle Gourd	Beans	Carnation
	Cabbage	Chilli	Beetroot	Cauliflower
	Cassava	Choyote	Celery	Chinese Cabbage
	Cherimolia	Ginger	Eggplant	Chrysanthemum
	Chiku	Marigold	Ferns	Coriander
	Coconut	Okra	Parsley	Courgette
	Cocoyam	Snake Gourd	Pawpaw	Cucumber
	Custard Apple	Sponge Gourd	Pumpkin	Dahlias
	Golden Apple	Wax Gourd	Radish	Gerbera
	Guava		Rosemary	Gherkins
	Heliconia		Zinnia	Gladiolus
	Maize			Lettuce
	Mango			Roses
	Orange Lily			Spring Onion
	Orchid			Sweet Melon
	Oxheart			Thyme
	Passion Fruit			Tomato
	Pineapple			Watermelon
	Sapote			
	Soursop			
	Star Fruit			

	Sugar Cane Swamp Sweet Potato Torch Ginger Watercress Yam			
Drought	Alpina Avocado Breadfruit Cherimolia Chiku Coconut Custard Apple Golden Apple Guava Heliconia Mango Orange Lily Orchard Oxheart Passion Fruit Pineapple Sapote Soursop Star Fruit Torch Ginger	Amaranth Carnation Cassava Citrus Cocoyam Dahlia Ferns Ginger Marigold Sugar Cane Sweet Potato Yam Zinnia	Anthurium Aster Banana Beans Beetroot Bitter Gourd Bottle Gourd Celery Chilli Choyote Coriander Eggplant Gladiolus Maize Okra Parsley Pawpaw Pumpkin Radish Rosemary	Cabbage Capsicum Cauliflower Chinese Cabbage Chrysanthemum Courgette Cucumber Gherkins Lettuce Spring Onion Sweet Melon Thyme Tomato Watermelon

			Roses Snake Gourd Sponge Gourd Swamp Cabbage Thyme Watercress Wax Gourd	
Wind	Amaranth Beetroot Cabbage Cauliflower Celery Chinese Cabbage Cocoyam Coriander Courgette Gherkins Ginger Lettuce Orange Lily Orchid Parsley Pumpkin Radish Rosemary Swamp Cabbage	Alpinia Anthurium Avocado Bread Fruit Carnations Cassava Cherimolia Chiku Chilli Citrus Coconut Custard Apple Eggplant Ferns Gerbera Golden Apple Guava Heliconia Mango	Aster Beans Bitter Gourd Bottle Gourd Capsicum Choyote Chrysanthemum Dahlia Maize Mandarin Roses Snake Gourd Sponge Gourd Spring Onion Star Fruit Tomato Wax Gourd	Banana Cucumber Gladiolus Pawpaw

	Sweet Melon Sweet Potato Thyme Water Cress Watermelon Yam	Marigold Okra Oxheart Passion Fruit Pineapple Sapote Soursop Torch Ginger Zinnia		

Source: Memo of the Seychelles Agricultural Agency, Agricultural Extension Services Section, 2006

4.5.2.13 Livestock Insurance

Livestock production is mainly exposed to natural perils and epidemic diseases. However, natural perils represent a lesser exposure since livestock (pigs & poultry) is predominantly kept in pens.

Diseases, others than epidemic diseases, are very much related to husbandry and farm management techniques applied, and should not be part of a livestock disaster insurance scheme. However, the inclusion of epidemic diseases is suggested because epidemic diseases exposure in the Seychelles is relative low. But, if epidemic diseases outbreaks strike, the consequences for the livestock farmer affected and probably the entire livestock industry on the islands affected can be of catastrophic nature.

Excessive rain, flooding including tsunami, wind storm, heat stress, diseases and epidemic diseases are identified as main the catastrophe perils for livestock production in the Seychelles.

4.5.2.14 Recommendation

For the suggested livestock catastrophe accident policy (for pigs, poultry and cattle) insurance coverage is recommended for excessive rain, flood, tsunami, windstorm, heat stress and epidemic diseases.

4.5.2.15 Fisheries Insurance

The fishing industry in Seychelles is of high economic importance for the country as a source of employment, income generation, foreign exchange earnings, government revenue and last but not least as a major source of food.

Seychelles is ranked fifth globally in terms of per capita consumption of fish, with annual consumption of approximately 65 kg per person.

It is estimated that the fishery sector, including ancillary activities, generates directly and indirectly around 4600 jobs amounting to about 14% of formal employment.

The fisheries sector is composed of a commercial fleet, mainly owned and/or operated by foreign companies and a large number of artisanal fishing boats. The total number of fishing vessels currently licensed in the Seychelles is approximately 420, according to information received from the Seychelles Fisheries Association (SFA) and the Seychelles Boat Owners Association (SBOA).

Marine hull insurance policies are standard policies and *per se* available to the fisheries sector in the Seychelles. However, according to the local insurer SACL and HSI only about 10% of fishing boats are currently insured.

The main reason for the very low insurance market penetration is the too high premium rates - 5 to 12% of insured value – was mentioned in the various meetings held.

Regarding personal accident insurance for fishermen, the situation is even worse. According to a market survey done by SACL and HSI in 2005/6, only 2% of fishermen are covered by personal accident insurance policies.

Since standard private industry insurance policies in the Seychelles are readily available via SACL and HSI for fishing vessels as well as personal accident policies for fishermen, the main attention must be given to increase the insurance uptake of these products.

As mentioned above, standard insurance products are available for fishing vessels and fishermen; no new insurance policies nor operating processes need therefore to be invented.

However, it is for the Seychelles' Government of great importance to ensure that all fishing vessels and fishermen – *like motor cars* – are insured to avoid disaster ad hoc payments as it happened after the December 2004 tsunami event.

4.5.2.16 Recommendation

It is recommended that for all licensed and registered fishing vessel owners, as defined in the Agriculture and Fisheries Incentive Act (2005), insurance be made compulsory.

The compulsory insurance should comprise:

- Loss of or damage caused to fishing vessels;
- Third party liability arising out of loss or damage caused by insured vessels against another party;
- Group Personal Accident insurance for all fishermen or crew working on the vessels.

The insurance terms and conditions should be based on prevailing market terms and conditions as available via SACL and HSI and supported by the international reinsurance market. However, due to full *(compulsory)* participation of the entire fishing industry in the suggested insurance scheme, premium rates will also be significantly lower than currently offered market rates on voluntary basis.

It is further suggested that the Seychelles' Government provide a premium subsidy of 50% plus allowing exemption from payment of GST and Trades Tax on SAFIF insurance premiums.

The suggested premium subsidy and exemption from insurance premium taxes will outweigh by far possible resistance against the recommended compulsory industry insurance scheme and will lead to easier acceptability of the suggested compulsory insurance scheme by the fishing industry.

At the same time, the Government of the Seychelles will also benefit from the suggested compulsory insurance scheme since it will be released from any ad hoc payments in case of future natural disaster events.

4.5.2.17 Seychelles Agriculture and Fisheries Insurance Fund (SAFIF)

It is suggested to organise the Seychelles National Disaster Insurance Scheme as a Public-Private-Partnership as **Seychelles Agriculture & Fisheries Insurance Fund (SAFIF)**.

SAFIF should be operated and administered and underwritten by SACL and HIS jointly, the insurance companies providing the legal basis for insurance/reinsurance and acting as policy issuing, premium collecting and loss paying entity; all insurance operations should be based on market principles.

Whilst SACL and HSI are providing the legal and administrative back office platform for SAFIF insurance services, all field operations should be carried out by the Seychelles Agricultural Agency (SAA). Regarding risk and loss data management, SAA should cooperate with the Department of Risk & Disaster Management (DRDM) in order to use the GIS know-how and risk information already developed by DRDM and to avoid parallel operations.

The Seychelles Agricultural Agency (SAA) should be indemnified for its field services rendered *(individual client data collection, risk and loss assessment services, etc.)* on an agreed commercial basis, as usual in the local insurance industry.

SAFIF is to be supervised by a board of directors, representing all stakeholders in the Seychelles Agriculture & Fisheries Insurance Fund which include the:

- Seychelles Government
  - Ministry of Finance
  - Ministry of Environment, Natural Resources & Transport
- State Assurance Company Ltd (SACL)/H. Savy Insurance Company Ltd (HSI)
- Seychelles Farmers' Association (SeyFa)
- Seychelles Fishing Authority (SFA)
- Seychelles Boat Owners Association (SBOA)

Seychelles Agriculture & Fisheries Insurance Fund is considered as the ideal insurance platform for the suggested public-private-partnership approach, combining in a holistic way agricultural extension services, risk mitigation & management and last but not least insurance services for Seychelles' farming and fishing sectors.

The suggested disaster risk management solution via SAFIF contains also elements of Mutual Insurance for the agriculture and fisheries industry *(e.g grass root industry control, low cost, public and private* *sector solidarity, etc.)* and the limited catastrophe insurance product range at the start of operations could gradually be developed into a full suite of specific insurance products tailored to the local risk exposure and insurance needs, as may be required by the farming and/or fishing sector.

4.5.3 Study 2: Seasonal Response of Lettuce to Weather Stresses and Implications of Climate Change on Crops in the Seychelles

4.5.3.1 Introduction

In Seychelles, crop production predominantly revolves around the two main seasons; the south-east monsoon from late May to September which brings cooler, dryer weather and the north-west monsoon from October to early May which brings warmer, wet and humid weather. The south-east monsoon has long been known as the most favourable season for leafy and fruit vegetable crops production such as lettuce, Chinese cabbage, melons and tomatoes. However, over the past few years growers have noticed a fall in leafy and fruit vegetable crops performance, particularly during the early south-east monsoon season, associated with the late onset of the cooling effects of the cooler conditions favourable for such crops. Crop growth and yield has been slow and relatively low compared to previous seasons. Disease prevalence has also been noticed to be relatively higher. One such popular cash crop which has been observed to be particularly affected is the lettuce, *Lactuca sativa.*

Lettuce, *Lactuca sativa* var. Minetto is a popular and an important vegetable crop in the Seychelles. It is a leafy lettuce with loose leaves suited for hot, humid zones in the tropical low land areas.

4.5.3.2 Objectives the Study

The primary objective of this study is to examine the relationship and impact of seasonal weather on growth, development and yield of lettuce in the Seychelles. This includes establishing best and worst season for cultivating lettuce, basic optimum seasonal weather conditions, and sensitive threshold values lettuce responds to and tolerates. Other objectives include exploring the induced climate change impact on lettuce performance in terms of simple trends for given projected years to assess seasonal crop vulnerability and implications on the food security in the Seychelles. Adaptation measures are drawn based on the study and other references.

4.5.3.3 Data

Field experiments were conducted at the Anse Boileau Research and Development Station, located on the central-western coast of Mahe with the objective of studying the crop/climate change relationship in order to establish an index for crop vulnerability to climate change. The experiments were undertaken from April 2008 to July 2009. The crop used for the study was lettuce *(Lactuca sativa),* var. Minetto (Figure 77). The lettuce seeds were sown in the nursery in sterilised media (top soil, well-decomposed cattle manure and coconut coir at ratio of 3:2:1). The seeds were sown at a rate of one seed per poly pot and watered frequently. One week after sowing stock solution composed of 97.5 g of urea, 45 g of mono-ammonium phosphate and 112.5 g of potassium nitrate diluted in 130 L of water was applied twice daily for a duration of one week. About three weeks after sowing, the seedlings were hardened by reducing the amount and frequency of watering.

Figure 77: Experimental lettuce at the Anse Boileau Research Station (Source: Anse Boileau Research Station).

4.5.3.4 Methodology

For analysis, the average weekly maximum and minimum temperatures, soil temperature, rainfall and humidity were computed up to one week before the fresh weight of lettuce was determined (Ts)(Table 51 and Table 52). The average fresh weight of lettuce for each replication is also computed. The time of sampling is adjusted to 0, 7, 14, 21 days respectively for each experiment corresponding to the actual dates as indicated in the table. The respective experiments for the year 2008 and 2009 are classified according to the climatological seasons. For example, the time of the 1st, 2nd, 3rd, and 4th experiments of the year 2008 are classified into the SE monsoon transition, SE monsoon, NW Monsoon transition respectively while the 1st, 2nd and 3rd experiment of the year 2009 are classified into late NW monsoon, SE monsoon transition, and SE monsoon. The timing of the experiments for each respective year is different.

First, an analysis of the 5 sampled fresh weights for each respective replication is presented to show the basic statistical properties such as the standard deviation as a measure of variation in lettuce growth performance with time for the two experiments in the year 2009. The second step analyses the average fresh weight with respect to time to show the seasonal growth and development of lettuce. Linear model regression equations are fitted to the average fresh weight data and the statistical variance of the fit are assessed. The third part of the analysis focuses on establishing the seasonal relationship for the late SE monsoon (mid August-mid September), NW monsoon transition (late October–late November), late NW monsoon (late February- mid March) and SE monsoon (June-July) through correlation analysis of the weather-soil stress parameters and the fresh weight of lettuce using SYTSAT (Statistical Analysis) software. Plant-soil atmosphere relationships are also established to understand the link and processes. The total yields for two comparable seasons are assessed to understand the underling differences determining the year to year lettuce performance.

The climate re-analysis data at the Earth System Laboratory, National Oceanic and Atmospheric Administration (NOAA) is also employed for the year 2009 with respect to the base period of 1970-1990 to understand weather-climate signals driving crop performance and yield.

The impact of climate change on lettuce for the late NW monsoon and the SE monsoon are also explored. The likely change in temperatures is added to the climatological minimum and maximum temperatures from the Seychelles Meteorological Services based at the Seychelles International Airport since the data are more than 30 years and are quality checked. In addition, the analysis considers the projected rainfall trend and intensity in the two respective seasons for the projected climate change scenarios years of 2025, 2050 and 2100. Finally, the study examines the potential consequences on lettuce performance under climate change conditions in the context of food security in the Seychelles and how to mitigate and adapt to the increased risk to crops.

Table 51: Computed Weekly Plant-soil and Weather Statistics for the Seasons of the Year 2008.

			Weekly Average						
T-Ts	Experiment SEASONS of the Year 2008	Time (Days)	MaxT (˚C)	MinT (˚C)	ST (˚C)	RF (mm)	EV (mm)	RH (%)	Fresh Weight (g)
(26-05) to **(02-06)**	1st Experiment SE MONSOON TRANSITION [2]	0	30.9	23.5	29.1	3.2	4.8	79.5	123.5
(02-06) to **(09-06)**		7	30.9	22.6	28.7	1.1	6.3	82	256.5
(24-06) to **(01-07)**	2nd Experiment SE MONSOON	0	31.2	22.5	29.2	22.7	3.3	81.0	59.7
(01-07) to **(08-07)**		7	29.0	23.6	30.1	1.1	4.8	79.6	147.0
(08-15) to **(15-07)**		14	29.5	21.6	27.1	1.9	5.1	80.7	353.3
(15-22) to **(22-07)**		26	29.4	23.8	28.4	4.3	4.0	80.1	471.4

[2] Only two samples were able to be collected before the end of the cycle

(13-08) to **(20-08)**	**3rd Experiment LATE SE MONSOON**	**0**	**29.1**	**23.2**	**28.7**	**0**	**5.1**	**78.5**	**11.5**
(20-08) to **(27-08)**		**7**	**29.5**	**22.5**	**29.6**	**1.1**	**6.2**	**78.1**	**45.3**
(27-08) to **(03-09)**		**14**	**29.5**	**22.9**	**287.1**	**5.5**	**5.1**	**80.6**	**133.8**
(03-09) to **(10-09)**		**21**	**29.2**	**23.1**	**30.0**	**1.0**	**5.2**	**79.9**	**245**
(28-10) to **(04-11)**	**4th Experiment NW MONSOON TRANSITION**	**0**	**31.1**	**24.1**	**32.4**	**5.7**	**7.4**	**79.0**	**28.0**
(04-11) to **(11-11)**		**7**	**32.4**	**22.4**	**33.3**	**1.2**	**6.3**	**76.0**	**107.1**
(11-18) to **(18-11)**		**14**	**31.0**	**23.6**	**32.1**	**24.1**	**5.3**	**80.6**	**115.0**
(18-25)- **(25-11)**		**21**	**31.6**	**22.6**	**32.5**	**18.4**	**5.5**	**78.1**	**122.5**

Table 52: Computed Weekly Plant-soil and Weather Statistics for the Seasons of the Year 2009

			Weekly Average						
T-Ts	**Experiment SEASONS of the Year 2009**	**Time (Days)**	**MaxT (˚C)**	**MinT (˚C)**	**ST (˚C)**	**RF (mm)**	**EV (mm)**	**RH (%)**	**Fresh Weight (g)**
(24-02) to **(03-03)**	**1st Experiment LATE NW**	**0**	**32.3**	**22.8**	**35.5**	**0.1**	**6.7**	**73**	**12.2**
(03-03) to **(10-03)**		**7**	**33.3**	**22.5**	**36.7**	**0**	**6.8**	**72.8**	**39.4**

(10-03) to **(17-03)**	**MONSOON**	**14**	**33.0**	**23.8**	**33.2**	**6.1**	**6.0**	**82.3**	**58.5**
(17-03) to **(24-03)**		**21**	**32.5**	**23.9**	**30.9**	**4.1**	**5.5**	**75.3**	**116.0**
(21-04) to **(28-04)**	**2nd Experiment SE MONSOON TRANSITION**	**0**	**32.1**	**23.3**	**30.2**	**11.5**	**2.9**	**78.7**	**5.2**
(28-04) to **(05 - 05)**		**7**	**33.2**	**23.1**	**31.9**	**12.3**	**3.8**	**76.1**	**9.3**
(05-05) to **(12 - 05)**		**14**	**32.6**	**24.9**	**30.6**	**6.5**	**3.4**	**77.0**	**23.5**
(17-05) to **(24 -05)**		**26**	**32.9**	**23.6**	**30.4**	**6.3**	**3.4**	**77.1**	**46.2**
(9 -06) to **(16 -06)**	**3rd Experiment SE MONSOON**	**0**	**30.6**	**24.5**	**32.0**	**0.5**	**3.8**	**74.1**	**1.8**
(16-06) to **(23-06)**		**7**	**30.2**	**22.6**	**30.9**	**0.6**	**3.5**	**74.2**	**4.8**
(23-06) to **(30 -06)**		**14**	**30.3**	**22.0**	**31.6**	**1.8**	**3.9**	**77.1**	**14.3**
(30-06) to **(07-07)**		**21**	**29.2**	**25.0**	**30.7**	**4.5**	**3.4**	**80.8**	**46.2**

4.5.3.5 Results

The basic statistical analysis of the four replications of the first experiment in the late NW monsoon (Table 53 below) was characterised by a minimum fresh weight (of lettuce) of 7.640 g (Replication 3), while replication 4 had sampled lettuce with maximum fresh weight of 215.420 g. Replication four had also the highest mean fresh weight of 88.890 g. It is also pointed out that replication 4 was characterised by the highest standard deviation of lettuce fresh weight while replication 1 showed the least variation in the sampled fresh weight of lettuce. When the experiment was repeated for example in the SE-monsoon (Table 54), replication 3 consisted of lettuce with a maximum and minimum fresh weight of 64.360 g and 1.120 g respectively. The average fresh weight was 22.875 g. The standard deviation in the sampled lettuce was also highest in replication 3 with 29.307 g. The basic statistical properties underline not only the issue of variability on lettuce within and between replications of the same experiment but also the likely micro-level, spatial and temporal variations in the agricultural management practices such as in the preparation of the beds, fertiliser application, irrigation, and the likely pest infestations which are actually assumed to be the 'controlled' parameters in this study.

Table 53: Basic Statistical Properties of Fresh Weight of Lettuce for Late NW Monsoon of the Year 2009

	Fresh Weight (g)			
Basic Statistical Properties	**Replication 1 Late NW Monsoon**	**Replication 2 Late NW Monsoon**	**Replication 3 Late NW Monsoon**	**Replication 4 Late NW Monsoon**
Minimum	8.080	14.200	7.640	18.820
Maximum	66.800	101.360	91.540	215.420
Range	58.720	87.160	83.900	196.600
Arithmetic Mean	41.370	58.015	37.885	88.890
Standard Deviation	25.877	39.411	36.870	86.631

Table 54: Basic Statistical Properties of Fresh Weight of Lettuce for SE monsoon of the Year 2009.

	Fresh Weight (g)			
Basic Statistical Properties	**Replication 1 SE Monsoon**	**Replication 2 SE Monsoon**	**Replication 3 SE Monsoon**	**Replication 4 SE Monsoon**
Minimum	2.020	1.760	1.120	2.300
Maximum	31.370	47.180	64.360	41.930
Range	29.350	45.420	63.240	39.630
Arithmetic Mean	13.493	15.685	22.875	15.028
Standard Deviation	12.874	21.173	29.307	18.452

4.5.3.6 Lettuce Temporal Growth and Development: Weekly Lettuce Fresh Weight

The fresh weight of lettuce sampled at weekly intervals after transplant, clearly indicates that lettuce growth and performance responds linearly with respect to time as indicated by the strong fit of the linear regression equations in Figure 78. It is highlighted that the results are consistent with findings of

Porter and Semenove (2005) who suggested that rates of development and progression through a crop life cycle more often show linear responses to temperature. In addition, the linear regression equation would suggest that the late NW monsoon of 2009 was the best time for lettuce growth and development compared to the SE monsoon transition and the SE monsoon. The linear regression equation of weekly average fresh weight of lettuce fits best during the late NW monsoon as depicted by the higher R-squared value of 0.9418. Independent analysis of the overall seasonal yield for 2009 (Anse Boileau Research Centre) also confirms that lettuce performed better during the late NW monsoon compared to the transition period and the peak cooler SE monsoon of the year 2009. The yields were 7.3, 3.8 and 2.7 tonnes per hectare for the respective seasons. It is observed that the fresh weight of lettuce increases more rapidly with time during the NW monsoon compared to the other seasons and that fresh weight of lettuce tends to double at weekly intervals.

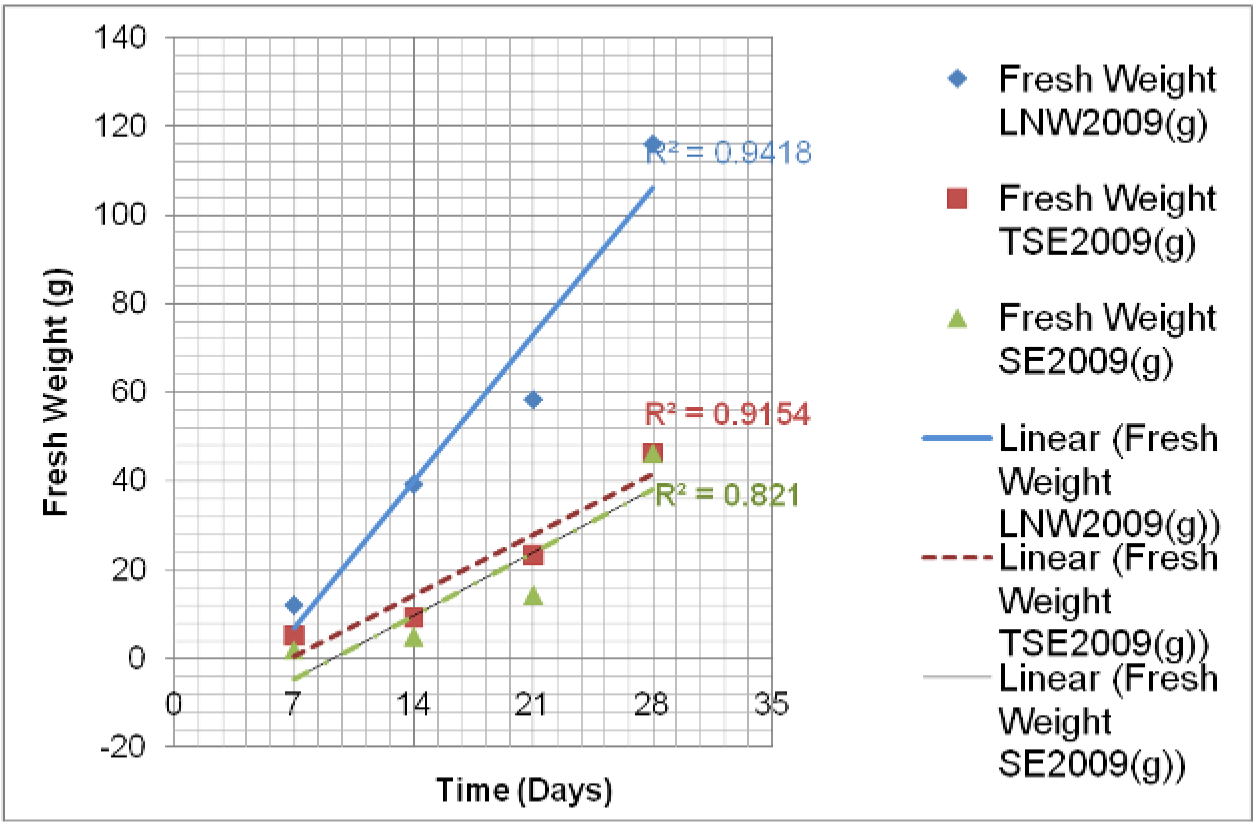


Figure 78: Weekly Fresh Weight of Lettuce as a Function of Time for the Year 2009.

4.5.3.7 Adaptation Measures

Finally, there is consideration as to how crops might be managed or be bred to adapt to variable conditions to minimise the effects of climate change. The increasing environmental climate change risk requires strengthened and sustained efforts to be able to better manage crops such as lettuce. Adaptation measures at the farm level would include adopting proper coastal engineering, which may help to manage and keep the seawater out of farmland. Seawater contaminates fresh water and causes inland coastal erosion. However, gradually retreating at least one metre higher from the mean sea level rather than retreating horizontally backwards as defined in the coastal zone management policies, would be the best policy. Other agricultural practices such as controlled environmental condition need to be developed on a larger scale and to develop institutional research capacities and training in scientific crop modelling to test strategies of adaptation to the modifications of the environment. Moreover, the key issue to help adapt to the likely negative impacts of climate change is to address cross cutting policies from coastal zone management, land use and building institutional support for food production.

4.5.3.8 Discussion

The study shows that lettuce growth and development responds linearly as a function of time. Its development is faster during the late NW monsoon; almost doubling at weekly intervals. It is found that the maximum temperature stress has a more complex, non-linear interaction with lettuce growth and development. An optimisation in the maximum temperature occurs at a temperature threshold of 32.8˚ C and 30.0˚ C for the late NW and SE monsoon respectively. The thresholds are effective over short time-periods and can extensively damage yield productivity, mainly via restrictions on carbon and nitrogen sink formation and activity (Porter and Semenov, 2005). The study shows that lettuce performed better during the late NW monsoon of the year 2009 compared with the transition periods and the cooler SE monsoon seasons. This is because of a combination of factors such as having more tolerance to higher threshold maximum temperature, due to adequate rainfall and moisture, and due to larger differences in the diurnal temperature stress. These conditions help to maintain a favourable and balanced evapo-transpiraton process.

The yields of the SE monsoon of the year 2008 was better than those of 2009 because it was slightly wetter, more humid, with warmer minimum temperature stress, cooler maximum temperature stress, lower soil temperature and evaporation compared to the SE monsoon of 2009. According to the long term observations, lettuce crop normally performs better in the southern SE monsoon. The SE monsoon of 2009 was characterised by anomalous weather pattern having profound negative impact on the usually best season for cultivating lettuce crop. This demonstrates the likely impact of climate variability and change on crops. The driving mechanism for the anomalous weather pattern and impact in terms of low performance in the SE monsoon of lettuce for the year 2009 is linked to the development of an El-Nino signal, an ocean-atmospheric coupling system governing climate variability globally and regionally (Figure 79).

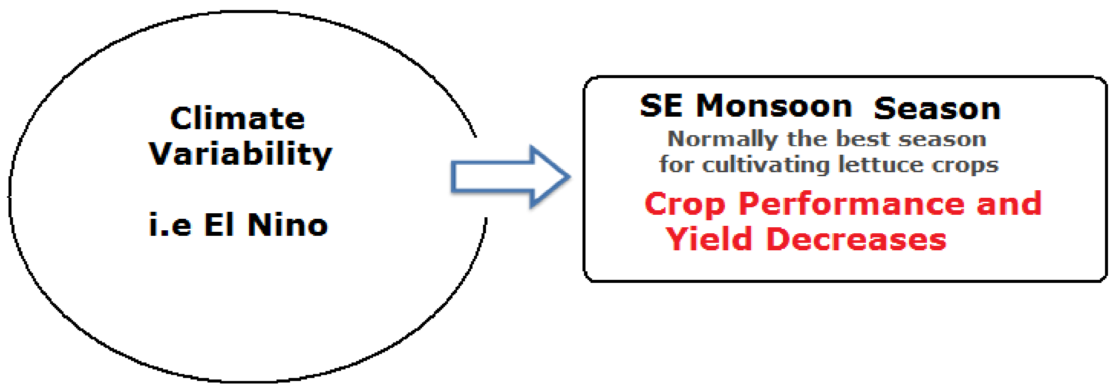


Figure 79: Impact of Climate Variability (i.e. El Nino) on the Normally Best Season for Cultivating Crop Lettuce.

Lettuce development and performance is more sensitive to the diurnal temperature difference in the SE monsoon compared to that of the NW summer monsoon. In the context of climate change impacts, it is expected that narrowing down the gap between maximum and minimum temperature stresses is very likely to have negative impact on the growth, development and yield of lettuce, particularly in the SE monsoon season. Furthermore, considering the climate change projections trends (Chang Seng, 2007) and the findings of this study, it is predicted that lettuce will become vulnerable to climate change towards the other half of the 21st century in the late NW monsoon and increasingly more vulnerable in the SE monsoon. However, pest infestations and sea level rise will likely add to the challenges. In this context, it is necessary to consider how vegetables and food crops might be managed to adapt to variable conditions, or seek alternative policies to minimise the negative impacts on food security in the Seychelles.

This study has also highlighted the urgent need to have an adaptive capacity in terms of developing or implementing an improved, tailor made and legitimate local climate-prediction product at different time scale (Chang Seng, 2009) rather than simply use seasonal prediction maps from derived centres to help farmers know in advance of probable abnormal-extreme weather conditions for better decision making. Equally, farmers need to be educated and sensitised on how to apply and make use of these forecast schemes. Finally, verification, validation and forecast skills are completely non-existent and need to be integrated in the operational services.

4.5.3.9 Recommendations

The specific recommendations of this study in terms of experimental, analytical and methodological approach include the following:

- More experiments and detailed modelling are required to confirm the optimum effects and the two critical threshold values of maximum temperature during the two respective seasons;
- Detailed modelling is required to understand the effects of narrowing down the gap between the daylight maximum temperature and the night time minimum temperature;
- Future experiments should be repeated each year at the same time to study the year to year performances;
- Carry out a variety of crop experiments to assess crop vulnerability;
- Improve crop data management and quality checks at farm level;
- Assess the challenges and impacts of climate-crop performance using an actor-oriented analysis approach at the multi-level and scales.

4.6 Vulnerability and Adaptation Measures on Water Sector

4.6.1 Introduction

Because of its small size and particular geological, topographical and climatic conditions, Seychelles face severe constraints in terms of both the quality and quantity of freshwater. Even when rainfall is abundant, access to clean water has been restricted by the lack of adequate storage facilities and effective delivery systems. Inadequate action to safeguard watershed areas and groundwater resources poses a further long-term threat, while in urban areas rapid population growth, changes in economic strategies and a growing per capita use of freshwater are significant challenges. In that context, sound long-term management strategies for water catchment and storage areas, including the treatment and distribution of limited water supplies, are of particular economic and environmental importance. Such strategies may involve substantial capital investment and ongoing maintenance programmes, which may affect the real cost of water. These are compounded by the threat of climate change and sea level rise within the archipelago.

The other constraint is the issue of water resource management. Several of these issues that pre-occupy water resource managers in Seychelles are demand forecasts, operation and maintenance of existing systems, new investments, and new water sources. As a result of recent impacts of ENSO, this also is a new area of pre-occupation in the management of water resources in the long term. Institutional adaptation may be an effective approach to ensuring the long-term availability of water. This would involve changes in organisations, water-taxes, and financial mechanisms

Government is cognizant of the potential climate change threat and the adaptations that are necessary within the water sector. According to Payet and Agricole (2006), the diversification of the Seychelles' economy toward tourism and fisheries since the 1970s has led to a number of industries operating outside the reach of the main water reservoirs (e.g. Le Niol, Hermitage, La Gogue, and Cascade reservoirs). The recent growth of the tourism industry has contributed to the increase in demand for water and its distribution. The projected demand in water in 2005 and 2010 in the Seychelles exceeds current water supply by approximately 14000 kilolitres per day. An adequate supply of water for the future is of highest national priority. This development need, however, is threatened by climate change, and, in particular, from predicted reductions in rainfall during the dry southeast monsoon season.

A number of measures already in the planning process provides additional impetus to the proposed project. For example:

- The Seychelles' Government is in the process of drafting legislation that will ensure that all new buildings and houses are fitted with water storage tanks and water saving devices. This will be implemented by the Ministry of National Development;
- The National Meteorological Services (NMS) has recently started to produce three-month weather forecasts that are delivered on a monthly basis to the PUC;
- The NMS is implementing a study on the effect of climate change on water supply in detail.

4.6.2 Review of the Water Supply Development Plan 2005-2025

In 2008, The Ministry of Environment and Natural Resources compiled a document entitled 'Review of Water Supply Development Plan 2005-2025'. The reasons for the ongoing water shortage crisis are detailed in this document and recommends urgent set of actions. These include: implementation of fiscal measures to promote water conservation, projects to increase the amount of water in the distribution system, measures to reduce water demand and measures to increase capacity in water resource management. The potential effects of a number of activities are detailed in the report, including inter alia: repair of leaking pipelines to reduce the unacceptably high losses of water (unaccounted for water) , implementation of public awareness campaigns, strict policing during the dry season to ensure water is not being used for non-essential uses, increased pipeline inspection, and rainwater harvesting.

In its 2000-2010 Environmental Management Plan, the Seychelles' Government identified priorities including demand and supply management and integrated water management. The following support programmes were identified:

- water demand management;
- desalination;
- improvements in safe yields of existing water sources;
- improvements to transmission/reticulation systems;
- improvements to water treatment works;
- water management, institutional and human resources capacity-building;
- water shed management.

Therefore, to better understand the impacts of climate change *and adaptation activities* on water resources, four studies were undertaken as follows:

1) integrated water resource evaluation, planning and management focusing on climate, socio-economic and technological change impacts on the water resources,
2) hydro-climate statistical prediction for better water resource planning and management,
3) a study on the potential of rain water harvesting study in Victoria as a water conservation and flood control measure, and
4) a national education and awareness program on climate change in the water sector.

In order to achieve set goals, the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report's (2007) findings forms the background setting, whilst the recent local climate change scenarios are used as direct inputs into the various water related analyses. One of the main focus of these studies is its fairly detailed analysis in terms of the integrated water resource evaluation planning and management, focusing on the climate, socio-economic and technological change impact on the water resources using a new decision support tool. Demand and supply policy scenario strategies are simulated to provide a guide as to how to mitigate or adapt to these likely expected stressors in the water sector. This approach essentially establishes the main difference with the Initial National Communication (1997-2000). Furthermore, the leading causes and mechanisms of droughts are uncovered while the multivariate statistical model is a predictive early warning tool for droughts, while the pilot rain harvesting study highlights potential water conservation strategies contributing to significant water demand reduction. Finally, the education and awareness activities have provided the benchmark for further initiatives, but have truly succeeded in mobilising both teachers and students throughout the country.

Recommendations of reducing the water sector's vulnerability to climate change are proposed with the normative goal of achieving the constitutional water access right and sustainable development in the Seychelles.

4.6.3 Study 1: A Modeling Assessment of the Climate, Socio-Economic and Technological Change Impact on the Water Resources in the Seychelles

4.6.3.1 Introduction

This study uses the Water Evaluation and Planning System (WEAP) software, which is a microcomputer tool for integrated water resources planning. It provides a comprehensive, flexible and user-friendly framework for scientific and policy analysis. Operating on the basic principle of a water balance, WEAP is applicable to municipal and agricultural systems, single catchments or complex trans-boundary river systems. Moreover, WEAP can address a wide range of issues, e.g sectoral demand analyses, water conservation, water rights and allocation priorities, groundwater and stream flow simulations, reservoir operations, hydropower generation, pollution tracking, ecosystem requirements, vulnerability assessments, and project benefit-cost analyses. The analyst represents the system in terms of its various supply sources (e.g rivers, creeks, groundwater, reservoirs, and desalination plants), withdrawal, transmission and wastewater treatment facilities, ecosystem requirements, water demands and pollution generation. The data structure and level of detail may easily be customised to meet the requirements of a particular analysis, and to reflect the limits imposed by restricted data.

The National Policy for Water Resource Management falls under the Ministry of Environment and Natural Resources, whilst the Public Utilities Corporation (PUC) is the institutional set-up with the mandate to plan, build and manage water abstraction and distribution. PUC has the responsibility to monitor river flow and the management of water supply. All the three main inhabited islands have an integrated supply plan. The Government has invested into four desalination plants to enhance the water availability of the three main islands, and has recently improved its water distribution system in the southern part of Mahe. The National Meteorological Services (NMS) supports PUC water with routine meteorological information to help plan on water allocation, particularly, during or prior to the onset of the dry season.

Under the prevailing climate, in spite of the plentiful annual rainfall with an average of 2,300 millimetres on the main island, the Seychelles often experiences water shortages and rationing with direct social hardship and economic impacts during the relatively dry months of the year. However, the climatic factors such as the inter-decadal fluctuations (Figure 80), the seasonal shift in rainfall during El Nino Southern Oscillation (ENSO) events (Figure 81) characterised by extreme heavy rainfall events (Figure 82), distinct rainfall cycles (Figure 83) and the increasing effect of climate change (i.e warming trend (Figure 84) all add to the complexity of the challenge (Chang Seng, 2007).

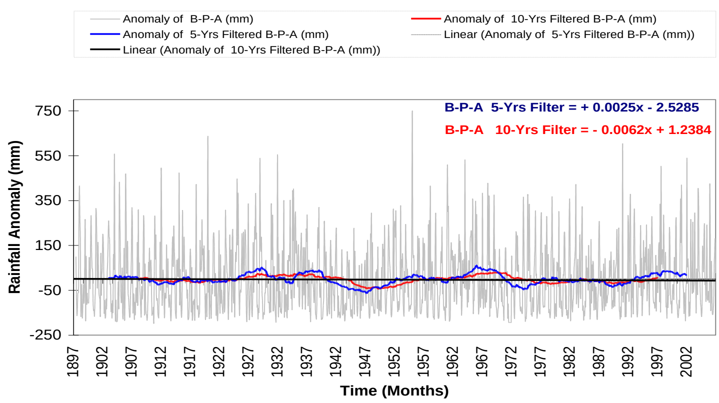


Figure 80: Inter-decadal Fluctuations in Rainfall[3] (Source: Chang Seng, 2007).

[3] *Time series of raw merged rainfall anomaly for the Botanical Gardens, Port Victoria and the Seychelles International Airport rainfall anomaly with 5 and 10 years filter*

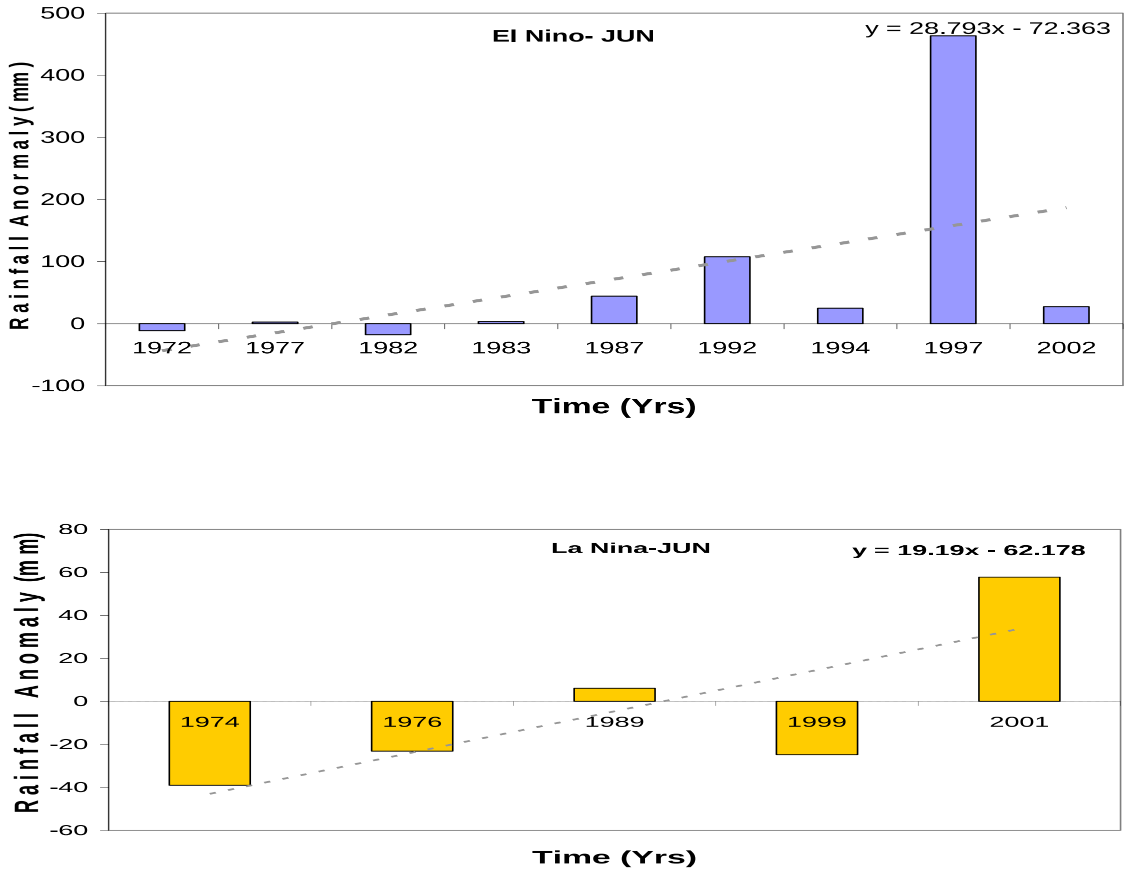


Figure 81: ENSO Impact on Monthly Rainfall during the Wet (top) and Dry (bottom) Season (Source: Chang Seng, 2007).

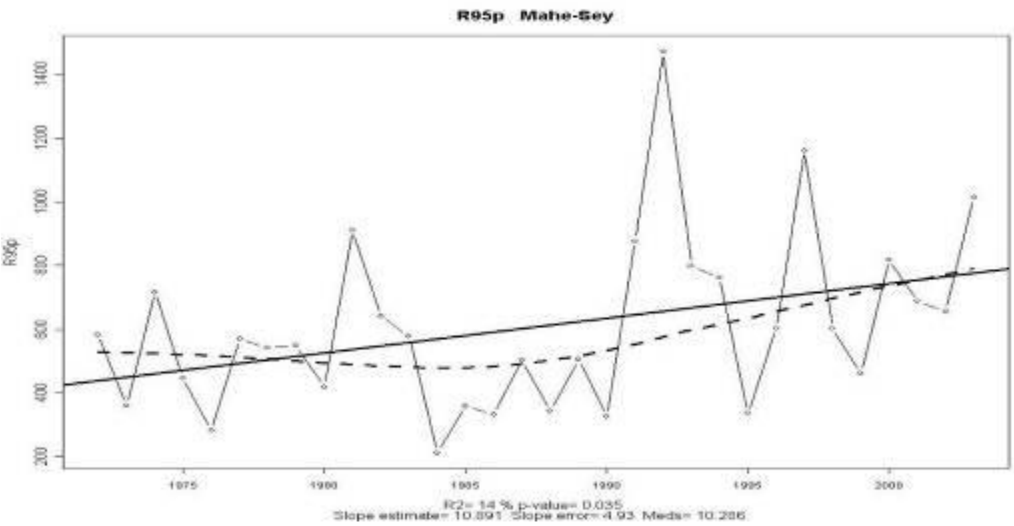


Figure 82: Annual Total Precipitation (mm) when RR>95p or Precipitation accounted for by Heavy Rainfall Events (Source: Lajoie, 2004).

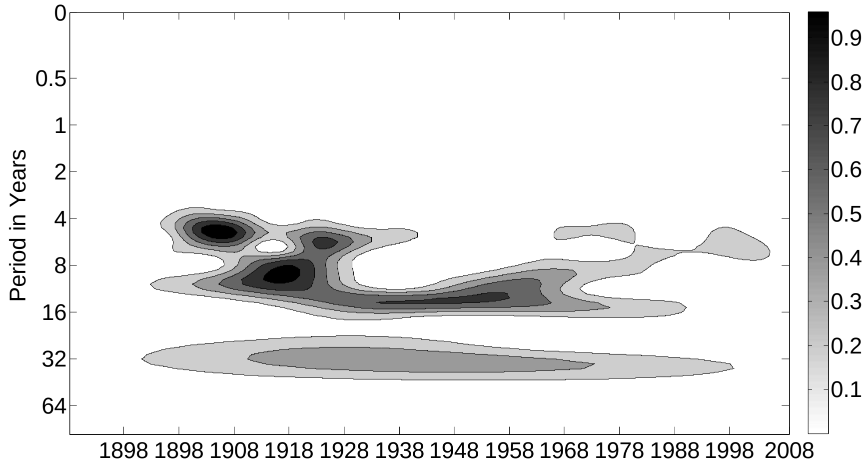


Figure 83-43b: Wavelet Power Spectral Analysis (Low Band Pass Filter>3 Years) of Merged Rainfall Data showing 4, 10 and 30 Rainfall Cycles (Source: Chang Seng, 2007).

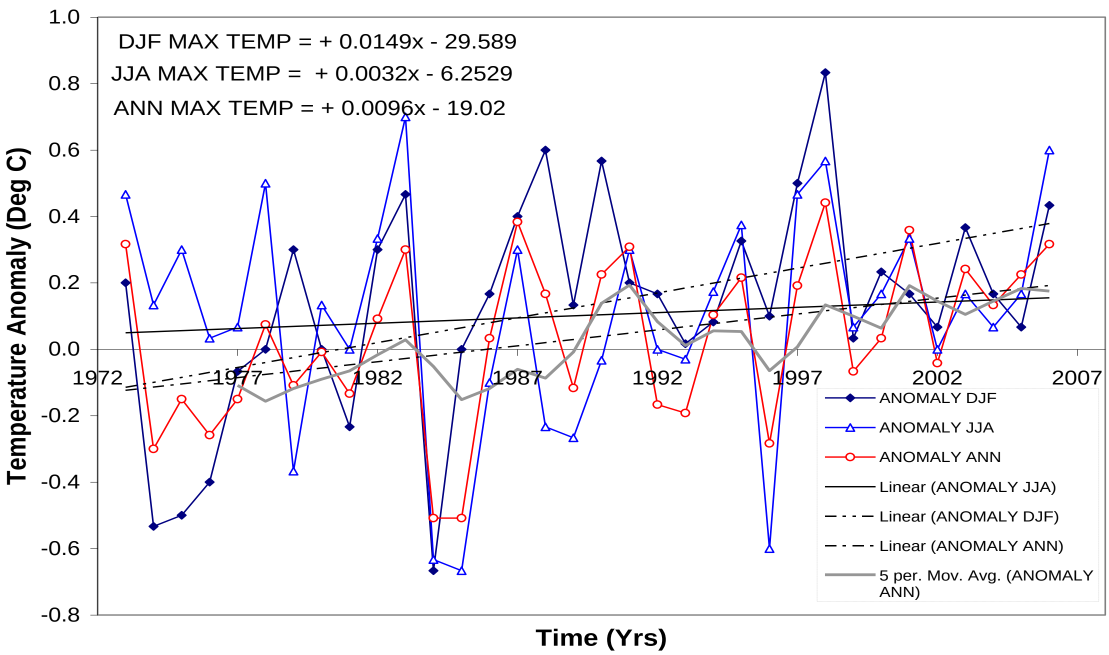


Figure 84: Seychelles International Airport DJF, JJA and Annual Maximum Temperature Anomalies with respect to the 1972-90 Period with Linear and 5-point Moving Average Trends (Source: Chang Seng, 2007).

4.6.3.2 Objectives

- To assess the climatic and socio-economic impact on the water resources on the main Island of Mahe;
- To provide policy-scenario options for better water resource management in the Seychelles;
- To make projections of the ''unmet'' water demand through scenario modelling;
- To evaluate the impact of global warming climate change impact on a catchment and stream flow level.

4.6.3.3 Data and Methodology

The study area focused on the main island, Mahe, however the results were nationally applicable. The water systems on the main island, Mahe, is quite complex in terms of the number of streams, catchments, reservoirs, water treatment facilities, transmission and distribution links. For instance, La Gogue Catchment located to the extreme north of Mahe transmits water to Hermiage for treatment and for national distribution. On the other hand, Le Niol and Cascade water works carry out their own water treatment and distribution, particularly to cover north and east Mahe respectively. The distribution does not target any specific sector or group and there are no water allocation priorities. Hydro-potential forces caused by steep terrain are really the important element determining water allocation over Mahe. The Figure 85 is a model designed for modeling such complex operations based on 1 to 1 demand and supply rule, regardless of the water processing in between the nodes. The model structure and network is flexible to allow for future changes in the WEAP programme. Overall, the water demand side is represented by the residential, tourism, fisheries and agricultural activities on the main island, while the supply facilities are modeled simply as reservoirs or other supply such as the desalination plants.

The year 2006 is considered as the baseline “Current Account”. The ‘Current Account’ is the dataset from which scenarios are built. In contrast, scenarios explore possible changes to the system in future years after the current account year. A default scenario , the ‘Reference Scenario’ carries forward the ‘Current Account’ data into the entire project period specified and serves as a point of comparison for other scenarios in which changes may be made to the system data. The ‘what if’ scenarios are employed to evaluate the impact of higher population growth, climate variability and economic development on the water resources. The analysis then offers demand and supply management scenarios to assess the impact on the water resources in terms of ‘unmet’ demands. A climate change simulation at a catchment level is explored to understand the likely changes on the stream flow.

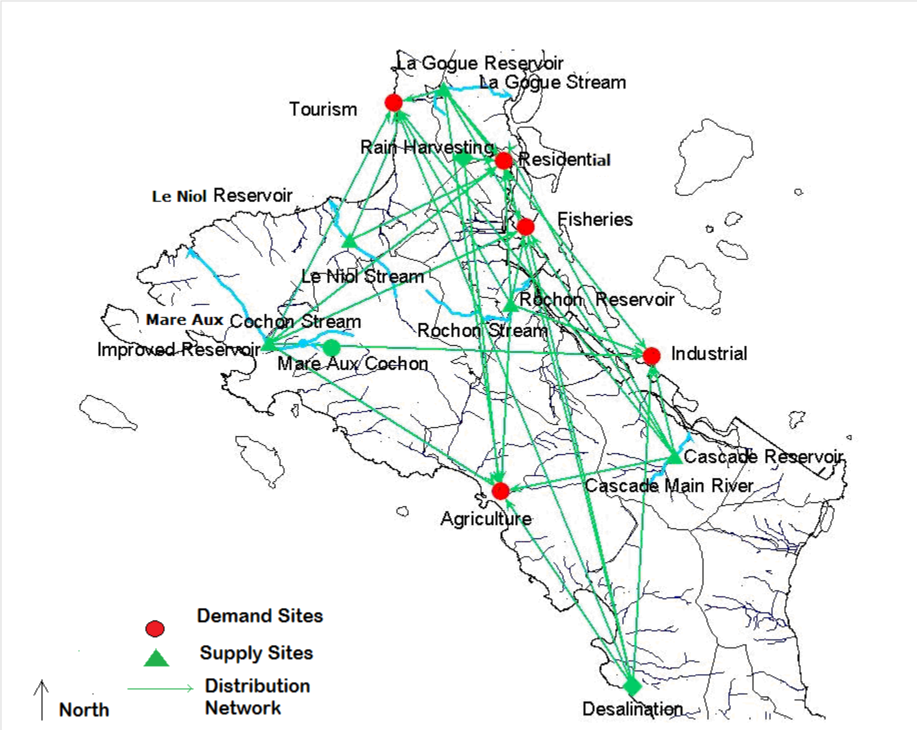


Figure 85: Network Design of Supply (Streams as Blue Lines, Reservoirs as Green Triangles), Transmission (Green Lines) and Water Sector Demand Sites (Red Dots) on Mahe, Seychelles.

4.6.3.4 The Residential Demand Site Baseline Conditions

The residential demand site is created with the name 'Residential'. Table 55 provides the details of the input data for the "Residential' demand site. The WEAP software tool is flexible and powerful to allow further detailed analysis. Therefore, the demand analyses for the "Residential" are refined further to include showers, toilets, washing machines and other demands. The annual activity level as a percentage share of the estimated water use rate is shown in the Table 55.

Table 55: The Residential Demand Site

Residential Demand Site	Quantity	Annual Water Use Rate (L)
Annual Activity level **(Total number of population on Mahe - estimates)**	73,900	
1. Showers	85% of Share	25,000
2. Toilets[4]	95 % of Share	30,000
3. Washing	69% of Share	15,000
4. Others	25% of Share	5,000

4.6.3.5 The Tourism Demand Site Baseline Conditions

The tourism demand site is created with the name "Tourism'. Table 56 shows the details of the input data for the tourism demand site. It shows the annual activity level in terms of total hotel rooms, showers, toilets, washing devices and the corresponding estimated water use rate per room.

Table 56: The Tourism Demand Site

Tourism Demand Site	Quantity	Annual Water Use Rate per Room (L)
Annual Activity level **(Total number of hotel rooms - estimates)**	6000	
1. Showers	100% of the share	15000
2. Toilets	100 % of the share	12500
3. Washing	100 % of the share	7500

[4] Data source: National Statistics Bureau (NSB, 2007)

4.6.3.6 The Fisheries Demand Site Baseline Conditions

The fisheries demand site is created with the name "Fisheries". Table 57 provides the details of the annual activity for the fisheries water-related site consisting of the ice plants, fishing vessels, office and the corresponding annual water use rate.

Table 57: Fisheries Demand Site

Fisheries Demand Site	Quantity	Annual Water Use Rate per production unit (m^3) per production unit
Annual Activity level		
1. Ice Plants	3	1130
2. Fishing Vessels	30	2000
3. Buildings	1	2565

Data Source: Seychelles Fishing Authority (SFA).

4.6.3.7 The Agricultural Demand Site Baseline Conditions

The agricultural demand site(Table 4-15) is created with the name "Agriculture" with a total of 600 hectares. The main demand for agriculture is the conventional watering (i.e sprinkler) which represents 95% of the annual activity with an annual water use rate 0.019475 million cubic metres per hectare. Irrigation activities are estimated at 5% with an annual water use rate of 0.001025 million cubic metres. Table 58 provides details of the input data for the agricultural demand site.

Table 58: Agricultural Demand Site

Agricultural Demand Site	Total Land Area (Hectare)	Percent of the Annual Water Use Rate	Annual Water Use Rate (Million m^3) per production unit
Annual Activity Level	600		
1. Watering (sprinkler)		95% of the share	0.019475
2. Irrigation		5% of the share	0.001025

Data source: Ministry of Environment and Natural Resources, Department of Natural Resources.

4.6.3.8 The Industrial Demand Site Baseline Conditions

The Industrial demand site is created with the name "Industrial". The water-related activities in the industrial sector are accounted for in terms of the total quantity of the various products such as soft drinks, spirit, squash, fruit juices and their corresponding water use rate in terms of litres as shown in Table 59.

Table 59: Industrial Demand Site

Industrial Demand Site		Quantity (Production Units)	Annual Water Use Rate[5] (L)
1.	Water Production	30,856	0.5
2.	Soft Drinks	22,140	0.3
3.	Fruit Juices	61,916	0.3
4.	Milk	3,100	0.3
5.	Paints	193,083	2.0
6.	Smirnoff	391	0.2
7.	Spirit	31	0.2
8.	Squash	69.5	0.3

Data source: National Statistics Bureau (NSB, 2007).

4.6.3.9 The Supply Sites Baseline Conditions

The water supply sites consist of the natural fresh water sources, rain harvesting and desalination plants.

4.6.3.10 Natural Fresh Water from Streams Baseline Conditions.

In this study, it is assumed that there are four existing fresh water supply sites consisting of Cascade, Le Niol, La Gogue and Rochon. La Gogue and Rochon have a total storage capacity of 250,000 cubic metres (0.25 million cubic metres) of untreated water which are transmitted to Hermitage Water Works for treatment and distribution. The combined storage capacities of treated water are 18,368 cubic metres

[5] Estimated

(0.018 million cubic metres) on Mahe. Table 60 below shows the shared storage capacities, catchments area in hectares and monthly evaporation for treated and untreated water.

Table 60: Natural Fresh Water Supply

Natural Fresh Water		Catchment Area (Hectares)	Storage Capacity (million cubic metres)	Monthly Evaporation (mm)
Supply Sites				
1.	La Gogue (Untreated)		0.150	215
2.	Rochon (Untreated)	2.133	0.100	100
3.	Cascade	3.204	0.0126	100
4.	Le Niol	4.616	0.0064	75
5.	Mare Aux Cochons	5.416	-	-

Data source: Ministry of Environment and Natural Resources, Public Utilities Corporation (Water Division).

4.6.3.11 Desalination Baseline Conditions

Desalination activities are already in operation in the Seychelles. However, for simplicity the desalination activities are modeled as a scenario rather than being active in the current account.

4.6.3.12 Reference Scenario

The 'Reference' scenario is established from the 'Current Account' to simulate the **likely evolution of the system without intervention**. The 'Reference' scenario is constructed with the key assumptions that the 1990-2000 population growth rate of 1.2% continues up to the year 2030, with current baseline socio-economic and technological conditions. The population in that case would increase from 73,900 to 98,395 individuals by the year 2030.

4.6.3.13 Scenario Modeling

Finally, the 'what-if' scenarios are created to alter the 'Reference' scenario and evaluate the effects of changes in policies/or technologies. In order to do that, the time horizon of the study area is changed. Therefore, the base scenario is the year 2006 and the last year of the scenario is the year 2030.

The 'what-if' scenarios constructed are as follows:

- Moderate to high population growth;
- Climate variability;
- Economic development in the tourism, fisheries, agriculture and industrial sectors;
- Demand management scenarios (i.e. improved technological devices at the residential and agricultural demand sites;

- Supply management scenarios (improved rain harvesting, water transmission and storage capacities).

In addition to the above, modeling is carried out at a catchment to evaluate the impact of various degrees of warming on the stream flow. This study also offers an integrated methodology for calculating the cost of water.

4.6.3.14 Water Supply Management Scenarios

The water supply management scenarios evaluate the impact of increasing water supply on the island through the following methods:

- Improved existing reservoir storage capacity;
- Improved water transmission (water losses);
- Introduction of desalination plants.

Ground water extraction and water re-use can also be modeled, but are not considered in this study.

4.6.3.15 Larger Water Storage Capacities

The Action Plan recommended by the Working Group set up by the President of Seychelles, and chaired by the Minister of Environment and Natural Resources to review the Water Supply Development Plan 2005 – 2025, agreed that the only reliable and most economic long term option to adapt and cope to climate change impacts is to build adequate storage to meet the country's current and future water requirements. A scenario is constructed to evaluate the impact of increasing the storage capacity by 30% in the year 2010 at Le Niol (Figure 86), and in 2012 at Cascade (Figure 87).

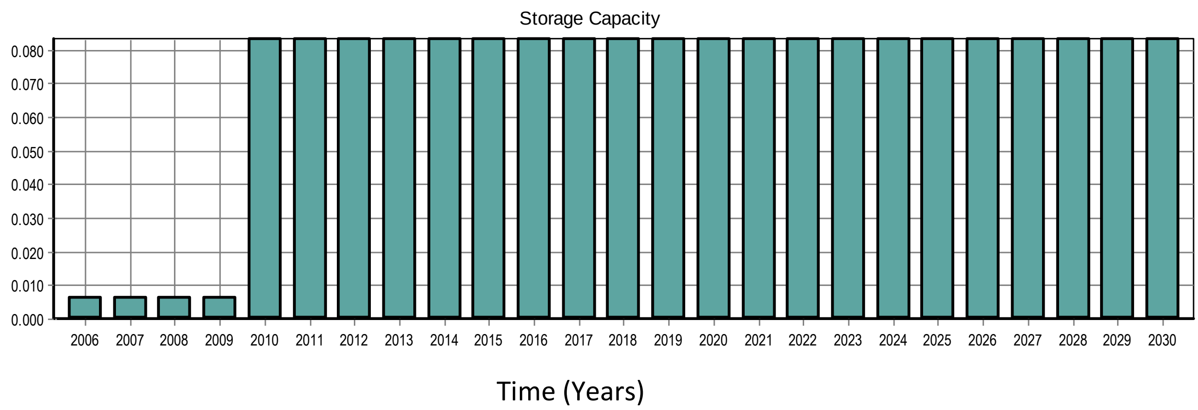


Figure 86: Projections of a Likely Increase of 30% of the Current Storage Capacities at Le Niol Water Works in the Years 2010 to 2030.

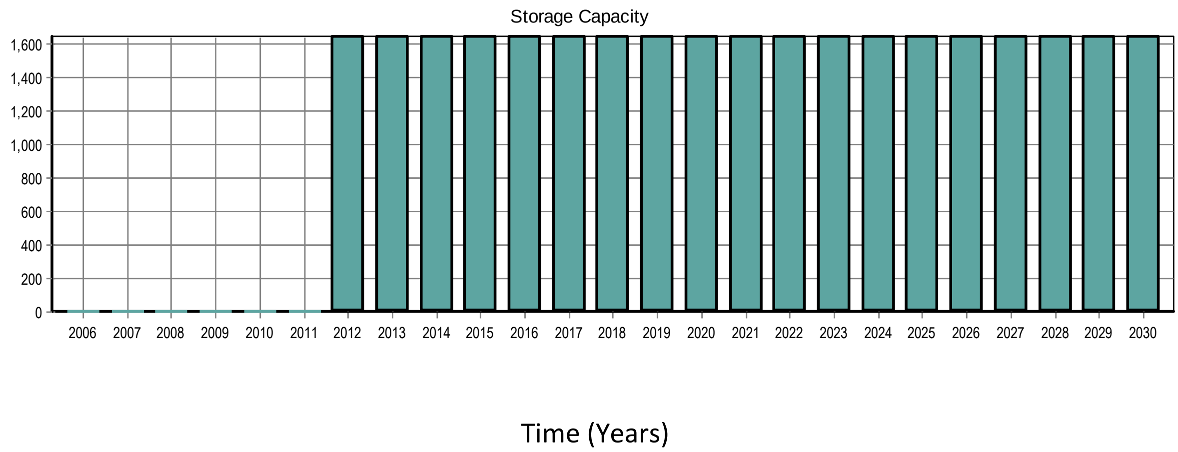


Figure 87: Projections of a Likely Increase of 30% of the Current Storage Capacities at the Cascade Water Works in the Years 2012 to 2030.

4.6.3.16 Improved Water Transmission

It is acknowledged that 40 % of the limited water captured is actually lost through pipe leaks during transmission to the various demand sites. Thus, each of the five demand sites accounts for 8% of the total water loss. Therefore, a supply scenario is constructed to demonstrate the likely impact of gradually reducing water loss from 8 % at each demand site to 2% (Figure 88). The overall gradual reduction in water loss during transmission is modeled to decrease from 40 % to 10% by the year 2030.

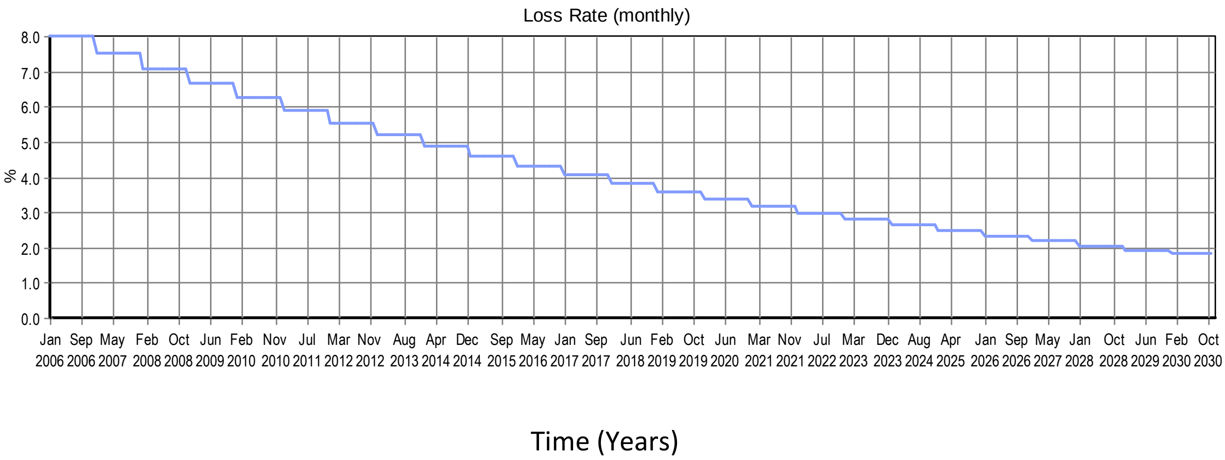


Figure 88: Projections of the Reduction in Water Loss during Transmission from 8% to 2% at each of the Five Modeled Demand Sites (i.e the Total Reduction is from 40% to 10%).

4.6.3.17 Desalination Technology

In this study, desalination activities are considered active only during the dry season with a supply flow of 0.1175 cubic metres per second from April to October as shown in the Figure 89.

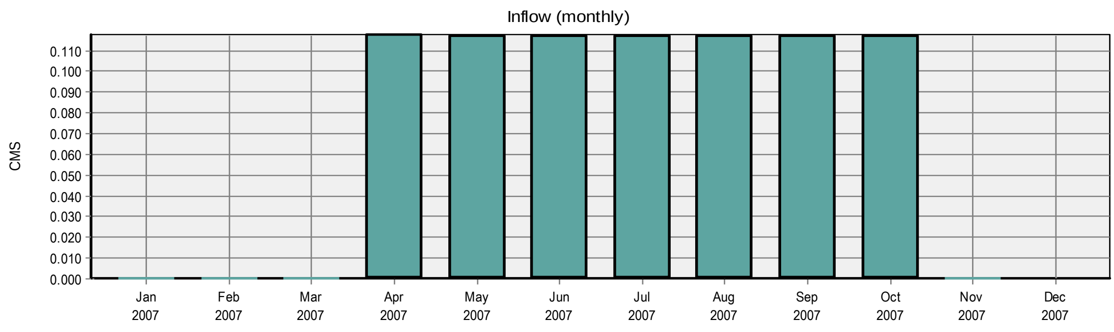


Figure 89: Desalination Plants Operational during the Dry Months. Data source: Ministry of Environment and Natural Resources, Public Utilities Corporation (Water Division).

4.6.3.18 Results and Discussions

The results of the various scenarios are shown from Figure 91 to Figure 105. They highlighted that high population growth, climate variably, economic development are the water related stressors. Demand management here includes strategies such as technological efficient water saving devices for water conservation, while supply management strategies simply are the methods by which supply of water can be increased. The following are deduced from the figures and tables.

4.6.3.19 Reference Scenario

The reference scenario characterised by current socio-economic and technological conditions representing business as usual situation shows unmet water demands of 1317.8, 1429,8, 1577.7, 1738.3, 1958.7, 2217.7 million litres for the 2006 base year and the projection years of 2010, 2015, 2020, 2025 and 2030 respectively as shown in Figure 91 and Table 61.

4.6.3.20 Water Stress Scenarios

On the other hand, the 'what-if' scenarios such as a possible high population growth rate of 1.8% shows a sharp increase indicated by the steepness in the exponential curve in terms of the unmet demand (Figure 92). The unmet demands are 1487.3, 1717.6, 2047.8, and 2549.7, 3173.6 million litres for the years 2010, 2015, 2020, 2025 and 2030 respectively. The increase in unmet demands compared to the reference or business as usual scenario are 57.5, 139.9, 309.5, 591.0, and 955.9 million litres respectively.

The economic development sector scenario bears the largest contributing factor for increasing unmet demand. The unmet demands are 1582.9, 2001.5, 2677.2, 3549.2, and 4621.0 million litres for the respective years of 2010, 2015, 2020, 2025 and 2030 (Figure 4-49, Table 4-18). The increasing differences in unmet demand compared to the reference or business as usual scenario are 153.2, 423.8, 938.9, 1590.5 and 2403.4 million litres for the same sequential years. Therefore, the economic development sector contributes to a larger unmet demand compared to that of the high population scenario.

Table 61: Unmet water demands (million litres) under economic development, high population growth scenarios and their differences compared to the reference scenario for the selected years.

	Year				
Scenario	**2010**	**Water Demands (million litres)**	**2020**	**2025**	**2030**
High Population Growth	1487.29	1717.55	2047.81	2549.68	3173.55
Economic Development	1582.95	2001.51	2677.15	3549.19	4621.03
Climate Fluctuation	1808.88	1577.67	1426.49	1958.72	1770.41
Reference	1429.77	1577.67	1738.30	1958.72	2217.65
High Population Growth-Reference	57.51	139.88	309.51	590.95	955.90
Economic Development-Reference	153.18	423.83	938.853	1590.47	2403.38
Sum of Water Stressors (WS)	4879.10	5296.70	6151.50	8057.60	9565.00
Sum of Water Stressors (WS)-Ref	3449.40	3719.10	4413.20	6098.90	7347.40

If the climate fluctuation is factored into the analysis, the unmet demands are 1808.9, 1577.7, 1426.5, 1958.7 and 1770.4 million litres respectively for the years 2010, 2015, 2020, 2025 and 2030. One should note that the performances in some years are better or worse depending on the climate. During the relatively wet years, the unmet demand is lower while it is higher in the projected dry years. For simplicity, climate fluctuation is considered as a stress because the perturbation added in this scenario is characterised by more consistent dry spells (see **Figure 4-50**).

The Figure 4-48 shows that when the high population growth rate of 1.8% is superimposed on the likely climate fluctuation cycles, the unmet demand increases further except for one or two occasions when the year(s) are considered to be very wet.

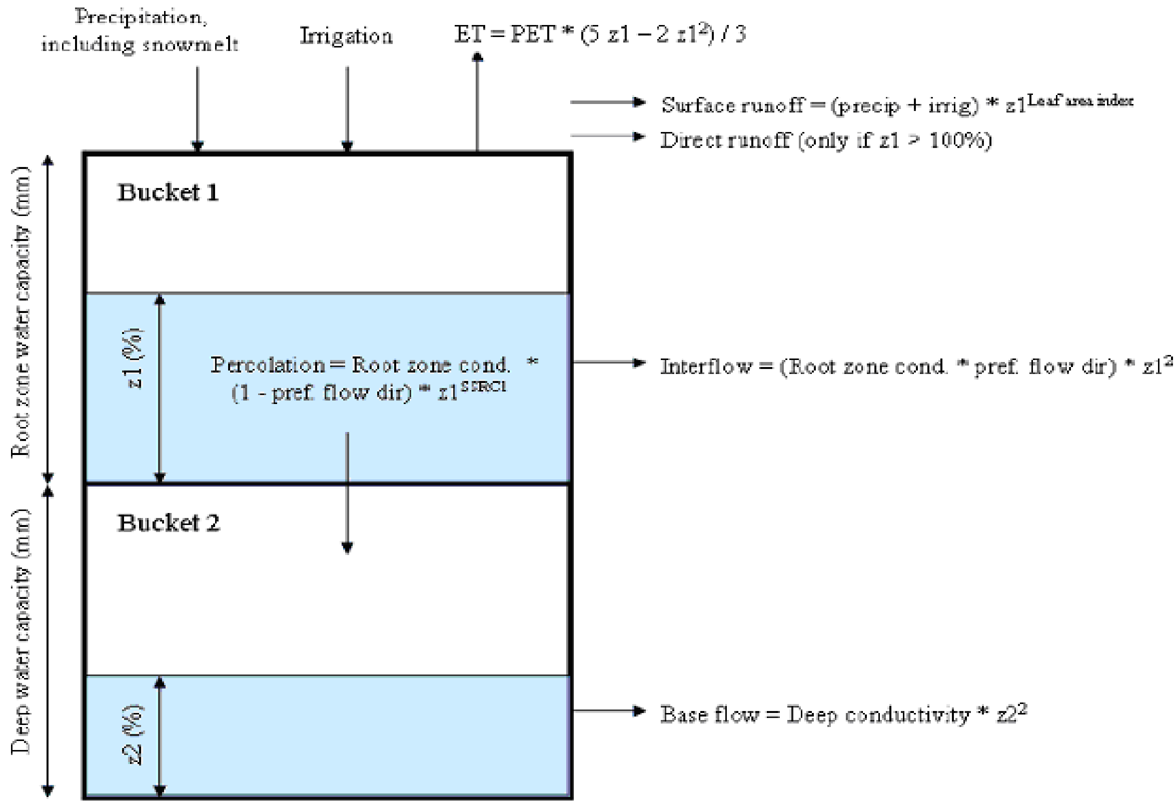


Figure 90: Conceptual diagram and equations incorporated in the two-bucket model. Source:http://unfccc.int/resource/cd_roms/na1/mitigation/Module_5/Module_5_1/b_tools/WEAP/Manuals/WEAP_User_Guide.pdf

The sum of the combined water stressor (WS) scenarios ranging from the effect of likely climate fluctuations, high population growth and economic development sector (i.e WS = $\sum$ Socio - Economic Development + Climate Fluctuations) shows unmet demands of 4879.1, 5296.7, 6151.5, 8057.6 and 9565.0 million litres of unmet demands for the years 2010, 2015, 2020, 2025 and 2030 respectively (Table 4-19 below). The increase in unmet demands compared to the reference scenario are +3449.4, +3719.1, +4413.2, +6098.9 and +7347.4 million litres for the years 2010, 2015, 2020, 2025 and 2030 (Table 4-18 above) respectively (i.e Unmet demand compared to the reference = ($\sum$ Socio-Economic Development + Climate Fluctuations) - Reference Scenario).

This clearly shows the increasing water deficit and the potential risk in the absence of demand and supply management measures.

4.6.3.21 Model Validation: Comparison between WEAP & PUC Water Projections

Ideally, it is very important to evaluate model results to understand the skill or degree of uncertainty in the results. In this study, it was not possible to compare the results with other similar models like WEAP. Secondly, one may want to vary one or more parameters and then observe the corresponding change in the model output. For instance, the comparison of observed historical water storage or gauge flow to the model values as indicated in "Documentation and Testing of the WEAP Model for the Rio Grande/Bravo Basin," by Danner et al., 2006. In another similar study, model calibration was achieved by estimating the historic pattern of water demand and simulating the resultant flows (Arrance, McCartney, 2005). However, model calibration in this study was not possible because there was no continuous historical data of unmet water demands to compare with. To address this issue, the WEAP and PUC water projections were compared in the initial time frame.

Comparison between WEAP and the PUC conventional supply projections (INC, 2000) shows larger deficit than the WEAP derived computations (see Table 4-19). However, the PUC projection for 2010 tends to agree more closely with the WEAP based result. It should be noted that PUC calculations show a sudden exponential increase in water deficit but then stabilises at around 5072.3 million litres per annum after the anticipated installation of the desalination system in the year 2000. It is not clear what are the underlying factors causing the sudden exponential increase in PUC projections from the late 1990s to the year 2000. It remains a key issue for discussion. It is important to note that PUC projections are not available after the year 2010. It is also noted that the actual observed deficit in water of 4141 kl per day (1511.5 million litres per year), which was reported in the INC (2000), also tends to agree closely with the WEAP 2006 unmet water demand of 1317.8 million litres per year. This suggests some degree of confidence in the initial simulation results using the WEAP model.

Table 4-19: Comparison between the WEAP Scenario and the PUC Conventional Supply Projections (INC, 2000).

	Year							
	1996	2000	2006	2010	2015	2020	2025	2030
PUC Projected Deficit (million litres/year)	2062.3	5055.3	5069.9	5091.8	n/a	n/a	n/a	n/a
WEAP (million litres/year)	-	-	3953.4	4879.1	5296.7	6151.5	8057.6	9565.0
Difference in Projection	-	-	+1116.5	+190.7	-	-	-	-

(PUC-WEAP) (million litres/year)								

4.6.3.22 Conclusion

The WEAP training had provided the required basic skills for better integrated water resource evaluation, planning and management. The preliminary study, using WEAP for integrated water resource assessment, focused on the impact of climate, socio-economic and technological changes on the water resources on the island of Mahe.

Because of the local limitations in ability to predict future water demand, different scenarios of demand with other superimposed factors that affect water resources were assessed. Each scenario was run for a period of 24 years up to the year 2030 to encompass a range of hydrological conditions. The results presented provide a “first estimate” of water demand trends and possible approaches to ensure that water resources are sufficient to meet demands. A number of estimates and assumptions were made in view of data limitations. These assumptions and limitations must be taken into consideration and must be carefully understood when interpreting the outputs and results presented. Nevertheless, the study’s findings provided useful insights into water resources management in the catchment and the following conclusions can be drawn:

The WEAP results showed that the sum of the combined water stressor (WS) defined here as the worse case scenario policy ranging from the effect of likely climate fluctuations, high population growth and sector economic development were characterised by 4879.1, 5297, 6151, 8058 and 9565 million litres of unmet demands for the years 2010, 2015, 2020, 2025 and 2030 respectively. These figures highlighted the drastic increase in the deficit of water which fundamentally poses a serious risk to the sustainable development of the country.

The WEAP based water stress-worse case scenario projected less water deficit compared to the PUC conventional water supply oriented projections, but seems to agree closely for the period 2010. The available PUC projections were limited up to the year 2010 only. The degree of confidence in the WEAP model simulation for the initial period is reasonably satisfactory as it agreed closely with observed, reported water deficit (INC, 2000).

The demand management scenarios such as the improvement in technological water saving devices (i.e toilets, showers and washing devices) in the tourism and residential demand sites showed large reduction of unmet demands compared to the reference or business as usual scenario ranging from -221.3 to -941.7 million litres less, from the years 2010 to 2030. The irrigation demand management scenario contributes to larger reductions of -829.4 to -2137.7 million litres for the same projected years.

In contrast, the desalination technology management scenario contributes to significant reduction of unmet demands compared to the reference-business as usual scenario with -744.7 to -1532.6 million litres from the years 2010 to 2030. In addition, improved water transmission contributes to a reduction of unmet demands compared to the business as usual scenario from -53.8 to -373.4 million litres from the years 2010 to 2030. The potential increase in reservoir storage capacity by 30 % at two existing storage facilities contributes to a reduction of unmet demands compared to the reference or business as usual scenario of -112.7 to -902.2 million litres for similar projected years. It was highlighted that the gradual transfer of technology from 5% to 95 %, in favour of irrigation in the agriculture sector, would contribute mostly to alleviating water shortages. However, the real world is integrated and no single measure can provide the exact solution.

The integrated WEAP water resource evaluation showed that if the Seychelles were to face worse case scenario condition (i.e socio-economic development and climate fluctuation), then the net demand (i.e improved technological devices, irrigation) and supply (i.e desalination, improved water transmission, improved water storage) management scenario strategies would alleviate the large water deficit. The combined strategies has the potential to contribute to water surplus of 14329.4, 16405.8, 19906.2 , 27342.2, and 33059.1 million litres for the years 2015, 2020, 2025 and 2030 respectively.

The impact of climate change, in terms of various degrees of warming, ranging from +0.8°, 1.6° and 3.0 °C for the years 2025, 2050 and 2100 (Chang-Seng, 2007) at the Mare Aux Cochons catchment, is likely to decrease stream flow by one thousand metre cube in the peak flows during the rainy season due to higher evapo-transpiration processes. In contrast, the stream flow is likely to be reduced by 0.2 thousand cubic metres during the low flows in November.

4.6.3.23 Recommendations

General National Water Strategies

The implementation of the various water management strategies are always tied to huge financial constraints or environmental elements. No country can address such challenges alone. Therefore, the Government of Seychelles should consider these two overarching key goals and actions:

- Water resource management should target both supply and demand management strategies;
- The government needs to consider enforcing or implementing the guidelines, plans and policies into concrete actions according to a well defined time frame (as indicated in the analysis).

Water Policies, Government Support and Community Participation

- An irrigation-technology policy should be introduced or enforced in the agricultural sector;
- The tourism establishment and the local households should be encouraged to have water efficient saving devices;
- New or existing legal framework should be enforced to prevent any adverse land use development in the catchments to minimise the impact of climate change through evapo-transpiration on the stream flow;
- The government should support a sustainable programme that will facilitate the availability of such technological efficient saving devices into the country;
- The community should be aware of the dual demand and supply management strategy with a view to foster wider sector and community participation.

Training

- Develop national capacities in water related science with international stakeholders such as the Stockholm Environment Institute (SEI).

Data and Modeling

- A comprehensive and detailed data collection process focusing on the physical, operational hydrology, socio-economy and land use water related parameters is needed to establish preliminary findings;
- Future analyses may involve simulations to understand the interactions of climate change and responses of the stream flow impact on the ecosystem;
- Future studies should focus on a smaller scale (i.e recommendations of the one day national workshop of 5th December 2008);
- Water re-use and water quality simulations as part of the integrated water assessment (i.e recommendations of the one day national workshop of 5th December 2008).

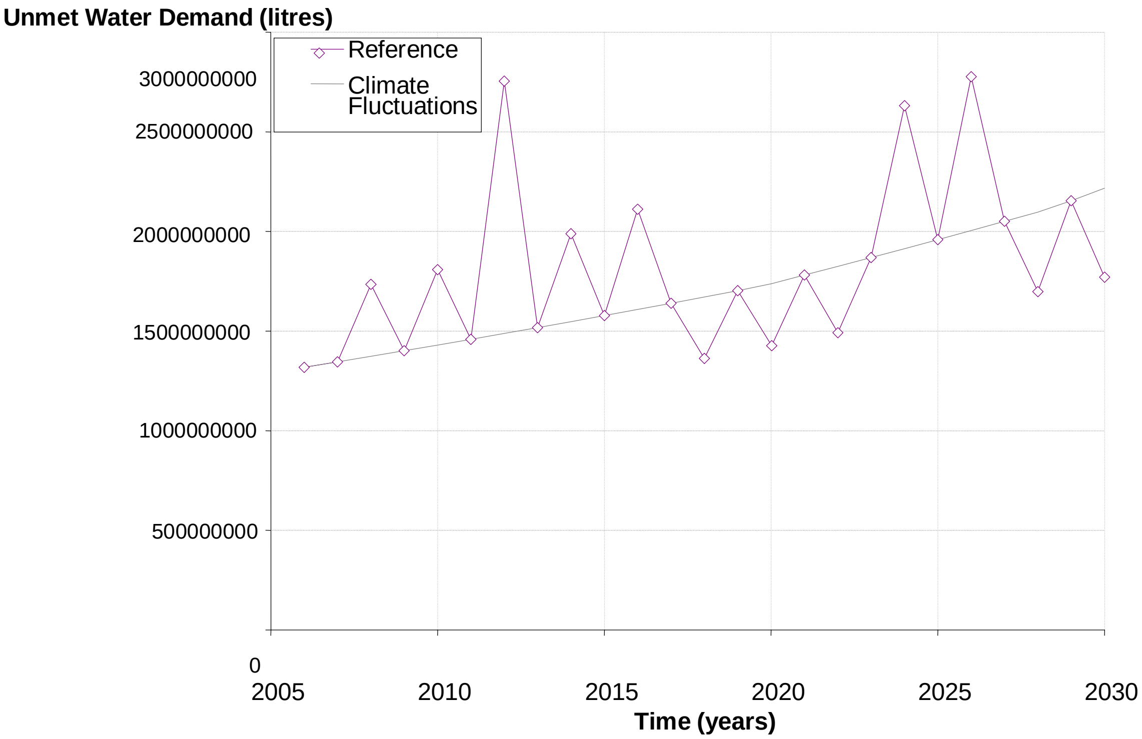


Figure 91: Water Stressors: Climate Fluctuations compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

Unmet Water Demand (litres)

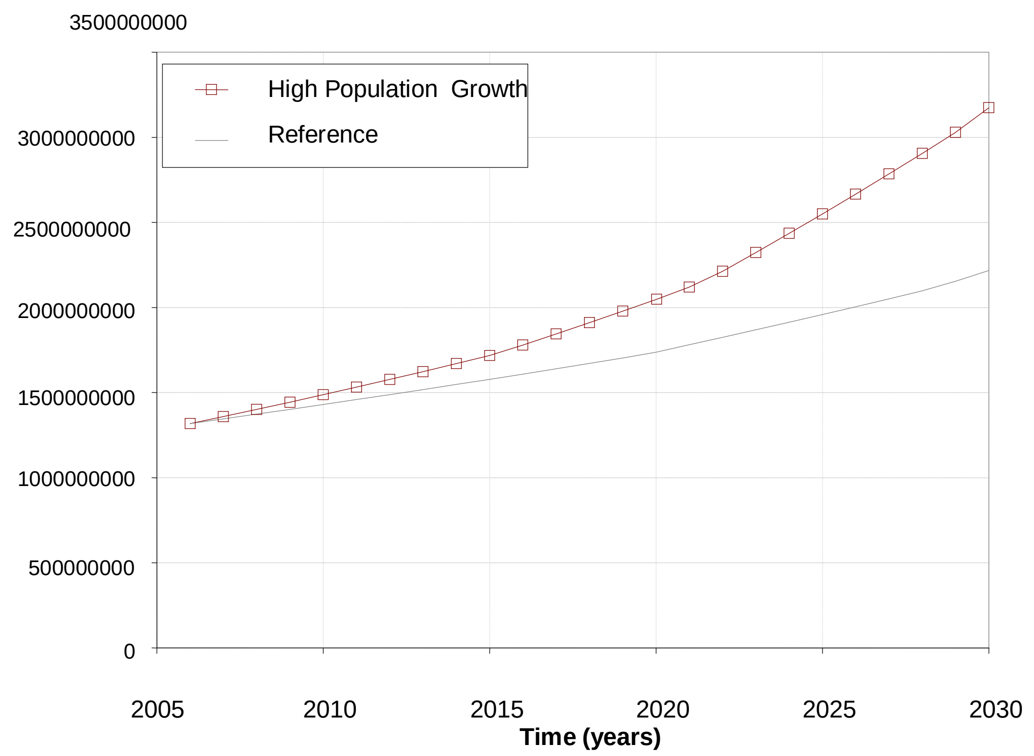


Figure 92: Water Stressors: High population Growth compared to the Reference Scenario (i.e Likely Evolution of the system without intervention).

Unmet Water Demand (litres)

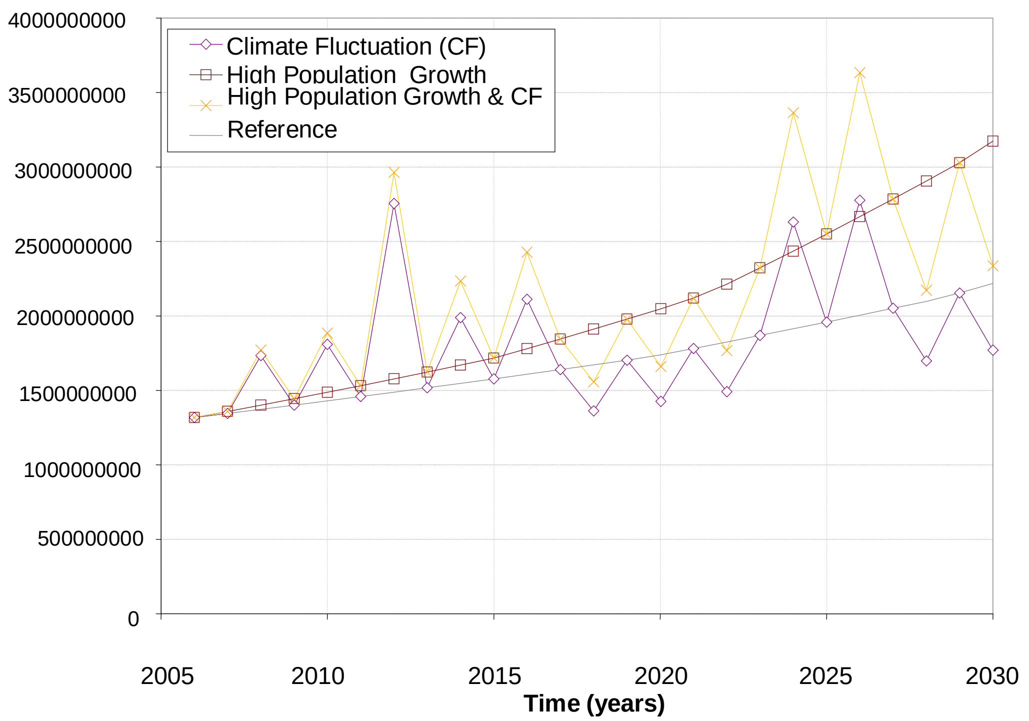


Figure 93: Water Stressors: High Population Growth and High Population Growth superimposed on Climate Fluctuation compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

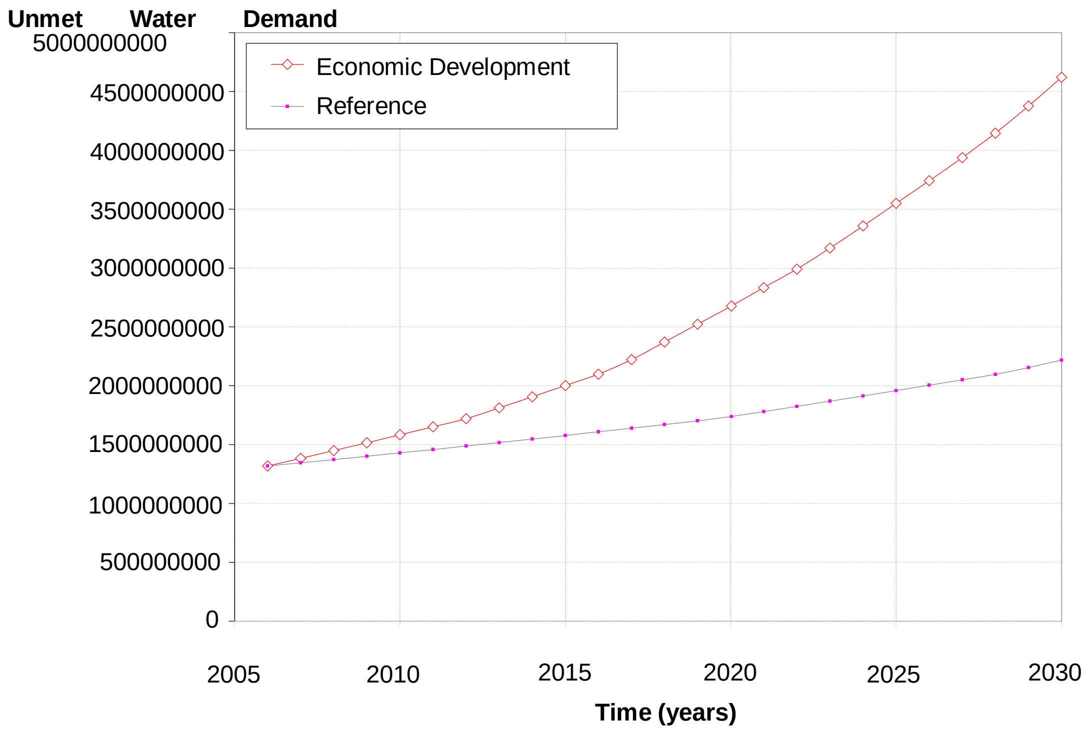


Figure 94: Water Stressors - Economic Development compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

Unmet Water Demand (litres)

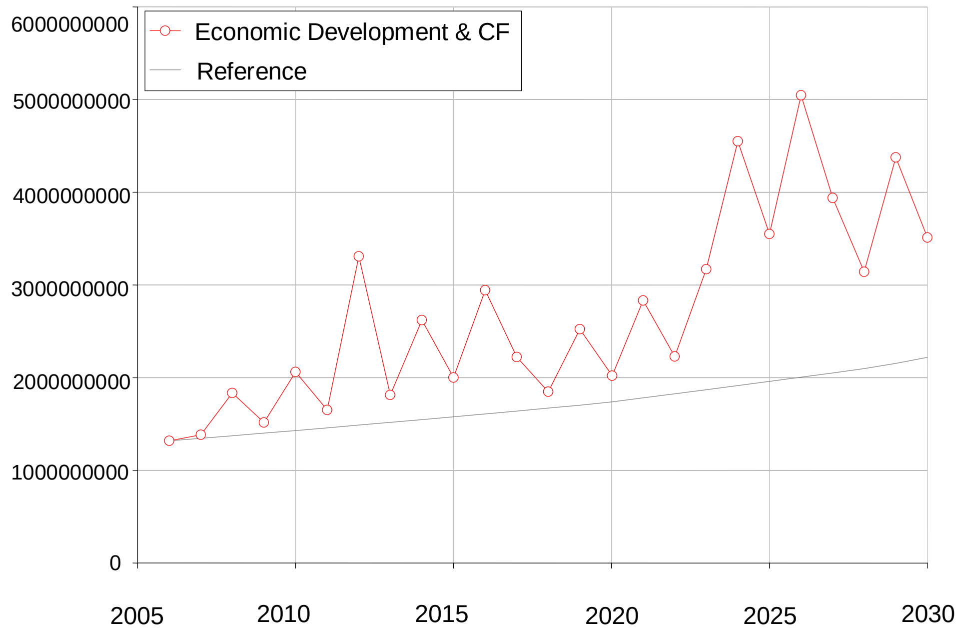


Figure 95: Water Stressors - Economic Development superimposed on Climate Fluctuation compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

Unmet Water Demand (litres)

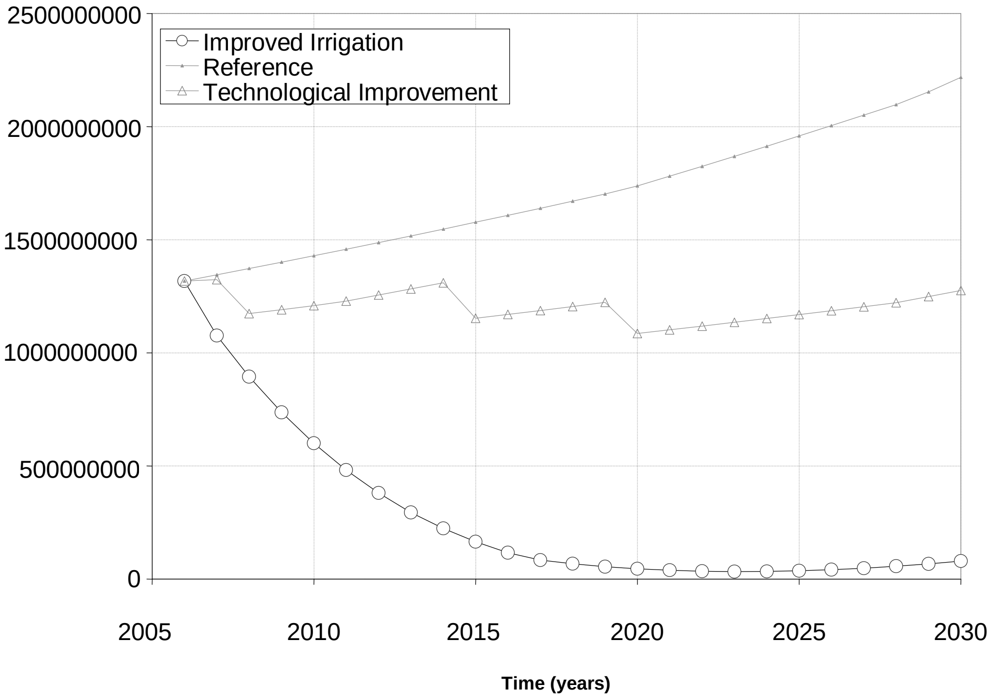


Figure 96: Demand Management Strategies - Improved Irrigation and Technology (i.e. Efficient Toilets, Showers) compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

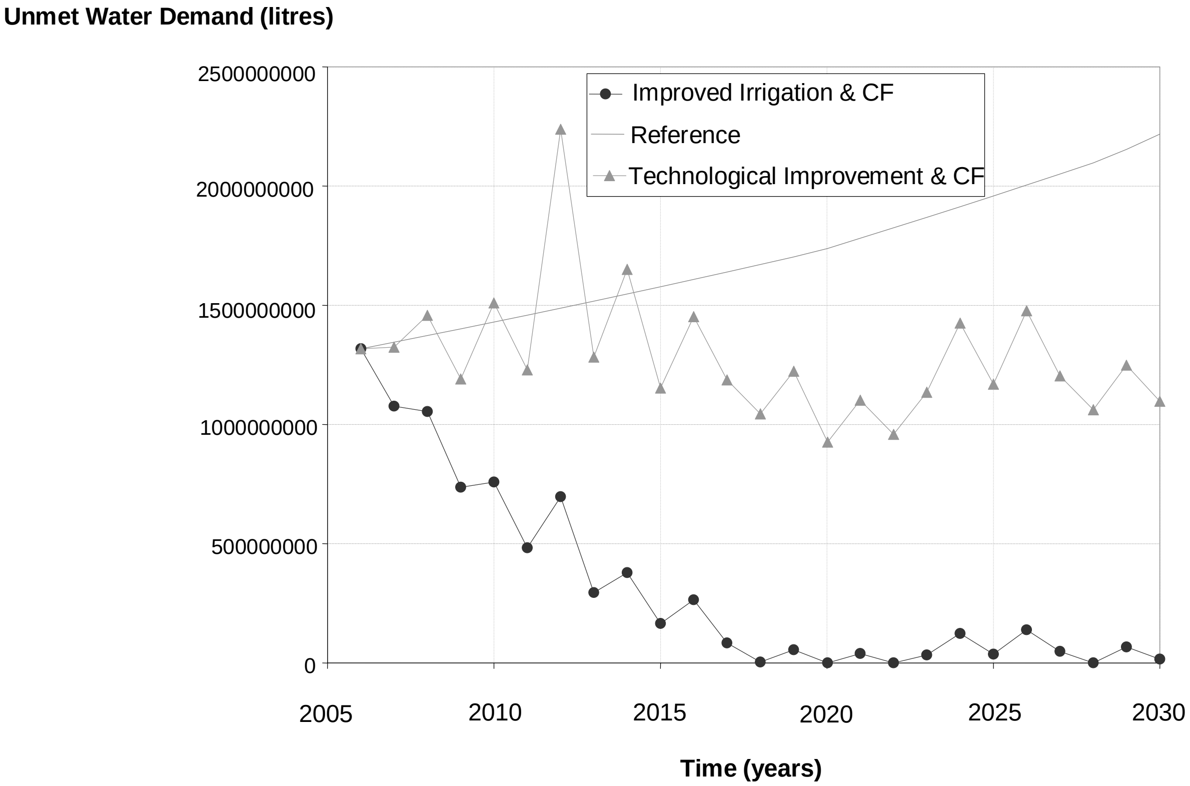


Figure 97: Demand Management Strategies - Improved Irrigation and Technology (i.e Efficient Toilets and Showers) superimposed on Climate Fluctuation compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

Unmet Water Demand (litres)

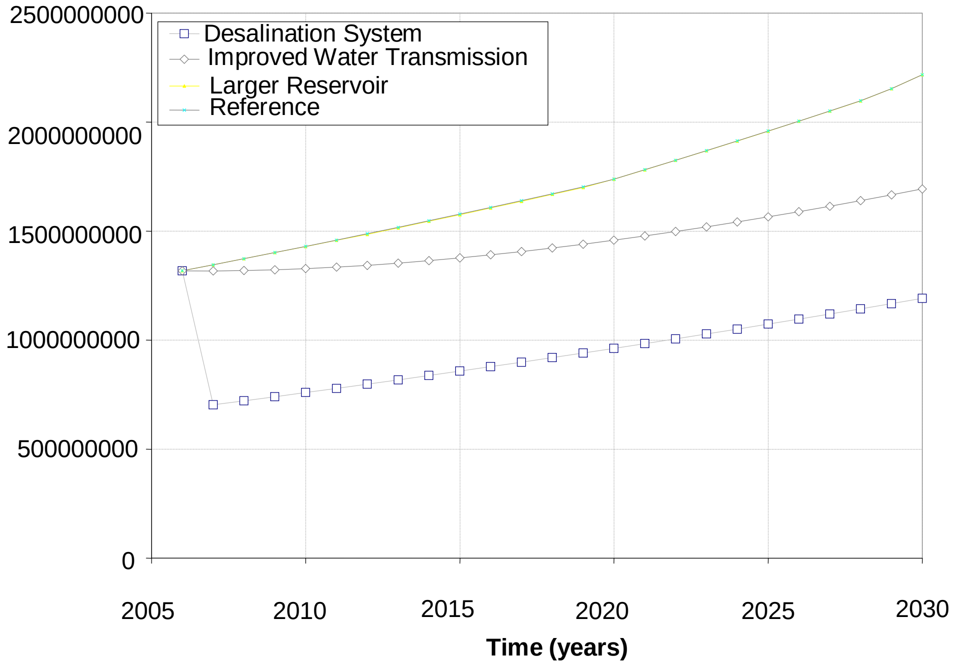


Figure 98: Supply Management Strategies - Desalination, Improved Transmission and Larger Storage Capacity compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

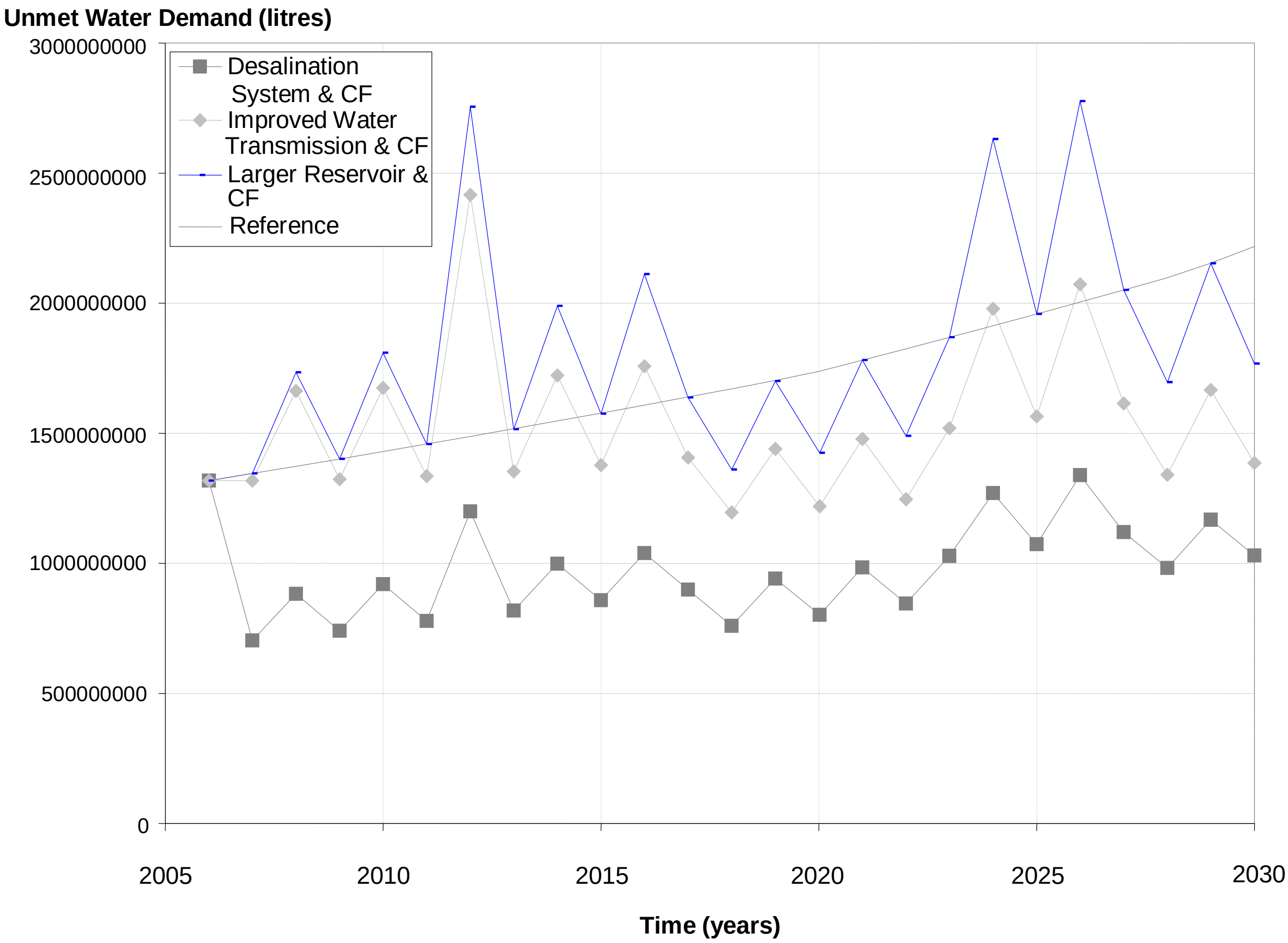


Figure 99: Supply Management Strategies - Desalination, Improved Transmission and Larger Storage Reservoir and the Likely Effect of Climate Fluctuations compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

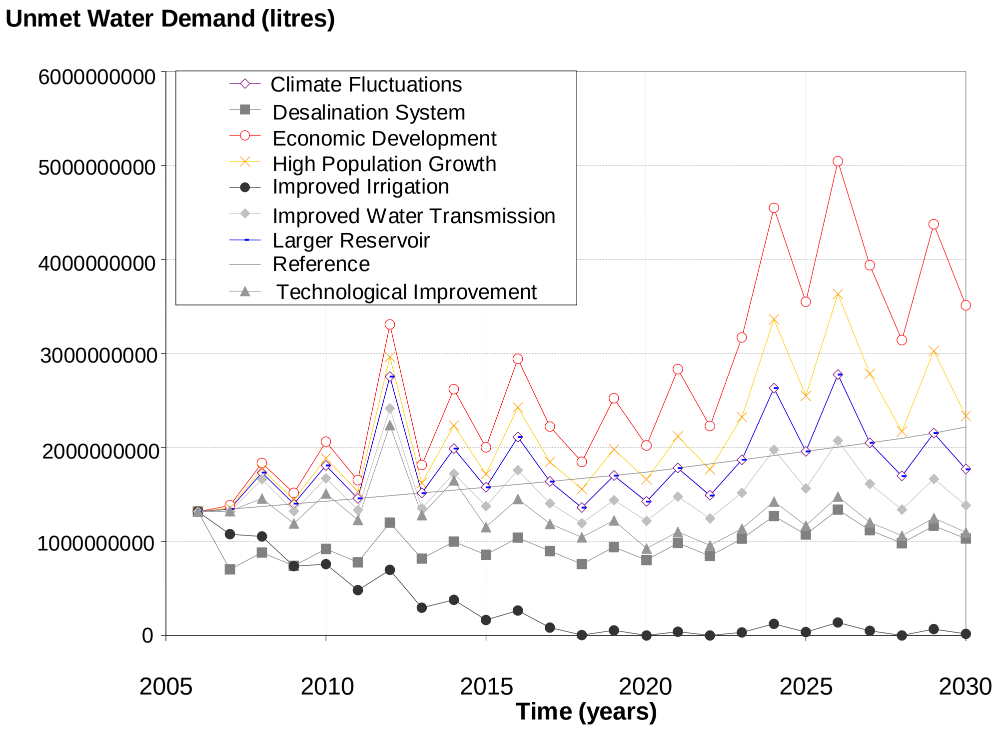


Figure 100: All Scenarios - Socio-economic (i.e Water Stressors) and Demand and Supply Management Strategy Scenarios as a Function of Climate Fluctuation compared to the Reference Scenario (i.eLlikely Evolution of the System without Intervention).

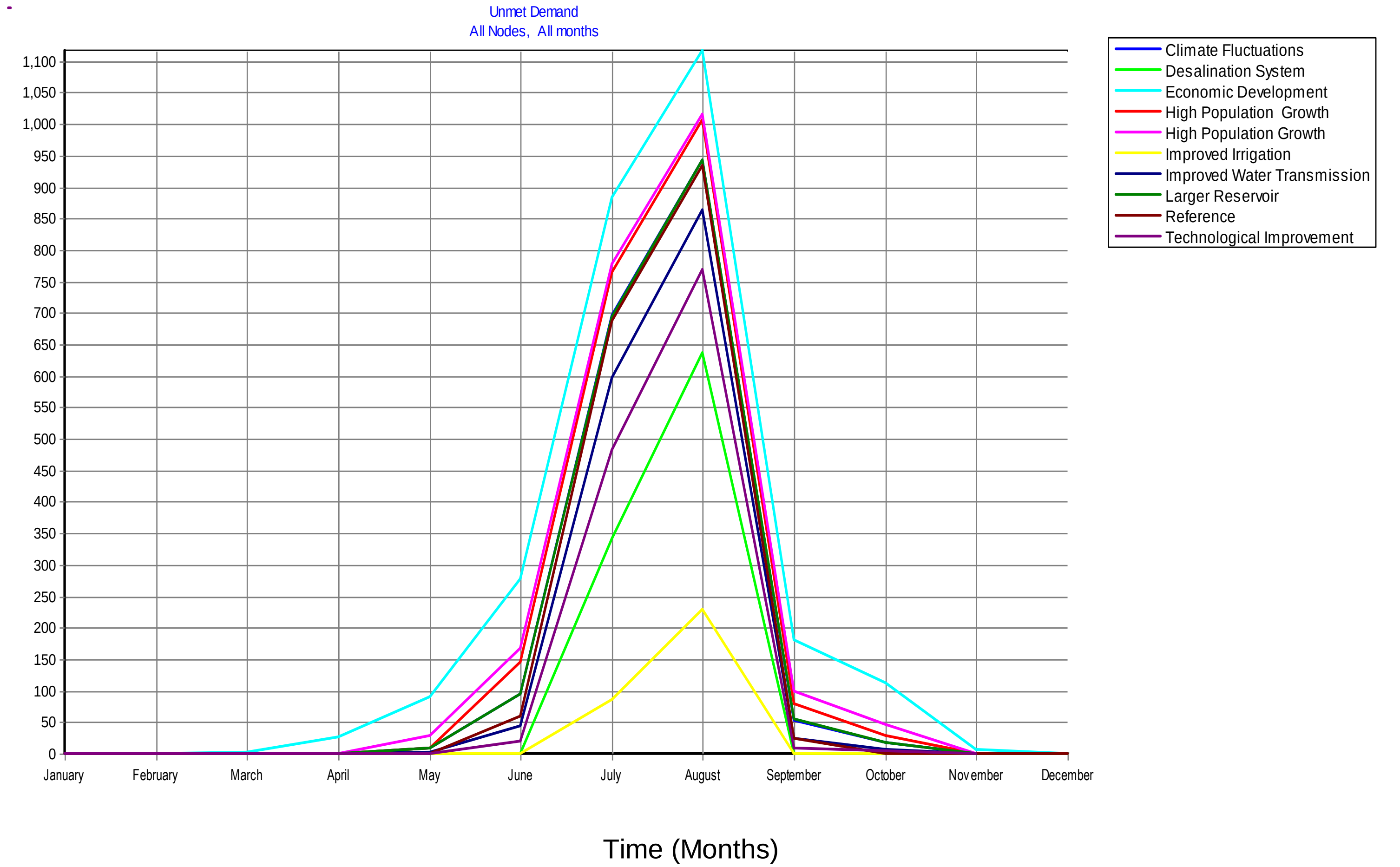


Figure 101: All Scenarios - Monthly Average Unmet Demand for Water compared to the Reference Scenario (i.e Likely Evolution of the System without Intervention).

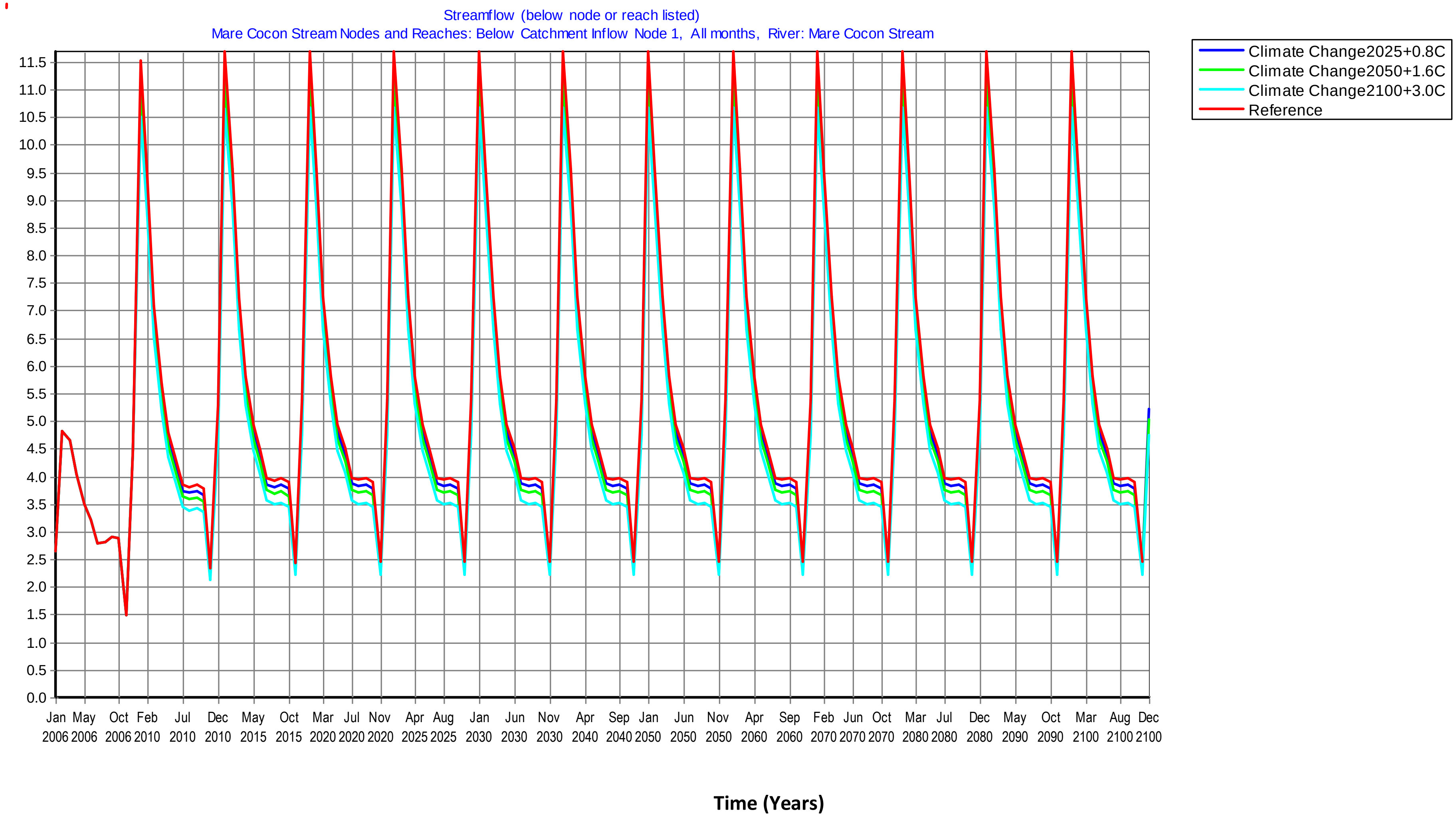


Figure 102: Projected Changes in Monthly Stream Flow due to Climate Change.

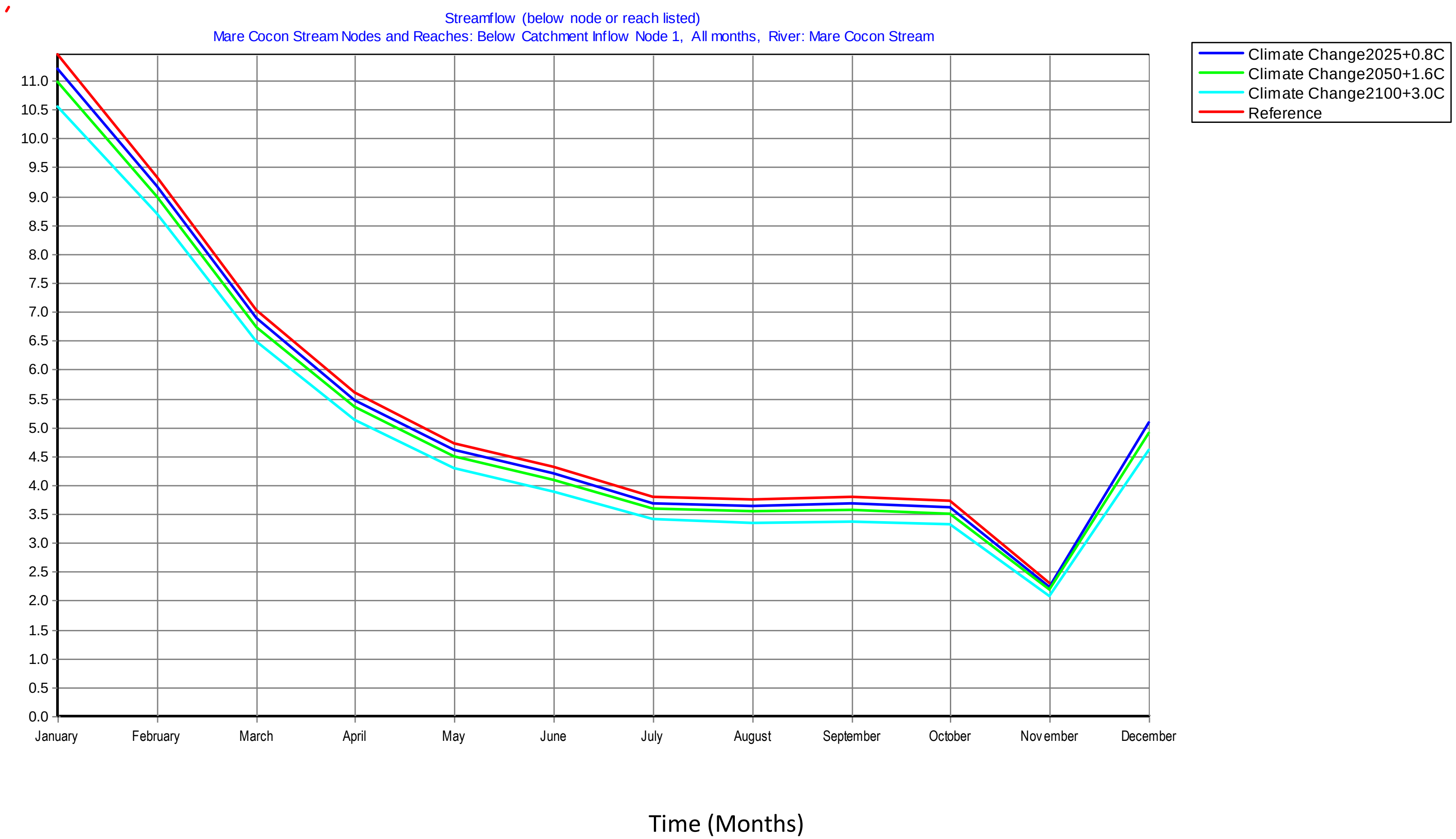
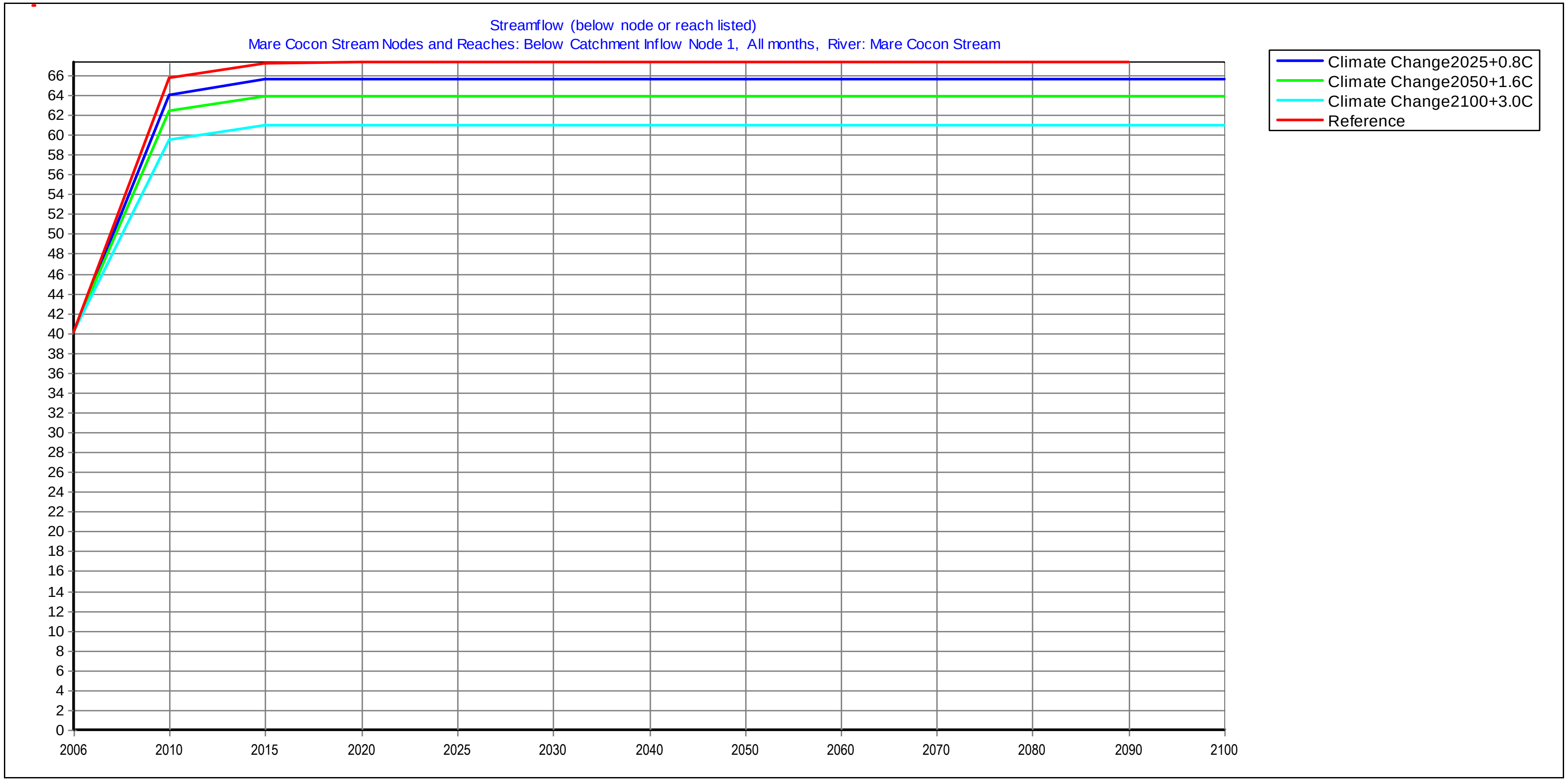


Figure 103: Projected Changes in Mean Monthly Stream Flow due to Climate Change.



Time (Years)

Figure 104: Projected Changes in Total Annual Stream Flow due to Climate Change.

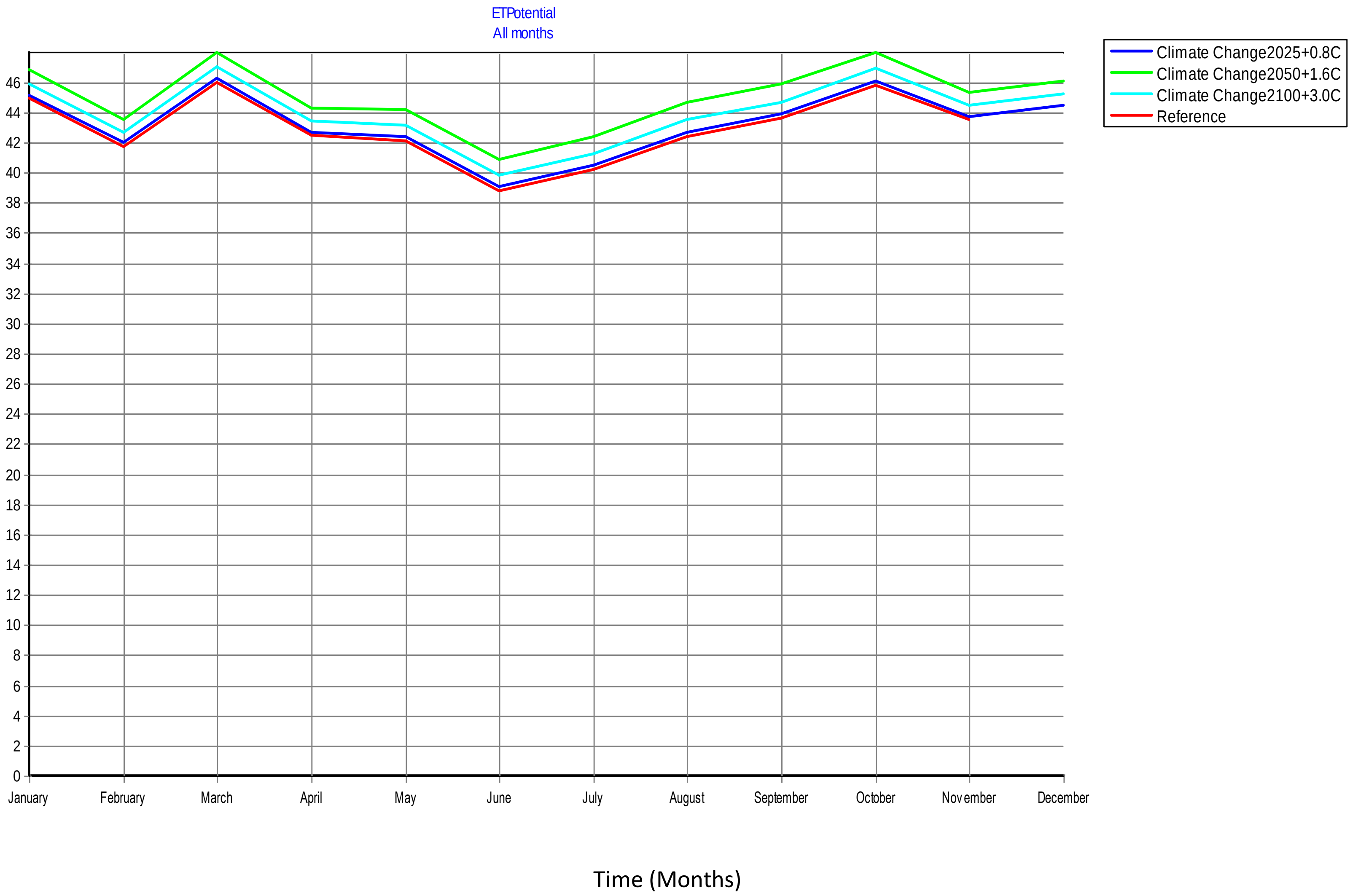


Figure 105: Projected Changes in the Amount of Water that would be consumed by Evapo-transpiration (ETPotential) in the Catchment.

4.6.4 Study 2: Hydro-Climate Statistical Prediction of the Extreme Dry Periods in the Seychelles

4.6.4.1 Introduction

Rainfall is abundant in the southern hemisphere's summer monsoon from December to April. Hence, water resources are replenished during the summer rainfall, contributed mainly by the inter-tropical convergence zone (ITCZ). In contrast, during the southeast monsoon from May to October, rainfall is of a relatively lower amount (Figure 106), representing 30 % of total average annual rainfall. High evaporation rate also prevails during the southeast monsoon. The spatial variability of rainfall is significant from the north to the south of Mahe, in both the wet and dry seasons. The highest total annual mean rainfall is slightly above 3400 mm near Mount Harrison and the lowest total annual rainfall occurs in the extreme south of the island with 1800 mm. The water resources of the main island, Mahe, are captured by an extensive network of streams (see Figure 4.67), but the water supply varies from year to year depending on the climatic conditions (Figure 4.66). In addition, the combined effects of steep topography, low retention of soil (high run-off) and high evaporation allow only 2-3 % of water to be captured through a network of streams around the island (Labodo, 1998).

On the other hand, water demand has increased exponentially as a result of socio-economic development. The fishery processing activities, the tourism establishments, the industrial production and population dynamics are believed to be exerting extra pressure on the available water resources. Many socio-economic activities such as tourism development have extended and are operating outside the reach of the Le Niol, Hermitage, La Gogue and Cascade main water storage facilities and water distribution network system (see Figure 4-67). The projected demand for water in Seychelles for the years 2005 and 2010 exceeds current water supply by +13,890 and +13950 kiloliters per day (PUC, 2000) respectively, hence water for the future is of highest national priority.

4.6.4.2 Objectives of the Study

The objectives of the study are as follows:

- To investigate the signals driving extreme hydro-climate droughts in the Seychelles during the southeast monsoon season;
- To develop multivariate statistical models for hydro-climate prediction;
- To carry out model verification to test their operational reliability.

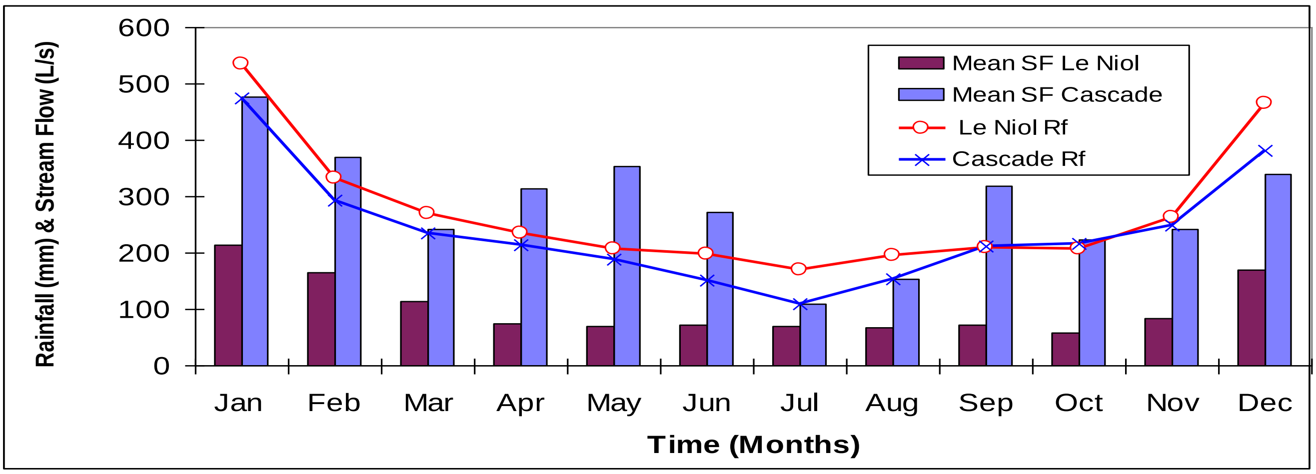


Figure 106: Le Niol and Cascade Mean Monthly Rainfall (mm) and Stream Flow Discharge (L/S)

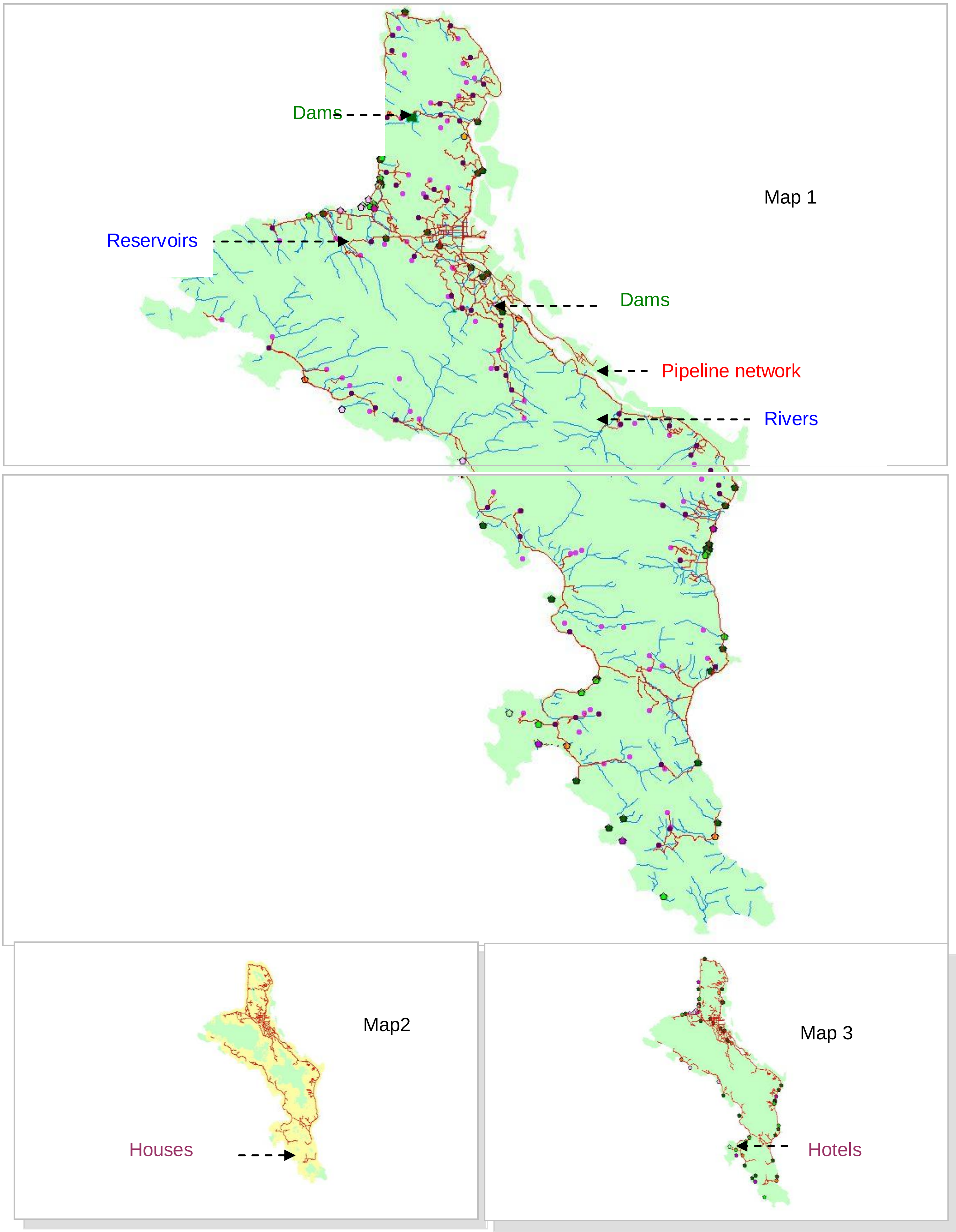


Figure 4-67: Water dams (deep green shading), reservoirs (round symbol with light purple colour), rivers (blue colour), pumping stations (round symbol with deep purple colour), pipe line network (red colour) on map 1, houses (light yellow map) on map 2 and hotels on map 3 for Mahe Island.

4.6.4.3 Results

Temporal Variability

The Figure shows the constructed hydro-climate time series index. The extreme dry hydro-climate years were: 1978, 1979, 1981, 1984, 1998, 1999, 2000, 2001, 2002 and 2004. The Morlet power wavelet spectrum (Figure4-69) analysis of the hydro- climate time series confirms the biennial and the decadal cycles of hydro-climate series.

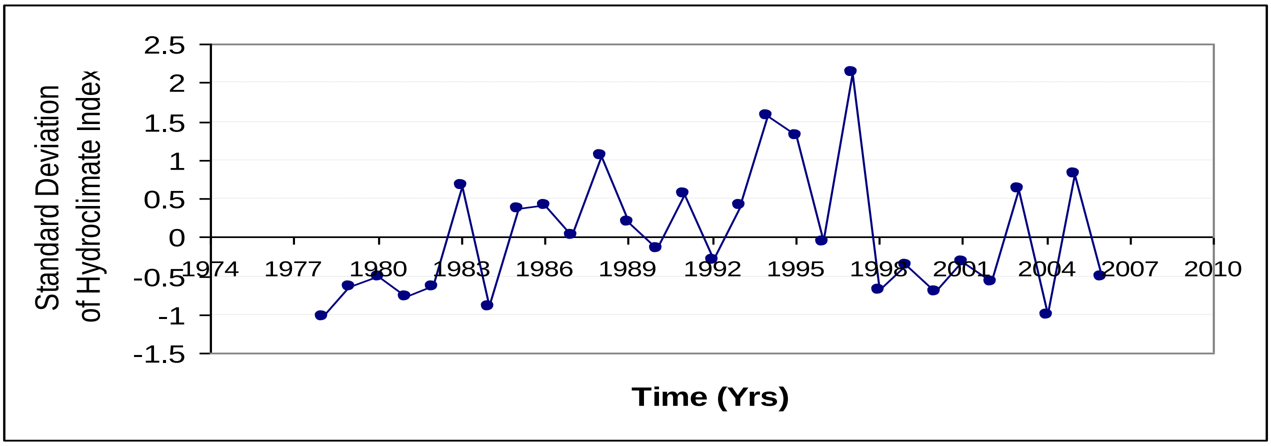


Figure 4.68: Standard Deviation of the Hydro-climate Time Series Index

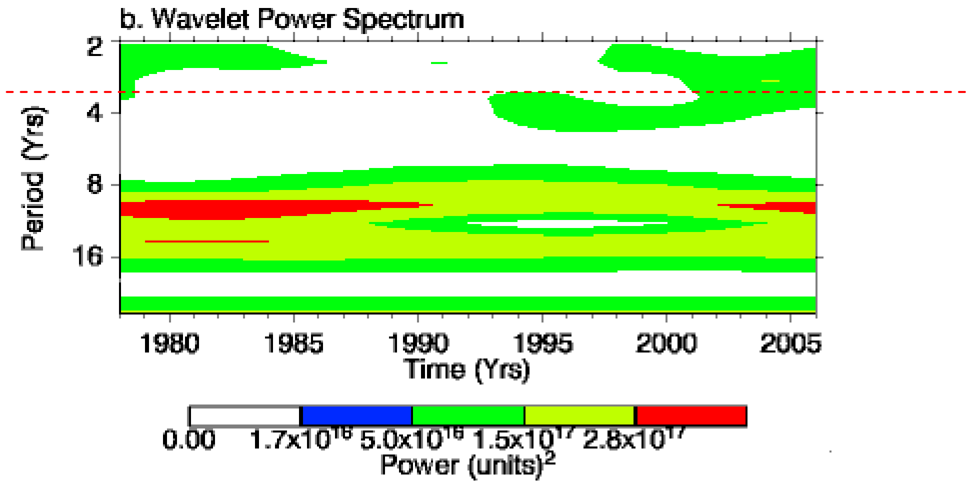


Figure 4-69: Morlet Power Wavelet Spectrum Analysis of the Hydro-climate Time Series Index

Composite Analysis of the Dry Hydro Climate years

A number of composite anomaly maps were generated to detect the signal governing dry hydro-climate years, however only a set of important maps at three months lead time and in-season analyses are illustrated here. Below are summaries of the sea surface temperature (SST), air temperature, vector, zonal winds, outgoing long wave radiation (OLR), specific humidity and precipitation rate composite maps.

Sea Surface Temperature (SST)

The SST composite pattern at three months lead time, prior to peak south-east monsoon, shows a weak La Nina signal developing in the central-eastern Pacific (see Figure: 4-70). The in-season SST pattern shows a well developed La Nina type of signal in the Pacific Ocean with temperature cooling down from -0.2 to -0.5 $^{\circ}$C (see Figure: 4-71). In contrast, a rather consistent and remarkable warming in SST between + 0.4 and +0.6° C is found in the North Atlantic and in the ocean of West Africa.

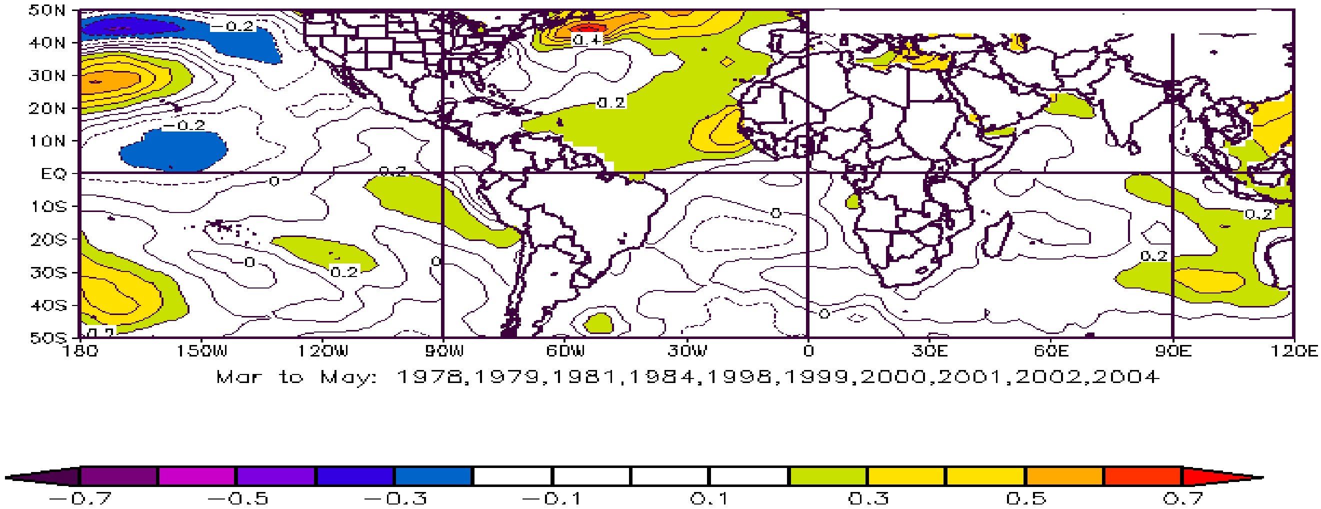


Figure 4-70.: Composite anomaly of SST ($^{\circ}$ C) maps at three months lead time (T-3) prior to the peak dry season (JJA)

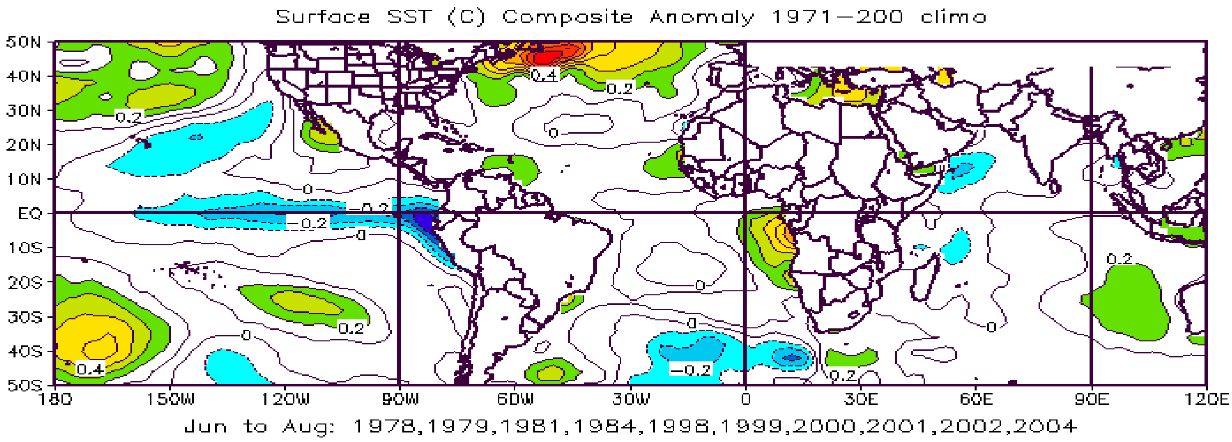


Figure 4.71: Composite anomaly of SST ($^{\circ}$ C) maps during the peak dry season (JJA)

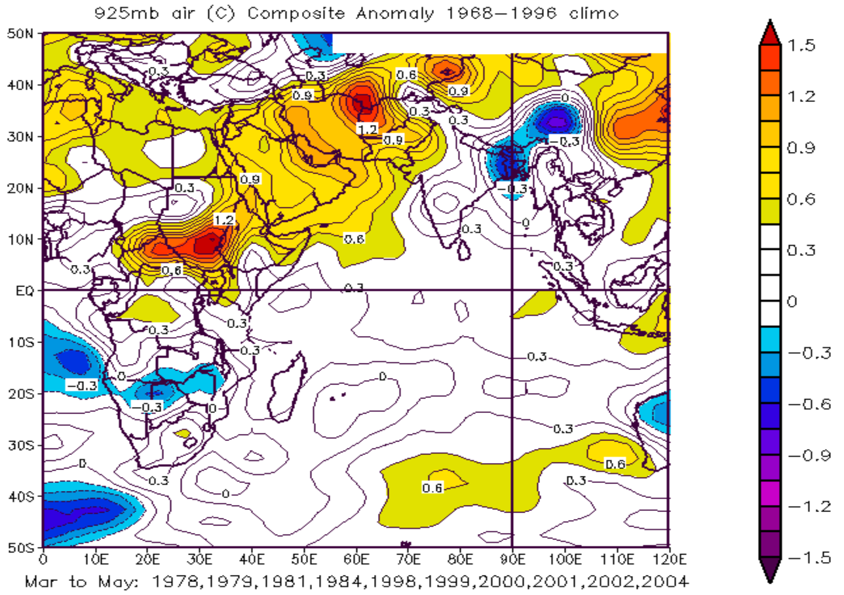


Figure: 4-72: Composite anomaly of 925 hPa air temperature (° C) maps at three months lead time (T-3) prior to the peak dry season (JJA)

Air Temperature and Sea Level Pressure

A warming in air temperature at 925 hPa ranging from +1.0 to +1.8 ° C is found particularly in the northern hemisphere centred at 50N, 60 E at three months lead time (see Figure:4-72). The signal is also strong even at six months lead time (not shown). The peak warming in air temperature is adjacent to an area of positive sea level pressure anomaly located north-east of India at 45 ° N, 100 ° E. On the other hand, a high pressure field anomaly is found to the south of the Indian Ocean, centred at 50 ° S, 80 ° E. During the peak of the south-east monsoon, the pressure field anomaly weakens slightly, but displaces to position in the South-west Indian Ocean at 45 ° S, 45 ° E (see Figure: 4-73).

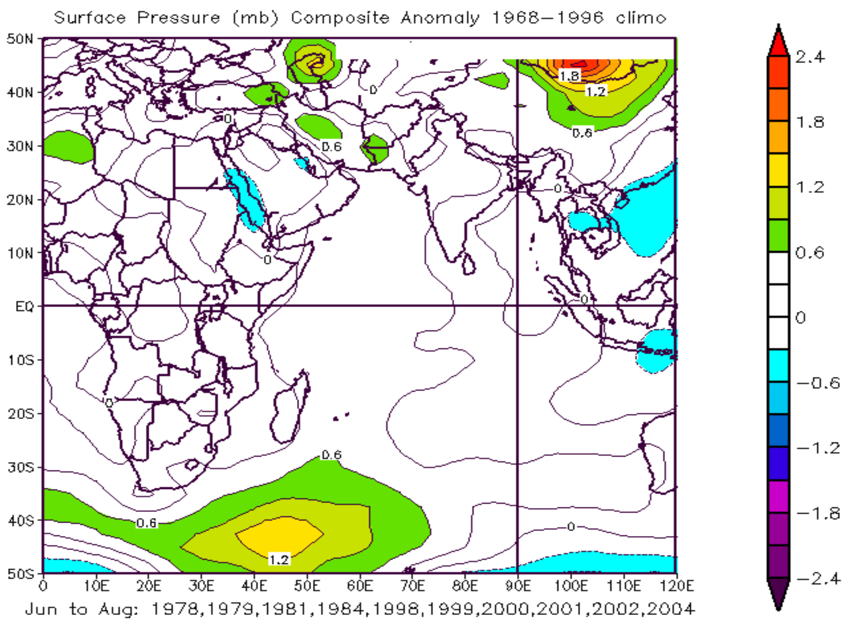


Figure 4.73: Composite anomaly of sea level pressure (hPa) maps during the peak dry season (JJA)

4.6.4.4 Summary

The hydro-climate dry years were 1978, 1979, 1981, 1984, 1998, 1999, 2000, 2001, 2002 and 2004. The wavelet power spectral analysis confirmed the biennial and decadal cycles of the hydro-climate time series index and was rather consistent with similar findings by Chang Seng (2007). The spatial composite analysis signals revealed that the La Nina signal in the Pacific Ocean, along with alternating warming effects in the West African coast and North Atlantic Ocean, were the background forces driving the dry hydro-climate years. Thermodynamic warming in the northern hemisphere, coupled with high pressure anomalies over northeast India and south Indian Ocean, were also linked with the low rainfall and stream flows.

One of the surprising results was the fact that during the peak of the dry season, dry and stable low level air mass swept across the Seychelles from the Sahara Desert. However, in the middle levels, anomalous south-easterlies prevailed. The contrasting air mass characterises the trade wind inversion and wind shear effects which suppresses rainfall in the south-west Indian Ocean. Upper level zonal winds at six months lead time were strongly westerly and centred over the Seychelles in the South West Indan Ocean (SWIO) while a core of easterlies remained fairly stable, even at 3 months lead time in the Arabia region; in the north-western Indian Ocean. The deficit in rainfall was associated with a shift in the cyclonic vortices north-east wards. The oscillation of energy from the Indian monsoon to the south-east Asia monsoon influenced rainfall pattern in the south-west Indian Ocean. The in-season composite of surface precipitation rate, specific humidity and outgoing long wave radiation anomalies agreed with the presence of the dry hydro-climate years.

Multi-variate analysis has been used to develop the 3-month and the 6-month lead time predictive models. Two approaches have been employed: namely the Multiple Linear Regression and the Principal Component Regression, which provided a useful supplement to the former due to its orthogonal property. The model relates the hydro-climate (i.e the combination of extreme low rainfall and the stream flows) index to the global predictors from a basket of potential predictors. Independent validation and verification procedures have revealed the usefulness of the forecast system across 12 years of data, with training of 15 years using various accuracy measures. Moderate to high categorical forecast skill levels of 37-60% is achieved for the dry season forecast at both lead time, which suggested significant operational value. In general, both methods were feasible, however due to high co-linearity between predictors, the stability of the Multiple Linear Regression approach is a concern. It is generally accepted in seasonal forecasting science that near normal conditions are the most difficult to forecast (Ward, 1998). Statistics have shown that algorithms could be used with high confidence in forecasting extreme events. Generally, the MLR (spell out) performed better at 3 month lead time than PCR (spell out), which could be used as early indicators of likely outcomes, with a higher chance of detection for the below normal category, followed closely by the above normal category.

The leading predictors of the dry season were the north-west Indian Ocean 200 hPa zonal wind, the Air Temperature at 925 hPa over Arabia and the Sea Level Pressure between India, China, and Russia. On the other hand, the six month lead time model have OLR-convection centred over central Africa, Sea Surface Temperature in the North Atlantic Ocean and the Specific Humidity at 500 hPa over central-southern Africa between Botswana and Zimbabwe. Case study examples during the two extreme years suggested that the El-Niño years were characterised by more frequent easterly propagating waves than during La Nina years, hence less extreme dry season was expected in El-Niño years. However, detailed analyses are required to make firm conclusions and to establish the wave dynamics.

4.6.4.5 Conclusion

The spatial composite analysis signals revealed that the La Nina signal in the Pacific Ocean, with alternating warming effects in the West African coast and North Atlantic Ocean, were the background forces driving the dry hydro-climate years. In addition, the combination of (1) atmospheric thermodynamic warming in the northern hemisphere (2) inter-hemispheric anomalous high sub-tropical pressure (3) dry and stable air mass of Sahara Desert origin and (4) the oscillation of energy between the Indian monsoon and the south-east Asia monsoon have profound impact causing the extreme low rainfall and stream flow over SWIO and the Seychelles.

Moderate to high categorical forecast skill levels of 37-60% could be achieved for the extreme dry season forecast at both lead times, which suggested significant operational value. In general, both methods were feasible, however due to some degree co-linearity between predictors the stability of the Multiple Linear Regression approach is a concern. The MLR performed better at the 3 month lead time than the PCR, which could be used as early indicators of likely outcomes, with a higher chance of detection for the below normal category, followed closely by the above normal category.

The leading predictors of the dry season are the north-west Indian Ocean 200 mb zonal wind, the Air Temperature at 925 mb over Arabia and the Sea Level Pressure between India, China, and Russia. On the other hand, the six month lead time model had OLR-convection centred over central Africa, the Sea Surface Temperature in the North Atlantic Ocean and the Specific Humidity at 500 mb over central southern Africa, between Botswana and Zimbabwe. Case study examples during two extreme years suggested that the El-Niño years were characterised by more frequent easterly propagating waves than during La Nina years, hence less extreme dry season were expected in El-Niño years.

4.6.4.6 Recommendations

- The multivariate statistical model needs to be incorporated into operations at the National Meteorological Services**;**
- Future models should extend and target specific months;
- Address the issue of co-linearity;
- Assess the degree of stability of the predictors as in Chang Seng (2005) studies;
- Efforts are also needed in helping users in the interpretation and application of the final product (i.e seasonal hydro- climate forecast).

4.6.5 Study 3 - Rain Water Harvesting Potential in Victoria, Mahe, Seychelles as an Adaptation Strategy to Climate Change.

4.6.5.1 Introduction

Rainwater harvesting activities are not new in the Seychelles, however, the practices are broadly patchy, few in numbers and mostly limited to individually oriented domestic use. There are, however, interesting case studies, and semi-detailed statistics from certain outer islands and conservation based NGOs, with direct reference to rain harvesting in the Seychelles.

There is also a general lack of understanding of rainwater harvesting's multi-purpose potential to address water demands, urbanisation and as mitigation for excess storm water run-off and climate change related problems. Furthermore, there is an overall lack of know-how, no sustainable mechanism and integrated framework among all the stakeholders to promote rain harvesting as an adaptation option towards flooding and water management.

4.6.5.2 General Facts Related to Rain Harvesting

- Average domestic water consumption = 157 litres per day;
- The roof on an average 4-bed family home captures more than 100,000 litres of rainwater each year;
- A typical family uses 70,000 litres of water each year on toilet flushing, clothes washing and outside use;
- One third of all water used in the home gets flushed down the toilet;
- Rain harvesting can replace up to 50% of household mains water consumption, and up to 85% on commercial installations;
- Collecting rain from the roof reduces surface water flow by approximately 60% per house plot;
- Rainwater harvesting in the UK has increased by approximately 300% in the last two years;
- The payback period can be as quick as 3 years on buildings with large roofs for a high non-potable water demand.

The Figure 107 below shows the possible contribution of rain harvesting for domestic needs.

Figure 107: Rain Water Harvesting Contribution to Domestic Needs[6]

4.6.5.3 Overall Objective

The overall objective of this study is to assess the feasibility of introducing rain water harvesting system (RWH) based on available sizes of roof tops in Victoria, the capital of the Seychelles, the chosen pilot site as a possible adaptation option to climate change.

4.6.5.4 Data and Methodology

Overall, the research study employs aerial data collected in 1999 and Geographical Information System (GIS) analyses coupled with standard analytical equations to estimate seasonal and annual single and total roof–runoff by size. Two analytical equations are applied and the resulting outputs are compared. One equation does not cater first flush losses and the wetted losses, while the second equation does. Water tank sizes for the different roof tops are estimated using a web based water tank calculator for the supply approach. Another method based on demand approach is used to provide a more realistic idea of water tank sizing for small, medium and large families. Furthermore, the study also involves setting up a simple

[6] Source: http://www.envireau.co.uk/images/pie_chart3.jpg

rain water harvesting system at the Belonie School with a view to evaluate the amount of rainfall captured from a given roof area and to serve as an education and awareness activity.

4.6.5.5 Results

Rain Water Harvested from Single Small Roof Top

Rain that can be harvested from an average small roof top is maximum in the JFM season with 153,732.4 litres of rain water captured, while in the dry season of JAS this amounts to 76,873.7 litres of water. The total rain that could be harvested from a single small roof is 451,531.9 litres annually.

Rain Water Harvested from Single Medium Roof Top

Similarly, rain that can be harvested from an average single medium roof top is maximum in the JFM season with 528,139.4 litres, while in the dry season 264,095.4 litres of rain water can be captured. The annual total potential rain harvested from a single medium roof is 1.55 million litres.

Rain Water Harvested from Single Large Roof Top

The rain harvested from an average single large roof top is maximum in the JFM season with 2.2 million litres of rain water captured, while in the dry season 1.1 million litres of water can be captured. The annual total rain harvested from a single large roof is 6.6 million litres. Figure 108 shows the seasonal and annual roof runoff from single roof top by size (i.e small, medium and large).

Rain Water Harvested from all Small Roof Tops

On the other hand, the total rain water which can be captured by all the small roof tops in Victoria as indicated in the light blue colour on the map in JFM season is 50.3 million litres, while in the dry season 25.1 million litres can be harvested. The total rain water that can be harvested from all small roof tops amounts to 147.7 million litres annually.

Rain Water Harvested from all Medium Roof Tops

On the other hand, the total rain water which can be captured by all the medium roof tops in Victoria as indicated by the purple colour on the map in JFM season is 59.2 million litres, while in the dry season 29.6 million litres can be harvested. The total rain water that can be harvested from all medium roof tops amounts to 173.7 million litres annually.

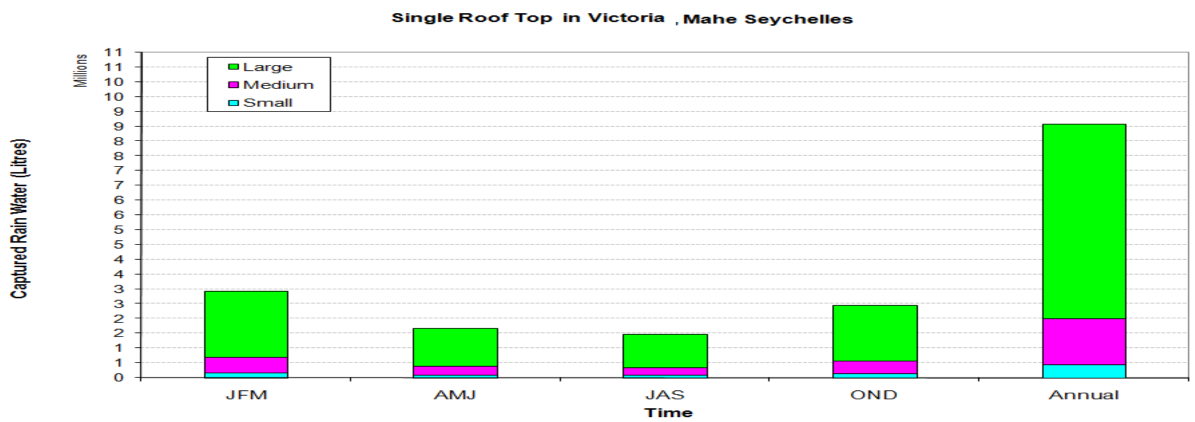


Figure 108: Seasonal and Annual Rain Water captured for an Average Single Small, Medium and Large Roof Top in Victoria, Mahe, Seychelles

Rain Water Harvested from all Large Roof Tops

The total rain water which can be captured by all the large roof tops in Victoria as indicated by the green colour in the JFM season is 105 million litres, while in the dry season 52.5 million litres can be harvested. The total rain water that can be harvested by large roof tops amounts to 290.9 million litres annually.

Rain Water Harvested from all Roof Tops

The totals of rain harvested from all roof tops in Victoria are 214.4 and 123.1, 107.2, 179.9 and 629.8 million litres in the JFM, AMJ, JAS, SON seasons and annually respectively. Figure 109 shows the estimated seasonal and annual runoff from all the roof tops in Victoria.

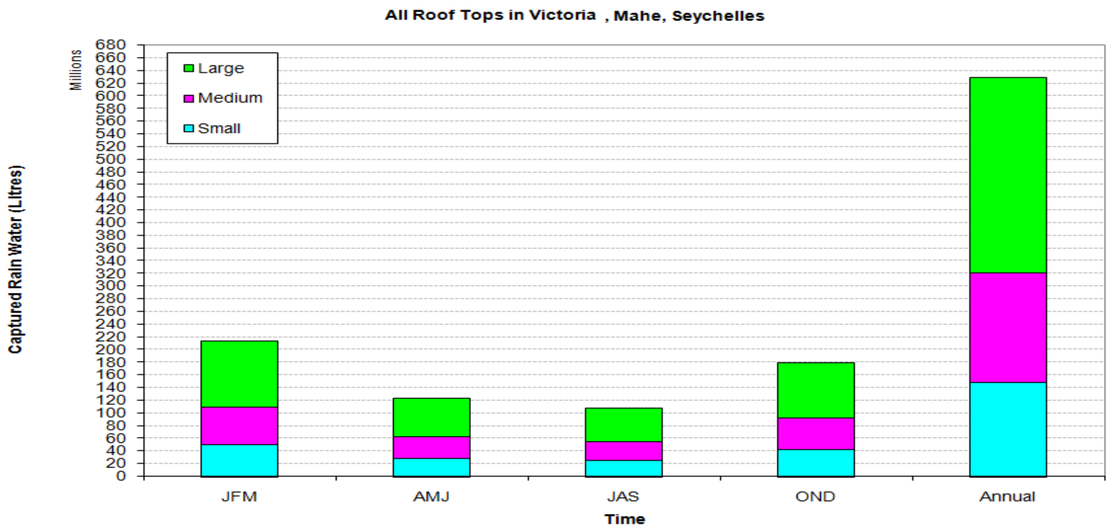


Figure 109: Seasonal and Annual Rain Water captured from all Small, Medium and Large Roof Tops in Victoria, Mahe.

Percentage Comparison between Roof Runoff by Size

The Figure 110 shows the percentage roof runoff by size. The total small, medium, and large roof tops can contribute to 23%, 28% and 49% respectively of the rain water harvested annually in Victoria.

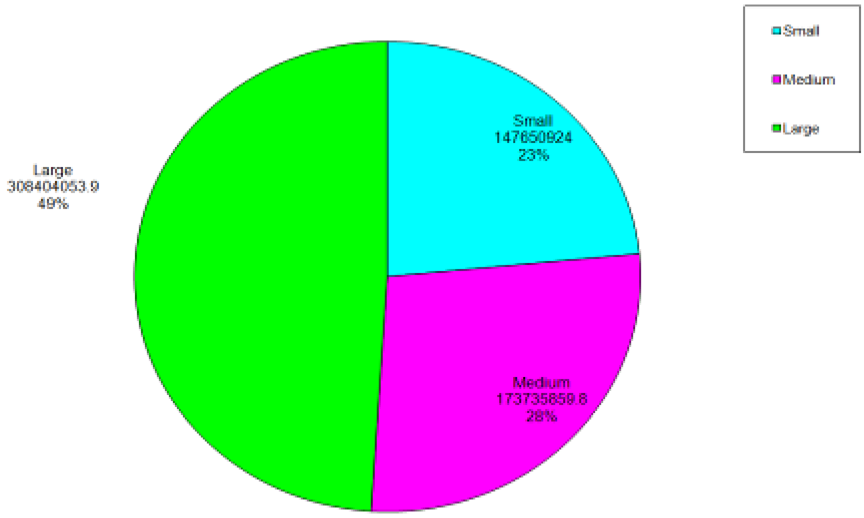


Figure 110: Percentage Comparison of Rain Water captured for all Small, Medium and Large Roof Tops in Victoria, Mahe, Seychelles

4.6.5.6 Rainwater Harvesting at Belonie School

The total rainfall measured for the period of April, May and June (AMJ) was 401mm, while the average computed K value for that period was estimated at 0.91. The estimated roof run off from the selected roof area at the Belonie School had a potential to capture 37,220 litres of water for the period of April, May and June 2009 (Figure 111), compared to the long term average amount of 51, 7934 litres. This reminds us that the efficiency of rain water harvesting will also vary according to the prevailing climatic conditions. The selected roof run off at Belonie School is smaller (102 metres square) than the GIS based approach (166 metres square), thus it is not surprising to find that the values at Belonie School are 2.5 times lower in amount.

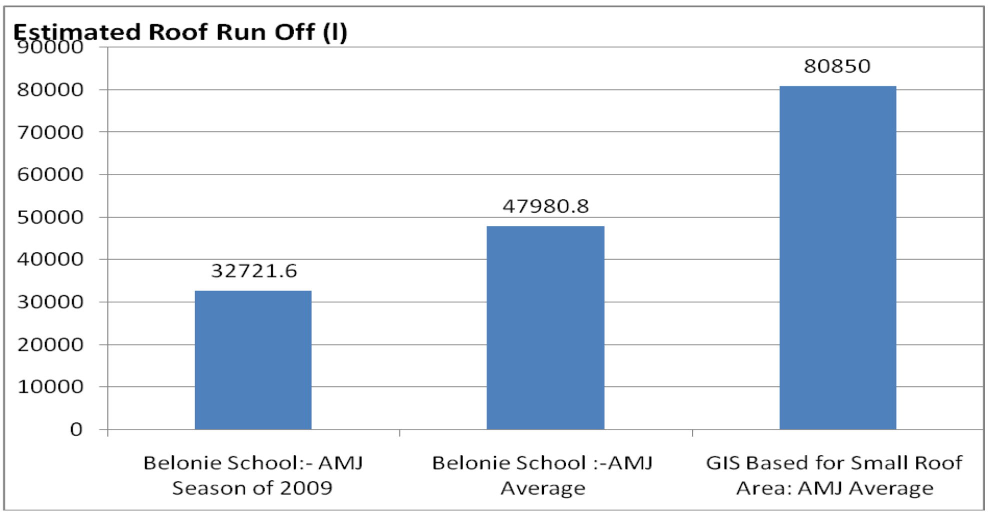


Figure 111: Estimated Roof Runoff at a Selected Roof Top at Belonie School for the Period of AMJ 2009 compared to Long Term Average and GIS based Approach

4.6.6 Conclusion

The study has shown that a single average roof top can capture 1708 and 854 litres of rain water per day during the wet and dry season respectively, whilst the total water captured can contribute to about 214 million litres of water during the rainy season, and 107 million litres in the relatively dry season of the year. The total rain water captured only in Victoria, Mahe, Seychelles is close to 630 million litres annually. This theoretically can contribute to 10% of the national water requirement by the year 2020. The GIS approach has provided useful ways at minimum cost to estimate rain harvesting, however, there are important considerations to take into account such as the apparent overestimation. Therefore, it is important to consider employing a correction factor applied to all the values computed using the GIS approach. This implies considering a quarter of the value obtained (i.e. 214/4 million of water during the rainy season; 107/4 during the dry season etc.).

However, such water may be used for domestic use such as washing cars, flushing toilets, general cleaning, and washing due to water quality issues, such as heavy metal composition. It is highlighted that medium to large buildings can catch up to 77 % of the total rain water in Victoria. This is encouraging as larger buildings are continuously being constructed on the main island of Mahe. Rain harvesting is an ideal management strategy some months prior to the dry season (i.e T-JAS rain harvesting strategy). Due to the increase in urban development and the natural geological setting, surface water storages would be most suitable for Victoria.

Full application of first flush and pollution issues into the usual rain harvesting equation provides for a more realistic view of the process, however the percentage differences compared to the simpler method appears not to be significantly different (i.e < 2% difference). The pilot rain harvesting system at Belonie School captured an estimated 37,220 litres of water for the period of April, May and June 2009 and was lower than its long term average, highlighting the rain water harvesting efficiency will all suffer from prevailing climate conditions, and there would be a need to consider even larger water storage tanks. Results from the supply-side approach show that the recommended tank sizes, especially for larger roof tops, are relatively too large and will prove to be a large investment. Using the demand approach, it is found that the tank sizes for small, medium and large families are estimated to be 2000, 3000, and 4000 litres respectively for a period of 20 days. In addition, the results proved to be realistic even for longer duration storage exceeding 2 months. Water tanks cost for small to large families does not exceed SR15, 000 and can effortlessly be covered in less than 30 months. The Dual Top Up Approach being explored in the Ministry of Environment, Natural Resources and Transport is promising and would help achieve a minimal demand load per capita per day though a likely persistent dry spell, and consistent cut off of the mains water supply may prove to be of decreasing satisfaction and reliability.

4.6.7 Recommendations

- Government organisations such as the Department of Environment, PUC's Water Division, the Ministry of National Development should cooperate with other key stakeholders to develop the following:
    - Policies and rules on rain water harvesting targeting medium to large buildings (i.e flats, schools, garages, hotels, public offices etc);
    - The provision of a water calculator at EIA stage to ensure that proponents compute the possible harvestable volumes and size of tanks accordingly;
    - Policies and rules for gradual replacement of roof containing high levels of lead.
- Encourage residents to gradually participate by raising awareness and education of its multipurpose benefit including managing land erosion, which often pollutes the ocean and impacts on the corals and ocean habitat;
- Ensure materials are available and affordable locally;
- Establish several rain harvesting systems at selected buildings such as schools, hotels etc to evaluate practical weaknesses, costs, benefits and opportunities of rain harvesting on a national scale. This involves testing the different tank storage capacities (supply and demand approaches);

- Further research would need to measure the values of rainfall coefficient, wetted loses and pollution factor in the context of the Seychelles to minimise errors in the calculations of rain harvesting.

4.6.8 Study 4 - Education and Awareness on Climate Change and Adaptation in the Water Sector in the Seychelles

4.6.8.1 Introduction

Education and awareness in climate change issues is viewed in terms of acknowledging climate change as an issue and learning the context and/or science of this phenomenon, which can be referred to as education about climate change; and more specifically, education about mitigation, particularly with a focus on ways of reducing greenhouse gas emissions. However, the greater concern here is about education and awareness for climate change adaptation. It is about the development of adaptive capacity and resilience - increasing the ability of individuals, groups, or organisations to adapt to changes associated with climate change through education and awareness. This approach promotes the development of critical knowledge and skills necessary for understanding the complexity associated with climate change issues and the systemic changes needed to address these. The project complements and strengthens the existing education and awareness activities nationally and in schools. The project activity's objective is to promote education and awareness, starting from selected schools, with interactions within the community and other national actors. This project activity is part of the four project activities of the climate water sector project prepared for the Seychelles Second National Communication (SNC) under the United Nations Framework Convention on Climate Change (UNFCCC).

4.6.8.2 Approach

The approach is to carry out a national water education and awareness activity programme on climate change and adaptation in the water sector, focusing on the schools' participation. The specific activities include the launching of the project activity (i.e rain harvesting pilot project) at school level, the integration of the activity at national science and technology fair, community survey and analysis on rain harvesting, the installation of rainwater harvesting in schools, data collection and analysis, national exhibitions, water day school education campaign, awareness publication materials such as leaflets, posters, and teachers capacity building basic climate change science understanding, its sectoral impact and the adaptation in the water sector. The project underlines the main constraints, the challenges and the existing efforts to ensure activities are widened and sustained in the Seychelles.

4.6.8.3 Launching of the Project Activity at School Level

Belonie School was identified and selected for launching the education and awareness project because it was located inside the study area of the previous case study on Rainwater Harvesting Potential in Victoria, using GIS.

4.6.8.4 Towards Sustainability in Education and Awareness

At the end of all projects, the big question is how to sustain the activities. How will the project initiatives be rooted in the society and become part of the way of living such that people will indeed adapt to long term climate change, which is a long term process? Apart from the institutional aspects of formalising such practices as outlined in the previous project activity , the immediate concern is how to keep the spirit and initiative alive. Thus, in this endeavour, a project proposal has been submitted to climate change DARE, supported by UNEP/UNDP for an extension of the project at Belonie School as well as in four other schools: Anse Royale, Grand Anse, Mahe, Grand Anse, Praslin Primary, and La Digue. Anse Royale has already adopted a scientific research approach to the project, and it would be encouraged to show case or publish the findings in the next National Science and Technology Fair (NSTF), to be held next year. Once the system is installed, the schools would also be encouraged to use the different research approaches compared to that used at Belonie School, especially the measurement of water collected from roof for comparison with recorded rainfall data. Schools will be encouraged to participate in as many exhibitions as possible to raise awareness on the issue. After the project has been well established and data have been collected by schools, presentations would be made to the Ministry of Education managers and eventually to School head teachers. The Ministry of Education would be recommended to incorporate the system in school building designs. If possible, the presentations by schools involved would target policy makers to influence them in integrating it in local policies. A special report and formal request will be submitted to the Cabinet of Ministers to support the national implementation.

4.6.9 Conclusion and Recommendations

The project activities have helped raise national awareness on climate change water-related impacts and adaptation in the water sector through various activities which include the following: launching of the project at school level, integration of project activities in the national science and technology fair, community survey, the installations of rainwater harvesting in a school and data collection and analysis, national exhibitions, water day school education campaign, awareness publication materials and capacity building. Most activities were well covered by the media for wider sensitisation of the community.

This initiative has motivated both teachers and students at many schools to educate themselves further on climate change, water and adaptation issues. It has attracted many people at exhibitions and has often been referred to in many meetings or workshops as an example of climate change adaptation. The project has also attracted private participation and contributions.

The survey carried by students, was done on a small sample of the community. Nevertheless, the results suggest that rain harvesting is not widely practised at household level but can be accepted by the people. It has great potential in Seychelles in contributing to economic benefits at the household level. It can help in water conservation during the dry season and it can be used as a mechanism to cope and adapt to the negative effects of climate change.

The project results suggest that with more awareness, sensitisation campaigns, commitment, coordination and funding the activities can be promoted more effectively on a national scale.

General input from meetings and workshops suggests that specific adaptation activities such as rain water harvesting can be incorporated in the different national environment, social and economic programmes or action plans to become rooted in society.For example two leaflets have been developed for awareness. A general leaflet and poster(see Figure 4-79) were developed, for wider circulation especially to schools and the community on the issue of climate adaptation in the water sector in terms of rain harvesting etc.. It is also recognised that more scientific based research is needed as well as the need to improve innovative design in the context of the Seychelles. Project activity four has provided the momentum for the development of adaptive capacity and resilience associated with climate change in the water sector through education and awareness, however the initiative should not only be sustained, but widened to capture a range of other adaptation options.

Figure 112: Poster on Climate Change Adaptation focusing on Rain Water Harvesting

4.7 Vulnerability and Adaptation To Fisheries Sector

4.7.1 Introduction

The 1997/98 coral bleaching event that decimated coral communities in Seychelles and the wider western Indian Ocean (WIO) was the most severe impact of climate variability in recent decades (Englehardt et al., 2002; Spencer et al., 2000; Wilkinson et al., 1999) Sea Surface Temperature (SST) monitoring capacity prior to and during the event was poor, but the ecological response clearly demonstrated high levels of variation in terms of coral mortality and survivourship (various studies reported in Burnett et al., 2001) and in terms of impacts to fish communities (Grandcourt & Cesar, 2003). The Initial National Communication of the Seychelles (INC) identified monitoring of SST as a key activity to facilitate adaptation to climate change, and the Seychelles Fishing Authority (SFA) was identified as the main institution for this activity. In recent years, however, the number of applications for SST data has increased as several other organisations, including the relatively new Seychelles Centre for Marine Research and Technology (SCMRT), and programmes (Burnett et al., 2001), have become more involved in marine environmental monitoring and science. In several cases, the same technologies are employed for similar objectives. However, there is little coordination between programmes in terms of SST monitoring, leading to duplication of effort, disparate datasets and a constrained potential to understand the wider dynamics of the large-scale ocean-climate and ecological processes.

Since the fisheries sector is the second pillar of the Seychelles' economy, two studies were undertaken focusing mainly on the vulnerability impacts of climate change in this sector. They are:

- Study 1: Establishment of the Seychelles Ocean Temperature monitoring Network;
- Study 2: Determination of the socio-economic impacts of climate variability on Seychelles' industrial tuna fishery, with a view to identifying management and policy strategies to adapt to future uncertainty and change.

These two studies aim to promote collaboration in SST monitoring and to establish a national SST network in order to strengthen knowledge of climate variability and climate change dynamics in marine ecosystems. It will involve a combination of networking, fieldwork and database development activities. In terms of fieldwork, new probes will be installed and maintained in areas of the archipelago for which SST data are lacking. The main outputs of this project will be an enhanced national capacity and coordination of SST monitoring and comprehensive metadata-base and databases in use for a range of research applications including, not the least of which, climate variability and change studies.

4.7.2 Study 1: Establishment of the Seychelles Ocean Temperature Monitoring Network

4.7.1.1 Introduction

Through the establishment of the Seychelles Ocean Temperature monitoring Network (SOTN)[7], the aim of this research project was to develop capacity and collaboration for ocean temperature monitoring, in order to improve knowledge of climate-driven changes in marine ecosystems and their implications for management. During conception, the primary rationale and justification for the project stemmed from the threats posed to the Seychelles' coral reefs by temperature-induced bleaching related mortality. However, it was recognised that the Network should serve to strengthen other marine research and management needs, especially to encourage a partnership approach.

4.7.1.2 Objectives

The specific objectives were:

- To establish an operational network of national and international partners and programmes with a shared interest in collaborating on monitoring and sharing ocean temperature data,
- To facilitate sharing and use of ocean temperature data through the development of a national database linked to online access to metadata.

The outputs of this project are not based on research findings but on the development of ocean temperature monitoring capacity and collaboration supported by operational aspects of data management and sharing. The research outputs derived from data collected by the SOTN are the responsibility of the signatory agencies, acting either individually or in groups, to analyse and apply the data to their specific research and management needs. As agreed by the partners involved in project implementation, the host institution of the SOTN will assist signatory agencies in data applications and will produce an annual report containing descriptive statistics and outlining the activities of the network. Therefore, this report outlines the steps taken to establish the SOTN, provides information on potential applications of the data and data products, and makes recommendations for strengthening the SOTN and supporting research applications.

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[7] In the project preparation phase and early stages of implementation, the proposed Network was referred to as a 'sea surface' temperature (SST) network. After discussions with partners, this was replaced by 'ocean' temperature since the networks would be monitoring and managing temperature data across a range of depths in addition to the surface 1 m layer.

Table 62. Sites selected by the SOTN that were operational as of December 2008

No	Site Name	Description	No. of loggers	Depth (m)	Logger source	Responsible
1	Anse Petite Court	Coral refugia site, protected, carbonate	2	5, 15	2 Project	SCMRT-MPA
2	Marianne Reef W	Coral refugia site, unprotected, carbonate	2	5, 15	2 Project	SFA
3	Conception NW	Coral refugia site, unprotected, granitic	2	5, 15	2 MCSS	MCSS/GVI
4	Baie Ternay	Coral refugia, protected, carbonate	2	5, 15	2 MCSS	MCSS/GVI
5	Aride S	Coral refugia, protected, carbonate, marginal: N granitic group	2	5, 15	2 Project	ICS
6	Fregate W	Coral refugia, unprotected, carbonate, marginal: E granitic group	2	5, 15	2 Project	Fregate Resort
7	North Island W	Coral refugia, unprotected, carbonate, marginal: W granitic group	2	5, 15	2 Project	North Island Resort
8	Anse Capucin	Coral refugia, unprotected, carbonate, marginal: S granitic group	2	5, 15	2 Project	SFA
9	Denis Island W	Unprotected, carbonate, marginal: northern margin reef	2	5, 15	2 Project	Denis Island Resort/GIF
10	Farquhar	Unprotected, carbonate, marginal: southern margin reef, atoll	2	5, 15	2 Project	ICS
11	Alphonse group	Unprotected, carbonate, marginal: central archipelago, atoll	4	5, 15	2 Project	ICS
12	Cousin Island	Low resistance/recovery, carbonate, protected	2	5, 15	2 Project	Nature Seychelles
13	Ile Cache	Low resistance/recovery, carbonate, protected	2	5, 15	2 Project	SCMRT-MPA
14	Topaze Bank	Bank slope site, oceanographic studies	3	25, 50, 75	3 Project	SFA

		Total loggers deployed	31			

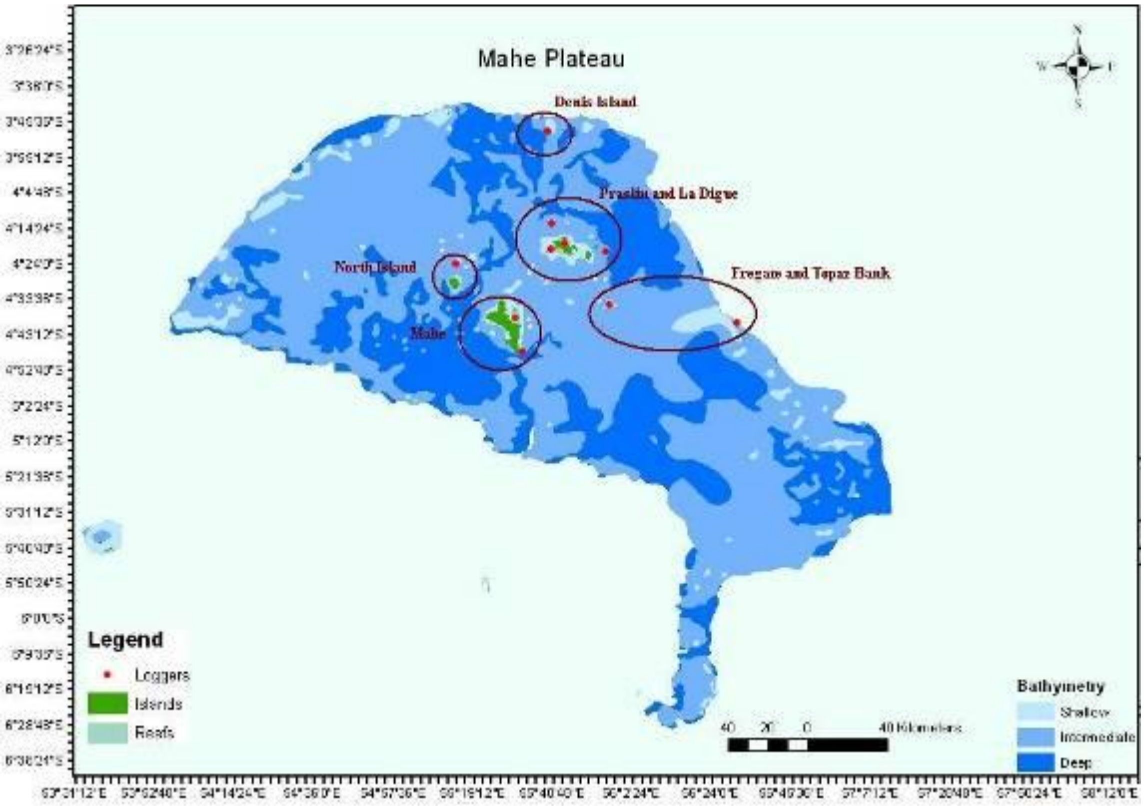

Figure 113: Temperature Monitoring Sites (Red Dots) established on the Mahé Plateau, using Project Loggers, by December 2008. (The Black Circles represent Island/Logger Groups. Note: Each site has 2 loggers set at approximately 5 and 15 m depth, except for Topaze Bank where 3 loggers where deployed on a mooring at depths of 25, 50 and 75 m).

Out of 45 loggers procured by the project , a total of 27 have been deployed, with 4 additional loggers provided by MCSS (see Table 4-20 and Figure 4-80).

4.7.1.3 Website Design and Access to Metadata

A website was designed to provide information on the SOTN and to enable access by the partners to the aggregated data. Ocean temperature metadata are available for different island groups within the Seychelles' archipelago, namely the Inner Islands, the Amirantes, the Aldabra group, the Farquhar group and Coetivy (see Figure 4-81). All of the island groups have graphic representation of the spatial distribution of installed temperature loggers together with basic metadata. As agreed upon by the partners during workshops, basic metadata that are available on the website include a brief description of where the data were gathered, information on the depth of the loggers, the time-period of data collection and contact details of the person responsible for the data. In addition, basic statistical information and graphs are available on selected aggregated data sets. The website will provide extra services to the partners of the Network through a member webpage whereby they can request and download annually aggregated datasets. It is planned to publish the website in February 2009.

4.7.1.4 Conclusion

Temperature is an important parameter for monitoring and assessing changes to marine ecosystems. As one of the locations most severely affected by the 1998 coral bleaching event, Seychelles has witnessed first hand the devastating consequences of anomalous shallow water temperatures. Ocean temperature data are, however, increasingly important for a wide range of research applications in Seychelles, encompassing studies on reef fish, turtles, sea birds and whale sharks, amongst others. Prior to this Second National Communication (SNC) project, ocean temperature monitoring was largely conducted in *ad-hoc* manner to meet the specific needs of projects or agencies. Under this approach, comprehensive monitoring could only occur on a limited geographic scale. Recognising that coordination was required to address the national need of monitoring as much of the archipelago as possible, this Project aimed to form a network of agencies and programmes with direct or indirect interests in ocean temperature data. This aim has been achieved with the first signatures to the SOTN MOU obtained at the 4th Project workshop in December 2008.

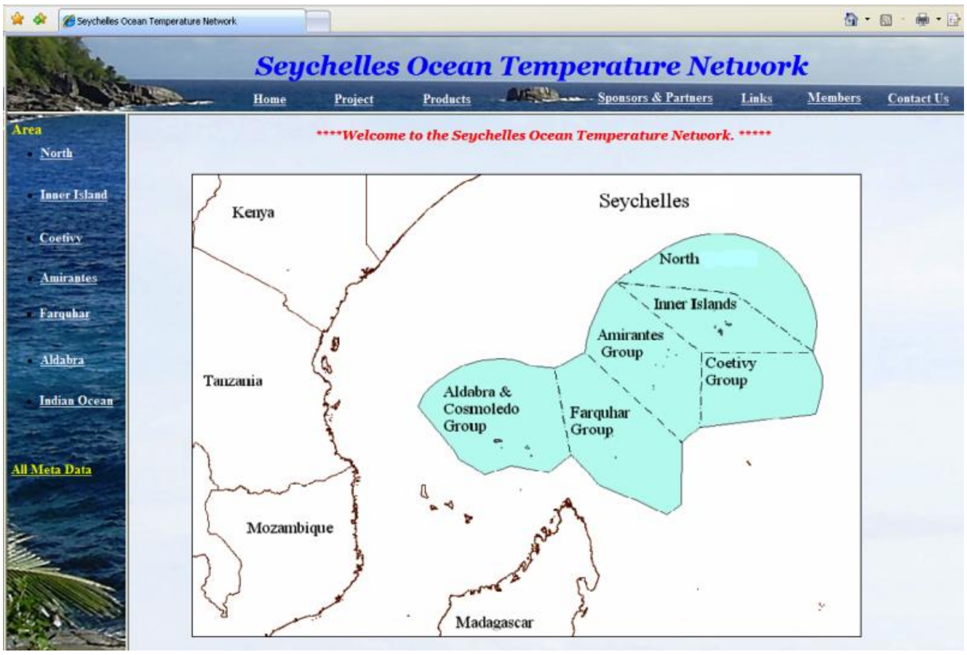

Figure 114: Homepage of the SOTN Website due to be published in Early 2009.

Partners to the Project and now to the MOU have collaborated in selecting and installing monitoring sites at locations spread widely over the archipelago, filling many of the geographical and research gaps identified through successive workshops. Data have now been collected at most sites for over a year. The website is nearing a final version for publication in early 2009 and will continue to evolve in order to provide improved data access for partners and more information for the public.

The implementation of this project and the establishment of the SOTN have built capacity for monitoring and assessing near-term climate-mediated changes to the marine ecosystems of Seychelles. A recent comprehensive study of the effects of past coral bleaching and the susceptibility to future impacts has highlighted Seychelles as one of the most vulnerable locations in the western Indian Ocean (McClanahan et al., 2008). However, the same study also demonstrated that, compared to many other countries in the region, Seychelles had high adaptive capacity in terms of coping with changes to marine SES. This capacity includes a potential for economic developments aimed at lessening the dependence on direct ecosystem services and thus reducing the vulnerabilities of the economy and livelihoods to climate change

(McClanahan et al., 2008). While the current system of MPAs provided limited refuge from the pervasive bleaching event of 1998 and its long-term effects (Graham et al., 2008), the demonstration of resilience in some locations and on certain reef types provides another option for spatial adaptive management. Now that a spatially and ecologically wide range of sites are monitored for temperature, the potential for understanding patterns of resilience and other ecosystem attributes and processes is strengthened.

4.7.2 Study 2: Determination of the Socio-economic Impacts of Climate Variability on Seychelles' Industrial Tuna Fishery, with a View to identifying Management and Policy Strategies to adapt to Future Uncertainty and Change.

4.7.2.1 Introduction

Many countries and regions, particularly developing coastal states, rely heavily on fisheries for economic development and the production of animal protein for human consumption (Weber, 1993). The collapse of fisheries results in severe socio-economic impacts for fishers and employees of related activities. The biological productivity supporting fisheries varies spatially and temporally and is influenced by climate variability. This relationship operates on seasonal, inter-annual, or decadal time scales and may affect various biological and ecological processes (Stenseth *et al*., 2004). In addition, marine ecosystems and productivity are affected by long-term global climate change, caused by both natural processes and human impacts, such as the emission of greenhouse gases (Hayward, 1997; Walther *et al*., 2002).

El Niño Southern Oscillation (ENSO) events impact ecosystem processes across the globe and are the major phenomena driving inter-annual ocean climate variability (Glantz, 1996). The ENSO signal propagates in the Indian Ocean (Nicholson, 1997; Torrence and Webster, 1999) and is manifested as sea surface temperature and heat storage anomalies (Tourre and White, 1995). The 1997-98 warm event[8], which coincided with one of the strongest ENSO events in the last century, caused dramatic temperature and wind stress anomalies in the equatorial Indian Ocean (Murtugudde *et al*., 2000). The oceanographic distribution of the purse seine tuna fishery was drastically modified, especially at the beginning of 1998, during the peak phase of the El Niño phenomenon (Marsac and Le Blanc, 1999). The usual fishing grounds of the Western Indian Ocean (WIO) basin were deserted, and the fleets underwent a massive shift to the Eastern basin, as far as 100°E, a longitude never before reached by the purse seine fleets based in the WIO (Marsac and Le Blanc, 1999). Consequently, landings and vessel activity in Port Victoria decreased substantially as the fleets operated from Asian ports (notably Phuket, Thailand), resulting in socio-economic impacts for the fishing industry and related activities in the Seychelles (Payet, 2005). Of major concern to the tuna industry in Seychelles is the prediction that ENSO anomalies may increase in frequency and severity in relation to climate change (Timmermann *et al*., 1999). However, this kind of prediction is still subject to debate in the scientific community as it results from complex interactions and feed-back processes, not well taken into consideration in the current climate models.

The scientific community now accepts that climate change and its impacts are inevitable (IPCC, 2007). In terms of ocean governance, it is widely recognised that management must focus on promoting ecosystem resilience and robustness to maintain adaptive capacity (Levin and Lubchenco, 2008). Management systems

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[8] Throughout this report, the Indian Ocean climate oscillation of 1997-1998 is referred to as the '1997-1998 warm event', recognising that warming in the Western Indian Ocean in that period can be attributed to the El Niño and positive Indian Ocean zonal dipole mode (IOD) that acted in phase.

will be strengthened by improved forecasting, the basis of which will be supported by robust hind-casting. There is an increasing body of evidence describing the effects of climate variability and change on tuna stocks and their ecosystems (Arnason, 2007; Miller, 2007). However, socio-economic analyses related to the impacts of climate change on tuna fisheries remains a high priority for research. To assess options for management and adaptation, research is needed on the effects of climate variability for decision-making and planning in the tuna industries in the context of wider market and trade issues. While the economic impacts of the strong 1997-1998 warm event have been estimated at a broad sector level (Payet, 2005; SFA, 1999), a thorough socio-economic analysis has not been conducted. Recognising this deficiency and its implications for adaptive management in the fisheries sector, this project was conceived under the Self Assessment Exercise for the preparation of the Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC). The aims of the project were to assess the impacts (direct or indirect) of climate variability on the socio-economics of the tuna industry of the Seychelles, and to assess the management measures and the policies for appropriate responses to aid adaptation under various scenarios of climate change.

Tuna population dynamics are complex and are subject to interactions between fishing pressure and climate-driven processes and changes that vary spatially and temporally. The socio-economic importance and development of tuna fisheries and tuna-related industries are also highly variable on spatial and temporal scale and are influenced by location in relation to tuna availability as well as by changes in trade and access to markets for tuna and tuna products. Understanding these complexities and their implications for Seychelles is critical for the interpretation of climate-related impacts and their historical and projected significance in the context of global issues and threats to the industry. This section provides relevant background information on the tuna industry in the Seychelles and its importance on local and wider scales, reviews the literature concerning the effects of climate change and variability on fisheries, and finally, examines the non-climate threats to the tuna fisheries and industries.

4.7.2.2 Climate Variability and its Effects in the Western Indian Ocean

It has long been recognised that the strong inter-annual variability in climate and oceanographic processes in the Indian Ocean has a profound effect on tunas and their fisheries (Marsac, 1991; 1998; Marsac and Le Blanc, 1998). However, the occurrence in 1997/1998 of an extremely strong warming event coinciding with major disruptions to the WIO-based purse seine fishery spurred more intensive research on the relationships between climate variability and tuna fisheries in the region. This was driven by a management need to understand the implications of climate change and variability for tuna population dynamics in a fishery that was still developing in terms of effective fishing effort. Indeed, the first analyses resulting from this new research effort were developed for the IOTC Scientific Committee through its Working Parties or for other tuna management RFMOs (Marsac and Le Blanc, 1998a; 1998b; 1999; 2000; Marsac, 2001; Nishida *et al.*, 2005). Together with subsequent studies (Ménard *et al.*, 2007; Marsac, 2008), which largely reinforce the hypotheses and findings of the early studies, a clearer understanding of the impacts of ENSO events on tuna in the Indian Ocean is emerging.

The equatorial Indian Ocean exhibits a clear response to ENSO (Tourre and White, 1995). During normal (non-ENSO) years, the wind convergence zone (ITCZ; 0-10°S) is characterised by weak westerlies resulting in an eastward ocean surface circulation that elevates sea level and deepens the thermocline[9] (i.e the mixed

[9] The thermocline is a thin but distinct layer in a large body of fluid, in which temperature changes more rapidly with depth than it does in the layers above or below.

layer depth) in the EIO, along the Indonesian coast. To balance the hydrostatic pressure, the thermocline in the equatorial WIO is shallower. Peak ENSO phases produce strong easterlies and an intensification of westward surface circulation. As a consequence, the depth of the thermocline responds by becoming deeper in the western equatorial basin and shallower in the eastern basin. The deepening of the mixed layer depth in the WIO is associated with warmer SSTs. The 1997-98 warming event, which coincided with one of the strongest ENSO events in the last century (Murtugudde *et al.*, 2000), caused large and sustained temperature and wind stress anomalies in the equatorial Indian Ocean. Concurrently, the spatial distribution of the purse seine tuna fishing activity was modified substantially, especially at the beginning of 1998 during the peak phase of the El Niño phenomenon, whereby the usual fishing grounds of the western basin were deserted and the fleets underwent a massive shift to the Eastern basin, as far as 100°E, a longitude never before reached by the purse seine fleets based in the WIO (Marsac and Le Blanc, 1999) (Figure 115). This movement was directly related to a collapse of purse seine catch-per-unit-effort (CPUE[10]) in the west, causing the vessels to explore fishing grounds further east where unusually high CPUE rates were found.

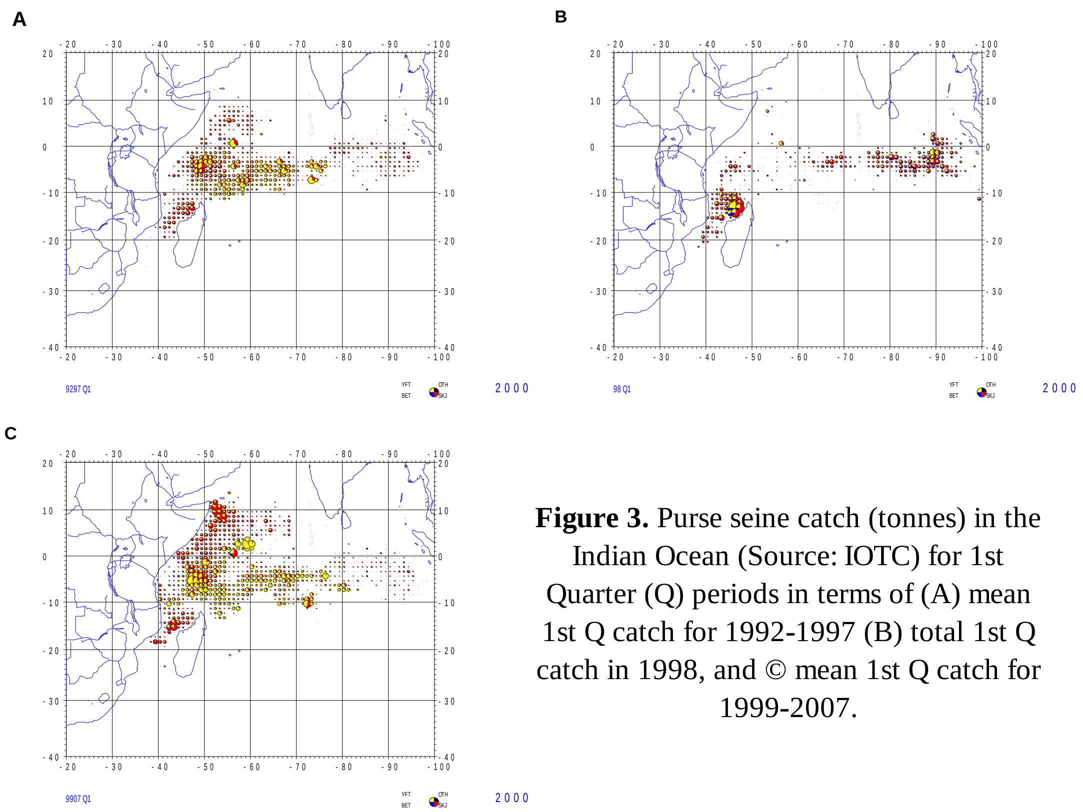

Figure 3. Purse seine catch (tonnes) in the Indian Ocean (Source: IOTC) for 1st Quarter (Q) periods in terms of (A) mean 1st Q catch for 1992-1997 (B) total 1st Q catch in 1998, and © mean 1st Q catch for 1999-2007.

Figure 115: Purse Seine Catch (tonnes) in the Indian Ocean (Source: IOTC) for the 1st Quarter (Q) Periods in terms of (A) Mean 1st Q Catch for 1992 – 1997 (B) Total 1st Q catch in 1998 and C) Mean 1st Q Catch for 1999 – 2007.

[10] Catch Per Unit Effort (CPUE) is often used in fisheries science as an indicator of stock status. It is assumed to be directly proportional to stock abundance, under the condition that effective fishing effort is correctly estimated over the years. The reality is different as CPUE is biased by the increasing fishing power of the fleets, which is not well tackled by the CPUE standardisation procedures. Thus, an increasing trend in CPUE can mask a steady status of even a declining trend in stock abundance.

Two main hypotheses have been proposed to explain the changes in CPUE that occur in relation to warming events such as those caused by ENSO. Firstly, that CPUE changes are related to changes in stock abundance and/or productivity, and secondly, that CPUE is affected by changes in catchability. Early indications of the effects of the 1997-1998 warm event supported the catchability hypothesis due to the fact the very low CPUE indices were largely in phase with the index used to track the oscillation; in this case the IOI. Changes in stock abundance/productivity (through growth and recruitment) would, instinctively, result in a lagged response between the resource and ENSO indices. Ménard *et al*., (2007) employed a wavelet approach to examine this issue, finding that "the synchronies between IOI and tuna catch rates argued for a non-lagged effect of the warm events on the catchability of tuna rather than for complex changes in the production regime" (Ménard *et al.*, 2007; pg 102). Changes in catchability resulted from the deepening of tuna habitat in the WIO, caused by the anomalous thermocline depth. The modification of habitat for the surface swimming tuna species (particularly yellowfin tuna, *Thunnus albacares*) produced a change in behaviour; the fish undergoing a vertical migration to the deeper thermocline to forage. Consequently, this reduced their catchability in terms of detection and capture. In the east, biological enrichment occurred through upwelling, keeping tuna in the surface layer and increasing their catchability (Marsac and Le Blanc, 1999; Ménard *et al.,* 2007).

The catchability hypothesis is further supported by recent analyses of CPUE with environmental data. Sea surface chlorophyll (a proxy of prey density and foraging conditions) was dramatically depleted during the 1997/1998 (El Nino-positive dipole) event and moderately depleted during the following warm event that occurred in 2006/2007. The thermocline was significantly deepened in the traditional purse seine fishery area during these two warm events. By contrast, an above normal sea surface chlorophyll and shallow thermocline were observed from 2003 to 2006, along with outburst of pelagic crustaceans that made the bulk of the diet of tunas (Marsac, 2008). Early in 2008, the oceanographic conditions were back to normal and harvest rates were much higher compared to 2007. However, given the tightly linked interrelationships between physical and biological processes that affect recruitment and growth (Bakun, 1996), ENSO-mediated changes in productivity may still occur, over longer time scales and possibly with a lagged signal in relation to ENSO phases. For instance, tuna have a critical larval phase that is strongly influenced by physical processes such as turbulence, which is in turn affected by zonal wind stress. Changes in turbulence are expected to affect abundance through larval survival and recruitment strength, with warmer SSTs and lower turbulence in the WIO, as occurs during a strong El Niño, enhancing recruitment (Marsac and Le Blanc, 1998a). Nevertheless, the impacts on productivity remain less pronounced and clear compared to those relating to catchability.

In comparison to the warm ENSO phase of El Niño, the opposite cold phase, La Niña, appears to have minimal impact on the purse seine fishery in the Indian Ocean (Marsac and Le Blanc, 2000), which is consistent with the relatively benign global impacts of this phase (Glantz, 1996). In the WIO, the large catches and high CPUE that occurred during the 1998/1999 La Niña, following the El Niño, were related to increases in catchability as the physical effects of this oscillation were similar to those of the 'normal' pattern, i.e a shallow thermocline enhanced productivity in the western basin. The fact that tuna stocks were subject to lower rates of fishing mortality during the preceding El Niño may have also contributed to positive performance of the fishery in 1999 (Marsac and Le Blanc, 2000).

Inter-annual climate variability in the Indian Ocean also results from coupled ocean-atmosphere-land interactions that operate independently of the ENSO forcing, originating in the Pacific (Marsac, 2006; Webster *et al.,* 1999). The Indian Ocean zonal dipole mode (IOD; Saji *et al.*, 1999; Webster *et al.*, 1999) is a "basin-scale pattern of surface and subsurface temperature that seriously affects the inter-annual climate anomalies of many nations around the Indian Ocean rim" (Meyers *et al.*, 2007). The positive or negative

IOD events may occur in the same years as ENSO, such as in 1998, or in the absence of that oscillation. Before the interactions between ENSO and IOD can be examined (and the implications of these interactions on the tuna fisheries understood), there is a need to classify and reach consensus on which years these events occurred in the Indian Ocean (Meyers *et al.*, 2007).

4.7.2.3 The Economic Impacts of Climate Change and Climate Variability on Fisheries

Many economic analyses are based on a cost-benefit approach aimed at evaluating the incidental effect a policy or a project may have on the environment or a resource (Pearce *et al.*, 2006; Costanza *et al.*, 1997). Environmental Impact Study, Life-Cycle Analysis or Cost-Benefit Analysis are then utilised to measure the environmental effect of a product or an activity through the individual preferences of agents. Less attention has been paid to the opposite effects of environmental changes on the economy and the economic tools, and concepts to deal with it are perhaps not as rich and original as those brought by welfare environmental theorists (contingent valuation method, travel cost approach, avoided costs method). Methods based on the existence and option values of the tuna resources are not appropriate in the scope of the present study, given assumptions regarding the effects of climate variability on tuna behaviour that are central to this study, i.e that the climate oscillation does not affect the existence of tuna but instead *temporally* modifies its behaviour and availability as an option to the fishery.

Whereas the effects of climate change and variability on fish and fisheries (including fisheries economics) have been subject to considerable research, this is not the case in terms of their impacts on a domestic economy, which forms the basis for this study. A couple of years ago, the famous Stern Report opened a new era of estimating the welfare loss due to global warming, estimating losses at around 15-20% of the global GDP (Stern, 2006). Beyond the anecdotal, though impressive, figures that were produced for the Stern Review, which remain the subject of debate, evaluating the economic impacts of climate change was accepted by the scientific community as a key issue that required a concerted research effort.

4.7.2.4 Discussion

The findings of this study are indicative of links between climate variability and the economy of a small island developing state. While it is recognised that causality has not been demonstrated, the coincidence in late 1997 and 1998 of a severe warming event and significant disruptions to the tuna purse seine fishery acting in phase with a dramatic fall in revenues from the tuna industry is compelling evidence for a climate effect. This discussion will focus first on the evidence for linkages between climate and economy, and secondly on the importance of climate effects in the context of wider threats to the tuna industry and their implications for Seychelles. Lastly, the relevance of the findings for adaptation to climate variability and change is discussed.

4.7.2.5 Climate Change and the Seychelles Tuna Economy

Similar to other SIDS situated in productive tuna fishing zones, Seychelles has come to rely heavily on a 'tuna economy' as the world demand for tuna has grown steadily over recent decades (Campling *et al.,* 2007; Campling and Havice, 2007). The importance of the tuna economy for Seychelles was, for the first time, demonstrated using a multiplier approach. On average, SR 1 spent by the purse seine fleet in Port Victoria leads to a doubling of inflows for the economy through household, shareholder, State and private company expenditures. Overall, it was estimated that the tuna related industries contribute SR 600 million to the local economy, equivalent to 14% of GDP and valued to 90-95% of exports. The coefficient of induction falls significantly from 2.5 to 1.6 when the cannery is removed from the spillover effects of landings/transhipments. However, beyond the impact on the domestic wealth, of greater importance is the presence of the cannery for national employment, since it represents 19% of private sector employment and 6% of total employment. Overall, transhipments of frozen tuna from purse-seiners to reefers at Port Victoria create fewer jobs than landings to IOT. Given that the availability of tuna in the Seychelles area is at the core of competitiveness for the canning industry, it is easy to comprehend the multiplier impact that climate oscillations may have on the local economy. As evidence, the warming episode of 1998 resulted in major disruptions in production at IOT for several months.

Of paramount importance for assessment of vulnerability is the finding that climate oscillations of low to moderate intensity did not act strongly on the Seychelles economy relative to the intense 1997-1998 warm event. Within the period corresponding to the expenditure dataset (1992-2008), there have been several warming events in the WIO in addition to 1998, some moderate (2003 and 2004-2005) and some relatively strong (1994 and 2006-2007)[11]. None of these oscillations resulted in a purse seine vessel expenditure response comparable to that experienced in 1998. This finding is both supported and possibly explained by analyses of tuna CPUE in relation to climate variability over longer time scales (since 1983) which indicates that moderate temperature anomalies in the Indian Ocean do not strongly affect the surface habitat of yellowfin tuna (Ménard *et al.*, 2007). As one of the strongest warm events that has been recorded in the region (Murtugudde *et al.*, 2000), the impacts of 1998 were disproportionate in terms of biological, ecological and socio-economic responses.

Before focusing on discussion of the socio-economic response to the 1998 event as the major climate variability impact over the study period, it is necessary to examine the occurrence of major declines in the fishery in 2007 and related to an observed effect on (seasonally adjusted and deflated) expenditures in 1994. Initially fully attributed by some, including SFA, to the warming event in the WIO in late 2006 and early 2007, other hypotheses are currently being examined in light of the fact that the moderate strengths of both the El Niño and IOD were not commensurate with the decline in purse seine CPUE and catches. One hypothesis ('increased catchability hypothesis') stems from analyses of environmental data indicating that the period 2001-2005 was marked by favourable conditions for purse seine fishing in the WIO, where increased biological productivity and a prevailing shallow thermocline resulted in increased catchability and record catches between 2003 and 2006. An alternative hypothesis ('increased biomass hypothesis'), which is not strongly evidenced, is that large pulses in recruitment occurred prior to 2003 and led to increased biomass, CPUE and catches over the following years.

In the framework of the first hypothesis, a consequence of the large catches is the potential for higher fishing mortality and declines in stock biomass between 2003 and 2006. Therefore, a reduction in biomass may have acted in concert with the climate oscillation of late 2006/early 2007 and enhanced the negative impact on CPUE and catch in the purse seine fishery (IOTC-2007-SC-R; Marsac, 2008), and subsequently lowered landings and transhipment in Port Victoria. Considering recent analyses of tuna stock status, the IOTC Working Party on Tropical Tunas that was held in Bangkok in October 2008, and subsequently the IOTC Scientific Committee of December 2008, concluded that the yellowfin stock was, by 2007, overfished. The current overfished status of yellowfin, supported by the convergence of several stock assessment models, provides evidence for the 'increased catchability hypothesis' where environmental conditions led

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[11]: Years: 1991-1992, 1994, 1997-1998, 2003, 2004-2005, 2006-2007 were defined as warm events for this study: based on analysis of the IOI index where moderate (not bold) anomalies are defined by an IOI value of less than or equal to -1 in five consecutive months and extreme anomalies (in bold) are defined by an IOI value less than or equal to -2 in five consecutive months. Both moderate and extreme events estimated using a three month running mean.

to increased catchability and fishing mortality between 2003 and 2006, resulting in biomass declines that coincided with a moderate warm event in late 2006/early 2007. While the reduction in many purse seine expenditures in 2007 were not of the magnitude observed a decade or so earlier, this latest event highlights the complex but important relationship between climate and tuna fisheries. In particular, it demonstrates how coupled ocean-atmosphere oscillations influence the levels of fishing mortality through the modification of tuna habitat and fisheries, which has important consequences for fisheries management.

A moderate impact on expenditures was observed in 1994. This year was possibly characterised by strong IOD event that resulted in SST warm anomalies in the western basin. While the classification of 1994 as an IOD event is still being debated, it potentially represents an example of an Indian Ocean climate oscillation acting independently of ENSO (Meyers *et al.*, 2007).

While the underlying changes to the fishery differ, the economic impacts of the 1998 warming event can be considered as an extended low season. In the Indian Ocean, the tuna purse seine fleets demonstrate a high level of spatial mobility as they follow seasonally varying patterns in abundance and accessibility to surface gear (Miller, 2007). Seychelles normally experiences seasonal lows in landings and transhipment during the second quarter of the year, when the fleets target tuna in the northern Mozambique Channel and operate out of other regional ports. In other quarters, landings at Port Victoria are comparatively large and stable between years. In 1998, the 2nd quarter low season was bracketed by low levels of vessel expenditures in the 1st and 4th quarters which significantly reduced annual revenue.

After accounting for inflation and seasonal variation, all expenditures were sensitive to the 1998 warming event, the extent of which was dependent on the relative strength of inter-annual trends in landings, transhipment and service unit costs. For the sole cargo handling costs, it was estimated, through the cointegration approach used in this study, that the 1998 episode had a negative impact of 34% on the purse seine expenditure at Port Victoria, in line with the cut in landings for that year and after taking into consideration the trend and seasonal components. Interestingly, this impact is comparable to ENSO impacts on the Chilean and Peruvian fishmeal fishery, where the social welfare loss due to ENSO was estimated to be 42% below a normal year of reference (Sun *et al.*, 2001). Climate oscillation impacts are, expectedly, strong compared to those of a climate regime shift, which is always difficult to predict (Arnason, 2007).

Looking at expenditures in more detail, port dues, ship chandlery and agency fees were particularly sensitive to the 1997-1998 event and all three expenditures were strongly related to the number of port calls. The latter has changed due to the increasing number of licensed vessels landing at Port Victoria over the period, while the average expenditure per call may have decreased due to declines in the number of days per call resulting from strong productivity gains in cargo handling onboard and ashore.

4.7.2.6 The Climate Oscillation Impact in relation to other Effects

It is difficult to distinguish the impacts of climate oscillations from other effects acting on the Seychelles tuna-related industries because no single model has explicitly attempted to account for all determining factors simultaneously. In the present study, the authors showed that climate variability was perhaps not the only cause of recent decreases (end of 2006/early 2007) in landings at Port Victoria. In the long-term, increases in fishing capacity and effective effort (the introduction of purse-seiners of bigger size, increasingly assisted in fishing by supply vessels, the deployment of fish aggregating devices, and sophisticated electronic means of fish detection, such as bird radars, sonar and echo-sounders) has played a significant role in the current levels of catch and landings. The availability of raw materials is a crucial component of increasing returns to scale and competitiveness for the canning industry. As the recent scarcity of tuna resources has led several purse-seiners to move to other oceans, this may threaten, in the short-term, the supply of frozen tuna to IOT, hence its costs and competitiveness on the global canned tuna market. It could be estimated that the shortage of raw tuna in 2007 (68,000 tonnes processed by IOT against 82,000 tonnes in a normal year, based on average 2000-2006 data and representing a 17% fall) has resulted in a 22% reduction of market share on the European market.

Economic and policy factors have also substantially influenced the tuna industry over the last decade. For instance, the trade preference on the EU markets, borne by the rule of origin applying to raw materials processed by the canning plant and with the duty-free entry of products, has allowed for the development of tuna exports by Seychelles since 1995. However, the recent erosion of this preferential treatment relative to Asian or American competitors (Economic Partnership Agreements, reduced rates for Asian countries, rate of exchange between the Euro and the US Dollar) combined with the decreasing demand for branded canned tuna products in southern Europe could jeopardise the market share of Seychellois products in the years to come. The partial erosion of trade preferences (competitors exporting at a 12% tariff rate to Europe) is not expected to significantly affect the exports of canned tuna as long as Seychelles maintains its comparative advantage of being at the centre of the fishing area. However, the effects of increased erosion (end of the rule of origin, duty-free entry for Asian products, etc.) or a change of share-holders following the recent bankruptcy of the US investment bank Lehmann Brothers, the main share-holder of IOT, are unknown in the long-term. By itself, a reduction in activity by IOT would not prevent the fishing vessels from transshipping its fish at Port Victoria (IOT does not buy more than one quarter of the tonnage passing through the Port), but this would be undoubtedly detrimental for the spillover effects of the tuna fisheries on the national economy due to the major source of employment that the cannery represents.

Certain purse seine fleet expenses have experienced exogenous shocks that have also affected their level and dynamics. This is obviously the case of gasoil, for which sharp rises in prices since 2004 have been detrimental to the domestic economy since the country is fully supplied by imports priced in US Dollars. More generally, the weakness of the Seychelles' currency with respect to most of the main international currencies is a key problem for the economy and a serious source of inflation[12]. As a result, gasoil now represents the bulk of port call expenditures and poses considerable constraints for the fishing companies. It is difficult to predict the response of the fishery to increasing bunker costs, but may include a retraction in the spatial distribution of fishing effort or an increasing reliance on smaller, more efficient vessels to locate tuna. Ultimately, purse seining may become economically inefficient without major changes to the markets for tuna products.

Geopolitical aspects are increasingly a threat to the purse seine fishery and the tuna industry in Seychelles. The continuing increase in piracy acts off Somalia in the last few months has considerably enhanced the risks to investment and fishing operations. The productive fishing grounds off the Somali coast, where much of the tuna are harvested during the third quarter each year, are increasingly out of bounds for the

[12] While this report is being achieved, the Seychellois Rupee (SR) has been declared convertible since Monday 10th November 2008, and the level of the domestic currency instantaneously adjusted to the major international currencies. As a result, the SR was depreciated by 75% in a few days and the official exchange rate with Euro has passed in less than one week from 12 to 21 SR per euro. The induced effects in terms of inflation should follow dramatically for the Seychelles' economy in a near future. Fortunately, the international oil price has substantially decreased for the last couple of months, although it must only be considered as a short or mid-term effect of the world-wide financial crisis.

purse seine fleet, where an exclusion limit of 300 nautical miles has, in September 2008, been extended to 400 miles. Overall, the now inaccessible area contributed to high ratios of the catches reported for the Somali basin in the period 1992-2007: 40% for skipjack, 21% for yellowfin and 33% for big eye (Fonteneau, pers. comm.). Between 1992 and 2007, the average amount of fish caught during the third quarter period is 72,000 tonne, i.e 30% of the annual catch in the whole WIO. The implications of this problem, should it continue, are of major importance to identifying and understanding the role of climate oscillations in the array of wider threats now facing the industry. The magnitude of losses caused by piracy preventing access to the productive grounds in and around Somali waters would be comparable to that provoked by a severe climate oscillation. The duration and impacts of the piracy problem are even less predictable that those posed by climate oscillations.

4.7.2.7 Adaptation to Climate Variability and Change

Climate indices representing dominant climate patterns in the oceans can be good predictors of ecological processes (Bakun, 1996; Stenseth *et al.*, 2002; Hallett *et al.*, 2007). In the current study, we demonstrate that climate indices can also be used to examine economic effects. In particular, the Indian Ocean Index (IOI) has now been shown to be robust in tracking warm and cold events in the Indian Ocean and their ecological impacts (Marsac and Le Blanc, 1998; Marsac, 2001; Menard *et al.*, 2007; Marsac, 2008) and, now, socio-economic effects. The climate oscillations described by the IOI and SOI (Southern Oscillation Index), and to a lesser extent the DMI (Dipole Mode Index), influenced the dynamics between landings/transhipments and gasoil consumption (as a proxy for fishing effort), whereby the indices predicted, in the short-term, the switching between the high and low regimes of these variables that were identified by the MS-VECM model. Given the relationship between landings/transhipments and purse seine vessel expenditure, this finding is important for understanding the significance between climate-related patterns and economic impacts. Since it has been demonstrated that the strength of anomaly may be critical in terms of the socio-economic impact, it is important that thresholds are studied that may facilitate real-time adaptive management responses. However, beyond real-time monitoring, predictability and forecasting climate variability remains controversial and the limitations with current models are well described. Debate continues regarding the independence of the IOD (Indian Ocean zonal Dipole mode) relative to El Niño (Baquero-Bernal *et al.,* 2002; Behera *et al.,* 2003), and understanding is hampered by a lack of consensus on how these events are defined. Meyers *et al.,* (2007) highlight the urgent need to improve our capabilities in predicting inter-annual SST anomalies in the Indian Ocean and recognise that existing coupled climate models are currently lacking in this respect.

Attempts at forecasting the socio-economic impacts of climate variability on a tuna economy would be complicated by a number of factors. Firstly, socio-economic effects are indirect in that they represent the end product of a process linking ocean-atmosphere interactions with a biological and ecological response that acts on the economy through a fishery that is evolving both in terms of technology and fishing strategy, hence effective fishing effort. Secondly, our study is based on the evolution of a fishery and tuna economy that has seen consistent, albeit variable growth since the early 1990s. That growth will likely be increasingly constrained through complex interactions involving fishery productivity and economics, trade regimes, market trends/consumer preferences, competition, the global economy and geopolitics. A significant research effort and multidisciplinary approach would be required to generate a stable forecasting socio-economic model, one that is beyond the scope of the present study.

In the fishing sector, the importance of adaptation to climate change and variability must be placed within an appropriate context, both in terms of the relative impacts of these changes compared to other factors and processes (such as global trade policy and the changing economic climate in which fisheries are now operating) and in consideration of the time-scales characterising the dynamics of these various processes. A key element in assessing the need for adaptation, which also has an important bearing on the potential engagement of stakeholders in any sector level adaptation programmes, is stakeholder perception of climate change and variability. Over the course of this study, interviews with key informants (mostly CEOs) from several companies, with business interests directly linked to the tuna purse seine fishery, revealed that most were relatively well informed of the impacts of climate variability on tuna purse seine operations in the WIO. Most informants could describe how their business was affected in 1998, which they clearly attributed to the effects of El Niño on the fishery. The coincidence of the timing of this study with the major disruption to the tuna industry that occurred in 2007, which was locally reported as a climate effect, reinforced the perception that climate variability was a significant threat. Nevertheless, when asked to rank climate variability relative to other threats, it scored at the low end of the scale, behind such factors as overfishing and competition, in both the short and long-term. This is unsurprising as even the most severe warming events are temporary and relatively short-lived, and tuna related businesses have quickly rebounded when normal conditions return. While climate change is not readily perceived, and its effects on tuna resources have not yet been determined, the long-term socio-economic implications are far greater than climate variability in the long-term, especially if resulting in a regime shift or climate oscillations of greater frequency and intensity.

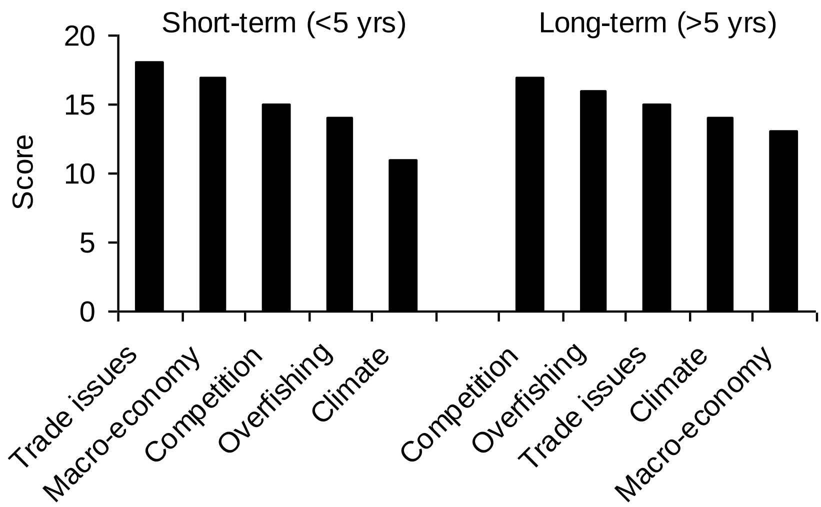


Figure 116: Key Informants (N=6) ranking of the Major Categories of Threats in the Short (<5 yrs) and Long Terms (>5 years). Threat Categories determined a priori.

It may not be important that climate variability ranks lower than other threats (see Figure 4-83) since certain sector-level adaptation strategies have the potential to target several threats simultaneously. For example, since catchability in the longline tuna fishery behaves differently to that of purse seine fisheries in relation to climate oscillations (longline fishing is less affected by climate variability than purse seine fisheries; Marsac & Nishida, in prep.), diversification of tuna processing (i.e. fresh and frozen whole tuna and loins) and improved services to longliners in Port Victoria could represent a strategic adaptation to climate variability that would also address the competitiveness of the port as a tuna hub and partially compensate for further losses in the canned tuna market share. Similarly, local macro-economic constraints which, optimistically, were perceived by stakeholders as a short term threat, are tightly linked to levels of investment in, and diversification of, the fishing sector. Removal or lessening of constraints associated with the local, and increasingly the international economy, may indirectly increase resilience to climate variability if resulting in development and diversification in the sector. There is clearly a need to engage stakeholders and policy-makers in assessing the need and scope for adaptive strategies which simultaneously address multiple threats and constraints.

Adaptation is critical to alleviating social impacts resulting from climate variation and change. While this assessment was largely based on economic analyses, the social implications of climate-induced reductions in expenditures are pervasive given that a large proportion of purse seine vessel and IOT expenditure are directed to local employment and companies. Recent analyses of direct, indirect and induced employment indicate that 8,400 persons are dependent on the tuna industry and related activities (Liam Campling, personal communication): approximately 10% of Seychelles' population. Reduced Government revenues resulting from climate variability and change would undermine social policy interventions (e.g. health, education and housing). Seychelles households are characterised by a relatively high degree of occupational multiplicity and mobility. Combined with relatively high levels of wealth and infrastructure development, compared to other countries in the region, this indicates that Seychelles has a relatively high adaptive capacity to cope with climate change (McClanahan *et al*., 2008). Nevertheless, social capital is often low and there is a high dependence on a welfare state that is in turn highly dependent on revenues from fishing.

In terms of shared and highly migratory fish stocks, a major challenge for adaptation to climate variability stems from the response of the fishery and its regional management (Miller, 2007). To date, Indian Ocean Tuna Commission (IOTC) has not managed the shared tuna stocks of the Indian Ocean through harvest limits or allocations. This partly stems from an incomplete understanding of climate effects on stock abundance and catchability, and on seasonal and inter-annual changes in the spatial distribution of productive fishing grounds (Miller, 2007). Consequently, scientific advice for management is often shrouded in uncertainty (IOTC, 2005). Attempts to model and predict the interactions of the fishery with climate are ongoing (e.g CLIOTOP; Maury and Lehodey, 2005), but there is risk that any such capacity could create more management problems than solutions, and there is some indication that the purse seine fleets are already adapting their fishing strategies in line with current understanding of the effects of climate variability. However, an understanding of these relationships is necessary to avoid misinterpretations and misunderstandings amongst competing coastal states and Distant Water Fishing Nation(DWFN) fleets that may affect the management of tuna stocks (Miller, 2007). Since much of the tuna is caught in international waters of the Indian Ocean, coastal states have less direct control over this resource compared, for example, to the Western and Central Pacific where most tuna is caught in the coastal states EEZs. Also noted by Miller (2007) is the significant threat posed by IUU fishing in the Indian Ocean, which unless tackled at a regional level may undermine management efforts and adaptation to climate changes.

4.7.3 Conclusion

The last decade has witnessed pervasive impacts from climate variability on the Seychelles' marine ecosystems and the fisheries they support. Both reef and pelagic ecosystems suffered extreme modification during the 1997-1998 warming event. The temporality of the modification and the corresponding impacts show important differences between the two ecosystems, with coral mortality and subsequent loss of structural complexity on reefs pointing to lag effects on reef fisheries that are not yet fully realised (Graham *et al.,* 2007), while pelagic ecosystems and tuna habitat were modified only for the duration of the climate oscillation (Ménard *et al.,* 2007). In the longer term, however, pelagic and reef ecosystems will potentially be subjected to the effects of climate change, dually in terms of increasing frequency and severity of climate variability and through gradual shifts in physical dynamics of the marine environment and productivity regimes. Adaptive management of the specific risks posed by overfishing (anthropogenic), habitat degradation, trade distortions, local macro-economic constraints and regional competition are more tangible than direct adaptation to climate change. Adaptive strategies should not, however, be considered mutually exclusive and should be assessed holistically, at the widest sector and macro-economic policy levels, to promote resilience to climate change. As a small island developing state with an almost exclusive reliance on the marine environment for fisheries, and tourism, the social, economic and cultural fabric of the Seychelles is inextricably linked to climate change.

4.8 Vulnerability and Adaptation on the Health Sector

4.8.1 Introduction

The focus of this study is on the impacts of climate change on vector-borne diseases especially those transmitted by mosquitoes in the Seychelles. Vector-borne diseases are infections transmitted by the bite of infected insects, such as mosquitoes, ticks, sandflies and blackflies (Confalonieri *et al.,* 2007). Mosquitoes are the vectors responsible for the transmission of many vector-borne diseases, such as malaria, dengue, yellow fever and others (Sattenspiel, 2000).

Although climate change will have impacts on human health in the Seychelles, it is worthy to note and understand that there are other underlying factors to the emergence, transmission and the spread of vector-borne diseases. Very often there are a combination of factors be it societal, environmental, behavioural and ecological that lead to the development and spread of diseases. These needs are to be taken into consideration and addressed accordingly. For this reason, the effective management of vector-borne diseases depends on a holistic approach, incorporating measures that address vectors, pathogens, hosts and their interactions with each other and the environment. Several recommendations and adaptation strategies are proposed in order to minimise impacts of climate change and other relevant factors.

4.8.2 Objectives

The following have been identified as the main objectives of the study:

- To establish an index of mosquito vector distribution in the Seychelles and possible impacts of climate change on the propagation trends and the associated risks to the human population;
- To identify and analyse the relevant information and datasets available that will best predict the impact of climate change and disease spread / epidemics;

4.8.3 Index of mosquito vector distribution in the Seychelles and possible impacts of climate change on propagation trends and associated risks to the human population

Currently there are 17 species of mosquitoes in the Seychelles of which 6 are vectors of diseases. The disease vectors are *Aedes albopictus, Aedes aegypti, Culex quinquefasciatus, Culex tritaeniorrhyncus, Culex fuscocephallus* and *Mansonia uniformis*. *Aedes albopictus* is the mosquito vector for chikungunya, dengue and yellow fever.

When understanding the distribution and density of mosquito vector, it is important to consider the best index to be used as an indicator of mosquito vector density. These are density and distribution of both the larvae (Breteau Index and House Index) and the adults (Adult density). Breteau Index is the percentage of container/recipients with mosquito larvae over the total number of houses. This index is specific to one species of mosquito; *Aedes albopictus.* House Index is the percentage of houses infected with mosquito larvae. Adult density determines the exposure to adult mosquitoes, and it is calculated by the number of mosquito bites per person per hour.

Of the three indexes (Breteau Index, Adult density and House Index), the House Index is a better indicator to determine vector density as it does not discriminate against mosquito larvae (larvae of any species of mosquito is considered), whilst Breteau and Adult density are specific to one species of mosquito; *Aedes albopictus.* To date only one survey of mosquito vector distribution has been conducted and this was on Mahé only. No consistent and adequate information is available for Praslin and La Digue. The survey was initiated with the aim of establishing the population density of mosquitoes in all districts of Mahé, especially the vectors of yellow fever and dengue fever i.e. *Aedes albopictus.* It was conducted between February and September 2003.

Table 4-21: Index of adult mosquito vector (Aedes albopictus) density by districts on Mahé in 2003. Density level is defined as follows: Low = 0 - 10; Moderate = 10 - 20; High = 20 – 50; Extremely high = Above 50.

District	Adult mosquito (No. Bites per Hr	Density level
English River	101	Extremely high
Anse Etoile	53	Extremely high
Mont Fleuri	31	High
Beau Vallon	27	High
Mont Buxton	23	High
Anse Boileau	20	Moderate
Glacis	19	Moderate
Bel-Ombre	16	Moderate
Anse Royale	16	Moderate
Port Glaud	14	Moderate
Anse Aux Pins	13	Moderate
Plaisance	12	Moderate
Takamaka	10	Low
Point Larue	9	Low
Baie Lazare	9	Low
Les Mamelles	8	Low
Cascade	6	Low
Saint Louis	5	Low
Grand Anse	5	Low
Bel Air	4	Low
Roche Caiman	2	Low
Au Cap	2	Low

4.8.4 Density and distribution of adult mosquitoes

The density of adult *Aedes albopictus* is determined by the number of mosquito bites per hour. Table 4-21 and Figure 4-84 below show the density of the mosquito vector *Aedes albopictus* on Mahé. English River has the highest density of *Aedes albopictus* with a biting rate of 101 bites per person per hour, followed by Anse Etoile and Mont Fleuri.

When grouped into regions, the Central Region stands out as the area with the highest adult mosquito density (Figure 4-85). English River, Anse Etoile, Mont Fleuri and Mont Buxton are amongst the first 5 districts with the highest adult mosquito densities. On the other hand Au Cap, Roche Caiman and Cascade of the East Region, are amongst the districts with the lowest density of adult mosquitoes.

Data to calculate the density of adult mosquitoes on Praslin and La Digue were not collected in the 2009 survey. Since there was an epidemic of chikungunya from 2005 to 2008, the risk could not be taken to expose staff to mosquito bites. The method of data collection whereby the density of adult mosquitoes is calculated by the number of mosquito bites a person receives per hour exposes that person to the possibilities of contracting a disease like chikungunya if the disease is still present. For this reason, such data were not available for analysis.

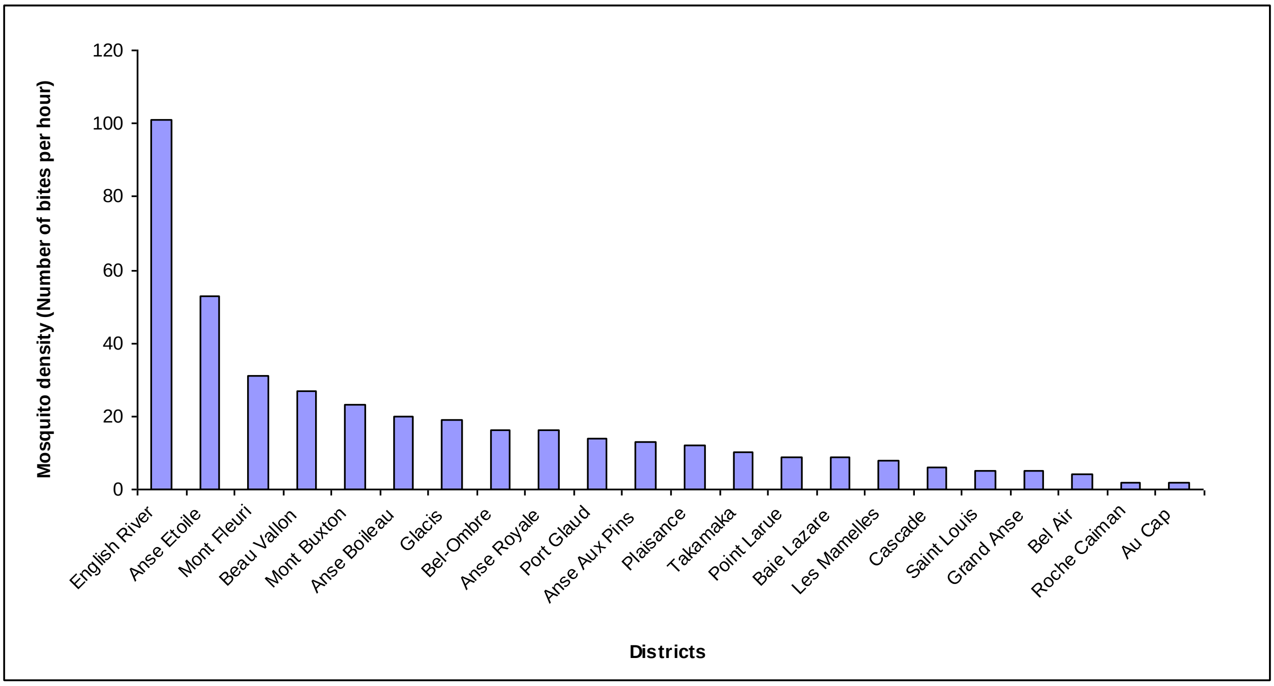


Figure 4-84: Index of adult mosquito vector (*Aedes albopictus)* density by districts on Mahé in 2003

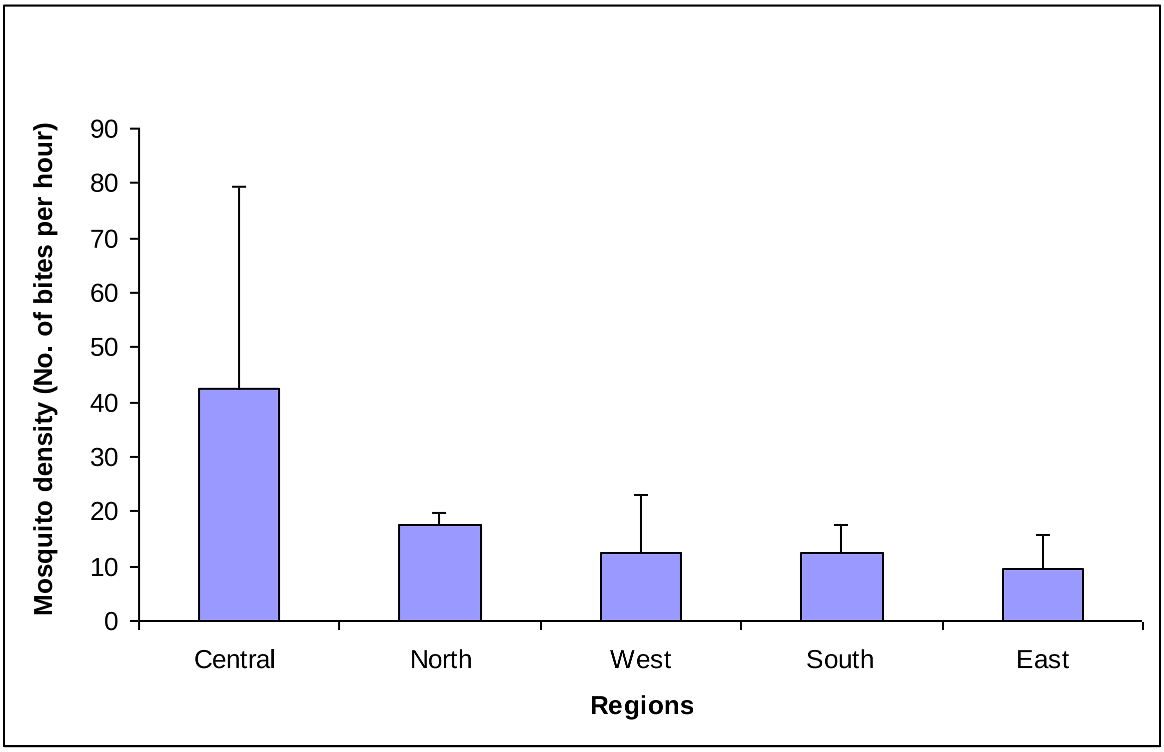


Figure 4-85: Index of adult mosquito vector (*Aedes albopictus)* density by regions on Mahé in 2003

4.8.4.1 Density and Distribution of mosquito larvae

i. The density of mosquito larvae as determined by the Breteau Index

The density of mosquito larvae (*Aedes albopictus)* is determined by the Breteau Index. Figure 4-86 shows the density of mosquito larvae by districts on Mahé. The Breteau Index differs from district to district from 1.28 to 22.07, with Beau-Vallon, Glacis, Mont Buxton, Anse Royale, Au Cap, Anse Aux, Bel-Ombre and Bel Air having the highest density of mosquito larvae.

When grouped into regions, the North region stands out as the area with the highest mosquito density, followed by the South region (Figure 4-87).

The survey undertaken on Praslin and La Digue in 2009 shows that the density of mosquito larvae is extremely high on Praslin, especially in the district of Baie Sainte Anne (Figure 4-88). On the contrary La Digue has a very low mosquito larvae density.

ii. The density of mosquito larvae as determined by the House Index

The House Index is the percentage of houses infected with mosquito larvae and it can predict the percentage of the population that can be affected if there were to be an epidemic. This Index is represented by Figure 4-89, in which it can be seen that Anse Etoile, Beau Vallon and Bel-Ombre are amongst the districts with the highest percentage of houses infected with mosquito larvae. Figure 4-90 indicates that the North region has the highest number of houses with larvae.

The percentage of houses infected with mosquito larvae on Praslin and La Digue in 2009 is very high, with Baie Sainte Anne having the highest density (Figure 4-91).

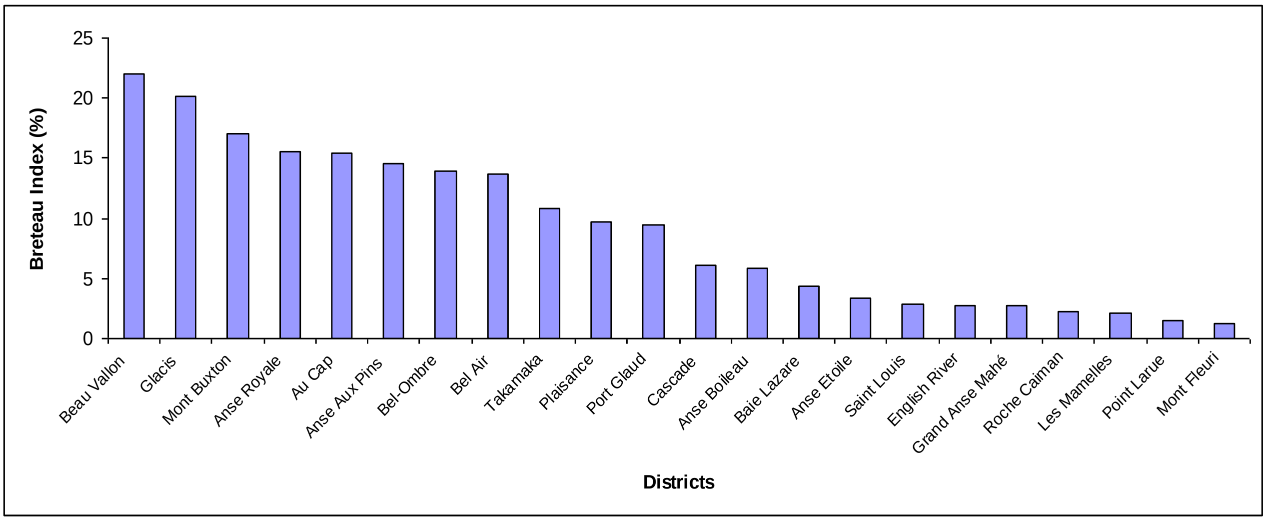


Figure 4-86: Index of mosquito larvae density (Breteau Index) by districts on Mahé in 2003

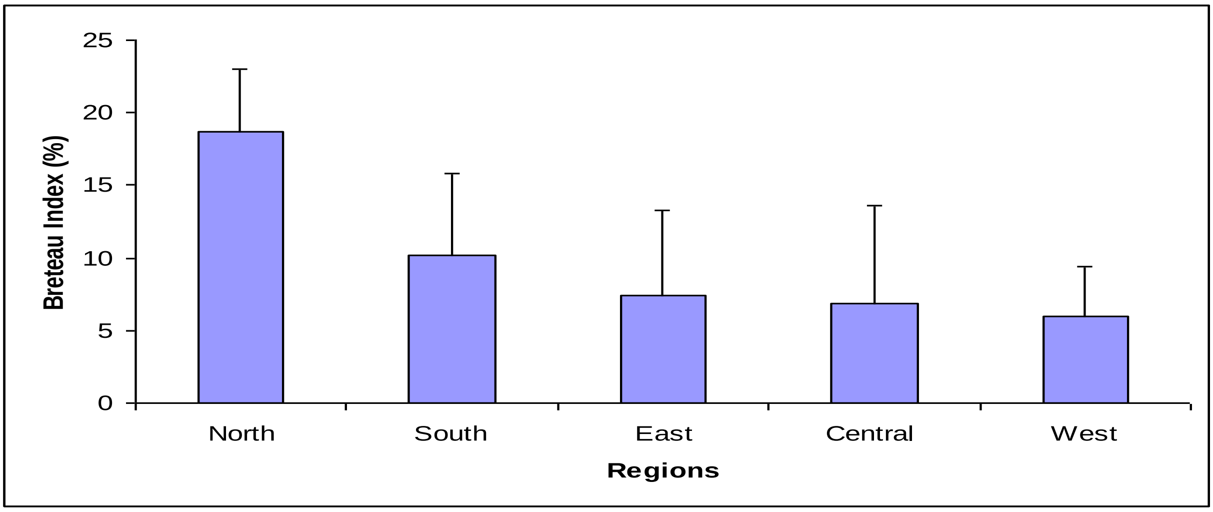


Figure 4-87: Index of mosquito larvae density (Breteau Index) by regions on Mahé in 2003

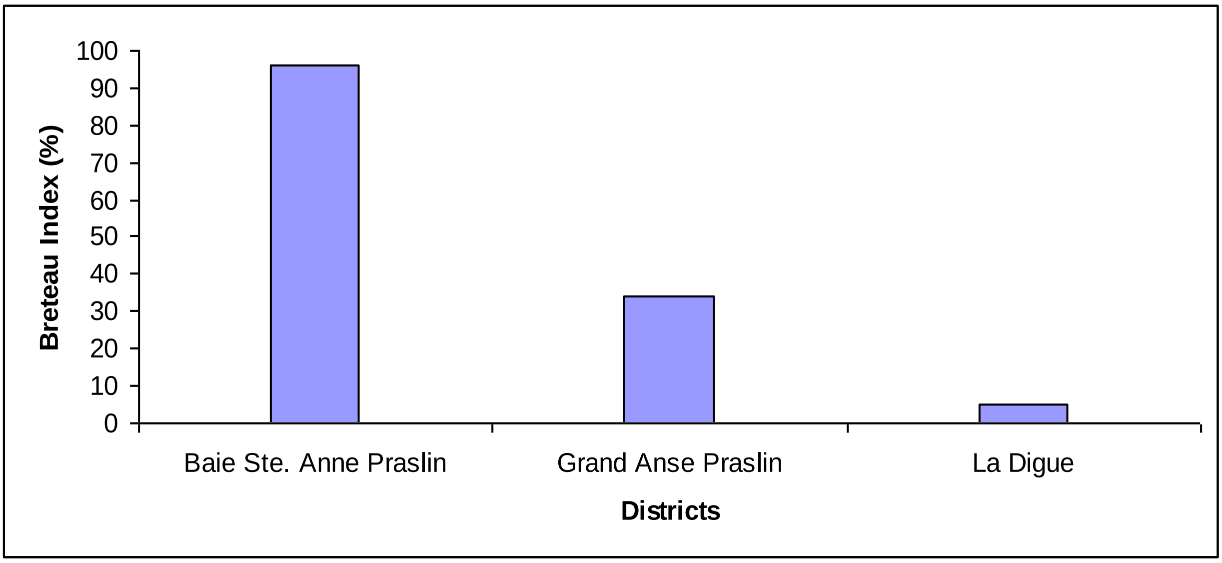


Figure 4-88: Index of mosquito larvae density (Breteau Index) by districts on Praslin and La Digue in 2009

4.8.4.2 Overall distribution and density of mosquito vector

The distribution and density of mosquito vector (*Aedes albopictus)* on Mahé in 2003 are shown in Figure 4-97 and those of Praslin and La Digue are depicted in Figure 4-98. Areas of highest density are depicted by the darkest colour, which reduces in tone to areas with the lowest density.

In conclusion, the main mosquito vector, *Aedes albopictus* (which is responsible for chikungunya, dengue and yellow fever), is widespread on Mahé with the highest density in the North and Central regions. The results of the 2003 survey indicate that over 63% of districts have a Breteau Index (mosquito larvae density) over the World Health Organisation (WHO) standard of 5%; and 68% of houses have a House Index above WHO standard (4%).

No consistent and adequate data were available for Praslin and La Digue until 2009 when a survey was undertaken. As was the case on Mahé in 2003, mosquito vectors were also observed to be widespread on Praslin and La Digue, with Praslin having an astronomically high mosquito density. This means that Praslin is a high risk area. Overall, mosquito vector densities on Mahé, Praslin and La Digue are extremely high, and this could lead to serious consequences in the event of an epidemic outbreak.

Breteau Index for Mahé and Praslin-La Digue cannot be compared since data were collected at two different periods (2003 and 2009 respectively). Moreover, there have been several developments on Praslin as well as more rubbish dumping compared to 2003, which may have increased the amount of mosquito breeding sites, hence resulting in a potentially higher index for 2009. In addition, recent data on the density of mosquito larvae for Mahé, were collected but proofing of these data showed that they were of poor quality, erroneous and unreliable. Therefore, they could not be analysed.

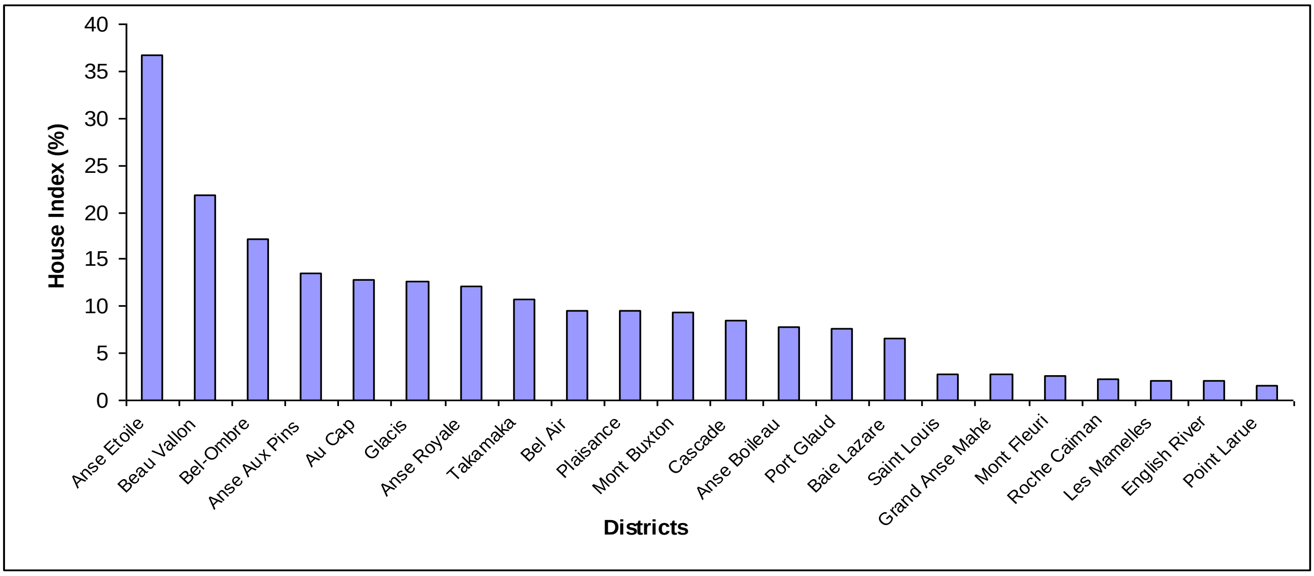


Figure 4-89: The percentage of houses infected with mosquito larvae (House Index) by districts on Mahé in 2003

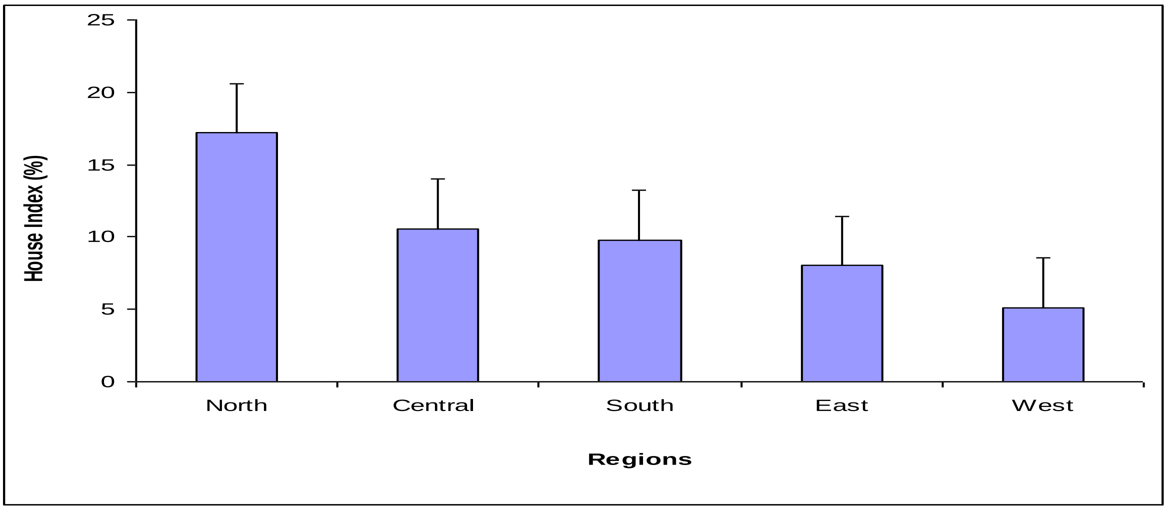


Figure 4-90: The percentage of houses infected with mosquito larvae (House Index) by regions on Mahé in 2003

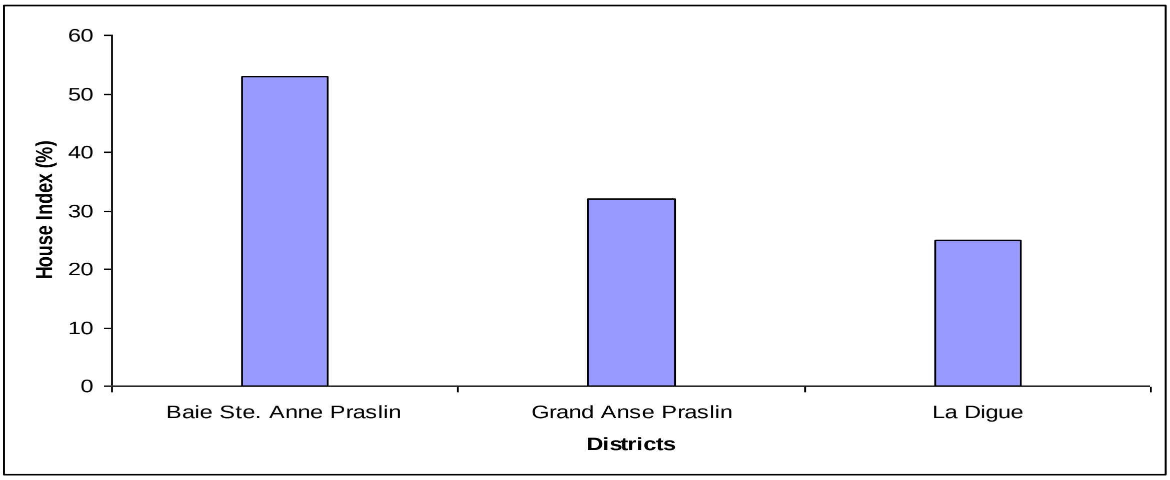


Figure 4-91: The percentage of houses infected with mosquito larvae (House Index) by districts on Praslin and La Digue in 2009

4.8.5 Potential impact of climate change on disease spread and epidemics in the Seychelles

In order to appreciate the potential impact of climate change on disease spread and epidemics in the Seychelles, it is important to understand past, present and future weather trends and their relationship with vector distribution and the spread of diseases.

4.8.5.1 Analysis of past climatic data

The Figures 4-92 and 4-93 respectively show the trends in temperature, rainfall and humidity in the Seychelles since 1972. As it can be observed, there has been a gradual increase in the monthly average temperature over the past 35 years from 26.7 ^{o}C in 1972 to 27.5 ^{o}C in 2007. The lowest monthly average temperature recorded was 26.2 ^{o}C in 1974 and the highest was 27.6 ^{o}C in 1998.

In terms of the annual rainfall, there have been considerable variations in the total amount of rain received, with very dry years such as 1986 (1656.1 mm) and very wet years such as 1997 (3559.2 mm). Overall, the amount of rain over the past 35 years has not increased. Moreover, a remarkable decrease in annual rainfall has been observed over the past 4 to 5 years (2942.4 mm in 2003 to 2068.1 mm in 2007).

The relative humidity has remained more or less constant with slight variations since 1972.

Analysis of weather trends data by other authors agrees with the above results.OVerall the latest temperature trends based on maximum and minimum temperature show warming between +0.33 to +0.82°C respectively as has been revealed within the document. Analysis based on oxygen isotope (O^{18}) extracted from corals in the Seychelles has shown a consistent upward trend suggesting a warmer climate over the years. Chang Seng 2007 further confirmed strong rainfall variability over Mahé, based on the analysis of longer term monthly rainfall data.

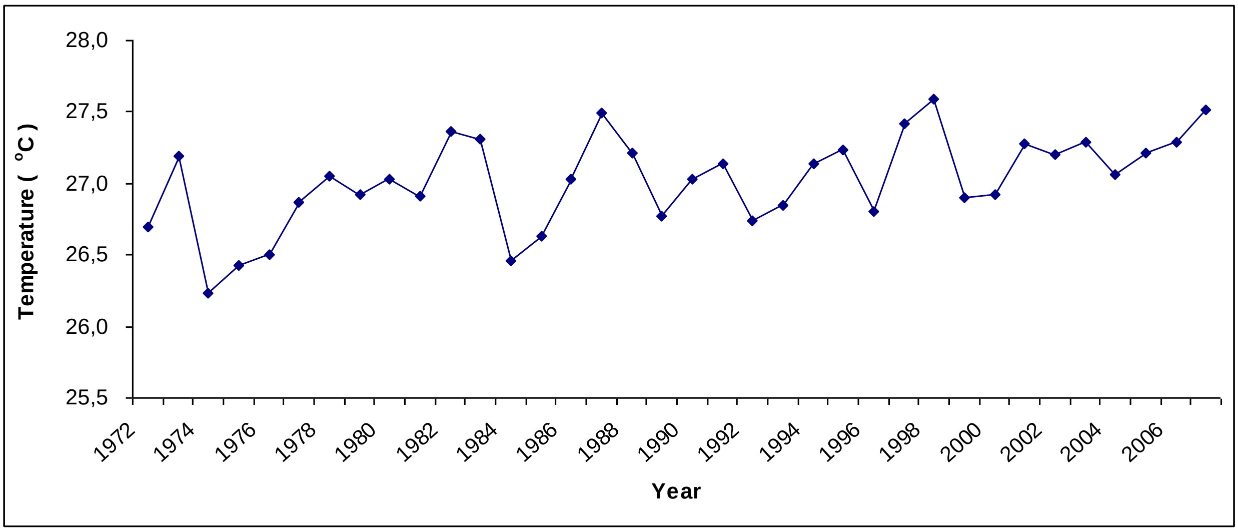


Figure 4-92: Trends in monthly average temperature data, 1972 – 2007

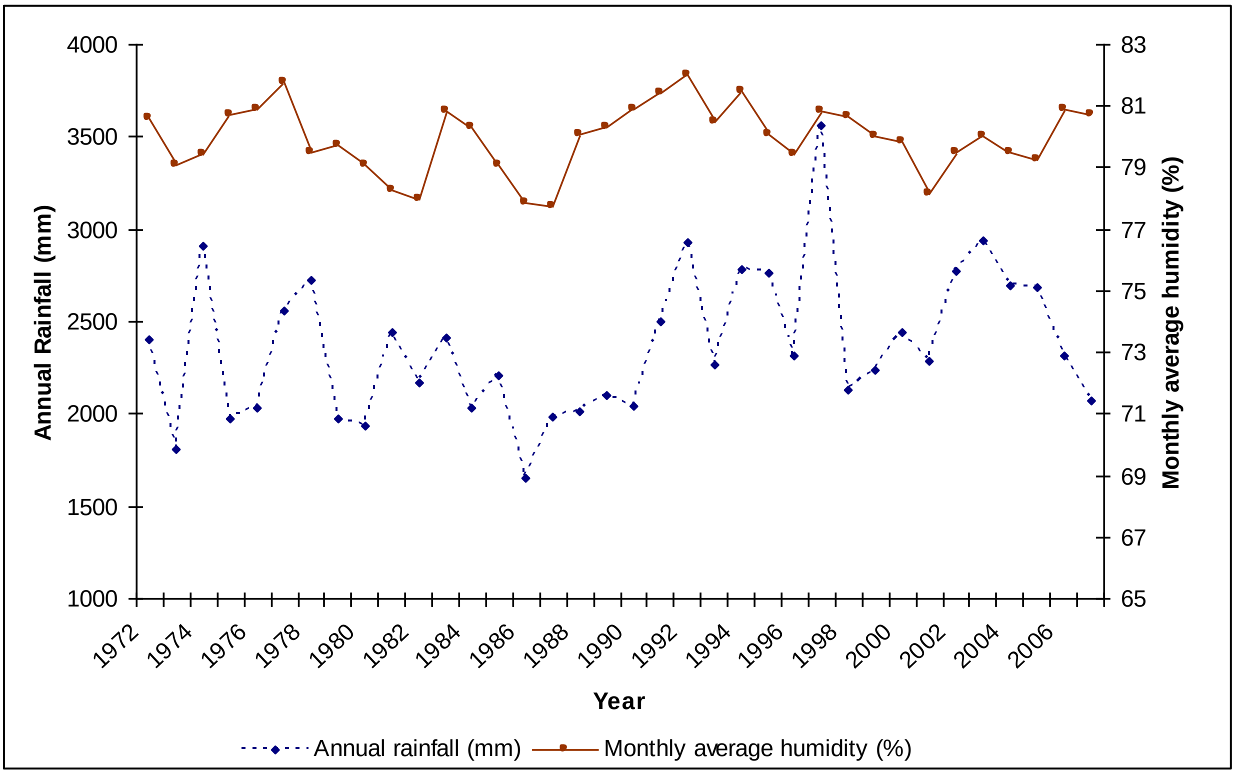


Figure 4-93: Trends in annual rainfall and monthly average humidity data, 1972 – 2007

4.8.5.2 Analysis of future weather trends data

Chang Seng (2007) provides a very detailed analysis and projections of future climate changes for the Seychelles. These are summarised in Table4-22 below. Modelling based on General Circulation Models (GCMs) shows a maximum increase in rainfall of +5.9 % (+19 mm) for the year 2025; +9.3 % (+25.4 mm) for the year 2050 and +12.4 % (+38.6 mm) for the year 2100. The models show a wetter climate especially during the rainy season (Northwest season) although it is unlikely for precipitation to increase during the dry season (Southeast season).

In terms of temperature, the GCM models predict warming between +0.5 to +0.6 ° C for the year 2025; +0.9 to +1.1 ° C for the year 2050 and +1.6 to +2.5 ° C for the year 2100.

Thus the projections predict a future climate characterised by a wetter Northwest season, a drier Southeast season, with extreme weather events (such as more rain in a shorter period) and hot episodes.

Table 4-22: Projections of future climate changes for the Seychelles based on projected increases in precipitation and temperature

Year	Precipitation	Temperature
2025	+5.9 % (+19 mm)	+0.5 to +0.6 ° C
2050	+9.3 % (+25.4 mm)	+0.9 to +1.1 ° C
2100	+12.4 % (+38.6 mm)	+1.6 to +2.5 ° C

The projections of future climate changes on a local scale are in accordance to those predicted on a global scale. The IPCC projected a global average temperature increase of 1.0 – 3.5°C by the year 2100. Results show that temperatures have been increasing by as much as 0.1°C per decade (IPCC, 1996a).

4.8.5.3 Analysis of the relationship between climate change patterns, vector distribution and the spread of disease

Future climate change projections predict a wetter, hotter climate with more extreme weather events. An increase in rainfall and temperature (Table 4-22) will create ideal environmental conditions for the proliferation and spread of mosquitoes. Increased rainfall or more variability in rainfall patterns will increase the availability of surface water which in turn will create more mosquito breeding sites, hence the production of more larvae, leading to the eventual increase in the size of mosquito populations. An increase in mosquito abundance is also expected as a result of future rise in temperatures especially coupled to an already high relative humidity in the Seychelles as these conditions favour the development, maturation and a prolongation of the survival of mosquitoes.

Mosquito biting rates and activity level tend to increase with higher temperatures. Furthermore, it accelerates the incubation and maturation of parasites and viruses associated with the mosquito vector. These latter two elements may eventually lead to intensification in the transmission of diseases.

A drier and hotter Southeast season as predicted by climate change projection might also favour an increase in mosquito abundance. It is common practice, especially during the dry season, for people to keep artificial reservoirs of water in containers and drums. Often these recipients are not covered properly or not at all. A future drier Southeast season would enhance this human behaviour, as more people will keep more water reservoirs. These reservoirs are ideal breeding sites for mosquitoes, which will contribute to an increase in mosquitoes.

Furthermore, in a hotter climate people have the tendency to remain outdoors to cool off especially at dusk (when mosquitoes are most active) and hence become more exposed to mosquitoes.

Even if the dry season becomes drier, it will nonetheless still have an effect on vector density and spread of diseases because the eggs of mosquitoes have the potential to resist desiccation for up to two years, awaiting much favourable conditions. They will eventually hatch during the rainy periods potentially leading to an explosion in the mosquito population. There may be serious consequences if this coincides with the emergence and transmission of a disease like chikungunya or dengue.

As depicted by past surveys, the main mosquito vector *Aedes albopictus* is widespread on Mahé. The island of Mahe already has an extremely high larvae and adult mosquito population, especially in human habitation, with a higher abundance in the North and Central regions (Figures 4-85, 4-88 & 4-91). People in districts like English River and Anse Etoile where the density of adult mosquitoes is very high, are more exposed to these mosquitoes. Moreover, a high density of adult mosquito means that the viral load is also high and hence these people have a higher risk of contracting a disease. On the contrary, people living in districts like Au Cap and Cascade where the density of adult mosquito is low (Figure 4-84 and Table 4-21), are less exposed and have a reduced risk of contracting a disease.

In addition, the Seychelles has a mosquito larvae index (Breteau and House Index) much higher than the accepted WHO standard. Predicted changes in climatic factors will create ideal conditions for our local mosquitoes, favouring a further and undesirable increase in the mosquito-vector populations, transmission rates and higher disease outbreaks. Moreover, local conditions will become more favourable/conducive for other mosquito-vectors that are currently absent in the Seychelles such as *Anopheles gambiae* and *A. arabiensis,* which are two African malaria vectors. Due to its proximity to mainland Africa, but also due to globalisation and ease of travel, the risk for their introduction is high and should be a great cause of concern.

4.8.5.4 Relationship with rainfall and temperature patterns to the spread of chikungunya between 2005 and 2007 in the Seychelles

The increase in chikungunya cases from the traditionally dry season of July 2005 to the early rainy season of the same year coincided with an increase in rainfall (Figure 4-95). A decrease in rainfall between December 2005 and February 2006 did not provoke a decrease in chikungunya cases. On the contrary, the number of cases rose and remained high. Another positive correlation was observed between rainfall and the number of cases between March and June 2006. Thereafter, there was a remarkable decrease in chikungunya cases, which negatively correlated with an increase in rainfall until November 2006. The number of chikungunya cases rose again in January 2007 until May/June 2007 as the amount of rainfall diminished. The period of July – December 2007 saw a reduction in the number of cases, which in turn was negatively correlated with an increase in rainfall.

The outbreak of chikungunya in July 2005 and its eventual increase was positively correlated to an increase in temperature until May 2006 (Figure 4-96). There was also a positive correlation of these two factors between May and July 2006 as both decreased. However, despite an increase in the temperature during the dry season of 2006, the number of chikungunya cases continued to decrease. It was only in January 2007 that the cases of chikungunya increased and was correlated with a general increase in temperature. The reduction in chikungunya cases was also positively correlated with a decrease in temperature from May to the end of the year 2007.

In general, there seems to be a positive correlation of the number of chikungunya cases with temperature. Warm temperatures could have created the ideal conditions for the rise in the number of chikungunya cases as it favoured an increase in mosquito abundance, higher biting rates and activity level, and increased exposure to mosquitoes (as people tended to stay outdoors during hotter weather).

Although it is plausible that an increase in rainfall and temperature could have explained the positive correlation between the number of chikungunya cases and rainfall patterns/temperature at the onset of chikungunya in 2005, it would be right to also suggest that more people contracted the disease through higher transmission rates as the number of infected persons increased. However, Figure 4-95 below shows that the number of chikungunya cases was only positively correlated with the amount of rainfall during the start of the outbreak.

This was followed by a negative relationship. Hence, there were other factors that played a role in influencing the number of chikungunya cases other than rainfall and temperature. These were intervention measures. On the onset of the outbreak of chikungunya in July 2005, the MoH undertook spraying activities of infected areas on Mahé.

This was intensified between January and September 2006. As of August 2006, the Combi (Communication for behavioural impact) was launched. This was a sensitisation programme in which the public was encouraged to regularly remove rubbish around their homes (i.e. every weekend), and to remove water from their flower pots every three days. These intervention measures were successful in reducing the number of chikungunya cases and explained the decrease and relatively low number of cases between August and December 2006 despite the increase in rainfall and temperature.

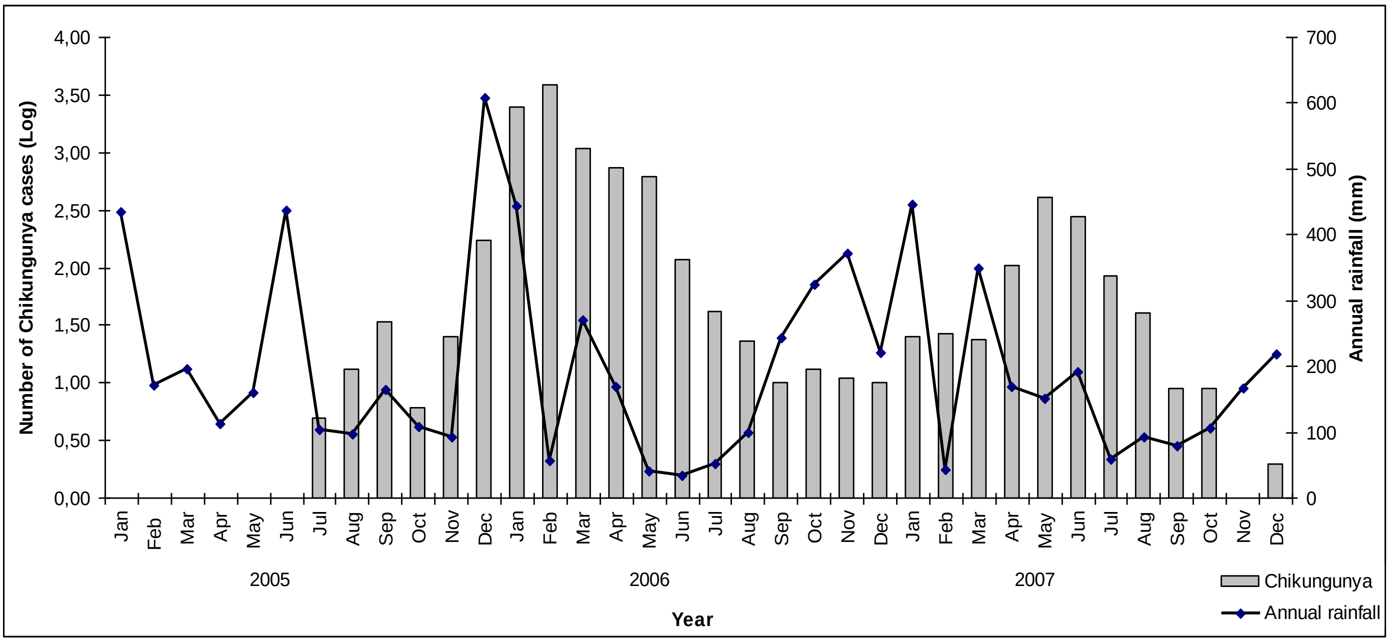


Figure 4-95: Relationship between rainfall and the spread of chikungunya between 2005 and 2007 in the Seychelles

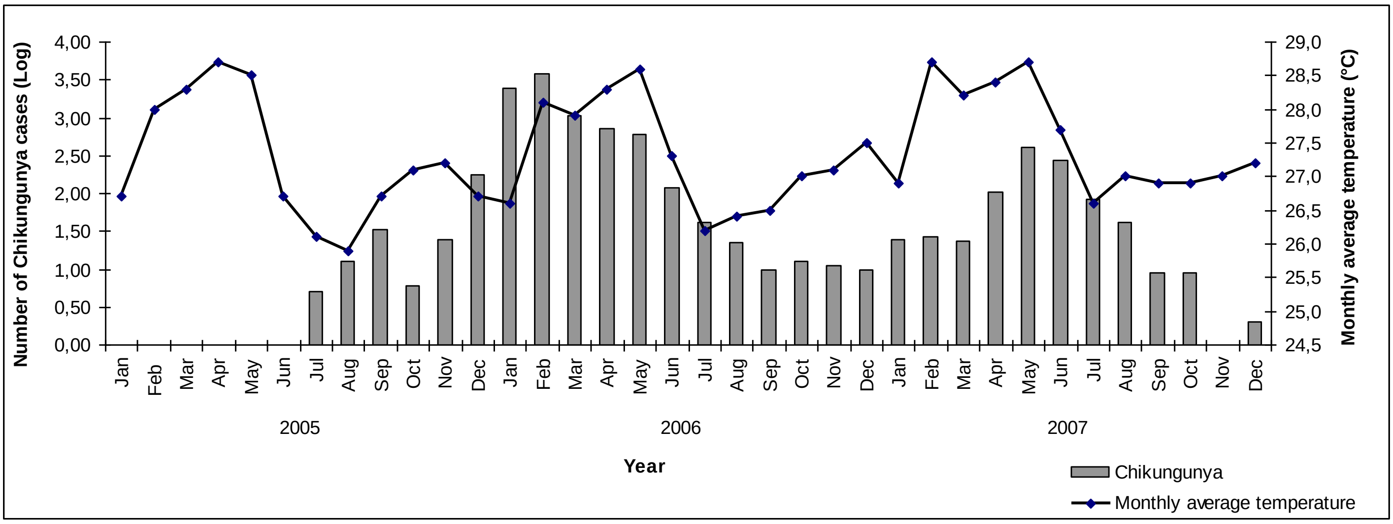


Figure 4-96: Relationship between temperature and the spread of chikungunya between 2005 and 2007 in the Seychelles

4.8.6 Conclusion

It is evident that change in climate is inevitable and that it will impact on human health in several different ways. Thus, there is the need to take a precautionary approach and to prepare for those impacts.

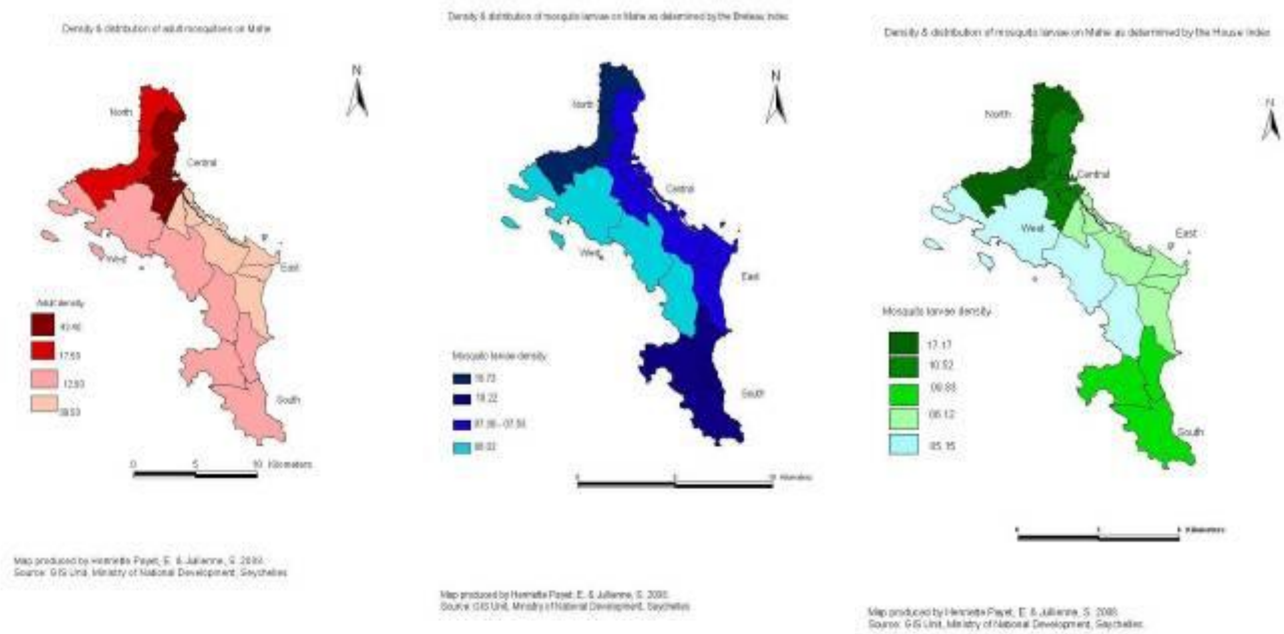
In order to develop policies to mitigate and adapt to climate change-related health impacts, it is important to continuously understand and seek evidence of the ways climate change will affect the patterns of human health. Priority should be assigned to developing and implementing effective adaptation measures. These measures can be used effectively to greatly reduce many of the potential health impacts of climate change. The most important measure is to strengthen public health infrastructure and resources, in addition to having adequate financial resources. Public health resources include public health training programmes, research to develop and implement more effective surveillance and emergency response systems, health education programmes, prevention and disease control programmes.

A country's capacity to adapt to climate change impacts will depend on many factors such as the level of public health infrastructure and resources, active surveillance, research to further the understanding of the associations between weather patterns and vector-borne diseases, in addition to research into the resistance of mosquitoes to insecticides, mosquito control programmes amongst others. Likewise, the vulnerability of a population to health outcomes will depend on health care facilities/infrastructure, health status of the population, and availability of technical, human and financial resources. These will also determine the country's resilience and its capacity to respond effectively and mitigate against any health impacts due to climate change.

Currently, the main government ministries, agencies and institutions involved in health management do not have the capacity to cope with the consequences of a major epidemic; especially one that will require hospitalisation like cholera or malaria. Health infrastructure is currently insufficient as there are not enough human, physical and financial resources. There is a lack of medical workers compared to the relative size of the population, as well as a lack of medical structures (hospitals, beds etc) and limited storage of medicines and vaccines. Hence, there is a need to identify other measures or facilities to cater for the population with a view to cope with the consequences of health impact of climate change.

Finally, the Seychelles, like several other small island developing states (SIDS) has a small economy and low economic resilience (high sensitivity to external market shocks), limited financial and human resources, which may severely limit its capacity to mitigate and adapt to the effects of climate change. Nonetheless, it is important to focus on adaptive options in the face of climate change.

Figure 117: Distribution and Density Map of the Mosquito Vector (*Aedes albopictus)* on Mahé in 2003



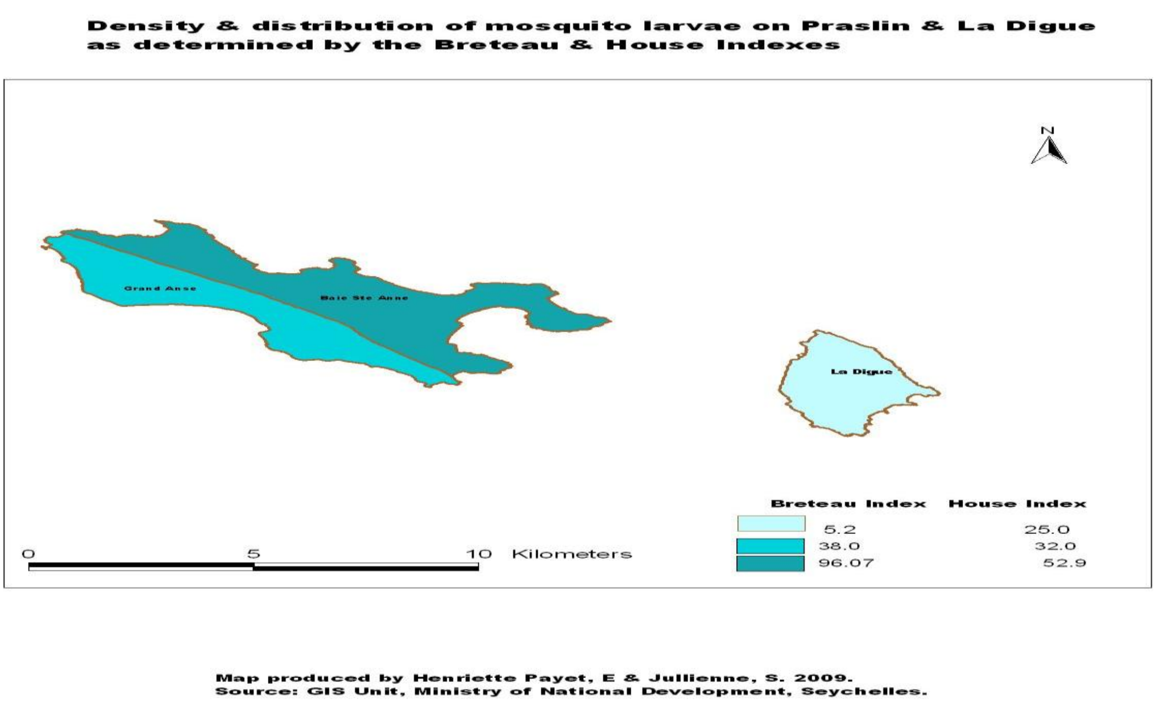


Figure 118: Distribution and density map of the mosquito vector (*Aedes albopictus)* on Praslin and La Digue in 2009

Chapter 5

Other Relevant Information

CHAPTER 5 OTHER RELEVANT INFORMATION

5.1 Introduction

Seychelles has already taken important steps in the implementation of the Framework Convention on Climate Change of the United Nations (UNFCCC) since the submission of its Initial National Communication (INC). This chapter builds upon the INC and further integrates climate change concerns into national economic development processes and policy dialogues.

5.2 Technology Transfer

5.2.1 Introduction

To put into practice adaptation technologies effectively is by producing community ownership of the technology. This can be accomplished through education and involving stakeholders in the formulation of policies appropriate to adaptation technology.

Education and raising public awareness remain the challenges for successful adaptation technology transfer. Both call for expertise and financial resources that currently neither Government nor responsible agencies possess.

5.2.2 Technology Needs Assessment

The transfer of coastal adaptation technologies firstly requires the support of coastal data of the area, which is an essential component during the planning and designing stages of such technologies.

In the past, emphasis had been put on the 'hard' technologies, the use of 'soft' technologies were rarely used. Now there is a need for more planning before implementation, closer analysis of coastal data collected and more training for those involved in coastal adaptation. With the increasing pressure for development on the coastal zones and also the increasing threat of climate change, primarily that caused by sea level rise, make the transfer of technology a high necessity. A more effective technology transfer process will mean more effective coastal adaptation technologies being put in place.

The National Greenhouse Gas Mitigation Options report of 2007 recommended increased efforts to promote Renewable Energy Technology (RET), and specifically Photo-Voltaic (PV) systems, to reduce CO_2 emissions. This report stated that with the use of current technologies, the average emission for the Seychelles for the period from 2000 to 2007 was 698 g CO_2/kWh. The government has embarked on various initiatives, some with international partners, to promote alternative technologies to satisfy a more significant portion of its energy needs. For example, negotiations with the Abu Dhabi-based company MASDAR has been carried out to install a small wind farm in the Seychelles. Technology Transfer for Grid-Connected Rooftop Photovoltaic Systems is also being considered. In addition, the

Government of Seychelles (GOS) has instituted significant changes in its energy management, including the establishment of a new Seychelles Energy Commission within the Ministry of Environment, Natural Resources and Transport. In July 2009 the said commission conducted an assessment to determine to what degree renewable energy can contribute to the energy production mix of the country, in support of the Government's commitment to increase energy security. In addition, the recently established Seychelles Energy Commission also strongly supports the idea of implementing more PV systems in the Seychelles. The said commission has also been charged with overseeing to the development of integrated energy project planning.

5.2.3 Conclusion

The development of technology transfer has permitted Seychelles to evaluate its technology needs and to invest in environmentally sound technology know-how along with implementing mitigation and adaptation efforts. The technology needs assessment for Seychelles carried out in 2003 has reiterated the nation's vulnerability to the effects of climate change.

Barriers to technology transfer can seem, at times, as numerous as the benefits. Barriers include a lack of private investment in technical development, systemic or monetary limitations in Government and a lack of coordination between Government and the private sector with respect to developing alternative energy technologies.

5.3 Research and Systematic Observations

5.3.1 Introduction

In response to Decision 5 of the Conference of Parties (COP) of the UNFCCC, Seychelles is upating its national report on the Systematic Observation activities under the Global Climate Observing System (GCOS) guidelines. GCOS was established in 1992 to ensure that observations and information needed to address climate related issues are obtained and made available to all potential users. GCOS is intended to be a long term, user-driven, operational system capable of providing comprehensive observations required for monitoring the Climate System; detecting and attributing Climate Change; assessing the impacts of Climate Variability and Change; and supporting research towards improved understanding, modeling and prediction of the climate system. The Seychelles currently participates in the GCOS Surface Network (GSN), the GCOS Upper Air Network (GUAN) and the Global Atmospheric Watch (GAW) programmes.[13] This covers observations of Meteorological, Atmospheric and Oceanographic nature that are undertaken routinely or regularly. The Seychelles do not at present support any Space-based Observation Programme.

[13] Govt. of Seychelles (2002) "Report to the UNFCCC regarding Seychelles' participation in the Global Climate Observing Systems GCOS) and on systematic observation in the Seychelles"

Climate-related disasters in recent decades have been the most economically disastrous in Seychelles recorded history, with events in the last decade being the most devastating. The economical consequences have forced the Seychelles' Government to take Climate Change seriously especially when there is a possibility that these disasters may increase in frequency and intensity in the future.

The UNFCCC invited parties to prepare detailed report on Systematic Observation activities in their respective countries under the Global Climate Observing Systems (GCOS) guidelines.

This report describes the Seychelles' contribution to GCOS. This covers observations of Meteorological, Atmospheric and Oceanographic nature that are undertaken routinely or regularly.

Data from systematic observation are required for detecting and predicting climate change. Such data are needed to enable observation of the current climate, monitoring of sea level rise and extreme events, and "early" warning of future climate change. Assessing both current and future climate conditions is central to national planning for adaptation measures. But climate observation often poses problems for developing countries because of the funds needed for modern equipment and infrastructure, adequate staff training, archiving of historical data and operating expenses.

The Climate Services Unit within the National Meteorological Services (NMS) is responsible for the collection, quality control, processing and archiving of climatological data which are used in a wide variety of global, national and private-sector activities, including the monitoring of climate and climate change.

5.3.2 Climate Monitoring and Systematic Observation

The Climate Services Unit within the National Meteorological Services (NMS) is responsible for the collection, quality control, processing and archiving of climatological data which are used in a wide variety of global, national and private-sector activities, including the monitoring of climate and climate change.

5.3.3 GCOS Surface Network (GSN) Station

The only Climatological station in Seychelles is located at the Seychelles International Airport at a position 04° 40' S 55° 31' E, and is the only designated GCOS Station. The station was opened in 1971 and has been operational throughout. It meets the GCOS standard for weather observing.

Hourly Observations and Climat data (monthly) are exchanged on the GTS via Meteo France (Reunion) and also sent by e-mail to Deutcher Wetterdienst in Germany.

5.3.4 GCOS Upper Air Network (GUAN) Station

The only designated GUAN station in Seychelles is located at position 04° 55' S 54° 31' E, and has been in operation since 1976. The station meets the GCOS observational standard of one high altitude sounding daily.

TEMP messages (daily) and Climat Temp (monthly) are exchanged on the GTS via Meteo France (Reunion) and also sent to the UK Meteorological Office and Deutcher Wetterdienst in Germany via e-mail.

5.3.5 Upper Air Observations in the Seychelles

Upper-air observations in Seychelles dates back to 1971 with the opening of the Meteorological Station at the airport. This comprised of upper wind observation using the Pilot Balloon theodolite method. This went on until 1976 when a complete Radiosonde Station became operational on the Southeast Island near Mahé. From its opening in April 1976 to 1983, the station was operated and fully funded by the UK Meteorological Office. An Officer –In- Charge (OIC) and a technician were seconded by the UK Meteorological Office with additional support staff being provided by the Seychelles' Meteorological Services. By 1983 the local staff had acquired enough knowledge and experience to operate the station so the UK Met' Office withdrew its staff support, however it continued with its financial support for the consumables and replacement spares.The Upper Air Observation Programme is described and portrayed in Table 5-1 below

Table 5-1: Upper Air Observation Programme

Upper Wind

Period	Type of Observation	Data Receiving/Processing Equipment	Data Extraction/Computation
1971-1976	Upper Wind	(Pilot) Pilot balloon Theodolite	Manual
1976-1985	Upper Wind WF3	Wind Finding Radar	Semi-automatic
1985-1996	Upper Wind WF33	Wind Finding Radar	Semi-automatic
1996-1998	Upper Wind Omega/Navaids	(STARDegreane)	Automatic
1999-To Date	Upper Wind GPS	(Vaisala)	Automatic

Upper Pressure, Temperature and Humidity (PTU)

Period	Type of Observation	Data Received/Processing Equipment	Data Extraction/Computation	RS Type

1976-1982	PTU (Temp)	Vaisala PP11	Manual	RS-20
1976-1996	PTU	Vaisala PP11	Manual	RS-80
1996-1998	PTU	Vaisala PP11/STARDegreane	Automatic	RS-80N
1999-2004	PTU	Vaisala PP15 (II)	Automatic	RS-80GPS
2004 – 2006	PTU	Vaisala DigiCora II	Automatic	RS-90GPS
2006 – To date	PTU/Wind	Vaisala DiGiCora II	Automatic	RS-92SGPS

5.3.6 Rainfall Observing Stations

Like it is common in most tropical areas, rainfall is the most variable weather element in both space and time and thus requires a much denser network than most other weather parameters. Due to the simplicity of undertaking measurements and the relatively low cost of instrumentation, most countries can afford a good network of rainfall stations often manned by voluntary observers. Rainfall measurements in Seychelles started back during colonial times; around 1860. Observers then were private plantation owners who collected rainfall data for their personal use. With the setting up of the Meteorological Services in the early '70s, the voluntary system of observation was further encouraged. Today there are some 38 rainfall stations scattered over the Seychelles' Archipelago. Most of the stations are operated by the Meteorological Services under a Voluntary Observer Programme with a few of the stations operated by the Water Division of the Public Utilities Corporation (PUC).

Readings are done at 0700 a.m. each morning and the data are collected daily by phone whilst a few will send in data at the end of each month.

5.3.7 Current Situation – Rainfall Network

- Today there are some 38 rainfall stations scattered over the Seychelles' Archipelago. Most of the stations are operated by the National Meteorological Services under a Voluntary Observer Programme with a few of the stations operated by the Water Division of the Public Utilities Corporation (PUC). Rainfall Reading is done at 0700 hrs each morning and the data are collected daily by phone.
- However, the entire country, particularly Mahé, has a good network of rainfall observation with readings taken by the voluntary observers once a day at 7am.
- Only 1 automatic rain gauge exists. It is a Casella Tilting Siphon Type with a clock operated drum chart.

5.3.7 Automatic Weather Observations

Automatic weather observations in the Seychelles dates back to 1990 when the Meteorological Services acquired two Automatic Weather Stations (AWS), type Pulsonic 500, from France under a WMO Voluntary Cooperation Programme (VCP).

One station was installed on Aldabra to replace the manned station, which had to be discontinued due to logistical problems related to its remoteness. The second station was installed on Coétivy. The two stations were very unreliable and gave very poor performance during the two years they were in operation.

In 1996, Seychelles acquired another eight (8) AWSs under the Indian Ocean Commission Meteorological Project to strengthen the capacity of the South West Indian Ocean countries in the monitoring of tropical cyclones. The table below show details of the operational status of the stations.

Again, it would seem that the stations were not well adapted to the harsh tropical conditions and need constant attention. This had been aggravated by the lack of replacement spares, which had led to the closure of some of the stations to obtain spares for the more remote stations.

In 2010, 4 more stations were acquired under the CC DARE project, plus 2 more under the WMO VCP Emergency Programme. Installations of those stations are on-going.

5.3.8 List of Weather Stations in Seychelles.

The Table 5-2 illustrate the number and type of Weather Stations within the Seychelles archipelego.

Table 5-2: List of weather stations in Seychelles

Island	Location of station	Coordinates	STATUS OF STATION	TYPE OF STATION	Record	
					Duration of operation	Kind of observation (please circle)
Mahe	Int. Airport	04° 31S 55°.31 E	**Operational**	Manned	1971 to date	Synoptic
	Int. Airport	04° 31S	**Faulty, needs replacement**	AWS	1996 to 2001	Hourly

		55°.31 E				
	Rawinsonde	04° 41S 55° 31E	**Operational**	Digital with GPS	1974 – to date	Upper Air (00UTC)
Praslin	Amitie	04° 16 S 55° 44 E	**New AWS Operational Oct 2010**	AWS	1996 – 2002 Oct 2010 – to date	Hourly
La Digue	Nil		**To be acquired**	Nil	Nil	No
Outer Islands						
	Aldabra	09° 24 S 46° 12 E	**Aldabra Atoll**	Manned	1965 - 1991	Synoptic
	Aldabra	09° 24 S 46° 12 E	**New AWS to be Operational soon in Dec 2010**	AWS	1992 - 2004	3 hourly synoptic
	Farquhar	10° 01 S 51° 01 E	**Faulty, needs replacement**	AWS	1998 -2000	3 hourly synoptic
	Desroches	05° 29 S 53° 26 E	**Faulty, needs repair**	AWS	1996 - 2002	3 hourly synoptic
	Coétivy	07° 07 S 56° 13 E	**Faulty, needs replacement**	AWS	1992 - 1994	3 hourly synoptic
	Alphonse	07° 00 S 52° 35 E	**Faulty, needs repair**	AWS	2008 – to date	Hourly
	Denis Island	03° 47 S 55° 40 S	**Operational**	AWS	May 2009 to date	Hourly

	Darros	05° 18 S 53° 22 E	**Operational**	AWS	2008 – to date	Hourly
	Aride		**Mast Broken, needs repair**	AWS	2008 – to date	Hourly

5.3.9 List of Tide Stations in Seychelles

The Table 5-3 depicts the number of Tide Stations within the Seychelles archipelego.

Table 5-3: List the number of Tide Stations in Seychelles

Location of station	Coordinates	Duration of operational	COST
Aldabra	09° 30.0S 046° 46.20E	1975 – 1977	
Hodoul Island (Port Victoria)	04° 40.0S 055° 28.0E	1962 - 1964 1975 - 1976 1978 - 1979	
Port Victoria-A Port Victoria-B	04 37.0S 055 28.0E 04 37.0S 055 28.0E	1977 - 1982 1986 - 1992	
Praslin	04 20.6S 055 46.0E	1987 - 1989	
Pointe La Rue	04 40.3S 055 31.7E	January1993 to date	Financed / supported by University of Hawaii Sea Level Centre (UHSLC)
Denis Island	03 47 S 55 40 S	May 2009 to date	Hardware/ Software: USD 40,000, Installation USD 30,000

5.3.10 Automatic Weather Stations (AWS) Acquired in 2009 and 2010.

Several Automatic Weather Stations (AWS) were obtained in 2009 and 2010 as shown in Figure 5-4 below.

Figure 5-4: Number of Automatic Weather Stations acquired in 2009 and 2010

TYPE	Nos.	Location to be installed	Date Acquired	Cost
Vaisala AWS	4	Praslin, Aldabra and 2 on Mahe	June 2010	USD 75,000
Casella Rainfall Data Loggers	5	4 on Mahe and 1 on Praslin	June 2009	GBP 5,000
Adolf Thies AWS	2	Farquhar & Desroches	WMO has procured for delivery in 2011	USD 90,000

5.3.11 Models utilised for Forecasting Weather and Climate Seasonal Forecasting.

The following products are utilised in weather forecasting as well as for seasonal forecasting:

- FNMOC
- ARPEGE
- ECMWF
- ALADIN
- UK MODEL
- SWFDP – Pretoria (SADC)

5.3.12 Capacity-Building Needs

It is recommended that fellowships be made available for university training of Seychellois graduates in meteorology and data processing at Bachelor Degree level. There is also a need to train personnel in the installation, operation, calibration and the maintenance of meteorological equipment, tide gauges and computer-based systems if there are to be expansion in the local network of observations and monitoring of climate within the Seychelles' archipelago.

Even though in the Seychelles much has been done in coastal zone management, sea level monitoring is yet to be integrated in that respect. The measurements currently being carried out by the Seychelles'

Coast Guards and the Meteorological Services have been a significant contribution to oceanographic centres worldwide, especially for the TOGA Programme.

It is envisaged that if there could be funding for a Climate Change Information Centre, such institution will be in a better position to coordinate activities related to climate monitoring.

5.3.13 Sea-Level Monitoring

The tide gauges on Mahe, at the Pointe Larue Airport and on Denis Island are contiguous to each other. In the past, there has been some good datasets of tide data from Aldabra. There is also the infrastructure for a tide-gauge over there. It is therefore recommended to have another permanent station over Aldabra. The Seychelles' Islands Foundation (SIF) has qualified personnel to retrieve the data to be dispatched to Mahe whenever there is an opportunity.

5.3.11 Other Meteorological Networks

5.3.12 Oceanographic Observations

The National Meteorological Services (NMS) is responsible for the physical care of, and collating the data that proceed from the tide gauge located at the Seychelles International Airport. The tide gauge has collected data for the past seventeen years and records the following data types at various intervals:

1. sea level (with calculated and adjusted residuals);
2. wind direction, speed and gust;
3. water temperature;
4. air temperature;
5. barometric pressure.

5.3.13 Stratospheric Ozone Monitoring

Measurements of ozone are conducted at the Rawinsonde Station at the Southest Island of the Seychelles International Airport for academic purposes . Activity includes the monitoring and archiving measurements of stratospheric and tropospheric ozone, including vertical profiles.

5.3.14 Hydrology

The PUC - Hydrology Section is responsible for Hydrology in the Seychelles. There are two main dams and quite a number of rivers and seasonal streams.

5.3.15 Oceans

At present, sea surface temperatures are not monitored at the Seychelles International Airport, but satellite data from NOAA and ORSTOM are available on the World Wide Web. But the Seychelles Fishing

Authority do collect SST data through the several SST data loggers installed within the Seychelles EEZ in 2007 and 2008.

5.3.16 Future Plan

- Already obtained 5 Rainfall Data Loggers from Casella (UK) to replace the manual gauges(One has been installed at the Main Station at the Airport and the rest are soon to be installed);
- The plan is to install as many automatic gauges to obtain Rainfall Intensity and Amount with data availability in Real Time.

The tide gauges on Mahe, at the Pointe Larue Airport and on Denis Island are contiguous to each other. In the past, there has been some good datasets of tide data from Aldabra. There is also the infrastructure for a tide-gauge over Aldabra. It is therefore recommended to have another permanent station over Aldabra. Seychelles' Islands Foundation (SIF) has qualified personnel to retrieve the data to be dispatched to Mahe whenever there is an opportunity.

Farquhar is the southernmost island of the Seychelles and it is directly in the cyclone track. Such cyclones can cause devastating surges and damages to coastal areas. It will be best to install an automatic weather station and tide-gauge on Farquhar and on other islands namely; Coetivy and the Amirantes Group, namely Alphonse.

Presently, physical oceanography is practically an unknown field in the Seychelles. Resources must be made available to provide necessary training to Seychellois, so that as far as possible there will be a **local** expert to carry out quality control and analysis of all available ocean data. Hence, there will be a continuous monitoring of sea level and sea level anomalies for future projections that could occur due to global warming, climate change and other forces. As such, training is required in the field of oceanography at Bachelor's level for analysis, interpretation of data and to carry out research on sea level anomalies and prediction.

There is no local expertise to carry out Tide Gauge installation. However, when the University of Hawaii installed the tide gauges at Pointe La Rue and Denis Island, local technicians were at hand to assist. Local technical staff maintains the gauges and if replacement is required this is done in conjunction with Hawaii.

There is a need for a common set of standards that all observation stations must have in place. However, it should be noted that many observation stations volunteered their services to the NMS with the knowledge that they may only have standards for particular meteorological variables. There was a need to examine the overall facilities, at all these stations, to ensure that there were sufficient calibration standards available to monitor performance and to calibrate the equipment. Therefore, capacities are needed to develop guidelines for calibration as well as for providing guidelines to the applications of accuracy requirements for standards to be applied. The capacities needed are:

- Install automatic weather stations on outlying islands to support international programmes and networks.

- Develop quality standard methods and tools for observations, data management and quality control.

5.3.17 Capacity-Building Needs

It is recommended that fellowships be made available for university training of Seychellois in meteorology and data processing at Bachelor Degree Level. There is also a need to train personnel in the installation, operation, calibration and maintenance of meteorological equipment, tide gauges and computer-based systems if it is to expand the network of observations and monitoring of climate within the Seychelles' archipelago.

Even though in Seychelles much has been done in coastal zone management, sea level monitoring is yet to be integrated in that respect. The measurements currently being carried out by the Seychelles' Coast Guards and the Meteorological Services have been a significant contribution to oceanographic centres worldwide, especially for the TOGA Programme.

It is envisaged that if there could be funding for a Climate Change Information Center, such institution will be in a best position to coordinate activities related to climate monitoring.

5.4 Education, Training and Public Awareness

5.4.1 Introduction

The Seychelles' Government is trying to build a society that is more informed about and resilient to climate change by supporting a Public Education and Outreach (PEO) programme geared towards improving decision-making, encouraging policy changes where required, strengthening information access and data resources for key stakeholders, disseminating project- generated data and information, and fostering public awareness about the potential impacts of climate change.

In keeping with their commitments under Article 6 of the UNFCCC, Seychelles is already promoting the development and implementation of educational and public awareness programmes, as well as public access to information and public participation. Such activities are intended to promote appropriate actions and discourage maladaptive practices for example, reconstruction of buildings in areas that are known to be extremely susceptible to extreme events.

By establishing the Climate and Environmental Services Division in the DOE, government is slowly building capacity to support the implementation of the National Climate Change Strategy (NCCS) by establishing a management system that is efficient, flexible and transparent, and that would facilitate the implementation of the strategic objectives and outputs in the time available, with the financial resources allocated according to the technical specifications and quality standards articulated within the third Environment Management Plan of Seychelles. It is critical now that the population of Seychelles becomes more aware and pro-active in terms of how they can both mitigate and adapt to the effects of climate change. One of the key strategies the country can use to achieve this is through education, awareness and training.

5.4.2 Education

A review of climate change content in the formal education system, including primary, secondary and tertiary education, as well as teacher education was carried out. Generally, the formal education system demonstrates support for environmental education initiatives at all levels of the system. A wide range of environmental topics are included in the primary and secondary curriculum, as well as in the curricula followed by many post-secondary schools, and these touch on climate related issues such as water conservation, energy conservation, coastal erosion and rehabilitation, coral bleaching etc. Several competitions, workshops and theme days have focused on climate change. However, climate change as a topic in itself still needs to be incorporated into the curriculum at different levels, and, perhaps even more importantly, there is an urgent need to produce a set of basic teaching/learning resources on climate change that would allow teachers from all levels and subject areas to design their own lessons (i.e a short film, a booklet, books, posters, etc).

5.4.3 Initiatives Government and NGOs

Numerous initiatives were undertaken by both government and non-governmental actors to promote public awareness of environmental issues. The media, including television, radio and print, has been a key player in many events and campaigns, working in close collaboration with government ministries, parastatals and NGOs. Many national campaigns and events have been initiated by the Ministry of Environment, Natural Resources and Transport, led by its Education, Information and Communication Section, but parastatals, NGOs and the private sector also initiated their own public awareness campaigns and events. All of these stakeholders came together in a workshop in June, 2008 to devise a national strategic plan for public environmental awareness and education, which is still being finalised, and within which climate change should feature as a key issue. Climate change has occasionally been the focus of media programmes or special events, but has not really been dealt with in any great depth in terms of helping the public to understand how it will affect Seychelles; what we can do to mitigate it, and most importantly what we need to do to adapt to climate change.

5.4.4 Information Sharing and Networking

Efforts exist both at the national and international level to promote information sharing and networking on issues of climate change libraries, documentation centres, websites and databases There are, in fact, a wide range of institutions, both governmental and NGO-based, which are engaged in climate related monitoring, and some of these have initiated strategies for sharing their information with researchers, technicians and the public. However, there is a need to establish a mechanism for better coordination and access to information and to establish the role of the National Climate Change Committee (NCCC), while the EMPS Steering Committee will need to be reviewed in that line. Climate change related information should be consolidated and made more accessible through the establishment of a website which would be of benefit to educators, the media, researchers, students, etc.

5.4.5 Sources of Funding

While there certainly are a number of local, regional and international funding sources that could contribute to climate change education, awareness and training, these are very competitive and not focused specifically on the issue of climate change, in particular, for education and awareness. Since education and awareness is considered important enough by the UNFCCC to be part of the SNC, it is clearly worthy of funding support. Seychelles' National Climate Change Committee, the United Nations Development Programme's (UNDP) Project Coordinating Unit (PCU) and the EMPS must coordinate this initiative and inform all stakeholders of funding opportunities as they arise.

5.4.6 Review of Programmes and Policies

Climate change education and awareness is addressed by a number of programmes and policies in the country. This is the case in the EMPS 2000-2010, the Fisheries sector (the Fisheries Development Plan and the Fisheries Policy 2005); wetlands management plans; programmes for coastal erosion and flooding under the UNFCCC; and the disaster management and early warning.

However, in some sectors the main policy documents remain silent on climate change education whilst subsequent policies and programmes address actions to mitigate and adapt to the effects of climate change. One example is the agricultural sector where the national agriculture policy is silent on the issue of climate change though the programmes of action and project actions in the field do take climate change into consideration (e.g an insurance scheme for selected crop and livestock farmers and a study to assess crop varieties, improved water management and irrigation systems as well as changes in planting schedules; the ADS 2007-2011 promotes increased food security through adaptation to changing condition, mitigation measures to climate change and increased local production). An effort should be made to address the issue of climate change education and awareness in all policy documents and programmes in a coordinated manner throughout each and every sector.

It is felt that education, awareness and training of climate change issues is not sufficiently addressed in certain sectors and should be further enhanced. This is the case of the HRDP; the National Wetlands Policy; development, land use policy and decision making processes; the Plant Conservation policy; and the health, forestry and land transport and tourism sectors. The new Energy Policy and Water Supply Development Plan being developed should also integrate climate change education and awareness.

The third EMPS for the next ten years, which is currently being formulated alongside the SNC, should provide the mechanism to integrate climate change education awareness & training into all relevant national policies.

5.4.7 Climate Change Education, Awareness and Training Stakeholders Workshop

A stakeholders' workshop was held on October 31st 2008 with the following objectives:

- To enable networking among stakeholders involved in education, awareness and training pertaining to climate change;
- To review past achievements;
- To produce and prioritise a list of recommendations for the further development of climate change related education, awareness and training programmes in Seychelles.

About 45 participants representing government, NGOs and parastatals attended the workshop. Participants provided additional information on other policies, action plans, networking & information sharing mechanism, awareness programmes and formal education programmes. Through group discussions, participants identified the strengths and weaknesses of the existing Climate Change education, awareness and training mechanisms, programmes and policies in place and made recommendations on how to improve the deficiencies identified. Participants also identified target audiences. This was not an exclusive list; simply a starting point focusing on audiences who have not been targeted yet, and would benefit from some kind of educational intervention. These included the following: tour operators/divers; tourists (different star types); policymakers- MNA's; SEYPEC, PUC; fishermen; artists; garbage collectors; media; hotel owners/managers; government & parastatal employees; Planning Authority; hospitals/RCSS); households (families); farmers (livestock, crops); industry–private sector; students/teachers; construction professionals (architects, builders, contractors); civil society: ngos, senior citizens, community, faith communities(priests, nuns etc.), animators (3rd age & NRA); donors; foreign investors & offshore businesses; car owners, drivers, taxi drivers, SPTC; researchers/scientists; police, army.

5.4.8 Recommendations from the Workshop

Participants strongly recommended that funds be made available for the implementation of priority education, awareness and training activities on climate change and urged the National Climate Change Committee to support this initiative**.** Please refer to **Annex 4** for the list of recommendations from the workshop.

5.4.9 Strategy to raise Public Awareness and promote Education related to Climate Change Issues

Goals:

All climate change education/awareness/training campaigns simultaneously must encompass three broad goals:

- Increase knowledge about climate change, the causes, the impacts, and what people can to help reduce it or adapt the changes in store;

- Help people develop attitudes of caring for each other and the environment (engage emotions);
- Help people adopt and practice changes in behaviour in response to climate change.

Climate change education, awareness and training programmes can only be successful if they are supported by political will through the unconditional enforcement of laws and policies related to environmental protection. Furthermore, any actions taken to promote greater awareness of climate change among the public, local businesses etc must be matched by opportunities to put the ideas into practice e.g availability of energy saving bulbs or appliances, water drums, solar water heaters, etc. Finally, any education or awareness strategies or policies must take into consideration the specific cultural contexts of the Seychelles.

5.4.10 Recommendations:

- Use this report as a policy document for climate change education and awareness, and provide support to integrate climate change education into all sectoral policies and strategies, i.e Energy Policy, Agriculture Policy, Education Policy, and National Environmental Education & Awareness Strategy, etc;
- Implement specific strategies and action plans for climate change education/ awareness and training focusing on specific target groups and ensuring that all sectors of society are included, as established in this study, with input from stakeholders;
- Promote ongoing stakeholder/community involvement in decision making regarding climate change education, awareness & training at national and district levels. Stakeholders would include NGOs, private sector, government agencies, community groups, youth, etc;
- Establish and nurture a common approach and mechanism for networking, partnership and information sharing among stakeholders, within the framework of the NCCC and the EMPS;
- Establish a system of sustainable financing for climate change education, awareness and training programmes;
- Use local case studies showing how Seychellois can help mitigate climate change and adapt to its impact.

In order to implement these recommendations, action was drawn up and is attached in **Annex 3**.

The formal education system demonstrates great commitment and support to environmental education initiatives in and for primary and secondary schools, and to a lesser extent environmental education in post-secondary institutions. A wide range of environmental topics are included in the primary and secondary curriculum, as well as in the curricula followed by many post-secondary schools, and these touch on climate related issues such as water conservation, energy conservation, coastal erosion and rehabilitation, coral bleaching etc.

However, the specific issue of climate change is not yet included as a topic in the primary or secondary school curriculum in any subject, and is only included as a topic in a few specific programmes at post-secondary level, namely: A level Geography at SALS, Fisheries Science at MTC, and primary teacher education at the NIE. Only at the SAHTC is climate change included as a compulsory topic covered by all students in the school.

There is however, great interest in further incorporating climate change and related issues into the curriculum at secondary and post-secondary level, but teachers are constrained by a lack of audio-visual resources related to climate change. To promote climate change education in schools, teachers must have access to more local audio-visual resources (i.e. a short film or PowerPoint presentation on climate change in Seychelles, posters, fact sheets for students, etc) as well as books and other resource documents in their school libraries.

Although climate change is not a major focus in the curriculum at any level of formal education, it has, however, been the focus of a number of different extra and co-curricular competitions, workshops and theme days coordinated by the Ministry of Education's Environmental Education Unit, particularly in the last two or three years.

Similar to the formal education sector, there have been numerous initiatives in Seychelles by both government and non-governmental actors to promote public awareness of environmental issues. The media, including television, radio and print, has been a key player in many events and campaigns, working in close collaboration with government ministries, parastatals and NGOs. Many national campaigns and events have been initiated by the Ministry of Environment, Natural Resources and Transport, led by its Education, Information and Communication Section, but parastatals, NGOs and the private sector also initiated their own public awareness campaigns and events. All of these stakeholders came together in a workshop in June, 2008 to devise a national strategic plan for public environmental awareness and education, which is still being finalised, and within which climate change should feature as a key issue. Climate change has occasionally been the focus of media programmes or special events, but has not really been dealt with in any great depth in terms of helping the public to understand how it will affect Seychelles, what we can do to mitigate it, and most importantly what we need to do to adapt to climate change.

5.5 Information Sharing and Networking

5.5.1 Introduction

Libraries and general documentation centres exist locally and these include the National Library, Alliance Francaise, and Documentation Centres at SBS, DoE, DNR and the Ministry of Education (MoE). Seychelles has various government and NGO environmental websites and databases which have been put in place to promote and facilitate public access to information and information sharing. The following are some examples:

- National Meteorological Services www.pps.gov.sc/meteo/;
- Department of Environment www.env.gov.sc;
- Nature Seychelles www.natureseychelles.org;
- Sea Level Rise Foundation www.sealevel-rise.org ; www.sealevelrise.blogspot.com;
- Island Conservation Society www.islandconservationsociety.com;
- Sustainability for Seychelleswww.s4seychelles.com;

- Marine Conservation Society of Seychelles www.mcss.sc;
- Denis Island www.denisisland.blogspot.com

Committees at the national level promote information sharing and networking such as the Environment Management Plan of Seychelles' Steering Committee (EMPS-SC), which oversees the implementation of the EMPS 2000-2010, the main policy document guiding sustainable development in the Seychelles; and the National Climate Change Committee (NCCC), which guides the implementation of national actions under the UNFCCC.

A **GIS Unit** exists within the Ministry of National Development. Its role is to create data, provide assistance to other organisations in creating data, provide technical support, advice and guidance to other organisations and provide basic information on standards to follow for creation of data. All governmental agencies and other defined users can obtain access to information subject to conditions on the use of the data obtained. Information for governmental organisations is free of charge whilst the public have to pay a fee.[14] A national survey of the major wetlands of Mahé, Praslin and La Digue has been completed and is now available on GIS.

There is much networking between many organisations. Most partnerships established are between organisations with similar objectives in terms of management and conservation of the environment and sustainable development, such as partnership in the field of plant conservation for the development of a National Plant Conservation Strategy or networking in the field of turtle conservation for the ultimate establishment of a management plan for turtles of the Seychelles.

5.5.2 The Sea Level Rise Foundation (SLRF)

The Sea Level Rise Foundation (SLRF), a non-profit organisation, was launched on 25th September 2007. It aims to provide a mechanism to bring global attention on the impacts of climate change on small island states and other low-lying areas with a more focused effort for adaptation to sea-level rise. Most of the initiatives are either at initial stages or are still being negotiated. Its main awareness tool is its website with a local version for the Seychelles. Partners and networks are being identified to create an online resource knowledgebase and clearinghouse for sea-level rise related research, technologies, tools and practices. This will support a common platform for the exchange, research and exchange of techniques and technologies to address adaptation to sea level rise. The SLRF aims to focus on capacity building and knowledge transfer to reduce vulnerability to sea level rise by mobilising resources to this end.

[14] Henriette, E. (2005) "The National Implementation Structure for the AEIN."

5.5.3 Beach Monitoring Programme

The Beach Monitoring Programme undertaken by the Environment Engineering Section (EES), in partnership with hotel owners and NGOs, focuses on the beaches of the main islands of Mahé, Praslin, La Digue, Ste. Anne and Silhouette. Its main objectives are to establish a long term monitoring system for Seychelles' beaches, creating a database of beach profile for Seychelles with data being collected every 1-3 months. Hotel employees are trained in methods of taking beach profile measurements and on the management approaches for the sustainable use of the beach, and are sensitised on the issue of sea level rise and coastal erosion and their potential effects on the beach.

5.5.4 Hydro Graphic Surveys

The Seychelles' Coast Guards (SCG) undertakes **hydro graphic surveys** in the country and is currently creating a database to that effect.

5.5.5 Coral Reef Monitoring Network

As part of its regional environment programme, the Indian Ocean Commission (IOC) launched a Regional Coral Reef Network in 1998, linking National Coral Reef Networks that were created in all member countries of the IOC. A monitoring programme of a number of coral reefs was initiated in each country; the programme would study both the coral cover of the reefs and the fish population of certain key species, mainly species that are of commercial value or can act as a bio-indicator of the ecosystem health. A status report is produced each year, both nationally and regionally. The regional data is then fed in a global database held by the Global Coral Reef Monitoring Network (GCRMN).

A **national sea surface temperature (SST) monitoring network** is in place in the country.

Information sharing and networking information on climate change is shared between neighbouring countries participating in the CORDIO project. Seychelles, through SCMRT-MPA is a member of WIOMSA and is also participating in projects such as Earthwatch.

Disaster/ Early Warning System: The DRDM secretariat coordinates responses to disasters at the national level.

The National Meteorological Services (NMS) has been designated as the Tsunami Warning Center for the Seychelles. It main activities include data observation and monitoring, seismic observation, tide/sea level monitoring, and dissemination. Tsunami advisories/warnings are normally dispatched to the DRDM Secretariat, to environmental and to media authorities. The partners are as follows: NMS, Seychelles National Oil Company (SNOC), Telecoms, Department of Risk and Disaster Management Secretariat and DOE.

For the tsunami warning centre, local tsunami warning templates have been prepared and loaded on the 'SYNERGIE' data and information system. Emergency addresses, telephone and fax numbers including mobile numbers have been reviewed, updated and published. Mobile service for alerts has also been implemented. Tsunami advisories/warnings are normally dispatched to the Department of Risk and Disaster Management Secretariat, to environmental and to media authorities.

A database exists with information on past disasters and events.

5.5.6 African Environment Information Network (AEIN) Project

The **African Environment Information Network (AEIN) project** was launched in 2004. This is a capacity building programme aimed at testing ways in which the Seychelles can harness and enhance access to information and knowledge to support the management of environmental resources, and reporting on both national (Status of Environment Reports) and regional (Africa Environment Outlook) levels. The AEIN implementation strategy focuses on developing a structure and support mechanism for collating and storing relevant data, harnessing professional skills and expertise within the country to analyse and generate policy-oriented information, and then using information and communication technologies to communicate this information to decision makers at various levels of society. The Seychelles along with twelve other African countries were chosen as pilot countries to participate in the AEIN initiative. The Ministry of Environment, Natural Resources and Transport of the Seychelles (MENRT) was mandated to implement this initiative at the national level.

5.5.7 Ocean Data and Information Network for Africa (ODINA)

The **Ocean Data and Information Network for Africa (ODINA)** The management of Ocean Data and Information Network for Africa (ODINA) was an Intergovernmental Oceanography Commission project which is being implemented in the Seychelles since 2003. It aims at the creation of metadata of marine data collected in the Seychelles waters through inventories, training of people in oceanography and ocean data collection, and finding ways to manage ocean data. Various organisations are involved in this initiative such as the MENRT, SFA, SCMRT-MPA, Marine Conservation Society of Seychelles (MCSS), SNOC and Nature Seychelles. Funding was obtained for conducting training including training in software use, workshops, undertaking of inventories and purchasing of necessary application software. The scope of the project was extended to include biodiversity, coastal zone and modelling of climate. The project is currently ongoing.[15]

5.5.8 The Seychelles National Clearing-House Mechanism

The Seychelles' national Clearing-House Mechanism (CHM**)** was set up under the Convention on Biodiversity (CBD). The CHM is a global cooperation and information network on the conservation and sustainable use of biological diversity and has three goals, which are necessary for achieving the goals of

[15] Henriette, E. (2005) "Preparation of the Country Implementation Plan for an Environment Information Management Systems/Network for the Seychelles."

the CBD: Cooperation - the promotion and facilitation of scientific and technical cooperation; Information Exchange - the development of a global mechanism for exchanging and integrating information on biodiversity; and Network Development - the development of the CHM Focal Points and their partners. Though the main objective of the CHM is to promote and facilitate scientific and technical cooperation, the CHM will also provide an information exchange service to enhance the capacity of countries to cooperate in the development of policies and technologies and assist countries in developing partnerships through joint programmes. In 1997, the Seychelles received assistance from the GEF Biodiversity Enabling Activity through the United Nations Environment Programme (UNEP) to support the initial establishment of the CHM, through the purchasing of equipment to make the CHM functional. Today, the Seychelles' national CHM is functional but not yet fully operational. There is as yet no interactive website to house the CHM functions and to allow for networking with national biodiversity information sources either nationally or internationally.[16]

The CBD seeks to develop an electronic portal and an alternative information and dissemination mechanism for the establishment of a global Communication, Education and Public Awareness network.[17] The aim is to link the portal to other networks, websites and communication for example the UNFCCC's website.

5.5.9 Nairobi Convention[18] Clearinghouse

The goal of the **Nairobi Convention[19] Clearinghouse** and information sharing system on the Eastern African coastal and marine environment is to improve the coordination and participation of the Western Indian Ocean countries in the management of their coastal and marine resources through efforts to develop outreach information, networking and public awareness for an effective management approach. The project is designed to enable the Nairobi Convention develop a comprehensive information base and access services to quickly provide information to decision makers. The objectives of the project are: to develop human resource capacities and appropriate information infrastructure to enable countries fully participate and benefit from lessons learnt from national and cross border activities; to develop an enabling environment for assessment through advocacy of standards necessary to acquire, process, store, distribute and improve utilisation of essential data in the region; and to

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[16] Henriette, E. (2005) "Preparation of the Country Implementation Plan for an Environment Information Management Systems/Network for the Seychelles."

[17] CBD Decision VI/19, 1 and CBD Decision VI/19, Annex (programme of work for a Global Initiative on Communication, Education and Public Awareness).

[18] The Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region 1985

[19] The Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region 1985

provide access to scientific, technical, environmental, legal and policy level information essential for the sustainable development of the coastal and marine environment. In working with partners and collaborating institutions, the project will enable the Nairobi Convention to collect, integrate and analyse the rich data collections available in the region and present the results in forms that specialists and non-specialists can understand. The project aims to provide a shared-services platform of accessing resources while being responsive to users needs.[20]

5.5.10 ReCoMaP

ReCoMaP is setting up a Knowledge Management System on Integrated Coastal Zone Management (ICZM) which will remain operational beyond the duration of the ReCoMaP project. Stakeholders will be able to contribute and access information from this system remotely.

5.5.11 Further Information Sharing and Networking

Further Information Sharing and Networking at the national level is enhanced through committees such as the EMPS Steering Committee and the National Climate Change Committee (NCCC), which comprise stakeholders involved in the climate change and environmental management processes. However, there is a need to establish the most appropriate mechanism for better coordination and access to information, and therefore the role of the NCCC and the EMPS Steering Committee will need to be reviewed in that line. As the role of the NCCC is limited, focusing exclusively on the development of the Second National Communication projects, it is felt that it should be also involved in the implementation phase of the Second National Communication and, particularly, in education and awareness. Furthermore, the role of the NCCC should be extended to ensure that climate change considerations are integrated into all relevant national policy developments. This can be achieved under the EMPS framework. It is timely that the formulation and development of the third EMPS for 2010-2020 is currently taking place. The NCCC should be directly involved in this process.

In addition, climate change related information should be consolidated and made more accessible to technicians, policy makers and the general public through the establishment of a website with information about climate change mitigation and adaptation for different target groups (teachers, students, contractors, businesses etc).

5.6 Climate Change Capacity Building Framework

The implementation of effective capacity building for climate change stems out from the Environment Management Plan 2000-2010 of the Seychelles. This plan, which identifies both climate change and capacity building as cross-sectoral issues, identified a number of areas where climate change capacity

[20] UNEP The Nairobi Convention Clearing House and Information System Information Sheet

building is linked to the wider strategy of sustainable development and conservation of biodiversity. The 2002 'Report to the UNFCCC regarding Seychelles' participation in the Global Climate Observing Systems (GCOS) and on Systematic Observation in Seychelles (GOS, 2002), with a specific section on capacity building needs for systematic observations.

Indeed, there have been a number of workshops and conferences aimed at raising awareness on the issue of climate change, but programmes aimed at building capacity for climate resilience and adaptation is virtually non-existent. Training programmes offered through some of the regional projects have been useful. The need to build capacity in adaptation and mitigation actions at all levels is therefore a priority for the Seychelles. The main priority areas for capacity building for climate change is outlined in the draft national circumstances report (Agricole, 2009) and the National Capacity Self Assessment Report (NCSA) for Climate Change (GoS, 2004).

Agricole (2009) concluded that there is an urgent need for supporting the capacity building process in climate change, with attention given to the capacity building of the Climate and Environmental Services Division (CESD) to deliver the information required by all stakeholders on climate change. Seychelles faces a lack of professionals in climate change, oceanography, meteorology, and other related fields (

Table 63). There is also a lack of appropriate instruments specialists. Capacity building is therefore seen as a critical area in planning for long term meteorological, oceanographic and climate monitoring.

Agricole (2009) prioritised the following areas of capacity building needs:

- Strengthen and increase observational networks over the islands of Seychelles, through community and private sector participation*;*
- Establish a database related to the performance of all basic meteorological instruments;
- Enhance efforts to monitor, document, understand and model climate processes and consequences at local, island, national and regional levels;
- Strengthen support for research and observing systems for meteorological/atmospheric, oceanographic and terrestrial variables in the Seychelles' archipelago, including the engagement of local observers and practitioners in the design and operation of climate observing systems;
- Improve information on the nature and consequences of climate conditions. Develop and apply predictions of climate variability on various timescales as well as reliable projections of climate change;
- Improve baseline information, including that on the physical, human and built environments, to better support monitoring and assessment studies at local, island, national and regional scales;
- Improve historical data sets that incorporate observations and insights from scientific and traditional sources (including anecdotal data) to better document past climate variability and the resilience of Indian Ocean island communities and ecosystems;
- Improve understanding of extreme events, from the frequency and severity of tropical cyclones and ENSO events to trends in heavy precipitation, including current patterns of frequency and severity and improved projections of how those patterns might change.

Table 63: Summary of Seychelles' Programme for Future Capacity Needs For Systematic Observations (Source: Agricole, 2009).

MANPOWER	**Current**	**Desired number**	**On training**	**Implementation Date**
WMO Class I Oceanography Hydrology Information Technology	2	8	None	2010- 2019
WMO Class II Oceanography Hydrology	7 1 0	10 2 2	None	2010-2019
WMO Class III & IV Aviation Oceanography/Marine Hydrology Agrometeorology	18	25		2010- 2019
Engineers / Technical Oceanography/Marine Hydrology Agro-meteorology Climatology	5	8	None	2010 - 2019
Climatologists Oceanographers Coastal Engineers Hydrologists Researchers CC Project officers CC Economists CC Negotiators CDM Specialist	1 1 1 0 3 1 0 2 1	3 2 2 2 3 3 2 3 3	None	2010- 2019

Chapter 6

Constraints and Gaps, and Related Financial, Technical and Capacity Needs

CHAPTER 6 CONSTRAINTS AND GAPS, AND RELATED FINANCIAL AND TECHNICAL AND CAPACITY NEEDS

6.1 Introduction

This chapter covers the information on constraints and gaps and related financial technical and capacity needs recognised through the preparation of the Second National Communication (SNC). This analysis examined the different constraints and gaps in the main chapters of the SNC and made proposal how to address them. It also examined the conformity of the methods used with UNFCCC recommendations for the accuracy, transparency and comparability of reporting, and the consistency according to the UNFCCC guidelines for the preparation of national communications from Non-Annex I Parties.

It also consists of background information on the analysis of constraints and gaps of the National Greenhouse Gas (GHG) Inventory, Mitigation Measures of GHG, Vulnerability and Adaptation Measures of the SNC. It also looks at capacity building, technology transfer, systematic observations and finance and come up with recommendations on how to address these in subsequent national communications.

References are also made to the gaps, constraints and needs relating to human resources development to increase the local knowledge base, institutional and infrastructural capacity-building, access to and adequacy of methodologies and the promotion of information sharing and networking. It also includes the need to mobilise financial resources to conduct studies, implement adaptation and mitigation projects and strengthen the legislative and institutional framework.

6.2 National Greenhouse Gas (GHG) Inventory

The National GHG Inventory is a key component of the SNC. Therefore, compiling a National GHG inventory requires a fairly lengthy and interconnected series of tasks, including collecting emission factors and activity data, selecting appropriate methods, estimating GHG emissions and removals, implementing uncertainty assessment and quality assurance/quality control procedures, reporting the results and documenting and archiving all relevant data and procedures.

This work requires fundamental decisions about data and methods, the establishment of a network of contacts for accessing data and reviewing results and the design of a system for data management, quality assurance, quality control, documentation and archiving. The inventory process should be planned, operated and managed to ensure optimal quality and efficiency, given available resources.

More accurate inventories enable a country to identify major sources and sinks of GHGs with greater confidence, and thus allow it to make more informed policy decisions with respect to appropriate response measures. For example, a technically defensible GHG inventory can serve as the foundation for public policy as it relates to air quality issues. Formulation of appropriate control strategies requires a reliable base of accurate emissions estimates. If the data used to derive control strategies are flawed, the public policy resulting from the strategy may also be in error. These errors can be costly to the public being exposed, the industries or economic sectors that are being controlled and to the environment.

6.2.1 Constraints and Gaps

The constraints and gaps identified to conduct the GHG inventories were the following:

- Data gaps and data availability in the format and quality needed for GHG inventory preparation;
- Non-applicability of emission factors especially in the land use, land use change and forestry sector;
- Lack of institutional arrangements for data collection and data sharing;
- Data are often available in formats that suit government planning purposes, but do not cover all the information required by the IPCC methodology for inventory.
- Improvement in data acquisition, analysis, management and dissemination;
- Development of local emission factors, where appropriate;
- Reduction in data uncertainties, especially in the land use, land use change and forestry sector;
- Development and regular update of an efficient activity database for all key socio-economic sectors;
- A database of emissions generated or sequestered is necessary, which requires sectoral co-operation in order to generate and collate useful data for improving the quality;
- Unavailability of local emission factors, thus the IPCC default values were used;
- Lack of participation of private sector;

Moreover, it has to be pointed out that a lot of time was wasted analyzing raw data, which were on hard copy, thus making the inventory process longer and more difficult. This was especially applicable to the energy sector. There were constraints to obtain data on the amount of forest converted to infrastructure development and also on the amount of trees harvested for commercial purpose.

There are very few people that are knowledgeable and competent to carry out GHG inventory, as such, it is difficult to get good quality inventory at sector level. The Sector Consultant for Waste and Industrial Processes did not complete the inventory, and there was no other competent person to complete this task, and as such, the Lead Consultant had to complete the inventory for these sectors. There was a lack of commitment from sector consultants to complete the inventory on time, and as such, the preparation of the inventory took longer to complete than expected.

6.2.2 Capacity Building Needs

In order to facilitate the preparation and improvement of future GHG inventories, it is recommended to address the identified Constraints and Gaps by implementing the following capacity building needs:

- Capacity building for inventory preparation through provision of training for local sector experts to undertake GHG inventory;
- Training of sector experts and consultants on the use of the new IPCC guidelines, methodologies, tools and software for GHG inventory;

- Design a structure and mechanism like a Clearinghouse and Information Sharing Mechanism for quality data collection and format, analysis, storage, retrieval and dissemination of data that are needed for preparation of GHG inventory;
- GHG inventory is carried out for the year 2005 as soon as possible;
- Yearly inventories are prepared for the Energy and LULUCF sectors from 2005 onward;
- An ongoing programme for education and awareness of GHG inventory is put in place.
- Develop the local capacities in using the new guidelines, methodologies, tools and software;
- Secure and mobilise financial resources to address the above mentioned needs.

6.2.3 Recommendations for Subsequent National Communications

Data Organisation

Where there is a mismatch in sectoral detail across different published documents, inconsistency in top-down and bottom-up data sets for same activities and data scattered in many agencies, the following are recommended:

- National GHG Inventory is assigned to lead sectoral agency;
- Establish sectoral disaggregation of data for higher tiers,
- Establish consistent key categories for each sector;
- Develop a centralised database with the design consistent with reporting formats and adopt IPCC requirements for reporting raw data.

Non-availability of Relevant Data

Where the data for refining inventory to higher tiers are not available, the following are recommended:

- Data requirements for GHG inventory would be sourced through the National Bureau of Statistics and other relevant stakeholders for future GHG inventories;
- Improve data depths as some require data surveys on all sectors.

Non-accessibility of Data

As there is lack of institutional arrangement for data sharing, time consuming to compile data and time delays in data access, the following are recommended:

- Establish better institutional arrangements for data sharing by setting up a Clearing House Mechanism and Data Sharing System;
- Establish and regulate systems for collection, formatting and presentation of data and information required for the planning and the preparation of the national inventory and other successive National Communications;
- Establish protocols and effective networking with data providers which will involve industry and monitoring institutions

Technical and Institutional Capacity Needs

Training in data gathering for relevant institutions in GHG inventory methodologies and data formats is needed and hence it is recommended to organise extensive training programmes.

Non-representative Emission Factor /Coefficients

There is inadequate data for representative emission measurements in the sectors and hence it is recommended to conduct measurement for key categories and develop local Emission Factors**.**

6.3 Mitigation Measures of GHG

6.3.1 Introduction

The constraints and gaps for the Mitigation Measures of GHG's chapter of SNC depend to a great extend on the outcome of the National GHG Inventory. Even though it is not binding for Seychelles as a Non-Annex 1 party to implement GHG mitigation options, the country stands to benefit, since it will lead to reduction in the growth of the energy demand of the country. Implementing GHG mitigation options in the energy consuming sectors will assist toward limiting the demand for petroleum products and reduce the energy bill of the country. Apart from implementing mitigation options to limit the growth in the demand for petroleum products, the country should seriously consider options for increasing the use of renewable energy technology, especially wind and solar. Renewable energy technology has a great potential in contributing significantly to the energy demand of the country.

6.3.2 Constraints and Gaps

The main constraints and gaps faced to prepare the GHG mitigation options were the following:

- Lack of data availability and quality;
- A lot of time was wasted in the collection and analysis of raw data, which were in hard copy, thus making the process longer and more difficult. The data collection process was like a project in itself. It is to be noted that if in future the data issue is not sorted out, it will definitely be required to undertake a separate project for data collection and analysis;
- Insufficient capacity to undertake mitigation studies on a sectoral basis, and mitigation options then identified and prioritised in accordance with key development initiatives and policies;
- Lack of institutional, scientific and technological capacity to respond to climate change;
- Lack of data in sectors other than energy;
- Limited expertise in the energy models;
- Limited technical expertise in some sectors such as transport and agriculture;
- Weak awareness among decision makers on climate change in general and on financial and environmental benefits of CDM;
- Lack of technical capacity in the least-cost analysis taking into account the environmental costs and benefits;
- Lack of technical capacity in the assessment and transfer of appropriate mitigation technologies;

- Lack of technical capacity in the development of mitigation strategies and policies;
- The ability to respond to climte change issues are hampered by the limited institutional, scientific and technological capacity.
- There is a need to improve public and political understanding of the potential impacts of climate change;
- Lack of information systems on construction and coastal adaptation technologies and land-use planning tools.

6.3.3 Capacity Building Needs

The objectives of the capacity building needs identified in the Mitigation Measures of GHG's chapter are the following:

- To improve data acquisition, analysis, management and dissemination;
- To develop local emission factors where appropriate;
- To reduce data uncertainties, especially in the land use, land use change and forestry sector;
- To develop and regularly update an efficient activity database for all key socio-economic sectors;
- To develop analytical techniques to prioritise mitigation options for energy conservations and renewable energy;
- To undertake mitigation studies on a sectoral basis, and mitigation options then identified and prioritised in accordance with key development initiatives and policies;
- To develop mitigation strategies and policies;
- To develop institutional, scientific and technological capacity needs to respond to climate change.

6.3.4 Recommendations for Subsequent National Communications

- Set up the necessary mechanism for data collection, analysis, storage and dissemination;
- Train GHG Mitigation Experts as there are very few local experts that are knowledgeable and competent to carry out GHG mitigation report so as to avoid delay in future;
- Build institutional and administrative capacity to implement the climate change programme of actions which must be strengthened at all levels by supportive partnerships and cooperation, including technical and financial assistance, the further development of legislation and mechanisms for information collection, monitoring and sharing.

6.4 Vulnerability and Adaptation Measures

6.4.1 Introduction

In the preparation of the Vulnerability and Adaptation Measures' chapter of the Second National Communication (SNC), the need to focus on the most vulnerable sectors which were agriculture, water, coastal zone and fisheries were confirmed. These sectors are the main indicators of national vulnerability to climate change and appropriate measures are needed to adapt. The constraints and gaps were identified to be used to upgrade and improve the subsequent National Communications, thus obtaining more accurate assessment at national level in future.

Needs for technical and financial support to complete vulnerability assessments and measures needed to adapt were further identified. Assistance needed for undertaking studies in relevant sectors not covered in previous work was also identified. Needs included building capacity to use and to improve climate impact models and to promote education and training. Other needs were related to capacity to collect and update relevant information, including data, and to undertake long-term monitoring activities. There was a need for enhancing existing methodologies and the capacities to undertake integrated assessment of climate change impacts in different sectors (such as water resources, agriculture and human health, coastal zones, human settlements, biodiversity, etc.). There was also a need to make a detailed assessment on the relationships between climate change impacts and impacts of extreme events and climatic variability events (such as El Niño, storm surges, strong winds due to tropical cyclones, etc.) including changes in their frequency and intensity.

6.4.2 Constraints and Gaps

There exist problems in developing climate change scenarios for assessing vulnerability of different sectors to climate change. One of the major areas of concerns is related to the use of general circulation models (GCMs). The definition of space and scope of GCMs limits the local and regional use. There is a need to enhance the capacity of local scientists to adapt, develop and run a climate model to generate relevant and localised scenarios for local use and for weather, as well as impacts of climate change on the environment. Further assistance are needed to undertake training and research on predictive modeling and interpretation of outputs of models and also the need for assistance to undertake or further improve socio-economic scenarios and, in particular, needs to integrate climate change impacts and concerns into the broader context of social development priorities.

Main Deficiencies in Addressing Climate Change Issues

- Lack of capacity in the development of adaptation project guidelines;
- Lack of financial resources and awareness;
- Lack of adequate tools, knowledge and methodologies;
- Lack of incorporation of climate change in developing policies, strategies and plans of climate sensitive sectors;
- Lack of capacity to adopt measures that will enable Seychelles to cope effectively, creatively and sustainably with Climate Change and Sea Level Rise, as well as to mitigate impacts on and reduce threats posed to marine and coastal resources;
- Lack of climate change scenarios and downscaling models at regional level;
- Non-applicability of current global and regional climate models to the condition of the Seychelles, which consists of a large groups of islands spread over a large EEZ of ocean;
- Limited capacity to enhance on case studies of extreme weather events, documentation and dissemination of study reports;
- Data availability, consistency and transparency was one of the main identified problems faced during the preparation of climatic scenarios and thematic vulnerability and adaption studies;
- Lack of regional climatic prediction models and downscaling models, thus Global Circulation Models (GCMs) were used with high spatial distribution;

- Lack of well developed methodologies and tools worldwide for undertaking vulnerability and adaptation studies especially for health and socio-economic sectors;
- Limited local and international V&A studies to perform comparisons with the studies conducted during the SNC preparation and to verify the results obtained;
- Lack of financial resources to address needs, conduct research and studies, and implement adaptation measures;
- Lack of capacity on predictions of extreme events and Early Warning System (EWS) to assure preparedness, thus reducing impacts;
- Lack of capacity to assess the effects and the socio-economic implications of the impact of climate change, climate variability and Sea Level Rise (SLR);;
- Lack of capacity to map areas vulnerable to SLR and to develop computer-based information systems covering the results of surveys, assessments and observations as part of the development of adequate response strategies, adaptation policies and measures to minimise the impact of climate change, climate variability and SLR;
- Lack of capacity to develop integrated coastal zone management plans, including measures for responding adaptively to the impacts of climate change and SLR;
- Lack of technical expertise on climate change scenarios to apply to relevant impact models;
- Lack of capacity in the marine sector, such as coastal zone management;
- Lack of capacity to better understand the impacts of climate change on agriculture (crops, livestock, forests etc.) possible adaptations to such change, and interactions with invasive/alien species;
- Lack of capacity in analysing coastal dynamic processes;
- Lack of capacity and skills development in coastal engineering across all sectors;
- Lack of capacity to better understand the coral reef ecosystems, coastal erosion processes, and land at risk from flooding and inundation. This requires an integrated approach, encompassing ongoing research, monitoring and capacity building including training, developing local expertise, strengthening institutions and improving integration of traditional and modern knowledge;
- Lack of capacity in the identification and promotion of traditional knowledge, skills and practices which enhance adaptation;
- Lack of community participation.

6.4.3 Capacity Building Needs

The Vulnerability and Adaptation chapter of SNC are in need of capacity development with the following objectives:

- To help improve the development of sea-level rise scenarios and monitoring and to adapt models to local conditions;
- To formulate comprehensive adjustment and mitigation policies for Sea Level Rise (SLR) in the context of integrated coastal area management;
- To assess the effects and the socio-economic implications of the impact of climate change, climate variability and SLR;
- To map areas vulnerable to SLR and develop computer-based information systems covering the results of surveys, assessments and observations as part of the development of adequate response strategies, adaptation policies and measures to minimise the impact of climate change, climate variability and SLR;

- To develop integrated coastal zone management plans, including measures for responding adaptively to the impacts of climate change and SLR;
- To improve regional information on future climate and sea-level changes as well as the cumulative and indirect effects of such changes;
- To conduct a national mapping exercise to identify coastal areas that are susceptible to the impacts of sea-level rise and to develop a national coastal vulnerability index;
- To undertake assessment in the area of water resources is underscored and specific needs include capacity to link climate change impact models to hydrological models and to adapt them to local conditions;
- To enhance the marine sector, such as coastal zone management;
- To better understand the impacts of climate change on agriculture (crops, livestock, forests etc.) and adaptation to such change, and interactions with invasive alien species;
- To enhance capacity in analysing coastal dynamic processes;
- To enhance capacity and skills development in coastal engineering across all sectors;
- To better understand the coral reef ecosystems, coastal erosion processes, and land at risk from flooding and inundation. This requires an integrated approach encompassing ongoing researches, monitoring, capacity building, and training, developing local expertise, strengthening institutional capacity and improving integration of traditional and modern knowledge;
- To improve understanding of impacts of extreme events on infrastructure, human health, agriculture; fisheries, coastal and water sectors;
- To develop a national policy framework to facilitate implementation of appropriate and effective adaptation strategies and mitigation measures;
- To improve meteorological and water monitoring through modernisation of equipment and extension of monitoring networks;
- To collect, manage and monitor data for the updating of basic data sets and databases;
- To conduct vulnerability and adaptation studies in the area of methodologies, tools and guidelines.

6.5 Technology Transfer and Development Status

The main constraints and gaps identified in the preparation of the SNC project can be summarised as follows:

- Lack of appropriate funding for technology transfer and research;
- Routine government procedures and lack of specialised staff in the public sector;
- Lack of incentives and high taxation and customs excise on modern technology;
- Insufficient information and training courses allocated to emphasise the effectiveness and the feasibilities of different technological options;
- Lack of legislative and institutional framework;
- Limited expertise in modern technology maintenance and spare parts availability;
- Limited opportunities for low-cost technology transfer and financial assistance for reducing the emission of GHGs;
- A need to strengthen national capacities for both public and private sector to assess, manage, absorb and utilize new technologies, including indigenous technologies;
- Lack of expertise in the identification and assessment of appropriate technologies;

- Lack of appropriate technology information needs including support for office and other relevant equipment;
- Lack of analysis of constraints to the transfer of technology exchange programmes (between Non-Annex I and Annex I Parties);
- Lack of general awareness raising regarding clean technologies in key sectors such as energy, transport, agriculture and residential sectors;
- Lack of identification and assessment of appropriate technologies;
- Lack of appropriate funding for technology transfer and research;
- Lack of incentives and high taxation and customs excise on modern technology;
- Insufficient information and training courses allocated to emphasise the effectiveness and the feasibilities of different technological options;
- Lack of legislative and institutional framework;
- Limited expertise in modern technology maintenance and spare parts availability.
- High transition cost, hence there is a delay in investing in renewable energy and therefore adopting cheap electricity generating technologies;
- Lack of incentives and motivation for private sector investment to embark on Technology Transfer;
- Lack of capacity to develop and establish close linkages with private sector to promote the transfer of environmentally sound technologies by removing economic barriers.
- Limited opportunities for low-cost technology transfer and financial assistance for reducing the emission of GHGs.

6.5.1 Capacity Building Needs

- Need to develop the capacity of policymakers to establish regulatory framework on the importance of technology transfer in promoting sustainable development by formulating a broad national incentive scheme;
- Need capacity to develop and establish close linkages with private sector to promote the transfer of environmentally sound technology by removing economic barriers;
- Build capacity to inform and encourage private sector investors to reap the benefits of investing in environmentally sound technology.

6.6 Education, Awareness and Training Status

- Lack of trained teachers, trainers and guest speakers, teaching aids and integration of climate change into educational curricula;
- Absence of long-term strategy for environmental education with clearly established national priorities;
- Absence of an effective advisory or planning body to guide the work of the section;
- Limited development of public awareness programmes, production of public awareness materials, and monitoring and evaluation to ensure goals and objectives are met;
- A need to enhance public debates and workshop awareness on climate change issues and the impacts it would have on livelihood;
- Inadequate involvement and consultation;
- Limited information about climate change being made available to the public through school libraries, public libraries and documentation centres;

- Lack of fellowships and scholarships for formal specialised training at scientific and technical levels;
- A need to develop strategies and mechanisms to promote awareness of climate change issues by the National Climate Change Committee (NCCC)

6.6.1 Capacity Building Needs Status

- Capacity is needed to improve public and political understanding of the potential impacts of climate change;
- Capacity is needed to develop and/or strengthen mechanisms to facilitate the exchange of information and experiences;
- A need to develop and promote an effective advisory or planning body to guide the work of the environmental education section;
- Capacity is needed to develop of public awareness programmes, and to provide improved access to information from the activities carried out to reduce uncertainties of climate change and to assist the exchange of this information with the public;
- A need to develop and promote capacity to lead a public debate on climate change issues;
- A need to develop and promote capacity for public participation, consultation and changes in behaviour;
- A need to make climate change information available to educational establishments.

6.7 Research and Systematic Observation Status

- Limited financial and human resources for capacity building to increase the base of local expertise;
- Lack of efficient networking in the research arena necessitates dedicated communication, consistent flow of and updating of information on contacts as well as widening of the net;
- Lack of awareness and knowledge;
- Lack of research, data and information;
- Lack of technical and policy capacity;
- Limited integration of climate change policies into national development strategies and plans.

6.8 Clean Development Mechanism Status

Constraints that need to be addressed for its proper implementation are as follows:

- A lack of human and institutional capacity to make use of the opportunities presented by CDM;
- CDM institutional capacity building needs are considered a priority in the Forestry section;
- A need to establish institutional linkages for implementation of the CDM;
- Lack of CDM institutional capacities for the identification, formulation and design, monitoring, verification, auditing and certification of projects activities;
- A needs to develop the capacity of the policymakers to establish regulatory framework, define baselines and cooperate with national institutions to establish a national CDM authority;
- A need for training on project negotiation skills ;
- A need for CDM demonstration projects to enhance capacity-building (learning by doing), including assessment of costs and risks (long- and short-term);
- Lack of data acquisition and sharing;

- Lack of financial capacity;
- A need for assistance to improve awareness and understanding of the CDM, as well as to assist policy-makers and economic enterprises towards better understanding of opportunities presented by CDM to enhance sustainable development;
- NCCC needs to develop strategies and mechanisms to exploit CDM opportunities.

6.9 Financial and Technical Assistance

One of the principal channels of financial resources and technical support for the preparation of national communications and for activities related to global climate change for small island developing states is the Global Environment Facility (GEF). Seychelles has been benefiting from ongoing support from the GEF through United Nations Development Programme (UNDP) as one of its implementing agencies over the past fifteen years, to support the development and implementation of appropriate adaptation programs aimed at reducing Seychelles overall vulnerability; Since 1998, the GEF and other funding agencies have financially supported Seychelles in executing the following climate change activities listed in Table 64.

Table 64: Climate Change Projects financed by GEF

Climate Change Project	Implementation Date	Budget (USD)
Initial National Communication (INC)	1997-2000	250,000
Enabling Activities phase II (top-up) The adequacy report on the Global Climate Observing System (GCOS) and on Capacity Building for Systematic Observations	2003-2005	100,000
Seychelles Stocktaking Exercise	8-9 June 2004,	15,000
National Capacity Self-Assessment (NCSA)	2004-2005	200,000
Second National Communication (SNC)	2006-2010	405,000

The importance of the financial and technical assistance received from the Global Environment Facility and various bilateral programmes is acknowledged but there is a need for further financial and technical assistance to improve and maintain national capacity to implement the United Nations Framework Convention on Climate Change and to prepare and to submit national communications. General needs identified can be summarised as follows:

- Strengthening of national institutional framework e.g National Climate Change Committees, technical and/or expert teams, etc.) for undertaking tasks related to the implementation of the Convention. The National Communications made references to assistance received from the GEF through the United Nations Development Programme (UNDP) as one of its implementing agencies;

- Enhancing national capacity for policy formulation and planning and the need to improve national legislation;
- Strengthening national coordination and, in particular, the role of the national UNFCCC focal point or national authorities designated to coordinate climate change activities, including coordination of participation in regional and international climate change activities;
- Improving infrastructure and equipment for data collection or monitoring, including by developing databases, providing access to satellite imagery data and monitoring equipment and establishing or upgrading stations for systematic observation of the climate system, and environmental monitoring systems;
- Enhancing the analytical capacity of experts, policy-makers and decision-makers regarding the linkages between technical and political issues related to climate change;
- Promoting the participation of key stakeholders, such as public and private sector, non-governmental organisations, academia, scientific, technical and local communities, and media practitioners;
- Promoting public awareness campaigns and incorporating the subject of climate change into national educational systems along with a need for increasing its opportunities to organise national technical events and workshops for exchange of information and training on climate change;
- Establishing national and/or regional clearing houses for information sharing and networking on climate change issues.

6.10 Conclusion

The SNC of Seychelles attempted to conform to its UNFCCC obligations, and was funded under the enabling activities of the convention. Although Seychelles' contribution to the global climate change is rather insignificant, it is rather apprehensive with the climate change related issues, its future and the future of its national heritage.

The experience and lessons that Seychelles has learned in the preparation of this SNC will guide the National Climate Change Committee in the enhancement of successive National Communications. A case in point is that it became apparent during the collection of data and information for the preparation of this SNC, it was found necessary to set up a proper data and information collecting and recording procedures and frequently updated databases. As a result of this observation, it has prompted the authority to establish a clearing house mechanism and data sharing system.

It should also be noted that National Communications under the UNFCCC are a practical way of spotting constraints, gaps and needs, and form the basis for identification of climate change activities, projects and programmes, and the anticipated financing so as to meet the sustainable development goals of the country as well as to realise the ultimate objective of the Convention.

The information provided on financial and technological constraints associated with the implementation of the Convention in various sections of the SNC has varying level of details.

In general, financial and technical assistance was requested to strengthen national institutional framework and coordination, enhance the capacity for policy development and planning, and improve infrastructure and equipment for data collecting and monitoring.

Others include the enhancement of analytical capacity of experts, policy-makers and decision-makers, promotion of participation of key stakeholders in climate change activities, promotion of public awareness campaigns, and incorporation of climate change in national educational systems.

In relation to the preparation of GHG inventories, this chapter expressed the need for assistance to ensure continuous collection and maintenance of activity data and improvement of the accuracy and reliability of data, especially in the land use and land-use change and forestry sector. Other needs relate to the enhancement of local technical capacity and expertise and the development of country-driven methodologies to estimate emission factors. The specific capacity needs relate to the energy, transportation, agriculture, and waste management sectors.

Financial assistance and access to appropriate technologies were identified as being crucial to the development of integrated mitigation strategies and policies. Specific needs included the promotion of renewable energies and achievement of energy efficiency, increase in sink capacities, research into sustainable agricultural practices, enhancement of national capacities for forest fire management, strengthening of national policies to manage solid and liquid wastes, and the promotion of the use of more energy efficient vehicles.

It also emphasised the need for improving its national capacities to prepare mitigation projects for funding.

Further, there are needs to complete studies initiated during the preparation of the SNC and to undertake vulnerability and adaptation assessment studies in sectors not covered in the national communications.

These included needs for integrated assessments; studies of the relation of climate change impacts to impacts of extreme events; improvement and development of climate change, socio-economic and sea level rise scenarios; development of climate impact models; and enhancing monitoring capacity. Specific measures requiring resources and technology were identified in the areas of water resources, agriculture, coastal zone management and preparedness to extreme natural events. Financial and technical assistance are needed to carry out further assessments of impacts on human settlements, population and health and to facilitate adequate adaptation to the adverse impacts of climate change. These included improvement in information sharing, education and training, as well as technical and scientific research relevant to the development of comprehensive adaptation plans. There is also the need for accessing adequate and appropriate technology to facilitate and ensure the participation of local stakeholders in planning for adaptation.

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ANNEXES

ANNEX 1: WORKSHEETS AND DATA TABLES FOR ENERGY SECTOR

This spreadsheet contains sheet 1 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	ENERGY
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)
WORKSHEET	1-1
SHEETS	1 OF 5
COUNTRY	SEYCHELLES
YEAR	2000

			STEP 1					
			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption
FUEL TYPES								F=(A+B-C-D-E)
Liquid Fossil	Primary Fuels	Crude Oil						0.00
		Orimulsion						0.00
		Natural Gas Liquids						0.00
	Secondary Fuels	Gasoline		7233	0	0	-3380	10,613.00
		Jet Kerosene		31568	0	28427	830	2,311.00
		Other Kerosene		823	0	0	0	823.00
		Shale Oil						0.00
		Gas / Diesel Oil		210180	0	184,125	-9806	35,861.00
		Residual Fuel Oil		39981	0	0	8847	31,134.00
		LPG		2420	0		0	2,420.00
		Ethane						0.00
		Naphtha						0.00
		Bitumen		1079	0		0	1,079.00
		Lubricants		820	0	0	0	820.00
		Petroleum Coke						0.00
		Refinery Feedstocks						0.00
		Other Oil						0.00
Liquid Fossil Totals								
Solid Fossil	Primary Fuels	Anthracite [(a)]						0.00
		Coking Coal						0.00
		Other Bit. Coal						0.00
		Sub-bit. Coal						0.00
		Lignite						0.00
		Oil Shale						0.00
		Peat						0.00
	Secondary Fuels	BKB & Patent Fuel						0.00
		Coke Oven/Gas Coke						0.00
Solid Fuel Totals								
Gaseous Fossil		Natural Gas (Dry)						0.00
Total								
Biomass total								
		Solid Biomass						0.00
		Liquid Biomass						0.00
		Gas Biomass						0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

This spreadsheet contains sheet 2 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

		MODULE	ENERGY				
		SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)				
		WORKSHEET	1-1				
		SHEETS	2 OF 5				
		COUNTRY	SEYCHELLES				
		YEAR	2000				
			STEP 2		STEP 3		
			G [b] Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon Emission Factor (t C/TJ)	J Carbon Content (t C)	K Carbon Content (Gg C)
FUEL TYPES			TJ/tonne	H=(FxG)		J=(HxI)	K=(J/1000)
Liquid Fossil	Primary Fuels	Crude Oil		0.00		0.00	0.00
		Orimulsion		0.00		0.00	0.00
		Natural Gas Liquids		0.00		0.00	0.00
	Secondary Fuels	Gasoline	0.0448	475.46	18.9	8,986.24	8.99
		Jet Kerosene	0.0446	103.07	19.5	2,009.88	2.01
		Other Kerosene	0.0448	36.96	19.6	724.42	0.72
		Shale Oil		0.00		0.00	0.00
		Gas / Diesel Oil	0.0433	1,552.78	20.2	31,366.18	31.37
		Residual Fuel Oil	0.042	1,307.63	21.1	27,590.95	27.59
		LPG	0.0473	114.47	17.2	1,968.82	1.97
		Ethane		0.00		0.00	0.00
		Naphtha		0.00		0.00	0.00
		Bitumen	0.0402	43.38	22	954.27	0.95
		Lubricants	0.0402	32.96	20	659.28	0.66
		Petroleum Coke		0.00		0.00	0.00
		Refinery Feedstocks		0.00		0.00	0.00
		Other Oil		0.00		0.00	0.00
Liquid Fossil Totals				3,666.71		74,260.03	74.26
Solid Fossil	Primary Fuels	Anthracite [a]		0.00		0.00	0.00
		Coking Coal		0.00		0.00	0.00
		Other Bit. Coal		0.00		0.00	0.00
		Sub-bit. Coal		0.00		0.00	0.00
		Lignite		0.00		0.00	0.00
		Oil Shale		0.00		0.00	0.00
		Peat		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel		0.00		0.00	0.00
		Coke Oven/Gas Coke		0.00		0.00	0.00
Solid Fuel Totals				0.00		0.00	0.00
Gaseous Fossil		Natural Gas (Dry)		0.00		0.00	0.00
Total				**3,666.71**		**74,260.03**	**74.26**
Biomass total				0.00		0.00	0.00
		Solid Biomass		0.00		0.00	0.00
		Liquid Biomass		0.00		0.00	0.00
		Gas Biomass		0.00		0.00	0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

(b) Please specify units.

This spreadsheet contains sheet 3 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

		MODULE	ENERGY				
		SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)				
		WORKSHEET	1-1				
		SHEETS	3 OF 5				
		COUNTRY	SEYCHELLES				
		YEAR	2000				
			STEP 4		STEP 5		STEP 6
			L Carbon Stored (Gg C)	M Net Carbon Emissions (Gg C)	N Fraction of Carbon Oxidised	O Actual Carbon Emissions (Gg C)	P Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES				M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil		0.00		0.00	0.00
		Orimulsion		0.00		0.00	0.00
		Natural Gas Liquids		0.00		0.00	0.00
	Secondary Fuels	Gasoline	0	8.99	0.99	8.90	32.62
		Jet Kerosene	0	2.01	0.99	1.99	7.30
		Other Kerosene	0	0.72	0.99	0.72	2.63
		Shale Oil	0	0.00		0.00	0.00
		Gas / Diesel Oil	0.00	31.37	0.99	31.05	113.86
		Residual Fuel Oil	0	27.59	0.99	27.32	100.16
		LPG	0.00	1.97	0.99	1.95	7.15
		Ethane	0.00	0.00		0.00	0.00
		Naphtha	0.00	0.00		0.00	0.00
		Bitumen	0.95	0.00	0.99	0.00	0.02
		Lubricants	0.33	0.33	0.99	0.33	1.20
		Petroleum Coke		0.00		0.00	0.00
		Refinery Feedstocks		0.00		0.00	0.00
		Other Oil		0.00		0.00	0.00
Liquid Fossil Totals			1.28	72.98		72.25	264.92
Solid Fossil	Primary Fuels	Anthracite [(a)]		0.00		0.00	0.00
		Coking Coal	0.00	0.00		0.00	0.00
		Other Bit. Coal		0.00		0.00	0.00
		Sub-bit. Coal		0.00		0.00	0.00
		Lignite		0.00		0.00	0.00
		Oil Shale		0.00		0.00	0.00
		Peat		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel		0.00		0.00	0.00
		Coke Oven/Gas Coke		0.00		0.00	0.00
Solid Fuel Totals			0.00	0.00		0.00	0.00
Gaseous Fossil		Natural Gas (Dry)	0.00	0.00		0.00	0.00
Total			**1.28**	**72.98**		**72.25**	**264.92**
Biomass total			0.00	0.00		0.00	0.00
		Solid Biomass		0.00		0.00	0.00
		Liquid Biomass		0.00		0.00	0.00
		Gas Biomass		0.00		0.00	0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

ANNEX 2: DISTRICTS / ZONES FACTFILE

MAHE ISLAND

Mahe is drained by twenty five main rivers and numerous minor ones. Some of the streams in the districts are mainly intermittent (ephemeral), that is, they flow during the wet season but are dry for most of the year.

The rivers take their source from the mountains and discharge into the sea. The lower reaches of these rivers are greatly influenced by tidal effects. The tides govern the hydraulic behaviour of the flow of the rivers into the sea ***(Drainage Task Force, 2004)***.

1. ANSE AUX PINS AND AU CAP

Anse Aux Pins is drained by two main rivers which flow in swampy areas and finally discharging into the sea. In addition, there exist lined drains which cater for storm water runoff in certain areas, for example near the bus terminal. There is a lack of roadside drains in the district, which result in flooding of certain areas during rainy spells. The situation worsens whenever rainfall coincides with very high tides, accumulated sand blocking the outlet, which prevents storm water from naturally draining into the sea.

2. ANSE BOILEAU

Anse Boileau is drained by about 5 main rivers and numerous minor ones. The rivers take their source from the mountains and discharge directly into the sea. Due to the steep nature of the catchments and the river beds, the rivers generally flow at a relatively high velocity.

Besides the natural drains, there is a network of open roadside drains running along some sections of the main roads which have been constructed to carry storm water runoff to the natural watercourses.

Similar to other districts, the areas which are currently experiencing flooding problems are located in the low-lying areas along the coast. As the rivers take their source from the mountains, Anse Boileau also has flooding problem on the upper reaches of the district due to rivers overflowing the community of Anse Louis and also the residents of Sailfish Estate.

3. POINTE LARUE

The northern part (Anse Des Genets) drains into the Talbot Lagoon through river channels and existing roadside drains. The drainage of this part is not adequate in capacity, thus resulting in road flooding during the rainy season.

The central part drains into Rivière Francois Lagoon via a network system of roadside drains, which connect to the main Pointe Larue roadside drain. This drain network which is covered (1.2m. x 0.8m) discharges into the marsh (Rivière Francois). This marsh is connected to the lagoon (on the eastern side of the road) close to the runway. Water from the lagoon is discharged through two box drains under the runway to the sea.

4. ROCHE CAIMAN

Roche Caiman District is part of the National Reclamation Project. All Estate roads have opened or covered drainage infrastructure which discharges water into the lagoon between the reclamation and the mainland. Lack of maintenance of these infrastructure in certain areas makes the Estate roads prone to flooding in the events of heavy rainfall.

5. ST. LOUIS, BEL AIR AND MONT FLEURI

Similar to other parts of Mahe, the main rivers take their source from the mountain and eventually discharge into the sea through existing man-made storm water channel. Due to the steep topography of the terrain and effectively the catchment, the rivers flow at high velocities until they reach the flood plain in the centre of Victoria, the country's capital.

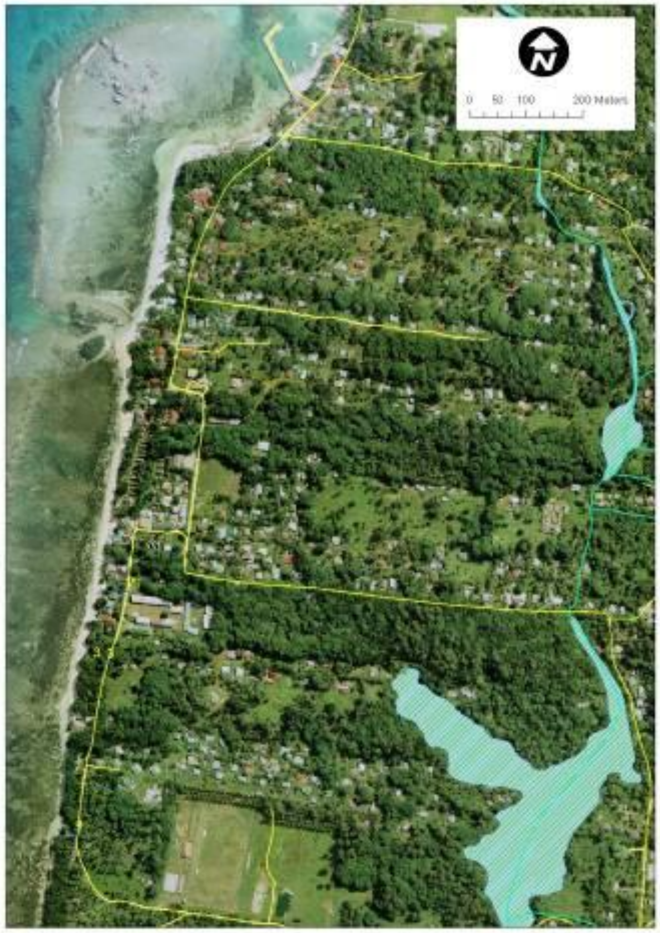
Besides natural rivers and drains, a network of man-made sparse open and covered drains running along some main and secondary roads has been constructed to carry storm water runoff to the natural watercourses.

PRASLIN ISLAND

Baie Ste Anne Praslin is drained by 8 main rivers and several minor ones. All the rivers have their headwaters in the mountains and discharge into the Indian Ocean. Similar to Mahe, the outflows from the rivers are controlled by tides. Storm water is conveyed in a system of open drains to the rivers. Besides the natural drains, there is a network of open drains running along some sections of the main roads which have been constructed to carry storm water runoff to the natural watercourses.

LA DIGUE ISLAND

The main watercourse on La Digue is the Rivière La Mare Soupape (and its tributaries) which drains about half of the island and flows through the swampy area on the west of the island and finally into the sea (near Pointe Source D'Argent). There are about 10 other relatively minor rivers draining the rest of the island.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ANNEX 3: ACTION PLAN FOR CLIMATE CHANGE EDUCATION, AWARENESS & TRAINING 2009 - 2014

GENERAL OBJECTIVES	ACTIONS	APPROX. COSTS (USD)	PARTNERS	TIME FRAME	PRIORITY
1. Develop education and awareness materials on climate change for schools / public / stakeholders	a) Produce and distribute a booklet on climate change impacts, and mitigation and adaptation strategies in Seychelles in general and with the aim of promoting sustainable living practices.	4000	S4S, SIT, STB, EAB, DRDM, RCSS	July 2009	High
	b) Produce a second booklet on climate change impacts, and mitigation and adaptation strategies, targeting specific sectors such as the construction industry, tourism industry, offices, etc.	2000	same	July 2009	High
	c) Produce and distribute a short film (through an episode of Karnen Lanatir, using local case studies) for public viewing and to be used as a teaching aid	2000	S4S with SBC, MENRT S4S,DRDM, RCSS	July-Sept 2009	High
	d) Produce and distribute a poster on climate change for use by teachers	1000	S4S	July-Sept 2009	High
	e) Assist in the production and distribution of the WCS magazine for youth focusing on climate change cartoon insert	500	WCS with S4S	March 2009	High
	f) Purchase books for school libraries (e.g Learning for Sustainable Living in Seychelles) and the National Library	10,000	MoE	April 2009	High
	g) Install climate change related stickers on SPTC buses	2,000	S4S	March 2009	High

	h) Produce a video clip to sensitise tourists on climate change, how it affects Seychelles and specifically outlining actions that can be taken during their visit. Clip to be aired on all incoming flights to Seychelles.	1000	TESS, STB, SBC, Air Seychelles, S4S, DRDM	June-Sept 2009	Medium
2. Empower/Use leaders, educators , artists and mentors to share their knowledge, values and experience with different target audiences	a) Conduct 3 in-service workshops for teachers (primary, secondary and post-secondary) to introduce them to climate change impacts, mitigation and adaptation and climate change education resource materials.	3000	S4S, NIE	Sept-Dec 2009	High
	b) Organise competitions (theatre, songs, poems) promoting education & awareness on climate change	Cost of prizes	S4S, NAC, DRDM, MOEd, MENRT	Jan-March 2010	Medium
	c) Promote arts-based strategies for climate change education campaigns (music, drama productions, art & photography exhibitions, etc.)	No cost	S4S, NAC, Arts Associations	Ongoing	Medium
3. Sensitise policy makers on climate change	a) Deliver a series of education and awareness presentations/organise site visits on climate change to policy makers (MNAs, Cabinet, PSs, DGs, Directors) to sensitise them on the issue of climate change	1000	S4S, National Assembly, Cabinet, DRDM, etc.	July-Dec 2009	High
4. Integrate climate change education into all sectoral policies and strategies	a) Provide support to integrate climate change education & awareness activities into the development of EMPS 2011-2020	2,000	EMPS SC, NCCC, sectors, DRDM	Ongoing (long term)	High
	b) Provide support to sectors to integrate climate change education & awareness considerations into all policies being reviewed and new ones being developed, i.e. Energy Policy, Agriculture Policy, Education Policy, Development policy, Water Policy	8,000	EMPS SC, NCCC, all sectors, DRDM, DOE	Ongoing (long term)	High

5. Establish a mechanism for information sharing and networking	a) Review the role of the NCCC in education and awareness on climate change	5000	DOE, NCCC, EMPS Committee, DRDM	Aug-Dec 2009	High (All)
	b) Consider and establish the most appropriate mechanism to use as the platform for networking and information sharing for climate change related issues (EMPS; EIC Section in DOE, NCCC, Sea Level Rise foundation)	5000	DOE, NCCC, EMPS, DRDM	Aug-Dec 2009	
	c) Establish a website with information about climate change mitigation and adaptation for different target groups (teachers, students, contractors, businesses)	To be finalised	DOE with S4S, DRDM & SLRF	Jan-March 2010	
6. Provide opportunities for training in climate change and related issues for media and professionals involved in CC issues	a) Offer training on climate change for journalists on environmental reporting, particularly on climate change issues	TBD	ETF, Private Sector, MOF, Manpower	Ongoing (long term)	High (All)
	b) Offer on-going and targeted workshops on climate change for health, environment, marine, fisheries, secondary and post-secondary teachers, agriculture, construction, planning and development	1000 /workshop	MoE, MENRT, S4S, DRDM, post-sec institutions, MoED	Ongoing (long term)	High (All)
	c) Provide scholarships for overseas graduate studies in climate change (meteorology, agriculture, etc. on e.g. adaptation strategies for Small Island Developing States)	TBD	MOF, Manpower	Ongoing (long term)	High (All)
7. Seek funding sources locally / internationally to support envl education,	a) Establish a mechanism for the sponsorship of education and awareness activities (consider ETF, the new EMPS and the Department of Risk and Disaster	5000	DOE PCU, NCCC, EMPS Steering Committee	Ongoing (long term)	High (All)

awareness and training programmes	Management)				
	b) Seek grants and sponsorship from private sector, industries e.g. STB, Air Seychelles, Seybrew, Cable and Wireless, IOT etc.	No cost	DOE PCU, NCCC, EMPS SC	Ongoing (long term)	High (All)
	c) Seek financial support for professionals (journalists, PR staff, educators, etc.) to participate in international workshops and conferences on climate change	No cost	DOE PCU, NCCC, EMPS SC	Ongoing (long term)	High (All)
8. Create opportunities for young people to learn more about CC	a) Organise holiday environmental camps for children and youth focused on climate change and sustainable living	2000	S4S, NGOs, MENRT community youth groups, schools, WCS, parents, , etc.	December-January 2009	Medium
	b) Organise a gathering of NGOs/Youth/faith communities promoting education & awareness on climate change and sustainability on the occasion of Youth Day 2009	10,000		September 2009	Medium

ANNEX 4: RECOMMENDATIONS FROM THE WORKSHOP

- Address weaknesses
- Attitude change should be a goal not just awareness
- Strategies to overcome barriers
- More involvement of stakeholders-community based campaigns/grass roots involvement in decision making
- Train the trainers, leaders (innovative/novel approach by empowering people giving them the opportunity to learn more and to pass on the info/knowledge))
- Avoid duplication, create synergies between partners
- Develop strategies for environmental education
- More networking e.g. for resources e.g. between NGO Private sector
- Need action as required by stakeholders
- Teach people not sectors on how to be resilient/ adapt
- Sharing of info/ responsibilities for climate change education & awareness
- Use ordinary people as examples for case studies for approaches/adaptation in climate change education
- Must educate for flexibility, resilience adaptability and problem solving at all levels e.g. food security, home gardens
- Political will and commitment to support climate change mitigation and education & awareness
- Put Seychelles in international situation e.g. price increases of fuel, food etc
- More sensitising of individuals + target groups e.g. community, decision makers though media, workshops, fairs, familiarization trips, etc.
- More enforcement of laws/policies/practices
- More availability of alternative equipment/appliances to promote energy conservation or use of renewable energy technologies
- Harmonise policies
- Offer incentives (financial e.g. though government subsidies and non financial) for change of behaviour
- Make available alternatives (dual flush toilets, solar panels, energy saving bulbs).
- Pilot projects: composting toilets
- Build stronger communities
- Redesign buildings (stilts, bamboo, wood, cross ventilation, passive cooling
- Local tourism to reduce carbon footprint of Seychellois travelling overseas