

Seychelles Initial National Communication

under the United Nations
Framework Convention
on Climate Change



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Ministry of Environment and Transport
Government of Seychelles

Seychelles

Initial National Communication Under the United Nations Framework Convention on Climate Change

Prepared for the Conference of the Parties

**Ministry of Environment and Transport
Republic of Seychelles**

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Preface

The Republic of Seychelles acceded to the United Nations Framework Convention on Climate Change (UNFCCC) on the 22nd September 1992, being the second country to do so. Likewise, the Seychelles was one of the earliest countries to sign the Kyoto Protocol on the 20th March 1998.

The Initial National Communication to the UNFCCC by the Seychelles reflects our continued commitment to the process. Although the guidelines provided for the preparation of initial national communications by non-Annex I Parties do not place much emphasis on issues of vulnerability, adaptation and capacity building, my country is convinced that without sufficient attention given to these issues many small island states will not be able to cope with the impacts of climate change.

The preparation of the National Communication enabled us to focus on issues that link climate change to sustainable development, which were not given much attention before. The process created awareness at all levels of government, local communities, NGOs and the private sector, making it a truly integrated and highly participatory engagement. Through the work of the National Climate Change Committee (NCCC) and the study teams, which involved broad participation, several studies and assessments were undertaken in order to ensure that this Communication reflects clearly our situation, constraints and circumstances. The Communication further reinforces our position as an insignificant emitter and a net sink of greenhouse gas. Nevertheless, we have also identified areas for mitigation, for which we are prepared to undertake consistent and meaningful actions.

Whilst the world continues to debate about global climate change and its effects, small islands like the Seychelles are the most vulnerable, with increased potential loss of coastal infrastructure due to sea-level rise. The socio-economic implications are enormous. Amidst the range of uncertainties and the inability for science to provide all the immediate answers, it is important that we build upon two principles adopted in Rio (1992) and Kyoto (1997), respectively. The ‘the precautionary principle’, emphasises that all countries urgently need to identify areas where they can reduce GHG emissions through changes in policy and technology. Secondly, whilst it is clear that climate change will occur despite measures adopted in the Kyoto Protocol, there is an urgent need to ensure that developing nations, including Small Island Developing States (SIDS), can continue to develop and prosper in an equitable manner. Thus, SIDS need to be fully equipped, both financially and technically, to adapt to global climate change and sea-level rise, without re-directing its limited resources from sustainable development and the eradication of poverty, which is still imminent in many island states.

It is, therefore, my sincere wish that this Communication has not only fulfilled our requirements under Article 12 of the Convention, but also provided a better understanding of the specific challenges faced and the efforts that have been made by my country in coping with the increasing threat of global climate change.

James Alix Michel
Vice-President and Minister of Environment and Transport, Seychelles
October 2000

by such atmospheric perturbations. Trade winds from May to October result in drier conditions, with droughts, which results in severe water shortages, and hence affecting agriculture and all other sectors of the economy.

The small economy of the country is primarily dependent on tourism and fisheries, which provide most of the country's total foreign exchange earnings. The government has been promoting privatisation with a view to increasing domestic investments in the country. The private sector is now employing 48.2% of the labour force. To encourage investment, a 1994 Investment Promotion Act offers a wide range of tax concessions for private sector activities.

The fisheries sector is second to tourism in terms of economic importance. The export of canned tuna, fresh and frozen fish constitutes about 83% of the value of Seychelles' exports of goods or about 10% of total foreign exchange earnings.

Only about 10% of the 60 km² of potential agricultural land is being utilised for intensive arable farming. A mountainous terrain and low soil-fertility severely constrains agricultural productivity. The country has now become almost self-sufficient in the production of poultry meat, eggs and pork, while it remains heavily dependent on the import of beef and staples such as rice, potatoes and some fresh produce.

The Seychelles has a per capita (including tourists) water consumption of 140 litres/day (l/d) with an increasing demand in the domestic, tourists, industrial and commercial institutions, and government sectors. Fresh water is an extremely important resource for the Seychelles, especially due to the steep profile of the granitic islands and the small, low-lying coral islands.

Like other oil-importing countries, the Seychelles is vulnerable to oil price fluctuations. Due to increases in tourism and fisheries development, the energy demand increased from 58,000 tonnes of oil equivalent (toe) in 1988 to 102,000 toe in 1994. The energy sector is dominated by the importation of petroleum products, which makes up about 95% of the primary energy supply. The transport sector is the largest consumer of petroleum products after electricity generation.

Presently some 46% of the archipelago's land and an additional 228 km² of ocean are legally protected in the form of national parks and reserves. An additional 20-25% are classified as being sensitive and may become protected areas in the near future. The Seychelles has more than 1,000 endemic flora and fauna found nowhere else in the world. The Aldabra Atoll, home of 150,000 giant land tortoises, and the Vallée de Mai Nature Reserve covered in the endemic Coco-de-mer palms, was added to UNESCO's World Heritage list in 1982 and 1983, respectively.

The quality of the environment supports the booming but exclusive tourism industry. Numerous new initiatives, for example, the Environment Management Plan of the Seychelles (EMPS) 2000-2010 (after the successful implementation of the EMPS 1990-2000) and the National Biodiversity Action Plan provide a framework for enabling sustainable development in the Seychelles. The creation of an Environment Trust Fund has allowed the government to reinvest revenues collected from taxes and donations into environmental protection projects, and to attract private and foreign

donations to support its efforts. Eco-tourism is also being developed in a sustainable manner in the Seychelles to ensure proper use of its natural resources.

Greenhouse gas inventory: Sources and sinks

The greenhouse gas inventory was undertaken and reported based on the 'Revised IPCC (IPCC, 1996b) Guidelines for the National Greenhouse Gas Inventories'. The year 1995 was chosen as the reference year because it was not possible to obtain complete datasets for 1990 or 1994 as recommended by the COP 2 guidelines.

- a. **Energy:** Only energy activities related to fuel combustion are relevant for the Seychelles, and carbon dioxide (CO₂) is the most important GHG released. The total emission of CO₂ in 1995 was 178,736 tonnes, of which 58% was from electricity generation, 31% from the transport sector, 8% from small combustion and 3% from industries. Using the IPCC Reference Approach, the total CO₂ emission was estimated as 195,402 tonnes. The emission of other GHG from fuel combustion is relatively small compared to that of CO₂. Carbon monoxide (CO) emission was 5,126 tonnes; nitrous oxides (N₂O): 1.9 tonnes; methane (CH₄): 11.4 tonnes; nitrogen oxides (NO_x): 589.7 tonnes; and non-methane volatile organic compounds (NMVOC): 576.0 tonnes.
- b. **Industrial processes:** There are very few industrial processes in the Seychelles. The GHG emissions (mainly CO₂ and NMVOC) from the production of beer and bread could not be determined due to the lack of emission factors. However, due to their small size, emissions are not expected to be significant.
- c. **Solvent and other product use:** The consumption-based approach was used to estimate the emission of NMVOC from solvent use because in the Seychelles there are no centralised production activities. Solvents are used in paint application, degreasing and cleaning. The overall emission of NMVOC as a result of solvent use was estimated at 17.0 tonnes.
- d. **Agriculture:** The GHG emissions from the agricultural sector included 202.0 tonnes of CH₄ from domestic livestock, in particular, cattle and swine, and 75.0 tonnes of N₂O mainly from agricultural soil where animal manure was applied as a soil ameliorant.
- e. **Land use change and forestry:** GHG emissions from this sector mainly came from land clearing, either for development purposes or biomass harvest. About 80 ha of land are allocated annually for building houses, but not all are necessarily cleared. An annual average of 8,000 m³ of biomass are harvested commercially. However, according to the Division of Environment (DoE), this figure is expected to drop significantly in the future.
- f. **Waste:** Biodegradable solid wastes in landfills and anaerobic wastewater treatment facilities in Seychelles were the main sources of methane emissions. The total emission of CH₄ from landfills and wastewater treatment plants were estimated at 2,080 tonnes and 270 tonnes, respectively.

Table II. : Summary of GHG inventory in the Seychelles for 1995 (tonnes)

GHG SOURCES & SINKS CATEGORIES	CO ₂ Emission	CO ₂ Removals	CH ₄	N ₂ O	NO _x	CO	NMVOC
Total national emission and removal	191,290	845,310	2,563.4	76.9*	589.7	5,126.0	594.0*
1. All energy	178,236		11.4	1.9	589.7	5,126.0	576.0
A. Fuel combustion	178,236		11.4	1.9	589.7	5,126.0	576.0
B. Fugitive fuel emission							
2. Industrial processes	NA						1.0*
3. Solvent & other product use	17.0*						17.0*
4. Agriculture			202.0	75.0			
5. LUCF	12,540	845,310					
6. Waste			2,350.0				
7. Other							
8. International bunkers	379,130				7,232.6	368.0	

Note: 1 tonne = 0.001 Gg; NA=Not Available. *=Partially estimated
The emissions from the international bunkers are not accounted as part of the national total.

As shown in Table II, the total CO₂ emission in 1995 was 191,290 tonnes, of which 93% was contributed from the energy sector. The per capita CO₂ emission was estimated as 2.54 tonnes, which was much lower than the world average of 4.0 tonnes, and it was about 7.6 times lower than that of the USA (19.5 tonnes). With about 90% of the land is covered with vegetation, the total CO₂ removal capacity by vegetation was estimated 845,310 tonnes, which was 4.4 times of that emitted. The environmental policy of the Government will ensure that this balance is maintained in the future.

The total CH₄ emission was 2,563 tonnes, of which 91% was from landfills and wastewater treatment; and the N₂O emission (partially estimated) was 76.9 tonnes, of which 97% was from the agricultural sector. The total emission of indirect greenhouse gases NO_x, CO and NMVOC were 589.7 tonnes, 5,126 tonnes and 594.0 tonnes (partially estimated), respectively.

Technologies and measures for mitigation

The GHG emissions in the (i) residential, commercial and institutional sectors; (ii) transport sector; (iii) industrial sector; (iv) energy supply sector; (v) agricultural sector; (vi) forestry and land use sector; and (vii) solid waste and wastewater treatment, were projected for the short term (present to 2010) and medium term (2010 to 2020), based on available data.

A number of possible mitigation options are suggested for each of the sectors. However, these options have yet to be further analysed, assessed and costed, and integrated within socio-economic scenarios.

a. *Residential, Commercial and Institutional Sector*

Emission projection: The residential sector consists of about 18,000 households (1997 estimate) and other commercial and industrial institutions like hotels, restaurants, tours operators, banks, retailers, government institutions, private companies, etc. In 1990, this sector consumed 412 TJ of final energy of which 248 TJ (60%) was electricity generation and 164 TJ (40%) was mainly used for cooking and water heating. This amounted to the release of an estimated 9,434 tonnes of CO₂, as a result of the direct use of fossil fuel. The emission in CO₂ is expected to grow at an annual average rate of 5% to 15,403 tonnes in 2000, 25,323 tonnes in 2010 and 42,118 tonnes in 2020 (Table III).

Mitigation options: The possible mitigation options for this sector include: (i) energy conservation; (ii) the use of energy efficient lighting devices such as compact fluorescent lamps (CFL) and energy efficient refrigerators and other appliances; (iii) establishment of an energy efficient use and conservation extension service within the Energy Affairs Bureau; (iv) incorporation of energy efficient measures and standards in building design; (v) energy audits for commercial, industrial and institutional buildings; (vi) 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.

b. *Transport Sector*

Emission projection: The CO₂ emission from the transport sector accounts for 31% of emissions from the energy sector, of which 84% originated from land transportation. There were 6,050 vehicles in 1990, which is expected to increase to 18,361 in 2020. The CO₂ emission from land transportation was 41,186 tonnes in 1990, and it is expected to increase 88,511 tonnes in 2010 to 123,693 tonnes in 2020 (Table III)

Mitigation options: Possible mitigation options for this sector include: (i) improvement of the public transport system; (ii) equipping of the Highway Patrol Unit; (iii) establishment of a second city on Mahe to reduce the flow of traffic to and from Victoria; (iv) build a light rail system along the east coast; (v) promotion of sea transport along the coast; (vi) implement a traffic management plan with integrated land use and transport planning; (vii) improvement of driver's awareness; and (viii) installation of pollution control devices in the vehicles.

c. *Industrial Sector*

Emission projection: In 1990, the industrial sector consumed 92 TJ of final energy, of which 75% was for the use of fossil fuel in boilers and 25% was used for electricity generation. This had resulted in 5,102 tonnes of CO₂ emission, which is expected to increase by an annual average of 5% to 21,685 in 2010, and 43,354 tonnes in 2020 (Table III).

Mitigation options: The possible mitigation options for this sector include: (i) energy conservation; (ii) use of energy efficient and clean technologies; (iii) demand-side management with regular energy audits and proper energy management plan; (iv) declaration and enforcement of emission standards; and (v) energy education and extension services.

d. *Energy Supply Sector*

Emission projection: Importation of petroleum products constitutes about 95% of the primary energy supply of the country. There are four storage sites, with a total storage capacity of 73,069 tonnes, of which 58% is gas oil, 25% is jet kerosene, 9.5% is fuel oil, 7% is gasoline and 0.5% is LPG. Electricity generation is the main source of GHG emissions. There are three power stations with a total installed capacity of 35.2 MW (1996 data) and the amount of power generated was 133.8 GWh (1996 data).

In 1990, the gas oil and fuel oil consumptions were about 14,555 tonnes and 8,979 tonnes respectively. Assuming a 'business as usual' scenario the consumption is expected to increase to 18,631 tonnes for gas oil and 164,320 tonnes for fuel oil in 2020. In 1990, about 74,160 tonnes of CO₂ were emitted from the energy supply sector, and this is expected to rise to 269,069 tonnes in 2010, and 570,227 tonnes in 2020 (Table III).

Mitigation options: Possible mitigation options for the sector include (i) heat recovery from the public electricity generation power stations; (ii) promotion of the use of renewable energy technologies and energy efficient appliances in the energy end-use sector; and (iii) supply-side management, including the reduction in electricity losses.

e. *Agriculture Sector*

Emission projection: In 1995 the agricultural sector produced 75.5 tonnes of N₂O (mainly from cultivated and fertilised agricultural soils) and about 205.0 tonnes of CH₄ (mainly from enteric fermentation in livestock). It is projected that crop and livestock production would generate an emission of about 243.0 tonnes of N₂O and 63.5 tonnes of CH₄ by 2010, and about 253.0 tonnes of N₂O and 56.0 tonnes of CH₄ by 2020 (Cooposamy and Moustache, 1998). The projected decrease is due to a decrease in foliage directly available for cattle farming.

Mitigation options: Soil nutrient management for effective and economic fertiliser use and farmer's awareness programmes are possible mitigation options, if required, for the reduction of N₂O and CH₄ emission within that sector.

f. *Forestry and Land Use Sector*

Emission projection: There are over 40,600 ha (90% of the total landmass) of forest areas, of which 18,440 ha are located within protected areas. The present forest management practices focus on conservation of biodiversity, reforestation, erosion control and water catchment management. The Forestry Section has set an annual average target of 8,000 m³ in terms of forestry products.

The CO₂ emission from this sector is projected to be 12,540 tonnes per year up to the year 2020. It is assumed that the removal capacity of CO₂ will remain fairly constant at about 845,000 tonnes up to the year 2020. The removal capacity of the Seychelles forests needs to be further studied using more appropriate estimation methods.

Mitigation options: The possible mitigation options include: (i) effective control of deforestation and commercial biomass harvest; (ii) protecting forests in reserves; (iii) reducing encroachment on forest areas; and (iv) sustainable forest management.

g. *Solid Waste and Wastewater treatment*

Emission projection: CH₄ is emitted during the anaerobic decomposition of the organic content of solid waste in landfills and in wastewater treatment plants. The aerobic wastewater treatment plants operated by the large hotels are the main sources of CH₄ emission. At times, due to improper maintenance, some of these plants tend to function as anaerobic plants.

Mitigation options: Possible mitigation options include: (i) recycling and composting of solid wastes, and (ii) aerobic treatment of wastewater.

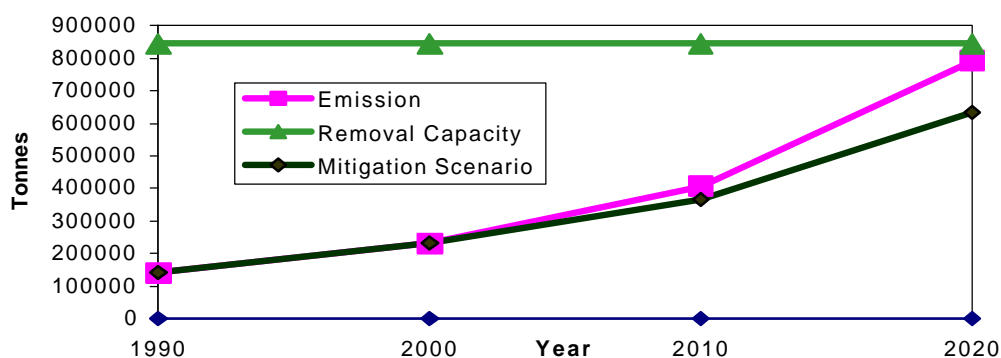


Figure I. Projections for CO₂ emission with (i) a “business as usual” scenario, and (ii) a mitigation scenario for the period 2000-2020. The removal capacity is assumed to be constant from 1990 to 2020.

Table III. Projected carbon dioxide emission and removal capacity (tonnes) in the Seychelles, 2000-2010

	1990	2000	2010	2020
Residential, Commercial & Institutional	9,343.0	12,057.0	15,403.0	42,118.0
Transport	41,186.2	63,354.6	88,511.3	123,693.0
Industrial	5,102.0	10,846.0	21,685.0	43,354.0
Energy Supply	74,159.6	133,949.4	269,069.4	570,227.1
Forestry & Land-Use	12,540.0	12,540.0	12,540.0	12,540.0
Total CO₂ Emissions Baseline Scenario	142,330.9	232,747.0	407,208.7	791,932.1
Total CO₂ Emissions Mitigation Scenario	142,330.9	232,747.0	366,487.8	633,545.7
CO₂ Removal Capacity	845,000.0	845,000.0	845,000.0	845,000.0

As illustrated in Figure I and shown in Table III, the Seychelles had a net sink of 702,569 tonnes of CO₂ in 1990. However, this amount of net sink is expected to decrease to 431,791 tonnes in 2010, and to 53,068 tonnes in 2020, assuming that the removal capacity remains constant. Thus, any enhancement of sink in the future would increase the removal capacity, and hence the net sink. The implementation of some existing and proposed mitigation measures is expected to have significant impact on the reduction of CO₂, and it is expected to save as much as 40,721 tonnes of CO₂ emission in 2010, and 158,386 tonnes in 2020.

Vulnerability, Impact and Adaptation Options

Natural habitats and biodiversity, the coastal zone and human settlements, agriculture, water resources, fisheries, human health, natural disasters and insurance are the key socio-economic sectors that were considered for sensitivity and vulnerability to climate change. However, without the proper tools such as digitised long-term meteorological data, higher resolution regional models, geo-coded and topographical maps, as well as the climate and impact models, the assessment was only based on some available historical data and based upon qualitative information. Further analysis based on climate scenarios generated by the GCMs and impact models relevant to the local conditions will be required. A number of possible adaptation options (not exhaustive) are identified for each of the above sectors, though each of these options has yet to be assessed.

Natural Habitat and Biodiversity: The Seychelles, which consists of a complex assemblage of extremely fragile and endemic ecosystems, is at serious risk from climate change, though the nature and extent of the potential threat has yet to be comprehensively researched and determined. Most habitats are expected to be severely modified by climate change, with some ecosystems being more vulnerable than others. An increase in sea level will flood the mangrove areas, most of which on the granitic islands are located behind the sand dunes and often below the sea level.

An increase in sea temperature, as evidenced in the 1997 El Niño event, will also have a huge impact on coral reefs. The destruction of coral reefs would effectively destroy vital habitats for a wide variety of coastal marine organisms, with dire socio-economic consequences. The Seychelles is also an important destination for migratory birds and other species. Climate change could severely affect their migrating patterns.

The long-term sustainability of the unique natural habitats in the Seychelles will depend on the preservation and protection of several types of habitats and conservation areas through various legal and management frameworks. Adaptation strategies will require the strengthening of technical and institutional capacity in monitoring and research, as well as the development and implementation of better and appropriate policies for integrated coastal zone management. All stakeholders must be mobilised in the conservation of nature reserves, so that they can play a useful role in the protection of natural habitats and biodiversity under the potential threat of climate change.

The Coastal Zone and Human Settlements: A rise in sea level, as envisaged in the IPCC reports, will particularly affect tourism and fisheries, which are the pillars of the economy. About 85% of human settlement and infrastructure in the Seychelles are located along the coast. A rise in sea level will result in the displacement of a large proportion of the population. Coastline recession will also adversely affect infrastructure and biodiversity. Several low-lying coral islands and sand cays could disappear. There would be enhanced coastal flooding, particularly associated with severe storms or abnormal high tides, resulting in erosion of shoreline and tourist beaches. This would be exacerbated by the fact that the steep slopes of the main granitic islands are prone to landslides, while the very narrow strip of coastal plain is prone to flooding. The quantity and quality of water resources is also expected to be affected.

Adaptation options include planned retreat strategies, accommodation strategies, defence strategies and the adoption of integrated coastal management when there are recurring opportunities to adapt to sea level changes. Capacity building in these areas is also an important factor in adaptation.

Agriculture: With a rise in population and an increase in tourism, the consumption of food in the Seychelles will substantially increase over the next few years. Climate change would tend to shift national agricultural efforts, and a decrease in self-sufficiency would place more emphasis on imported agricultural products. The main direct effect will be through changes in temperature, rainfall and timing of extreme or critical threshold events related to crop development. A rise in sea level will contaminate coastal land and thus render the soil unsuitable for cultivation. Other effects are expected to include, *inter alia*, the potential detrimental changes in diseases, pests, and weed propagation, the impacts of which are not yet well studied in the Seychelles.

Adaptation is required at farm and national levels. All farmers would need to account for risks in extreme events, which may lead to low yields. There may be a need to develop an index of crop vulnerability to variability in weather patterns and seasonal climate. As such, all farmers would need to adopt a level of risk aversion or a willingness to bear risks. At national level, adaptation such as changes in crop and

crop varieties, improved water management and irrigation systems, and changes in planting schedules and tillage practices, would be important in limiting negative effects and taking advantage of some possible beneficial changes in the climate system. Potential agricultural land should be allocated in the light of adaptation options.

Water Resources: Despite the plentiful rainfall the islands receive annually, 98% is lost through run-off and evapotranspiration, primarily due to the steepness and length of the catchment. Only 2% is left as infiltration to feed the streams and groundwater. Because of the high run-off and the seasonality of the rainfall, the country experience water shortages during the dry months of the year.

Climate change is expected to result in changes in rainfall pattern, evaporation, river runoff, groundwater recharge, and water quality in the Seychelles. These could have significant implications for the water resources in the country. In most part of the country, anomalies in climatic conditions, such as prolonged periods of drought and abnormal high quantity of rainfall, had been experienced, and these had brought much economic cost to the country. However, the issue requires further study, especially, the nature of the changes in the rainfall pattern expected.

In view of the increased uncertainty about future supply of fresh water, adaptation options include more efficient management of existing water supplies and infrastructure; institutional arrangements to limit future demands; promotion of water conservation; improved monitoring and forecasting systems for floods/droughts; rehabilitation of watershed and enlargement of reservoir capacity to capture and store excess water flows produced by altered pattern of storms.

Fisheries: Coastal systems are economically and ecologically important, in terms of fisheries. They are expected to vary widely in their responses to climate change and sea level rise. Demersal fisheries and offshore industrial fisheries will also be affected. Global warming can influence ocean-atmosphere interactions, altering ocean currents, and hence the delivery of nutrients into the euphotic layer. This could result in changes in reproductive pattern, migration routes and ecosystem relationships. Sea level rise would result in saltwater intrusion in rivers, marshes, or wetlands and adversely affect habitat of certain species of fish. It would also impede ability of coastal shellfish to relocate. A rise in sea surface temperature will cause coral bleaching with serious economic consequences as evidenced during the 1997 El Niño. Aquaculture would also be severely affected by sea level rise, which could result in destruction of facilities and bacteriological diseases.

Given the uncertainty and the lack of appropriate adaptation options at this stage highlights the need for further research, monitoring and capacity building at both the local, national, sub-regional and regional levels.

Human Health: Climate change is likely to have wide-ranging impacts on human health in Seychelles, with possible loss of quality of life. An increase in extreme weather events is expected to result in higher incidence of death, injury, respiratory disorders, psychological disorders and exposure to contaminated water supplies. Indirect effects include increases in transmission of vector-borne diseases. Elevated temperatures and increased flooding could result in increases even in non-vector-

borne infectious diseases like cholera. The major tropical scourges, such as malaria and yellow fever, are currently unknown in the Seychelles. With a warmer or wetter climate, the risk for their introduction is high and it is a cause for concern.

Several adaptation options are proposed in order to minimise the direct and indirect impacts of climate change on human health. In view of considerable lack of data and expertise on the nature and magnitude of these impacts, it is important to undertake research at both population and individual levels so as to provide a solid basis for the formulation of adaptation strategies.

Natural Disasters and Insurance: As sea surface temperature rises, the ocean area, which can spawn tropical cyclones, may increase the probability of occurrence of extreme events in the Seychelles. A feeder-band within an active convergence zone passing over Mahe can bring in winds gusting in excess of 50 knots (100 km/hr), with torrential rains causing flash floods. With a warming of the ocean, there could be changes in frequency, intensity and locality of tropical cyclones, which can make the Seychelles islands far more vulnerable. Storm tides and extreme wave action pose the greatest threat to tourism activities in low-lying coastal areas. Intense conventional storms can be localized, but the resulting flood wave can move rapidly down valleys resulting in coastal flooding and landslide.

The absence of appropriate insurance framework for natural disasters increases the default risk on debt and thereby increases its price and/or limits its availability.

“No Regrets” Policy and Measures

The Government of Seychelles has adopted certain short-term and long-term “no regrets” policies and measures, especially in the energy sector, to reduce GHG emissions, so as to fulfil its commitments to the UNFCCC. For example, a number of measures has been implemented to reduce energy consumption in various sectors, including the residential, commercial and institutional buildings (e.g., zero tax on energy efficient appliances; promotion of the use of renewable energy; public awareness on energy conservation and energy efficiency); transport sector (e.g., high import taxes on vehicles; mandatory standard and emission control; improvement of roads and the public transport system) and energy supply sector (e.g., tariff structure that discourages the excessive use of electrical energy). The Government of Seychelles has also adopted policies for the conservation of forests.

Capacity Building Needs and Priorities

During the process of the preparation of this National Communication, many constraints have been experienced. These include: (a) very limited financial resources, including for the participation in regional and international meetings, workshops and seminars (the physical isolation of the country in itself is a major constraint, and this has incurred additional costs for all expenses); (b) limited technical and institutional capacity to undertake various relevant research and studies; (c) the lack of GHG data and long-term climatological (except rainfall) data; (d) the non-applicability of current global and regional climate models to the condition of the Seychelles, which consists of a large group of islands spreading over a large EEZ; (e) non-applicability of

emission factors especially in the land use and forestry sector; (f) the general lack of public awareness on climate change issues; (g) the lack of access to necessary technologies and know-how (including information technology); (h) the lack of a regular forum for exchange of information and networking within the sub-region and the region; and (i) limited financial and technical support provided by the various international agencies, especially with regard to the participation in regional workshops.

A number of capacity building needs and priorities have been identified in the following areas:

- **Planning and management:** Integration of climate change concerns into sustainable development planning for all socio-economic sectors, with special focus on integrated coastal zone management, including the protection of coastal areas from erosion and the promotion of eco-tourism); formulation and implementation of a comprehensive National Climate Change Action Plan;
- **GHG inventory:** Improvement in data collection and analysis, management and dissemination; reduction in data uncertainties; development and management of an efficient activity database for all key socio-economic sectors; development of local emission factors where appropriate; participation of private sector;
- **Mitigation options:** Least-cost analysis (taking into account the environmental costs and benefits); assessment and transfer of appropriate mitigation technologies; development of mitigation strategies and policies;
- **Technology transfer:** Assessment of technologies, including indigenous technologies;
- **Vulnerability and impact assessment:** Data acquisition, analysis, management and dissemination; development of computer-based data and information systems; possible application of climate scenarios generated by the GCMs and the application of relevant impact models specific to the country's conditions for various key socio-economic sectors; ecosystem and system level based analyses; monitoring and systematic observations; research (e.g., climate variability, sea level rise, extreme events and coral bleaching); predictive capacity including early warning systems;
- **Adaptation options:** Least-cost analysis (taking into account the environmental costs and benefits), assessment and transfer of appropriate adaptation technologies; development of adaptation strategies and policies;
- **Disaster preparedness:** Strengthening of existing disaster preparedness and management institutions and polices, including building codes, regulatory and enforcement systems; observational systems; strengthening of local broadcasting capacity especially on remote rural outer islands; strengthening of cultural and traditional systems that improve the resilience of local communities to disaster events; appropriate insurance for catastrophic risk;

- **Clean Development Mechanism (CDM):** Participation and negotiations in CDM and compliance mechanisms as provided in the Kyoto Protocol; CDM projects design, development, formulation and implementation; baseline calculation; mobilization and participation of private sector in CDM projects;
- **Education, training and public awareness:** Effective implementation of Article 6 of the Convention; integration of climate change and related issues into environmental education curriculum; development and implementation of educational and public awareness programmes; public access to information related to climate change and its impacts; public participation in developing response strategies; training of policy, scientific, technical and managerial personnel; training of trainers (teachers);
- **Sub-regional, regional and international collaborations and networking:** Promotion of sub-regional, regional and international collaborations; information networking (including access to the climate data, model outputs and other information technologies); fora to share experiences, success stories and lessons learned; and development of sub-regional and regional action plans.
- **Effective participation in the UNFCCC and the Kyoto Protocol processes,** including adequate financial resources for participating their meetings;

Most of the above needs have been highlighted by developing countries in decision 10/CP.5 adopted in COP 5 of the UNFCCC, while some of the priorities have also been identified in the Barbados Programme of Action adopted at the Global Conference of Sustainable Development of Small Island Developing States held on 2 April-6 May 1994 in Barbados.

Clearly, human resources, scientific, technical, technological and institutional capacity would need to be urgently built or strengthened in order to enable the country to fulfil its commitments under the UNFCCC and to effectively participate in the UNFCCC and the Kyoto Protocol process.

Capacity building through national projects

Capacity building can also be achieved through the development and implementation of national projects of most relevance to the country. A total of six project concepts covering five thematic areas are proposed, with a view to soliciting funding from the Financial Mechanism of the Convention and from the bilateral and multilateral agencies for their development, formulation and implementation. The thematic areas cover the coastal zone, fisheries, water resources, human health and reduction in GHG emissions. However, the total and incremental costs for these project concepts have yet to be estimated.

1 NATIONAL CIRCUMSTANCES

1.1 Geography

The Seychelles archipelago is made up of 115 islands scattered over an exclusive economic zone covering an area of 1.374 million square kilometres, situated to the west of the Indian Ocean between 4 and 9 degrees south of the equator. The total land area is 455.3 square kilometres. The archipelago is divided into two distinct groups of islands: the granitic group, 43 islands in all, with mountainous peaks and narrow coastal lands, and the low-lying islands, all coralline numbering 72.

All the 43 granitic islands are found within a radius of 50 kilometres from Mahe (Figure 1-1). With a land area of 148 square kilometres, Mahe, the seat of the government, constitutes about one-third of the total land area. The two other islands of major importance as regards to size and population are Praslin and La Digue, 33.6 km and 48 km from Mahe, respectively. Of the coral islands, Aldabra is the largest and furthest, located 1,150 km to the southwest.

The granitic islands are of Precambrian origin, formed from the break-up of Gondwanaland approximately 755 million years ago, by tectonic activity (Stephens, 1994). The granitic islands rise from the Seychelles Bank, a sunken micro-continent and shoal area of about 31,000 square kilometres, with depths ranging up to 60 meters. Many islands in the group are characterised by a very narrow coastal plateau, which rarely rises 2m above sea level. The plateaus consist of calcareous reef material, which builds up as sand dunes and pocket beaches known as "anses". Mahe has about 36 kilometres of sandy beaches. The plateau area on the islands where most of the development including tourism, transport and housing is located, is small, the largest occurring on Praslin and La Digue. The 397 km of surfaced roads (MISD, 1999), servicing the transport sector, run mostly on the coastal zone, hugging the coastline

The coral islands, which are more recent, consist of two types: low sand cays such as Bird and Denis, and elevated reef limestone like the Aldabra group (Stoddart, 1984). They are generally low-lying, average altitude of 2-6 m above mean sea level, although sand dunes on some islands may reach as high as 32 meters. Sand cays however, rarely rise above 1m of mean sea level.

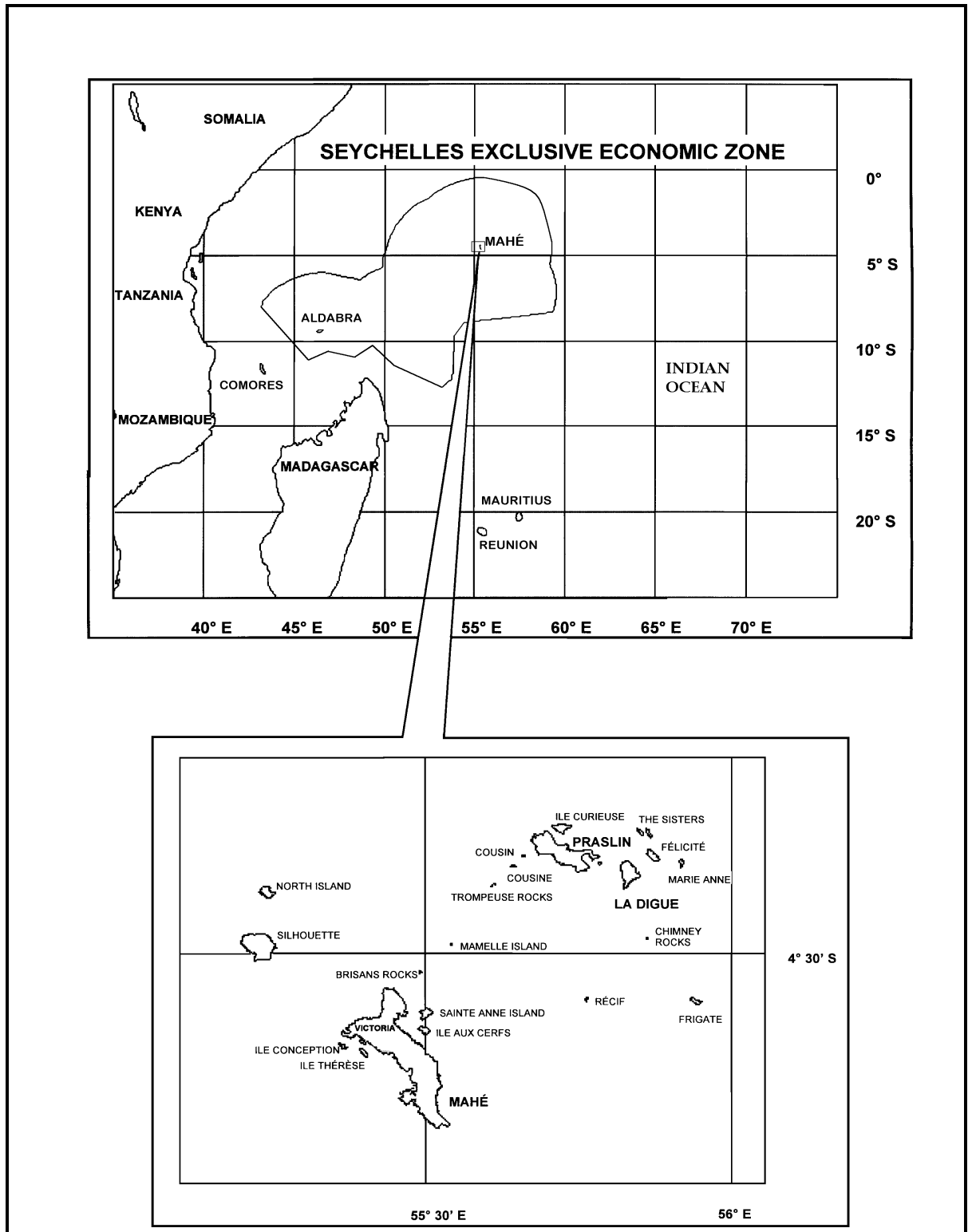


Figure 1-1. The Seychelles Archipelago

1.2 History and Demography

It was in 1770 that the first twenty-eight settlers were brought in to live on the island of St. Anne. Seychelles, up until its independence in 1976 was colonised by both the French and the British (Vine, 1989).

The population originates from French settlers, African plantation workers, British sailors, and traders from India, China and the Middle East. There is no state religion in Seychelles. While Christianity is more predominant, Hinduism, Islam, and Bahai are also practiced (Vine, 1989).

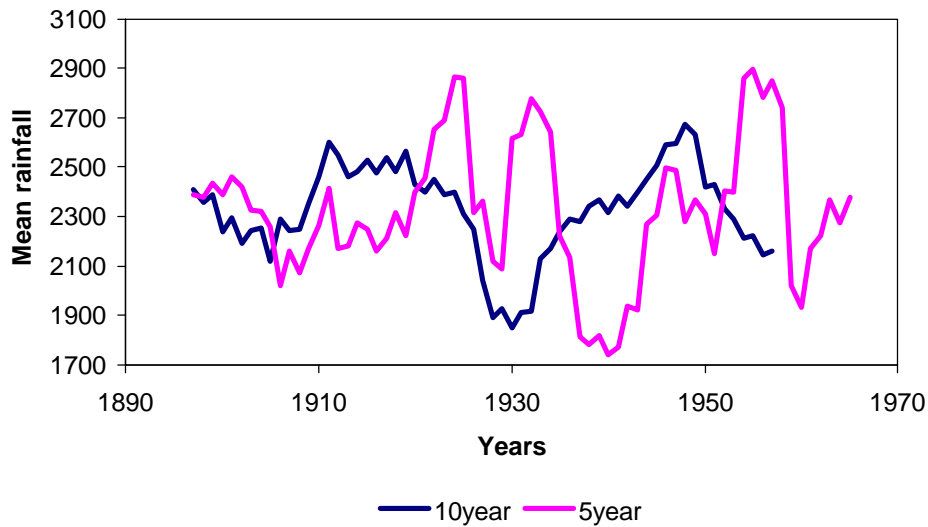
Seychelles became a one party socialist state in 1977 up until mid-1993 when a new constitution was adopted, and a multi-party democratic system was put in place. Seychelles is divided into twenty-three political districts.

Every year about 1,400 young people reach the working age while only 400 retire each year. This is a serious cause for concern for the government, in terms of employment opportunities for those people. Overall, population statistics show an adult literacy rate of 89 percent, a human development index (HDI) of 0.792, making it one of the most highly ranked countries in the Sub-Saharan region (UNDP, 1997).

On Mahe, areas urban to Victoria, the capital city, can be described as the narrow corridor of coastal plain to the south and uphill settlements to the north and west of the city. Internal migration in the Seychelles has not yet created a sizeable new urban working class. Also there have been considerable changes of internal and inter-island mobility patterns over the last few years. Migration from Praslin and La Digue to Mahe has also been significant, the three main driving forces being employment, education and housing. The return to multiparty democracy and privatisation of the economy has resulted in a positive international migration into the country.

1.3 Climate, Variability and Change

The climate of the Seychelles is strongly influenced by the equatorial maritime air originating either from the Mascarene Anticyclone during the Southern Hemisphere winter or from the inter-tropical convergence zone (ITCZ) during the Southern Hemisphere summer months. Climate records in the Seychelles date back to the late 1890s mainly as rainfall records as shown in Figure 1-2 (Stoddard et al., 1979). Consequently, very little is known about the Paleo-climatic conditions of the Seychelles, although a few isolated indirect studies have been conducted. It has been postulated that the climatic range during the late Triassic showed clearly that the ITCZ also influenced climatic conditions at the time. Also, sedimentological evidence supports the hypothesis that drier rather than wetter conditions prevailed during the late Pleistocene period (Heirtzler, 1977). Recent coral reef core samples indicate a strong relationship between the El Niño phenomenon and the Indian Ocean.



(Source: Payet, 1998; adapted from Stoddard, 1979).

Figure 1-2. Running means of combined rainfall records in millimetres (5 year and 10 year) for the period 1897-1979.

1.3.1 Climate of Seychelles

Temperature and humidity remain generally high throughout the year with a mean temperature of 26.9⁰ C, and humidity of 80%. Daytime maximum is about 5⁰ C. warmer than night minimum temperatures. Table 1-1 provides a summary of meteorological statistics from 1972 to 1998. There is very little seasonal variation. From May to October, the Southeast trades usually result in relatively cooler and drier conditions.

The period October to May is considered as the cyclone season for the Southwest Indian Ocean. The tropical cyclones are usually formed within the ITCZ, where the sea surface temperature is at least 28⁰ C. Located just south of the equator, Mahe and other main granitic islands are not within the direct track of the tropical cyclones. At latitude zero, Coriolis force is also zero and this makes it impossible for the tropical cyclone to cross the equator. However, all the islands of the archipelago are affected by the feeder-bands of tropical cyclones in the region and this can result in gale-force winds, flash floods and severe thunderstorm activity.

During the Southern summer, the wind is predominantly northwesterly. Originating from the high-pressure ridge of the Arabian Peninsula, it brings in warmer air with very high moisture content, which is characteristic of Seychelles weather at that time of the year, whether or not there is a tropical cyclone in the South-West Indian Ocean.

The length of the dry season also varies significantly throughout the Seychelles archipelago. Trade winds from May to October result in drier conditions to most of the Seychelles archipelago. However, in the northeast atolls of Bird Island (1973 mm) and Denis Island, the mean annual rainfall is twice as high (1973 mm & 1730 mm

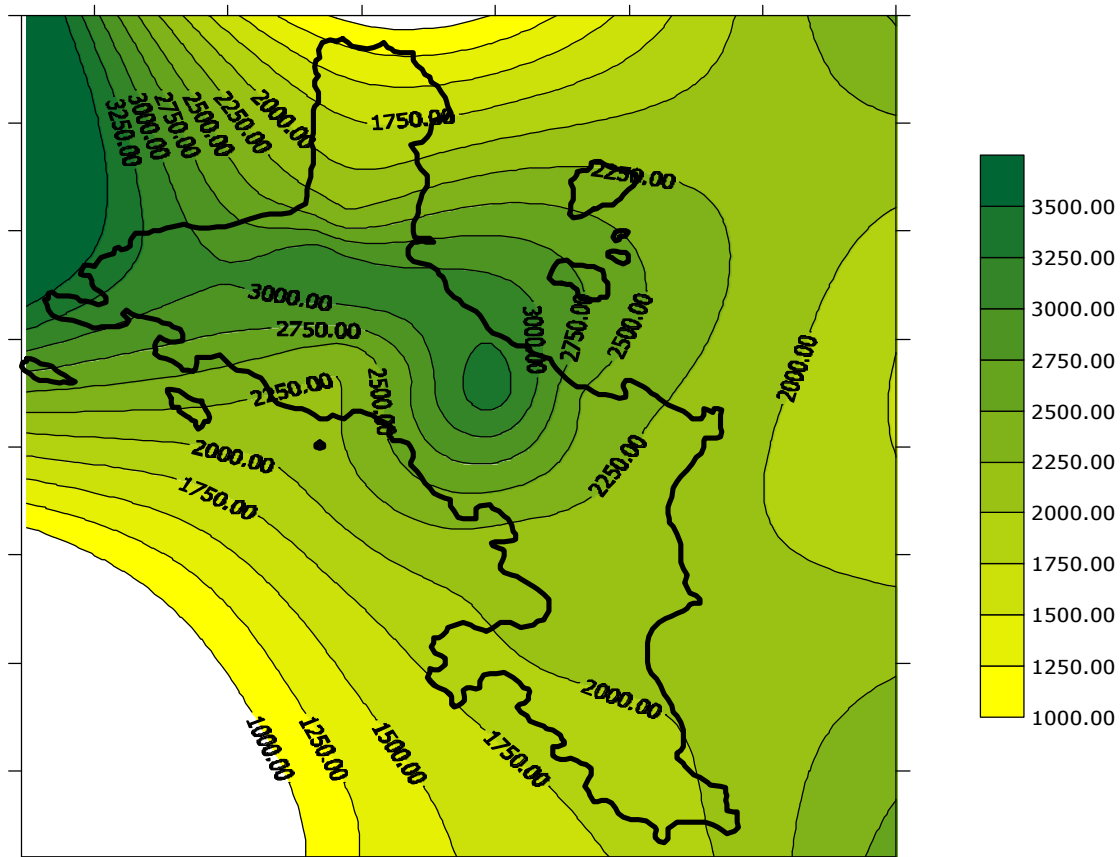
respectively) as in the Southwest atolls of Aldabra (984.5 mm) and Assumption (867 mm). Both spatial and temporal precipitation variability is affected by tropical cyclones.

Figure 1-3 shows mean annual rainfall over Mahe island, showing a higher mean rainfall along the mountainous area, and lower mean rainfall along the northern and southern tips of the island. The rainfall over Mahe exhibits large variations on all time scale ranging from a day to intra-seasonal, inter-annual, decadal and even in century scales. The year-to-year variations or otherwise known as inter-annual variability has the most profound effect on the socio-economic activities. The variability is linked to that of the global circulation like the El Niño-Southern Oscillation (ENSO). Dry conditions more common during Southern winter, can result in severe water shortage affecting agriculture and all other sectors of the economy (Payet, 1998).

Table 1-1. Meteorological Statistics For Mahe (1972-1998)

	Average Rainfall (mm)	Mean Temperature (Deg. C)	Ave. Maximum. Temp. (Deg.C)	Ave. Minimum. Temp (Deg. C)	Sunshine Hours	Relative Humidity (%)
January	389.9	26.8	29.9	24.2	5.1	82
February	274.3	27.4	30.5	24.8	6.1	80
March	178.5	27.8	31.0	24.9	6.9	79
April	196.5	28.0	31.4	25.1	7.7	80
May	149.3	26.7	30.6	25.4	8.0	79
June	96.0	25.9	29.2	24.7	7.6	79
July	78.4	25.9	28.4	24.0	7.5	80
August	125.7	26.5	28.5	24.0	7.4	80
September	146.6	26.8	29.1	24.3	7.4	79
October	201.7	26.8	29.8	24.4	7.2	79
November	208.4	26.8	30.1	24.1	6.8	80
December	281.9	26.8	30.1	24.1	5.6	82
Year	193.9	26.9	29.9	24.5	6.9	80

(Source: National Meteorological Services)



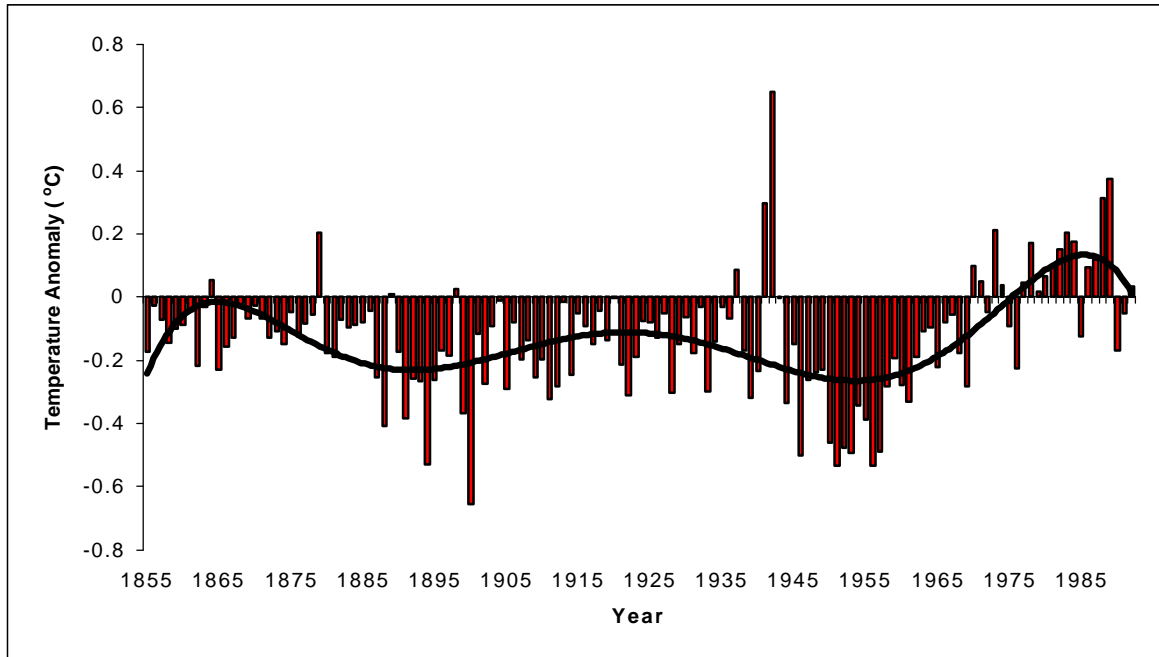
(Source: Prosper, 2000).

Figure 1-3. Mean Annual Rainfall over Mahe Island in mm

1.3.2 Climate variability

Studies have shown that there has been substantial climate variability over the past hundred years in the Seychelles (Figure 1-4). The recent changes in surface air temperature is analysed using data collected by the Seychelles Meteorological Services from 1970 till now, relative to the 1972-1997 average. The current trend shows an increase in mean air temperature on Mahe Island for the period under analysis. The warming in the Seychelles region is estimated to be of the range of 0.25°C. In 1995, it was 0.3°C and in 1997 the warming was 0.5°C, and was the highest since 1972 (Payet *et al.*, 1998).

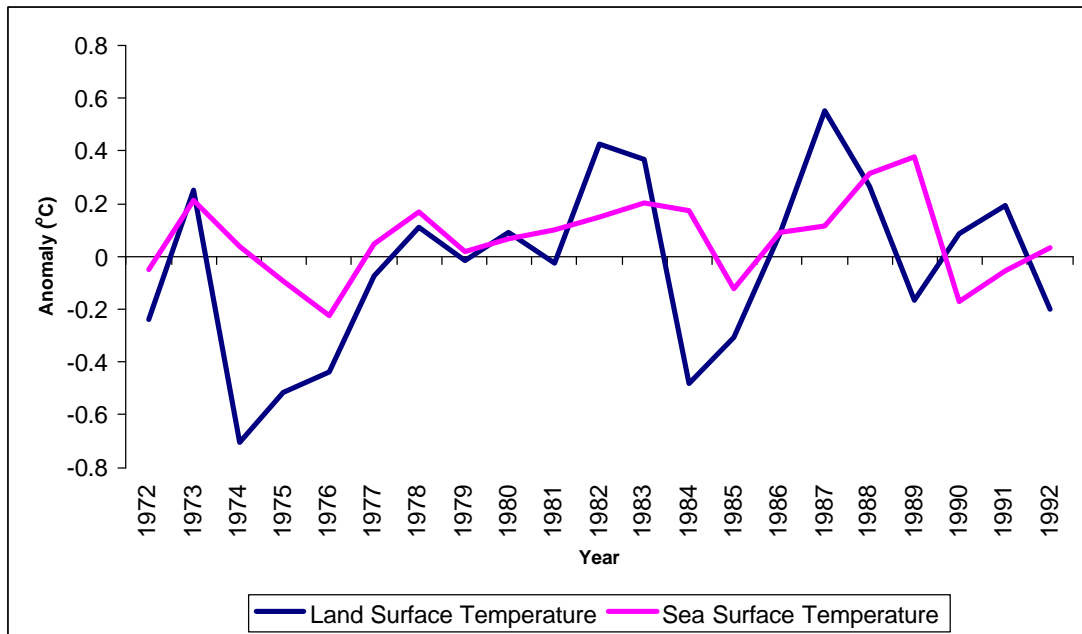
On the other hand, an analysis of the diurnal temperature range, which is derived from monthly, averaged maximum (day) and minimum (night) temperatures, show a decreasing diurnal temperature range. This observation would indicate an increase in cloud cover over Mahe, and since there is an overall warming of the island, the range between the maximum and minimum temperatures has decreased. However for the last hundred years observations indicate a cooling of the sea surface temperature and the rise in sea surface temperature is only recent. Further monitoring and data fine-tuning will be required before a conclusive trend in favour of increasing sea surface temperatures can be confirmed.



(Source: Payet, 1998)

Figure 1-4: Annual Indian Ocean sea surface temperature anomalies from 1855 to 1992, relative to the 1961-1990 mean.

Figure 1-5 shows an inter-comparison of the Mahe air temperature with that of the sea surface over the last twenty years and reveals a strong decadal relationship. However, further analysis needs to be undertaken to draw better conclusions.



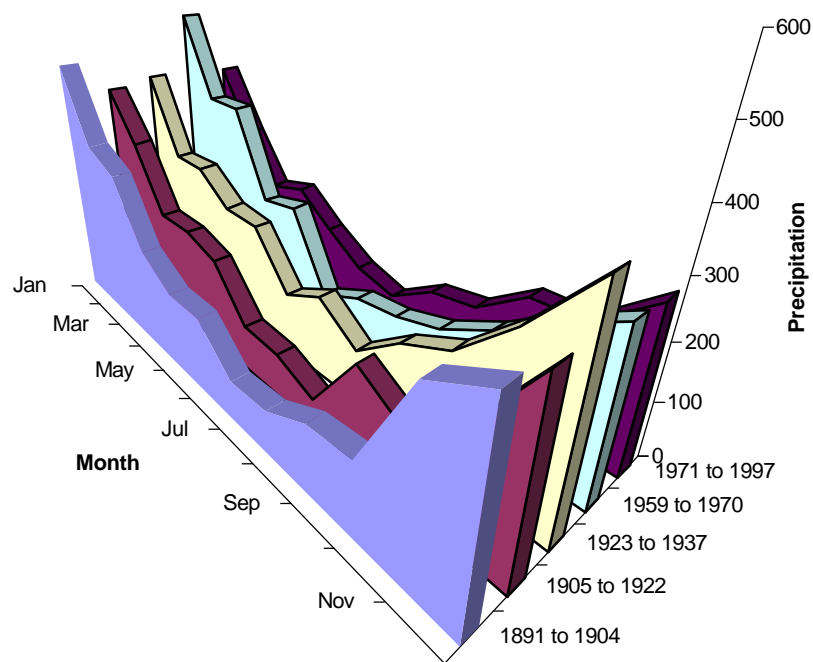
(Source: Payet, 1998, data from National Meteorological Services)

Figure 1-5: Comparison of sea surface temperature and land surface temperature for the Seychelles region

On Mahe, the main granitic island, the annual rainfall, rainfall regime, mean length of dry season and the frequency of dry periods have all significantly changed. The changes in rainfall are dramatic in terms of scale, periodicity and consistency. High rainfalls occurred before 1905, from 1923 to 1937, from 1959 to 1970; much lower rainfalls characterised the intervening 1905-22 and 1938-58 epochs, as shown in Figure 1-6. The changes are of the order of 500 mm, or 20% between each period, and all are statistically significant at the 99% level. The rainfall for the period 1972 to 1997 is particularly high and interesting.

Long series of rainfall data are available only for a few stations, mostly on Mahe, the main island in the Seychelles group. On Mahe most of the increase in rainfall in the wetter epochs occurred in the Southern summer months from November to March. A much higher frequency of longer dry periods of 4-6 months duration characterised the dry 1938-58 epoch than other epochs.

The markedly higher rainfalls on Mahe before 1905 to some extent support the fact that the increase in rainfall, for the period 1959-1970, is definitely linked to a shift of the subtropical pressure belts towards the equator and the restriction of the intertropical troughs to the narrow zones on either side of the equator. Overall there has also been an increase in rainfall for the period 1971 – 1997, especially during periods when lower rainfall were expected, in the dry season.



(Source: Payet, 1998; adapted from Stoddard 1984, and data from National Meteorological Services).

Figure 1-6. Rainfall Regimes for the period 1891 –1997 for Mahe.

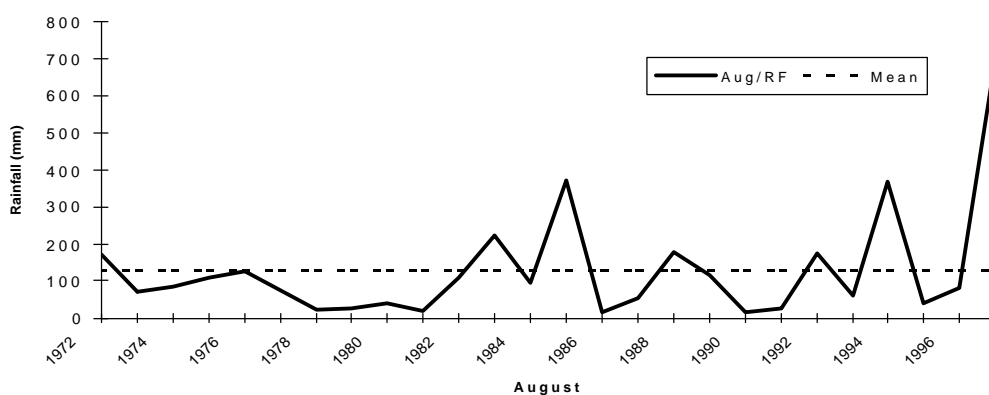
1.3.3 Impact of ENSO years on rainfall

As climate involves the motion of the entire ocean-atmosphere system of the earth, it is expected that a climatic event in one part of the globe may have its impact, in some form, in another part. But nothing was more striking in this respect than the ENSO phenomenon.

It has been found that in general there was an increase in rainfall in all the regions of Mahe in all the two seasons – southeast monsoon and northwest monsoon during El Niño years. It has also been observed that in the 1997/1998 strong El Niño year catastrophic floods hit the Seychelles. It is thought to have greatly enhanced convection and precipitation particularly between August 13th to 16th 1997 over the Seychelles where continuous torrential rain wreaked havoc for four days over the country. Figure 1-7 shows this variation for the month of August from measurements of rainfall from 1972-1998, showing the highest peak in 1998. A record maximum of 480 mm of rain fell over a 24-hour period at Grand'Anse, on Mahe island. The Seychelles International Airport Meteorological station registered a monthly record of 694.1 mm of rain as compared to the long-term mean of 107.1 mm. The extent of damage was estimated between 3 to 4 million U.S dollars (Payet, 2000). Two young men lost their lives in the rainstorm. The highest previous record for August was 371.6 mm in 1985 when again torrential rain created widespread damage over these islands. A mother and her two children lost their lives when their house collapsed in a landslide at St. Louis.

The 1997/1998 El Niño also generated hazy conditions over Mahe during the last week of October obscuring the atmospheric visibility. Abnormal high tides ranging from 30 to 50 cm above the mean high tide were also observed on the 15th and 17th November 1997 which resulted in sands being brought on the main roads and causing coastal erosion (Agricole, *pers com.*).

During the 1986/87 El Niño phenomenon, continuous heavy rain in January caused significant damage to the tourism, fishing, agriculture infrastructure as over as to all key sectors of the economy estimated at over 1 million U.S dollars.



(source: National Meteorological Services)

Figure 1-7. Interannual rainfall variation for the month of August.

Due to increases in surface temperatures, coral reefs were severely bleached in the region, with Seychelles being the most affected (Quod, 1999).

In the past, occurrence of drought in this region of the world also coincided with La Niña years. The years of weak El Niño or when the El Niño Index is positive it seems to be favourable for the occurrence of drought or deficit in rainfall over Seychelles as was the case of past La Niña years of 1972, 1975, 1980 and 1988. A marked reduction in agricultural outputs was experienced.

1.3.4 Sea level change

Since there is no global synchronism in eustasy and the effect of other climate variables, Seychelles has started to monitor sea-level rise.

There are at present several sea level monitoring stations in the Indian Ocean, of which two are to be found within the Seychelles group. However, the data is only recent (1980s till now) and the stations are not adequate considering the extent of the Seychelles plateau and its EEZ. Also sea level data in Seychelles has not been consistent for various reasons: lack of maintenance, effects of storm surges, and error in the assignment of the datum.

The trend shows an increase of sea level of around 20 cm by 1998 and stabilized by 1999 to 2000 due to the effect of La Nina in 1999 (see Figure 1-8). But the linear trend shows it may be rising.

The University of Hawaii performs tide predictions, through the use of a harmonic analysis model, which is executed on a year of apparently good data for a given station. Data from the Pointe La Rue tide gauge are sent automatically by satellite to the University of Hawaii and the tide staff readings and floppy disk are sent through the post. Data obtainable are hourly, daily & monthly.

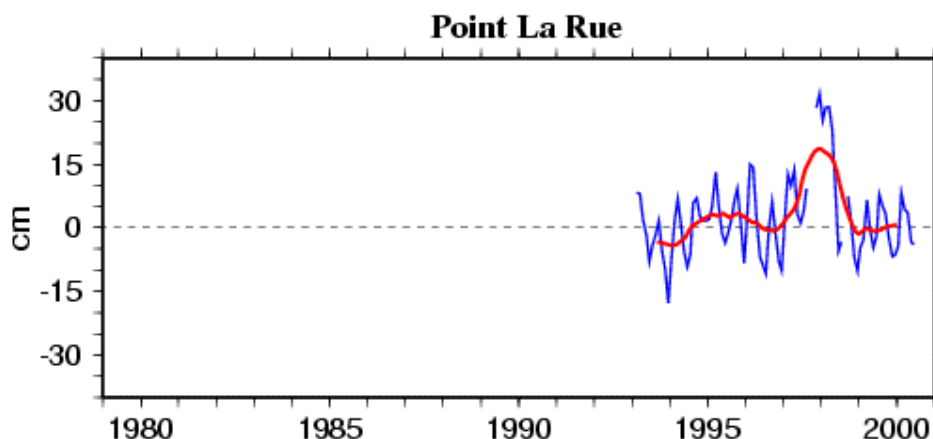


Figure 1-8. Sea Level Variation at the Seychelles International Airport, 1993-2000

1.4 Macroeconomic Development

1.4.1 Overview

Seychelles has managed its development in a pragmatic way, evolving an ambitious development strategy in the light of emerging problems and opportunities. The underlying philosophy behind this strategy has been the promotion of “equitable growth” through active state participation in economic activity. A formal planning process, embodied in various national development plans beginning in 1978, has been an integral instrument of the government in the pursuit of its economic and social objectives. In 1994, the emphasis on formal 5-year national plans was de-emphasized in favour of annual budgets ‘as part of economic plan’ and the new ‘Public Sector Investment Programme (PSIP), and a policy of privatisation was promulgated. Nevertheless, development activities continued to be dominated by public and parastatal (Government owned companies) expenditures. Within the framework of these plans and programmes, the state continues to intervene directly into various production and distribution activities. The Government implemented a large public sector investment programme to improve physical infrastructure like public utilities and social housing. Simultaneously it introduced a generous and comprehensive welfare system, including free education and health care, unemployment benefits, old age pension benefits, subsistence level supplementary benefits, etc. As a result of these policies, significant progress has been made in the country’s social indicators with the literacy rates rising to 89%, the infant mortality rate falling to 1.7%, and life expectancy at birth rising to 71 years, and gross primary enrolment becoming almost universal by 1997. Seychelles per capita GDP has also increased from about US\$ 800 at the time of independence in 1976, to around US \$ 7,000 in 1998.

In the recent years, however, Government has suffered from large budget deficits combination with other macroeconomic policies, have recently manifested themselves in increasingly large liquidity of the economy, higher debt, balance of payment deficits and acute foreign exchange shortages. So far the government has reacted to these developments by imposing tighter import and exchange controls on top of the existing controls on domestic prices and trading margins. These adverse developments threaten the socio-economic gains that Seychelles has achieved. It is in recognition of this threat and the need to preserve and promote equitable growth that the government is considering various macroeconomic options to redress these imbalances (PSIP, 1977-99).

1.4.2 Economic policy framework

Before independence in 1976, Seychelles was a tropical island nation operating at the subsistence level. Since then incomes have risen almost 10 times, led by a strong tourism industry, which provides 70% of the foreign exchange and employs about a third of the work force (MISD, 1999).

The country is being guided by a dynamic vision for its growth and future. In line with regional and international developments, it has to redefine its role and refocuses

its international relations efforts, abandoning a more classic diplomatic strategy in favour of global economic diplomacy. Making the country's development plan as widely known as possible is now the top priority. The plan will expand the two main pillars of the national economy – tourism and fishing – and build a third pillar in the financial services sector.

Seychelles' aim is to position itself in the regional and international arenas as a land of opportunity for investors. The objective is to become a leading international business centre, offering both financial and commercial services. This strategy is centred on a free zone intended for transshipment, redistribution, assembly, and the processing of products for export. Heinz International, a leading exporter of canned tuna to the European market, is one of the most prominent firms currently operating in the zone.

In an effort to reach this objective, the country will have to step up its efforts considerably, not only because of the decline in development aid, but also because it does not qualify for the reduced loan rates that are vital for the country's development. As such, Seychelles is being penalized because of its GNP – an economic indicator, which does not necessarily reflect the economic realities of Small Island States like Seychelles. There are now diplomatic efforts striving to win recognition of the unique situation in island states. The plan calls for the international community to create vulnerability indexes that would paint a faithful picture of the situation in island states – one that reflects their environmental vulnerability and fragile economies. The World Bank and the Commonwealth, in conjunction with other international organizations, are working very hard to come up with an appropriate definition of the notion of vulnerability.

The country's social welfare system – which includes a good social security system, and strong education, health and housing policies – is being gradually reformed and updated, bringing it in line with international trends and developments. In its 1999 recurrent budget, the government implemented a rigorous new system for managing public finances. There are new tax measures designed to curb the purchase of non-essential goods, to protect the country from the effects of the financial crisis in Southeast Asia and to stimulate economic growth. The measures included lowering interest rates on Treasury bonds along with the interest rates on bank loans and savings accounts. The government is also counting on the sale of various hotel assets to boost its revenue.

With regard to new development strategy, the government is now playing supportive role in the business sector. It is devoting its efforts to creating a healthy economic climate in which businesses can prosper and grow

A new investment law known as the "Investment Promotion Act (IPA) has been in force in the country since December 28, 1994. It outlines the general and specific concessions granted to investors, not only for export, but also in sectors like industry, tourism, fishing and agriculture, and to small and medium-sized firms. Investors can now do business in Seychelles under a guaranteed tax regime.

The government has also set up the legal framework for a reliable international financial centre that will be attractive for investors. It has passed legislation

(Seychelles International Trade Zone) that permits foreign firms to begin operating in its free zone. This centre will be principally for distribution, for re-packing products for re-export, and for transshipment and storage activities. There is already an institutional framework that guarantees investors that the procedures will be organized in a rational manner.

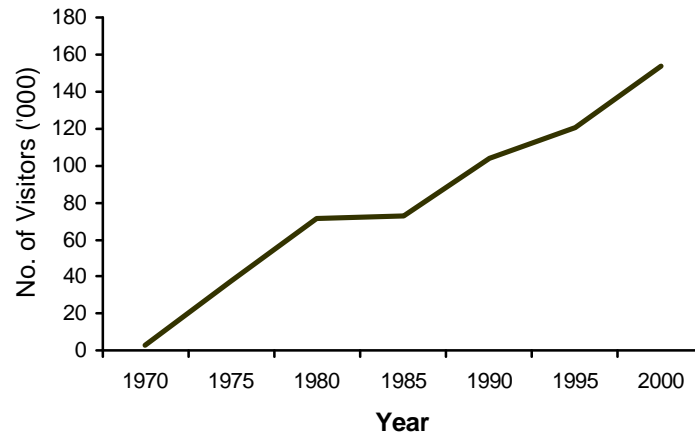
Revitalisation of the tourism industry also occurred in 1999, with the creation of a new Tourism Marketing Authority, (STMA) and a high-level tourism board, STAB. The private sector and NGOs have got permanent representations on STAB.

1.4.3 Tourism

The largest foreign cash inflow to Seychelles results from tourism. Over 131,000 visitors arrived in 1996 (Figure 1-9), contributing well over US \$100 million (70% of foreign exchange revenue). Most of tourists are from Europe (France, Great Britain, Germany, Italy and Ireland). About 85% of arrivals are tourists and the average stay is 9.7 nights. Tourism contributes about 17 % of the GNP and employs 18% of the total workforce (MISD, 1999).

The early 1990s was characterised by a gradual withdrawal of the government from the tourism sector and increased incentives for private sector initiatives and investments in all areas of tourism development. At present the Government has privatised most of its interests in the tourism sector. Government-owned hotels, which could not yet be sold, have been passed on to private companies through management contracts. To encourage investment in the tourism sector, the 1994 Investment Promotion Act offers a wide range of tax concessions for tourism related activities. By the end of 1995, 26 companies had been granted Certificates of Approval under the Investment Promotion Act for tourism development investments (UNDP, 1997).

The expected explosion of international tourism over the next decade will present the country with an excellent growth opportunity. Seychelles will continue to specialize in *haut de gamme* tourism, but will also target a broader clientele, offering new discovery tours in eco-tourism and Creole living.



(Source: MTCA Data, 1999)

Figure 1-9. Visitor arrivals to the Seychelles since the opening of the International Airport (per 000's) (Source: MTCA Data, 1999)

1.4.4 Fisheries

Because of its exceptionally large Exclusive Economic Zone (EEZ), Seychelles is a world leader in transshipment of tuna fish and its products. Considerable income is generated by the foreign fishing vessel licensing and by supplies and services for those ships. The Indian Ocean Tuna Company (with majority share owned by Heinz International) processes over 110 tonnes each day amounting to US \$20 million, the largest single export. Almost all the commercial fishing transshipment goes on through Victoria harbour (MISD, 1999). The fishing sector is the country's leading employer.

There is diversification in the fishing industry as well. Seychelles has launched measures designed to make Port Victoria the leading tuna fishing port in the Indian Ocean. The government has created new jobs on the production line, and strengthened local training programmes. The production facilities and fishing equipment have been modernized and export activities have also been set up (D'Offay, 1999).

The artisanal fishery is comprised of four broad categories; small open boats, whalers, schooners and semi-industrial fishing vessels. Whilst the small open boats are engaged mostly in daily fishing activities, operating inshore and along the reef areas, bigger vessels can operate as far as 200 nautical miles from Mahe, in the Amirantes and on the Mahe plateau to the Northwest which has the most productive fishing grounds.

1.4.5 Agriculture

Agriculture, forestry, and fishing account for about four percent of GDP. It has been estimated that the Seychelles has a total of 6000 hectares of potential agricultural land of which only about 600 hectares are under arable agriculture. The food production

index (FPI) for fruits and vegetables stands at 55 kg per capita per year respectively (1990 estimates). A difficult mountainous terrain and low fertility put severe constraints on agriculture (Moustache, 1998). The traditional copra and cinnamon industries are also slowly showing signs of revival. The country became in the past few years almost self-sufficient in the production of poultry meat & egg and pork, while it remains heavily dependent on the import of beef and staples such as rice, potatoes and some fresh produce. In an effort to increase food security, Seychelles has taken steps to make the sector more productive and to provide incentives to farmers. Almost all of the state holdings in the agricultural sector have been privatised, while the role of the government has been reduced to providing the enabling environment. An Integrated Agricultural Development Project funded by the African Development Bank, and initiated in 1996, provides credit to small farmers to encourage mechanisation and to improve farming techniques along with the provision of enhanced agriculture infrastructure (UNDP 1997).

The 1994 population census indicated that a large number of the Seychellois households are also involved in some form of agricultural production.

1.4.6 Water resources

Fresh water is an extremely important resource for island states especially due to their inability to source from neighbouring countries. All sectors of the economy and social welfare depend on adequate and quality supply of water. While rainfall is abundant (on average 2,200 mm annually), most is lost through run-off and evaporation (98%). Only 2 percent infiltrates streams and ground water, which form the principal sources of potable water (Labodo, 1998). The 1994 census reveals that about 83 percent of the population are connected to the treated water supply. Due to the topography and conservation importance along with infrastructure cost, possibilities for construction of adequate dams and other water capture infrastructure is limited.

The Seychelles has a per capita water consumption of 140 litres/day (l/d). During drought periods, the facilities at the two main dams, La Gogue and Rochon, are inadequate to meet the demand (see Table 1-2), hence the need for water rationing.

Table 1-2: Comparison between Water Supply and Demand (Kl/d)

Year	1996	2000	2005	2010
Projected Gross Demand	19,150	27,350	27,390	27,450
Safe Yield (1996)	13,500	13,500	13,500	13,500
Deficit	5,650	13,850	13,890	13,950

(Source: PUC)

Desalination plants have now been put in place by at least two large companies, and Government is planning two medium-sized plants to guarantee supply during the dry season.

1.4.7 Energy needs and transportation

Being more than one thousand kilometres from any neighbouring country, and deprived of any source of fossil fuel, Seychelles depends heavily on the import of refined petroleum to satisfy national needs as well as the demands for international marine and aviation bunkers. The import costs 10% of the Gross Domestic Product (GDP) and can be higher during periods of high oil prices. As other oil importing countries, Seychelles is vulnerable to oil price fluctuations. However, the re-export of fuel to foreign vessels and aircraft, which accounts to 60 and 75 % of the total amount of imported petroleum, has so far been a profitable market.

The energy demand in Seychelles increased from 58,000 tonnes of oil equivalent in 1988 to 102,000 tonnes in 1994. The Public Utilities Company (PUC), which has the monopoly for the generation and distribution of electricity on Mahe, Praslin, and La Digue, has four power stations with an annual consumption 30,000 tonnes of gasoline. The total generating capacity PUC in 1995 was 18.6 GWh and the average growth rate of national consumption is 4.9 GWh per year. The transmission and distribution grid has a total of 165 km of high and medium voltage lines and 350 km of low voltage lines. Mahe and Praslin have separate grids whereas La Digue's grid is connected to that of Praslin via a submarine cable. A new 50 MW power station to fuel development on Mahe was opened in June 2000.

Electricity generation on the outer islands, except for a few private ones, is under the responsibility of the Islands Development Company Ltd. (IDC), a parastatal organisation. The government plays the role of regulator by implementing appropriate tariffs as well as energy conservation projects. The usage of renewable energy is very marginal and limited to the use of solar water heating. The per capita electricity consumption is presently 1600 kWh/yr and there are nearly 21,000 consumers out of which 19,000 are from the domestic/residential sector (36%), and 1,500 from government (14%), industry and commerce (50%). In term of geographical distribution, energy consumption is 90% for Mahe, 8% for Praslin and 2% for La Digue.

The transport sector is the largest consumer of petroleum products after electricity generation. There were a total of 7,500 vehicles in 1995. The two primary fuels used are motor gasoline and gas oil. Unleaded gasoline was introduced for the first time in 1999. In general there is more traffic on the East Coast of Mahe than in other parts of the island

There are few large industries in the Seychelles, with the Indian Ocean Tuna (IOT) canning factory being the biggest consumer of electricity and water. Tourism is the major economic sector, and in a typical large hotel of 200 rooms, a central boiler is usually running on gas oil or kerosene to supply hot water to the rooms, to the laundry and to the kitchen. LPG is used for cooking by most of the restaurants, guesthouses and hotels, and is rapidly replacing kerosene in households (Coopoosamy et al, 1998).

1.4.8 Trade and regional cooperation

Seychelles' biggest advantage in the trade arena is clearly its geographic location in the Indian Ocean, between Africa, Europe and Asia. The archipelago lies in a favorable time zone. It also offers a multilingual climate, political stability, and the latest in telecommunication services. It has other important advantages – such as its recent admission to COMESA and SADC, and its membership in other regional organizations and eventual membership in the WTO – which will make Seychelles an excellent and reputable International Financial Services Centre for the region and beyond.

At the dawn of the third millennium, no country can hope to prosper and grow on its own, which is why several cooperation zones have been created in the region, and Seychelles has readily joined them. These zones are the first step towards full integration in the global economy. The most important zone is the Indian Ocean Commission (IOC), which has allowed Seychelles to harmonize its efforts with a global vision of the islands' interest in mind.

Each and every country is acutely aware that these organizations offer great potential for setting up exchanges on the economic, commercial and technical levels. Several agreements have been signed in 1994 in the transportation, telecommunications, energy and water sectors, permitting Seychelles to make great headway towards harmonizing its work throughout the entire region there has also been a significant amount of inter-regional investment particular (D'Offay, 1999).

1.5 Environment Management

The country has a long and distinguished history of conservation and management of its natural resources. With two World Heritage Sites, fifteen marine protected areas (of different legal categories), with an area exceeding 46 km², and at least 45% of the land area protected, Seychelles plans to designate for protection, and is committed to manage more land and marine areas through the Environment Management Plan of the Seychelles (EMPS) 2000-2010.

1.5.1 The Environment Management Plan of Seychelles 2000-2010

Despite the small size of the Seychelles economy and the vulnerabilities of small island economies, Government has been consistent in providing substantial annual budget (about US\$ 5 million) to direct environmental activities which are also funded through private sector participation, loans and its own budgetary contributions, capital and recurrent costs for solid waste management, sewerage and waste water treatment, as well as marine resources management. This took place within the framework of the first EMPS (1990 to 2000). Since then Government has matched donor funding for EMPS projects through budgetary and other financing. An Environment Trust Fund (ETF) was also established.

As a direct outcome of the first EMPS, Seychelles now has a Ministry of Environment, a Marine Parks Authority, and various national institutions involved in

the management of solid waste, sewerage and resource management. Seychelles has numerous legislations pertaining to biodiversity conservation, and addressing pollution control, coastal zone management, environmental impact assessments, plant protection, ozone regulations, air emissions and pesticide import & utilization.

As regards international cooperation the Seychelles has signed and ratified key conventions including the CBD, the Framework Convention on Climate Change, the Law of the Sea, MARPOL, Desertification Convention, World Heritage Convention, the Montreal Protocol, CITES, and the Nairobi Convention. The Seychelles has been the host of the Regional Coordination Unit (EAF/RCU) of the Nairobi Convention.

Environmental education has been introduced at all levels of the national educational curricula, and within the national media. The national newspaper, the Nation, has been carrying a weekly environment page since 1987.

There has also been an increase in NGO participation with a few involved in the implementation of environment and GEF projects. The Wildlife Clubs, a school-based NGO operates in various schools on Mahe, Praslin and La Digue with over 600 active members.

One of the fundamental principles adopted in designing the EMPS 2000-2010 is that the process should also lead to a greater capacity to understand, monitor and cope with emerging environmental issues, all of which call for a greater and wider involvement of all stakeholders. The formulation process started in early 1999 and has included significant public participation. A consultation process involving technical experts within and outside the Working Groups and stakeholders, through meetings, presentations and a public workshop has taken place and will continue. The Cabinet of Ministers endorsed the EMPS 2000-2010 on the 26th of April 2000.

The issue of climate change was addressed as a cross-sectoral issue, in view of the perceived impacts climate change would have on all the various sectors within the Environment Management Plan. However, the issue of climate change proper is addressed within an action plan, prepared as a result of this National Communication preparation process.

1.6 Integrated Coastal Zone Management

Seychelles can be considered to be a coastal zone its entirety due to its size and homogeneity. Even on the high granitic islands, where the so-called plateau areas are the most easily recognisable landward part of the coastal zone, all human activities and ecosystems further "inland" usually tie in with coastal zone concerns through natural processes and geography of the islands. The coastal zones of the Seychelles can therefore be said to be a contiguous system, which includes human activities, landward areas, wetlands, sea grasses and coral reefs.

It is estimated that 90% of the population is concentrated on the narrow coastal strip. Approximately 40% of the population is located on the East Coast of Mahé, on a

coastal belt from Victoria to the International Airport, which is only about 7 km long by 1 km wide.

Seychelles has been since the early nineties at the forefront in the development of ICZM in the region. The Regional Ministerial Conference on ICZM in 1997 in Seychelles also addressed the increasing impacts on coastal zones, as well as the emerging issues of global change and sea-level rise. Preparation for the next regional Ministerial Conference on ICZM in early 2001 is already ongoing, and the issue of climate change is likely to feature prominently in the discussions and resolutions.

The most serious concerns for coastal zones of islands of the Seychelles are sea-level rise, extreme events such as temperature and precipitation extremes, and storm surges. For islands in the southern part of the Indian Ocean, cyclones may pose a further impact on the coastal zone.

1.7 Institutional Arrangements and the National Team

A National Climate Change Committee (NCCC) was established 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. The primary objective was to build capacity to foresee significant climate variability and change, either natural or man-made, which can markedly affect national welfare.

The National Climate Change Committee was formed under the joint aegis of the Meteorological Services and the Division of Environment, which was in the Ministry of Foreign Affairs, Planning and Environment. However, all activities have generally been co-ordinated by the Meteorological Services, and will now be assumed by the Policy, Planning Services Division, within the Ministry of Environment and Transport. This indeed has facilitated the inter-relationships between the activities of the World Meteorological Organisation (WMO), the Intergovernmental Panel on Climate Change (IPCC) and the UNFCCC. Participation in the activities of the National Climate Change Committee involves professionals from various socio-economic sectors, like agriculture, fisheries, police, health, education, press, transportation, marine services, private individuals in their professional capacity, NGOs and visiting experts as shown in Figure 1-10 (Chang-Ko, 1992).

1.8 UNFCCC and the Kyoto Protocol

It was in June 1992, in Rio de Janeiro, during the United Nations Conference on Climate and Development (UNCED) that the Seychelles along with another 150 countries signed the UNFCCC. Only a few months later, on 22 Sept. 1992, the Seychelles became the second country to ratify the Convention. The Kyoto Protocol was signed on 20th March 1998, and once again Seychelles was amongst the first ten countries to do so. Ratification process is underway and is expected to be in the year 2000.

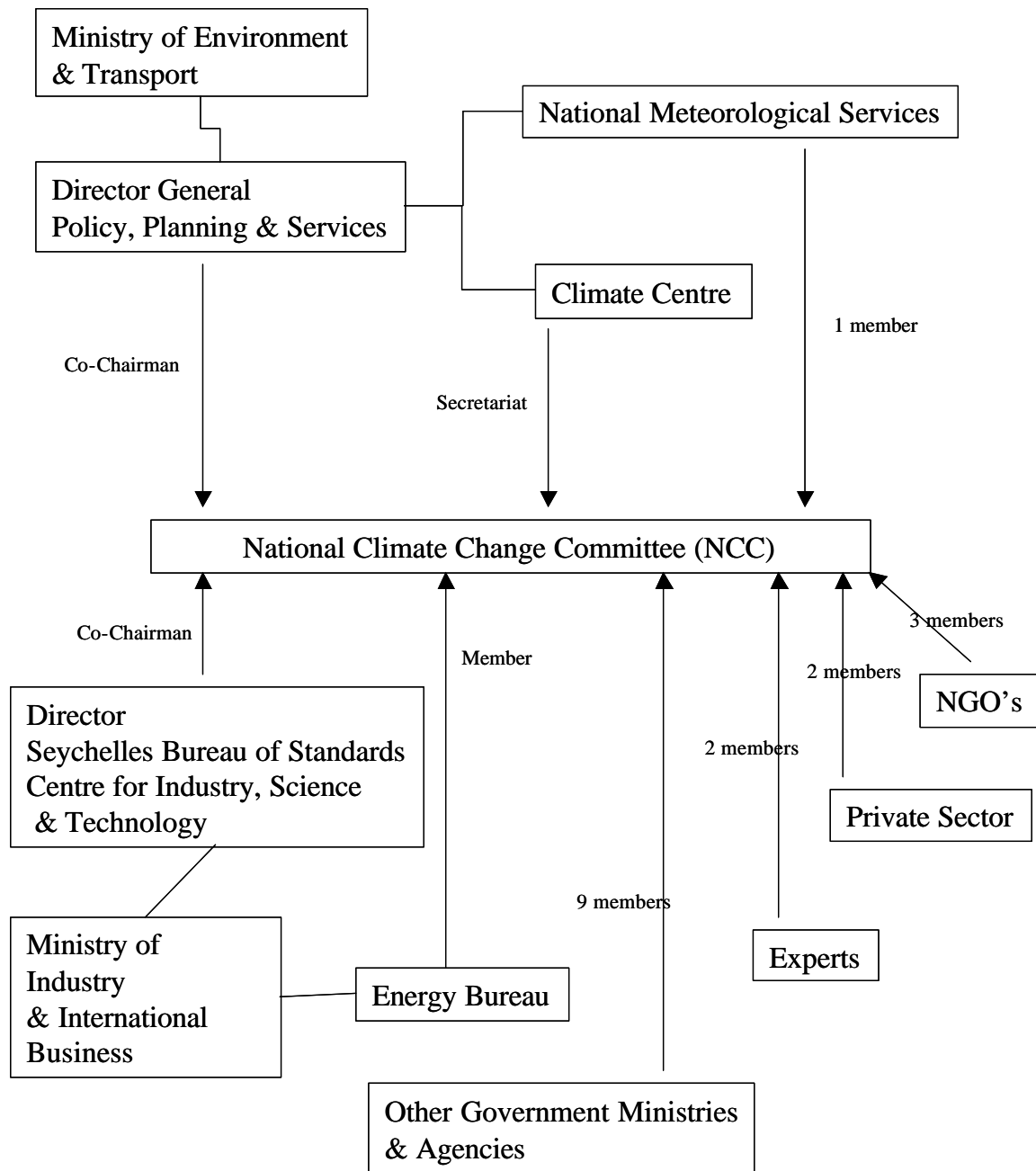


Figure 1-10. Present institutional arrangement of the National Climate Change Committee

The full membership of the NCCC is shown in Annex 1.

2 GREENHOUSE GAS EMISSION: SOURCES AND SINKS

2.1 Introduction

An essential component of the Initial National Communication was the preparation of a national inventory of greenhouse gas (GHG) emission from sources and removal by sinks. The GHG inventory was undertaken by a team of experts in the Seychelles Bureau of Standards (SBS), a government institution for standards, science and technology matters under the Ministry of Industry and International Business. A report entitled “Greenhouse Gas Inventory of the Seychelles” was completed in July 1997 (see Coopoosamy *et. al.*, 1997). The draft of this report was reviewed in a workshop organized by the NCCC on the 17th-19th April 1997. The workshop was attended by twenty participants.

Since this was the first GHG inventory undertaken in the Seychelles, all sources and sinks categories have been covered, though it was evident that for some of the sources, the emissions were negligible. The year 1995 was chosen as a reference year rather than the year 1990 or 1994 as recommended by the Guidelines of Decision 10/CP.5, because the complete set of required data for 1990 or 1994 were not available.

The inventory was based on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, using both the Reference (or top-bottom) Approach (see Section 2.3) and the Detailed Technology Based (or bottom-up) Approach (see Section 2.4), which are complementary to each other.

This chapter is based on the results presented in the report prepared by Coopoosamy *et. al.*, (1997).

2.2 Energy Supply

With no neighbours within a radius of 1,000 km, and deprived of any fossil fuel resources, the Seychelles relies heavily on the importation of refined petroleum to satisfy national energy needs as well as the demand of its market for international marine and aviation bunkers. Indeed, imported fuel accounts for up to 95% of the primary energy supply of the country. This costs the country, on average, an equivalent 6 to 10% of the Gross Domestic Product (GDP), which can be higher during periods of high oil prices. Clearly, the national economy is most vulnerable to oil-price fluctuations.

The Seychelles’ Petroleum Company (SEPEC), which has the monopoly for the import of petroleum products in the country, imported a maximum of 200,000 tonnes of oil equivalent (toe) in 1996, which was roughly twice the amount imported ten years ago.

The Public Utilities Corporation (PUC), which exclusively provides the generation and distribution of electricity on Mahe, Praslin, and La Digue, has four power stations

where electricity is generated with gas oil from diesel generators. Annual consumption of gas oil by the PUC is about 30,000 tonnes.

In mid-1995, the total installed power capacity was about 36.88 MW, of which 32.2 MW was on Mahe, 2.68 MW on Praslin and 2.0 MW on the outer islands. The peak demand was 20 MW and it occurred at 7 p.m. The total generation in 1995 was 18.6 GWh and the average annual growth rate of national consumption is 4.9 GWh.

The transmission and distribution grid has a total of 165 km of high and medium voltage lines and 350 km of low voltage lines. Mahe and Praslin have separate grids whereas La Digue's grid is connected to Praslin grid via a submarine cable. Electricity generation on the outer islands, except a few private ones, is under the responsibility of the Islands Development Company Ltd. (IDC), a parastatal organisation.

The Government also plays the role of regulator by implementing appropriate tariffs as well as appropriate energy policies. The usage of renewable energy is very marginal and limited to solar water heating.

2.3 Energy demand

The per capita electricity consumption of the Seychelles is presently 1600 kWh/yr. and there are nearly 21,000 consumers, of which 19,000 are from the domestic/residential sector, 1,500 from the industry, commerce and government, and 500 from other sectors. The domestic sector consumes 36% of the total electricity sold; the industry, commerce and other non-profit organizations 50%, and the government 14%. Mahe consumes 90% of the electricity produced, while Praslin 8% and La Digue 2%.

The transport sector is the second largest consumer of petroleum products after electricity generation. There were a total number of 7,500 road vehicles in 1995, of which about 5,800 were passenger cars, 160 were buses and 1,560 were trucks, lorries and other special vehicles.

There are a few large industries in the Seychelles, the largest being the Indian Ocean Tuna Ltd. (a tuna canning factory), and the Seychelles Breweries (a beverage manufacturing company), which are the largest consumers of electricity in the industrial sector. Some smaller industries use gas-oil or fuel oil in steam boilers, or kerosene in central water heaters or in ovens. Electricity is the most used energy in industry.

Tourism contributes an important share of the GDP and it is also the largest generator of foreign exchange. There are about 80 large and small hotels and guesthouses in the Seychelles. The total number of visitors arriving every year is still increasing (see Figure 1-9). Electricity is used in hotels for air-conditioning and refrigeration, lighting and other use in special equipment. In a typical large hotel of 200 rooms, a central boiler is usually runs on gas oil or kerosene to supply hot water to the rooms, to the laundry and to the kitchen. LPG is also used for cooking by most of the restaurants, guesthouses and hotels.

The residential sector comprises of about 18,000 of households with about an average of 4.1 persons per household. It consumed 36% of total electricity supplied by PUC in 1995. Households usually use kerosene and LPG for cooking.

2.4 Sources of energy data

There are three types of statistics on petroleum products provided by the Seychelles Petroleum Company (SEPEC), namely:

SEPEC SUPPLY AND SALES FROM 01/01/95 TO 31/12/95 IN TONNES AND IN LITRES. This statistics reports data on the imports, initial/final stock positions, inter-product transfer, local sales and international sales (re-exports) for the year 1995.

ACTUAL SALES FOR 1995 IN TONNES BY CLASS OF MARKET AND PRODUCT: This statistics gives aggregate sales by fuel type for six main classes of market in Seychelles namely: Inland Sales, *Conserverie de l'Ocean Indien*, PUC-Electricity division, International Aviation and Marine Bunkers.

PRODUCT GROUP SALES BY MARKET FOR THE 12 MONTHS.: This gives a list of all the consumers of SEPEC and their respective purchases during a year for different petroleum products. The list covers all consumers including large filling stations and retailers. This statistics provides the basis of the data for fuel consumption by sector and sub-sector of the economic activity.

These statistics alone were not sufficient to complete the inventory. It was necessary to conduct a survey in order to obtain detailed data on energy consumption by sector of activities.

2.5 Reference Approach

The principle is based on the accounting of carbon in fuels consumed by the country and the assumption that once carbon is brought into a country in fuel, it can only be saved in some way in fuel stocks or stored in products, left non-oxidized in ash or released to the atmosphere.

It is not necessary to know exactly how the fuel was used or what intermediate transformations it underwent to calculate the carbon released. The approach assumes that all non-stored oxidized carbon is released to the atmosphere as carbon dioxide. In general, the emissions as estimated by the Reference Approach should be slightly higher than those by the Detailed Technology Based Approach.

2.5.1 Estimation of national emission of carbon dioxide from combustion

Using the Reference Approach, the apparent consumption by type of fuel in the Seychelles in 1995 was estimated, as shown in Table 2-1. Table 2-2 presents the actual carbon emissions from these types of fuels. The details of the calculations can

be found in Coopoosamy *et. al.* (1997). The total carbon dioxide emission from the Seychelles in 1995 was 195,402 tonnes as per the IPCC 1996 Reference Approach.

Table 2-1. The apparent consumption for each type of fuel in the Seychelles for 1995.

	Unit	LPG	Gasoline	Kerosene	Jet-Kerosene	Gas-oil	Fuel oil
Production	tonne	0.00	0.00	0.00	0.00	0.00	0.00
Imports	tonne	719.4	8,517.39	45,484.51	45,485.51	102,241.44	2,203.15
Exports	tonne	0.00	0.00	0.00	0.00	0.00	0.00
International Bunkers	tonne	-	-	-	41,506.39	71,044.12	2,736.45
Stock Change	tonne	9.44	-483.39	-3,231.35	-708.74	-12,136.90	-1,483.68
Apparent consumption	tonne	710.0	9,000.78	3,231.35	4,687.86	43,334.22	950.36
Net calorific value	TJ/10 ³	47.31	44.80	44.75	44.59	43.33	40.19
Apparent consumption	TJ	33.59	403.23	144.60	09.03	1,877.67	38.19

Table 2-2. The actual carbon dioxide emissions for each type of fuel in the Seychelles for 1995.

	Unit	LPG	Gasoline	Kerosene	Jet-Kerosene	Gas-oil	Fuel oil
Apparent consumption	TJ	33.59	403.23	144.60	209.03	1,877.67	38.19
Carbon emission factor	tC/TJ	17.20	18.90	19.50	19.50	20.20	21.10
Fraction of carbon stored	%	0%	0%	0%	0%	0%	0%
Fraction of carbon oxidised	%	99%	99%	99%	99%	99%	99%
Carbon dioxide emission	tonne	2,097	2,097	10,236	14,796	137,682	2,825

Total carbon dioxide	tonne	195,402
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2.6 Detailed Technology Based Approach

This approach estimates emission of GHG at a more detailed level as by sector of economic activity, by type of technology and by type of fuel. Data on consumption of fuel at sector and sub-sector level of economic activity are necessary. The emissions calculated from end-uses and transformation activities are then summed up to give the national emissions.

To apply this approach, energy supply and demand statistics provided by SEPEC were not sufficient to complete the inventory. It was necessary to carry out a survey to

obtain more data on energy consumption by sub-sector of activities. Basically, the survey consisted of obtaining average shares from major buyers of gas oil, gasoline, kerosene and LPG. A survey of the main retail stations in the Seychelles, especially concerning the sale of fuel to domestic consumers, fishermen and boat owners was also undertaken.

For some sectors like public electricity generation, domestic civil aviation, and international aviation and marine bunkers, consolidated data were already available. However for certain economic activities, where data are not yet available anywhere, aggregate data from suppliers were used. Fugitive fuel emissions are considered as produced in the second category of energy activities (non-combustion activities) and hence not relevant. Emissions from the combustion of biomass were not considered because the use of these fuels is extremely small in Seychelles. There are no railways in the Seychelles.

2.6.1 Emissions from energy and transformation industries

The sole Energy and Transformation industry in Seychelles is the generation of electricity using diesel or gas oil in thermal power stations.

Public electricity

PUC is the largest local consumer of petroleum fuel as 100% of its annual production is generated from gas oil, which is the fuel used by its three power stations. PUC's annual consumption of gas oil has reached a maximum of 31.2 thousand tonnes or 37.2 million litres in 1996. Figure 2-1 shows the annual fuel consumption of PUC for electricity generation; it can be noted that fuel oil was also used until 1992.

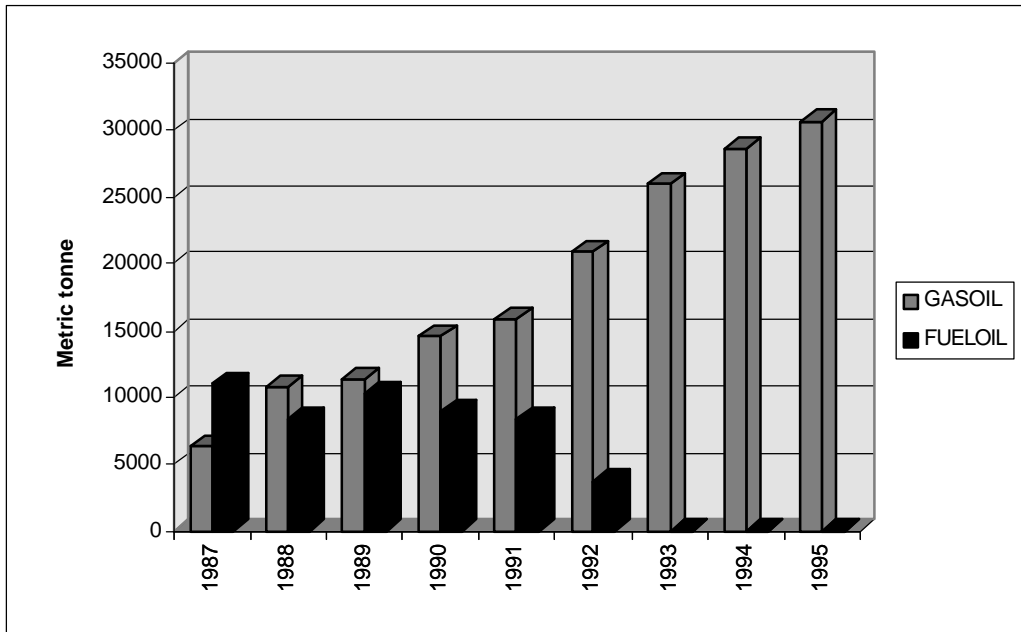
As reported in PUC's Generation Statistics for 1995, the total annual consumption of the three Power Stations, A and B on Mahe and Baie Saint Anne Station on Praslin, was 36,562,643 litres for gas oil and 378,611 litres for lubricant.

The emission of greenhouse gases is presented in Table 2-3. The total carbon dioxide emission for the year 1995 was 97,795 tonnes.

Table 2-3. The emission of greenhouse gases from public electricity generation and their shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOC
Emission (tonnes)	97,795	0.0398	0.797	90	20	NE
Share in total	54.71%	0.35%	NA	15.26%	0.39%	NE

NE = Not estimated; NA = Not available



(Source: PUC)

Figure 2-1. Fuel consumption by PUC for electricity generation.

Auto-generation

There are very few private auto-producers of electricity, and some, especially in the tourism industry, only operate a small generator as stand-by. On the outer islands, the Islands Development Company Ltd. (IDC) is responsible for the generation of electricity. Few private islands have auto-producers. The total installed capacity on the outer islands was estimated to be 2 MW in 1995. Fuel consumption by auto-producers was estimated in 1995 and reported in Table 2-4 below. The method of calculation of the emissions from auto-generation is the same as for public electricity except that it was not possible to take into account the contribution from lubricant (Table 2-5).

Table 2-4. Fuel consumption in litres by auto-producers in 1995

Sector	Fuel used	Quantity (litres)
Hotels, institutions (incl. USTS)	Gas oil	2,065,860
Industry (incl. IDC)	Gas oil	233, 530
TOTAL		2,299,390

(SBS Short Survey – 1997)

Table 2-5. GHG emissions from auto-producers in 1995.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	6,156	0.00252	0.0504	5.71	1.3	NE
Share in total	3.44%	0.02%	NA	0.97%	0.39%	NE

NE = Not estimated; NA = Not available

2.6.2 Emissions from Industry

All the industries in Seychelles using petroleum fuels have been classified according to the International Standard Industrial Classification (ISIC). However, it was more convenient to keep only two large groups accommodating the important industries where there is combustion of fuel as follows:

Group 1: Manufacture of food products and beverages

Group 2: Mining and quarrying & construction

Most of the industries in the group, Indian Ocean Tuna Ltd., Seybrew, SMB industries: Fish Division, Meat Division, Agro-Division, Animal Feed Division, Tea Company, etc, use a steam boiler either to produce steam and hot water or to dry products such as tea and yeast. Fuel oil is used to generate steam for cooking canned tuna. Gas oil is used by other industries, except SMB Fish, which is using kerosene in a boiler in the manufacturing of polystyrene packaging for fish. The fuel consumption (in litres) by industry for the heat process in 1995 is shown in Table 2-6. The estimated GHG emissions from industry and their respective shares in the national total for combustion are shown in Table 2-7.

Table 2-6. Fuel consumption in litres by industry for heat process in 1995.

Usage	Fuel oil	Kerosene	Gas oil
Industrial Boiler	960,000	37,100	863,955

Table 2-7. Emission (in tonnes) from industry in 1995.

Greenhouse Gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	5,528	00.204	NA	15.750	12.254	NA
Share in total	3.09%	1.79%	NA	2.67%	0.24%	NA

NA = Not available

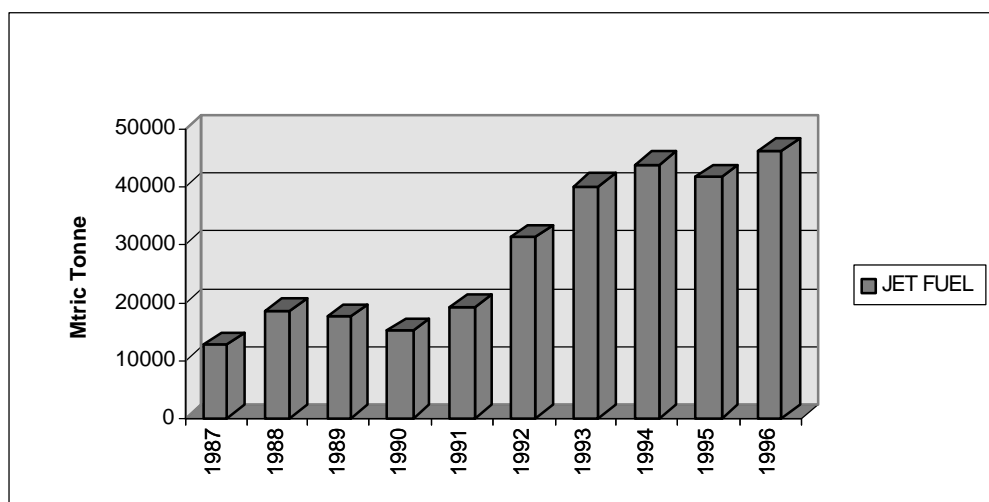
2.6.3 Transport

International civil aviation

The international civil aviation sector consists mainly of large passenger aircraft arriving, departing and in transit. This sector is the second largest consumer in the re-exportation of petroleum products. Only one type of fuel, namely Jet A-1 of Jet kerosene, is used. According to the Directorate of Civil Aviation (DCA), the total landings and take-off of international aviation bunkers in 1995 was 2,595 (Table 2-8).

Table 2-8. Aircraft movements in 1995 for international aviation.

Airline Company	Type of plane	Total landings and take-offs per year	Fuel used
Air Seychelles	Boeing 767, 757	940	Jet A-1
Air France	Boeing 747	638	Jet A-1
British Airways	Boeing 747	416	Jet A-1
Air Inter	Boeing 737	96	Jet A-1
Condor	Boeing 767	142	Jet A-1
Kenya Airways	Airbus 310	136	Jet A-1
Aeroflot	Tupelev 54	208	Jet A-1
Air Austral	Boeing 737	19	Jet A-1
TOTAL		2,595	



(Source: SEPEC)

Figure 2-2. Fuel consumption by international aviation bunkers

The total annual fuel consumption by international aviation bunkers from 1987 to 1996 is shown in Figure 2-2. The estimated GHG emissions from this category and their respective shares in the national total for combustion are shown in Table 2-9.

Table 2-9. GHG emission from international aviation bunkers in 1995 and their respective shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOG
Emission (tonnes)	132,360	3,702	NE	536.80	222.14	33.32
Aviation bunkers/National total for combustion	74.05%	32.4%	NA	91.04%	4.33%	NA

NE = Not estimated; NA = Not available

Domestic aviation

The domestic aviation consists mainly of the following:

- Inter-island flights by small planes of Air Seychelles; there are four twin-otters doing regular daily flights to Praslin, and weekly flights to Fregate and Desroches;
- Excursion flights by Helicopter Seychelles; there are two helicopters providing this service mainly for tourists;
- Inter-island flights by one Cessna of IDC;
- Occasional flights by Cessna military planes;

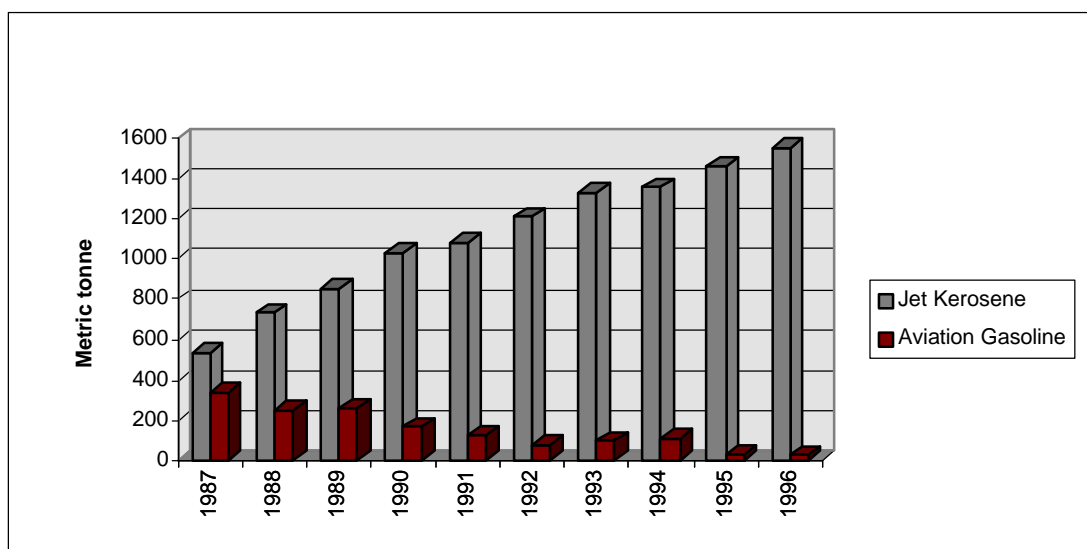
The two types of fuel used are Jet A-1 (Jet kerosene) and aviation gasoline.

The total annual fuel consumption by domestic aviation from 1987 to 1996 is shown in Figure 2-3. The estimated GHG emissions from this category and their respective shares in the national total for combustion are shown in table 2-10.

Table 2-10. GHG emission from domestic aviation in 1995 and their respective shares in the national total for combustion.

Greenhouse Gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOG
Emission (tonnes)	4.713	0.202	NA	18.870	36.800	1.82
Share in total	2.64%	1.77%	NA	3.20%	0.72%	NA

NA = Not available



(Source: SEPEC)

Figure 2-3. Fuel Consumption by Domestic Aviation

Road transportation

The vehicle fleet counted 7,438 units in 1995 and comprised mainly of Japanese cars dominated by Toyota, followed by Nissan. Other makes included Mitsubishi, Subaru, Ford, Leyland, Peugeot, etc. The average age was between six and ten years old, with a few between three and five years old. Motor gasoline and gas-oil are the two primary fuels used for road transportation. In 1995 unleaded gasoline was still not available locally.

Generally, there is more traffic on the East Coast of Mahe than on other parts of the island. Most of the emissions from vehicles arise along the roads in that region and in the capital, Victoria. The total length of public roads at the end of 1995 was 331 km of which 252 were surfaced with tarmac. The total surfaced road on Mahe was only 203 km.

At the vehicle testing station at Roche Caiman, emissions are measured while the vehicle is stationary. The following average levels of emissions were recorded for gasoline vehicles, during several measurement campaigns.

For carbon monoxide CO: maximum 6%, average 4% and 1997 averaged 4.5%;

For hydrocarbons HC: maximum 1200 p.p.m. and averaged 500 p.p.m.

A proper approach for estimating the total emissions from the road transportation sector should be based on the total distance travelled in a year, the vehicle age, driving pattern, vehicle maintenance and the terrain. However, there wasn't enough and reliable data to do so. It must be noted that in Seychelles there is a great difference between the urban and the highway speed. There is traffic congestion in Victoria during rush hours; with the average speed being 10 km/h, whereas on the highway the

average speed is 60 to 80 km/h. There are also few roads across the mountains from the east coast to the west of Mahe, so there is a lot of uphill driving as well.

Passenger Cars without 3-way catalysts

There were 4,786 passenger cars running on gasoline and 824 running on gas-oil in 1995, all of them without 3-way catalysts. The fuel consumption was estimated to be 11,128,000 litres of gasoline and 1,675,000 litres of diesel. Estimation for the inventory was based on the proportions of gasoline vehicles in the sector. The estimated GHG emissions from these vehicles and their respective shares in the national total for combustion are shown in Table 2-11.

Table 2-11. GHG emissions from passenger cars in 1995 and their respective shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	29,604	7.673	0.479	215.17	4,760.94	446.66
Share in total	16.56%	67.17%	NA	36.49%	92.88%	NA

NA = Not available

Light Duty Trucks without 3-way catalysts

This sub-sector consists of commercial vehicles of the type of light duty trucks. In 1995 there were 1561 such vehicles, 90% of which run on gas oil and 10 % run gasoline, none of which with 3-way catalytic converter. The fuel consumption was estimated as 2,856,650 litres of gas oil and 362,737 litres of gasoline. The estimated GHG emissions from this category of vehicles and their respective shares in the national total for combustion are shown in Table 2-12.

Table 2-12. GHG emission from light duty trucks in 1995 and their respective shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	8,467	0.673	0.209	22.58	101.23	34.38
Share in total	4.55%	9.82%	NA	19.01%	1.10%	NA

NA = Not available

Heavy duty trucks and buses

This category includes 163 buses, belonging to SPTC (public transport company), large trucks being used by construction and quarry companies, ground equipment used at the airport, and forklifts used in industries. Most of the vehicles run on gas oil and only this fuel has been accounted for in the calculations of emissions. The consumption of gas oil in 1995 from this sub-sector was estimated to be 3,038,035 litres, of which 1,552,100 litres were consumed by SPTC. The estimated GHG

emissions from this category of vehicles and their respective shares in the national total for combustion are shown in Table 2-13.

Table 2-13. GHG emissions from heavy duty trucks and buses in 1995 and their respective shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	8,134	1,110	0.211	112.08	56.60	19.97
Share in total	4.55%	9.72%	NA	19.01%	1.10%	NA

NA = Not available

Motorcycles

This is a relatively small sub-sector as in 1995 there were only 97 motorcycles, all running on gasoline. Total consumption was estimated to be 135,900 litres. The estimated GHG emissions from motorcycles and their respective shares in the national total for combustion is shown in Table 2-14.

Table 2-14. GHG emissions from motorcycles in 1995 and their respective shares in the national total for combustion.

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	356	0.667	0.005	0.359	47.24	12.84
Share in total	0.20%	5.84%	NA	0.06%	0.92%	NA

NA = Not available

Marine transportation

International Marine Bunkers

Many of the international marine bunkers are foreign fishing vessels having activities in the region under a fishing agreement with Seychelles. These include French, Spanish, Japanese, Korean and Taiwanese fishing vessels. There are also some cargo and passenger ships refuelling at Port Victoria. The total consumption in 1995 was 2,736 tonnes for medium fuel oil and 71,044 tonnes for gas oil. The estimated GHG emissions from international marine bunkers in 1995 and their respective shares in the national total for combustion are shown in Table 2-15.

Table 2-15. GHG emissions from international marine bunkers in 1995 and their respective shares in the national total for combustion

Greenhouse gas	CO ₂	NO _x	NMVOC
Emission (tonnes)	246,776	6,695.5	NE
Marine bunkers/ National total for combustion	138.1%	1135.4%	NA

NE = Not estimated; NA = Not available

National Navigation

This sub-sector consists of navigation for all purposes, except for fishing. It includes inter-island navigation between Mahe, Praslin and La Digue for cargo and passengers, trips to the outer islands, excursion trips for tourists, etc. An estimation of the fuel consumption by this sub-sector is shown in Table 2-16.

Table 2-16. Fuel consumption (in litres) by national navigation in 1995.

Type of navigation	Gasoline	Diesel
Inter-island navigation (passenger and cargo boats)		382,986
Leisure/Excursion/ Tourism	139,060	776,290
TOTAL	139,060	1,159,276

The estimated GHG emissions from national navigation in 1995 and their respective shares in the national total for combustion are shown in Table 2-17.

Table 2-17. GHG emissions from national navigation in 1995 and their respective shares in the national total for combustion

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOC
Emission (tonnes)	4,081	0.357	0.107	83.234	41.098	19.604
Share in total	2.28%	3.12%	NA	14.11%	0.80%	NA

NA = Not available

2.6.4 Emissions from small combustion sources

Commercial and institutional buildings

This sub-sector comprises of hotels, restaurants, institutions, public and private organisations. The usage of fuel is vital to all of them and there are three types of fuel being used; LPG, gas oil and kerosene. LPG is mainly used for cooking. Gas oil is used in hotels in central boilers to supply hot water and to generate steam for the kitchen. Kerosene is used in some cases in central boilers. Many organisations and

institutions use LPG for cooking in their working places for their employees. The fuel consumed by commercial and institutional sector in 1995 is shown in Table 2-18. The estimated GHG emissions from this sector in 1995 and their respective shares in the national total for combustion are shown in Table 2-19.

Table 2-18. Fuel consumed by commercial and institutional sector in 1995.

	LPG (kg)	DIESEL (l)	KEROSENE (l)
Hotels and Guest houses	90,072	331,840	37,100
Restaurants	18,722	0	0
Hospital	17,049	0	0
Other institutions and commerce	17,175	0	0
TOTAL	143,018	331,840	37,100

Note: l = litres

Table 2-19. GHG emissions from this sector in 1995 and their respective shares in the national total for combustion

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	4,081	0.357	0.107	83.234	41.098	19.604
Share in total	2.28%	3.12%	NA	14.11%	0.80%	NA

NA = Not available

Residential sector

The population of the Seychelles was estimated to be 75,300 in 1995 and the number of households was 18,000. Two fuels play a vital role in many households: Kerosene and LPG, which are used for cooking and water heating. The use of wood and charcoal is very marginal and has not been considered. The same applies for the use of gasoline in grass mowers by households. The fuel consumed by the residential sector in 1995 is shown in Table 2-20. The estimated GHG emissions from the sector in 1995 and their respective shares in the national total for combustion are shown in Table 2-21.

Table 2-20. Fuel consumption by the residential sector in 1995.

KEROSENE	3,732,925 litres
LPG	591,464 kg

Table 2-21. GHG emissions from the sector in 1995 and their respective shares in the national total for combustion

Greenhouse gas	CO ₂	CH ₄	N ₂ O	NO _x	CO	NM VOC
Emission (tonnes)	10,838	0.148	NA	7.87	1.95	NA
Share in total	6.06%	1.30%	NA	1.33%	0.04%	NA

NA = Not available

Agriculture, forestry and fishing

This sector is largely dominated by fishing where the fuel consumption by fishing boats is significant, whereas that of agriculture and forestry is marginal because of the limited activities use of machines in these sub-sectors. The greenhouse gas emissions accounted for is only from artisanal fishing fleet. According to a survey by Seychelles Fishing Authority (SFA) in 1996 there are some 457 boats engaged in artisanal fishing activities on Mahe, Praslin and La Digue. The three types of fuel used by boats are gas oil, gasoline and kerosene. The fuel consumption by artisanal fishing boats in 1995 is shown in Table 2-22. The estimated GHG emissions from artisanal fishing in 1995 and their respective shares in the national total for combustion are shown in Table 2-23.

Table 2-22. Fuel consumption (in litres) by artisanal fishing boats in 1995.

Supplier	GASOLINE	DIESEL	KEROSENE
Filling stations (excl. La Digue)	112,320	31,200	31,200
SFA and others (incl. La Digue)	87,260	546,090	0
TOTAL	199,580	577,290	31,200

Table 2-23. GHG emissions from artisanal fishing in 1995 and their respective shares in the national total for combustion

Greenhouse gas	CO₂	CH₄	N₂O	NO_x	CO	NM VOC
Emission (tonnes)	1,500	0.316	0.030	16.77	46.43	39.05
Share in total	0.84%	2.77%	NA	2.84%	0.91%	NA

NA = Not available

2.7 Results and Analysis

2.7.1 Carbon dioxide (CO₂)

The total carbon dioxide emission from combustion in 1995 was estimated as 178,736 tonnes, of which 58% was from electricity generation and 31% from the transport sector. The remainder was from Industry (3%) and from small combustion (7.8%). In the small combustion category, the residential sub-sector is accountable for 6% of the national emissions, the agriculture/forestry/fishing 0.8%, and the commercial/Institutional buildings 0.87%. The distribution of carbon dioxide emission from various energy activities is illustrated in Figure 2-4.

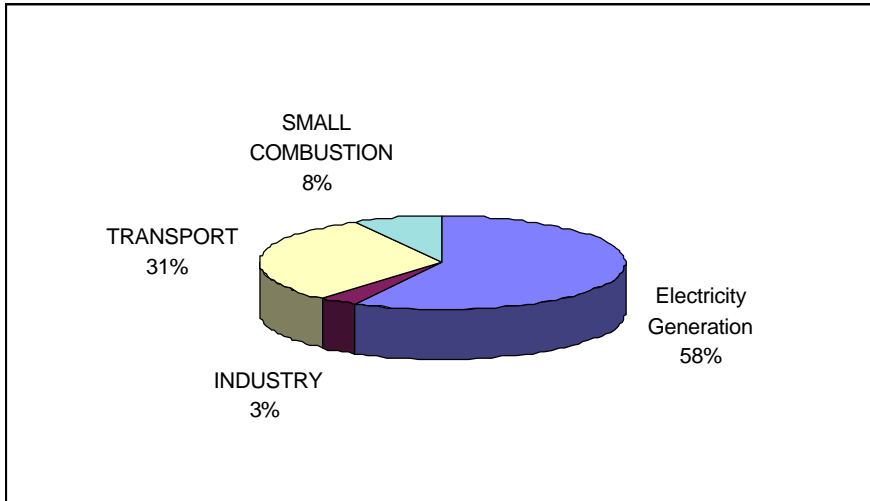


Figure 2-4. Distribution of carbon dioxide emissions from energy activities.

The two largest emission sources of carbon dioxide from fuel combustion in Seychelles are:

- Public Electricity Generation accountable for 54.7% of national total
- Road Transportation accountable for 26% of national total. In the road transportation, the category of passenger cars shares 16.5% in the national total, the light duty trucks 4.7%, and the heavy duty trucks and Buses 4.5%. The share of motorcycles is negligible.

2.7.2 Methane (CH₄)

The total methane emission from combustion for 1995 was estimated as 11.42 tonnes and 93.5% (Figure 2-5) of which came from the transport sector with road transportation emitting 88.6% and navigation 2.2%. Artisanal fishing accounted for 2.7%.

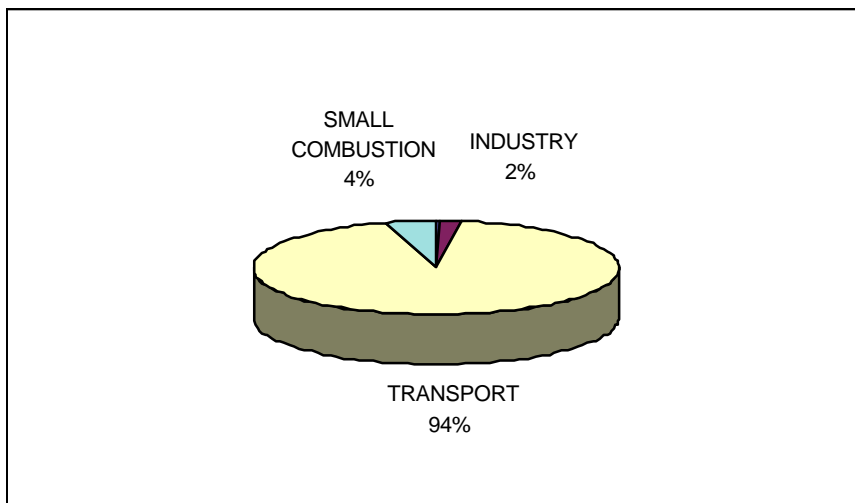


Figure 2-5. Distribution of methane emission from energy activities.

2.7.3 Nitrous oxide (N₂O)

Because of insufficient data on the emission factor for nitrous oxide, estimation was made only for electricity generation and road transportation. About 0.84 tonne was emitted from electricity generation and 0.903 tonne from road transportation. The national total is not known but would be in the order of a few tonnes.

2.7.4 Nitrogen oxides (NO_x)

The total nitrogen oxides emission from combustion for 1995 was estimated as 589.7 tonnes. About 76.7% of the emission came from the transport sector and 16.2% from electricity generation, the rest from industry (2.6%) and small combustion (4.4%), as shown in Figure 2-6. In the small combustion category, artisanal fishing is accountable for 2.8% of the national nitrogen oxides and the residential sector for 1.3%.

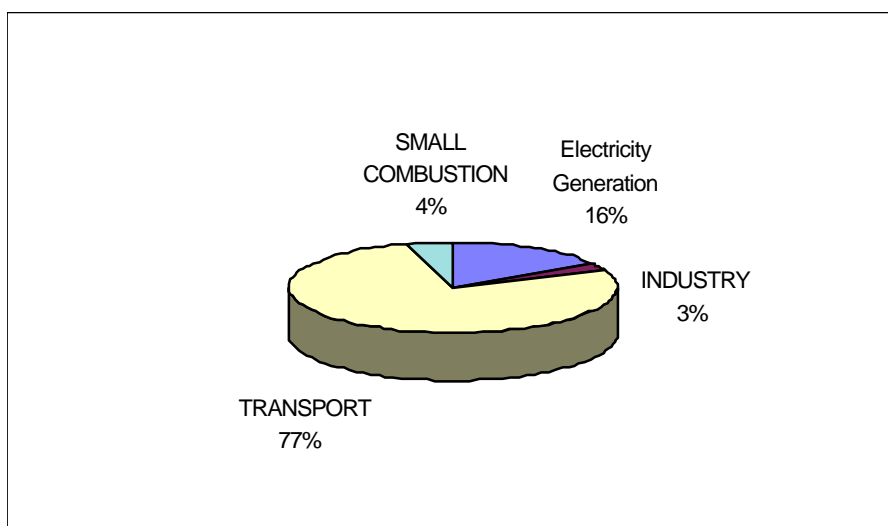


Figure 2-6. Distribution of nitrogen oxides emissions from energy activities.

2.7.5 Carbon monoxide (CO)

The total carbon monoxide emission from combustion for 1995 was estimated as 5,126 tonnes. About 92.8% of the emission came from passenger cars, which numbered at 5,610 in 1995. About 2% came from light duty trucks, which numbered at 1561 in 1995 and 1.1% from heavy duty trucks, buses and other transportation vehicles, forklifts, etc. The distribution of carbon monoxide for energy activities is illustrated in Figure 2-7.

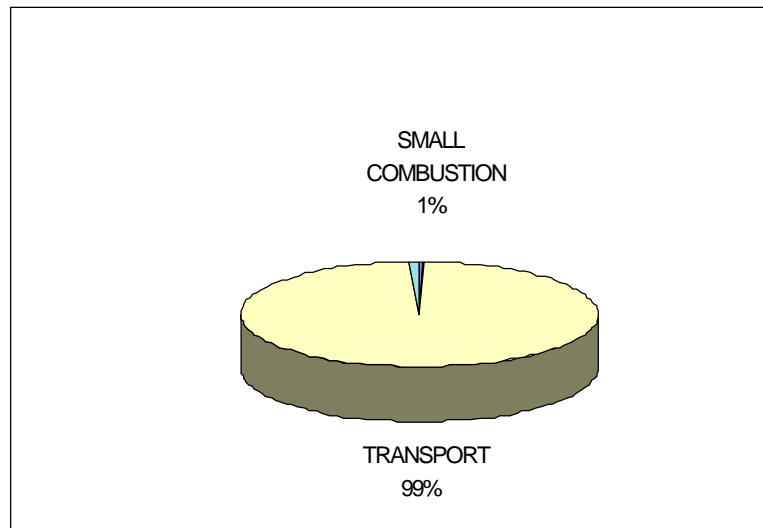


Figure 2-7. Distribution of carbon monoxide emission from energy activities.

2.8 Comparison of Results from both Approaches

As shown in Table 2-24, the national total carbon dioxide emission as estimated by the Reference Approach was 16,666 tonnes or 8.5% higher than that estimated by the Technology Based Approach, while the carbon dioxide from the international aviation bunkers and from the international marine bunkers as estimated by the Reference Approach were 1,324 tonnes or 1.1%, and 12,784 or 5.5%, respectively lower than that estimated by the Detailed Technology Based Approach. However, within the limits of uncertainty (assuming 10%), these two sets of results can be regarded as comparable.

Table 2-24. Comparison of carbon dioxide emission with the Reference Approach and Detailed Technology Based Calculation Approach.

Carbon dioxide emission	Reference Approach (tonnes)	Detailed Technology Based Approach (tonnes)	Difference (tonnes)	% Difference
National total	195,402	178,736	-16,666	-8.5%
International Aviation Bunkers	131,036	132,360	1,324	1.1%
International Marine Bunkers	233,992	246,776	12,784	5.5%

2.9 Uncertainties and assumptions

2.9.1 General

There are two sources of uncertainties:

- a) The uncertainties due to emission factors;
- b) The uncertainties due to energy data.

The uncertainties due to emission factors are assumed to be minor and therefore not discussed here.

The uncertainties due to energy data are as follows:

- a) They are associated with the estimate of fuel consumption by sector and sub-sector;
- b) For sector or sub-sectors with large consumption of fuel like public electricity, road transportation, aviation and marine bunkers, the uncertainties are small in the range of 1 to 3%.

For sub-sectors having smaller consumption of fuel like fishing, auto generation, industry and commercial/ institutional, the uncertainties could be as high as 50%.

2.9.2 Industrial processes

Cement production is perhaps the most notable example of such an industrial process that releases a significant amount of CO₂. However, there is no cement production in Seychelles, and the only pollutants from industrial processes (as per Table 2.1 of the IPCC Reference Manual) that have been noted are from bread and beer production, that produce NMVOC and CO₂. Total emissions from this sub-sector are insignificant and have not been considered.

Solvent and other product uses

The data for solvent used in paint application were obtained from the Ministry of Finance, Trades Tax and Import Division (TTI) and the Management Information & Systems Division (MISD). These organisations maintain computerised database on imports as per the Harmonised System for classification of goods.

The total consumption of solvents for the year 1995 was as follows:

Paint Application	19.25 tonnes
Degreasing and cleaning	10.84 tonnes

The overall emission of NMVOC as a result of solvent use is 17 tonnes.

2.9.3 Agriculture

Land for agriculture in Seychelles is limited to the narrow coastal strip and the steep hillsides. The soil being laterite is not fertile, and yields increase only after extensive use of manure and fertilizer.

The main problems encountered in carrying out the inventory for this sector was the lack of readily useable data. Consequently, a more detailed study needs to be carried out to correctly assess the contribution of GHG from this sector. Even though it was assumed that the contribution from manure management is too insignificant to be considered, a more comprehensive study and data gathering might report otherwise given the prevailing equatorial climate.

The reference year for the collection of data was 1994. This was the year when a national census was carried out and the most consistent data available. As far as livestock is concerned the figures did not vary greatly from 1989 to 1993 (see Table 2-25).

Table 2- 25. The population of chicken (1989-93)

	1989	1990	1991	1992	1993
Chicken	385,000	390,000	400,000	440,000	450,000

(Source: MISD, 1994)

CH₄ Emissions From Enteric Fermentation in Domestic Livestock

In the Seychelles, traditionally, cattle are raised primarily for manure and to provide fresh milk for the local consumption. After having served those purposes, they are slaughtered for meat.

Locally produced pork meets 60 – 65% of the national demand. Formerly pigs were ideally kept in individual household to consume all the leftover food. Pigs are now commercially bred for pork and pork products.

Poultry are commercially kept for both meat (broilers) and for egg (layers) production. While broilers are kept alive for only a short period of time, layers on the other hand are kept for, as long these can be commercially beneficial. There is still a small portion of free-range poultry practices.

CH₄ Emissions From Manure Management

This section is not yet applicable to the Seychelles. Cow manure is usually left in the open to rot, before being directly applied to the soil; while poultry manure is sometimes kept in piles. Pig manure is collected as slurry in tanks, but this is not left to decompose. It is usually disposed of as a soil ameliorant so as to collect fresh slurry in the tank. This in fact produces little or no methane.

CH₄ Emissions From Rice Cultivation

This section is not applicable to the Seychelles, as rice is not grown. Seychelles imports 100% of its rice.

CH₄, CO, N₂O and NO_x Emissions from Agricultural Burning (Savannah and Agricultural Burning)

This section is also not applicable for the Seychelles, as there are no savannahs and clearing land for agriculture through burning is virtually non-existent. The amount of agricultural waste produced is quite minimal and is mostly fed to animals, turned into compost.

N₂O, CO and CH₄ Emissions from Agricultural Soils.

The land allocated to agricultural activities is quite minimal. Table 2-26 shows the types of fertilizer used in Seychelles.

Table 2-26. Fertiliser used in the Seychelles.

Type of Fertiliser	Quantity used in tonnes
Inorganic	158
Cow manure	2,555
Poultry	9,110
Pig	9,000
Total	20,823

(Source: MAMR)

Outcome of Estimate

Table 2-27 shows estimated methane emissions from livestock, and Nitrous oxide emissions from soils, being the total estimated GHG emissions for the agriculture sector.

Table 2-27. GHG emissions from agriculture (tonnes).

Methane emissions from livestock (tonnes)	N ₂ O emissions for Soils (tonnes)
202.0	75.0

2.9.4 Land use change and forestry

The Seychelles' archipelago has a total land area of 45,539 hectares covering all of the 115 islands. The land is about 90% vegetated with a mixture of different plants about half of the land area is protected in the form of reserves and national parks.

Changes in Forestry and Other Woody Biomass Stocks:

The annual increments of biomass in plantations, forest, which are logged or harvested, were obtained from the Forestry Section of the Division of Environment. It is estimated that the average annual harvest for commercial use was around 8000 cubic metres. However, e since environmental policies now discourage the gathering of fuel wood, and with provision of electricity in rural areas, deforestation is very low. Deforestation occurs primarily as a result of urbanisation, but that is also slow.

CO₂ Emissions from Forest and Grassland Conversion

The forest/grassland areas converted to cropland and pasture, by type over the last three time periods: inventory year, past 10 years, past 25 years could not be determined, but is known that of 982 hectares of land allocated for all agricultural purposes including animal production, 600 hectares are used for intensive agricultural practices. Due to severe land constraints, it is not expected that more agricultural land will be allocated rather; intensive practices will dominate on existing land.

Non- CO₂ emissions from on-site burning of forests

According to the Forestry Section of the Division of Environment, there is very little burning on site, except on rare occasions with diseased plants. Generally, the waste from forest (either commercial or forest maintenance) is left to rot *in situ*. As this takes place in the open, the decomposition can be assumed to be aerobic, and hence little or no methane is produced.

Abandonment of managed lands

The different types of managed land considered for this inventory include:

Cultivated Land (Arable Land for Cultivation): With land being so limited, there is a need to maximise its use and hence there is not much abandonment in the country. In the pre-1970s, coconut and cinnamon plantation produced the primary cash crop. As the economy has evolved from a mainly production one to a more consumer based, plus the fact that the world demand for copra and cinnamon has declined, these plantations are now not productive. Most of the plantations are still there and the coconuts are hardly used.

Pastures: There are no pastures in the Seychelles. Most animals are kept in confined areas or are allowed to graze in very few limited areas.

Outcome of estimate

The time periods considered for the purpose of the inventory are:

Abandoned during 20 years prior to the inventory year (1970);

Abandoned between 20 to 100 years prior to the inventory year (1870 - 1970).

It must be noted that certain areas of reclaimed land were allowed to vegetate before being cleared for housing and other development projects. A total of 300 (hectares) have been reclaimed so far, of which 30 to 40% is vegetated. The total uptake capacity of the country as a carbon sink is around 832,770 tonnes of CO₂ per year, which makes the Seychelles a **net sink** compared to emission by sources as reported in the inventory, as shown in Figure 2-28.

Table 2-28. Removal capacity of CO₂ sinks (tonnes).

Category of source/sink	Amount of CO ₂ released (+)/absorbed (-)
Total vegetated area	- 845,310
Total removal of bio-mass	+ 12,540
Net emission/removal	- 832,770

Total vegetated area includes natural forest cover and managed agricultural, 90% of total land area of Seychelles

Waste

For the purpose of this inventory, only methane emissions from anaerobic wastewater treatment plants and landfills were considered.

The emission contributions from the major hotels were considered for the following reasons (a) the wastewater treated by the plants were considered to be domestic in nature, and (b) the plants were considered to be functioning as anaerobic plants due to bad maintenance.

No efficiency data were available from hotel or from PUC for their wastewater treatment plants, hence, in order to estimate the methane emission for the inventory, plants at the hotels were assumed to be 70 % efficient in terms of aerobic treatment of wastewater. This was based upon standard operating efficiencies used for different types of wastewater treatment plants. In any case, the missing data would not have made significant differences from the total methane emission for the waste sector.

Outcome of estimation

Table 2-29 shows the estimated total emission of methane from the waste sector to be 2,350 tonnes.

Table 2-29. GHG Emissions from various sources of the waste sector.

Sources	Emission Estimates (tonnes) CH ₄	Emission Factor CH ₄ (tonnes)
Landfills	2080.0	514,850
Wastewater treatment plants	270.0	15,600

2.10 Summary of Results

Table 2-30. Summary of greenhouse gas emissions from combustion activities in the Seychelles in 1995 (Share by sector and sub-sector)

Sector/sub-sector source category	CO ₂	CH ₄	N ₂ O	NO _x	CO	NMVOCs
1A1 ENERGY AND TRANSFORMATION INDUSTRIES						
1A1 ai Electricity Generation						
Public Electricity	54.71%	0.35%	NA	15.26%	0.39%	NE
Auto-generation	3.44%	0.02%	NA	0.97%	0.03%	NE
<i>Sub-total</i>	<i>58.16%</i>	<i>0.37%</i>	<i>NA</i>	<i>16.23%</i>	<i>0.42%</i>	<i>NE</i>
1A2 INDUSTRY (ISIC)						
1A2 e Food Processing and Beverages	2.79%	0.93%	NA	1.34%	0.02%	NA
Road Construction and mining	0.30%	0.86%	NA	1.33%	0.22%	NA
Manufacture of non-refractory ceramic ware	0.001%	0.000%	NA	0.00%	0.00%	NA
<i>Sub-total</i>	<i>3.09%</i>	<i>1.79%</i>	<i>NA</i>	<i>2.67%</i>	<i>0.24%</i>	<i>NA</i>
1A3 TRANSPORT						
1A3 a Civil Aviation - ii Domestic	2.64%	1.77%	NA	3.20%	0.72%	NA
1A3 b Road Transportation						
i Passenger Cars	16.56%	67.17%	NA	36.49%	92.88%	NA
ii Light Duty Trucks	4.74%	5.90%	NA	3.83%	1.97%	NA
iii Heavy Duty Trucks and Buses	4.55%	9.72%	NA	19.01%	1.10%	NA
iv Motorcycles	0.20%	5.84%	NA	0.06%	0.92%	NA
<i>Road Transportation - Sub-total</i>	<i>26.05%</i>	<i>88.63%</i>	<i>NA</i>	<i>59.38%</i>	<i>96.88%</i>	<i>NA</i>
1A3 c Railways	0%	0%	0%	0%	0%	0%
1A3 d Navigation - ii Internal Navigation	2.28%	3.12%	NA	14.11%	0.80%	NA
<i>Transport - Sub-total</i>	<i>30.97%</i>	<i>93.52%</i>	<i>NA</i>	<i>76.70%</i>	<i>98.40%</i>	<i>NA</i>
1A4 SMALL COMBUSTION						
1A4 a Commercial / Institutional Buildings	0.87%	0.26%	NA	0.22%	0.01%	NA
1A4 b Residential	6.06%	1.30%	NA	1.33%	0.04%	NA
1A4 c Agriculture / Forestry <u>Fishing</u>	0.84%	2.77%	NA	2.84%	0.91%	NA
<i>Sub-total</i>	<i>7.78%</i>	<i>4.32%</i>	<i>NA</i>	<i>4.40%</i>	<i>0.95%</i>	<i>NA</i>
TOTAL	100%	100%	NA	100%	100%	NA

NE = Not estimated; NA = Not available

3 TECHNOLOGIES AND MEASURES FOR MITIGATION

3.1 Introduction

As discussed in Chapter 2, the per capita GHG emission from the Seychelles is much lower than the global average. Although the national energy consumption will increase with the increase of population and with the present pace of economic development, it is expected that the per capita GHG emission in the country would consistently remain much below the global average in the future. However, in order to protect the national and global environment, the Seychelles is following the good practice of pursuing the “no regrets” options to reduce its GHG emission in a cost effective manner.

As part of the studies for the preparation of the Initial National Communication, a small study team was established to assess the technologies and measures that can be used by the Seychelles to reduce the GHG emissions in the key socio-economic sectors, such as energy end-use, transport, energy supply, agriculture, and the forestry and land use, solid waste and wastewater. Following the guidance provided by the “*IPCC Technologies, Policies and Measures for Mitigating Climate Change, 1996*”, the study team completed a report entitled “Technologies and Measures for the Mitigation of Greenhouse Gas in Seychelles” (Coopoosamy and Moustache, 1998), which provides a comprehensive analysis on the past trends and the future projections for the CO₂ emissions in the key socio-economic sectors, and proposes various possible mitigation options. However, the proposed mitigation options will need to be further assessed based on least-cost analysis that takes the environmental costs and benefits into consideration, before the Government can endorse them for implementation.

It may be noted that the draft of this report was first presented to a workshop organized by the National Climate Change Committee (NCCC), and it was reviewed by the working groups established during the workshop. The report was finalized based on the comments and recommendations of the working groups, and then presented to the NCCC for endorsement.

The chapter is largely based on the data and analysis provided in the above-mentioned report.

3.2 Residential, Commercial and Institutional Sector

3.2.1 Energy consumption

In 1995, 289 TJ of energy were consumed in residential sector. This represents 130 TJ (36 GWh) of electrical energy, plus 3.73 million litres of kerosene and 159 tonnes of LPG, which is equivalent to 159 TJ of energy. Almost 70% of energy used in the homes is primarily for cooking purposes.

The commercial and institutional sector consumed 276 TJ of final energy of which 224.1 TJ (67.8 GWh) is electrical energy, and the rest is for the other petroleum products. Of the total electricity production, the residential sector consumes 36.7%, while the commercial and institutional sector consumes 63.3%.

3.2.2 Trends and projections

Table 3-1 shows a growth in electricity consumption (in GWh or millions of units) of 5% annually and the sum of LPG and kerosene (used primarily for cooking) consumption (<5% growth per annum) up to the year 2020. The figures for kerosene and LPG are combined for the simple reason that, though there are past figures for both, it is a difficult exercise to predict how the consumption of each of these will grow. For social and economic reasons, it is a government policy to replace kerosene by LPG for cooking. This means that the consumption of LPG is expected to rise and the kerosene consumption will decrease to a minimum.

Table 3-1. Projection of energy consumption in gigawatt-hours (GWh) in the residential sector from 1990 to 2020.

Types of Energy	1990	1995	2000	2010	2020
Electricity (GWh)	25.7	36.2	47.8	94.2	178.3
Kerosene + LPG (ktoe)	2.83	3.79	5.06	8.56	14.50

The projection in Table 3-1 takes into account that LPG is more efficient and less carbon intensive than kerosene. This information is based on the 1988 Energy Survey, which shows that domestic cooking consumes the bulk of the energy in the residential sector. This is equivalent to about 70% of the total energy use. LPG and kerosene are the two most commonly used fuels for cooking. The remainder of the households uses electricity, while the use of fuel wood and charcoal is negligible. The projection of energy consumption in gigawatt hours in the commercial and institutional sector from 2000 to 2020 is shown in Table 3-2.

Table 3-2. Projection of energy consumption in gigawatt-hours (GWh) in the commercial and institutional sector from 2000 to 2020.

Energy types	1990	1995	2000	2010	2020
Electricity (GWh)	43.0	67.8	92.9	177.0	337.1
Fuels (ktoe)	0.90	0.55	0.77	0.93	1.12

Table 3-3 shows the projection of total energy from 2000-2020 (ktoe) for the residential, commercial and institutional sectors. The results show that there was not much difference in the projection between the two sectors. Assuming a rapid growth in industry compared to residential uses, the projected values maybe different. Also implementation of energy alternatives or conservation in one sector only may considerably widen the gap.

Table 3-3. Projection of total energy consumption in kilo-tonnes of oil-equivalent (ktoe), for residential, commercial and institutional sectors from 2000 to 2020.

	1990	1995	2000	2010	2020
	ktoe				
Residential	5.21	6.90	9.34	16.67	29.83
Commercial & institutional	4.60	6.38	8.76	16.15	30.11
TOTAL	9.81	13.28	18.10	32.82	59.94

(Source: Energy Affairs bureau, Seychelles Bureau of Standards)

3.2.3 Emission of greenhouse gas

The estimation of emission of GHG from fuel combustion in the Residential, Commercial and Institutional Sectors is calculated using the IPCC methodology and as per the details given in the GHG Inventory report.

Direct emission as shown in Table 3-4 below is obtained from fossil fuel combustion to produce heat. This is either in the form of LPG for cooking in homes or diesel in fuel boilers for producing hot water in hotels. The indirect emission of CO₂ results from the use of electricity (produced by thermal power stations) to operate various types of electrical appliances.

Table 3-4. Projection of CO₂ emission (tonnes) from residential, commercial and institutional sector from 2000 to 2020.

		1990	1995	2000	2010	2020
		Tonnes				
Direct Emission	Residential	8,070	10,654	13,860	23,457	39,761
	Commercial and Institutional	1,273	1,403	1,543	1,866	2,357
Total		9,343	12,057	15,403	25,323	42,118
Indirect Emission	Residential	20,420	28,761	39,579	74,879	141,661
	Commercial and Institutional	35,273	55,577	76,148	145,047	276,285
Total		55,693	84,338	115,727	219,926	417,946

3.2.4 Technologies and measures

The mitigation options presented below contain a number of projects, which if implemented in the short and medium term, will reduce and limit emission of GHG in the Seychelles. Capacity building in those areas is also very important to ensure sustainability of options implemented.

Use of low-wattage and renewable energy technologies, such as, Compact Fluorescent Lamp (CFL) and Solar Water Heater (SWH): The use of compact fluorescent lamp instead of incandescent bulb, and solar water heater instead of electric water heater has great potential for significant reduction of emission of GHG in Seychelles. Wide scale use of CFL and SWH would reduce the demand for electricity significantly, thereby putting less pressure on the supply authority to meet the ever-increasing demand capacity. The government is adopting measures to

promote the use of CFL and SWH, and to make these appliances affordable. Adoption of these technologies in the main government and private sector building will also be beneficial.

Use of LPG for domestic cooking: Over the last few years, government has taken steps to encourage the use of LPG in domestic cooking rather than the use of electricity and kerosene. Consequently there has been substantial investment to ensure constant and reliable supply of LPG, as well as subsidies on LPG cooking stoves. The government is committed to continue to promote LPG for domestic cooking, because there is potential for reduction of emission of GHGs and it reduces demand during peak periods. The price of kerosene has gone up as an economic disincentive. The majority of people are using LPG for cooking is therefore expected to increase.

Use of energy efficient refrigerators and freezers: Refrigerators and freezers are appliances that operate round the clock, and this contributes significantly to the electrical energy consumption in the domestic sector. It is therefore very important that these appliances are energy efficient. New cooling and refrigeration technologies adopted as a result of controls put in place as a result of the Montreal Protocol will also need to be considered for energy efficiency.

Setting up of an energy efficient use and conservation extension service within the Energy Affairs Bureau: The Energy Affairs Bureau is putting in place an extension service for advising users on energy efficient use and conservation. This extension service would help to reduce the energy consumption and emission of GHG.

The incorporation of energy efficient measures and standards in building design: Building design and orientation sometimes does not take into consideration how various energy end-use activities will be implemented. Inefficient use of lighting and air-conditioning systems is sometimes a direct result of bad design and orientation of the building. It is quite common to find air-conditioning system which does not match the space to be cooled, windows that are not properly sealed, direct sunlight entering the rooms, inadequate temperature control, etc. Proper design and orientation of the building would contribute toward the reduction of energy consumption and emission of GHG. The Government, through the Planning Authority has introduced energy efficient measures and standards in building design, and architects are being asked to put these measures into practice.

Energy audits for commercial and institutional buildings: Energy audits could be an effective method for the introduction of energy efficient use and conservation measures, which would contribute to reduction in emissions of GHG. The energy audits could identify areas where there is the energy wastage and actions could then be undertaken to limit wastage and reduce consumption of energy. The Energy Affairs Bureau is taking steps to put in place measures for energy audits in commercial and institutional buildings to be undertaken on a yearly basis.

3.3 The Transport Sector

The transport sector is divided into three main sub-sectors:

- Road transportation of passengers and freight;
- Domestic air transport or passenger transport using small aircrafts and helicopters;
- Domestic sea transport for passenger and freight using schooners.

The GHG inventory for the year 1995 revealed that the domestic air transport contributed 4,710 tonnes of CO₂ and sea transport contributed 4,080 tonnes, compared to 46,560 tonnes for road transportation. Since the emissions of GHG from these sub-sectors are expected to remain at a low level, mitigation options have not been considered. Emphasis is being put on the road transport, which represents nearly 43 % of the national total energy consumption.

Since all the fuel used in the transport sector is imported, government GHG reduction policies in the road transport sector may include:

- Present fiscal policies to encourage motorists to import more fuel-efficient vehicles and to minimise travel;
- Adopt alternative vehicle technologies;
- Promote the use of public transport;
- Encourage non-motorised transport;
- Annual or more frequent vehicle testing for roadworthiness and air pollution;
- Reduce congestion;
- Land use planning promoting more efficient transport.

3.3.1 Background information

The development of the road network in Seychelles has been incremental, each stage reflecting the needs and resources available at the time. The roads either follow the coastline or cross the mountains from one side of the island to the other. The total length of roads in Seychelles is 331 km, as shown in Table 3-5.

Table 3-5. Status and length of public roads as a function of location, as at 31 December 1996.

Road Types	km			Total
	Mahe	Praslin	La Digue	
Surfaced	203	45	6	254
Un-surfaced	55	12	10	77
Total	258	57	16	331

(Source: Land Transport Division)

The roads in Seychelles are generally winding and steep, with relatively low geometric standards and about 6 metres wide. This has necessitated a general speed

limit of 40 km/hr in urban and residential areas, up to 65 km/hr in other areas. The only exception is the new East Coast Road, which is on level terrain and on which the upper limit is 80 km/hr.

Vehicles in Seychelles, particularly goods and service vehicles and public buses, are considerably smaller than in most other parts of the world to allow for geometry and narrow roads. The Seychelles Public Transport Corporation (SPTC), a state-owned company, which has the monopoly, provides the public bus service. A taxi service is available. Car companies own about 7% of all the vehicles in Seychelles. Tour operators are now using a number of air-conditioned buses to transport tourists.

Most commodities arrive by sea at Victoria harbour, and freight is generally transported in fairly small trucks (3 – 10 tonnes). Permissible size and weights are closely controlled, and oversized vehicle movements require special permission.

Other islands are linked with Mahe by small aircrafts and helicopters while schooners provide regular ferry service between Mahe, Praslin and La Digue, serving tourists and Seychellois, and transporting essential goods to those islands as well as other outlying islands.

3.3.2 Projection of vehicle population

Different vehicle types meeting a diverse range of travel needs provide Land transport in Seychelles. These may be classified as follows:

- Personal transport - bicycles, motorcycles, cars, pick-up trucks as well as minibuses in private company or in government ownerships;
- Passenger transport - taxis, minibuses, public usage, government/company/NGO buses, tour operator buses, pick-up trucks used to transport workers;
- Other - service vehicles such as fire engines, ambulances, mechanical plants, such as mobile cranes, earth movers, etc.

Table 3-6 shows the results of the projection of vehicle population in Seychelles. The projection includes bicycles, however assuming that the present levels continue and that the current control on imports remains. There was a huge growth in cars in the early 1990's due to permits issued to import second-hand cars. This was discontinued in 1998. Therefore, the projection in 2000 may be an under-estimate.

Table 3-6. Projection of vehicle population from 2000 to 2020.

Year	1990	2000	2010	2020
Vehicle Population	6,050	9,921	12,798	18,361

3.3.3 Energy consumption in the road transport sector

Gasoline and gas-oil are the two main fuels used in the road transport sector. The projected fuel consumption for the road transport sector is shown in Table 3-7.

Table 3-7. Projected fuel consumption, in ktoe and tonnes, in the road transport sector from 2000 to 2020.

Year	1990		2000		2010		2020	
Fuel/types	ktoe	tonnes	ktoe	tonnes	ktoe	tonnes	ktoe	tonnes
Gazoline	7.00	6,542.20	10.99	10,271.25	15.10	14,112.46	20.75	19,392.95
Gas oil	6.80	6,355.28	10.25	9,579.65	14.56	13,607.78	20.68	19,327.53
Total	13.68	12,897.48	21.24	19,850.90	26.66	27,720.24	41.43	38,720.48

3.3.4 Emission of GHG in the transport sector

The IPCC Detailed Technology Approach was used to calculate the GHG and the approach is based only on fuel consumption for the overall vehicle population. The Emission Factors used are specific only to fuel consumption. The GHG considered are CO₂, CH₄, CO and NO_x. Table 3-8 shows the projection of GHG emissions in the road transport sector from 2000 to 2010.

Table 3-8. Projection of GHG emissions in the road transport sector from 2000 to 2020.

Year	Total GHG Emission (tonnes)			
	CO ₂	CH ₄	CO	NO _x
1990	41,186.24	9.21	2,202.29	162.73
2000	63,354.59	14.45	3,454.29	252.40
2010	88,511.32	19.85	4,749.89	350.19
2020	123,693.03	27.30	6,532.53	486.01

3.3.5 Technologies and measures for reducing GHG in the transport sector

The mitigation options proposed for this sector are:

To continue to improve the Public Transport System: A reliable and efficient public transport system would attract more passengers and lead to a reduction in the use of private vehicles. Less private vehicles on the road would result in a reduction of fuel consumption in the transport sector and hence the emissions of GHG. Since the formation of the SPTC, the government has undertaken a number of projects and programmes to improve the public transport system. The SPTC will continue with its programme to upgrade its services with the view of attracting more passengers, while the government will continue to upgrade the road network so that a higher percentage of the roads are served with public transport.

Equipping the Highway Patrol Unit with required resources to enforce measures and regulations: There are measures and regulations that already exist to ensure proper flow of traffic, control speeding, parking, movement of mechanical plants, emissions, etc. These measures and regulations can become ineffective if not enforced. A Highway Patrol Unit has been set up within the Land Transport Division and the Unit is being equipped to enforce measures and regulations related to traffic.

If these measures and regulations are properly enforced, it is expected to assist with the reduction of fuel consumption in the transport sector, thereby a reduction in emission of GHG.

Setting up of a second city on Mahe: Presently, there are traffic congestions in Victoria because all government and business activities are centralised within the city centre. People have to travel from all corners of the island to come to town for most activities. If there were decentralisation of some services, this would reduce the distance travelled, and hence the consumption of fuel and emissions of GHG in the transport sector. The government has already initiated the process to build two other cities on the southeast and the west coast. The public are participating through a competition to design these cities.

Light electric rail system for the East Coast / Shifting to sea transport: After the completion of the next phase of the reclamation project, there will be flat land from the Airport to Anse Etoile. The Land Transport Division is looking into the possibility to undertake a feasibility study for the construction of a light electric rail system for public transport on the reclamation along the east coast. This would help to relieve pressure on the road as a result of the ever-increasing number of vehicles. Such mass transport system could contribute to a reduction in energy consumption for public transport and hence the emissions of GHG.

A Traffic Management Plan: The Land Transport Division is developing a traffic management plan that would address problems such as congestion on the road, use of traffic lights, parking space, etc. The government is planning to construct a by-pass around Victoria for vehicles travelling north/south and south/north, because at present all traffic has to pass through the centre of Victoria. The by-pass road will be constructed on the east-coast reclamation.

Driver awareness campaign for efficient use of vehicles: It is widely recognised that the way drivers use their vehicles can significantly affect vehicle fuel consumption and emissions. Information on techniques that could result in improved fuel consumption should be made available to the drivers. This could be implemented through a public awareness campaign to cover the importance of better driving to increase fuel efficiency and improving overall fuel consumption. The Land Transport Division and the Police have ongoing programme for driver's awareness.

3.4 The Industrial Sector

The industrial sector consists mainly of light to medium industries involved in manufacturing and construction activities. The government's policy vis-à-vis industrial development is to keep Seychelles free of heavy industries that may destroy the fragile and pristine environment. Emphasis is placed on light industries aimed at import substitution and the creation of employment.

3.4.1 Projection of energy consumption in the industrial sector

The projection of energy consumption in the industrial sector from 2000 to 2010, in GWh and in ktoe is shown in the Table 3-9 and Table 3-10, respectively.

Table 3-9. Projection of energy consumption in GWh in the industrial sector from 2000 to 2020.

Energy Consumption (Year)	1990	1995	2000	2010	2020
Electricity (GWh)	6.49	8.48	9.65	15.55	25.05
Fuel (ktoe)	1.62	1.77	3.44	6.88	13.76

Table 3-10. Projection of total energy consumption from the industrial sector in ktoe for 2000 to 2020.

Year	1990	1995	2000	2010	2020
Energy Consumption (ktoe)	2.18	2.50	4.27	8.22	15.92

3.4.2 GHG emissions for the industrial sector

The emission of CO₂ from this sector is expected to grow by an average of 5% per year if the “business as usual” scenario is maintained (see Table 3-11). The bulk of this emission would come from the direct use of fossil fuel, especially in the food processing industries.

The other GHG, such as CO, CH₄ and N₂O have not been estimated because of the low amount of fuel consumed in this sector, hence, the emissions of these gases will be very low

Table 3-11. Total CO₂ emissions (in tonnes) from the industrial sector.

YEAR		1990	1995	2000	2010	2020
		Tonnes				
CO₂ Released	Direct	5,102	5,575	10,846	21,685	43,354
	Indirect	5,157	6,738	7,667	12,354	19,906
TOTAL		10,259	12,313	18,513	34,039	63,260

3.4.3 Technologies and measures for reducing GHG Emissions

The proposed mitigation options for this sector are as follows:

Use of renewable energy technologies in hotels and guesthouses: Presently a number of hotels and guesthouses are still using electric water heaters. Some of the larger hotels, however, are using industrial boilers fuelled by gas oil, fuel oil or kerosene to produce hot water. The use of Solar Water Heaters (SWH) in those tourism establishments would contribute significantly to a reduction in the energy consumption and emissions of GHG. The Energy Affairs Division is promoting the use of SWH in hotels and guesthouses. The main constraints regarding the use of SWH have always been associated with the initial investment costs.

Use of more energy efficient and clean technology: Government should set up mechanisms and provide incentives to encourage the use of energy efficient and clean technology in industries. The industries should be kept informed of the availability of such technologies. The use of energy efficient and clean technology would result in a reduction of energy consumption and emissions of GHG. The Energy Affairs Division is undertaking this activity.

Carry out regular energy audits and put in place Energy Management Plan: Energy audits would need to be undertaken within the scope of an energy management plan to ensure efficient use of energy. The implementation of such a plan would result in a reduction of energy consumption and emissions of GHG over a period of time.

Declare Emission Standards: Emissions standards for mobile and stationary sources have been introduced, but the capacity to enforce is still a constraint. Organisations should be given assistance to be able to comply with such standards when introduced. Stack Emission standards are being developed by the Seychelles Bureau of Standard in collaboration with the Division of Environment.

Set up energy education and extension services: The Energy Division should put in place extension services to assist industries with energy-conservation practices. This should be an ongoing activity of the Division.

3.5 Energy Supply Sector

The energy supply system of Seychelles is characterised by the importation of all the petroleum products, which make up not less than 95% of the primary energy supply to the country.

3.5.1 Energy policy

The Seychelles' Energy Policy, put in place in 1999, places particular emphasis on the need to increase security of the energy supply, its availability, the implementation of energy conservation practices, and enhancing the level of energy services.

3.5.2 The Energy infrastructure

The energy infrastructure includes mainly the storage infrastructure for petroleum products and that for the generation and transmission of electricity. The SEPEC operates bulk storage depots at Port Victoria, Ste. Anne, the International Airport and Praslin where it stores gas oil, dual-purpose kerosene/jet fuel, fuel oil, motor gasoline, gas oil and LPG. The total storage capacity is 73,069 tonnes, about 36% of the annual import. Figure 3-1 shows energy consumption by sector in 1996.

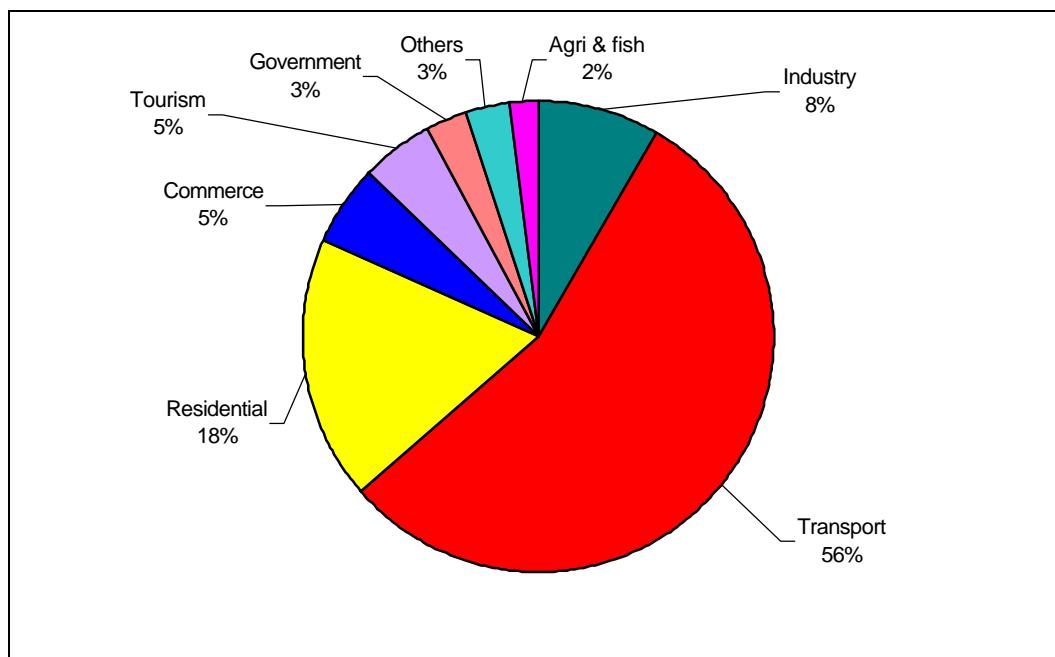


Figure 3-1: Energy consumption as percentage by sector for the year 1996.

3.5.3 The supply of electricity

The Public Utilities Corporation (PUC) is a government parastatal with monopoly for the generation and distribution of electricity on Mahe, Praslin and La Digue.

3.5.4 Generating capacity and statistics

The total generating capacity of PUC on Mahe at the end of 1997 was 35.8 MW and increased to 41.6 MW in mid-1998 when the two new 3 MW generators were installed. On Praslin, there is only one power station at Baie Ste Anne, with a total capacity of 4.18 MW at the end of 1997. This station also supplies La Digue through a sub-marine cable.

3.5.5 Trend and Projection for Public Electricity Generation

There has been an average 6 % annual growth in the generation of electricity. This has required PUC to invest in new generating sets to meet the electricity demand. In 1982, PUC commissioned the first 5 MW- generator set and started using fuel oil.

The annual average growth approach was used to project the gas-oil consumption for Mahe from 1996 to 2003. The new 50 MW power station recently commissioned in 2000, uses fuel oil as its main fuel. On Praslin, PUC will continue to use gas-oil to generate electricity. So the annual average growth rate was used to project the gas-oil consumption for Praslin

3.5.6 GHG emissions from the energy supply sector

Since there is no refinery of crude oil in Seychelles, the only source of greenhouse gas in the energy supply sector is from the combustion of fossil fuel for electricity generation. For the purpose of this GHG mitigation assessment, only the combustion of gas oil and fuel oil has been considered as the most significant sources of GHG emissions. Projection of GHG emissions from public electricity generation for the period 2000 to 2020 is shown in Table 3-12.

Table 3-12. Projection of GHG emissions in tonnes from public electricity generation for the period 2000 to 2020.

Year	CO ₂	CH ₄	CO	NO _x
	Tonnes			
1990	74,159.64	1.06	14.85	100.25
2000	133,949.40	0.55	27.41	122.70
2010	269,069.38	9.00	52.23	527.15
2020	570,227.05	19.08	110.70	1,117.18

3.5.7 Technologies and measures for reducing GHG emissions

Heat recovery from the public electricity generation power stations: In thermal power stations, only about 35% of the energy content of the petroleum product is converted to electrical energy, the rest being dissipated as noise and heat. Waste heat recovery system could be installed to harvest the waste heat, which could then be sold to other industries for other industrial purposes. Heat recovery system will increase the thermal conversion efficiency. According to the IPCC report, an increase in thermal conversion efficiency from 35 to 40% would reduce GHG emission by 12.5%.

Promote the use of renewable energy technologies and energy efficient appliances in the energy end-use sector: Large-scale use of renewable energy technologies and energy efficient appliances in the energy end-use sector will reduce the electricity demand considerably for this sector. This reduction in electricity demand would mean less fuel for electricity generation, resulting in a reduction of emission of GHG from the sector.

Reduction in electricity supply system losses: The system losses amount to nearly 14.72 GWh in 1996. The PUC has been undertaking measures to maintain system losses to a minimum, as this would contribute to reduce the emission of GHG from the electricity supply sector. This is an energy conservation measure that is being put into practice by the PUC.

3.6 Agricultural Sector

In 1995, the effective consuming population of the Seychelles spurred on agricultural development both in the domain of crop and livestock production, which in consequence led to the production of 75.5 tonnes of N₂O and about 205 tonnes of CH₄. In the same manner, with an expected effective consuming population of 101,700 individuals in the year 2010, agricultural undertakings both in crop and livestock production would emit into the atmosphere about 242 tonnes of N₂O and 68 tonnes of CH₄. By 2020 the country would have a projected effective consuming population of 112,000 individuals. Agricultural production both in crop and livestock would then lead to the emission of about 253 tonnes of N₂O and 56 tonnes of CH₄.

The principal source of CH₄ is from enteric fermentation in livestock. As a consequence of the reduction in the availability of forage there is a projected reduction in the cattle population over the given time period (i.e. from 4,460 heads in 1995 to about 1,000 heads in 2020, Table 3-13) resulting in a reduction of CH₄ emission level. The principal source of N₂O is from cultivated and fertilised agricultural soils the area of which is expected to increase from 200 hectares in 1995 to 460 hectares in 2020 (Table 3-14). This will be the most significant greenhouse gas emission in Seychelles. Even with significant increases in poultry and pig population, the subsequent increase in manure production will not enhance GHG emissions. This is because manure management stipulates that cow manure is allowed to rot in the open before being applied to the soil, while pig manure is collected in slurry tanks and regularly (weekly) disposed of as a slurry spray onto agricultural crops.

The depicted pattern of agricultural production relates to the present policy of the sector, which stipulates progressive enhancement of food security. Soil nutrient management for effective and economic fertiliser use, and farmers' awareness programmes are possible mitigation options for the reduction of emission of N₂O over time.

Table 3-13. Projection of methane (CH₄) emission in tonnes from enteric fermentation in domestic livestock from 2000 to 2020.

Year	Cattle population (heads)	CH ₄ Emission (tonnes)	Pig population	CH ₄ Emissions (tonnes)
1995	4460	196.24	8900	8.90
2000	1400	61.60	6250	6.25
2010	1200	52.80	10640	10.64
2020	1000	44.00	11700	11.70

Table 3-14. Projection of nitrous oxide (N₂O) emissions in tonnes from agricultural soils from 2000 to 2020.

Year	Soil organic matter input (tonnes)	Soil inorganic fertiliser input (tonnes)	Cultivated land (hectares)	Total nitrogen input (tonnes)	Nitrous oxide (N ₂ O) emission (tonnes)
1995	20,823	158	243	20,981	75.5316
2000	43,600	200	200	43,800	157.6800
2010	66,900	250	350	67,150	241.7400
2020	69,875	300	460	70,175	252.6300

3.6.1 Technologies and measures for reducing GHG emissions

It has become apparent that existing technologies for reducing GHG, especially in open piled manure accumulations, are no longer efficient and consequently there would be limited developments to enhance the efficiency of such technologies. With a reduced cattle population over the years, GHG emission from enteric fermentation would not be significant.

The mitigation measures are:

Soil Nutrient Management: Soil fertility management would allow proper fertilizer use avoiding excesses of any nutrient, especially nitrogen, which produces products like nitrous oxide.

Awareness Programme : Regular broadcast of short video clips on various topics in agriculture highlighting the necessity for the implementation of correct cultural practices would help curb GHG emissions.

3.7 The Forest and Land Use Sector

3.7.1 Forest distribution

Reports dating back to the late 18th Century, prior to the establishment of permanent settlements on the major granitic islands of the Seychelles, suggest that the granitic islands of the Seychelles were covered with thick, almost impenetrable evergreen forests, comprising of tall trees with large trunks. On Praslin certain areas are now completely void of any vegetation for several years following occasional forest fires. The coral islands have their own peculiar vegetation types and consist mostly of low tree forests.

The forest ecosystems on these granitic islands can be classified as follows:

- Lowland forests 0-300m above sea level;
- Intermediate forests 300-550m above sea level;

- Mountain mist forest 550-910m above sea level;

Parts of the forests have been highly invaded by species like cinnamon (*Cinnamomum zeylanicum*), albizia (*Albizia falcata*) and creepers. The original lowland forests have vanished and have given way to various infrastructure developments at that altitude. On the larger granitic islands mangrove swamps along the coast have been mostly replaced by human habitat, compared to the outlying coral islands where they are still found in abundance. Table 3-15 presents the area of the distribution of forests on some of the major granitic islands of the Seychelles.

Table 3-15. Forest area (hectares) of the Seychelles.

Island	Total Area	Forest Area	Of which in National Parks	Plantations
Hectares				
Mahe	15,470	11,740	2 980	410
Praslin	3,760	2 970	330	50
Curieuse	290	290	290	20
La Digue	1,010	760	30	0
Silhouette	2,000	1,840	0	0
Others	23,010	23,000	14, 810	4,400
Total	45,540	40,600	18,440	4,880

(Source: Indufor, 1993)

3.7.2 Forest management practices

Conservation of Bio-diversity can be achieved as follows: Integrated management of biodiversity zones; Propagation of endemic trees and ex-situ conservation.

Conservation of Soil and Water Resources can be achieved through: Integrated Management of Catchment Zones; Protection of River Reserves.

Production of Forests Products can be done through: Management of Production Zones; Management of Trees Outside Forests.

3.7.3 Forest policy of the Seychelles

The Forest Policy of the Seychelles stems from environmental policy as expressed in the Environmental Management Plan of the Seychelles (EMPS 1990-2000), as well as from other international conventions, which Seychelles has assented to, and these would include:

- The Convention on Biodiversity;
- The Framework Convention on Climate Change;
- The Chapter 11 of the Agenda 21 of UNCED on deforestation;
- The Forest Principles of UNCED.

In the same manner, the Forest Policy of the Seychelles is also influenced by other international agreements having a bearing on forest management. These would include:

- The Convention on International Trade in Endangered Species (CITES);
- The International Plant Protection Convention;
- The General Agreement on Tariffs and Trade (GATT).

The Forest Policy statement of the Seychelles would embody the basic principles, broad objectives, main forest functions and priorities as well as strategies for forestry development in the Seychelles.

3.7.4 Projection for CO₂ removal

The 8,000 m³ of biomass harvest per year until year 2020 represents an emission of 12,540 tonnes of CO₂. It is expected that the removal capacity will remain fairly constant at around 845,000 tonnes of CO₂ till 2020. However, there is the possibility of a small decrease over this period.

3.7.5 Technologies for maintaining CO₂ removal capacity

The options listed below are for maintaining the CO₂ removal capacity at the 1990 level.

Controlling of deforestation: There are regulations in place and mechanisms have been set up to control deforestation. Endemic species, as well as certain other wild vegetation are being protected. About 45 % of the forest areas are protected within national parks. However, to ensure effective implementation of these regulations through the mechanisms that have been set up, extra resources are required.

Protecting/managing forests in reserves and protected areas: A total of 18,440 hectares of forest are either national parks or some other nature reserves. This represents 45 % of the total forest area or 40 % of the total land area. This balance should be maintained and if possible increased to cover other forest areas.

Controlling commercial biomass harvest: The Forestry Section of the Division of Environment has set the annual allowable cut at 8,000 m³, based on past surveys. Since most of the trees that are commercially exploited are covered under regulations, permission must be obtained from the Forestry Section before felling. Through this mechanism, the Division is able to ensure that the annual allowable cut is respected. This annual allowable cut should be maintained and ensure that there is no over exploitation.

Controlling residential housing projects: The Division of Environment is represented on the Planning Authority and therefore influences all residential housing projects to ensure that environmental regulations are being followed. There are existing regulations that limit construction up to only 200 metres above mean-sea-

level. Moreover, due to the steep gradient of available land, it is very difficult and costly to build houses on higher ground. Furthermore, the high cost for the provision of essential services, such as roads, water supply, electricity and communications, have forced the government to establish some residential areas on land reclaimed from the sea. To a certain extent this will limit encroachment on forest areas.

Controlling forest fires: There already exists a Forest Fire Contingency Plan, which focuses on three main issues: fire prevention, fire vigilance, and fire fighting. It is estimated that more than 90 % of forest fires are caused by man, either due to careless use of fire, or sometimes even intentionally. During the dry season, there is stringent control on burning of charcoal, garbage or debris. The Division of Environment organises regular public awareness campaigns on causes and effects of forest fires with the view to reduce fire incidences, and there are steps being undertaken to set up continuous fire vigilance in the more fire prone areas. Even though the fire fighting crews are also being trained and equipped for efficient fire fighting, the Division of Environment needs the necessary resources to ensure effective implementation of the Forest Fire Contingency Plan

Reclamation of the sea: The present and future demand of land for residential housing projects could lead to encroachment on forest areas. Having recognised the possible adverse effects on the environment, the government have opted to reclamation projects, even though there is a high capital investment cost. Some of the reclaimed land will be used for residential housing projects. Implementation of reclamation projects necessitates significant external resources. The impact on the marine environment needs to be carefully evaluated though, especially on globally stressed ecosystems such as coral reefs.

Enforcement of existing regulations: The Division of Environment could be better equipped both in term of human resources and equipment, to enforce existing regulations for forest management and conservation. There is also a need to review all existing regulations for more effective forest management.

Controlling outbreak of pests and invasive species: The Plant Protection Section of the Ministry of Agriculture and Marine Resources provides technical support for the control of plant pests and diseases. However, with certain cases as the latest outbreak of the Takamaka tree disease, the Division of Environment had to seek expert services from foreign sources.

3.8 Solid Waste and Wastewater Treatment

Methane (CH₄) is emitted during the anaerobic decomposition of the organic content of solid waste in landfill, and in wastewater treatment plants. There are large uncertainties in emissions estimates due to the lack of information about waste management practices, the portion of organic wastes that decomposes anaerobically, and the extent to which these wastes will ultimately decomposed.

The Solid Waste Agency (SWAC) has the mandate for solid waste collection and disposal. A private company, STAR, has been contracted for the collection and

disposal, and for the management of the landfills. There is only one landfill on Mahe, situated at Providence. This landfill has now reached its maximum capacity and will soon be closed. A new landfill will be opened at Anse Royale to cater for the disposal of solid waste on Mahe. There is a small landfill on both Praslin and La Digue.

The main source of emission of CH₄ from wastewater treatment plants is from large hotels, which were meant to be operating aerobic wastewater treatment plants, but at times, due to improper maintenance, some of them tend to function as anaerobic plants.

3.8.1 Ongoing activities

Since the economy of Seychelles depends a lot on the environment, the Division of Environment has been very active to ensure that solid waste is properly disposed of. There has been an increase in the number of bins available for public use and also most of the housing estates have access to bins. Public awareness campaign to encourage the people to use bins for their solid waste disposal have been an ongoing activity to keep Seychelles clean as a tourist destination and to avoid breeding of pests, such as mosquitoes and rats. This, coupled with positive public response, has resulted in an increase in the amount of solid waste collected and going to the landfills, resulting in an increase in methane emission

The Pollution Control Unit of the Division of Environment has a regular programme to monitor the performance of wastewater treatment plants and to ensure compliance to the requirements for discharge of effluents into the environment as per the Environment Protection Act.

3.8.2 Emission of Methane

The 1995 CH₄ emission was estimated at 2,350 tonnes, of which, 2,080 tonnes were from landfills and 270 tonnes from wastewater treatment plants. The value for landfill was based on an estimate of 70 tonnes of solid waste per day, based on the national reporting on the inventory (see chapter 2). Moreover, the data from STAR, as measured from June 1998, now indicate that the figure is only 30 tonnes per day. So the emissions of CH₄ from landfills should then be about 1,000 tonnes per year.

3.8.3 Technologies for reducing GHG emissions

The mitigation options proposed for this sector are as follows:

Recycling and composting of solid waste: The STAR Company, which is responsible for the collection and disposal of solid wastes in Seychelles, has plan to set up a waste re-cycling and composting plant. Once the plant is set up, this will further reduce the emission of CH₄ from landfill as a result of the expected reduction of solid waste going into landfill. SWAC is also encouraging households to establish

composting pit for their domestic organic wastes. It is to be noted that a lot of projects for the School Science Fair cover recycling of both household and industrial wastes. There should be incentives and mechanisms set up to encourage small businesses to set up waste re-cycling and composting plants.

Aerobic treatment of wastewater: CH₄ emissions can be virtually eliminated if wastewater and sludge are stored and treated under aerobic conditions. Therefore, wastewater treatment plants should be properly designed and maintained to operate under aerobic conditions. The Division of Environment should continue to monitor the performance of the wastewater treatment plants to ensure that such plants are operating as aerobic plants.

3.9 Mitigation Options Implemented

In line with the long and short-term energy policies of Seychelles, the government has already implemented a number of measures to reduce energy consumption, especially in the transport sector. At the same time, the government has continued to provide financial assistance to improve and upgrade the public transport system. The mitigation options already implemented in the various sectors are listed below.

3.9.1 Residential, commercial and institutional buildings

- Zero tax on energy efficient appliances such as CFL, LPG stove, SWH, etc;
- Awareness campaign for efficient use of energy;
- Promoting the use of LPG for domestic cooking;
- Promoting the use of renewable energy technologies.

3.9.2 Transport sector

- High import taxes on vehicles;
- Ban on import of second-hand, often inefficient vehicles;
- High cost of fuel;
- Road taxes for all vehicles;
- Regulations for emission control;
- Mandatory test for emission control;
- Improvement of the public transport systems;
- Use of traffic lights in Victoria;
- Control on movement of mechanical plants;
- Pay parking in City centre;
- Road improvement programme.

3.9.3 Energy supply sector

- Tariff structure that discourages the excessive use of electrical energy.

3.9.4 Forestry and land-use sector

Since the government has adopted a strong conservationist policy, there are already a number of projects which have been implemented, such as:

- Forest management and conservation programmes;
- Reclamation of land from the sea.

4 VULNERABILITY, IMPACT AND ADAPTATION OPTIONS

4.1 Introduction

The IPCC Second Assessment Report (IPCC, 1996a) defines **vulnerability** as the extent to which climate change may damage or harm a system. It depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions.

Impact, which will depend on sensitivity, is defined as the degree to which the system will respond to a change in climatic conditions (e.g. the extent of change in ecosystem composition, structure and functioning, including primary productivity, resulting from a given change in temperature or precipitation).

Adaptation refers to the degree to which adjustments are possible in practice, processes or structures of systems, to projected or actual changes in climate. Adaptation can be spontaneous or planned and can be carried out in response to or in anticipation of changes in conditions.

A study was undertaken by an expert team to address the vulnerability of the Seychelles islands to climate change (Payet, 1998). Unless stated or referenced otherwise, all information in this chapter is derived from this study. The vulnerability assessment, which accounts for the extent to which climate change may damage or harm the Seychelles environment and its people, is based on available past historical information and an analysis of the sensitivity of current systems to climate change.

The following key socio-economic sectors were addressed in terms of sensitivity and vulnerability: natural habitats and biodiversity; the coastal zone and human settlements; agriculture; water resources; fisheries; human health; natural disasters and tourism.

For a small island state like Seychelles, adaptation to climate change needs to be guided initially by a thorough and comprehensive quantitative assessment, followed by an informed policy framework, which allows for the implementation of cost-effective measures. The successful implementation of adaptation strategies will depend on the availability of financial resources, technical and institutional capacity, technology transfer, and integrated planning and management. Incorporating climate change concerns into resource-use, land use, development, and decisions and plans for regularly scheduled investments in infrastructure are a prerequisite for effective adaptation.

As future climate extends beyond the boundaries of empirical knowledge (i.e. the documented impacts of climate variation in the past), it becomes more likely that the actual outcomes will include surprises and unanticipated rapid changes. Enhanced support for research, observational networks, monitoring and modelling, including cooperative efforts from national, regional, international and multi-lateral institutions, is essential in order to significantly improve the regional scale climate projections; understand the responses of human health, ecological and socio-economic systems to changes in climate and other stress factors; and improve our understanding of the efficacy and cost-effectiveness of adaptation strategies (IPCC, 1996a).

The lack of adequate climatic and oceanographic forecasting systems, disaster management infrastructure, as well as friable ecosystems and populated coastal areas contribute to vulnerability to the impacts of climate change. For example, in Seychelles, the 1997-1998 ENSO episode left behind a solid memory of floods, loss of business, high infrastructure repair costs, the indirect impact of coral bleaching (during El Niño) and the economic impacts of drought (during La Nina episode) (Payet, 2000).

Although there have been various in-depth sectoral studies, they all reveal significant gaps and uncertainty in our knowledge of the magnitude of the impacts and the extent to which adaptation options can be implemented. It is envisaged that this first study will lay the foundation for a more focused and integrated approach and attract the attention of both policy-makers and financial institutions. The issues at stake are not only financial but also revolve around complex issues such as planning, technology transfer, capacity building, management approaches and long-term visioning. However, in view of the emerging threats of climate change, the need for support to meet adaptation cost becomes an absolute priority and necessity.

The adaptation strategies evolved out of several sources and workshops involving key experts and stakeholders. An extensive survey of published literature outside of Seychelles was also conducted so as to appreciate what are being done elsewhere and the constraints associated with implementing adaptation options.

In this chapter, adaptation strategies proposed for each sector have taken into consideration the particular specificity of the islands, and also the fact that almost half of the islands are granitic, and the other half are of coral origin. The vast expanse of the ocean and the small areas of the islands have a dramatic influence on the choice of adaptation options identified within each sector. The aim of identifying adaptation options is, therefore, to encourage further thought and research to develop effective mechanisms for solutions to the predicted impact of climate change. In fact strengthening adaptive capacity through monitoring, planning, technology transfer, institutional strengthening, information exchange and financial support may pave the way for effective implementation of many future adaptation actions that may come out of the current UNFCCC negotiation process (Payet, 2000).

4.2 Natural Habitats And Biodiversity

4.2.1 Sensitivities and impacts

Protected natural areas in Seychelles constitute a total land area of 19,760 hectares (ha), i.e. about 43% of Seychelles' total land area, as well as some additional 23,000 ha of surrounding reefs and marine areas. Consequently, Seychelles has one of the largest proportions of protected conservation areas in the world, in relation to its surface area and per capita. A number of legislations protect habitats, national parks, marine protected areas, and individual species such as endemic land birds, sea-birds, marine turtles, at least 25 species of trees, shells, marine mammals, pond terrapins and giant tortoises.

The oldest islands of the Seychelles complex have a biota of mixed origins. Regarding plants, the fern flora is largely oriental in its origin, and the original dominant forest trees of the granitic islands have also oriental affinities. Of the species of indigenous flowering plants recognized, 54% are Tropicopolitan, 13% are Ethiopian/Mascarene, 18% are Oriental/Mascarene, and 15% are Mascarene in their affinities. Of the species endemic to the granitic islands, 34% are Oriental, 11% are Ethiopian, 36% Mascarene, and 19% of various origins. Based on insect affinities, it has been considered that the granitic Seychelles is a sub-region of the oriental region (Shah, 1998).

Given the relative youth of the raised reef islands and the cycles of emergence and submergence to which they were subjected, it is logical that the biota of these islands would be of recent origin from nearby source areas. Lying in the southwestern portion of the Seychelles Archipelago, the raised reef islands are expected to have a strong Ethiopian/Madagascar influence on their flora and fauna, and such is the case (Braithwaite 1984).

Several coastal tree species have adapted to the often-harsh marine conditions, and they serve as primary barriers to the increasing threat of shoreline decline and erosion. Furthermore, changes along the shore due to human development and encroachment have reduced the beach crest vegetation to scattered semi-natural stands or a narrow line of trees. The reefs serve as a natural wave breaker and the calm of the lagoons contrasts with the energetic environment in areas where reefs are absent. Apart from acting as a wave breaker, one of the important contributions of coral reefs is the long-term natural supply of coral sand (Ominde *et al.* 1991), which nourishes the beaches of the Seychelles.

Large mangrove swamps are absent from the non-atoll coralline islands. Aldabra, Cosmoledo and Astove are the only important mangrove localities, where sheltered lagoons provide habitat. On Aldabra, where mangroves occupy a total land area of 800 ha, one will find large colonies of various species of sea birds, in particular boobies and frigate birds (Stoddart, 1984).

There are approximately 36 km of sandy shores on Mahe, 21 km on Praslin and 8 km on La Digue. With regards to vegetation, the Seychelles sandy coasts are more like those of the Pacific islands than those of the shores of the East African coasts. Marine fauna such as turtles and sea birds use sandy shores as nesting sites. Several islands of the Seychelles archipelago are nesting sites for migratory sea birds. There are still different predictions from various experts concerning the impacts of global warming on migratory birds. Some believe that migratory birds may, in general, expand their ranges, and breeding success may increase owing to warmer temperatures. Other researchers, however, suspect that the impact on bird population could be calamitous, as finely calibrated hatching and nurturing patterns may no longer be synchronized. Disruption of feeding patterns could affect the young generations.

Dune ecosystems are also very important to many species of birds and other animals as nesting and foraging areas. During the nesting season, which occurs in the dry season, the sandy soil is barren as a result of sea birds trampling and guano deposition. But during the wet season, when the birds are not nesting, a dense mat of

annual and seasonal herbs develops. Sea-level rise can modify those dunes and it could be detrimental to important nesting sites, especially for threatened species such as the green turtle.

Much of the biodiversity seen in the open ocean of the Seychelles EEZ are pelagic organisms, with discoveries of new species still occurring. The ocean around the Seychelles is the realm for over one thousand fish species, and countless other marine invertebrates and microorganisms.

Coral reefs represent one of the most important natural resources for many tropical islands. They are a source of biodiversity, food, beach sand, building materials, and function as natural breakwaters along the coast. They also provide habitats for many marine mammals, reef fishes, and generate significant revenues through tourism (e.g. snorkelling and scuba-diving). Owing to their narrow temperature and salinity tolerances, some species currently live at or near their thermal limits (Goreau 1992; IPCC, 1998). There is now substantial evidence which indicates that “episodic” warming of the ocean surface, as occurred in El Niño years, led to significant coral bleaching (Goreau, 1992; Brown and Ogden, 1993; Wilkinson and Buddenmeier, 1994; Brown, 1997). The major coral bleaching episodes in the past 20 years were found to be associated with periods of increased ocean temperature of 1°C (Hoegh-Guldberg, 1999). Bleaching was particularly severe and widespread during the most recent 1997-98 El Niño; considered to be perhaps the most intense event on record (Goreau, 1999). There was also extensive bleaching of the coral reefs in Seychelles, the extent of which is still being investigated.

The latest concern by the scientific community is the impact of increasing CO₂ concentrations in the oceans. It has now been suggested that the ability of reef plants and animals to make the limestone skeletons that build the reef is being reduced by rising atmospheric carbon dioxide concentrations (Pittock, 1999). It has been projected that a doubling of CO₂ by 2065 would reduce calcification by approximately 17% and to 35% by 2100 (IPCC, 1998).

The conclusion from previous IPCC assessment reports was that the threat of sea-level rise (SLR) to reefs (as opposed to reef islands) is negligible. This was based on projected rates of global SLR of the order of 2-9 mm year⁻¹ over the next 100 years (Warwick *et al.*, 1996) and the assumption that healthy reef flats would be able to keep pace with that rise, given an approximate upper limit of vertical reef growth of 10mm year⁻¹ during the Holocene (Schlager, 1999). However, the prognosis is far less positive in many small island states (e.g. those located in the Caribbean and the Indian Ocean), where reef structures have been weakened by a variety of anthropogenic stresses (Zann, 1994).

A further variation is foreseen in the case of high islands surrounded by fringing reefs. More intense precipitation and flood conditions on the high islands, such as Mahe and Praslin would create more sediment in the form of soil and sand, which would be deposited in the lagoons thus contributing to further deterioration of fringing reefs already under stress through various human activities. Consequently, the fringing reefs will be further stressed, with consequential effects of further wave action and impact of erosive forces on the coastal areas.

When the first settlers arrived on Mahe in 1772, it was reported that mangrove fringed most of the east coast, but this has been almost completely wiped out as a result of coastal development. They are usually found in abundance close to river mouths and marshlands. However, on the Mahe east coast, colonies of mangroves are re-establishing in the lagoon areas created by coastal reclaimed land (Payet, 1998). Various species of sea birds, in particular boobies, are associated in large colonies in mangrove areas on Aldabra.

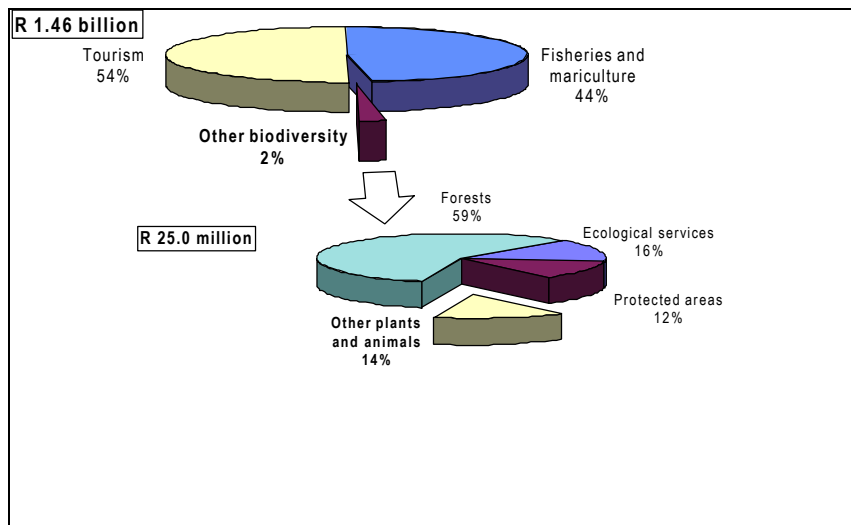
Existing mangrove areas show a zonation typical of western Indo-Pacific region. The general features of the mangrove assemblage in Seychelles are low species diversity, high species abundance and the preponderance of a few species of herbivorous gastropods and bivalves (Shah, 1998).

The mangrove systems are a vital part of the land/sea interface and are the breeding grounds for prawns and small fish. The propagation of mangroves also consolidates sedimentary coasts and acts as a natural barrier to erosion. With a slow rate of rising sea level, the mangrove systems have the possibility of migrating inland, but in the dense utilization patterns of these islands for development purposes, there may not be room to accommodate them. There are real risks that hyper-salinity may affect the growth of mangroves, and this, in turn would affect the marine life that depends on them for their breeding grounds. The lagoons abound in marine resources, and it is quite likely that the cumulative effects of sea-level rise, salt-water-intrusion, occurrence in storms and swells as well as increased sedimentation will have negative effects upon those resources.

Trees reaching up to 20-25 m, with a circumference of 4-5 m and with very straight trunks formerly dominated the coastal plains of Seychelles. Even though the lowland flora was partly endemic, it is clear that endemic species were more prominent at the higher elevation. Following human settlement, most of the coastal and lowland forests on the granitic islands were developed for agriculture. Forests at 200 to 500 m altitude have numerous endemic species and with a high canopy occasionally reaching up to 30-40 m, although a number of introduced and invasive species thrive (Carlstrom, 1998).

Biodiversity provides multiple economic benefits to the Seychelles. The major sectors of the economy, which are agriculture, fisheries, forestry and tourism, depend on the raw materials provided from biological resources. Human and industrial production and consumption also indirectly rely on the ecological services that they provide as a sink for wastes and residues.

Figure 4-1 summarises the contribution of biodiversity resources to the Seychelles economy. Economic activities impact on the biological resource base and through their own means of production use up renewable and non-renewable natural resources and convert them into other forms (e.g. fisheries, agriculture, construction and land reclamation activities). If the biodiversity is conserved it will continue to provide economic benefits. If it is destroyed or environmental quality declines, such goods and services will progressively decrease and the Seychelles' economy will suffer.



(Source: Shah et al., 1997)

Figure 4-1 Summary of quantified biodiversity values in Seychelles Rupees (SR)

4.2.2 Adaptation strategies and constraints

It is difficult to determine the vulnerability of specific types of ecosystems to climate. Because of the barrier provided by the surrounding oceans, the high ratio of endemism, and small and fragmented habitats put some ecosystem at great risk. Adaptation will vary according to the systems to which they occur and the climatic stimuli that prompt them as well as the timing, functions, form and effects. In unmanaged natural systems adaptation is autonomous and reactive, and is the process by which species and species respond to changed conditions.

a. Provide Natural Migration Corridors: In Seychelles, rare localised species, some of which are very few in number, would be extinct unless facilitated migration or human intervention is successful. The problem is even greater where such habitats are on small islands and the opportunity to provide natural migration corridors are not possible. One requires habitat assessments and research to determine survivability of rare species in another environment.

b. Establishment of Reserves, Protected and Conservation Managed Areas: The establishment of additional reserves and conservation of managed areas should continue, especially in areas not yet encroached by human activities, including those requiring rehabilitation. Strengthening in terms of research, management and monitoring of existing areas so as to adapt to climate change is equally important. All stakeholders should be involved in the conservation of unique habitats so as to take up planning, research and stewardship roles. Capacity to manage these sites is required.

c. Reforestation Areas: Such areas, especially abandoned plantations, in the inner islands, cover approximately 900 ha. About 25% have been established for protection

purposes with the remaining 75% for production. The Forestry Section has not yet fully met its annual target of 100ha established in the 1989 National Development Plan.

d. Restoration, Re-creation of Natural Favourable Habitats: This approach is exceedingly difficult, costly and often with a very low rate of success. Several problems are anticipated including: (i) species that may not establish a viable population required for long-term survival; (ii) if successful they would impact on habitats of other species already under stress from climate change; (iii) low success rate in relocating endemic species, unless habitat conditions are appropriate.

e. Wetland Conservation and Restoration: Wetlands are important ecological habitats, and would probably be one of the first land-based systems to be affected by climate change. Very poorly studied, they are often not managed as fragile ecosystems. Several adaptation options could be considered for minimizing potential losses from accelerated sea-level rise. These options require the concerted efforts of coastal planners, developers and all other stakeholders.

f. Coral Reef Conservation and Restoration: The years 1997 and 1998, with a rise of just about one degree Celsius in sea-surface temperature, signalled some critical impacts linked to coastal climate change in coastal marine landscapes. In Seychelles, significant bleaching resulted in a reduction in fish availability (at this stage not quantified), and consequently affected the local economy, which is very dependent on the fishing industry. Although there are no immediate adaptation options, it is very important to consider conservation of unaffected habitats, and commence restoration of damaged reefs. Over thousands of years corals have successfully adapted genetically to various thermal and climatic regimes. Following extensive bleaching during the 1997-1998 El Niño episode, several species have shown signs of recovery, and there is evidence of thermal adaptation and tolerance in certain species. However, one cannot conclude that reefs will recover and regain the same species diversity, as a consequence of global warming due to anthropogenic emissions of greenhouse gas. Adaptation strategy should focus on protection of coral reefs through better-integrated coastal zone management policies.

g. Genetic Adaptation: Rates of global warming may likely exceed the rates of adaptation in some plant and animal species. Low genetic variability in endemic populations, as is characteristic of those in Seychelles, will likely make such species less genetically fit to adapt. Lack of natural migration corridors may also increase the vulnerability of such species to changes in precipitation and temperature. Consequently, genetic adaptation may be the only route to many species' long-term survival. In spite of their potential relevance, micro-evolutionary responses have been neglected in detecting biological consequences of climate change at both the local and global level. Most studies assume that worldwide climate change will lead primarily to shifts in species' geographic boundaries, and have correspondingly focused on tracking population movements at species borders, with little or no interest in genetic analyses.

4.3 The Coastal Zone and Human Settlements

4.3.1 Issues and impacts

Vulnerability assessment may be a starting point for Coastal Zone Management Planning (CZMP). Vulnerability profiles were established by considering three sets of main components: (1) sea level rise and accompanying impacts; (2) Coastal development scenarios; (3) management response strategies.

The preparation of an assessment which analyses vulnerability sets the agenda for efforts to be undertaken to prevent disasters, minimize the risk and manage the consequences. In the context of coastal zone, it should provide an indication if, and to what degree, conditions for sustainable development are adversely affected by the impact of sea level rise (IPCC, 1992).

The main granitic islands of Seychelles are characterised by a narrow coastal plain, flanked by steep mountains. Consequently, most development has been focused on that small coastal strip to accommodate growing socio-economic activities. Coastal settlements accommodate almost 90% of the population, and are concentrated in the areas where competition for space is acute and where fragile ecosystems, both aquatic and terrestrial coexist. Land reclamation, which is barely a few metres above mean sea level, has become an inevitable practice in order to accommodate important infrastructure such as roads, airports and port facilities, to keep pace with socio-economic development. It must be noted that the coastal zone is most at risk to extreme events such as storm surges, flooding and sea level rise against which human interference is futile (Gillie, 1997).

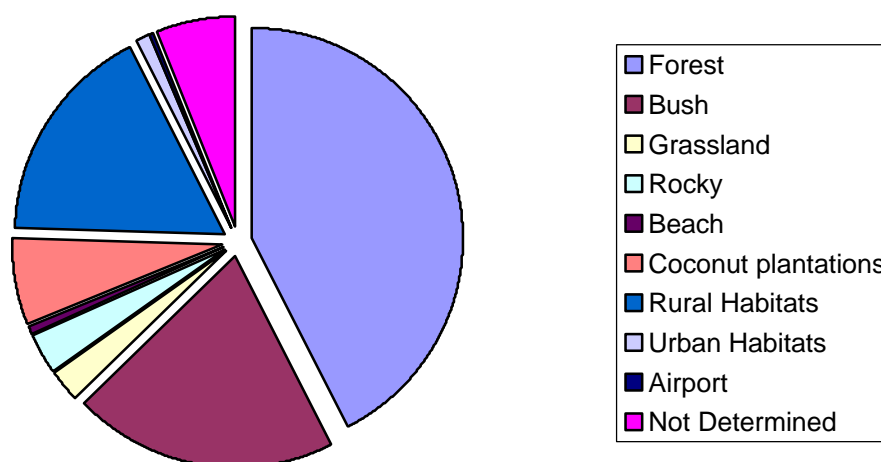
Most of the coastal development has been made in the past without taking into consideration sea-level rise and the possibility of any increase in the frequency and intensity of extreme natural events such as tropical cyclones, flooding and storm surges. Critical infrastructure such as airports, port facilities, roads, coastal protection walls, and bridges will be highly vulnerable to expected sea-level rise and extreme events. This would be quite disruptive to several types of economic, social and cultural activities. Seychelles has taken a proactive approach by elevating the East Coast reclamation by an additional 70 cm to allow for sea-level rise and/or anticipated subsidence (Payet, 1998). An attempt to show the degree of resilience associated with socio-economic development is shown in Table 4-1.

Table 4-1: The Degree of Resilience associated with socio-economic Development

<u>Social Development Sector</u>	<u>1977</u>	<u>1994</u>	<u>Resilience factors</u>
Coastal Population (100%)	~61,998	~74,331	Very High risk
Households	~12,664	17,107	Very high risk
Household Size	4.9	4.3	No direct risk
Housing Stock	12,315	16,808	Moderate risk to extreme events
Block/stone	39%	67%	
Wood/leaves	61%	33%	High risk to extreme events
Treated water Supply	47%	82%	High Health Risk
Electricity Supply	43%	90%	
Sanitation			High Health risk
Flush Toilets	33%	78%	
Pit Latrines	62%	16%	
Vehicle ownership	15%	21%	Increased emission
Telecommunication		41%	Moderate risk
Television		71%	
Radio	90%	92%	Extensive media coverage
Employment (Labour force)	25,947	34,935	Moderate risk
Full Employment	90%	87%	
Seeking Jobs	10%	13%	High risk
Economically Inactive	62%	53%	High Risk
Education: Literacy		82.5%	Low Risk
Student: Teacher		1:14	
Health: Life Expectancy		68 M/75 F	Low Risk

(Sources: Payet, 1998 ; MISD., 1995)

The range of complex sensitivities associated with shoreline change and erosion indicates a highly negative influence of human-derived impacts on the coastal systems, which increases the sensitivity of the system to climate change. The adaptability of the coastal system is limited by the fact that there are severe stresses of anthropogenic origin at play. For example, beaches and sand dunes are in dynamic equilibrium with the rest of the coast. If there is sand removal in one area, future storm events will not be adequately contained by the coastal system due to the instability caused by this activity. Similarly, houses constructed on the steep hill slopes will become more vulnerable as people indiscriminately block streams for construction, and interrupt the flow of water with improper drainage. Mechanisms to address such anthropogenic impacts on the coastal zone will decrease vulnerability to climate change in the long term (Cazes-Duvat, 1998). Figure 4-3 shows current land use on Mahe as estimated by satellite remote sensing methods.



(Source: Payet, 1998)

Figure 4-3: Land use on Mahe as determined by satellite imagery

At this there are no quantitative studies undertaken to determine the impact and cost of sea-level rise. However, a rise in sea -level will most probably affect Seychelles in the following manner:

- Destruction to property and infrastructure located on the coastal plains and reclaimed land;
- Inundate potential agricultural areas and displace wetlands and the coastal plains;
- Cause shift in human habitats, with further encroachment into the tropical mist forest;
- Cause the several low-lying islands, especially the sand cays to disappear;
- Enhance coastal flooding, initially, when there is a thunderstorm or heavy showers and abnormal high tides;
- Erode shorelines and tourist beaches;
- Threaten water resources quantity and quality, especially the ground water aquifers and coral island fresh water lens.
- Increase salinity of mangrove swamps and raise ground-water level, affecting plant growth;
- Threaten availability of potable water from groundwater aquifers;
- Alter tidal ranges in the rivers and bays;
- Alter sediment deposition patterns;
- Reduce light penetration required by coral reefs to survive.

4.3.2 Adaptation strategies

Whether a nation should plan for a low, medium, or high scenario depends on the relative costs of over- or under-protecting. For incremental responses like beach nourishment, the best estimate may be the most appropriate with respect to flexibility

and the lifetime of this measure. In the case of construction with long lifetimes, however, the cost of overprotecting may be small compared to the cost of underprotecting. Hence, the most logical response is to plan for a relatively high scenario, even though it is improbable. Land-use planning offers numerous cases of low-cost solutions or low-cost extension of solutions that would be implemented anyway (IPCC, 1992).

Virtually all of the possible responses to sea level rise are best implemented within a broader coastal zone planning and management context. If carried forward in isolation, policies or actions taken by other coastal sectors could reduce the effectiveness of those responses. Thus, planning for sea level rise should be integrated with coastal zone management practices, weighing alternatives and balancing the diverse and often competing interests within the coastal zone (IPCC, 1992).

A coastal zone management programme is an important pro-active tool for implementing measures to reduce vulnerability to sea level rise. Having the capacity to make decisions and manage coastal resources through integrated resource management planning, would in itself constitute a strong response option toward addressing the consequences of sea level rise.

a. Planned Retreat Strategies: Planned retreat strategies place emphasis on the planning authority to demarcate land that would be impacted on or inundated as a result of sea level rise, and restricting development in those areas. Areas with high risk of flooding or coastal erosion could be utilised for semi-permanent purposes, and other critical infrastructure such as roads, hotels and houses be re-located further inland.

- Delineating buffer areas: Locating tourism infrastructure beyond a buffer line has its costs and constraints especially with the scarcity of coastal land, but it provides the best long-term security on investments.
- Phase-out development: Reclamation projects should be designed to mitigate the effects of sea-level rise.
- Relocation: A major programme to relocate major roads away from the coast is under consideration as a result of rising costs of repairs and maintenance of coastal roads damaged by severe storms and sea level changes.
- Regulating Population Migration: Effective coastal- zone management and land-use regulation can help direct population shifts away from vulnerable locations such as flood plains, steep hillsides and low-lying coastlines.

b. Accommodate Strategies: Accommodation strategies focus on options aimed at moulding development and other actions around impact areas.

- Management of coastal habitats such as mangrove and estuaries: Such habitat fulfils very important hydrodynamic role within the coastal environment.
- Elevation and Modification of Buildings: The architecture can be attractive and cost-effective when compared to existing conventional approaches.
- Upgrade and Maintain Drainage Systems: Maintenance of drains needs to be systematic and constant, otherwise silt, which gets deposited, obstructs the

flow, exacerbating floods during heavy rain. An attempt at preventing the sea from penetrating drainage network will be an effective adaptation strategy.

- Insurance: The sensitisation of insurance companies can act as a positive force in guiding coastal development policies. Construction of infrastructure in high-risk areas will attract a higher insurance premium. However, without knowing the extent of potential impacts of climate change, the ability of private markets to insure against losses associated with climate change is unknown (IPCC, 1996a).
- Increasing height of the Ground Level: This is currently being practiced in Seychelles, but it turns out to be a very expensive accommodating activity, and what is being done is not sufficient to accommodate the full impact of climate change and sea level rise.

c. Defence Strategies: This has traditionally been the most preferred and quick solution to a coastal regression problem. However, implementation of defence strategies on various islands has only been successful within narrow boundaries and in the medium term. Consideration of defence strategies will certainly be an area of intense investment and focus as a part of adaptation portfolio of strategies adopted. Adoption of the least cost option is highly dependent on the response to adaptation, as more delays in implementing adaptation options in many cases imply implementation of costly mitigation measures.

- Hard Structural Options: These include the more traditional groynes, floodwalls, seawalls, detached breakwaters and so on. They are quite common in Seychelles, especially on Praslin Island. These can be successful adaptation options in the medium term and can be utilized to protect property at risk to the immediate problem of sea level ingress. Investment in such options is considerably high as it involves hydrodynamic studies. Another constraint is the lack of expertise to undertake the various steps.
- Intelligent Structural Options: These are mechanical or electronic tide and flood control systems, responding to the various tidal and other coastal sea-level changes. The commissioning costs are enormous, but they should be kept in mind when planning for reclamation, coastal development and the construction of waterways, marinas and ports.
- Soft Structural Options: Artificial nourishment and dune restoration: If sea-level rise accelerates in response to global warming, conventional beach restoration and replenishment programmes become increasingly futile. Management techniques such as “sand banking” may be used to reverse unnatural patterns of coastal retreat. The natural ability of beaches to act as self-adjusting buffers in the face of rising sea levels is re-established.

d. Recurring Opportunities to Adapt to Sea Level Rise: Adaptation can exploit the fact that coastal infrastructure is not static, as there is a constant turnover in coastal infrastructure, such as roads and ports, every 20 to 30 years. Hence, there is a need for active networking between all stakeholders during such redevelopment so that adaptation options can be taken into account in land-use planning, management and engineering design criteria. The adoption of integrated coastal management principle is one way of obtaining critical direction on how to make better use of resources and take into consideration views of all concerned.

4.4 Agriculture

4.4.1 Sensitivities and impact

Annual local food crops production averages 60% of local food consumption, thus 40% of the total consumption has to be imported. Up to the beginning of the 70s the Seychelles economy was primarily dependent on the export of copra, vanilla, patchouli and cinnamon. Agriculture then contributed up to 90% of the GDP employing more than 75% of the total workforce. Since the opening of the international airport in the early 70s, the Seychelles economy has changed and is now dependent on tourism and fishing. As a result, the contribution of agriculture to GDP has dropped significantly from 40% in 1970 to about 4% in 1995.

The 1994 population census indicated that a large percentage of the Seychellois households were now involved in some form of agricultural production. Across all the islands roughly 6,000 hectares are potential agricultural land of which only 600 hectares are currently under arable agriculture. Presently 525 farmsteads of between 0.5-2.0 hectares are registered with the Ministry of Agriculture and Marine Resources and thus benefit from a large range of services and concessions offered by this sector.

With a rise in population and an increase in tourists' arrivals, the consumption of food will substantially increase over the next few decades. The severity of the impact of climate change on the agricultural sector is yet to be determined. It is now felt that with an intensification of production on land, there are climate-enhanced impacts of increased chemical pollution, availability of water, soil erosion and diseases. A rise in sea level would contaminate coastal land and thus render the soil unsuitable for cultivation. The remaining hill slopes will probably become highly eroded due to increased rainfall, and the lack of effective erosion control measures.

Possible changes in climate to wetter and warmer conditions will interact with stresses that result from actions to increase agricultural production. The main direct effect will be through changes in factors such as temperature, rainfall, and timing of extreme or critical threshold events related to crop development. Other effects will include potentially detrimental changes in diseases and pests' dynamics and weed propagation, the impacts of which are not known in Seychelles.

The nature of an accelerated sea-level rise is crucial because many environments have so far kept pace with a slow rise (e.g. through coral or silt accretion) but may not be able to do so in the future. Agricultural lands could be flooded permanently, some lost by increased marine erosion and some frequently inundated as a result of disrupted river and tidal regimes together with greater storm and high wave incidence. On coastal plains and coral islands, salt-water intrusion into surface water and ground water could have deleterious effect.

4.4.2 Adaptation strategies

Arable agriculture is periodically affected by extreme meteorological events like tropical storms, floods and drought (Payet, 2000). To the extent that many small

islands are susceptible to these phenomena, it is highly likely that crop production would be impacted by alterations in the patterns of these events, as a consequence of climate change. In August 1997, the Seychelles' agricultural sector suffered costly damages (estimated at 1.5 million US \$) as a result of a severe storm resulting in heavy rain and extensive flooding in coastal areas. Several hundred tonnes of agricultural products were also lost.

Like in most countries agriculture is currently affected in many different ways by a wide range of government policies that influence product prices, cost of farm inputs, marketing arrangements, the cost of credit and even the level of production of specific commodities. It is likely, then, that changes in policy resulting in changes in climate would have a marked influence on how agriculture ultimately responds.

a. Farm Level Adjustment to Climate Change: Agricultural adaptation to climate change at the farm level depends on the technological potential, soil, water and the biological response as well as the capacity of farmers to utilise climate services and undertake necessary mitigation. The role of management and the potential for adaptation can be used in assessing the impact of climate change on livestock farming. The use of fans in chicken farms is a testament to the creativity of farmers in finding ways to cool animals during the warm season in Seychelles. Other adaptations may include coop density reduction during warm seasons and shifting to heat-tolerant breeds.

There are lots of uncertainties in estimating the effects of possible climate change on farm yields and annual farm productivity. All farmers have a level of risk aversion, or willingness to bear risks. There may be a need to develop an index of crop vulnerability to variability in weather pattern and seasonal climate. The following are incremental risks from a changing climate that farmers will need to account for:

- The risk of extreme events;
- Field-time availability risks;
- Low yields risks;
- Interactions between risk factors.

b. National Level Adjustments: Adaptation, such as changes in crop and crop varieties, improved water management and irrigation systems, and changes in planting schedules and tillage practices, will be important in limiting negative effects and taking advantage of beneficial changes in climate change.

A variety of models that integrate understanding of crop yield and climate relationships can be used for monitoring changes in potential crop yield, zonal production shifts, and regional and global production.

Cropping practices that maintain a more closed ground cover over long periods, which include crop rotation, planting of cover crops, and reduced or minimum tillage, are quite effective management practices, which can reduce vulnerability, and also reverse current land degradation trends in certain areas.

Climate change threatens to shift national agricultural efforts, and a decrease in local production would place more emphasis on imported agricultural product. As a result, the response of Seychelles to climate change, then, will depend not only on how domestic farmers adapt to new environmental conditions, but also on a host of other factors that affect national food supply and imports. Land use planning at national level needs to be synergistic with adaptation options adopted by the sector. Allocation or repossession of potential agricultural land must be undertaken in the light of the adaptation options determined through studies on yield and soil productivity. The existing policy for agricultural development will need to be modified to include adaptation options to climate change (Moustache, 1997).

4.5 Water Resources

4.5.1 Impacts

Climate change will lead to an intensification of the global hydrological cycle and can have major impacts on the national water resources. A change in the volume and distribution of water will affect both ground and surface water supply for domestic as well as for industrial uses. Changes in the total amount of precipitation, its frequency and intensity directly affect the magnitude and timing of runoff, and the intensity of floods and droughts. Relatively small changes in temperature and precipitation, together with the non-linear effects of evapotranspiration and soil moisture can result in relatively large changes in run-off. More intense rainfall will tend to increase run-off and the risk of flooding, although this would depend not only on the changes in rainfall but also on the catchment's, physical and biological characteristics.

Climate change is likely to have a significant impact on both the supply and demand for water. A lot depends on the ability of water resource managers to respond not only to climate change, but also to population growth and to changes in demands, technology, and economic, social and legislative conditions. There could be cases of substantial economic, social and environmental cost, particularly in regions where natural sources of water are very limited (Henri, 1998).

As mentioned in chapter one, water is an important resource for island states. In Seychelles the current demand for water has risen beyond the actual planned capacity of all the islands' reservoirs and the country is already experiencing severe water shortages during the dry months of the year. Furthermore there has been a general increase in the frequency and intensity of flash floods, but little changes in the annual distribution of precipitation. Vulnerability assessment of climate change impact on water resources should therefore be an important element in the long-term planning of water resources management.

While rainfall is abundant (on average 2,200 millimetres annually), water is a scarce resource in Seychelles. This amount of rainfall converts to 339,000 million litres of water annually on Mahe alone, and the total water needs for all of Seychelles, including agriculture, is approximately 13,000 million litres per annum. Most of the water is lost through run-off and evapotranspiration that amounts to approximately 98% of the rainfall. Hence, only 2% is left for infiltration to feed the streams and

ground water. Because of this high run-off and the seasonality of Seychelles' rainfall, the principal sources of potable water on Mahe are the numerous small streams found throughout the island. Due to steep topography and the low retention capacity of the soil, the flow in these streams is erratic, and falls to very low level during the dry season. A total of 83% of the population (1994 Census) receive treated water supply. Table 4-2 shows possible impacts on water resource following various scenarios.

Table 4-2: The Possible Impact of Climate Change on Water Resources in Seychelles.

EFFECT OF GLOBAL WARMING	IMPACT ON WATER SUPPLY RELIABILITY
Change in rainfall pattern	Severe drought and frequent flash floods; Increase in storage capacity
Change in river runoff	Yield in dam and reservoir system Yield in direct water abstraction
Change in water quality	Yield of treatment systems
Rise in sea-level	Saline intrusion in coastal aquifers Yield of coral island water-lens Movement of saline front upstream
Change in evaporation	Yield of reservoir systems

(Source: Adapted from IPCC, 1996a)

4.5.2 Adaptation and response

Options for dealing with the possible impacts to climate change and increased uncertainty about future supply and demand for fresh water include more efficient management of existing supplies and infrastructure; institutional arrangements to limit future demands/promote conservation; improve monitoring and forecasting systems for floods/droughts; rehabilitation of watersheds; and the construction of new reservoir capacity to capture and store excess flows produced by the altered pattern of storms.

To address adaptation and response strategies in the water resources sector, both supply adaptation and demand adaptation need to be considered. Supply adaptation implies management and planning for watershed management, infrastructure development, water distribution and water quality. Demand adaptation includes issues such as pricing policies, conservation and efficiency technology changes and land use planning.

a. Water Resource Management: The issues that pre-occupy water resource managers in Seychelles are demand forecasts, operation and maintenance of existing systems, new investments, and new water sources. As a result of recent impacts of ENSO, a new area of pre-occupation is the management of water resources in the long term. Institutional adaptation may be an effective approach to ensuring the long-term availability of water. This would involve changes in organizations, water-taxes, and financial mechanisms. The adaptation strategy should focus on:

- Human resource development in the area of hydrometeorology and water resources management;

- Effective water conservation programmes and economic mechanisms including appropriate pricing policies;
- Water resources management programmes;
- Restoration of water bodies and protection of water catchment areas;
- Long-range forecasting of river variability due to climate change.

b. Improvement and modification of existing physical infrastructure: With climate change impacts there is a need to re-evaluate the performance of current infrastructure in terms of capacity, age, sediment removal, and water recovery, and loss reduction. Adaptation to meet the demand has already started in Seychelles. For example, tapping into other rivers, which were not exploited and which could not be developed into cost-effective and environmentally sound dam catchments, has increased the throughput of one dam. This has increased supply, but there is a need to undertake further studies on the hydrological regimes of these rivers and especially the impact of groundwater recharge on surface output. Possible adaptation strategies include:

Further research and monitoring aimed at identifying and increasing sources for water extraction.

c. Watershed Management: The importance of watershed management in adapting to changes in river discharge will be an important element of the adaptation strategy. Individual activities that affect land-use practices in a watershed are often regarded as minimal, but it is incremental making the overall aggregate impact of very small encroachments substantial. The adaptation strategy should focus on:

- Watershed land use plans, which identifies beneficial uses of watersheds;
- Greater enforcement of laws discouraging unmanaged development in watershed areas;
- Reduction of sedimentation through anti-erosion mechanisms;
- Availability of hydrological, meteorological and geological information and the study of watershed sensitivities.

d. Water quality management: Many water management problems, which affect the cost of supply, relate to the quality of the surface water and ground water. For various reasons given earlier in the chapter, climate change may exacerbate some of these problems by complicating an already expensive treatment and distribution system. The main issues that could be considered within the adaptation strategy are:

- Water quality management standards and legislation which are enforceable;
- Strengthening of existing institutional arrangements with respect to water quality management;
- Early warning system for pollution incidents and flood potential as a result of river strangulation;
- Strengthen existing water quality monitoring system.

e. Construction of new infrastructure: Planning for new infrastructure, especially dams have always been difficult in the Seychelles. The main reasons being the infrastructure costs which have consistently increased as well as the environmental impacts and costs. However, with increased drought periods, there is a need to

consider more reliable and cost-effective types of water resource technologies. Possible adaptation strategies include:

- Technology transfer assessments;
- Explore flexible financing mechanisms;
- Planning and location of new infrastructure.

f. Water Conservation: The most effective long-term strategies for dealing with water scarcity include conservation and more efficient water use; better utilization of water resources not only conserves water, but also reduces treatment and pumping costs. Water harvesting, which involves collecting and storing rainwater for use, has numerous advantages at community and household levels, including:

- Increase national water storage capacity;
- Community participation in water sourcing;
- Water conservation at district/community level;
- Water-harvesting from roofs of residential houses and public buildings.

It has been calculated that if each household on Mahe were to harvest 100 litres, then the amount of water reserve will effectively double at any one time. This is a strategy that needs to be pursued especially where investments in new reservoir and dam facilities are delayed due to financial constraints and land use. However, there is a need to consider mechanisms to encourage and drive such a strategy. These may include:

- Concessions on the manufacture of water storage tanks;
- Provide soft loan financing facility;
- Integrate as part of planning regulations for each house to be equipped with a suitably sized storage tank;
- Provide rebate on water bills for owners of water tanks.

g. Water generation/purification technologies: Desalination of seawater could theoretically be a sustainable source of fresh water for the Seychelles. However, it is only seen as an emergency back-up system (in the case of extended period of drought) because of the high capital and energy requirements. Desalinated water costs several times more than water supplied by conventional means. Water generation technologies are not designed to replace conventional water resource harvesting activities but rather to complement existing approaches. Table 4-3 summarises various water conservation measures that can be effectively adopted.

Table 4-3 Water Conservation Adaptation Strategies

Use Area	Adaptation Strategy	Implementation timescale
Domestic	Reduce water in toilets, showers and laundry through better technology and use practices. Commercial car washing with recycled water. Water harvesting.	Now Near Future Now
Tourism	Tourism education. Water conservation technology. Laundry and washing process and technology improvements. Recovery of water from air-conditioning & heating systems. Swimming pool water management.	Long-term Now Near future Now Now
Industry	Recycling Water conservation technology Treatment and alternative re-use of polluted water.	Near future Long term Near future
Agriculture	Night irrigation. Improved water delivery systems. Drainage re-uses.	Now Near future Now

(Source: Payet, 1998)

4.6 Fisheries

4.6.1 Sensitivities and impacts

Coastal zones and small islands contain some of the world's most productive resources. Coastal systems are economically and ecologically important and are expected to vary widely in their responses to changes in climate and sea level. Some coastal ecosystems are particularly at risks, including saltwater marshes, mangrove ecosystems, coastal wetlands, sandy beaches, coral reefs and coral atolls, which can all be encountered in the Seychelles islands. Changes affecting those ecosystems would have serious adverse effects on fisheries, aquaculture, tourism, freshwater supplies and transportation. In the case of small islands coastal zone includes the entire island (IPCC, 1996a).

Fishing is the most important industry after tourism in Seychelles, contributing 4% of the GDP. Around 4,500 tonnes of fish are landed annually by the artisanal fishery, which supplies all the fish required for domestic consumption, plus about 370 tonnes for export, generating more than two million US dollars in revenue. The tuna processing industry is generating approximately 35 million US dollars. The consumption of fish per capita is about 80 kg/year.

Large schools of demersal fish species apparently frequent certain areas of the Mahe Plateau. Research has indicated that the maximum sustainable yield of demersal fish on fishing grounds up to 150 m depth to be about 6,200 tonnes (Mees, 1992.). Such information however imprecise should be considered when managing the offshore fish resources. However, much more needs to be known of the response of the resource to fishing to be confident of the long-term sustainability of the fishing operations. The diverse tropical demersal fish communities on these grounds consist of numerous fish species that interact (for example, eat or are eaten) in many ways that are not clearly understood. Under intense fishing pressure unexpected changes may take place; a highly commercial species may be heavily reduced or replaced (may be permanently) by worthless species (Harris and Poiner 1991; Sainsbury, 1998).

Although the effects of environmental variability on fisheries are increasingly being recognized, the contribution of climate change to such variability is not yet clear. Climate change on a regional scale is even more uncertain. Since no models have been computed to predict the response of the Indian Ocean to global climate change, one way of analysing the possible impacts is by considering global changes.

Projected global warming would have limited biological effects on fish stocks, if considering only the increase on sea-surface temperature. Higher temperatures should not affect significantly the potential yield because of the thermal inertia of the ocean and the ability of fishes (at least the pelagic resources) to migrate towards a more suitable environment. In this context, the total catch will be distributed differently from present, and changes in the prominence or commercial importance of certain species will be far from negligible. However, the picture will be different economic-wise, if the changes result in migration of species from one EEZ to another. There would be a reduction in revenue from fishing licenses in Seychelles, and services provided by the port authorities.

Global warming can influence ocean-atmosphere interactions, altering ocean currents, and hence the delivery of nutrients into the euphotic layer. This could result in changes in reproductive pattern, migration routes and ecosystem relationships. Sea level rise will result in saltwater intrusion in rivers, marshes or wetlands. For coastal shellfish, an accelerated sea-level rise could impede their ability to relocate.

During the last ENSO episode the impact of the elevated sea surface temperatures on coral reefs was severe leading up to 95% mortality in some areas of Seychelles (Wilkinson et al, 1999). The actual secondary impacts are yet to be felt along the coastlines, as the reefs cease to play active roles a natural coastal defence. Although conclusive data have not yet been published, it is expected that coastal fisheries and dependent communities may be severely affected as a result of the coral bleaching event. There is even the risk of increased toxicity in fisheries, uncommon to the Seychelles region. More information on the likely impacts and cost will emerge as more research is undertaken on the 1997/98 bleaching event (Payet, 2000).

Seychelles is engaged in extensive prawn farming on Coetivy Island. Possible adverse effects of sea level rise on such aquaculture are: destruction of facilities, oxygen depletion, bacteriological diseases or algal blooms.

4.6.2 Adaptation

The management of the fisheries resource is extremely complex. However, the Seychelles has very clear policy on fisheries, ensuring that there is no over fishing and that natural fish nurturing areas are protected. With decreased revenue from fisheries as a result of sea surface temperature variability, the pressure for increasing fishing effort emerges. In many ways revenue from the fishing industry is also entrenched into resource monitoring and support, so a decrease in revenue will also affect this important decision support and policing activity (Payet, 2000).

a. Strengthening existing International agreements and Cooperation: This is achievable with the strengthening of the Indian Ocean Tuna Commission, especially in ecosystem research, resource management and stock allocation, as well as establishing linkages with institutions or programmes focused on climate change impacts on Fisheries.

b. Improving existing fisheries management policies: Policies in terms of licensing and catch monitoring will need to be implemented in the light of projected climate change.

c. Promoting healthy fisheries habitat by minimizing development impacts: Adequate management and protection of such habitat may improve stocks and continue to support a diverse range of coastal habitats.

d. Restoration of critical coastal habitats essential for fisheries: With the reclamation project dominating the East Coast of Mahe, some fisheries habitat has been virtually destroyed, thus a need for further habitat generation.

e. Conserving habitat needs for marine mammals: This could be approached as a resource for eco-tourism.

f. Promoting fisheries educational programmes, especially amongst fishermen: The Seychelles' Fishing Authority is in the best position to organize educational programmes for local fishermen.

g. Implementing measures to reduce risk of introduction of biotoxins and diseases into local stocks: Effective monitoring programmes needs to be in place, as changing climatic conditions may favour the proliferation of pathogens which were previously inert.

h. Institutional strengthening and capacity building for research and monitoring: Key institutions like Seychelles Fishing Authority, and the Indian Ocean Tuna Commission can play a more vital role in research especially relating to vulnerability of fish stocks to climate change.

i. Development of sustainable aquaculture industry: This is already being tried at both large and small scale in Seychelles. One large aquaculture farm on the island of Coetivy is producing tiger prawns for export and the other smaller farm on Praslin is culturing mother of pearl.

j. Restocking/Restoration with ecologically sound species: This is a valid adaptation strategy where the species existence is threatened. Bringing Gaps in species structure and relationships will have significant impacts on food webs and stability of a climate-stressed marine habitat.

k. Adapting to fish redistribution with better fishing techniques: This is achievable with the use of satellite, faster vessels, on-board storage, and on-shore infrastructure.

Whilst there are many difficulties associated with the adaptation options proposed, the considerations of the scale provides some guidance to the essential features of an effective adaptation strategy. As adaptation takes place on smaller scales, minimizing the net losses to individuals and places must dominate whilst aiming for no loss overall. Given the uncertainty of possible outcomes, further diversification and flexibility at the local level is needed.

4.7 Human Health

4.7.1 Impacts

Climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life. These impacts would arise by both direct and indirect pathways and it is likely that the indirect impacts would, in the longer term, predominate.

An increase in extreme weather conditions may cause a higher incidence of death, injury, psychological disorders and exposure to contaminated water supplies. Indirect effects of climate change include increases in the potential transmission of vector-borne diseases (e.g. malaria, dengue, yellow fever, encephalitis and some viral infections) resulting from the extensions of the geographical range and season for vector organisms. Some increases in non-vector-borne infectious diseases, such as salmonellosis and cholera may also occur as a result of elevated temperatures and increased flooding.

Additional indirect effects include respiratory and allergic disorders due to climate-enhanced increases in some air pollutants, pollen and mild spores. Exposure to air pollution and stressful weather events combined increase the likelihood of morbidity and mortality. The Seychelles may experience a decline in nutritional status as a result of adverse impacts on food and fisheries productivity. Limitations in fresh water supplies also will have human health consequences.

Quantifying the projected impacts is difficult because the extent of climate induced health disorders depends on numerous coexisting and interacting factors that characterize the vulnerability of a particular population. These include environmental and socio-economic circumstances, nutritional and immune status, population density and access to quality health care. Adaptive options to reduce health impacts include protective technology (e.g. housing, air-conditioning, water purification and vaccination), disaster preparedness and appropriate health care (IPCC, 1996a).

As a result of the Government's strong commitment to the development of the health care services, in particular the Primary Health Care approach, which involves the individual and community participation, Seychelles has made remarkable improvements in the health status of its population (see Table 4-4). The major tropical scourges, such as malaria and yellow fever are currently unknown in the Seychelles, but the risk for their introduction is high and is a cause for concern. Due to its proximity to mainland Africa and more conducive tropical environment, increased rainfall or drought may provide ideal conditions and opportunities for the proliferation of the vectors and the pathogen itself. Historical records show that the Seychelles has ideal conditions for the propagation of malarial diseases since during the early days of colonisation (1908, 1931 and 1933) outbreaks were reported in two outlying islands.

Table 4-4: Main Health Indicators.

Indicator	1970s	1992	1994	1995	1996	1997	1998	1999*
Infant Mortality (%)	32.3 (1976)	11.9	8.8	18.3	9.3	8.1	8.5	9.5
Birth Rate (%)	27.1 (1976)	22.6	23.0	21.0	21.1	19.1	17.9	
Total Fertility Rate (%)	4.3 (1978)	2.5	2.6	2.3	2.32	2.14	2.04	
Life Expectancy (Male) Year	64.6 (1978)	67.5	65.6 (1994 -99)		66.01	65.67	67.61	67.36
Life Expectancy (Female) Year	71.1 (1978)	73.2	74.7 (1994 - 99)		77.39	77.02	76.07	77.90
Life Expectancy (both sexes) Year					71.32	71.01	71.37	72.44

(Source: Statistical Abstract, 1998, Health Statistics, 1999).

4.7.2 Adaptation

Several adaptation strategies are proposed in order to minimise impacts of climate change. In view of considerable lack of data on the nature and magnitude of these impacts, it is important that research strategies are properly defined so as to formulate additional adaptation strategies. Research and appropriate medical data analysis is required at both population and individual levels in order to identify the direct or indirect health impacts of climate change.

a. Adaptation Strategies at Population Level:

The indirect effects of climate change may put entire island population at risk from vector-borne diseases. Newly affected populations would initially suffer high fatality rates due to their lack of natural acquired immunity, and medical response. The

Seychelles maintains very strict regulations on international arrivals both by air and sea. Under present circumstances, the proposed adaptation strategies are:

- Environmental management of infrastructure and settlements;
- Proper drainage systems to reduce conditions for disease vectors that are likely to increase with climate change;
- Maintenance of stagnant water bodies;
- Integrated public health surveillance and control programmes;
- Introduction of protective technologies;
- Continuous improvements of primary health care;
- Disease prevention and population education.

b. Adaptation Strategies at Individual level:

- Personal Health education;
- Personal health responsibility;
- Behavioural responses to limit exposure.

4.8 Natural Disasters

4.8.1 Impacts

Climate change and resulting sea-level rise can have a number of negative impacts on energy, industry and transportation infrastructure; human settlements; property insurance, industry; tourism; cultural systems and values. One of the potentially unique and destructive effects would be forced internal migration of population.

The natural disasters that could affect the Seychelles' archipelago directly or indirectly are:

- Tropical cyclones (southern islands only);
- Storm surges;
- Flooding, including coastal, estuarine and river flooding;
- Landslides;
- Drought.

a. Tropical cyclones

The disasters attributed to tropical cyclones are caused not only by wind, but also by torrential rainfall, lightning, and the associated phenomena: storm surges, floods, tornadoes and landslides.

As sea surface temperature rises, the ocean area, which can spawn tropical cyclones, is expected to increase. Although the area of sea having temperatures over the critical value will increase as the globe warms, the critical temperature itself may increase in a warmer world. Some scientists argue that the intensity of those storms may

increase. (IPCC,1992). In Seychelles only the islands to the south (Aldabra atoll, Farquhar group, Cosmoledo, Assumption, Desroches and Coetivy) are in the direct track of tropical cyclones. Over the last decades, with the exception of Coetivy, there has been a reduction in economic activity, except for tourism, on most of those islands, and there are no records of assessments of damages caused by tropical cyclones. However, all the islands are indirectly affected. A feeder-band within an active convergence zone, passing over Mahe, can bring in winds gusting in excess of fifty knots, with torrential rain causing flash floods. With a warming of the ocean, changes in frequency, intensity and locality of tropical cyclones can mean the Seychelles islands could become a lot more vulnerable.

b. Storm Surges

Factors such as very strong on-shore cyclone winds, a gently-sloping ocean floor profile along the coast, and extremely low barometric pressure near the centre of the cyclone, can combine to produce a storm surge, which is a rapid rise in sea-surface level near the area of strong wind as it approaches the coastline. Storm tides may also be affected by other factors such as the simultaneous occurrence of a flash flood on land. The storm tide and the superimposed waves may flood beaches and coastal areas and even spread some distance inland if the topography allows. It must be noted that storm tides and sea actions can pose the greatest threat to tourism activities in low-lying coastal areas of the Seychelles.

c. Flooding

Flooding is quite common in Seychelles, and is mainly due to heavy and/or excessively prolonged rainfall. Most damages are caused by flash floods, resulting from torrential downpours. Intense convectional storms can be very localized, but the resulting flood wave can move very rapidly down valleys resulting in river flooding.

d. Landslides

The short history of Seychelles has several instances of landslides resulting in extensive property damages and even loss of lives on few occasions. Long-lasting heavy rains often trigger them. On 12th October 1862 a huge mass of earth came from the mountain and completely submerged Victoria under a thick layer of mud and debris. The capital city, Victoria, was almost completely flattened, and several people lost their lives. The land that was brought into the sea became the main centre of Victoria more than one hundred years later (Shah, 1996).

In August 1997, a cloud mass extending from the Indian monsoon resulted in heavy rains over a period of three days with a flash flood on 17th August. The coastal plains of Mahe, Praslin and La Digue were all flooded and there were landslides at several locations. Agricultural losses were estimated at US \$ 1.5 million, whereas temporary repair to the 40 % of the public road that was damaged came to approximately US \$ 1.5 million. The damage to residential houses was about US \$ 2.0 million (Payet, 1999; Moustache, 1997).

e. Drought

Many models suggest increase in the probability of intense precipitation with increased greenhouse concentrations. In some regions of the world a number of simulations show an increase in the probability of dry days and the length of dry spells (consecutive days without precipitation) (IPCC, 1996a).

In recent years, there have been several occasions of dry spells in Seychelles leading to water shortages, with adverse effect on the economy. As explained under the previous section on water resources, increase in demand has aggravated the situation. During La Nina of 1998-1999, Seychelles experienced severe droughts with dire economic consequences. The demand for water was so intense that many companies decided to make heavy investments in adaptation options such as storage and desalination plants (Payet, 1999). Forest fires can be quite common during drought (INDUFOR, 1993), placing at risk numerous species and unique habitats.

4.8.2 Adaptation

Technical measures can prevent, or at least reduce, many natural risks, but as with many other preventive measures, the people or nations concerned must be able and also willing to bear the costs. In Seychelles, policies for land use and development are being developed to reduce impacts on housing and infrastructure. The number of houses being constructed along the unstable slopes of the granitic islands has decreased, where numerous roads are now being diverted inland, and coastal set-back lines are being introduced by hotel developers. However, sustainable land development requires the availability of suitable land, adequate institutional and technical support, and international participation. A new agency to study the effects of landslides and to identify mitigation measures has been proposed (Abbey, 1998). Restrictions on building houses and other facilities in flood-prone areas can also be achieved through land-use planning or by shifting damage risks toward insurance companies that may, by adequate structuring of their premiums help to deter settling in threatened areas.

The United Nations Department of Humanitarian Assistance (UN-DHA) has identified nine crucial requirements and mechanisms for effective implementation of disaster reduction. These requirements apply to tourism areas as well as to other zones in countries affected by natural disasters. They are as follows:

a. Government resources

- Political will and commitment;
- Resources;
- Leadership, management and coordination.

b. Knowledge and skills

- Public awareness;
- Community Participation;
- Training and education;

- Research and development.

c. Restrictions and incentives

- Legal and administrative framework;
- Financial incentives. (WMO, WTO, 1998)

The UN has made the prevention and preparedness against disasters caused by extreme events their task and has declared the nineties as the International Decade of Natural Disaster Reduction (IDNDR). The targets of the IDNDR is achievable through the implementation of a detailed programme consisting of the following ten goals, which can be successfully implemented in Seychelles given that the capacity building and resource requirements are fulfilled.

- Identification of hazard zones and hazard assessment;
- Vulnerability and risk assessment, cost benefit analysis;
- Raising the awareness for disaster reduction at the level of decision and policy makers;
- Establishment of monitoring, prediction, forecast, and warning systems;
- Planning and construction of long-term preventive measures (structural, non-structural);
- Preparation of short-term preparedness measures and emergency plans;
- Early intervention measures;
- Education and training of disaster personnel, public information;
- Transfer of technology;
- Research on improved technology and disaster management.

4.9 Insurance

In Seychelles the insurance market is not well developed and insurance of catastrophe risk is either unavailable to individuals, or available only at terms that exceed willingness or capacity to pay. Moreover, insurance firms have typically not developed products that enable sovereign governments to insure catastrophic risk either as a direct way of indemnifying the state for the budgetary implications of the loss (increased expenditure and/or reduced revenues) or as proxy policy holder acting on behalf of its citizens. Insurance has been largely unavailable in many small nations as a way of hedging against the costs of natural disaster. The reasons are many; distribution systems are undeveloped, underwriting criteria are unclear, the cash economy is limited and informal forms of ‘insurance’ are available in the form of extended family (Doherty, 1999).

Small island states, like Seychelles, have limited borrowing capacity. A loan is often used in funding new investment such as urban development, tourism, infrastructure projects and new industries. These projects are considered necessary for sustainable economic growth. Yet after a natural disaster, such projects can easily be derailed as they compete with disaster recovery for limited funding. Thus, the country emerges from the disaster with considerable debt but without the economic momentum to

service that debt and without the borrowing capacity to re-start its development projects.

The absence of insurance also has prospective implications. The terms of private debt would rationally reflect risk considerations. The absence of insurance increases the default risk on debt and thereby increases its price and/or limits its availability. By insuring the debt, the implicit risk adjustment can be priced and the default risk transferred from the lender to specialized risk bearers who can measure and diversify the default risk due to natural disasters. This process should ease the access of developing countries to provide capital markets. Moreover, explicit pricing of risk also has advantages for the development banks that can transfer the default risk to outsiders who can manage the risk efficiently.

In the past two or three years new solutions to managing catastrophe risk have started to appear, however these are as yet to be developed in small island states. Capacity building and transfer of knowledge is required in this area.

4.9.1 Adaptation options

To get better catastrophe insurance in Small Island Developing States (SIDS) a new institution or scheme may be necessary. Some elements that could contribute to improvements through such institutions need to be considered and are:

Restricted coverage: Three classes of property need to be considered: government owned, commercial and residential. The case for specific action on social grounds would seem to be highest with residential property and lowest with commercial. A scheme to cover only dwellings and their contents is both simplest and fulfils the greatest need.

Enough premiums: The issue is not just the rate of premium but finding ways in which the lowest income groups can be subsidised. External aid may well be a possible source as donor countries seek ways of providing better assistance other than disaster relief after major hurricane.

Risk is spread: The more complete the coverage in a single territory the better is the spread of risk within that territory. So there is an argument for an element of compulsion. But spread of risk across territories where the risk is reasonably uncorrelated is even more helpful. For small island states this argues for at least a regional institution. If states in other regions were to participate as well, the spread of risk would be even greater. The better the spread of risk the less capital is required for any total level of exposure.

Capital is necessary: Neither the governments nor the local insurance industry would seem to have capital to spare to support an expanded (or new) insurance operation. Private sector capital from abroad would only be available if the operation is bankable in its own right with commercial returns on capital, or if it were guaranteed by governments.

Risk is transferred: The risk to governments (both as owners of any institution and as moral guarantors of housing) can be reduced through the transfer of risk through reinsurance. While reinsurance markets are still overwhelmingly dominant in this transfer today (often using a non-traditional be spoke products) other forms of risk transfer should be evaluated on a case-by-case basis.

Risk is measured: Good modelling of hazards, the exposure and the loss distribution can reduce uncertainty and bring down the cost of reinsurance (or other risk transfer). But even with considerable uncertainty products can still be designed to efficiently transfer risk.

Private Sector Servicing: The use of the private sector for issue or recording of policies, the collection of premiums and the adjustment of claims have two major advantages; it saves the costly establishment of a duplicate structure for these tasks; and it strengthens rather than weakens local industry.

Element of Compulsion: Purely voluntary schemes for residential cover are not likely to be successful – either because the insurers do not offer broad cover satisfactory to householders or because many householders will decide to take the risk and rely on the aid from their government or external sources if they are unlucky and their dwelling is damaged or destroyed.

Mitigation: Risk reduction is also of major importance and desirably should be linked to the premium rating so that those who make their properties safer pay less.

Inter-country Fairness: If an institution were established and it covered more than one country, it is important that the premium setting take into account of experience so that over the longer term no one country can fee-load at the expense of its partners.

Funds Invested Locally: There is always the temptation for governments to require that funds built up by a government institution be invested locally – often in government bonds. The problem is that after a disaster the government has to repay the bonds (essentially by new borrowing.) Thus to the extent that the government has spent the accumulated funds itself it has not transferred the risk (McLean & Paterson, 1999).

5 CAPACITY BUILDING NEEDS AND PRIORITIES

5.1 The Seychelles Environmental Management Plan

In the formulation of the Second Environmental Management Plan of the Seychelles (EMPS 2000-2010), capacity building was regarded as one of the most important elements for the successful implementation of the Plan. A fundamental principle was adopted to follow a process, which would lead to greater capacity to understand, monitor and address the emergent environmental issues, all of which call for greater and wider involvement of all stakeholders. Capacity building provides the basis for continuous improvement and incorporation of new ideas and innovations to improve sustainable development in the Seychelles.

The main areas for capacity building, which includes both human resources development and institutional strengthening, as highlighted in the Plan, are:

- Education and training;
- Science, research and technology;
- Policy development, implementation and management;
- Monitoring and assessment;
- Government, community and private sector partnerships;
- Awareness by decision-makers, private sector and the public;
- Public consultation and participation;
- Vulnerability and global climate change.

Thus, the EMPS has also incorporated vulnerability and global climate change as one of the major areas to be considered for capacity building. However the fine print for capacity building in the above areas has yet to be comprehensively laid out.

5.2 The National Communication Process

5.2.1 General constraints for capacity building

As a small island state, the Seychelles suffers from many disadvantages, as identified in the *Report of Global Conference on the Sustainable Development of Small Island Developing States held on 26 April-6 May 1994 in Bridgetown, Barbados*. These disadvantages include:

- a. A narrow range of resources, which forces undue specialization;
- b. Excessive dependence on international trade and hence vulnerability to global developments;
- c. High coastal population density, which increases the pressure on already limited resources;
- d. Overuse of resources and premature depletion; relatively small watersheds and threatened supplies of fresh water;
- e. Costly public administration and infrastructure, including transportation and communication; and
- f. Limited institutional capacities and domestic markets, which are too small to provide significant scale economies, while their limited export volumes, sometimes from remote relocations, lead to high freight costs and reduced competitiveness.

In absolute terms, the Seychelles' population is quite small, insufficient to generate economies of scale in several areas, and it therefore has limited scope for the full utilization of certain types of highly specialised expertise. Like most other small island developing states in a similar situation, the country is experiencing some migration, particularly of skilled human resources, which not only places undue burden on the resources for training, but also forces the country to import high cost foreign expertise.

The lack of opportunities for achieving economies of scale, together with their narrow resource base, tends to limit the total production of small island developing states such as the Seychelles to a narrow range of crops, minerals and industries, both manufacturing and services. Any adverse development concerning those productive factors, whether arising from market forces, natural or environmental constraints, is likely to lead to a significant reduction in output, a fall in foreign exchange earnings and increased unemployment.

All these disadvantages are likely to have profound implications on capacity building during the implementation of the EMPS 2000-2010.

5.2.2 Specific constraints

During the process of the preparation of this National Communication, the Seychelles has experienced a number of specific constraints, as follows:

- Very limited financial resources, including for the participation in regional and international meetings, workshops and seminars (the physical isolation of the country in itself is a major constraint, and this has incurred additional costs for all expenses, including travelling);

- Limited technical and institutional capacity to undertake various relevant research and studies;
- The lack of GHG data and long-term climatological (except rainfall) data;
- The non-applicability of emission factors especially in the land use and forestry sector;
- The non-applicability of current global and regional climate models to the condition of the Seychelles, which consists of a large groups of islands spreading over a large EEZ;
- The general lack of public awareness on climate change issues;
- The lack of access to necessary technologies and know-how (including information technology);
- The lack of a regular forum for exchange of information and networking within the sub-region and the region; and
- Limited financial and technical support by international agencies, especially with regard to the participation in regional workshops.

These specific constraints have, in one way or another, affected the progress of the preparation of this National Communication.

5.3 Past Capacity Building Initiatives and Activities

Workshops can be one of the effective means for building or strengthening capacity. During the process for the preparation of this National Communication, the Seychelles has participated several IPCC Working group meetings, as well as some regional workshops on issues such as the Capacity Development Initiative and Technology Needs Assessment. Members of the team have also had the opportunity to attend some of the Subsidiary Body meetings of the UNFCCC.

5.4 Capacity Building Needs and Priorities

Based on the experiences gained during the preparation of this National Communication, a number of capacity building needs and priorities have been identified in the subsequent sections. Clearly, human resources, scientific, technical, technological and institutional capacity would need to be urgently built or strengthened in these areas in order to enable the country to sustain its climate change activities, and hence to fulfil its commitments under the UNFCCC.

5.4.1 Planning and management

Proper planning and management, including the aspects for appropriate project design and implementation, is a pre-requisite for success for environmental management. The following issues are of high priority:

- Integration of the climate change concerns into sustainable development planning for all socio-economic sectors, with special focus on integrated coastal zone management;
- Formulation and implementation of a comprehensive National Climate Change Action Plan as part of the sustainable development plan;
- Protection of coastal areas from erosion;
- Promotion of eco-tourism.

5.4.2 GHG inventory

During the preparation of GHG inventory, a number of capacity building needs have been identified to improve data quality and to provide updates of the GHG inventory. These include:

- Improvement in data acquisition, analysis, management and dissemination;
- Development of local emission factors, where appropriate;
- Reduction in data uncertainties, especially in land use change and forestry sector
- Development and regularly update of an efficient activity database for all key socio-economic sectors;
- Participation of private sector.

5.4.3 Mitigation options

It is necessary to strengthen the technical capacity in the following areas:

- Least-cost analysis taking into account the environmental costs and benefits;
- Assessment and transfer of appropriate mitigation technologies;
- Development of mitigation strategies and policies;

5.4.4 Technology transfer

Technology transfer plays a vital role in sustainable development and in meeting the objectives of the UNFCCC. This is addressed in Article 4.5 of the Convention, while Article 4.7 links developing country commitment to technology transfer. Increased climate variability and relocation of investments to climate-sensitive sectors will have several major direct impacts on the energy sector.

Due to its high absorptive capacity, the Seychelles may delay investments in renewable energy and adopt cheap electricity generating technologies. It may also boost energy consumption to diversify into other areas of the economy, which may be less vulnerable to climate impacts, like investing in the desalination of seawater to cater for the projected water resource impacts. All these options may have negative global impacts, but in view of the increasing visible impacts of climate change, small island states are increasingly given very few options to consider, and too many global concessions to bear responsibility for. Opportunities for low-cost technology transfer and financial assistance for reducing such vulnerabilities are also limited under the current framework of the Convention.

The national capacity for both public and private sector to assess, manage, absorb and utilize new technologies, including indigenous technologies, should be strengthened. In this context, the existing administrative and technical infrastructure will need to be further improved. The capacity building process should include training and skill development especially for the youth.

5.4.5 Vulnerability, impact and adaptation options

The topography of the Seychelles with limited flat land makes it highly vulnerable to climate change and ensuing sea-level rise with severe consequences on the fragile environment, biological diversity, economy and infrastructure. The ability to respond is hampered by the limited institutional, scientific and technological capacity. Climate change and sea level rise are therefore life and death issues for the islanders and the need to monitor the changes over time is imperative. Like all small island developing states, the country requires all available information concerning those aspects of climate change, as it may affect their ability to enable appropriate response strategies to be developed and implemented.

The Barbados Programme of Action has identified priority areas at national, regional and international levels and indicated the specific actions that are necessary to address the special challenges faced by SIDS. In particular, capacity building, including human resource development, institutional development at the national, regional and international levels is needed for these actions.

At the national level, the specific areas that are of most relevant to the Seychelles are highlighted as follows:

- Monitor, survey and collect data on climate change and sea-level rise;
- Formulate comprehensive adjustment and mitigation policies for sea-level rise in the context of integrated coastal area management; Assess the effects and

the socio-economic implication of climate change, climate variability and sea-level rise;

- Map areas vulnerable to sea-level rise and develop computer-based information systems covering the results of surveys, assessments and observations as part of the development of adequate response strategies, adaptation policies and measures to minimize the impact of climate change, climate variability and sea-level rise;
- Improve public and political understanding of the potential impacts of climate change;
- Formulate comprehensive strategies and measures (including the preparation, facilitation and collection of information) on adaptation to climate change that would contribute to a better understanding of the range of issues associated with the development of methodologies to facilitate adequate adaptation to climate change;
- Increase participation in the bilateral, regional and global research assessment, monitoring and mapping of climate impacts, including the adoption of measures and policies for the development of response strategies;
- Develop information systems on construction technologies and land-use planning tools;
- Introduce coastal adaptation technologies and conduct regular assessment on such technologies;

In addition, it would be appropriate to explore the feasibility of the application of climate scenarios generated by the GCMs and the application of relevant impact models specific to the country's conditions for various key socio-economic sectors; ecosystem and system level based analyses.

5.4.6 Disaster preparedness

The WMO/UNESCO sub-forum on science and technology in support of natural disaster reduction, held on 6-8 July 1999 in Geneva, highlighted the importance of capacity building for disaster preparedness. Awareness and capacity building, it was agreed, forms an essential part of any disaster preparedness programme. In the Seychelles, the following areas need to be addressed.

- Establish and/or strengthen disaster preparedness and management institutions and policies, including building codes and regulatory and enforcement systems, in order to mitigate, prepare for and respond to the increasing range and frequency of natural and environmental disasters and promote early warning systems and facilities for the rapid dissemination of information and warnings;

- Strengthen the capacity of local broadcasting to assist remote rural and outer island communities within the countries and among neighbouring countries during disaster events;
- Establish a national disaster emergency fund with joint private and public sector support for areas where insurance is not available in the commercial market, taking into account the relevant experience to be gained from the operation of similar funds;
- Integrate natural and environmental disaster policies into development planning processes and encourage the development and implementation of public and private sector pre- and post-disaster recovery plans drawing on the capacity of the United Nations Department of the Humanitarian Affairs;
- Strengthen cultural and traditional systems that improve the resilience of local communities to disaster events.
- Appropriate insurance for catastrophic risk.

5.4.7 Clean Development Mechanism (CDM)

Clean Development Mechanism is one of the three Kyoto Mechanisms that is of direct relevance to non-Annex I Parties. Its purpose is "...to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments..." (Article 12 of the Kyoto Protocol). Capacity building is needed in the following areas:

- Participation and negotiations in CDM and compliance mechanisms;
- CDM projects design, development, formulation and implementation;
- Mobilization and participation of private sector in CDM projects.

5.4.8 Education, training and public awareness

Under Article 6 (a) of the UNFCCC, Parties are required to promote and facilitate at national and, as appropriate, sub-regional and regional levels the following:

- Development and implementation of educational and public awareness programmes on climate change and its effects;
- Public access to information related to climate change and its impacts;

- Public participation in addressing climate change and its effects and developing adequate responses;
- Training of policy, scientific, technical and managerial personnel;
- Training of trainers (teachers).

Awareness of some local environmental issues, particularly in relation to tourism, fisheries and agricultural sectors, is relatively high in the Seychelles. The socio-ecological study conducted by the Indian Ocean Commission in 1996 suggested that over 50% of the Seychellois population has a fairly good understanding of the environment and the inter-relationships between its direct components, while 80% felt that pollution was the most serious environmental problem.

The major constraints to the development of formal education in climate change and development of public awareness strategies include:

- Lack of trained teachers;
- Lack of trainers and guest speakers;
- Limited availability of teaching aids;
- Lack of training in environmental studies and/or education and communication amongst the staff;
- Absence of long-term strategy for environmental education with clearly established national priorities;
- Absence of an effective advisory or planning body to guide the work of the section.

The short-term goal is therefore to generate greater awareness amongst the general public, the private sector and decision-makers of the known causes of climate change and actions needed to minimize it. The long-term objective would then be to develop a new generation of Seychellois that are prepared to meet the challenges offered by climate change, and are able to reduce societies contribution to climate change. In the event of negative impacts due to climate change, to prepare the population for such changes and to promote their participation

The specific capacity building needs in the implementation of Article 6 is highlighted in below:

- To develop a comprehensive public awareness strategy through the media and other appropriate avenues, focusing on climate change issues;
- Workshops for policy and decision-makers in the government, private and NGO sectors focusing on climate change issues and their implications for the Seychelles;

- The Ministry of Education to develop and implement a comprehensive environmental education curriculum covering climate change through the science, geography, and personal and social education curricula in primary, secondary and polytechnic education;
- The Ministry of Education to provide students with an opportunity to explore local, national, regional and global environmental issues in greater depth;
- More information about climate change being made available to the public through school libraries, public libraries and documentation centres;
- Public awareness and education strategies should be result-orientated and evaluated wherever possible.
- Scientific and technical training in various relevant fields, such as climatology, meteorology, atmospheric chemistry, physical oceanography, hydrology and economics of climate change;

The activities would include the following:

- Comprehensive research to establish the current level of awareness of climate change issues amongst the population;
- Audience research to establish the most cost-effective means of communication;
- Evaluate activities to establish the impact and outcome of the strategies adapted, and their relevance for future campaigns.

5.4.9 Sub-regional, regional and international collaborations and networking

Capacity building in the Seychelles and other small island states can be enhanced through sub-regional, regional and international collaboration and networking (this includes to state-of-the-art information technologies), so as to share experiences, success stories, as well as lessons learned.

Sub-regional and regional action plans should be developed where possible so that common actions can be taken to tackle the common problems. This would also optimise the available limited resources in the sub-region and region.

5.4.10 Participation in the UNFCCC and Kyoto Protocol processes

The paucity of human and financial resources makes it impossible for small island states to be as effective on the international fora and negotiations as they would like.

Given the fact that Island States are the first and the most affected victims of certain aspects of climate change, their presence and effective participation in the UNFCCC and the Kyoto Protocol processes is an indisputable priority. For all the Small Island Developing States, engaging effectively international and regional meetings is an enriching process of capacity building. Adequate financial resources must be provided to these countries for participating in the processes.

Most of the above needs have been highlighted by developing countries in Decision 10/CP.5 adopted in COP 5 held in 1999 in Bonn, Germany

Since COP 5, the UNDP and the Global Environment Facility (GEF) has undertaken a project entitled the “Capacity Development Initiative (CDI)”, under which a draft report on the “Assessment of Capacity Development Needs in the Context of the Priorities of SIDS” has been completed (Binger and Douglas, 2000). This report largely confirms the above capacity building needs generally faced by the SIDS.

The report also pointed out that “many SIDS simply do not have the professionals, institutional resources, financial means or systematic capacity to meet their international obligations without significant financial and technical support from the international community.”

5.5 Capacity Building through National Projects

Capacity building can also be achieved through the development and implementation of national projects of most relevance to the country. A total of six project concepts covering five thematic areas (see Section 5.6) are proposed, with a view to soliciting funding from the Financial Mechanism of the Convention and from the bilateral and multilateral agencies for their development, formulation and implementation.

These proposed projects aim to:

- a. Develop integrated coastal zone management, including the integration of climate change concerns into development planning, especially in land use and human settlement;
- b. Monitor the impact of climate change on fish stocks in Seychelles;
- c. Improve water resources management;
- d. Update the catalogue of the Seychelles mosquito species, and the control of mosquitoes and mosquito-borne diseases;
- e. Reduce the GHG emissions in various key socio-economic sectors through energy conservation and energy efficiency, as well as the promotion of renewable energy such as solar energy;

However, it is not possible to estimate the total and incremental costs for these proposed project concepts at this stage without any comprehensive project

development and preparation, which requires the participation of all relevant stakeholders in the country

All project concepts are regarded as important. However, the one on the integrated coastal zone management is regarded as the highest priority.

1. Thematic area: Coastal zone

Project concept No.1: *Integrated coastal zone management in the Seychelles*

Objective: To promote and implement Integrated Coastal Zone Management (ICZM), including land use planning and human settlement, taking climate change concerns into consideration

Activities:

- Establishing national and regional sea level and sea surface temperature monitoring network;
- Monitoring of coastal sea-circulation and coastal erosion;
- Assessment organic carbon accumulation in surface coastal sediment;
- Monitoring of changes in plankton;
- Monitoring of benthic communities of coral reef ecosystem;
- Improvement of coastal planning and enforcement;
- Assessment of the impact of tourism;
- Disaster preparedness – strategies and measures; hazard analysis; insurance and other sustainable financial mechanisms for reconstruction after disaster losses.
- Assessment of cost-effective adaptation options (policy and technical) for sea level rise;
- Economic and legal instruments for the protection of coastal zone.

Expected results:

- Greater understanding of the effects of changes in sea-temperature and sea-level by all relevant stakeholders in the region;
- Enhancement of sea level and sea surface temperature data-bank;
- Effective application of best practices of adaptation options.

- Risk cover against disaster available and affordable;
- Legislation for achievement of a strong and effective insurance regulation with broader coverage for residential and commercial properties;
- Institutional strengthening of infrastructure for disaster mitigation;
- System in place to ensure the availability of reconstruction financing following a natural disaster;
- Legislation adopted for the protection of coastal zone.
- Effective enforcement of land disaster plan/measures;
- Standards for infrastructure and housing established.

2. Thematic Area: Fisheries

Project concept No.2: *Monitoring and assessment of the effects of climate change on fisheries in the Seychelles*

Objective: Monitoring and assessment of the effects of climate change on the fish stocks within the Seychelles economic zone.

Activities:

- Seychelles Fishing Authority (SFA) to set up a unit with qualified technicians to monitor sea-surface temperature;
- Re-enforcement of the coral reef monitoring;
- Regular assessment of fish stocks.

Expected results:

- Establishment of linkages between sea-surface temperature and the quantity of fish stocks.

3. Thematic Area: Water Resources

Project concept No.3: *Water resources management in the Seychelles in the light of extreme events such as prolonged draught*

Objective: To ensure adequate fresh water to meet demand in the light of extreme events such as prolonged draught.

Activities:

- Preparation of a water management plan for outer islands.
- Introduction and enforcement of legislation related to measures for water conservation, such as to include water tanks on new housing and industrial infrastructure;
- Training of public Utilities Corporation (PUC) technicians in water supply and demand management;
- Monitoring of underground water table (especially for outer islands) and effective management and preservation of important catchments areas.

Expected results:

- Effective management of water resources.
- Adequate supply of fresh water for all householders.

4. Thematic Area: Human Health

Project concept No.4: Updating the catalogue of the Seychelles mosquito species, and the control of mosquitoes and mosquito-borne diseases.

Objective: To produce an up-to-date catalogue of the Seychelles mosquito species and their distribution, and to significantly reduce their densities to such a level that it will not pose a threat to public health.

Activities:

- Engagement of an entomologist to develop for a scientifically based programme to catalogue the mosquito species and their distribution in all inhabited islands, with Aldabra and Assumption as the starting point, as these two islands had an epidemic of malaria in 1930;
- The design of an effective mosquito control programme.

Expected results:

- An updated catalogue of mosquitoes in the Seychelles;
- An effective monitoring of climate change on mosquito propagation;
- Initiation of a good control programme at district/community level;
- A full database of disease vectors in the Seychelles.

5. Thematic area: Reduction in GHG emissions

Project concept No.5: Barriers removal for energy conservation, energy efficiency and the promotion of renewable energy for residential, commercial and industrial sectors

Objectives: To promote energy conservation and energy efficiency, and the use of renewable energy (e.g., solar) for residential, commercial and industrial sectors.

Activities:

- Identification and removal of barriers for energy conservation and energy efficiency, as well as for the promotion of renewable energy such as solar energy for residential, commercial and industrial sectors;
- Public awareness campaigns on energy conservation and energy efficiency: means and measures;
- Setting energy efficient measures/standards in building designs by 2005;
- Encouraging wider use of photovoltaic cells; through demonstrating projects, such as the installation of photovoltaic panels on rooftop of public buildings to generate electricity;
- Economic incentives strategy to promote clean and efficient technologies in industry (e.g. fluorescent lamps, energy efficient air conditioning).

Expected Results:

- Significant saving in energy consumption in residential, commercial and industrial sectors;
- Increase in the use of renewable energy especially on outer islands;
- Increase in the use of alternative energy supply.

Project concept No.6: Improvement of transportation system in the Seychelles

Objective: To improve existing transportation system and to promote the use of alternative "clean" modes of transportation.

Activities:

- Traffic Management Scheme to spread out the rush hour;
- Setting emission standards for vehicles (Air Care);

- Equipping traffic police with appropriate tools to enforce emission standards;
- Upgrading the bus fleet of the Seychelles Public Transport Corporation (SPTC) to improve service and fleet management;
- Studying the feasibility of introducing electric train or tram along the East Coast;
- Conducting the feasibility study through pilot projects on the use of alternative sources of energy for private and/or public vehicles e.g. Compressed Natural Gas (CNG) or Liquid Petroleum Gas (LPG). The pilot project could be initiated for either Praslin or la Digue Islands;
- Review of present economic instruments such as fuel taxes, mandatory vehicle testing, subsidies for public transport, road taxes, movement of Heavy Duty Vehicle (HDV), emission standards, etc;
- Programme of education and sensitisation to private owners to maintain and service their vehicles, to maximize KM/litre of fuel.

Expected results:

- More efficient public transport system;
- Decrease in emissions of GHG from vehicles;
- Public awareness of the environmental impact of emission from vehicles.

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Mr. Raymond De Silva	Ministry of Tourism and Civil Aviation
Mr. Chung-Faye	Seychelles Chamber of Commerce and Industry
Ms. Vivienne Fock-Tave	Division of Economic Planning
Mr. Antoine Charlette	Department of Internal Affairs, Police Force
Mr. Nirmal Jivan Shah	BirdLife Seychelles
Mr. Francis Coeur-de-Lion	Ministry of Land Use and Habitat
Mr. Lindsay Chong-Seng	Seychelles Islands Foundation
Mr. Andrew Jean-Louis	Ministry of Industry & International Business
Mr Rondolph Payet	Seychelles Fishing Authority

Past members:

Mr. Luc Chang-Ko	Former Co-Chairman
Mr Francis Marsac	Former Member
Mr Peter Sinon	Former Member
Ms Belinda Micock	Former Member

The updated list of members and their contacts will also be available on our website:
www.seychelles.net/meteo

Annex 2: List of Abbreviations and Acronyms

AAGR	Annual Average Growth Rate	SBS	Seychelles Bureau of Standards
AMSL	Above Mean Sea Level	SBSTA	Subsidiary Body for Scientific and Technical Advice
AOSIS	Alliance of Small Island States	SEPEC	Seychelles Petroleum Company Ltd
ASLR	Accelerated Sea-Level rise	SIDS	Small Island Developing States
BAPoA	Barbados Programme of Action	SLR	Sea-Level-Rise
CDM	Clean Development Mechanism	SPTC	Seychelles Public Transport Corporation
CEF	Carbon Emission Factor	SWAC	Solid Waste Agency
CFCs	Chlorofluorocarbons	SWH	Solar Water Heater
CFL	Compact Fluorescent Lamp	TJ	Terra Joules
CH ₄	Methane	toe	Tonne of Oil Equivalent
CISTID	Centre for Industrial Scientific and Technical Information and Documentation	TSSD	Technology Support Services Division
CO	Carbon Monoxide	TTI	Trade Tax Import Division
CO ₂	Carbon Dioxide	UNCED	United Nations Conference on Environment and Development
COMESA	Common Market of Eastern and Southern Africa	UN-DHA	United Nations Department of Humanitarian Affairs
COP	Conference of Parties	UNDP	United Nations Development Programme
CTI	Climate Technology Initiative	UNEP	United Nations Environment Programme
CZMP	Coastal Zone Management Planning		UNESCO United Nations Educational, Scientific and Cultural Organization
DOE	Division of Environment	UNFCCC	United Nations Framework Convention on Climate Change
EEZ	Exclusive Economic Zone	USCSP	United States Country Studies Program
EMPS	Environment Management Plan of Seychelles	USTS	United States Tracking Station
ENSO	El Niño Southern Oscillation	VA	Vulnerability Analysis
EnviRO	Environment Research and Oceans	WCED	World Commission on Environment and Development
FCS	Fraction of Carbon Stored	WHO	World Health Organization
FPI	Food Production Index	WMO	World Meteorological Organization
GCMs	General Circulation Models	WTO	World Trade Organization
GDP	Gross Domestic product		
GEF	Global Environment Facility		
GHG	Greenhouse Gas		
GOS	Government of Seychelles		
GWh	Giga Watt hour		
HDI	Human Development Index		
HFO	Heavy Fuel Oil		
ICZM	Integrated Coastal Zone Management		
IDC	Island Development Company Ltd.		
IDNDR	International Decade of Natural Disaster Reduction		
IOC	Indian Ocean Commission		
IOR	Indian Ocean Rim		
IPCC	Intergovernmental panel on Climate Change		
ISIC	International Standard Industrial Classification		
ITCZ	Inter-Tropical Convergence Zone		
km	kilometres		
ktoe	Kilo Tonnes of Oil Equivalent		
LPG	Liquid Petroleum Gas		
LUCF	Land Use and Climate Change		
MAM	Ministry of Administration and Manpower		
MAMR	Ministry of Agriculture and Marine Resources		
MIBB	Ministry of Industry and International Business		
MISD	Management Information System Division		
MW	Megawatts		
N ₂ O	Nitrous Oxide		
NAPCC	National Action Plan for Climate Change		
NCC	National Climate Committee		
NCCC	National Climate Change Committee		
NGO	Non-Governmental Organization		
NMVOV	Non-Methane Volatile Organic compound		
NO _x	Nitrogen Oxides		
ODA	Overseas Development Administration		
PAT	<i>Plan d'Aménagement du Territoire</i>		
PGES	<i>Plan de Gestion de l'Environnement de Seychelles</i>		
PSA	Power Station A		
PSB	Power Station B		
PSC	Power Station C		
PSIP	Public Sector Investment Programme		
PUC	Public Utilities Corporation		
SADC	Southern African Development Community		
SBI	Subsidiary Body for Implementation		

