Seychelles National Climate Change Strategy

Vision: **To minimise the impacts of climate change through concerted and proactive action at all levels of society**

November 2009
The Seychelles National Climate Change Committee

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Abbreviations

AIACC Assessments of Impacts and Adaptation to Climate Change
CDM Clean Development Mechanism
COP Conference of the Parties
DRDM Department of Risk and Disaster Management
EIA Environnemental Impact Assessment
EMPS Environment Management Plan
ENSO El Niño Southern Oscillation
GCM Global Climate Model
GDP Gross Domestic Product
GEF Global Environment Facility
GHGs Greenhouse Gases
GIS Geographical Information System
GoS Government of Seychelles
GPS Global Positioning Satellite
ICRC International Committee of the Red Cross
IFRC International Federation of the Red Cross and Red Crescent Societies
INC Initial National Communications
IPCC Intergovernmental Panel on Climate Change
ITCZ Inter Tropical Convergence Zone
LDCs Least Developed Countries
LUNGOS Liaison Unit for Non-Governmental Organisations in Seychelles
LSAT Land-surface Air Temperature
NAPA National Adaptation Program of Action
NCCC National Climate Change Committee
NDC National Disaster Committee
NGO Non-government Organization
NPV Net Present Value
PIROI Platform d'Intervention Régional Océan Indien
RAF Resource Allocation Framework
RCSS Red Cross Society of Seychelles
SIBA Seychelles International Business Authority
SNC Second National Communications
SRES Special Report on Emission Scenarios
SST Sea Surface Temperature
TCPA Town and Country Planning Authority
TOGA Tropical Ocean Global Atmosphere programme
UNDP United Nations Development Programme
UNEP United Nations Environment Programme
UNFCCC United Nations Framework Convention on Climate Change
WHO World Health Organization
WMO World Meteorological Organization

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Acknowledgements

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Executive Summary

The scientific evidence that present day climate change is being caused by human interference with the functioning of the atmosphere is unequivocal. The 2007 Intergovernmental Panel on Climate Change (IPCC) concluded that humans are responsible for the measured global warming which is causing the ice caps to melt, the oceans to warm hence affecting the climate around the planet. Small Island Developing States (SIDS) are especially vulnerable to climate change and the IPCC Fourth Assessment Report concludes with a very high level of confidence that SIDS will be affected by global sea level rise, which would increase coastal inundation, erosion and magnify the impact of storm surges and affect coastal agriculture. Climate change impact on coral reefs and fisheries, through warming of the ocean and ocean acidification are threats that would undermine food security and livelihood in SIDS. Changes in precipitation will also affect water resources availability, which would in turn affect biodiversity (including high-altitude islands) and other ecosystems dependent upon water. Climate change will also directly impact human health in SIDS as well as key economic sectors such as tourism and fisheries.

The Seychelles is economically, culturally and environmentally vulnerable to the potential effects of climate change and associated extreme events. Vulnerability characteristics such as concentration of development on narrow coastal zones, non-resilient populations and ecosystems make the Seychelles extremely sensitive to climate change and its associated impacts. 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 in the Seychelles. The effects of climate change on tourism in small islands are expected to be largely negative. Furthermore, recent studies suggest that changes in long-term rainfall patterns and temperature changes will also have adverse consequences for water, food and health. However, climate models for Seychelles, over the period 2010-2100, indicate that the rainy season is ‘more likely than not’ to be wetter, while the dry season is ‘more likely than not’ to be dryer. The probability of an increase in the Aldabra area annual rainfall is lower than that in the Mahé area and it is

more likely that the Aldabra area rainfall will decrease compared to the Mahe area in the Jun-Jul-Aug season up to the year 2100.

In response to those challenges, government, the private sector and non-governmental organizations are already implementing a number of activities enshrined in the Environment Management Plan 2000 to 2010 and the Seychelles First National Communication. An increase in extreme weather events prompted government to strengthen its national meteorological services and establish a fully-fledged institution for disaster prevention and response. The Climate and Environmental Services Division (CESD) was established in 2008, which incorporated the National Meteorological Services (NMS), the Environment Engineering Section (EES) and Programme Management Section (PMS) to enable focus on climate change issues. The creation of the Seychelles Energy Commission in 2009 was a concrete step aimed at reducing the energy insecurity of Seychelles, through cost-effective mitigation options.

The second national communications process, which will be completed in April 2010, 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 - Fisheries Sector, the Agricultural Sector, the Water Sector and the Coastal Zone Sector. Preliminary findings indicate that climate change will affect agriculture in numerous ways, in particular availability of water and changes in the risk of plant disease propagation. Seychelles is also at high risk from climate-sensitive diseases such as malaria and other food and water-borne diseases. 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. 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. The findings of this study also show that the Mahé group, which consists of narrow coastal areas and steep mountain slopes, are highly vulnerable to floods and landslides. Short, intensive rainfall may trigger landslides in severely deforested areas and zones cleared for construction. 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 is described. Sea-level rise, rising sea surface temperatures, increased tropical cyclone 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. Furthermore, forest fires, especially evident during periods of extended drought, poses risks to human habitation, critical infrastructure and also the unique biodiversity of the islands.

Although, it is classified as an upper middle-income country, the Seychelles has a number of inherent vulnerabilities related to its insularity; lack of substantial natural resources; vulnerability to natural disasters; excessive dependence upon imports and limited economic base; high costs of transportation and communication; and inaccessibility to economies of scale and technology. As a result key weaknesses in the human, scientific, financial, technical, technological and institutional capacity are observed. Seychelles faces a lack of professionals in climate change, oceanography, meteorology, and other related fields.

Within the framework of the second National Communication to the UNFCCC, this National Climate Change Strategy (NCCS) was initiated in part to take advantage of upcoming opportunities arising from the 15th Conference of the Parties to be held in December 2009. The NCCS will provide a coherent and consolidated response to climate change. This strategic document will remain a "working" document intended to be updated and revised on an ongoing basis in response to new challenges and opportunities. Central to the strategy is the mainstreaming of climate change into sustainable development as a national

cross-sectoral programme addressing matters of policy, institutions, capacity building and civil society involvement.

Five strategic objectives have been proposed to support the Seychelles towards adaptation and developing resilience to climate change and its effects. These are dependent upon the achievement, at global level, of an agreement on GHG emissions reductions which would reduce current 'dangerous' levels of GHG gases in the atmosphere to safe levels in the least possible delay.

The strategic priority objectives proposed are:

1. To advance our understanding of climate change, its impacts and appropriate responses.
2. To put in place measures to adapt, build resilience and minimize our vulnerability to the impacts of climate change.
3. To achieve sustainable energy security through reduction of greenhouse gas emissions.
4. To mainstream climate change considerations into national policies, strategies and plans.
5. To build capacity and social empowerment at all levels to adequately respond to climate change.

The NCCS also presents an action plan with an indication of priority, implementation arrangements and recommendations on the way forward.

1 Background and Introduction

1.1 Global Climate Change

Global climate change arising from human activities is the concern of the planet in this third millennium. During much of the planet's history, climate change was driven by natural phenomena producing climate change over periods of decades, centuries and millennia (Crowley, 2000). However, Crowley concludes that a 21st-century global warming projection far exceeds the natural variability of the past 1000 years and is greater than the best estimate of global temperature change for the last interglacial.

There is increasing scientific evidence that present day climate change is being caused by human interference with the functioning of the atmosphere. Over more than 20 years, the Intergovernmental Panel on Climate Change, IPCC, (est. 1988) has published four assessment reports which progressively incriminate human activities as the driving force behind present and future global climate change. Rapid industrialization and use of fossil fuels have led to a rapid build-up of greenhouse gases in the earth's atmosphere (Watson *et al.* 1990). Whilst such gases (namely carbon dioxide, methane and nitrous oxide) occur naturally, in large quantities it increases the 'greenhouse effect' hence trapping more heat into our atmosphere. The main sources of man-made greenhouse gases include burning of fossil fuels, deforestation, agriculture (livestock and crop farming) and use of certain types of refrigerants. Such trapped heat translates into a warmer planet and can alter the climate. Since 1850, long-term research data shows that our atmospheric concentration of carbon dioxide ($CO_{2)}$ has increased from 270 ppm (parts per million) to 380 ppm in the present day(IPCC 2007).

The 2007 Intergovernmental Panel on Climate Change (IPCC) reports present the most comprehensive, authoritative and up to date analysis of climate change, global warming and its consequences for humankind and the planet in general. It also includes options for averting such consequences. The intergovernmental panel concluded unequivocally that

humans are responsible for the measured global warming which is causing the ice caps to melt, the oceans to warm and affecting the climate around the planet. This report (IPCC 2007) further states that human influences on the climate have:

- _ *very likely* contributed to sea level rise during the latter half of the 20th century;
- _ *likely* contributed to changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns;
- _ *likely* increased temperatures of extreme hot nights, cold nights and cold days;
- _ *more likely than not* increased risk of heat waves, area affected by drought since the 1970s and frequency of heavy precipitation events.

To support its argument, the IPCC report presented scientific evidence which showed that global temperature has increased by an average of 0.74°C in the last 100 years (1906-2005) (see Figure 1). Sea level rise is also consistent with this observed warming, observed at an average rate of 1.8 mm per year from 1961 to 1993, and at 3.1 mm/yr from 1994 to 2003. Likewise there is evidence of increased droughts and intensity of extreme weather events (IPCC, 2007). The IPCC Report (IPCC, 2007) argues that these changes are unlikely to have been driven by solar and volcanic factors but rather by the exponential growth in man-made greenhouse gas emissions since the beginning of the industrial age.

The IPCC (IPCC 2007) projects that for the next two decades a warming of about 0.2°C per decade is expected for a range of emissions scenarios. Assuming that if the concentrations of all GHGs and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would still be expected. Thereafter it is expected that temperature and sea level rise projections will increasingly depend upon the specific emissions scenarios.

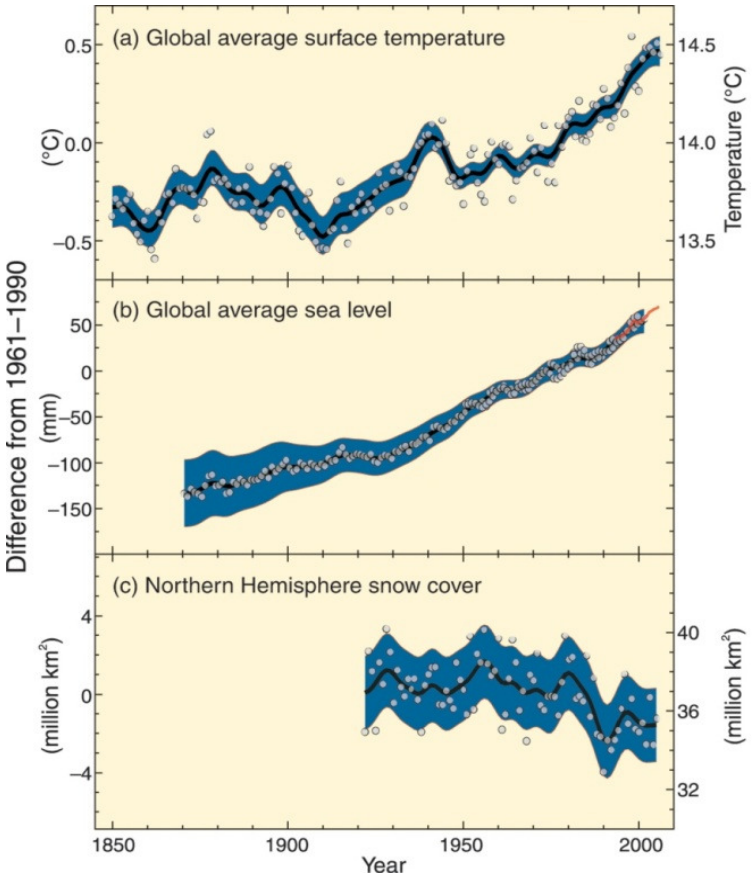


Figure 1 Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). Source: (IPCC 2007))

1.2 Climate Change and Small Island States

Spread across the Atlantic, Pacific and Indian Oceans, and the Caribbean and Mediterranean Seas, Small island developing States (SIDS) form a distinctive group, each with its own unique characteristics but nevertheless sharing many features in common. SIDS are recognized by virtue of their small size, small populations, lack of substantial natural resources, remoteness, vulnerability to natural disasters, excessive dependence upon imports or few economic sectors, high costs of transportation and communication, inaccessibility to economies of scale and disproportionately higher costs of conducting business (Payet, 2008).

SIDS are especially vulnerable to climate change (IPCC,2007) and the international community is generally of the view that SIDS have legitimate concerns over their future based on observational records, experience with current patterns and consequences of climate variability, and climate model projections. The IPCC Fourth Assessment Report concludes with a very high level of confidence that SIDS will be affected by global sea level rise, which would increase coastal inundation, erosion and magnify the impact of storm surges and affect coastal agriculture. Climate change impact on coral reefs and fisheries, through warming of the ocean and ocean acidification are threats that would undermine food security and livelihood in SIDS. Changes in precipitation will also affect the availability of water, which would in turn affect the population, key economic secotrs such as tourism and agriculture, as well as biodiversity and other ecosystems dependent upon water. Climate change will also directly impact human health in SIDS as well as key economic sectors such as tourism and fisheries.

The findings of the IPCC (IPCC, 2007) are documented in a specific chapter in the Fourth Assessment Report and the three most critical are summarised below:

1. Sea level rise presents the biggest challenge for small island states leading to island abandonment, exposure to storm surges, damage to coastal economies and infrastructure.
2. Meeting the demand for water in small island states will be strongly compromised under most of the climate change scenarios.
3. Changes in the ocean and coastal marine environment (such as elevated sea surface temperatures, ocean acidification) will disrupt critical ecosystem services, for example coral reefs and fisheries, on which small islands depend upon for food and economic development.

1.3 Responding to Climate Change – The UNFCCC

The Earth Summit held in Rio de Janiero, Brazil, in 1992 resulted in three important global international agreements, one of which was the United Nations Framework Convention on

Climate Change or UNFCCC. The UNFCCC, which entered into force on the 21st of March 1994, provides the overall framework in which governments can develop approaches to tackle the issue of climate change. With over 192 countries that have ratified the convention, in summary its remit focuses on strategies to reduce greenhouse emissions and develop measures to address adaptation to climate change.

Adaptation to climate change refers to actions taken in response to the potential impacts of climate change. Countries report on their progress through a special report entitled 'The National Communications' which contains the national greenhouse gas emissions inventory, measures to reduce those emissions, an assessment of vulnerability to climate change and measures for adaptation.

The Kyoto Protocol was negotiated under the UNFCCC as an international instrument that sets binding targets for over 37 industrialised countries to reduce greenhouse gas emissions (GHG) to an average of 5% of their 1990 levels, during what is called a first commitment period from 2008-2012. Although over 180 nations have ratified the treaty to date, the Protocol has not yet been effective in stabilizing GHG emissions.

While there is now widespread political attention being given to climate change, the planet faces a number of challenges - that of bringing down global emissions to safe levels (stabilization as defined by the IPCC as "a level that would prevent dangerous anthropogenic interference with the climate system") and the survival of many of the world's nations and civilizations. The planet is now on the brink of a global shift in climate and although the science is compelling and the economic findings are credible, the international community is caught in an impasse over the commitment of larger economies to address the issues of mitigating causal emissions and adapting to impacts and threats proactively.

2 Overview of the National Context

2.1 Country Background

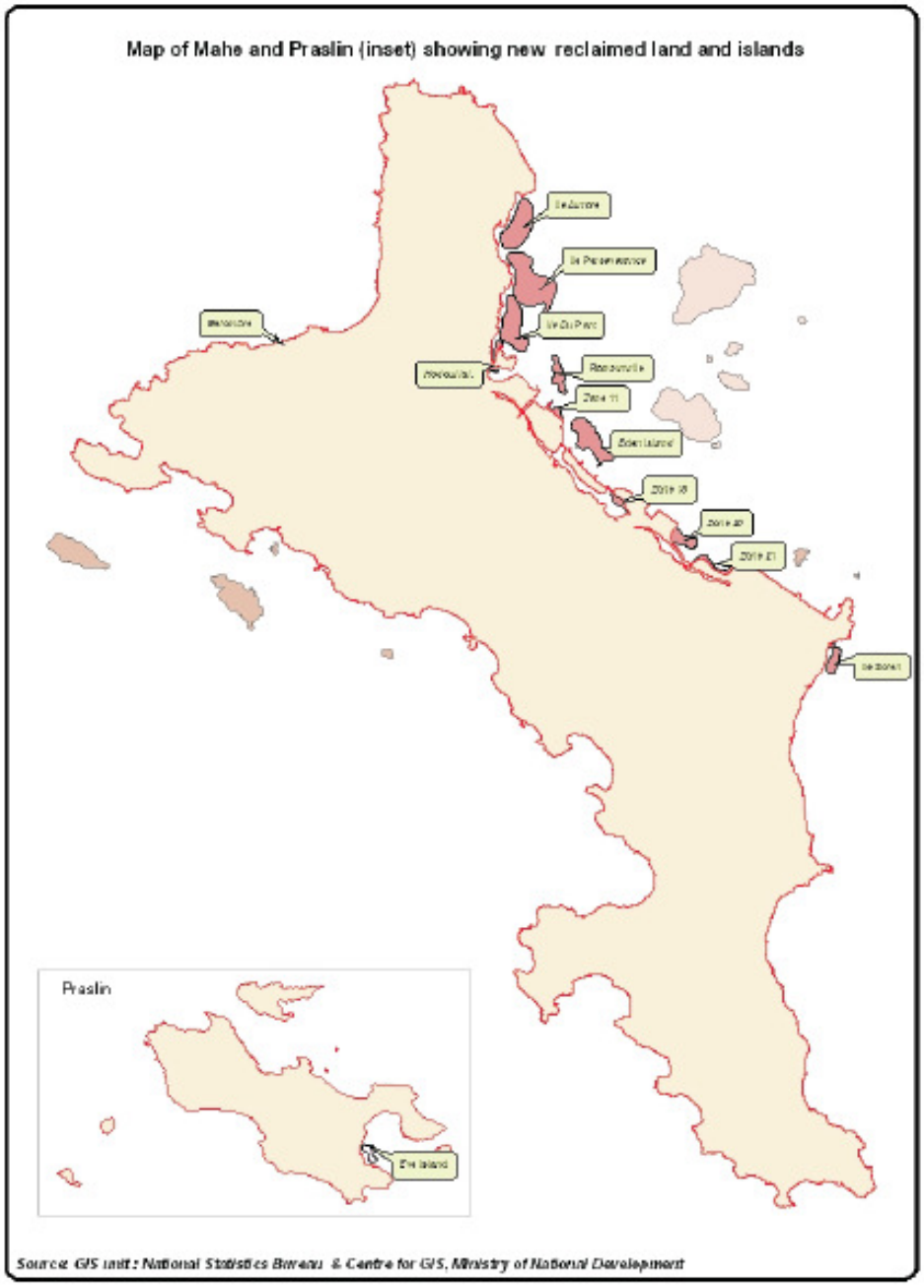
The Seychelles consists of over 115 islands of which some 40 are granitic and the rest coral with a total human population of about 84,600 (NSB, 2007 – '2006 population estimates'). The four main inhabited granitic islands in order of size are Mahe, Praslin, Silhouette and La Digue, and vary in age from some 650 to 750 million years old. The Seychelles islands are located within 4° and 9° South of the equator, and with a total area of 455.3 km^2. All the islands put together result in a coastline of about 491 km (The World Fact Book, 2008). The majority of the islands are surrounded by coral reefs with an area of about 1,690 km^2 (Payet, 2004), many of which were affected by the mass coral bleaching event of 1998 which was caused by abnormally warm waters (Linden *et al.*, 1999).

Figure 2 Map of the Seychelles Archipelago

More than 90% of the population and all economic activities are located on the narrow coastal plateau of Mahe Island, at an average elevation of 2 m above sea level. Due to steep

land conditions and lack of suitable land for infrastructure, extensive areas have been reclaimed on the east coast of Mahe Island, the largest inhabited island in the group.

Figure 3 Coastal areas reclaimed (pink) on Mahé and Praslin in the last 20 years. (Source: NSB, 2007)



2.2 Population growth and migration

Seychelles was first settled in 1771, with an initial population of 28 persons. The population has subsequently grown to its present estimated at 86,000 in 2008, 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.

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 project 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 kilometer. 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.

There are no cases of mass movements as a result of natural disasters or climatic anomalies. A rare outbreak of the disease, smallpox, is known to have staggered the population growth between 1887 and 1895. On 21st December 2006, 35 residents of Farquhar and Providence Atolls had to be evacuated due to category 4 cyclone Bondo (max. winds of 190 km/h). According to records cyclones in this latitude is extremely rare. The last such event occurred in 1956.

2.3 Economic and Social Vulnerability

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.

However, since the early nineties, Seychelles development strategy slowed down primarily due to external shocks and also internal macroeconomic imbalances, a relatively centralized economy and other longstanding structural issues. In response, Seychelles adopted a Macro-Economic Reform Programme in 2003 which resulted in further liberalisation of the economy and reduction in debt. However, these measures proved insufficient to address the macroeconomic imbalances and the economic vulnerability of the country remained high. Persistent foreign exchange shortages resulted in shortages in basic items, inflation as well as external public debt, which in 2008 represented 98% of GDP (US$808 million) of which USD 313 million was in arrears.

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 stabilized 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 stabilization of the economy, the vulnerability of the Seychelles to global shocks cannot be underestimated. 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 4%.

2.4 Energy and Greenhouse Gas Emissions

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 1995 consumption levels. In 2007, Seychelles primary energy consumption reached 115,000 toe (GoS, 2008). This rapid growth is attributed to recent economic expansion, in particular in the tourism sector in the last 5 years (see Figure 4). Fuel imports was 22% of the GDP in 2005, and the Seychelles energy import bill rose from 6 million US$ in 1998 to approximately $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.

Figure 4 Trends in primary energy consumption (GoS, 2008).

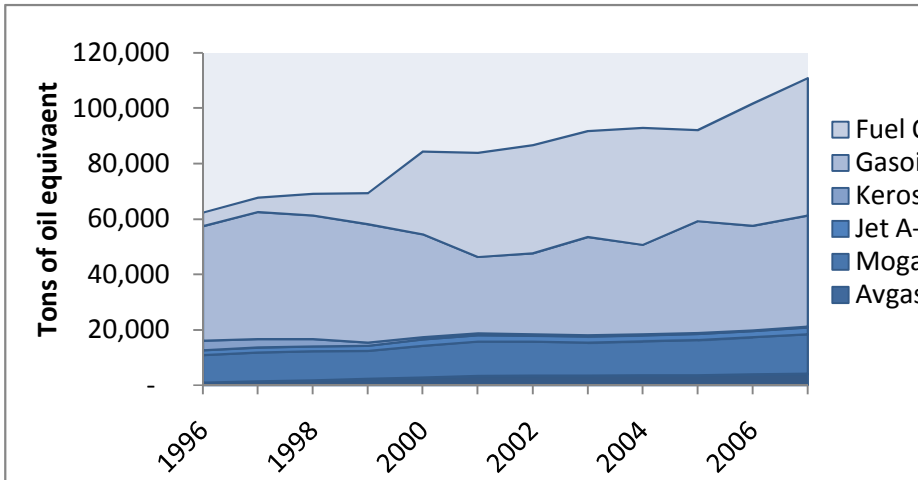
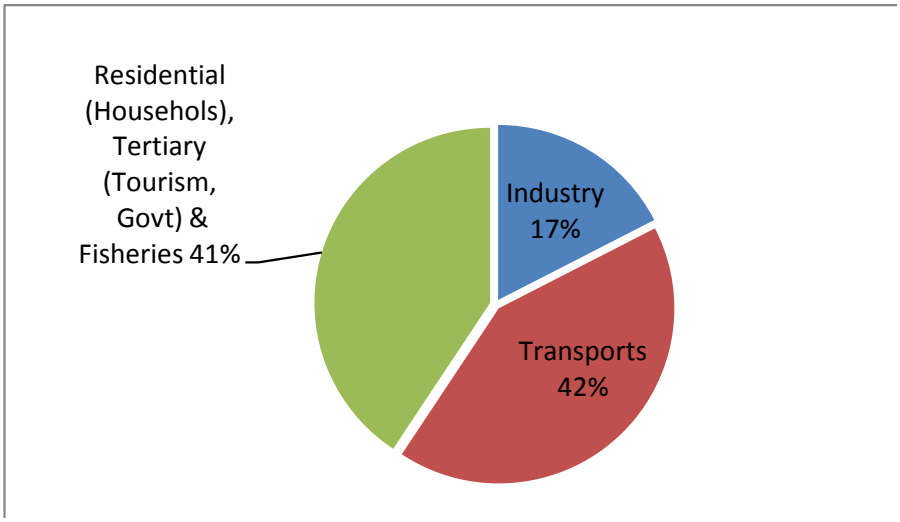


Figure 5 Consumption of energy by sector 2005



Seychelles is an archipelagic state and depends upon air and sea transport to connect 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.

Within the context of the Second National Communications, a second greenhouse gas (GHG) inventory in accordance with the guidance provided by the UNFCCC has been undertaken. A Tier 1 approach was adopted for the determination of GHG emissions for the year 2000(Coopoosammy & Jean Louis, 2008). The inventory recorded a 34% increase in CO2 emissions from 1995 (date of first GHG Assessment) and 2000. This increase from 194.342 Gg in 1995 to 260.640 Gg in 2000 is primarily attributed to significant economic expansion and the availability of more accurate data in the last five years. A large proportion can also be attributed to the increased use of fuel oil for the production of electricity, whose CO2 emissions increased from 1.5% in 1995 to over 37% in 2000. Other shifts included a decrease in the use of gas oil and kerosene, and an increase in LPG (liquefied petroleum gas). The inventory concluded that the most significant source of GHG in Seychelles is the consumption of fuel oil for the production of electricity.

Sequestration of carbon was estimated at 821.74 Gg assuming that all of the Seychelles forests fall under the managed category. The GHG inventory concluded that Seychelles was a net sink of CO2 by a factor of 3, which could ideally be traded on the international carbon market. Emissions from other GHG gases such as methane and NOx were insignificant.

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 a total of 18 MW of wind energy farm on Mahe, the most inhabited island. Detailed feasibility studies for the wind turbines are ongoing and other options such as solar photovoltaic farms are being explored.

2.5 Future energy demand forecast

The 2008 Energy Task Force (GoS, 2008) based their energy forecasts upon two demand scenarios – (I) business as usual and (II) accelerated growth in line with Strategy 2017 whose aim is to double the Seychelles GDP by 2017. Scenario I and Scenario II assumed annual average growth rates (AAGR) of 2.6% and 7%, respectively. Under those conditions it was estimated that energy demand will grow by about 2.7 orders of magnitude under scenario II, with a Toe of 514,460 in 2017. This is equivalent to more than 5 times that of the 2007 level of consumption. Electricity demand will exceed 650 million KWhr by 2017, effectively tripling demand under Scenario 2.

3 Past and Present Climate Trends

Climatological records in the Seychelles dates back to the 1880s. Generally, the climate of the Seychelles archipelago is strongly influenced by the ocean, mainly through (i) monsoonal wind shifts; (ii) changes in the position and intensity of the South Indian Ocean tropical anticyclone; (iii) seasonal migrations and changes in intensity of the complex intertropical troughs, and; (iv) ocean currents and sea surface temperature patterns in the equatorial Indian Ocean (Payet & Agricole, 2007). Studies have shown that there has been substantial climate variability over the past hundred years in the Seychelles, although lack of data precludes any conclusive evidence for changes arising from anthropogenic climate change.

3.1 Rainfall

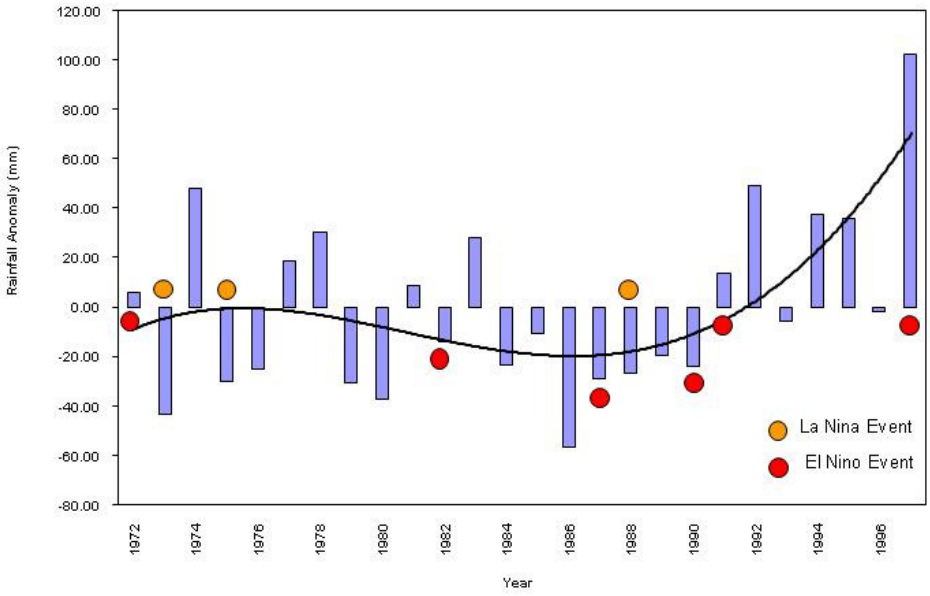
Annual rainfall anomaly trends on Mahe for the period 1972 to 2006 are upward by 13.7 mm per year, indicating a wetter climate. Higher rainfalls may also have occurred before 1905, from 1923 to 1937, from 1959 to 1970; and much lower rainfalls characterized the intervening 1905-22 and 1938-58 periods (Stoddard, 1984). However, Lajoie (2004) seem to indicate that these anomaly trends may have been distorted by heavy rainfall events rather than subtle changes in rainfall. According Chang-Seng (2007) there has been an overall increase in spatial rainfall over Mahe over the period 1972-1990, however with slight decreases in Bel Ombre and Anse Boileau during the North-West season.

Long range data trends indicate the presence of 2-4, 10 and 30 year rainfall cycles. Decadal cycles could possibly be linked to the sunspot cycle (Marguerite, 2001) or the decadal variability in intense tropical cyclone. Whereas the more active 30-year cycle is thought to be linked to the Atlantic Multi-Decadal Oscillation (AMO) in sea surface temperature via deep ocean thermohaline circulation. Further 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.

The effects of the El Nino Southern Oscillation (ENSO) are also observed, in particular in 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.

Figure 6 Annual precipitation anomalies for Mahé, 1972-1997 (source: National Meteorological Services Seychelles)



3.2 Surface Air Temperature

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). The early seventies were characterised by a predominantly cooler atmosphere, which progressively got warmer. The effects of major global perturbations, e.g. the Pinatubo eruption 1991 effect, are not apparent in the analysis of the Seychelles data. Recent work by Chang-Seng (2007) confirms such a positive warming trend, estimated to be 0.33 ^{0}C in the past 34 years, with the maximum warming

occurring during the north-west monsoon (December to February) and during the last 10 years. Analysis by Lajoie (2004) indicates that the number of cold nights (or minimum temperature events) have been decreasing at a rate of 0.14 nights per year.

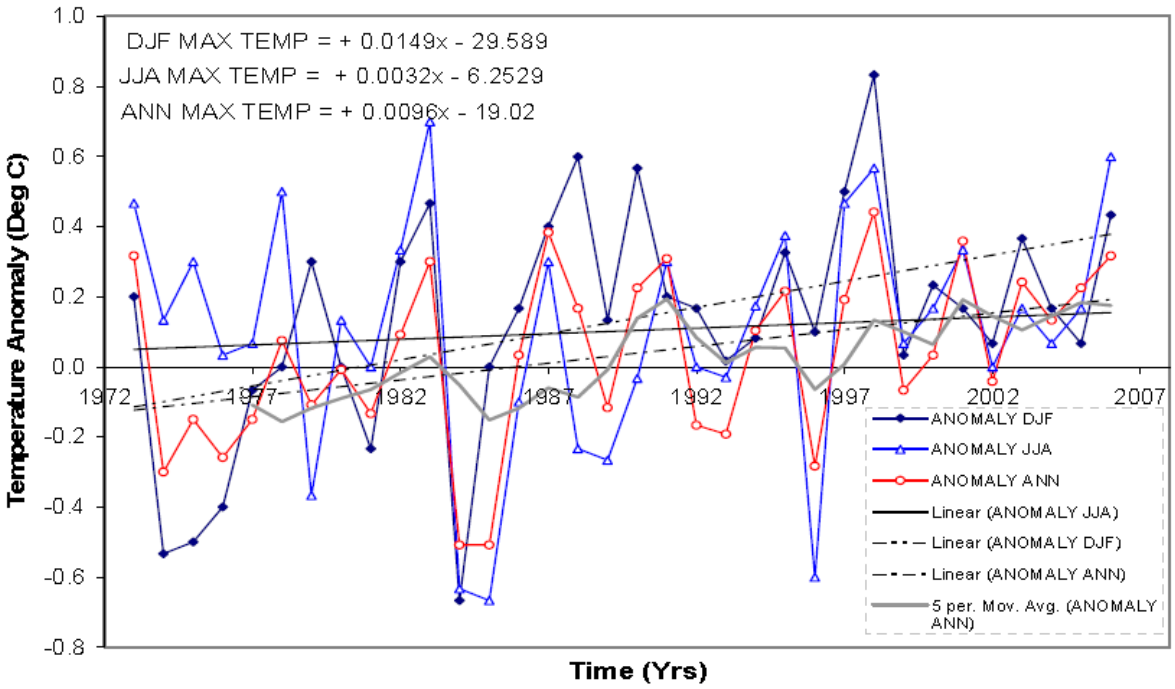


Figure 7 Seychelles International Airport DJF, JJA and annual maximum temperature anomalies with respect to the 1972-90 period with linear and 5-point moving average trends. (Chang-Seng,2007)

3.3 Sea Surface Temperature

Sea surface temperature observations on Mahe show two maxima and minima (see Figure 8), linked with the changes in the monsoon winds and the equatorial ocean currents (Chang-Seng, 2007). Of concern are the extreme maximum and minimum temperatures which impact on fisheries and coral reefs, respectively. Extreme minimum temperatures dropped to 24.9 ^{o}C in 2005, and extreme maximum temperatures increased to 30.1 ^{o}C in April 2001, according to recent records. Data analysed from CRU (Climate Research Unit, UK) indicates an upward trend in sea surface temperature, whereas a spatial regional scale

SST variability analysis by NOAA shows a cooling in the Western Indian Ocean (Chang-Seng, 2007). Lack of data makes these observations inconclusive at this juncture.

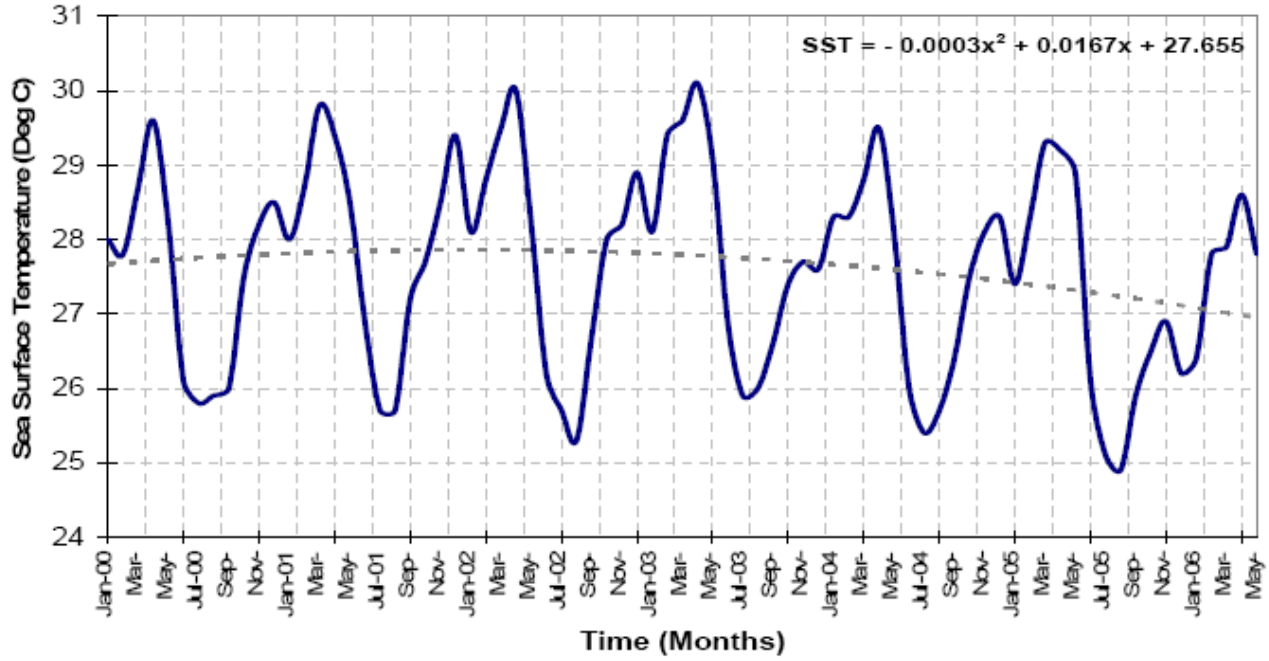


Figure 8 Sea surface temperature at Seychelles International Airport Pointe Larue

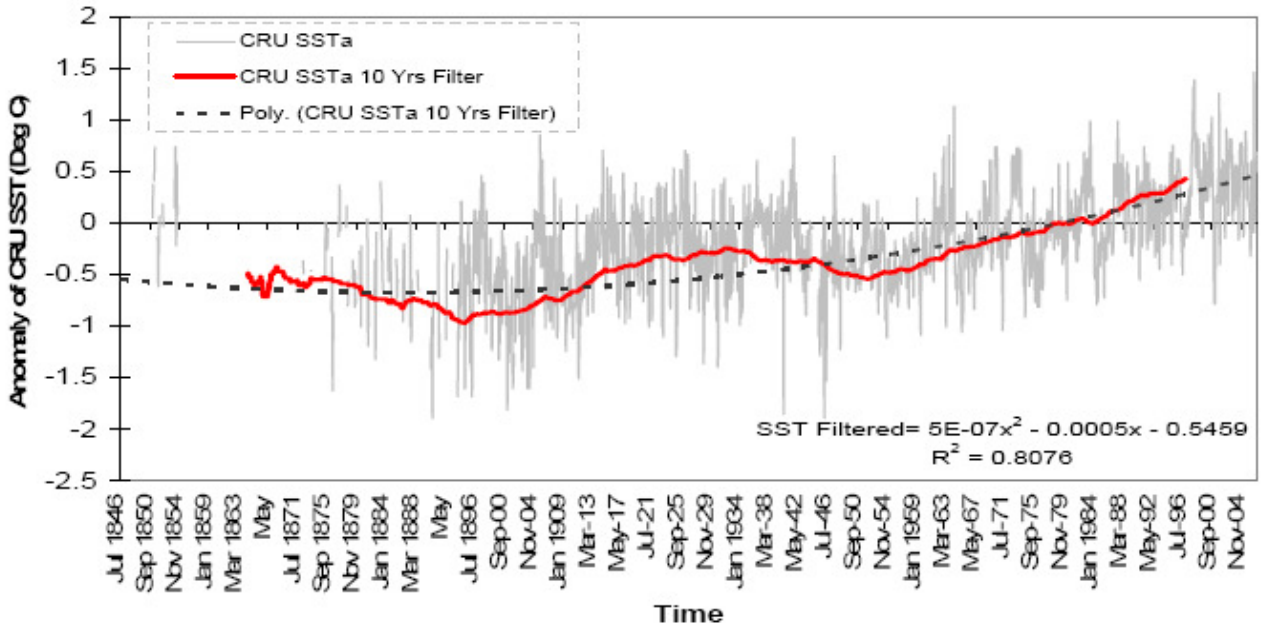


Figure 9 Area time series CRU SST in the Seychelles. The smoothed curve is the 10-year filter with a quadratic trend.

An inter-comparison of the Mahé air temperature with that of the sea surface over the last twenty years reveals a strong decadal relationship (Payet, 2006.) In contrast, Chang-Seng (2007) found a strong positive correlation at a 3-4 year cycle rather than a strong decadal relationship.

3.4 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 meters to 9 meters above sea level. Ste Pierre is the most uplifted reef in the Seychelles group, being surrounded by cliffs of up to 10 meters. Sea level monitoring data for the Seychelles is limited. Data is available from 1993 to present, and not consistent.

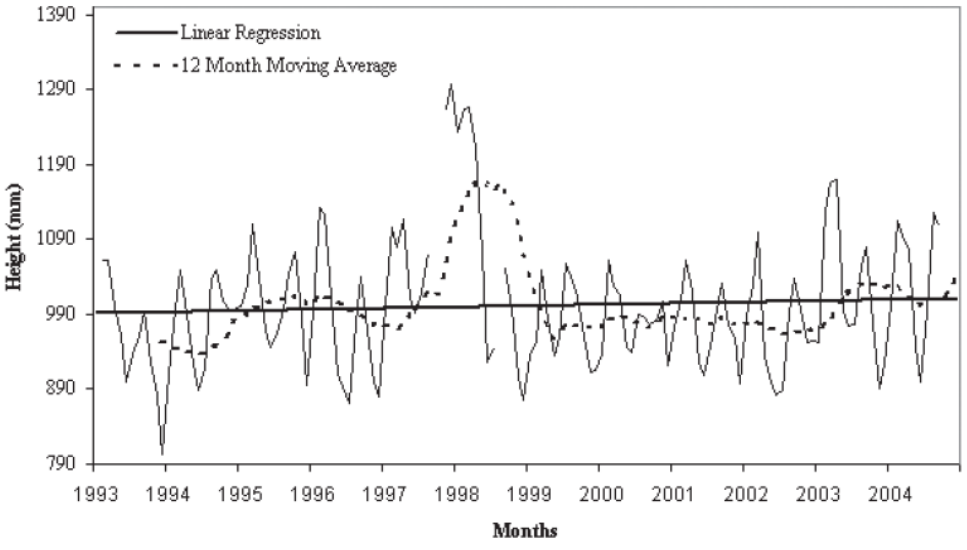


Figure 10 Time series of monthly mean sea level at Pointe La Rue, Seychelles (Source: Hawaii Sea Level Monitoring Centre)

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 ranges from 1982 to 2004 which makes any conclusive assessment difficult (see

Figure 10).

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 (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 Pte Larue, Mahé (Seychelles) as shown in Figure 11 , 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.

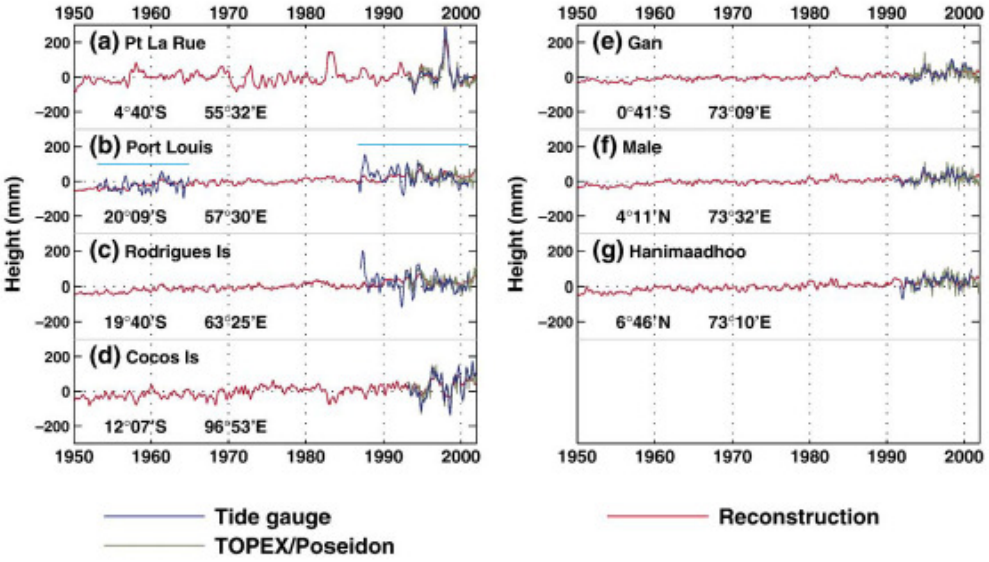


Figure 11 Time series of tide-gauge (blue), TOPEX/Poseidon (green) and reconstructed sea level (red) for Indian Ocean sites. The light blue lines on panel (b) show the time spans of the two separate records for this site (From Church et al., 2006).

Attributing rising sea level to climate change has become much clearer following recent research, which indicates that for the period 1993 to 2003, the contributions from thermal expansion (1.6 ± 0.5 mm/yr) and loss of mass from glaciers, ice caps and the Greenland and Antarctic Ice Sheets together give 2.8 ± 0.7 mm/yr (Bindoff et al., 2007).

3.5 Cyclones

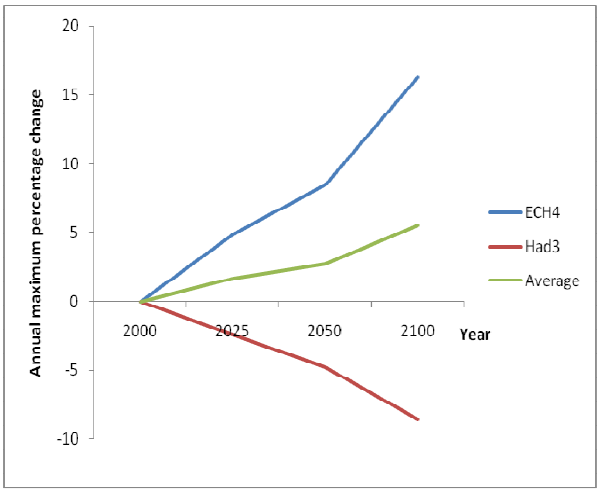
Nearly all significant weather events in Seychelles are directly or indirectly associated with the Inter Tropical Convergence Zone (ITCZ), and tropical cyclones in the region. In fact, the Indian Ocean is the most prolific of all other oceans in generating tropical cyclones. However, tropical cyclone 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.

Peak frequencies occurred around 1905 and from 1930 to 1960, with a trough in frequency between 1910 and 1930. Chang-Seng (2007) reports a slight decrease in the number of intense tropical cyclones from 1980 to 1989, whilst the decade of 1900-1999 shows the greatest number of intense cyclones. While there is clear evidence that the number of storms reaching categories 4 and 5 globally have increased since 1970 due to increases in their intensity and duration (Trenberth *et al*., 2007), there is no evidence that the same has occurred in the Indian Ocean.

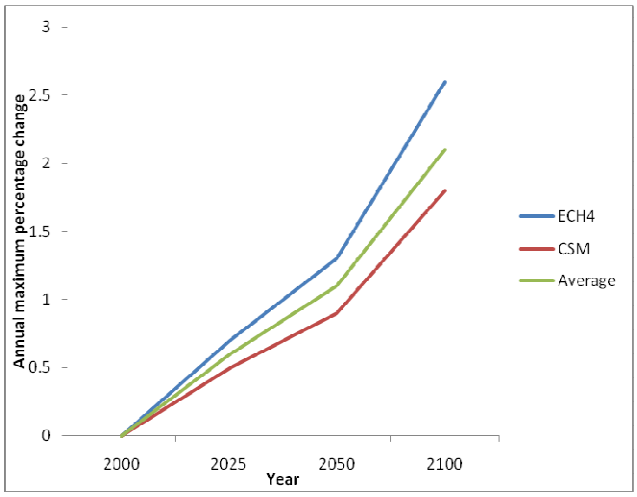
4 Scenarios of Future Climate

Climate Scenarios for the islands of Mahe and Aldabra were constructed using the MAGICC SCENGEN model and the GCM-Guided Perturbation Method (GPM) and the Regional Climate-Change Projection from Multi-Model Ensembles (RCPM) technique (Chang-Seng, 2007).

Seychelles is highly vulnerable to climate change. Individual GCM output 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 (Chang-Seng 2007). However, the range of percentage change in annual rainfall is -2.4 to +5.0 %; -4.8 to +8.5 %; -8.6 to +16.3 % respectively for the years 2025, 2050 and 2100. Based upon these results, Chang-Seng (2008) concludes that the rainy season is 'more likely than not' to be wetter, while the dry season is 'more likely than not' to be dryer with the exception of the Jun-Jul-Aug season of the year 2050. He concluded that it is likely (50-80 %) that for the Dec-Jan-Feb period, rainfall will increase, whilst it is unlikely to increase in the Jun-Jul-Aug period (20-40%). The probability of an increase in the Aldabra area annual rainfall is lower than Mahe and it is more likely that the Aldabra area rainfall will decrease compared to the Mahe area in the Jun-Jul-Aug season up to the year 2100. Figure 12 shows the outputs of various global circulation models (GCM) over the period 2010-2100 for the Mahé area.



Outputs based upon several GCM models for rainfall anomalies



Outputs based upon several GCM models for temperature anomalies

Figure 12 Outputs of GCM models for the Mahé area (Seychelles) over the period 2000-2100 (Data source: Chang-Seng, 2008)

Climate scenario uncertainties and model limitations are important to note, especially in the context of small islands. Disagreement in the outputs of GCM models is therefore expected to stimulate further debate on what is likely to occur as a result of climate change in the next 50 years. Chang-Seng (2008) concluded that model ECH3 and ECH4 demonstrated the lowest model error and mean difference in simulating current climate patterns with observed climate at an annual scale. Using an average of the model outputs some reasonable policy inferences can be made.

For sea level rise, Church et al. (2006) using tide gauge data combined with TOPEX/Poseidon satellite altimetry data from 1950-2001 estimated a rate of relative sea-level rise of 0.5 ± 0.5 mm/yr is expected for the Seychelles. Against the global mean sea level rise (1961 to 2003) of 1.8 ± 0.5 mm/year (Bindoff et al., 2007), these results appear to fall below the global average but not low enough to minimise the risks involved. Chang-Seng (2007) estimates using the HadCM2 and HadCM3 models (with the IS92 or P50

business as usual emission scenarios) an annual sea level rise ranging from +0.4 to +0.6 meters for the 2070-2100 period.

Observations of coastal erosion in naturally stable areas have been linked to this increase in sea level combined with coral bleaching and storm surges (Sheppard et al., 2005). Sheppard (2003) argues that in view of predicted sea surface temperature rises, coral reefs will not fully recover but most probably experience a coral cover decrease in the next 40 years.

Coastal issues, in particular, beach erosion is also linked to human activities and therefore requires a proper assessment of the root causes of the changes before implementing any adaptation technology. Furthermore, institutional frameworks will be needed to support the implementation of the chosen technology.

5 Future Impacts and Vulnerability to climate change

Assessments of vulnerability in the Seychelles have been derived from three main studies – the preparation for the first national communication (INC, 2001), the AIACC Project (Payet, 2006) and preliminary outcome of the Second National Communications (SNC)[1]. The Initial National Communications (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 the climate on tourism, also considered issues such as coastal zones and coral reefs. The second national communications 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 - 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.

[1] Draft sector reports prepared under the 2nd National Communications Process (see bibliography).

5.1 Agriculture

It is very likely that subsistence and commercial agriculture on small islands will be adversely affected by climate change (high confidence) (IPCC 2007 - Mimura et al., 2007).

Agriculture is only 3% of the Seychelles GDP (NSB, 2006), but with the recent global food crisis, the issue of national food security has taken the highest priority in Seychelles. A report by the FAO Commission on Genetic Resources found that the Seychelles' dependence on plant genetic resources is 85%. (Ximena, 1998). Whilst there is evidence that the impending food crisis will likely persist in the near future, climate change is thought to affect agriculture in numerous ways, in particular availability of water and changes in the geographical range of plant diseases. An increase in atmospheric carbon dioxide has been shown to increase productivity of certain agricultural crops. Risk of disease introduction of pandemic proportions is a serious threat, especially when it is linked to climate factors.

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 insight 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.

Whilst agriculture is inextricably linked to the climate, the recent increase in food prices, which has aggravated access to food in many parts of the world, is caused by a number of other factors beside climate change. Climate change will affect food security by affecting local and global food production and by affecting access to food supplies. Agriculturally-

based livelihood systems in small islands are already vulnerable to climate change, especially in terms of crop failure and loss of livestock due to either extended droughts or persistent floods. Furthermore on average many small island states import more than 30% of their cereal consumption needs, and in many cases more than 50% of total food supply is imported (source: www.fao.org/sids).

5.2 Fish and 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).

The sector is dominated, economically, by the industrial purse-seine tuna fishery and production of canned tuna. Strong climate oscillations (ENSO and Indian Ocean Dipole) have profound effects on the purse-seine fishery, due to modifications of tuna habitat and, consequently, catchability (Menard et al. 2007). In 1998, when ENSO and dipole interacted, the direct, indirect and induced economic effects of the tuna industry declined by 58%, 34% and 60%, respectively (Robinson et al. 2009). The sector currently faces numerous challenges, including overfishing, competition and changes in trade regimes. Sector-level strategies to adapt to climate change and other challenges are not mutually exclusive, and include fishery and market diversification, improved services, development of mariculture and sustainable fisheries management (Robinson et al. 2009).

Of minor economic importance compared to the industrial fisheries, the artisanal fisheries sub-sector plays a vital role for food security and employment. Severe degradation of coral reef habitat occurred in the wake of the 1998 coral bleaching event (Graham et al. 2006).

Loss of structural complexity and slow recovery at some sites has affected reef fish biomass, suggesting possible lag effects on reef fisheries (Graham et al. 2007). However, coral reef fisheries are of relatively minor importance in value and volume compared to the demersal line fishery based on the extensive banks of Seychelles, for which the effects of climate change are less immediate. Combining a relatively high level of adaptive capacity, conferred by socio-economic factors (McClanahan et al. 2008), with a strong institutional background in environmental and resource management (Cinner et al. 2009), there are tenable opportunities for adaptation to climate change in the artisanal fisheries sub-sector.

5.3 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)

Seychelles is at risk from climate-sensitive diseases such as malaria and other food and water-borne diseases. Ebi *el al.* (2005) provides a summary of the main impacts of climate change on human health in small island states. Major tropical diseases such as malaria, leishmaniasis, yellow fever, sleeping sickness and bilharziasis are as yet non-existent in the Seychelles. However, Seychelles has the ideal conditions for malaria and there were indeed reported outbreaks in 1908, 1931 and 1933 on the Atoll of Aldabra and Assomption.

Other 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 year-long study on the prevalence of leptospirosis in Seychelles concluded that it was more frequent in middle-aged males with environmental exposure with an incidence of 101 per 100,000 population (Yersin et al., 1998). The link between increased incidences of leptospirosis and the rainfall season is observed and documented for the years 1989-1990 (Pinn, 1992) and 1993 (Yersin, 1995).

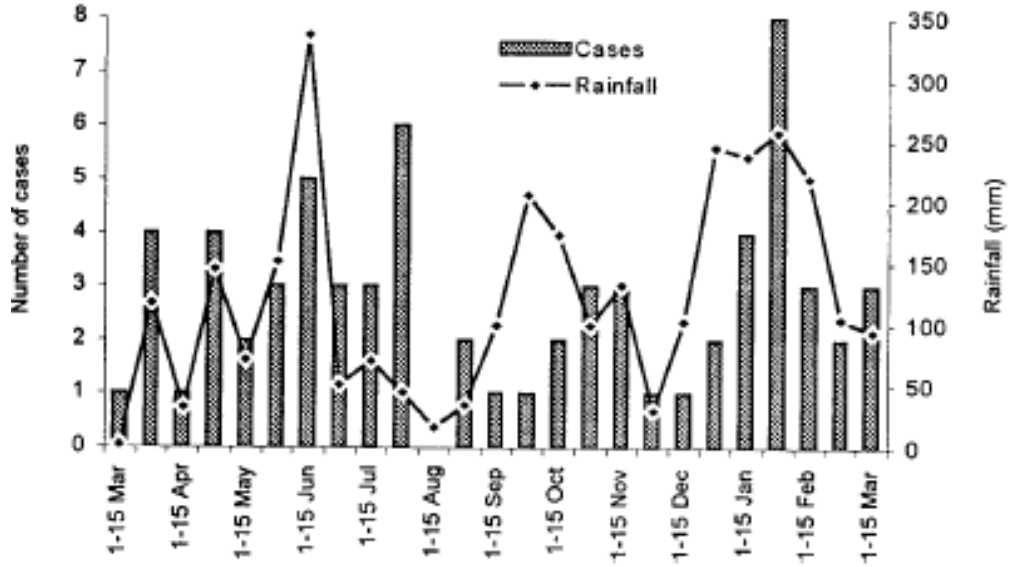
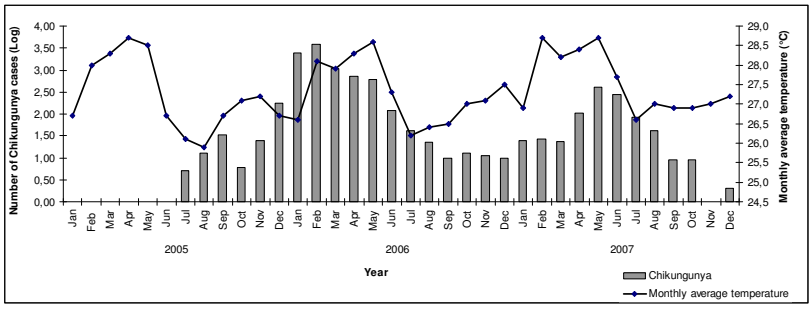


Figure 13 Admissions for leptospirosis and average rainfall by 15-day period in the Seychelles. (Yersin, 1998)

From 2005 to 2006 a viral epidemic, the Chikungunya fever, propagated by mosquitoes spread through the Indian Ocean, the worst hit being the island of Reunion, a French Department. In Seychelles a total of 8,818 suspected cases (more than 20% of the working population) were reported between 1 January 2006 and 26 February 2006, affecting the economy which depends upon its local labour in tourism and other services (HPA, 2006). Most affected were women between the ages of 15 and 54 years (DREF, 2006). The spread of Chikungunya in Seychelles was also closely related to climate especially rainfall and temperature, creating ideal breeding sites for *Aedes aegypti* mosquitoes, the primary vector (Chretien, 2007). Chretien also argues that Chikungunya can also be drought associated, especially in areas where water is stored in open receptacles. Henriette-Payet & Julienne

(2009) found an even greater correlation between the Chikungunya outbreaks and temperature variations. They argue that 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 US$ 1.84 million in economic losses, against an estimated cost of less than 200,000 USD for disease control (which can be roughly assumed to be related to disease prevention).

(a)



(b)

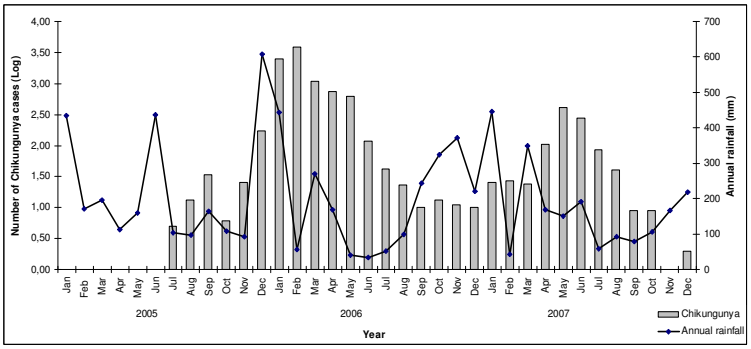


Figure 14 (a) Rainfall and Chikungunya outbreaks 2005-2007, (b) Atmospheric temperature and Chikungunya outbreaks 2005-2007. (Henriette-Payet & Julienne, 2009)

Outbreaks of Dengue (Type II) in Seychelles have occurred periodically; notable cases include (i) December 1976 to September 1977 affecting almost 75% of the population (Metselaar, 1980); (ii) December 1978 and (iii) January 1979. This shows how crippling disease epidemics linked to climate change can be. Believed to be transmitted by *Aedes albopictus* mosquitoes (13), the virus is purported to originate from South East Asia. An

entomological survey conducted in Mahé in 1995 showed a high prevalence of *Ae. albopictus*. The Breteau Index is a method used for mosquito larval surveillance before and after the monsoons in tropical areas. According to the WHO definition, this index notes the number of larvae containers per 1000 sites inspected. On Mahé Island, the Breteau index varied between 17.0 to 100.0% and the house index from 14.3 to 53.3%, implying that the risk of transmission at the time of analysis was very high and cause for serious concern. *Ae. albopictus* is known to have desiccant resistant eggs which facilitates its dispersal in portable containers, and its distribution is closely associated to temperature, rainfall and humidity – important climate change variables. Of serious concern is the report by Henriette Payet & Julienne (2009) which, in a follow-up survey undertaken in 2003, indicate that over 63% of districts have a Breteau Index far above the World Health Organisation (WHO) standard of 5%; and 68% of houses have a House Index above WHO standard (4%). Such result implies a worsening of the situation, requiring immediate attention.

Other climate-sensitive diseases including other vector-borne diseases, non-vector diseases, heat-related diseases, diseases from urban air pollution, and diseases related to extreme weather conditions such as floods, droughts, strong winds and fires may occur in the Seychelles but there is little documented evidence of this.

Increase in the non-vector borne infectious diseases such as cholera, salmonellosis and other food and water related infections could also occur as a result of changes in rainfall, flooding incidences and poor sanitation at community and household level. Further research is required to determine the exact links between such diseases and the climate in the context of Seychelles.

Rapid increases in air temperature, such as during a heat wave (although not documented in the history of Seychelles) can affect individuals suffering from old-age, cardiovascular, cerebrovascular, respiratory, endocrinal, renal and consumptive diseases such as chronic infections and terminal carcinoma.

The impact of climate change on agriculture and fisheries, locally and globally, will also have an indirect impact on nutrition. The increase of fruit and vegetable pests associated with climate change will also affect availability and increase prices, having a direct impact on population nutritional health.

Due to a strong commitment in Seychelles to the development of primary and secondary health care (20% of total public expenditures) as well as substantive investments in sanitation there have been remarkable improvements in the health status of its population, in comparison to a number of other small island states. However, although Seychelles may have experienced relatively low climate-sensitive health impacts in the past, its vulnerability to such impacts remains very high and prevention as well as potential adaptation measures will need to be further developed.

5.4 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)'. The IPCC 2007 (Mimura *et al.*, 2007)

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).

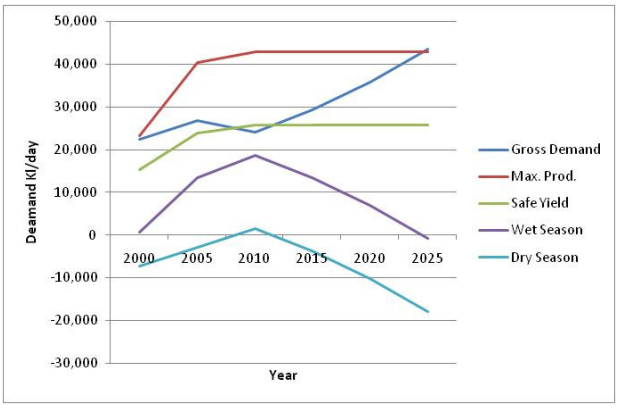


Figure 15 Mahé Projected Daily Water Demands, Yields & Shortfall in Supply - Revised October 2004 (from PUC, 2004)

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 note 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.

5.5 Coastal Zones

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 (Vista do Mar and Quatres Borne – both on Mahe) which were apparently caused by heavy rainfall. The coastal plateau in the granitic islands (Mahé region) is characterized 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 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.

5.5.1 Sea Level Rise and related phenomena

Global sea level rise has been increasing at a rate of 1.8 mm per year from 1961 to 2003, and further IPCC projections (IPCC 2007), using the SRES (Special Report on Climate Change Scenarios) indicate that global average sea level rise will vary from 18 cm(best case scenario) to 59 cm (worst case scenario) by 2100. This difference in estimates indicates uncertainty levels in predicting future temperature increases. It is also very difficult to

predict the rate the ice sheets (in particular on Greenland and Antarctica) will melt and slide into the ocean. The matter is further complicated by the superimposition of global natural cycles such as the 18-year tidal cycle which can generate extreme tidal ranges in some parts of the world. Another factor which contributes to local sea level rise is the expansion of the sea water body due to increasing warming of the ocean. In addition, we expect a loss in coral height due to global warming (Sheppard et al. 2005), which would in effect allow much more wave energy to reach the coastline. These combined factors are expected to cause further erosion of the coastline, inundate agricultural areas, aggravate coastal flooding, and affect salinity balance in mangrove areas. Such impacts on the physical and ecological environment in most cases translate into socio-economic impacts such as loss of coastal infrastructure (such as tourism establishments and homes), loss of crops and coastal fisheries.

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 destabilized the beach to the point where one land owner is estimated to have lost over 10,000 m2 of land in the last few years (Quatre, 2005). Extreme tide levels in the last few years have also served to destabilize the coastline. Climate change will exacerbate these problems and lead to further destabilization of the coastline.

5.5.2 Tropical depressions

Three intense tropical depressions have affected the Seychelles in recent times, tropical depression Ikonjo in 1990 at 7.5^{o}S with a maximum wind speed of 96 km/hr affecting Desroches in the Amirantes, Tropical depression 01S in 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 2006 with a maximum wind speed of 287 km/hr within the Farquhar island group (11.1^{o}S). The last documented evidence of a cyclone hitting the Farquhar group was

in 1956, exactly 50 years ago. Aside these direct events, the Seychelles is also affected by the spiral rain band of intense tropical cyclones propagating further south of the island group.

Chang-Seng & Guillande (2008) constructed model simulations of wind hazard zones over the Seychelles Island and classified Farquhar island group within the highest hazard zone with a return period between 14-50 years. The Mahé group was classified as the fourth highest wind hazard zone, with maximum gusts exceeding no more than 90km/hr over a 30 year period. This finding has important implications for construction codes and hazard response planning. Storm surges, generated by severe storms, can cause extensive coastal damage. These are particularly severe when combined with high and extreme tidal events. For example, Cyclone Bondo (2006) generated storm surges with wave heights of about 2.7 m over the Providence Atoll in the Farquhar group (Chang-Seng & Guillande, 2008).

Although there is no clear evidence of an increase in frequency or intensity of tropical depressions, the damage caused by such events can cripple coastal infrastructure and accelerate beach erosion.

5.5.3 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, indicates 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 Pte Larue Station on Mahe. This caused extensive damage to agriculture and some residential areas were flooded.

5.5.4 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 per cent 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 per cent of foreign exchange earnings, 20 per cent 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 cyclone 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).

5.6 Other impacts

5.6.1 Forest Fire

Forest fires pose risks to human habitation, critical infrastructure and also 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 US$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 US$1 million per year (GoS, 2000).

Forest fires are much more common on the island 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.

6 Institutional and Capacity

6.1 Institutional Arrangements for Climate Change

Climate Change became a topical issue in Seychelles following the signature of the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992. One of the first steps towards this endeavor was the setting up of the Seychelles National Climate Change Committee (NCCC) in August 1992 to provide an overall co-ordination of the development and implementation of the national climate programme, and to act as an interface between national climate programme and the government (INC, 2000). Members of the committee included representatives from most government departments, the private sector and non-governmental organizations. The NCCC was the organization behind the preparation of the Seychelles first national communication to the UNFCCC and is currently preparing its second national communication due in January 2010.

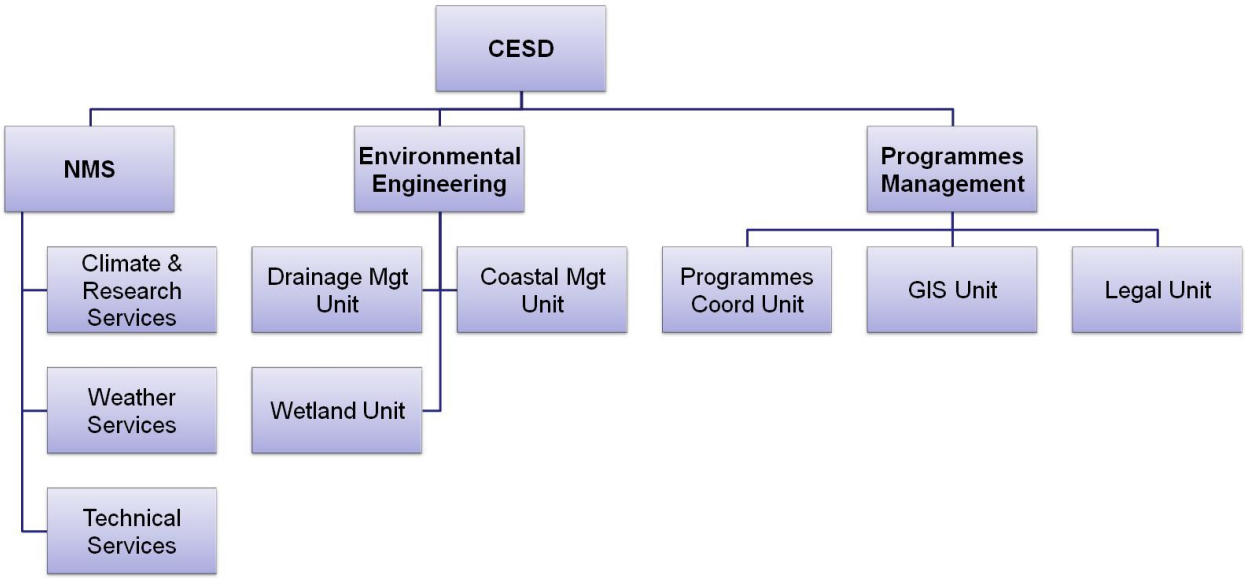
Another key objective of the NCCC was to build the necessary in-country capacity on climate change which has today resulted in a national network of experts, one of which is lead author with the Intergovernmental Panel on Climate Change (IPCC), and another as contributor.

To facilitate its work, the NCCC Secretariat was established in 1992 under the support of the Seychelles Meteorological Services (Department Civil Aviation) and the Division of Environment. Subsequently, the Seychelles Meteorological Services was transferred to the Department of Environment, and to this date, the UNFCCC secretariat has been hosted by the Ministry responsible for the environment. This institutional support has been significant in the development of a national framework on climate change, the development of closer ties with the World Meteorological Organisation (WMO), the IPCC and the UNFCCC. It has also enabled the country to strengthen its negotiating position, as the ministry was already involved with a number of international multilateral environment conventions.

The Seychelles Meteorological Services established a climate centre in 1998, with two experts in climatology. The centre has not been able to grow due to staff mobility; however it has contributed significantly to the development of various climate studies, including retrieval of historical meteorological data. The Seychelles Meteorological Services is also responsible for the management of the country's network of meteorological stations, the tide and sea level monitoring stations as well as the ozone monitoring station.

In 2007, with a reorganisation of government, a Climate and Environmental Services Division (CESD) was created which incorporated the National Meteorological Services (NMS), the Environment Engineering Section (EES) and Programme Management Section (PMS) (Agricole, pers com.). See Figure 16.

Figure 16 Organizational Structure of CESD. The Head of the Climate and Research Services Unit under NMS is the current Chairman of the NCCC



Until early 2008, there were no NGOs in Seychelles that specifically focused on climate change issues. The setting up of Sustainability 4 Seychelles (S4S) aims to focus on climate

change issues and sustainability. The Sea Level Rise Foundation (SLRF) was founded in 2007 to raise global awareness of sea level rise and its impact on small island states and coastal communities. Furthermore, numerous other NGOs, such as the Wildlife Clubs of Seychelles have participated in numerous activities to promote climate change awareness among school children. A special publication, entitled 'Sustainable Living in Seychelles' attempts to tackle, among other environmental issues, practical ways in which schools can reduce their greenhouse gas emissions and also adapt to climate change.

6.2 The government's mitigation and adaptation strategies

The activities of government on mitigation and adaptation strategies are enshrined in the Environment Management Plan 2000 to 2010 (EMPS, 2001) and the Seychelles First National Communication (INC, 2000). The development of the national communication to the UNFCCC necessitates the development of a country profile, a greenhouse gas inventory, a vulnerability assessment to climate change, and an adaptation and mitigation strategy. These elements constitute the government strategy on mitigation and adaptation.

The first Environment Management Plan of Seychelles or EMPS 1990-2000 was developed in the early nineties. At the time, climate change was not considered a relevant issue, although EMPS 1990-2000 had some programme areas such as the Energy Policy and Conservation Programme and the Coastal Management Programme, focusing on mitigation and adaptation, respectively. It was in the EMPS 2000-2010 that climate change took a much more prominent role in guiding environmental management in Seychelles. EMPS 2000-2010 considered climate change as a cross-cutting issue, which implied mainstreaming climate change across all of the priority programmes. It is not clear whether this has been achieved in practice as the institutional changes that are required to mainstream climate change at national level is still being developed. Seychelles was allocated USD 5 million under the Global Environment Facility (GEF) resource allocation framework (RAF) for biodiversity projects. Whilst the RAF will cover a number of important biodiversity issues, its links to climate change issues will need further strengthening. Seychelles has a GEF group allocation for access to climate change funds.

The resources are yet to be made available although Seychelles has submitted a project on adaptation to water resources management.

The First (or Initial) National Communication (INC) was published in 2000 and contains information on emissions and removals of greenhouse gases, and details of activities undertaken to implement the UNFCCC convention. Whilst Annex 1 countries (mainly developed ones) have to submit their report annually; non-annex 1 countries are under no obligation to do so unless they have received funding for preparation of the communication. Seychelles is a non-annex 1 country and has already submitted an initial national communication. It is currently in the preparation of its second national communications (SNC). Since the SNC will only be available late 2009, reports for this document were derived from the INC.

The INC concluded that Seychelles is a net sink of greenhouse gases, but recommended that a number of mitigation options could be considered since Seychelles is also a net importer of fossil fuels. Mitigation options that are already under implementation or being considered include (i) use of compact fluorescent light in the domestic and commercial sectors, (ii) adoption of energy efficient appliances in the home and the office, (iii) incorporation of energy efficient measures and standards in building design (iv) promotion of the use of renewable energy technologies such as solar water heater (SWH); and (vii) increased use of LPG in hotels and domestic cooking, (viii) implement a traffic management plan with integrated land use and transport planning; (ix) declaration and enforcement of emission standards; (x) energy education and extension services, (xi) effective control of deforestation and commercial biomass harvest; (xii) protecting forests in reserves and (xiii) plantation of new forest areas.

Possible adaptation actions identified in the First National Communications are, however, much more complex to implement. An evaluation of these options is summarized in Table 1**Error! Reference source not found.**.

Table 1 Status of adaptation options outlined in Seychelles First National Communications[2].

Adaptation Options outlined in INC 2000	Institution	Status
Integrate adaptation guidelines into development planning	Town and Country Planning Authority, Department of Environment	Ad-hoc, no formal legal amendments have been made to cater for these guidelines.
Setback lines for coastal development	Town and Country Planning Authority, Department of Environment (DoE)	Enforced as part of the Environment Impact Assessment Process.
Strengthening of technical and institutional capacity in monitoring and research, the adoption of integrated coastal management	Coastal Engineering Section (DoE), Seychelles Centre for Marine Research and Technology	Ongoing beach monitoring programmes in partnership with hotels.
Changes in crop and crop varieties to climate resistant ones	Department of Natural Resources	Experiments for heat resistance, pest and disease resistance
Improved water management and irrigation systems, and changes in planting schedules and tillage practices	Department of Natural Resources	Low volume water applicators, shade technology and fertigation
More efficient management of existing water supplies and infrastructure	Public Utilities Corporation	Maintenance programme to reduce leakages, water pricing tariffs linked to consumption.
Improved monitoring and forecasting systems for floods/droughts	Seychelles Meteorological Services	Climate centre focusing on improved forecasting of significant weather event.
Rehabilitation of watershed and enlargement of reservoir capacity	Public Utilities Corporation, Forestry Division	Annual reforestation programme, plans for increasing reservoir capacity.
Further research to determine adequate adaptation to climate change on fisheries	Seychelles Fishing Authority, Seychelles Centre for Marine Research and Technology	Ongoing research programme under Second National Communication.
Improved sanitation to reduce mosquito propagation	Ministry of Health, Department of community development, DoE	Ongoing campaign to remove waste and fumigate infested areas.
Environmental health education and awareness	Ministry of Health	Ongoing efforts in the media and at community level.
Strengthen prevention of communicable diseases	Ministry of Health	Government funded disease prevention programme.
Strengthen and institutionalize disaster preparedness and management	Department of Disaster and Risk Management	Ongoing development of appropriate plans, infrastructure and support.
Institutions and policies, including building codes	Town and Country Planning Authority	Some codes but not adequately enforced.
Strengthening of local media awareness and broadcasting capacity especially on remote rural outer islands	Seychelles Broadcasting Corporation, local newspapers	Few TV programmes, more radio programmes, frequent newspaper reports
Develop appropriate insurance for catastrophic risk.	Department of Disaster and Risk Management, Department of Natural Resources, Insurance companies	Some work in developing an insurance scheme for farmers; housing insurance in place.

[2] A detailed review will be published in the Seychelles Second National Communications due in 2010.

Although many of these activities are being implemented, the human resources, scientific, technical, technological and institutional capacity required is still lacking. Various mechanisms for financing adaptation in developing countries are being explored and in December 2007 the Conference of the Parties to the United National Framework Convention on Climate Change (UNFCCC) in Bali, mandated the Global Environment Facility to establish and manage the Global Adaptation Fund. This Global Adaptation Fund was established to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. The Fund is to be financed with a share of proceeds from clean development mechanism (CDM) project activities and received funds from other sources.

6.3 Climate Change Capacity Building Framework

The implementation of effective capacity building for climate change stems out of 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 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), provided the status of observation systems in Seychelles, including the 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 mitigations at all levels is therefore a priority for 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 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 2). 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) prioritized the following areas of capacity building needs:

- Strengthen and increase observational networks over the islands of Seychelles, through community and private sector participation*;*
- Establishment of a database related to the performance of all basic meteorological instruments;
- Enhancing efforts to monitor, document, understand and model climate processes and consequences at local, island, national and regional levels;
- Strengthening 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;
- Improving information on the nature and consequences of climate conditions. Developing and applying predictions of climate variability on various timescales as well as reliable projections of climate change;
- Improving 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;

- Improving 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 Pacific island communities and ecosystems;

- Improving 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 2 Summary of Seychelles Programme for Future Capacity Needs For Systematic Observations (Source: Wills, 2009).

MANPOWER	**Current**	**Desired number**	**On training**	**Implementation Date**
WMO Class I Oceanography Hydrology Information Technology	2	8	None	2009- 2019
WMO Class II Oceanography Hydrology	7 1 0	10 2 2	None	2009-2019
WMO Class III & IV Aviation Oceanography/Marine Hydrology Agrometeorology	18	25		2009- 2019
Engineers / Technical Oceanography/Marine Hydrology Agrometeorology Climatology	5	8	None	2009- 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	2009- 2019

7 The Seychelles National Climate Change Strategy

7.1 The strategic framework

Seychelles was the second signatory to the United Nations Framework Convention on Climate Change (UNFCCC) on the 22nd September 1992, and signed the Kyoto Protocol on the 20th March 1998. Seychelles continues to be a strong advocate of Small Island States and remains at the forefront of the climate change issue, having represented the small island states community on numerous international forums and bodies.

In 2001, Seychelles with the financial support of the Global Environment Facility (GEF) submitted its first national communication in accordance with Article 4, paragraph 1, and Article 12, paragraph 1, of the United Nations Framework Convention on Climate Change (UNFCCC). Seychelles is currently undertaking the preparation of its second national communication (SNC) due for submission in April 2010.

In November 2001, the UNFCCC[3] decided that the least developed countries (LDCs) should be assisted in preparing national adaptation programs of action (NAPAs) to address urgent and immediate needs and concerns related to adaptation to the adverse effects of climate change. Seychelles, being a non-LDC, did not benefit from this support in spite of its vulnerability and priority to address climate change. As a consequence no long term climate strategy is available for the Seychelles, except for that which is presented in the first national communication to the UNFCCC and the Second Environment Management Plan of the Seychelles (EMPS 2001-2010).

Within the same framework, the 2nd National Communication to the UNFCCC was initiated in 2006. As part of this process and to provide the basis for financing under this project, the Seychelles National Climate Change Strategy (SNCCS) was developed.

[3] Established by decision 7/ CP.7 of the COP of the UNFCCC.

Such a strategy will provide a coherent and consolidated approach to new climate change related policies, programs and projects. The strategy will remain a "working" document intended to be updated and revised on an ongoing basis in response to new challenges and opportunities.

This strategic document will address three key issues:

1. What are the characteristics of the key risks and opportunities of climate change?
2. What is required to build a resilient approach to mitigate and adapt to climate change impact and consequences?
3. How can key climate change issues be integrated or mainstreamed into key national policy areas and other stakeholder areas?

The strategic plan was developed through a consultative process and based upon the work undertaken in preparation of the Second National Communications. The consultative process included a workshop, circulation of the first draft to a wide range of stakeholders and presentation of the first draft to the National Climate Change Committee.

The strategy is developed with due consideration of the following:

a. A review of the latest studies on climate change and their impact on the Seychelles, with particular attention to the numerous sectoral issues and priorities;

b. The encouraging performance of the recent macro-economic reform programme with the support of the International Monetary Fund and other international organization, to restore macro-economic stability in Seychelles;

c. A complementary approach which builds upon existing plans and programs, including national and regional action plans under other international environmental agreements, especially as they relate to climate change issues;

d. The recommendations of the International Meeting of the Small Island States 2005, the Mauritius Strategy on Sustainable development;

e. Builds upon the national environment and sustainable development strategy, the EMPS 2000-2010, addressing national concerns to reduce vulnerability to climate change;

f. A multi-stakeholder approach where government, communities and non-government organizations work together to achieve the strategic objectives;

g. Emphasis on investment in long-term capacity building for resilience at all levels of society.

7.2 The relationship between the Second National Communications (SNC) and the National Climate Change Strategy (NCCS)

To ensure coherence and effective coordination and implementation of the NCCS, it is important that it is seen as part of the SNC overall preparatory process as the country moves towards adopting a national strategy on climate change and seeking access to financial and technical support from bilateral and multilateral partners.

The NCCS is being developed under the mandate of the National Climate Change Committee, whose mandate is also to oversee the production of the SNC. Therefore at the institutional level the NCCS is adequately positioned within the body mandated to oversee the implementation of climate change adaptation and mitigation in Seychelles. Whilst the traditional nesting of the climate activities within the ministry responsible for environment is not necessarily effective in many countries, the context of Seychelles in terms of capacity and the structure of government allows the NCCC to work with various sectors at the technical level and access political support as and when necessary through Cabinet interventions. However, the NCCC should be further empowered in the following manner to ensure successful implementation of this strategy:

1. A mechanism is established to engage support at the highest political level, especially in the implementation of key cross-sectoral activities identified in this strategic plan;

2. The NCCC should comprise of high level representatives of stakeholders to ensure decisions taken have the high level of support at operational level;

3. Strengthening the secretariat for effective and efficient institutional coordination is needed for monitoring and exchange of knowledge;

4. Adequate technical support to provide assistance to stakeholders in the process of mainstreaming climate change issues;

5. Availability of sufficient resources to support the implementation of the strategy.

The Seychelles Energy Commission, whose primary role is to ensure national energy security, and encompasses mitigation, should become actively involved in the implementation of this strategy. The development of a comprehensive energy policy, jointly funded by the Government of Seychelles and UNDP will lay the foundations for the implementation of a number of activities identified as part of this strategic plan. The policy which is expected to be presented to government at the end of 2009 includes a consideration of the institutional and legal reform in the energy sector, renewable energy, energy conservation and financing. However, a key constraint remains the availability of trained capacity in the area of mitigation and renewable energy.

In preparation of the SNCCS, an extensive review of the draft documentation in preparation for the SNC was undertaken to ensure that the strategy is in line with the findings of the SNC, and addresses the main issues raised in the SNC process.

It is expected that the SNCCS will operationalise and implement certain aspects of the SNC priorities. Outcomes of the strategic implementation process will also likely influence the preparation of the third national communication, as and when this is initiated.

7.3 Links with the Third Environment Management Plan (2011-2020)

The Seychelles is also engaged in the preparation of its third environment management plan. However, based upon strong recommendations the plan will treat climate change as a cross-sectoral issue similar to the case of the EMPS 2000-2010. Adoption of a cross-sectoral approach acknowledges the multidimensional nature of climate change; the important role all stakeholders have to play in achieving effective adaptation and mitigation.

This is indeed an important issue as the environment is likely to be affected by both human pressure and also climate change. Whilst human populations will need to adapt, biodiversity will also result in important ramifications for past and future conservation activities. This is particularly evident in small islands where the scope for natural biodiversity adaptation may be very limited. Typically, many of the Seychelles endemic species have narrow geographic ranges, some of which are only restricted to particular islands and at particular altitudes.

Mainstreaming of climate change into sustainable development should indeed be a core cross-sectoral programme of the third EMPS, addressing matters of policy, institutions, capacity building and civil society involvement.

7.4 A SWOT Analysis

The July 31 2009 stakeholder workshop also generated a SWOT analysis (Strength-Weakness-Opportunities-Threat) of the climate change context of the Seychelles. The SWOT focused on adaptation, mitigation and capacity issues.

7.4.1 Adaptation to climate change in Seychelles –

Adaptation to climate change in Seychelles is linked to the ability to implement actions through existing institutions as well as solutions on the ground. The SWOT analysis

revealed a number of impediments to successful implementation of adaptation activities. These impediments relate to:

1. the effectiveness of government action and intervention;
2. the lack of in-country capacity to tackle the issue of climate change and;
3. inadequate resources to implement climate change adaptation.

The full SWOT is shown in Figure 17.

Figure 17 SWOT Matrix on adaptation capacity in Seychelles

Strengths	**Weaknesses**
• A number of existing laws, regulations & policies invoke adaptation approaches • Reliable institutional structures in place • Emerging community-based structures • Strong NGO and civil society involvement in biodiversity issues • Voluntarism, cooperative arrangements and collaborative processes appear well developed • High level of public awareness on climate issues • Strong government support to implement adaptation measures • Strong health and education systems in place	• Poor enforcement and lack of consistent implementation of policies and laws • Lack of capacity and knowledge to address emerging issues • Limited financial resources for adaptation • Lack of coordination and communication between certain sectors • Poor involvement of the private sector in adaptation activities • Insufficient training and capacity building opportunities • Physical isolation of the country • Insufficient external project funding for adaptation
Opportunities	**Threats**
• Increased number of training and capacity building for adaptation at international level • Role of the media in building awareness and action for adaptation • Further expansion of CBOs and NGOs involved in adaptation activities • Greater involvement of the community • Involve the private sector in adaptation planning and financing • Increased donor funding.	• International climate taxes impact on tourism and reduce national capacity to adapt • Loss of employment and economic returns as a result of damaged facilities • Continued inappropriate development in high risk areas, especially from sea level rise and landslides. • Ignoring policies and guidelines • Bureaucracy, especially in decision-making • Loss of human resource capacity • Risk of global crises (e.g. food, energy, financial) undermining adaptation efforts.

7.4.2 Mitigation of Greenhouse Gases in Seychelles – A SWOT Analysis

The mitigation of greenhouse gases in any country is dependent upon the availability and pricing of fossil fuels and Seychelles was no exception. During the period of cheap oil and expensive renewable technologies, Seychelles energy policy was wholly dependent upon the use of fossil fuels. With demand peaking in 2008, the cost of fossil fuel increased to a point where Seychelles could not afford to run its economy on fossil fuel alone. Hence the creation of the Seychelles Energy Commission and the development of a comprehensive energy policy to look at increasing the energy security of Seychelles through investments in renewable energies. Whilst there are expected global benefits, Seychelles will also benefit through access to much more reliable sources of energy.

The main issues inhibiting effective mitigation measures in Seychelles include the lack of:

1. A clear policy and legal framework for the introduction of alternative energy technologies;
2. Access to appropriate and cost-effective technologies for mitigation;
3. A weak implementation of energy conservation measures and awareness.

The full SWOT is shown in Figure 18.

Figure 18 SWOT matrix on mitigation capacity in Seychelles

Strengths	**Weaknesses**
• High level of commitment among agencies & NGO to move towards renewable energy options • Moderate level of awareness on mitigation • Availability of an educated workforce • Private sector initiatives to reduce greenhouse gas emissions • High reliability from small scale technologies • International financing can have an immediate and positive impact. • High level of conservation and management of major sinks.	• No capacity for national energy management • Lack of financial incentives for industry to implement mitigation • Poor access to technologies appropriate for mitigation in small island context • Lack of awareness at policy level • Resistance to adopt other technologies by industry • Archaic legal framework for energy • No incentives to stimulate early adaptors • Incomplete data on energy • Poor awareness programmes on mitigation
Opportunities	**Threats**
• Availability and affordability of alternative energy technologies on the international market • Gain from the extensive experience of other small island states • Improvements in public transport • Earn from a suitably development Carbon finance framework • Standards for conservation of energy and associated infrastructure	• Persistence or recurrence of financial and oil crisis • Maintain reliance on fossil fuel only • Poorly implemented renewable energy technologies • Inappropriate energy conservation technologies and practices • Lack of financial resources to implement mitigation activities

7.4.3 Capacity Issues in addressing Climate Change in Seychelles

Capacity is central to addressing both adaptation and mitigation in Seychelles. Often despite the availability of financial resources and technology, lack of capacity inhibits the implementation of adaptation and mitigation in small islands. Furthermore, lack of poor capacity, increases the vulnerability to climate change. A highly resilient nation is one in which there is sufficient capacity to monitor, anticipate and respond to climate change in an efficient and cost-effective manner. The issue of capacity has been identified in numerous studies, including the preparation of this strategic document.

The main capacity issues are:

1. Development of capacity at tertiary level, especially in areas of supporting mainstreaming of climate change, research and monitoring of climate change, including capacity for adaptation and mitigation.
2. Expressed need for the development of a framework for empowering stakeholders in tackling climate change issues at all levels of society.
3. Managing transformation and change through appropriate building of capacity in government needs to be further developed.

Figure 19 SWOT matrix on capacity issues for climate change in Seychelles

Strengths	**Weaknesses**
• Reliable and compulsory education system in place. • Small population base. • Major improvements in communication. • Strong community and extended family linkages.	• Lack of access to tertiary level education • Mobility of capacity is very high despite training efforts • Empowerment being recently emphasized • Climate not mainstreamed • Resistance to adopt new approaches and technologies • Resentment to Adaptation – A barrier to change
Opportunities	**Threats**
• Mainstream climate change issues into national development policies • Creation of University of Seychelles • Focus on capacity building	• High mobility and brain drain • Insufficient resources to address the capacity gap • Perpetuation of the reliance on government • Empowerment poorly developed or focused on only one segment of society

To operationalise these long-term strategic objectives and address the issues raised in the SWOT analyses, the following section presents the strategic priorities and action plan. It is important to note that some of these targets may be subject to modifications as the required sectoral studies in preparation of the Second National Communications are not yet completed.

8 Strategic Responses

A new vision is required to address climate change issues in Seychelles. This vision is based upon a short visioning exercise undertaken during a stakeholder workshop in preparation for this strategy. In formulating the vision, participants shared the following convictions and were of the view that:

1. Climate change is a reality and happening, although observations have yet to be confirmed through scientific research.
2. Noting the prevailing notion of the uncertainty principle, action needs to be taken now to reduce vulnerability and avoid long-term costs associated with climate change impacts.
3. Early planning and proactive approaches are needed. A number of existing and proven planning tools are available which could be implemented immediately.
4. Although the exact nature and extent of the impacts are as yet unclear, combined with uncertainties, further knowledge development and applied research is critical to build capacity for adaptation and resilience building
5. Climate change has important links to the economy, noting especially the effects of the recent food and energy crisis, as well as the impact of recent extreme events on coastal infrastructure and tourism.

8.1 Vision

The shared vision is:

To minimise the impacts of climate change through concerted and proactive action at all levels of society

8.2 Principles

This vision is supported by the following key principles which seek to create the framework for the effective implementation of the action plan. These key principles have been derived from the SWOT analyses and represents the opportunities, whilst taking into account the potential weaknesses and threats. Seychelles has implemented two generations of Environment Management Plan, and as a consequence has laid the foundations for the implementation of these identified opportunities. A number of critical weaknesses exist, some of which is being tackled as part of a national reform process which resulted in the transformation of the economy into an open market system and the downsizing of the public service to increase effectiveness and reduce bureaucracy. These foundations will play a vital role in advancing the implementation of the principles outlined in Table 3 .

Table 3 Principles supporting the implementation of the strategy and action plan

Principle	Rationale
1. Early action is more cost-effective and builds long-term resilience capacity	Pro-active response to both adaptation and mitigation is more cost-effective than trying to react to damage caused by floods, for example. Careful planning and design can avoid costly damage to infrastructure.
2. Sustainable development is an integral part of resilience building	Sustainable use of resources ensures that resources are not exploited beyond their capacity to recover. Climate change impacts should be integrated into sustainable development plans and targets.
3. Consistent progress in advancing towards the Millennium Development Goals (MDGs) will enhance economic growth and quality of life	Achieving the MDGs will enhance the national capacity to adapt to climate change. An educated, fed and housed workforce can better respond to the impacts of climate change.
4. Integrated planning enables cross-sectoral harmonization and effectiveness of adaptation measures	Integrated planning will enhance effectiveness of actions through extensive consideration of issues and involvement of all stakeholders. Implementation of the strategy needs to be integrated with other plans such as the EMPS and Energy Policy.
5. Effective implementation of policy at all levels of management	Policy implementation should be backed by effective awareness campaigns and enforcement measures. Implementation of policy should build credibility and apply to all levels of society.
6. Actions and adaptation response should rely on proactive planning and available scientific information	Better use of long-term monitoring data and scientific research in planning and design. Consideration of technical information in decision-making and selection of options.
7. Capacity building and empowerment at all levels of society	Continuous and long-term approach for capacity building through existing institutions. Capacity building should be designed to target all levels of society in line with their required response and actions.
8. Ecosystem-based adaptation needs to be further developed to decrease vulnerability to climate change	The use of ecosystems to respond to adaptation, combined with engineering technology presents the optimum opportunity to adjust to natural variability and change. Ecosystem conservation and management provides additional services which can significantly reduce impacts of climate change.

9 Strategic Priorities and Action Plan

A number of strategic objectives were derived from the stakeholder workshop organized within the context of the development of this plan. These objectives are intended to ensure that the Seychelles is able to adapt and develop resilience to climate change and its effects. This is dependent upon the achievement, at global level, of an agreement on GHG emissions reductions which would reduce current 'dangerous' levels of GHG gases in the atmosphere to safe levels in the least possible delay. Small Island States (SIDS) are proposing that a 40% reduction in GHGs can be achieved by 2020. Failure to achieve these levels may result in catastrophic and costly impacts on the Seychelles, its people and economy.

To address these issues, the following five strategic priority objectives are proposed:

1. To advance our understanding of climate change, its impacts and appropriate responses.
2. To put in place measures to adapt, build resilience and minimize our vulnerability to the impacts of climate change.
3. To achieve sustainable energy security through reduction of greenhouse gas emissions.
4. To mainstream climate change considerations into national policies, strategies and plans.
5. To build capacity and social empowerment at all levels to adequately respond to climate change.

The following section presents the objective, strategy and action plan. An indication of priority is given within the context of opportunities available and capacity to implement. It is expected that a short-term and long-term action plan can be extracted from this report. Recommendations for implementation are also given under each objective.

9.1 Objective 1 - To advance our understanding of climate change, its impacts and appropriate responses

Research and monitoring are fundamental to our understanding of the implications and consequences of climate change in the context of Seychelles, an archipelagic state situated within a 1,000 km of any land mass. The strong influence of oceanography on the climate of Seychelles would thus require programmes that improve our understanding of natural variability and interplay with human-induced climate change. Much of the existing models are at very low resolution and thus more precise high resolution models are required to better understand the impacts of climate change in small islands, especially when the impacts of climate change are not uniform around the planet. Uses of global averages are useful in guiding global or regional policy but limited in its use for decision-making and adaptation at local levels. There is a critical need for estimations of sea level rise and other oceanographic phenomenon within the Seychelles archipelago. Limited time series undermines the ability of appropriate models to determine future climate scenarios.

This issue was raised by all of the sectoral reports in preparation of the 2nd National Communications. Through research and monitoring, response measures such as adaptation can be most effectively implemented. Seychelles has a very weak research and monitoring capability which will need to be enhanced and reinforced in implementation of this strategy. With the establishment of the first university in Seychelles, it is expected that research into climate change and its effects will take importance. In instances where data is collected, long-term monitoring is not consistent and in areas where these are available, analysis and use of the data in decision making is lacking.

Specific sectors such as health, coastal areas, agriculture and fisheries have highlighted key research gaps. Health, especially the potential widespread of disease epidemics, is a national concern in Seychelles. The coastal zone is an important consideration for Seychelles in terms of climate change. The majority of activities occur on the coastal zone, thus research and monitoring needs are especially important in determining the optimal zoning potential and potential impacts on beaches and port areas. Since food security is at

the centre of survival in small islands, the availability of basic foodstuffs is heavily dependent upon local agricultural production, although islands do import substantially large amounts of agricultural products to supplement and meet demand especially in the tourism industry.

9.1.1 Implementation Arrangements and constraints

The objective will be implemented by the various research and monitoring institutions in Seychelles. The Seychelles does not have a strong research culture but organisations such as the National Meteorological Services, the Department of Environment and the Seychelles Fishing Authority, have been maintaining monitoring programmes and assembling long-term data sets. Some environmental NGO's also undertake scientific research and collects data. The establishment of the University of Seychelles in 2009 will lead to the expansion of research and monitoring in Seychelles, but this likely to take several years as the university will tend to focus on immediate structural issues in the short-term. However, development and promotion of research capacity will enhance the country's ability to achieve objective 1.

The following mechanisms need to be established and/or strengthened:

1. A national research council needs to be established to ensure that research is coordinated at the national level. The research council will ensure there is appropriate coordination of research and monitoring, knowledge transfer as a result of the research, and also ensure that appropriate knowledge platforms are maintained and accessible.

2. The Climate Unit within the National Meteorological Services needs to be strengthened and appropriately staffed to ensure long-term sustained research. Partnerships with other institutions in the region, for example Meteo-Reunion, and internationally, e.g. the Hadley Centre and the University of Hawaii's Sea Level Centre needs to be further reinforced.

3. Strengthen the capacity of the University of Seychelles and other institutions to develop research programmes and deliver capacity building programmes aimed at implementing activities identified in this strategic plan.

The major constraints to monitoring and research remain the availability of resources to fund those programmes. In Seychelles, other constraints include the availability of trained personnel to manage those monitoring equipment and also conduct the necessary research. Support to expand the Seychelles weather monitoring network is vital in capturing local variations.

9.1.2 Action Plan

			Timescale	Priority	Lead Org.
Strategy	**1.1**	**Identification of gaps and research priorities required to predict the impacts of climate change in Seychelles**			
Actions	1.1.1	Assess data needs and important gaps in knowledge that impede adaptation to climate change.	1 year	High	NCCC[4]
	1.1.2	Establish long-term monitoring of oceanographic parameters, including sea level rise and sea surface temperature.	5 years	High	NMS[5]
	1.1.3	Consolidate the existing beach and wetland monitoring programmes.	2 years	Moderate	MoE[6]
	1.1.4	Improve data collection and monitoring for vector distribution on the main inhabited islands, in particular mosquito species.	2 years	High	MoH[7]
	1.1.5	Study and prescribe the monitoring/technical requirements required for early warning of extreme storm and wind events.	1 year	High	NMS
	1.1.6	Identify climate sensitivity and develop relevant ecological and socio-economic indicators for the artisanal fisheries sub-sector.	2 years	High	SFA[8]

[4] National Climate Change Committee
[5] National Meteorological Services
[6] Ministry responsible for Environment
[7] Ministry responsible for Health
[8] Seychelles Fishing Authority

Strategy	**1.2**	**Development of capacity to manage, analyse and present such data in a manner in which it can be useful for guiding policy and influencing adaptation.**			
Actions	1.2.1	Undertake small and basin-scale modelling using oceanographic monitoring stations and arrays.	3 years	High	NMS/SFA/UniSey[9]
	1.2.2	Use high resolution models in the development of climate change scenarios for Seychelles.	5 years	Moderate	NMS
	1.2.3	Assess and research trends and relationships of disease outbreaks or vector distributions within the context of climate variability and change.	2 years	Moderate	MoH
	1.2.4	Develop health risk plans based upon climate change scenarios.	2 years	Moderate	MoH
	1.2.5	Acquire high resolution DEM data for use in mapping climate-related risks, zoning, and vulnerable areas.	2 years	High	GIS Unit[10]
	1.2.6	Incorporate sector data (e.g. agriculture, tourism, fisheries, forestry, etc.) into risk, vulnerability and distribution maps.	2 years	High	SAA[11]
	1.2.7	Establish farm-level value at risk database.	2 years	High	SAA
	1.2.8	Develop ecosystem modeling for climate-sensitive fisheries.	4 years	Moderate	SFA
	1.2.9	Model changes in the distribution and productivity of marine resources at a relevant spatial scale under climate change scenarios.	3 years	high	SFA

[9] University of Seychelles
[10] Geographical Information Systems Unit, Ministry responsible for Land Use.
[11] Seychelles Agricultural Agency

Strategy	**1.3**	**Establishment of sustainable long-term monitoring programmes in strategic areas, with focus on climate scenarios, risk assessments and adaptation.**			
Actions	1.3.1	Access to high-resolution regional and global ocean and coastal datasets.	5 years	Moderate	MoE
	1.3.2	Establish Sea Level Rise/Tidal Observation stations on other islands of Seychelles.	5 years	High	NMS
	1.3.3	Expand rainfall monitoring network for development of appropriate predictive and design tools.	3 years	High	NMS
	1.3.4	Establish operational network for monitoring and sharing of data at national & regional level.	3 years	Moderate	NMS/UniSey
	1.3.5	Implement mechanisms to ensure sustainability in financing and support of oceanographic research and monitoring.	2 years	Moderate	MoE/MF[12]
	1.3.6	Implement fisheries-independent monitoring system for coral reef fisheries resources that incorporates resilience indicators.	1 year	High	SFA/NPA/NGO's

[12] Ministry responsible for Finance

9.2 Objective 2 - To put in place measures to adapt, build resilience and minimize our vulnerability to the impacts of climate change

Adaptation can be defined as those actions or activities that people undertake, individually or collectively, to accommodate, cope with, or benefit from, the effects of climate change. But generally people are continually adapting to climate variability, thus adaptation is a constant process of adapting to their immediate environment and the complex interactions within the economic, social and political dimensions. However, in some instances the ability and resources to continually adapt is limited or non-existent, thus causing significant impacts. The ability to cope with climate change therefore incorporates a wide range of measures to increase the resilience of the environment and the affected community.

The SNC sector reports have elaborated a number of adaptation measures to reduce vulnerability and enhance resilience across the sectors considered. Adaptation in the health sector is fundamental to any other adaptation response as regards the resilience of the nation to respond to other impacts and concerns of climate change. Effective response will also depend upon the achievements of key actions outlined under objective 1. The coastal zone climate change assessment undertaken indicates that the narrow coastal areas, where most of the development is located is most at risk from sea level rise and coastal flooding. These studies highlight the vulnerability of the coastal regions of the Seychelles islands and proposed a number of adaptation actions. The issue of capacity building for adaptation is considered a priority as well. Monitoring the effectiveness of adaptation measures is equally important to enable the sharing of knowledge.

9.2.1 Implementation Arrangements and constraints

The implementation of this objective requires the involvement of several key ministries such as the Ministries of Environment, National Development (Land use Planning), Community Development, Health and a number of other government agencies, non-governmental organisations and local government. A number of cross sectoral committees

already exists such as the Environment Management Plan Steering Committee and the National Climate Change Steering Committee. However, a more focused inter-sectoral task force to facilitate implementation of adaptation is recommended. This task force shall comprise of representatives from: the ministries concerned, socio-economist, climatologist, disaster expert, community leaders, NGO's, the media, tertiary and research institutions in Seychelles, the insurance industry, and education.

The functions of this task force will include:

1. Coordinate the effective implementation of the actions identified in this strategic plan.
2. Identify key stakeholders and increase coordination and communication on key climate adaptation issues.
3. Identify synergies and approaches to implementation of adaptation actions across all sectors.
4. Designate and support a national adaptation knowledge platform accessible to all levels of society.
5. Create and maintain a network of key partners for the facilitation of adaptation projects.
6. Identify and act on cross-cutting, cross sectoral issues that require the action of government and collaboration of stakeholders.
7. Make recommendations to the highest level of government on cost-effective and feasible adaptation solutions.

A number of constraints can influence the effectiveness of adaptation measures proposed in this plan. Such constraints includes (i) the ability of government to implement those identified actions; (ii) availability of adequate human capacity, and (iii) the financial capacity to implement and sustain those proposed adaptation options.

9.2.2 Action Plan

			Timescale	Priority	Lead org.
Strategy	**2.1**	**Identify priorities for adaptation, especially in critical sectors**			
Actions	2.1.1	Study to identify and prioritise areas for adaptation intervention	1 year	High	NCCC
	2.1.2	Undertake review of policies and institutions with a view to ensure consideration of adaptation issues.	2 years	Moderate	NCCC
	2.1.3	Evaluate potential coastal risk zones, vulnerabilities and level of protection in place.	2 years	Moderate	MoE
	2.1.4	Assess the effectiveness of existing adaptation techniques, including impediments to implementation.	2 years	High	NCCC
	2.1.5	Assess levels of disease/pest control resistance in climate-related vectors.	3 years	High	MoH
	2.1.6	Determine adaptation opportunities in fisheries considering socio-economic conditions, fishing pressure, and international trade.	2 years	High	SFA

Strategy	**2.2**	**Assess and improve ongoing management activities and their contribution to adaptation**			
Actions	2.2.1	Identify key areas of management which entails consideration of adaptation.	1 year	High	NCCC
	2.2.2	Development of legally binding coastal land-use plans (incorporating the impact of climate change and natural changes in coastal processes).	3 years	Moderate	TCPA[13]
	2.2.3	Improvements, awareness and further investments in waste collection and management to reduce flooding and vector-disease propagation risks.	4 years	Low	LWMA[14]
	2.2.4	Improvements to the public health infrastructure in response to climate-driven epidemics improved.	2 years	Moderate	MoH
	2.2.5	Adoption of coping approaches with regards to the management of protected areas for resilience to climate change.	2 years	Moderate	NPA
	2.2.6	Establish basic design specifications, incorporating climate change considerations, into coastal drainage, coastal protection, road and other infrastructure development projects	2 years	High	MoE/Private Sector
	2.2.7	Establish and strengthen the role of EIA and SEA in climate change adaptation and risk/impact reduction	1 year	High	MoE/TCPA
	2.2.8	Develop social and ecological resilience in exploited marine ecosystems through adoption of an ecosystem-approach in fisheries management plans.	4 years	High	SFA

[13] Town and Country Planning Authority
[14] Landscape and Waste Management Agency

Strategy	**2.3**	**Implementation of adaptation activities**			
	2.3.1	Develop and implement on a pilot scale effective adaptation measures and tools at community level, including coastal restoration approaches	Ongoing	High	MoE/MLG[15]
	2.3.2	Research and develop alternative coastal designs (such as elevation of buildings) which accommodate sea level rise.	2 years	High	TCPA
	2.3.3	Implement nation-wide rainwater harvesting programme.	1 year	High	MoE/PUC[16]
	2.3.4	Demonstration of adaptation technology implementation, with focus on nature-based methods.	3 years	Moderate	MoE/NGOs
	2.3.5	Enhance the management of coral refugia and resilient areas.	Long-term	High	NPA, NGOs
	2.3.6	Evaluate and implement new plant varieties, strategies for pest and invasive control for agriculture and forestry, to cope with changed climatic conditions.			
	2.3.7	Reinforce approaches for sustainability in fisheries through improvements in monitoring and management of fishing zones.	Long-term	Very High	SFA
	2.3.8	Develop and implement cost-effective beach restoration techniques in support of the tourism industry.	5 years	High	MoE, private sector

Strategy	**2.4**	**Establish financing mechanisms for adaptation**			
Actions	2.4.1	Dedicated financing for preventative measures and early warning of climate-related vector disease prevention established.	3 years	High	MF
	2.4.2	Develop the capacity to mobilise and implement resources from international agencies to address the climate risk.	2 years	High	MoE
	2.4.3	Explore and develop micro-insurance, risk reduction and financing mechanism and private sector financing options for adaptation.	3 years	High	MF/Private Sector
	2.4.4	Establishment of a National Disaster Crop Insurance scheme.	3 years	High	SAA

[15] Ministry responsible for Local Government
[16] Public Utilities Corporation

9.3 Objective 3 - To achieve sustainable energy security through reduction of greenhouse gas emissions

Although Seychelles is not required under the UNFCCC and its Kyoto Protocol to implement emission reductions, it is nevertheless of strategic and economic importance that Seychelles reduces its dependence on fossil fuels and embraces low carbon and in particular renewable forms of energy, which is abundant in Seychelles. Following the recent increases in oil prices, Seychelles realized that it needed to transform its energy sector and diversify into other forms of energy, especially those with little or no greenhouse gas potential. Seychelles also depends upon long-haul travel for its tourism industry, in view of its insularity. So mechanisms to reduce its tourism carbon footprint are critical to the continued development of the tourism industry in Seychelles.

However, the Legal framework for energy conservation is non-existent, thus there is no incentive, except through price signals to achieve innovation and implementation of energy efficiency in industry and domestic sectors. A number of initiatives aimed at energy conservation have been introduced with fixed success. However, a previous project to transfer users from kerosene to LPG for cooking has been very successful, which indicates that end-users are conscious of the issues and wish to engage further in conservation or transfer of technology within the energy sector. The demand for electric vehicles or hybrids is expected but not stimulated due to highly taxed vehicles in Seychelles. There is also concern that these technologies do not really bring any benefits to the climate change threat. The adoption of energy conservation in buildings is also lacking and was raised during the SWOT exercise as well as in the sector reports.

9.3.1 Implementation Arrangements and constraints

The establishment of the Seychelles Energy Commission (SEC) is expected to place energy at the centre of economic growth and development in Seychelles. A statutory law is being developed to legally institutionalize the SEC. A new energy policy, which will be coordinated by SEC, is also being developed.

A number of barriers impact on the ability of Seychelles to transfer to a clean energy framework. These barriers include the availability of such technologies at affordable prices and lack of national legislation. The capacity to transfer such technologies, including support infrastructure is also lacking in Seychelles.

One of the recurring constraints in undertaking greenhouse gas (GHG) emission inventories is the lack of data, or in many cases data are not properly kept. To enable better planning and assessment of GHG, the GHG emissions report makes a number of recommendations including the establishment of a database and repository for all archived data.

9.3.2 Action Plan

			Timescale	Priority	Lead Org.
Strategy	**3.1**	**Diversify the energy portfolio of Seychelles towards renewable forms of energy**			
Actions	3.1.1	Develop a comprehensive energy policy aimed at charting a strategy to achieve energy security	1 year	High & Ongoing	SEC[17]
	3.1.2	Feasibility studies for the establishment of wind, solar and waste-to-energy technologies	2 years	Moderate	SEC/PUC
	3.1.3	Upgrading of national grid to accommodate alternative sources of energy	4 years	Moderate	PUC

Strategy	**3.2**	**Modernise the energy legislation and institutional framework to encourage innovation and transfer of technology in the energy sector**			
Actions	3.2.1	Establish legally and strengthen the Seychelles Energy Commission to oversee energy management in Seychelles	1 year	High & Initiated	MoE/SEC
	3.2.2	Development of new Energy Act	1 year	High	SEC
	3.2.3	Develop and implement framework for enabling financial incentives, including feed-in tariffs, for technology transfer and conservation in the energy sector	2 years	High	MF
	3.2.4	Implement market-based mechanisms to enhance energy efficiency in industry and other sectors	2 years	Moderate	MF
	3.2.5	Develop appropriate codes and specifications for energy efficiency in the transport, building and commercial sectors.	2 years	High	TCPA
		Establish a carbon market in Seychelles	2 years	Moderate	MoE

[17] Seychelles Energy Commission

Strategy	**3.3**	**Improve monitoring and assessment of energy use and emissions**			
	3.3.1	Establish legal requirement for sharing of energy data	Ongoing	High	SEC/NSB[18]
	3.3.2	Develop and maintain energy statistics	1 years	High	SEC/NSB
	3.3.3	Maintain data on other sources of GHG emissions as specified in the UNFCCC guidelines	2 years	Moderate	SEC/NSB

Strategy	**3.4**	**Technology transfer in the energy production and transport sector**			
Actions	3.4.1	Establishment of a clearinghouse and advisory services platform on efficient technologies and appliances	3 years	High	SEC
	3.4.2	Establish demonstration projects for various energy technologies with the participation of the private sector	2 years	High	SEC/Private Sector
	3.4.3	Create an enabling environment for the piloting and testing of new vehicle technologies	1 years	High	SEC/LTA[19]

[18] National Statistics Bureau
[19] Land Transport Agency

9.4 Objective 4 - To mainstream climate change considerations into national policies, strategies and plans.

The risks posed by climate change to communities and livelihoods, as well as investments have rarely been included into development planning. The issue of mainstreaming adaptation to address climate change in small islands is largely unexplored. Indeed the knowledge on how small island states can better adapt to climate change through mainstreaming of adaptation at policy, institutional and community levels is lacking and deserves urgent attention if climate risk reduction in small island states is to be successful. Mainstreaming adaptation implies linking climate change to sustainable development, and the integration of policy, socio-economic issues, coastal and ecosystem management, knowledge transfer and capacity building that address climate change. Mainstreaming adaptation creates an effective framework for building national and community resilience as well as effective climate risk reduction.

One example is the creation of the Environment Engineering Section within the Department of Environment, tasked with dealing with coastal issues such as beach management and storm-water drainage. Both these issues are clear climate risks and thus needs adequate coordination with other departments such as tourism and transport. However, there is a serious lack of capacity to implement measures to reduce this climate associated risk.

Another important institutional interface is the Town and Country Planning Authority (TCPA) whose mandate is to regulate development in the Seychelles. To facilitate its work, a number of formal and anecdotal guidelines are available, with poor links to climate change reduction. Although the TCPA has multi-sectoral representation which includes the private sector it has had limited influence on defaulters, or in empowering designers and architects to take into consideration climate risk issues in development proposals and plans.

9.4.1 Implementation Arrangements and constraints

The implementation arrangements for mainstreaming adaptation can be implemented within the mandate of the proposed Adaptation Task Force. Since the implementation of this objective requires the participation of government, the community and the private sector, it is vital that the task force puts in place a mechanism for the coordination of the activities in mainstreaming which involved stakeholders from these three distinct groups.

The key constraints include the ability of the task force to engage all sectors in the promotion and compliance to policies and laws, mobilising the required resources for mainstreaming, motivating the private sector and communities to get involved in adaptation.

9.4.2 Action Plan

			Timescale	**Priority**	**Lead Org.**
Strategy	**4.1**	**Addressing institutional learning and stakeholder flows**			
Actions	4.1.1	Identify and undertake a review of the main institutions involved in responding to climate change, identify conflicts or parallel efforts and explore networking and synergies.	1 year	High	NCCC
	4.1.2	Review of key procedures, guidelines and specifications to include climate change adaptation considerations into national planning.	2 years	Moderate	NCCC
	4.1.3	Develop programme to raise awareness of the likely impacts of climate change for all identified stakeholders.	2 years	Moderate	NCCC

Strategy	**4.2**	**Incorporate climate risk assessment and response into Government**			
Actions	4.2.1	Engagement of government (incl. the executive & legislative) with the scientific community for input of climate risk information into the development of national development strategies, policies and laws.	1 year	Moderate	NCCC, Gov. & UniSey
	4.2.2	Identify key stakeholders and develop policy for involvement of key stakeholders in climate change adaptation through a multi-stakeholder coordination committee.	1 year	High	NCCC
	4.2.3	Update TCPA guidelines and *modus operandi* to mainstream climate change into key national risk sectors.	2 years	High	TCPA
	4.2.5	Develop a knowledge platform on mainstreaming adaptation in small islands.	2 years	High	SLRF[20]
	2.2.6	Revise and implement the Fisheries Policy, Inshore Fisheries Strategy and Fisheries Development Plan to incorporate sector adaptation mechanisms to climate change.	2 years	High	SFA

Strategy	**4.3**	**Incorporate climate risk assessment into the Private Sector**			
	4.3.1	Development of incentive structures by reducing bureaucracy, barriers to introduction of new technologies and supporting capacity building activities.	1 years	High	SCCI[21]/MF/ MA[22]
	4.3.2	Adoption of guidelines and codes for development which take into consideration climate change issues.	2 years	Moderate	TCPA

[20] Sea Level Rise Foundation
[21] Seychelles Chamber of Commerce
[22] Ministry responsible for Administration

9.5 Objective 5 - To build capacity and social empowerment at all levels to adequately respond to climate change.

Capacity building is central to climate risk reduction and building human resilience to climate change. Climate change is indeed a very complex subject with scientific underpinning, and socio-economic and cultural ramifications. Thus clear and effective communication of climate change issues is critical in the implementation of actions outlined in this strategic plan. There is a need to improve consumer communication on the real cost or impact of the consumer products, in terms of carbon footprint. Communication of the outcomes of climate research is also an important activity and is especially relevant to those operating in the private sector such as fisheries and tourism. Effective communication can also stimulate public discussions and action on climate change issues.

Incorporation of climate change education into primary and secondary curriculum is another opportunistic approach to building long-term resilience and adaptation to climate change. Since climate change is a multi-faceted issue, it can be easily integrated into any subject and as an extension to geography. The training of teachers and lecturers in the field of climate change can be part of this strategy. Government has serious capacity gaps in areas of planning, technical aspects of development and in responding to potentially damaging environmental issues.

The main strategies and actions for objective 5 are derived from the Carolus & Martin (2009) Assessment of Capacity within the context of the preparation of the Seychelles Second National Communication. The need to integrate climate change education into national strategies and policies, and mobilize resources for capacity building.

The National Capacity Self-Assessment (NCSA) process funded by the Global Environment Facility (GEF), in collaboration with United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP), aims to assist countries with capacity

development in global environmental management. The priority needs for developing Seychelles' capacity to meet its commitments to global environmental management was undertaken in 2006 as part of this NCSA process.

As part of their study, Carolus and Martin (2009) presented a summary of the capacity issues in each sector. The report also proposed a detailed and costed action plan. The priority actions were drawn from these works.

Table 4 Capacity needs and priorities at sectoral level.

Sector	Programs & Policies
Agriculture	SNC: Insurance scheme for selected crop and livestock; Study to assess changes in crop and crop varieties, improved water management and irrigation systems as well as changes in planting schedules.
	Agricultural Development Strategy 2007-2011 makes no reference to Climate change directly but promotes increased food security through adaptation to changing conditions and increased local production.
	Arable Crops Development Policy and Strategies 2007-2011 promote CC adaptation and mitigation measures.
Disaster	**National Disaster Management Policy awaiting Cabinet approval.**
	National Disaster Response Plan addresses risk of Tsunami, Cyclone and Flood at national and district levels. (25 district response plans and 1 specific response plan for Silhouette).
	National Meteorological Services designated as Early Warning Centre for the Seychelles.
Cross-Cutting	EMPS 2000-2010: Education, awareness and advocacy as well as vulnerability and global climate change are the cross-cutting themes of the EMPS. Climate change, education awareness & training (EA&T) are integrated into plans for many sectors, i.e. agriculture, energy.
Fisheries	**Fisheries Development Plan** currently being drawn up, makes reference to climate change effect on fisheries, strengthening research capacity.
	Fisheries Policy 2005 promotes training and research related to fisheries conservation & management, in light of climate, environmental and socio-economic factors.
Energy	Goals of New Energy Policy will allow optimal use of local and renewable energy sources; reduction of the emission of greenhouse gases & promote energy efficiency.
Plant Conservation	Targets of **Seychelles National Strategy for Plant Conservation 2005-2010** relating to climate change: Conserving crop diversity; Managing Alien Invasive Species & Sustainable production of valuable plants.
	Seychelles Plant Conservation Research Agenda 2008-2015 (Objective 6) identifies the impact of climate change on habitats and plant species.
Wetlands	Management plans for wetlands with sea level rise considered a factor.

(Source: Carolus & Martin, 2009).

9.5.1 Implementation Arrangements and constraints

Education and capacity building has always been at the core of development in Seychelles, so the Ministry of Education has also played an important role in advancing environmental education in the schools. However, climate change is not a curriculum subject per se, but there exists a number of wildlife clubs in schools in which students learn about climate change and its effects. The implementation of this objective requires the full participation of the Ministry of Education and other training institutions in Seychelles. Developing capacity for climate change is a long-term priority and whilst the focus on the young generation is important, life-long learning approaches towards climate change needs to be planned for.

Key constraints include the mobility of people trained in various professional fields. This is especially critical in Seychelles with its very small professional base. The establishment of the University of Seychelles will enable more Seychellois to attend graduate studies and ensure long-term development of capacity at tertiary level.

The proposed strategies and actions are listed below.

			Timescale	Priority	Lead Org.
Strategy	**5.1**	**Develop Climate Change education and communication**			
Actions	5.1.1	Develop and deploy climate change curriculum and teacher support materials in Seychelles Schools.	2 years	High	MoEd[23]
	5.1.2	Design and implement climate change educational and advocacy activities.	3 years	Moderate	MoEd, WCS[24], S4S[25]
	5.1.3	Integrate climate change education in all relevant national policies and strategies.	2 years	High	NCCC
	5.1.4	Organize awareness and educational activities for the youth.	Ongoing	Moderate	Youth Orgs.
	5.1.5	Promote ongoing stakeholder/community involvement in decision making regarding climate change education, awareness & training at national and district levels.[26]	2 years	Moderate	NCCC
	5.1.6	Develop capacity for emissions trading and carbon management with focus on CDM, NAMA and other mechanisms.	Ongoing	Moderate	MoEd

Strategy	**5.2**	**Implement climate change awareness at all levels**			
Actions	5.2.1	Identify gaps in communication and implement awareness raising activities within government, private sector and other organizations.	1 year	Moderate	NCCC, SCCI
	5.2.2	Integrate climate change education into all sectoral policies and strategies, i.e. tourism, fisheries, energy, agriculture, education, development, disaster response, etc.	3 years	High	
	5.2.3	Identify vulnerable groups and prioritise for capacity building activities to address climate change risk.	1 year	High	NCCC, MoSA[27]
	5.2.4	Develop communication and awareness strategies to engage the community in responding and adapting to climate change.	2 years	High	MoE & NGOs
	5.2.5	Identify the main gender issues in connection with climate change and implement capacity building programmes to address any specific gender-biased needs.	2 years	Moderate	NGO's

[23] Ministry responsible for Education
[24] Wildlife Clubs of Seychelles
[25] Sustainability 4 Seychelles
[26] Stakeholders would include NGOs, private sector, government agencies, community groups, youth, etc.
[27] Ministry responsible for Social Affairs

Strategy	**5.3**	**Strengthen formal climate change capacity building institutions**			
	5.3.1	Introduce climate change research and adaptation training at university level.	2 years	High	UniSey
	5.3.2	Develop and maintain a knowledge-base and use case studies for climate risk reduction.	1 years	High	SLRF
	5.3.3	Integrative and adaptation leadership training in "Climate change, climate variability and coastal security".	2 years	High	MoE, UniSey
	5.3.4	Development of appropriate modes of learning for adaptation at all levels and sectors of society, including aspects of empowerment at the local level.	2 years	Moderate	NCCC
	5.3.5	Establish a system of sustainable financing for climate change education, awareness and training programs.	1 year	High	MoE

Strategy	**5.4**	**Develop the capacity for global environment management, in particular climate change**			
Actions	5.4.1	Develop capacity for negotiations at international level.	2 years	High	MoE
	5.4.2	Develop policy research projects focused on analysis of global policy and mechanisms in relation to the specificities and priorities of small island states.	1 years	High	UniSey

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