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Protecting and enhancing the livelihoods, environments and economies of the Caribbean Basin

THE CARIBSAVE CLIMATE CHANGE RISK ATLAS (CCCRA)

Climate Change Risk Profile for Saint Lucia

Prepared by The CARIBSAVE Partnership with funding from
UKaid from the Department for International Development (DFID) and the
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Caribbean Climate Change & Livelihoods: A sectoral approach to vulnerability and resilience

Water, Energy, Biodiversity, Tourism, Agriculture, Human Health, Infrastructure and Settlement, Gender, Comprehensive Disaster Management

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PROJECT BACKGROUND AND APPROACH

Contribution to climate change knowledge and understanding

Climate change is a serious and substantial threat to the economies of Caribbean nations, the livelihoods of communities and the environments and infrastructure across the region. The CARIBSAVE Climate Change Risk Atlas (CCCRA) Phase I, funded by the UK Department for International Development (DFID/UKaid) and the Australian Agency for International Development (AusAID), was conducted from 2009 – 2011 and successfully used evidence-based, inter-sectoral approaches to examine climate change risks, vulnerabilities and adaptive capacities; and develop pragmatic response strategies to reduce vulnerability and enhance resilience in 15 countries across the Caribbean (*Anguilla, Antigua & Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Grenada, Jamaica, Nevis, Saint Lucia, St. Kitts, St. Vincent & the Grenadines, Suriname and the Turks & Caicos Islands*).

The primary basis of the CCCRA work is the detailed climate modelling projections done for each country under three scenarios: A2, A1B and B1. Climate models have demonstrable skill in reproducing the large scale characteristics of the global climate dynamics; and a combination of multiple Global Climate Model (GCM) and downscaled Regional Climate Model (RCM) projections was used in the investigation of climatic changes for all 15 countries. RCMs simulate the climate at a finer spatial scale over a small area, like a country, acting to 'downscale' the GCM projections and provide a better physical representation of the local climate of that area. As such, changes in the dynamic climate processes at a national or community scale can be projected.

SRES storylines and scenario families used for calculating future greenhouse gas and other pollutant emissions

Storyline and scenario family	Description
A2	A very heterogeneous world; self reliance; preservation of local identities; continuously increasing global population; economic growth is regionally oriented and per capita economic growth and technological change are slower than in other storylines.
A1B	The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The three A1 groups are distinguished by their technological emphasis. A1B is balanced across all sources - not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.
B1	A convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

(Source: Adapted from the IPCC Special Report on Emissions Scenarios, 2000)

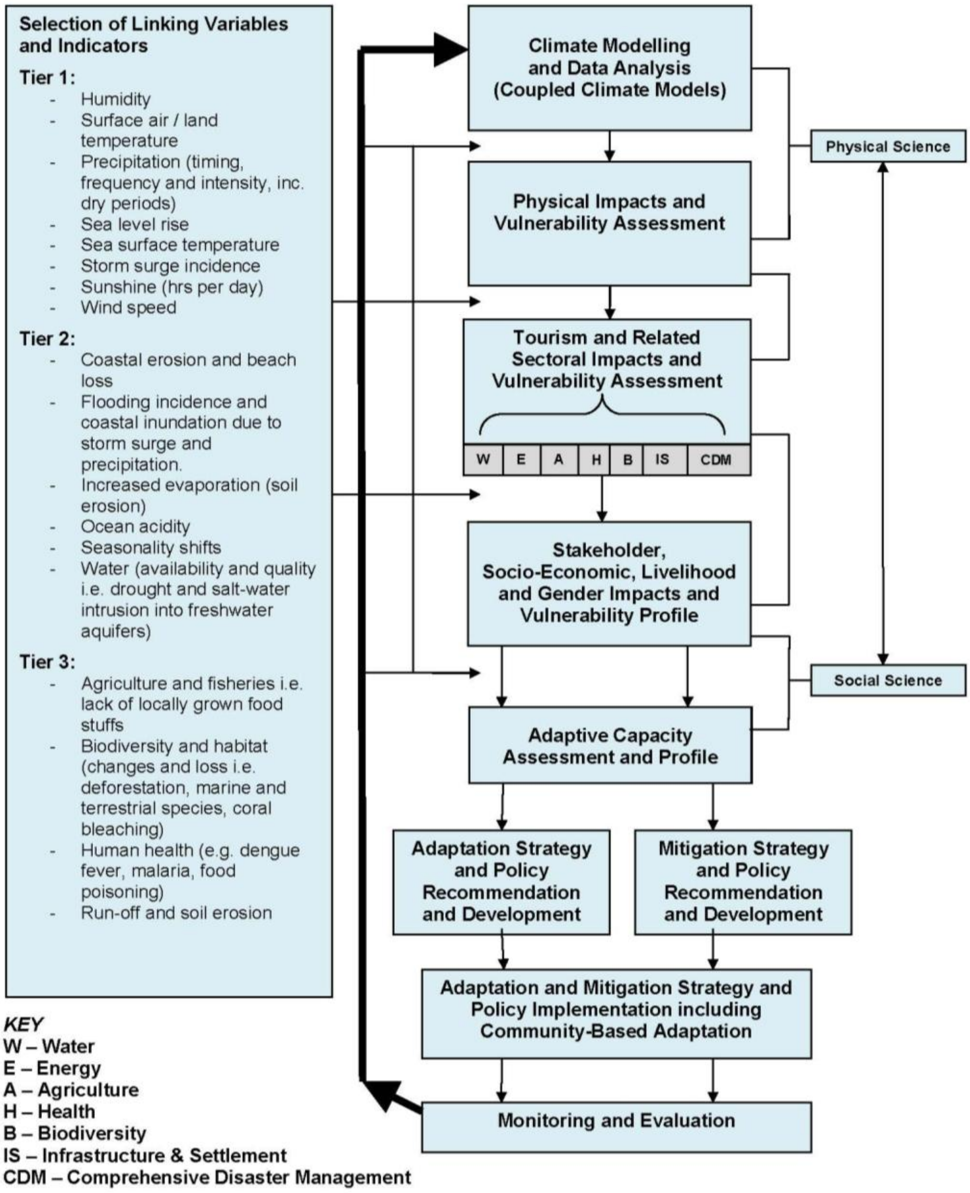
The CCCRA provides robust and meaningful new work in the key sectors and focal areas of: Community Livelihoods, Gender, Poverty and Development; Agriculture and Food security; Energy; Water Quality and Availability; Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements; Comprehensive Disaster Management; Human Health; and Marine and Terrestrial Biodiversity and Fisheries. This work was conducted through the lens of the tourism sector; the most significant socio-economic sector to the livelihoods, national economies and environments of the Caribbean and its' people.

The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change, coastal management methods and community resilience. Having been completed for 15 countries in the Caribbean Basin, this work allows for inter-regional and cross-regional comparisons leading to lesson learning and skills transfer.

A further very important aspect of the CCCRA is the democratisation of climate change science. This was conducted through targeted awareness, tools (e.g. data visualisation, GIS imagery, animated projections and short films), and participatory approaches (workshops and vulnerability mapping) to improve stakeholder knowledge and understanding of what climate change means for them. Three short films, in high-resolution format of broadcast quality, are some of the key outputs. These films are part of the *Partnerships for Resilience* series and include: '*Climate Change and Tourism*'; '*Caribbean Fish Sanctuaries*'; and '*Living Shorelines*'. They are available at www.youtube.com/Caribsave.

Project approach to enhancing resilience and building capacity to respond to climate change across the Caribbean

Processes and outputs from the CCCRA bridge the gap between the public and private sectors and communities; and their efforts to address both the physical and socio-economic impacts of climate change, allowing them to better determine how current practices (which in fact are not isolated in one sector alone) and capacities must be enhanced. The stages of the CCCRA country profile protocol (see Flow Chart on following page) are as follows: a) Climate Modelling and Data Analysis (including analysis of key 'Tier 1' climate variables linking the climate modelling to physical impacts and vulnerabilities) b) Physical Impacts and Vulnerability Assessment c) Tourism and Related Sector Vulnerability Assessments (including examination of the sectors of water, energy, agriculture, biodiversity, health, infrastructure and settlement, and comprehensive disaster management) d) Development of Vulnerability Profile with stakeholders taking account of socio-economic, livelihood and gender impacts (including evaluation of 'Tier 2' linking variables and indicators such as coastal inundation) e) Adaptive Capacity Assessment and Profiling f) Development of Adaptation and Mitigation Strategies and Policy Recommendations (action planning). The final stages depicted in the flow chart focusing on the implementation of policies and strategies at ministerial/government level and the implementation of actions at community level, using a community-based adaptation approach, are proposed to be implemented as part of the forthcoming CCCRA process as projects to be funded by other donors post the country profile stage.



CCCRA Profiling Flow Chart

The work of the CCCRA is consistent with the needs of Caribbean Small Island and Coastal Developing States identified in the document, "*Climate Change and the Caribbean: A Regional Framework for Development Resilient to Climate Change (2009-2015)*", published by the Caribbean Community Climate Change Centre (CCCCC); and supports each of the key strategies outlined in the framework's Regional Implementation Plan.

The CCCRA continues to provide assistance to the governments, communities and the private sector of the Caribbean at the local destination level and at national level through its primary outputs for each of the 15 participating countries: National Climate Change Risk Profiles; Summary Documents; and high-resolution maps showing sea level rise and storm surge projections under various scenarios for vulnerable coastal areas. It is anticipated that this approach will be replicated in other destinations and countries across the Caribbean Basin.

The CCCRA explored recent and future changes in climate in each of the 15 countries using a combination of observations and climate model projections. Despite the limitations that exist with regards to climate modelling and the attribution of present conditions to climate change, this information provides very useful indications of the changes in the characteristics of climate and impacts on socio-economic sectors. Consequently, decision makers should adopt a precautionary approach and ensure that measures are taken to increase the resilience of economies, businesses and communities to climate-related hazards.

This report was created through an extensive desk research, participatory workshops, fieldwork, surveys and analyses with a wide range of public and private sector, and local stakeholders over 18 months.

LIST OF ABBREVIATIONS AND ACRONYMS

ACP ------------------- Africa, Caribbean and Pacific Regions
AGIL ------------------ Banana Commercialisation and Agricultural Diversification in Saint Lucia
AOSIS ---------------- Alliance of Small Island States
APD------------------- Air Passenger Duty
AR4 ------------------- Fourth Assessment Report
ASTER --------------- Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ------------------ Business as usual
CAD------------------- Caribbean Application Document
CANARI -------------- Caribbean Natural Resource Institute
CARDI ---------------- Caribbean Agricultural Research Development Institute
CAREC --------------- Caribbean Epidemiology Centre
CARICOM ----------- Caribbean Community
CATHALAC ---------- Water Centre for the Humid Tropics of Latin America & the Caribbean
CAWASA ------------ Caribbean Water and Sewerage Association Inc.
CBD------------------- Convention on Biological Diversity
CCCRA --------------- CARIBSAVE Climate Change Risk Atlas
CCD------------------- Convention to Combat Desertification
CCRIF----------------- Caribbean Catastrophe Risk Insurance Facility
CDEMA -------------- Caribbean Disaster Emergency Management Agency
CDM------------------ Comprehensive Disaster Management
CEHI ----------------- Caribbean Environmental Health Institute
CFP ------------------- Ciguatera Fish Poisoning
CITES ----------------- Convention on International Trade of Endangered Species of Wild Fauna and Flora
COP------------------- Conference of Parties
CPU------------------- Central Planning Unit
CRFM ---------------- Caribbean Regional Fisheries Management
CROSQ --------------- Caribbean Regional Organisation for Standards and Quality
CTO------------------- Caribbean Tourism Organization
CUBiC ---------------- Caribbean Uniform Building Code
CZM ----------------- Coastal Zone Management
CZMU --------------- Saint Lucian Coastal Zone Management Unit
DANA ---------------- Damage and Needs Assessment
DFID ------------------ Department for International Development
DJF-------------------- December, January, February
DOA ----------------- Department of Agriculture
DOF ------------------ Department of Forestry
DREF ----------------- Disaster Relief Emergency Fund
DRM------------------ Disaster Risk Management
DRR------------------- Disaster Risk Reduction
ECLAC---------------- United Nations Economic Commission for Latin America and the Caribbean
EIA -------------------- Environmental Impact Assessment
ENSO ---------------- El Niño Southern Oscillation
EOC------------------- Emergency Operations Centre
ETS-------------------- Emissions Trading Scheme
EU--------------------- European Union
EWS ------------------ Early Warning Systems
FAO------------------- Food and Agriculture Organization
GCM ----------------- General Circulation Model
GCP------------------- Ground Control Point
GDEM---------------- Global Digital Elevation Model

GDP ------------------ Gross Domestic Product
GHG ------------------ Greenhouse Gas
GIS -------------------- Geographic Information Systems
HFA ------------------- Hyogo Framework for Action
IATA ----------------- International Air Transport Association
ICC -------------------- International Code Council
IDA ------------------- International Development Association (World Bank)
IDB -------------------- Inter-American Development Bank
IICA ------------------ Inter-American Institute for Cooperation on Agriculture
INSMET -------------- Meteorological Institute of the Republic of Cuba
IPCC ------------------ Intergovernmental Panel on Climate Change
ISDR ------------------ International Strategy for Disaster Reduction
IUCN ----------------- International Union for Conservation of Nature
IVM ------------------- Integrated Vector Management
JICA ------------------- Japan International Cooperation Agency
JJA -------------------- June, July, August
MAFF ---------------- Ministry of Agriculture, Forestry and Fisheries
MAM ----------------- March, April, May
MDG ----------------- Millennium Development Goals
MEA ------------------ Multilateral Environmental Agreement
MEAEPND ---------- Ministry of Economic Affairs, Economic Planning and National Development
MOH ---------------- Ministry of Health
MPA ------------------ Marine Protected Area
MPDEH ------------- Ministry of Physical Development, Environment and Housing
NAFTA --------------- North American Free Trade Area
NASA ----------------- National Aeronautics and Space Administration
NBSAP --------------- National Biodiversity Strategic Action Plan
NCCC ----------------- National Climate Change Committee
NEMAC -------------- National Emergency Management Advisory Committee
NEMO ---------------- National Emergency Management Organisation
NWSC --------------- National Water and Sewerage Commission
OECS ---------------- Organisation of Eastern Caribbean States
PAHO ---------------- Pan-American Health Organization
PPCR ----------------- Pilot Program for Climate Resilience
RH -------------------- Relative Humidity
RNAT ----------------- Rapid Needs Assessment Team
RRI ------------------- Reefs at Risk Index
SALT ------------------ Sloping Agricultural Land Technology
SCF ------------------- Strategic Climate Fund
SIDS ------------------ Small Island Developing States
SLBS ------------------ Saint Lucia Bureau of Standards
SLR ------------------- Sea Level Rise
SMMA --------------- Soufriere Marine Management Area
SON ------------------ September, October, November
SPCR ------------------ Strategic Plan for Climate Resilience
SST -------------------- Sea Surface Temperature
TIN -------------------- Triangular Irregular Network
UKERC --------------- UK Energy Research Centre
UN Women --------- UN Entity for Gender Equality and the Empowerment of Women
UN -------------------- United Nations
UNCCD --------------- United Nations Convention to Combat Desertification
UNDP ---------------- United Nations Development Programme
UNEP ----------------- United Nations Environment Programme
UNESCO ------------ United Nations Educational, Scientific and Cultural Organization

UNFCCC ------------- United Nations Framework Convention on Climate Change
UNIFEM ------------- United Nations Fund for Women
UNWTO ------------- United Nations World Tourism Organisation
USACE --------------- United States Army Corps of Engineers
USAID---------------- United States for International Development
UWI ------------------ University of the West Indies
VAT------------------- Value Added Tax
WASA --------------- Water and Sewerage Authority *(predecessor)*
WASCO ------------- Water and Sewage Company Limited
WCMC--------------- World Conservation Monitoring Centre
WEF ------------------ World Economic Forum
WHO ----------------- World Health Organization
WRMA -------------- Water Resource Management Agency
WTO------------------ World Tourism Organization
WTTC ---------------- World Travel and Tourism Council
WWTS --------------- Waste Water Wetland Treatment Systems

EXECUTIVE SUMMARY

A practical evidence-based approach to building resilience and capacity to address the challenges of climate change in the Caribbean

Climate change is a serious and substantial threat to the economies of Caribbean nations, the livelihoods of communities and the environments and infrastructure across the region. The CARIBSAVE Climate Change Risk Atlas (CCCRA) Phase I, funded by the UK Department for International Development (DFID/UKaid) and the Australian Agency for International Development (AusAID), was conducted from 2009 – 2011 and successfully used evidence-based, inter-sectoral approaches to examine climate change risks, vulnerabilities and adaptive capacities; and develop pragmatic response strategies to reduce vulnerability and enhance resilience in 15 countries across the Caribbean (*Anguilla, Antigua & Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Grenada, Jamaica, Nevis, Saint Lucia, St. Kitts, St. Vincent & the Grenadines, Suriname and the Turks & Caicos Islands*).

The CCCRA provides robust and meaningful new work in the key sectors and focal areas of: Community Livelihoods, Gender, Poverty and Development; Agriculture and Food security; Energy; Water Quality and Availability; Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements; Comprehensive Disaster Management; Human Health; and Marine and Terrestrial Biodiversity and Fisheries. This work was conducted through the lens of the tourism sector; the most significant socio-economic sector to the livelihoods, national economies and environments of the Caribbean and its' people.

SELECTED POLICY POINTS

- Regional Climate Models, downscaled to national level in the Risk Atlas, have provided projections for Caribbean SIDS and coastal states with enough confidence to support decision-making for immediate adaptive action.
- Planned adaptation must be an absolute priority. New science and observations should be incorporated into existing sustainable development efforts.
- Economic investment and livelihoods, particularly those related to tourism, in the coastal zone of Caribbean countries are at risk from sea level rise and storm surge impacts. These risks can encourage innovative alternatives to the way of doing business and mainstreaming of disaster risk reduction across many areas of policy and practice.
- Climate change adaptation will come at a cost but the financial and human costs of inaction will be much greater.
- Tourism is the main economic driver in the Caribbean. Primary and secondary climate change impacts on this sector must both be considered seriously. Climate change is affecting related sectors such as health, agriculture, biodiversity and water resources that in turn impact on tourism resources and revenue in ways that are comparable to direct impacts on tourism alone.
- Continued learning is a necessary part of adaptation and building resilience and capacity. There are many areas in which action can and must be taken immediately.
- Learning from past experiences and applying new knowledge is essential in order to avoid maladaptation and further losses.

Overview of Climate Change Issues in Saint Lucia

Saint Lucia is already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events, as well as more subtle changes in temperatures and rainfall patterns.

Detailed climate modelling projections for Saint Lucia predict:

- an increase in average atmospheric temperature;
- reduced average annual rainfall;
- increased Sea Surface Temperatures (SST); and
- the potential for an increase in the intensity of tropical storms.

And the extent of such changes is expected to be worse than what is being experienced now.

To capture local experiences and observations; and to determine the risks to coastal properties and infrastructure, selected sites were extensively assessed. Primary data were collected and analysed to:

1. assess the vulnerability of the livelihoods of community residents in the Soufriere area to climate change; and
2. project sea level rise and storm surge impacts on Pigeon Island, Pigeon Causeway, Rodney Bay and Soufrière.

The sites were selected by national stakeholders and represent areas of the country which are important to the tourism sector and the economy as a whole, and are already experiencing adverse impacts from climate-related events.

Vulnerable community livelihoods

- With its many unique attractions, Soufrière is the "tourism capital" of Saint Lucia. However, it has one of the highest poverty rates in the country.
- After Hurricane Tomas, the cost of ground provisions, plantains and green bananas became very high, resulting in a shift in diets as people began to rely on rice and flour as staples.
- The cycle of poverty and vulnerability to climate change is very apparent in Soufrière.
- Adaptation interventions must also address poverty.

Vulnerable coastlines

- The areas of Pigeon Island, Pigeon Causeway, Rodney Bay and Soufrière have been identified as some of the most vulnerable to SLR and include notable resorts, ports and an airport that all lie within less than 6 m above sea level.
- 1 m SLR places 7% of the major tourism properties at risk, along with 50% of airports and 100% of the ports.
- 2 m SLR places 10% of major tourism resorts at risk.

Climate change effects are evident in the decline of some coastal tourism resources, but also in the socioeconomic sectors which support tourism, such as agriculture, water resources, health and biodiversity.

Climate Change Projections for Saint Lucia

The projections of *temperature, precipitation, sea surface temperatures;* and *tropical storms and hurricanes* for Saint Lucia are indicated in Box 1 and have been used in making expert judgements on the impacts on various socio-economic sectors and natural systems, and their further implications for the tourism industry.

Stakeholders consulted in the CCCRA have shared their experiences and understanding about climate-related events, and this was generally consistent with observational data.

Box 1: Climate Modelling Projections for Saint Lucia

Temperature: Regional Climate Models (RCMs) indicate increases ranging from 2.4˚C and 3.3˚C by the 2080s in higher emissions scenarios.

Precipitation: General Circulation Models (GCMs) indicate overall decreases in annual rainfall of -37 to +7 mm by 2080, with RCMs are indicating decreases between -11% and -32%.

Sea Surface Temperatures (SST): GCM project annual mean SST increases of +0.8 to 3˚C by 2080s.

Tropical Storms and Hurricanes: North Atlantic hurricanes and tropical storms appear to have increased in intensity over the last 30 years. Observed and projected increases in SSTs indicate potential for continuing increases in hurricane activity and model projections indicate that this may occur through increases in intensity of events but not necessarily through increases in frequency of storms.

Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements

Much of the coastal zone of Saint Lucia is characterised by high-density tourism and these areas already face pressure from natural forces (i.e. wind, waves, tides and currents) and human activities (i.e. beach sand removal and inappropriate construction of shoreline structures). Saint Lucia's beaches have been monitored since 1995 by the Fisheries Department, who measure the beach slope and width at regular intervals at numerous sites around the island. Beaches change from season to season and from year to year, but the underlying trend in many locations has been a loss of beaches due to accelerated erosion. The impacts of climate change, in particular SLR, will magnify these pressures and accelerate coastal erosion.

Figure 1: High Resolution Coastal Profile Surveying with GPS

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Ministry of Physical Development, Environment and Housing to complete detailed coastal profile surveying.

The areas of Pigeon Island, Pigeon Causeway, Rodney Bay and Soufrière have been identified as some of the most vulnerable to SLR and include notable resorts, ports and an airport that all lie within less than 6 m above sea level. Results of the surveys indicate that 1 m SLR places 7% of the major tourism properties at risk, along with 50% of airports and 100% of the ports in Saint Lucia. With a 2 m SLR, 10% of major tourism resorts will be impacted. Critical beach assets would be affected much earlier than the SLR-induced erosion damages to tourism infrastructure; indeed, once erosion is damaging tourism infrastructure, it means the beach, a vital tourism asset, has essentially disappeared! With 100 m of erosion, 30% of the major tourism resorts would be impacted and 53% of sea turtle nesting sites, a key tourism attraction, would be impacted.

The high resolution imagery provided by the techniques utilised in this project component is essential to assess the vulnerability of infrastructure and settlements to future SLR, but its ability to identify individual properties also makes it a very powerful risk communication tool. Having this information available for community / resort level dialogue on potential adaptation strategies is highly valuable. Results for the popular Sandals Grande resort area found that a 3.5 m flood scenario resulted in a total loss of more than 17,690 m^2 of beach area and an additional loss of 10,650 m^2 of land area (See Figure 2).

Figure 2: Total Land Loss, Sandals Grande, Saint Lucia

Similar results were found for The Landings resort in Rodney Bay and a 3.5 m flood scenario resulted in a total loss of more than 15,020 m^2 of beach area and an additional loss of 29,066 m^2 of land area (See Figure 3).

Figure 3: Sea Level Rise Vulnerability at The Landings in Rodney Bay

Table Table 1 identifies what tourism infrastructure would be at risk of inundation from a 0.5 and 1 m SLR scenario and to erosion of 50 and 100 m. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 7% of the major tourism properties at risk, with 10% at risk with a 2 m SLR.

Table 1: Impacts Associated with 1 m and 2 m SLR and 50 m and 100 m Beach Erosion in Saint Lucia

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Road Networks	Seaport Lands
SLR	1.0 m	7%	6%	50%	0%	100%
	2.0 m	10%	10%	50%	0%	100%
Erosion	50 m	2%	30%	-	-	-
	100 m	30%	53%	-	-	-

Even under a 0.5 m SLR, 90% of the highly valued beach at The Landings on Rodney Bay would be inundated, as would 52% of the beach at Sandals Grande in Rodney Bay. The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive that these beach areas along with the prevailing climate are the island's main tourism attractions.

Based on a mid-range scenario, Saint Lucia will incur annual losses between US $41 million in 2050 to over US $144 million in 2080. Capital costs are also high, with rebuild costs for tourist resorts damaged and inundated by SLR amounting to over US $134 million in 2050 up to US $315 million in 2080. Infrastructure critical to the tourism sector will also be impacted by SLR resulting in capital costs to rebuild an airport estimated to be between US $42 million by 2050 to US $98 million by 2080. Capital costs to rebuild ports are estimated to be between $57 million in 2050, to $132 million by 2080.

Adaptations to minimise vulnerabilities in Saint Lucia will require revisions to development plans and investment decisions especially since there are currently no institutional frameworks that require setbacks, nor that state what types of developments are permissible along particular areas of the coast. These considerations must be based on the best available information regarding the specific coastal infrastructure and eco-system resources along the coast, in addition to the resulting economic and non-market impacts.

Hard engineering structures such as dikes, levees, revetments and sea walls, can be used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. However, it is important to consider that, the capital investment needed for engineered protection is expensive.

When hard engineering is not possible or feasible, soft engineering methods which require naturally formed materials to control and redirect erosion processes should be considered. For example beaches, wetlands and dunes have natural buffering capacity which can help reduce the adverse impacts of SLR and storm surge. Through beach nourishment and wetland renewal programmes, the natural resilience of vulnerable areas against SLR impacts can be enhanced. Moreover, these adaptation approaches can simultaneously allow for natural coastal features to migrate inland, thereby minimising the environmental impacts that can occur with hard engineering protection.

The Government of Saint Lucia, through its continued commitment towards sustainable development and climate change adaptation, is working towards the development and implementation of the necessary mechanisms required for achieving sustainable development and climate resilience on the island. A key policy undertaken is the Saint Lucia National Climate Change Policy and Adaptation Policy and Plan, recognising the island's vulnerability to climate change and global warming, especially with regard to SLR. This policy aims to "foster and guide a national process of addressing the short, medium and long term effects of climate change in a coordinated, holistic and participatory manner"[i]. Consistent with this policy, SLR should be integrated in the design of all new coastal structures and the adaptive capacity of the tourism sector should be assessed so that specific interventions at the facility level can be implemented.

Community Livelihoods, Gender, Poverty and Development

More than 50 residents and workers from the town of Soufrière and surrounding communities [ii](in the District of Soufrière) on the west coast of Saint Lucia participated in CARIBSAVE's vulnerability assessment

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[i] MPDEH. (2001). Saint Lucia Initial National Communication to the United Nations Framework Convention on Climate Change. Castries: Government of Saint Lucia, Ministry of Physical Development, Environment and Housing.

[ii] In this report these areas are collectively referred to as "The community" or "The Soufrière community".

which included a vulnerability mapping exercise, focus-groups and household surveys which were developed according to a sustainable livelihoods framework. This research an understanding of: how the main tourism-related activities, including fishing, vending and other micro- and medium-sized commercial activities located along the coast and have been affected by climate-related events; the community's adaptive capacity and the complex factors that influence their livelihood choices; and the differences in the vulnerability of men and women.

Fishing and agriculture are significant contributors to the local economy and livelihoods of Soufrière residents but tourism is the mainstay of the district, employing the majority of the residents directly and indirectly (See Table 2).

Table 2: Natural Resources and Uses/Livelihoods in Soufrière, Saint Lucia

RESOURCE	USE / LIVELIHOOD
Land	Farming/Agriculture
Waterfalls	Tours Hikes (both locals and tourists)
Forests	Trails for hiking Tours (both locals and tourists)
Marine Biodiversity	Fisheries

Some of the main attractions include the Sulphur Springs and geothermal system, the Pitons and the Diamond waterfall, therefore branding Soufrière as the "tourism capital" of Saint Lucia. However, despite its prosperity in tourism, a recent report found that, between 2005 and 2006, Soufrière had one of the highest poverty rates in the country (42.5%).

Community Characteristics and Experiences

The community has some degree of awareness of climate change, although knowledge of concepts, details and perceptions of risks and impacts vary widely. Observations from community members include:

- the lack of distinction between the wet and dry seasons;
- fewer numbers in certain species of fauna;
- mangoes coming into season earlier than they did in the past, whereas citrus trees bear fruits later than normal; and
- coral bleaching.

Figure 4: Community residents creating a vulnerability map of Soufriere

The vulnerability of the community and the urgent need to improve adaptive capacity to climate change was no more evident than after Hurricane Tomas. In Saint Lucia, the district of Soufrière suffered the greatest losses and damage to housing stock, forests, agricultural holdings and marine fisheries resources; thereby affecting the livelihoods and well-being of residents who rely heavily on these resources.

The majority of farmers in Soufrière are male, so they were directly impacted by the damages to their farmlands. Women use streams and rivers for washing and obtaining water, but immediately after the storm, rivers were unsuitable for these uses. Many employed in tourism were also heavily impacted, since most of the tourism facilities were not operational for some time after the event. Community residents are now far more vigilant about extreme climate events compared to the laid-back approach that was taken in the past when warnings were issued. However, despite this, economic force some persons to continue practices that essentially place themselves and the community in danger, such as undermining the natural resource base that provide eco-system services in order to save money (e.g. cutting down trees to make coal as an alternative to gas, sand mining to build less sturdy houses instead of concrete). The viscous cycle of poverty and vulnerability is apparent as is the need for: awareness and education on linkages between eco-system health and disasters; and capacity building for alternative livelihoods.

It is important to note that some pre-existing conditions in the area contributed to the extent of the hurricane damage. Lack of proper drainage, which is a chronic issue, was indicated as an exacerbating factor for flooding and damage to roads – some of which ultimately collapsed. Following Hurricane Tomas, some roads were repaired temporarily to make them usable, however, residents remain concerned that unless the drainage issue is addressed, flooding will continue to affect the area and roads will be repeatedly damaged. Additionally, the cost of food (especially ground provisions, plantains and green bananas) became very high after the hurricane, resulting in a shift in diets as people began to rely on rice and flour as staples.

Given the extent of the damage to crops, the Ministry of Agriculture assisted farmers by providing subsidies and small grants (average EC $1,000) to help them to replant and to cover personal expenses. The international aid community was also strongly acknowledged for their rapid response to assist the country as a whole but for residents of Soufrière, non-governmental organisations, family and friends came to their aid and contributed to community recovery efforts.

Community-specific adaptation responses are important if they are to be successful and understanding the demographics of a community contributes greatly to determining the most suitable interventions. Our research shows that, on average, more men (56%) are the heads of their households when compared to women. However, more females are the heads of single-parent households (poor and non-poor) and poor women in particular have generally been found to bear more children than other more financially stable women. Men in general and male-headed households also have greater reserves and levels of support than women and female-headed households, apparently placing women (and the children they look after) at a clearly higher level of vulnerability. Despite this, women take the lead and are more involved in activities in the interest of community development.

With the regard to the aftermath of hurricane Tomas, women perceived their own experiences to be far more difficult than for the men. Some women and single mothers reportedly lost homes and many or all their possessions and mothers were unable to adequately provide for their children's school and home needs after the hurricane. One resident said: "*the women had to send the children back to school, so it was kind of hard, getting books, getting uniforms*".

Men, on the other hand, believe that they are the more vulnerable gender with regards to climate change impacts since the majority of farmers in Soufrière (and Saint Lucia on a whole) are male, so they were directly and severely impacted by the damages to their farmlands. An entrenched community norm is such that if a man is unable to support his family he is looked down upon. So affected farmers resorted to other means to cope by planting more short term crops while others sought employment elsewhere (e.g. as security guards).

With agriculture as a main activity and the repeated occurrences of flooding, land use planning and watershed management (in particular the protection of water catchments) should be priorities for Soufrière. It is also important to conduct hazard assessments for the area as this should inform land use planning to avoid development in vulnerable areas. Assessments should of course be participatory in nature and involve community members who could share invaluable information and garner wider support. An important factor which makes residents in Soufrière so vulnerable is poverty. As such, economic development in this area should be promoted and facilitated. This also addresses the problem of increasing urbanisation. Community members shared their concerns relating to the economic prospects for people living in rural areas and have identified the following as hindrances to their development. As such, interventions should seek to address these areas.

- Lack of access to markets for agricultural products
- Lack of access to technology for improved agricultural practices
- Lack of access to resources for purchasing land and technology

Additionally, the use of fruit trees instead of mahogany trees (which are currently used) for reforestation programmes will have the added benefit of supplying a source of food for subsistence and for sale. This could also support food processing enterprises and provide employment opportunities for community members, in which case, the capability for food processing should be explored. Overall the residents in Soufrière are fully aware of their vulnerabilities and desperately need them to be addressed. However it is unlikely that they can do this on their own at this time.

Agriculture and Food Security

Traditionally, the agricultural sector in Saint Lucia was heavily dependent on banana cultivation, which has been in a state of steady decline due to rising competition. This has serious implications for national food security because historically, the banana trade financed food imports and provided rural households with a steady source of income. Despite its contraction over the years, banana production remains central to the sector, occupying 48% of all cultivated land and accounting for 41.4% of gross agricultural output.

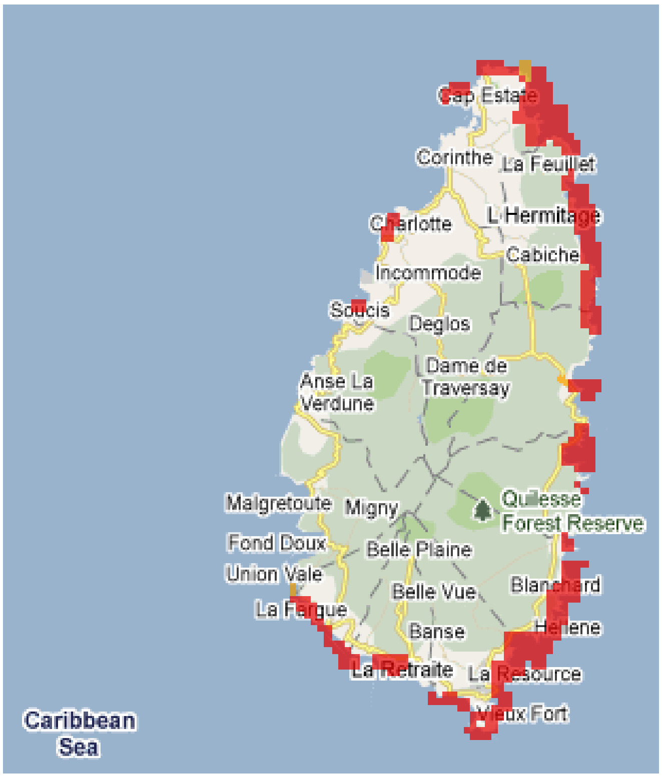


Figure 5: Areas of Over Fishing in Saint Lucia

(Source: IUCN and UNEP. 2009)

The agricultural sector exhibits high sensitivity to climate and is susceptible to extended periods of drought, unevenly distributed rainfall and natural disasters. The implications of climate change suggest worsening soil conditions, soil erosion and land degradation from flooding; and potentially increased crop loss due to high temperatures and changing rainfall patterns. Uncontrolled agricultural intensification, poor agricultural practices and the current trend of converting prime agricultural lands to other uses, exacerbate the vulnerability of this sector.

The prevalence of small-scale agriculture in Saint Lucia and the large number of ex-banana farmers who have limited experience in viable agricultural diversification hinders national efforts to adapt to environmental and climatic changes. Further, unlike most other Caribbean countries, Saint Lucia is recording a growing interest in very young and female farmers. However, there has been a marked decrease in able-bodied farmers between the ages of 20 to 34 years.

The social vulnerability of agricultural communities in Saint Lucia was dramatically exposed with the passing of Hurricane Tomas in October 2010. The event demonstrated that rural families in Saint Lucia are in fact largely vulnerable to extreme weather events. The United Nations Economic Commission for Latin America and the Caribbean (ECLAC) assessment of the damage and losses caused by Hurricane Tomas also suggests that women who are responsible for their households are at a distinct disadvantage because they are unable to earn an income or meet their family's food needs by subsistence farming after such an episode. Many women lost crops and land through land slippage and others lost their shops and the goods in them with the passage of the hurricane. Male farmers were also unable to farm in the weeks after the hurricane as their land was washed away, or they had no access to their farm lands because of blocked roads and damaged forest trails. These implications for the different genders are consistent with the findings in the CARIBSAVE community vulnerability and adaptive capacity assessment in Soufrière.

A review of the agricultural policies in Saint Lucia shows that the major provisions for the sector focus on agricultural diversification, enhancing food security and promoting competitiveness and do not specifically address climate change. It is also evident that farm level adaptive capacity for addressing climate change impacts is severely limited. A recent study found that farmers are mostly unaware of the type of soil of their farms, with a large share having no access to sustainable crop alternatives or to current agricultural technology. Saint Lucian farmers are therefore in dire need of climate change sensitisation and adaptation training to improve and increase agricultural outputs. Delivery of training courses should be farm-based, practical and should target organised groups such as female farmers, youth and farmers' associations based in agricultural districts. The Caribbean Agricultural Research and Development Institute (CARDI) has endorsed the Sloping Agricultural Land Technology (SALT) to control soil erosion in agricultural areas, help to restore soil structure and fertility and increase efficiency in food crop production. Training in such an area would be of great benefit to farmers in Saint Lucia.

Energy and Tourism

In the case of Saint Lucia, per capita emissions are currently considerably less than the global average (3.2 t CO_2 compared to 4.3 t CO_2). However, tourism is an increasingly significant sector in energy use and emissions of greenhouse gases in the Caribbean and estimates of current tourism related energy use in Saint Lucia put emissions at almost 70% of national emissions because tourism is a mainstay of the economy. Energy consumption in Saint Lucia has grown alongside economic and tourism growth, with diesel consumption increasing by 68% between 2002 and 2010 and aviation fuel use increasing by over 300% in the same period. Within the tourism sector, estimates show aviation (56%) and accommodation (20%) to be the biggest contributors to CO_2 emissions.

Since Saint Lucia currently depends almost entirely on fossil fuels for energy production, the potential physical climate change impacts on traditional energy systems are of critical concern. Impacts on the proposed renewable energy infrastructure should be also considered. The omission of these considerations in the current system means that the vulnerability of the energy sector remains a worry that is likely to have negative physical and financial impacts for the country.

An increase in the intensity of severe low pressure systems, such as hurricanes, has the potential to affect both traditional and renewable energy production and distribution infrastructure, including generating plants, transmission lines and pipelines, as experienced during Hurricane Tomas in 2010. Power generating stations and other major infrastructure located on the coastline are also highly vulnerable to damage from flooding and inundation resulting from SLR and storm surges. Temperature increases have been shown to reduce the efficiency of energy generation at thermal power plants and reduced precipitation may affect water availability for non-contact cooling of power generators.

Rising prices for fossil fuels and emerging climate policy will make the tourism sector in Saint Lucia increasingly vulnerable, in addition to climate change impacts that will threaten energy infrastructure. Specific targets have been set in the National Energy Policy for the reduction of demand as well as increasing capacity from renewable energy technologies (30% of capacity by 2030), thereby reducing fossil fuel imports and emissions. Geothermal, wind and solar energy are the main options being investigated.

The National Energy Policy has identified the tourism sector and hotels in particular, as potentially large consumers that will be required to conduct energy audits and based on the results, undertake energy efficiency initiatives to reduce their consumption. New resorts will also be mandated to use solar water heaters and energy product pricing has been identified as a key mechanism to address energy efficiency generally. The Saint Lucia Government has already determined that an energy efficiency building code will be developed that will ensure all new developments and commercial retrofits incorporate the appropriate technologies.

To support the initiatives outlined in this policy mechanisms are needed to engage stakeholders in tourism planning with regard to energy use and emissions. Without clear policy goals regarding energy use and emissions, as well as the communication and monitoring of these goals, it is unlikely that stakeholders will effect major changes in their operations. Consequently, measures ranging from regulation to market based instruments to incentives will have to be implemented.

Water Quality and Availability

Water supplies in Saint Lucia mainly come from surface run-off sources such as rivers, wetlands, streams and springs and these supplies are highly susceptible to climate variability and change. Also, five of the seven main rivers in Saint Lucia are at risk from contamination[iii] because of the unregulated development of riverbanks which has compromised the quality of water, with sediments, sewage (from pit latrines), agro-chemicals and the use of rivers for bathing and washing. Population growth, rapid urbanisation, conversion of forests on steep slopes (for banana plantation and other crops and for grazing) and developments in the tourism sector are further challenging the water resources management system to address supply and demand adequately. Moreover, water production costs are not reflected in the prices charged to consumers, leaving little incentive for water efficiency.

Table 3 shows the water demand in various sectors (2005), but the unaccounted water value is believed to be much higher now. The high water losses are due to a number of problems, among them being the mountainous terrain and long distances water has to be transported via aged infrastructure from water source to treatment plants and then finally to the consumers. The agricultural and industrial (construction and mining) sectors can also abstract water easily, with near limitless access to rivers.

[iii] MPDEH. (2006). GEO Saint Lucia 2006 State of the Environment Report. Castries: Sustainable Development and Environment Section, Ministry of Physical Development, Environment and Housing, Government of Saint Lucia

Table 3: Demand Distribution Among Sectors

Description	Percentage	Projected Percentage
	1987	2010
Domestic/minor commercial	48.6	53.0
Hotels	9.6	10.0
Government/Institutional	7.0	6.7
Industrial	2.5	5.3
New commercial	0	2.0
Unaccounted for water	32.3	23.0

(Source: Springer, 2005)

In the tourism sector, the water demand is concentrated in the north of the island. Saint Lucia has approximately 5,000-room capacity, however, the actual visitor arrivals is far higher, with some 982,764 visitors recorded in Saint Lucia in 2009 (mainly due to cruise ship arrivals).

With only one major water storage facility on the island, Saint Lucia is highly vulnerable in situations of lower than normal precipitation. During the wet season, heavy precipitation from storm events leads to flooding, with rivers prone to overflowing their banks. While efforts to address these issues have been employed via a National Water Policy, the policy does not support water conservation technologies, with the need for legislation to regulate and licence the abstraction of surface water to ensure future water supplies are of good quality and widespread availability. Another significant challenge is siltation because sedimentation and the inability of treatment plants to treat water after heavy rains means that some communities do not have access to water for as much as 3 to 4 days while plant operators wait for water turbidity in river courses to clear up.

During the dry season, water levels fall drastically, with aged infrastructure contributing to unequal water distribution problems, including limited or no access to water in some rural areas of the country. The dry season (December to April) coincides with a time when there is a high influx of tourists to the island, which increases demand on already limited water supplies. Saint Lucia most commonly experiences agricultural drought conditions, where the quantity and timing of rains throughout the growing season affects the value of outputs from dry land agricultural producers. However, rural areas are prone to water-stress as distribution to remote communities is unequal. To ameliorate this problem of chronic water shortages, a policy of water rationing has been implemented by WASCO to promote the conservation of water supplies.

Water and drought monitoring takes place across the island. Approximately 90% of the island uses meters, installed in 2006. Several of these meters were faulty and are currently being replaced with the hope of increasing the meter coverage and effectiveness on the island. Saint Lucia has a number of drought monitoring stations which are also rain monitoring stations. One of the ways that the Water and Sewerage Cooperation (WASCO) copes with water shortages is through the use of rationing and by issuing Drought Rationing Schedules stipulating the areas expected to be affected and the date and times when water will not be available.

Water resources in Saint Lucia are considered sufficient for current and projected demands but severe vulnerabilities clearly exist. Water infrastructure should be repaired and replaced to reduce vulnerability during drought events and after major storms and hurricanes. In particular, (i) water storage should be encouraged through incentives and every new building should have its own stored water storage infrastructure; (ii) the viability of additional storage facilities to supplement the John Compton Dam should be assessed, allowing improved access to potable water in different communities; and (iii) losses in water distribution should be reduced through pipe replacement. Robust land management policies should also be developed to reduce the discharge of pollutants including sediments, sewage and agro-chemicals into water systems.

Ground water sources should also be explored further to augment surface sources in times of drought. Public education in water resources should be also undertaken. In particular, communities and the population should be educated in conservation and treatment of water and the proper use of rainwater harvesting systems.

Springer (2005) has made three additional recommendations:

(a) Charging the full cost of water, including the cost of building and operating water supply systems.
(b) Reduce losses in distribution.
(c) Protect forests, watersheds and other eco-systems required to regulate and maintain water quality.

Comprehensive Natural Disaster Management

The geography and topography of Saint Lucia creates a diversity of natural hazards that have the potential to cause damage and loss, including flooding, landslides, hurricanes, earthquakes and volcanic eruptions. Changes in climate are likely to create more disasters as changes in seasonal precipitation cause more droughts, more heavy rainfall events and stronger storms.

Figure 6: Evidence of Landslides along Steep Slopes

In 2010, the impact of Hurricane Tomas reminded Saint Lucians of their vulnerability to natural hazards as flooding and high winds damaged many homes, roadways, bridges and public utilities. Damages to access roads to the main dam in Saint Lucia caused concerns for water supply and further damages to transportation posed challenges for the repair of damaged utility poles. The hurricane also had economic impacts in several sectors. As a result of interrupted service in the tourism sector, advisories were issued for travellers to the island to confirm electricity and water conditions at their hotels before departure. In addition, banana farmers lost 100% of their crops. Although Saint Lucia received financial assistance from the Caribbean Catastrophe Risk Insurance Facility (CCRIF), it will take time to fully recover from these impacts.

Figure 7: Flooding in Dennery from Hurricane Tomas

Source:http://www.djmrp.com/slu-crisis/slu-crisis-hurricane-tomas.htm

The historic development process of locating settlements near steep slopes and valleys puts many communities at risk to damage and loss. The long history of flooding and landslides in Saint Lucia has motivated the National Emergency Management Organization (NEMO) to produce hazard maps and therefore seek to reduce loss of lives and livelihoods.

NEMO leads the country's emergency management and hazard mitigation efforts with a mixture of policy and technological instruments. NEMO considers three types of hazard scenarios i) rapid onset (natural and manmade); ii) slow onset and iii) sink holes. The primary difference between these hazards is the timing of the impacts, which affects the ability of individuals and NEMO to respond. Hurricanes and tropical storms generate the conditions for both rapid and slow onset debris flows and landslides by bringing periods of sustained and/or intense rainfall. There is a strong understanding of comprehensive disaster management and a willingness to apply regional standards in Saint Lucia. Nevertheless, more effort is needed in the promotion of hazard mitigation plans throughout all of the sectors, especially within tourism and the general public.

Saint Lucia has experienced many debris flows in its history but the 1999 Black Mallet/Maynard Hill Landslide is one notable example where there were significant damages to this community south-east of Castries. As early as 1999 residents reported cracking in masonry walls but it was not until 2008 that 80,000 cubic metres of colluvial material flowed toward the river, destroying several concrete structures and rupturing public utility lines that served the communities. A few weeks later, another slippage 70 m higher on the slope caused debris to slide over Maynard Hill Road. Although many coastal areas of the country are at high risk of landslides, the area with the most extreme risk is in the Parish of Soufrière, an area with a growing population.

Figure 8: A collapsed road from Hurricane Tomas' torrential rains

Source: http://www.djmrp.com/slu-crisis/slu-crisis-hurricane-tomas.htm

NEMO has detailed many good efforts in this regard in their Landslide Response Plan (2008) and their acknowledgement of the need to include the community in planning and preparedness exercises will ensure that deaths from such events are kept to a minimum. In addition to this, the monitoring of deforestation and intensive agricultural practices on slopes is needed to minimise risks of landslide and down-slope impacts from the reduced soil stability. Furthermore, in urban and peri-urban areas, clearance of gutters and drainage canals is important for the control of the flow of rain water. NEMO acknowledges the need to conduct regular cleaning of these waterways. However, by educating the public on the link between the presence of debris and garbage and flooding, the risk can be reduced more effectively.

Major tourism developments in Saint Lucia are primarily located on the western coast near the capital of Castries. Tourism infrastructure is at great risk to increasing coastal erosion and rising sea levels will slowly inundate vital beach areas. In November 1999, surge damage in Saint Lucia associated with Hurricane Lenny was in excess of US $6 million, even though the storm was centred many kilometres offshore. Because much of the tourism infrastructure is near the coast, much of that damage was likely to the tourism and hospitality industry. As a result, extreme events threaten the safety and security of tourists and locals alike. Therefore, a Hospitality Industry Crisis Management Plan for Saint Lucia was developed in 1996 to provide an institutional mechanism for the management of disasters within the tourism and hospitality industry.

To address disaster management in the Caribbean tourism sector, CDEMA, with the support of the Inter-American Development Bank (IDB) and in collaboration with the Caribbean Tourism Organization (CTO), CARICOM Regional Organization for Standards and Quality and the University of the West Indies has implemented a Regional Disaster Risk Management (DRM) Project for Sustainable Tourism (The Regional Public Good) over the period of January 2007 to June 2010. The project aimed to reduce the Caribbean tourism sector's vulnerability to natural hazards through the development of a '*Regional DRM Framework for Tourism'*. Saint Lucia has much to offer in terms of beauty in the interior of the island so the diversification of tourism away from the vulnerable coast should be considered – bearing in mind that the interior has its own risks and vulnerabilities.

In recent years, Saint Lucia has experienced significant damages from climate-related events and disasters. As a result, the Government of Saint Lucia has acknowledged some areas that need improvement in the disaster management system and the importance of public awareness. The Strategic Programme for Climate Resilience (SPCR) released in June 2011 offers a few key initiatives that will build resilience in Saint Lucia to reduce vulnerability to current and future disasters. One of these projects is "Mainstreaming the Lessons of Hurricane Tomas and other Recent Climate Events" which should be as a matter of urgency. It also is a priority to build awareness and capacity in communities, especially those that are more remote, to reduce their vulnerability and enable them to respond in times of disasters. Through the use of Soca and Calypso music which have a tradition of telling stories and are still popular today, key messages can reach a wide range of persons. NEMO is already successfully using mobile phone technology to issue advisories and this should be continued.

Human Health

Health is an important issue in the tourism industry because tourists are susceptible to acquiring diseases as well as potential carriers of vector-borne diseases. Additionally, Saint Lucia's tropical climate makes it suitable for the transmission of a number of vector-borne diseases. The effects of climate-related phenomena on public health can be direct or indirect. The former includes weather related mortality and morbidity arising from natural disasters (e.g. hurricanes) and high temperatures (e.g. 'hot' days/nights). Indirect impacts are more extensive, including vector borne diseases such as dengue fever and malaria.

Saint Lucia's population is concentrated in the capital city of Castries, which is low-lying and consists of reclaimed land prone to flooding during heavy rainfall events. Also, because most of Saint Lucia's water resources come from surface sources such as rivers and streams, these are prone to flooding due to higher than normal volumes of water. During such events, the water intakes, dams and reservoirs may be damaged or more commonly become blocked due to debris. This can impact water distribution and lead to health problems such as dengue fever as mosquitoes breed in standing water. It also compromises water quality and may result in municipal supplies being disconnected for a period of time. Curiously, the potential implications for public health are similar to those experienced in drought conditions. Diarrheal illnesses, cholera, shigellosis, salmonella and gastroenteritis are still a concern in Saint Lucia and have been shown to be significantly associated with temperature and rainfall, as a reduction in domestic water supply can impact quality and the standards of sanitisation. This is so despite the fact that 98% of the population has access to piped-water in their houses. As a result of higher temperatures, it is expected that the population of Saint Lucia will be exposed to a higher incidence of heat and stress-related illnesses.

The adaptive capacity of the health sector is influenced by numerous factors, including institutions, government bodies, legislation and actions at the local, national and regional level. However, one of the most relevant issues that may be impacting health in Saint Lucia is poverty. In the last decade, various internal and external factors have affected the Saint Lucian economy, including high oil prices, trade liberalisation and high external debt, making the economy highly volatile. Limited financial resources will impair the ability of the Government to effectively address vulnerability and adaptation challenges that are presented in this sector.

The Saint Lucia National Climate Change Policy and Plan (2003) has as one of its broad policy objectives to 'foster the development of processes, plans, strategies and approaches to avoid or minimise the negative impact of climate change on human health'. In terms of managing vector borne diseases, limited financial resources or improper allocation of resources will impair the ability of the government to effectively address the challenges that are presented with dengue and malaria outbreaks. Positive areas to note in the health sector that add to its resilience include emergency services designed to help people cope with mental health and traumatic stress during times of disasters and associated disruptions (MOH, 2007) and provision of information for forecasting extreme heat events.

A greater focus on socio-economic issues is needed to isolate and therefore address underlying factors which exacerbate vulnerability to climate change and more research is required for the development of appropriate environmental, agricultural and trade policies so as to strengthen the resilience of the economy. Although existing national policies in Saint Lucia acknowledge the need to conduct further research on diseases and health, specific studies linking the epidemiology of diseases with climate change are recommended. For some diseases such as malaria and diarrhoea which are entirely preventable, education campaigns would be important providing both locals and tourists with continued information to ensure in sustainable disease prevention.

Marine and Terrestrial Biodiversity and Fisheries

Saint Lucia possesses a variety of eco-systems and biological species, including 1,436 vascular plants (1,147 of which are native) and 175 species of amphibians, birds, mammals and reptiles (157 of which are native). Saint Lucia's coastal and marine eco-systems also include 333 finfish coral reef and pelagic fish species and 3 species of marine turtles that belong to the global stock. The island's natural resources provide numerous goods and services in terms of food, water and agricultural products, the prevention of soil erosion, removal of environmental pollutants, maintenance of soil fertility and resources for recreation. Saint Lucia's forests, waterfalls and freshwater systems, beaches and coral reefs are also important as they provide the main attractions in the tourism industry. However, climate change and SLR threaten the beachscape and will continue to affect recreation activities as well as the livelihoods of those employed who depend on climate-sensitive natural resources if no or inadequate interventions are made.

Persistent heavy rainfall often results in massive landslides in Saint Lucia, as was recently experienced during Hurricane Tomas in 2010. As a result of Hurricane Tomas, approximately 54 km of forest trails were damaged, some of which were used as eco-tourism attractions and are still inaccessible to date. The repercussions on the livelihoods of those who were employed in forest trail tours have reportedly had weighty effects on their morale.

The cost of maintaining roads and trails across Saint Lucia's steep and rugged terrain will almost certainly increase with the projected acceleration of climate change and intensification of extreme weather events. This projected trend further justifies the strategic and economic importance of protecting and managing the integrity of the island's forests and watersheds.

Scuba diving is a popular activity among tourists, mostly occurring along the west coast of the island. A valuation study on coastal capital in Saint Lucia estimated that about 25% of tourists who visit the island do so at least in part for the coral reefs[iv]. Approximately 45,000 total dives and 95,000 snorkelers engaged in reef based activities during 2006. The combined direct and indirect expenditures, including accommodation, glass bottom boat/snorkelling trips, diving, MPA user fees and miscellaneous expenditures on reef-related tourism and recreation in that year was estimated to be between US $160 and $194 million (Table 4).

Table 4: Coral Reef Associated Tourism Economic Impact* for Saint Lucia

Expenditure Categories	($US million)
Accommodation	64.7
Reef recreation - diving	4.9
Reef Recreation – Snorkelling and glass-bottom boats	$0.8
Marine Park Revenues	$0.05
Miscellaneous Visitor Expenses	$21.2
Total Direct Impact	**$91.6**
Indirect economic impact (from multiplier)	$68 – 102
Total Direct and Indirect Impact	**$160 – 194**
Other Values	
Consumer Surplus	$2.2 – 2.4
Local use	52-109

*Not to be confused with climate change impacts. The evaluation by Burke *et al.* (2008) uses the term "impact" to describe the economic contribution of coastal resources. (Source: Burke *et al.*, 2008)

Coral reefs, especially those along the west coast, have long supported vibrant fisheries for Saint Lucian society and economy. Grunts, snappers, parrotfish and groupers are common species extracted from coral reefs and have been valued to between US $520,000 and US $841,000 annually[iv]. This strongly supports the protection of coastal and marine biodiversity.

Figure 9: health coral reefs in Soufriere

Source: SMMA

The healthiest reefs are found off the coast of Soufrière but the development of tourism in this area, a historically agricultural community, is increasing the pressures on those reefs. Furthermore Soufrière is at high risk to landslides and consequently its reefs are prone to sedimentation. Unfortunately, all 90 km of reefs around the island are at risk to human activities and the general trend shows that coral cover around Saint Lucia is on the decline while growth of macro-algae is increasing.

The fisheries sector is an important livelihood activity for many, employing over 2,300 fishers and some 120 fish processors[v]. Two weekly community fish festivals - Fish Fridays at Gros Islet and at Anse-La-Raye- are highly popular street parties among tourists and locals alike. These attractions feature a wide range of freshly caught seafood including octopus, conch, lobster, whelks and a variety of fish. The events support livelihood activities for cooks, vendors and entertainers.

[iv] Burke, L., Greenhalgh, S., Prager, D., & Cooper, E. (2008). Coastal Capital - Economic Valuation of Coral Reefs in Tobago and Saint Lucia. Washington, DC: World Resource Institute.

[v] FAO. (2007). Fishery Country Profile, Saint Lucia. Rome: Food and Agriculture Organization.

Unsustainable levels of harvest, illegal fishing methods, habitat degradation and sedimentation of coastal waters are threatening Saint Lucia's fisheries. Near shore fisheries are considered overfished while the pelagic fisheries are regarded as under-utilised. Degradation of coral reef and mangrove eco-systems, which are vital nursery areas for many commercial species, has also been detrimental to the status of fish stocks.

Climate change impacts on beaches will threaten the survival of species such as marine turtles, iguanas and shore birds. A 1 to 2 m SLR is predicted to damage 6-10% of turtle nesting sites on the island[vi]. More dramatic changes can occur to the beach profile during a single extreme weather event and although recovery occurs, it may not be to pre-hurricane conditions. During the 1990s, Saint Lucia's beaches appeared to be experiencing net erosion attributable to a series of tropical cyclones that affected that region. The frequency of events did not allow sufficient time for beaches to recover in between events. The reduced aesthetic appeal of beaches will mean reduced quality of one of the island's primary tourism attractions and visitor experience.

The long term effects of extreme events on mangrove stands are uncertain but will most likely mean a loss of the many essential services provided by this eco-system. Of particularly concern will be the reduced coastal erosion protection from lost and damaged mangroves. To address these issues, the management of the island's eco-systems must become central to government policy, since Saint Lucia's economy well-being depends on biologically diverse eco-systems. Greater biodiversity affords greater resilience to climate change and provides more options and opportunities for adaptation.

Climate change related variations in average daily temperature, seasonal precipitation and extreme weather events will exacerbate the effects of existing human stressors on forest eco-systems. Mount Gimie is the tallest peak in Saint Lucia rising to 959 m and grows a type of vegetation classified as cloud montane forest. These species require almost continual cloud coverage and are most vulnerable to climate change. Assuming a cooling rate of 1°C per 150 m of altitude, a projected increase of 1.7°C would require vegetative zones to migrate vertically by 260 m and up to 530 m in a 3.5°C scenario[vii].

The people of Saint Lucia recognise the importance of biological conservation and there is extensive awareness among the population as evinced by a number of successful community-participation management projects. The Government has also taken steps toward integrating biodiversity issues into the national agenda, with several inter-sectoral communities responsible for the over-sight of national legislation and international multilateral environmental agreements.

Adaptation strategies for biodiversity should take an eco-system based approach. This means that strategies should aim to enhance the quality of terrestrial and marine eco-systems, strengthen the linkages between habitats, resource users and resource managers and increase the size and number of protected areas. The tourism sector should be more engaged in biodiversity conservation and the management of protected areas since these resources are a critical component of the very product they promote.

[vi] Simpson, M. C., Scott, D., Harrison, M., Silver, N., O'Keeffe, E., Harrison, S., et al. (2010). Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean. Barbados: United Nations Development Programme.

[vii] Day, O. (2009). The impacts of climate change on biodiversity in Caribbean islands: what we know, what we need to know and building capacity for effective adaptation. Caribbean Natural Resources Institute (CANARI).

One means of strengthening the linkages between stakeholders and natural resources is by building capacity through education/awareness and empowering resource users to be environmental stewards. If the tourism sector, a significant consumer of natural resources, is to be sustainable, it must engage more actively in the conservation and management of protected areas. Planning and managing for resilient eco-systems and adapting to a dramatically changing climate must become a key priority for the Government of Saint Lucia. One mechanism which facilitates this is the Caribbean Fish Sanctuaries Partnership Fish Fund which was conceived by The CARIBSAVE Partnership as a sustainable financing mechanism to supplement existing funding particularly of those sanctuaries which demonstrate strong community involvement. Income will be generated from a variety of sources, including:

- Contributions on the sale of locally made crafts, eco-tourism tours and diving/snorkelling trips
- Donations from tourists and residents
- On-line micro donations from international supporters viewing website
- International and national institutional donors
- Donations from High Net Worth Individuals with interests in Saint Lucia

Conclusion

Saint Lucia has a strong dependence on the tourism industry and the many natural assets that enable tourism to be successful. The natural resources and biodiversity on the island, particularly terrestrial and marine eco-systems and water resources are already facing serious pressures from increasing development and poor land use practices. It is evident that the Government of Saint Lucia is committed to adapting to climate change. Many policies and plans for action are in place, but serious financial resource shortages along with limited technical capacities hinder the successful adaptation efforts across most government ministries and other stakeholder groups.

The CCCRA explored recent and future changes in climate in Saint Lucia using a combination of observations and climate model projections. Despite the limitations that exist with regards to climate modelling and the attribution of present conditions to climate change, this information provides very useful indications of the changes in the characteristics of climate and impacts on socio-economic sectors. Consequently, decision makers should adopt a precautionary approach and ensure that measures are taken to increase the resilience of economies, businesses and communities to climate-related hazards.

Saint Lucia has a history of damages and losses from natural disasters. Given climate change projections, preparedness for disasters and climate change adaption become common goals. There is a large percentage of vulnerable persons in Saint Lucia who are only too aware of the dangers of climate change. However, resource users with little or no awareness of alternative courses of action continue to degrade or over-extract from marine and terrestrial eco-systems and consequently increase their own vulnerability. Poorly planned land development and population expansion degrades habitats and increases the risk of damages from flooding. Climate-change driven impacts will pose even greater threats to eco-systems and populations in Saint Lucia as SLR, increased intensity of extreme weather events, oceanic and atmospheric temperature increases and altered patterns of precipitation interfere with their functions and livelihoods.

Considerations for gender, economic security and livelihood activities must be considered in this education plan as not all persons are affected equally and would consequently need to respond differently. Implementing the specific recommendations proposed for each sector can ensure a balanced approach to Saint Lucia achieving its vision for 2030.

1. GLOBAL AND NATIONAL CONTEXT

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), published in 2007, provides undisputable evidence that human activities are the major reason for the rise in greenhouse gas (GHG) emissions and changes in the global climate system (IPCC, 2007a). Notably, climate change is on-going, with "observational evidence from all continents and oceans … that many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC, 2007b: 8). Observed and projected climate change will in turn affect socio-economic development (Global Humanitarian Forum, 2009; Stern, 2006), with some 300,000 deaths per year currently being attributed to climate change (Global Humanitarian Forum, 2009). Mitigation (to reduce the speed at which the global climate changes) as well as adaptation (to cope with changes that are inevitable) are thus of great importance (Parry *et al.*, 2009).

The IPCC (IPCC, 2007a: 5) notes that "warming of the climate system is unequivocal, as it is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level". Climate change has started to affect many natural systems, including hydrological systems (e.g. increased runoff and earlier spring peak discharge, warming of lakes and rivers affecting thermal structure and water quality), terrestrial ecosystems (e.g. earlier spring events including leaf-unfolding, bird migration and egg-laying, biodiversity decline, and pole ward and upward shifts in the ranges of plants and animal species), as well as marine systems (e.g. rising water temperatures, changes in ice cover, salinity, acidification, oxygen levels and circulation, affecting shifts in the ranges and changes of algae, plankton and fish abundance).

The IPCC (IPCC, 2007b) also notes that small islands are particularly vulnerable to the effects of climate change, including SLR and extreme events. Deterioration in coastal conditions is expected to affect fisheries and tourism, with sea level rise (SLR) being "expected to exacerbate inundation, storm surge, erosion and other coastal hazards, threatening vital infrastructure, settlements and facilities that support the livelihood of island communities" (IPCC, 2007b: 15). Climate change is projected to reduce water resources in the Caribbean to a point where these become insufficient to meet demand, at least in periods with low rainfalls (IPCC, 2007b). Together, these changes are projected to severely affect socio-economic development and well-being in the world (Stern, 2006), with the number of climate change related deaths expected to rise to 500,000 per year globally by 2020 (Global Humanitarian Forum, 2009). However, not all regions are equally vulnerable to climate change. The Caribbean needs to be seen as one of the most vulnerable regions, due to their relative affectedness by climate change, but also in terms of their capacity to adapt (Bueno *et al.*, 2008). This should be seen in the light of (Dulal *et al.*, 2009: 371) conclusion that:

> *If the Caribbean countries fail to adapt, they are likely to take direct and substantial economic hits to their most important industry sectors such as tourism, which depends on the attractiveness of their natural coastal environments, and agriculture (including fisheries), which are highly climate sensitive sectors. By no incidence, these two sectors are the highest contributors to employment in the majority of these countries and significant losses or economic downturn attendant to inability to adapt to climate change will not increase unemployment but have potentially debilitating social and cultural consequences to communities.*

Climate change has, since the publication of the IPCC's AR4 (IPCC, 2007b), been high on the global political agenda. The most recent UN Conference of Parties (COP) in Mexico in December 2010 agreed that increases in temperature should be stabilised at a maximum of 2°C by 2100. Notably, the 39 member states of the Alliance of Small Island States (AOSIS) have called in a recent Declaration to the United Nations for a new climate change agreement that would ensure global warming to be kept at a maximum of 1.5°C (AOSIS, 2009).

So far, the European Union (EU) is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. As a group, AOSIS member states account for less than 1% of global GHG emissions (UN-OHRLLS, 2009). However, according to a recent report of the IPCC the projected impacts of global climate change on the Caribbean region are expected to be devastating (IPCC, 2007c).

An analysis of the vulnerability of the Caribbean community (CARICOM) nations to SLR and associated storm surge by the CARIBSAVE Partnership in 2010 found that large areas of the Caribbean coast are highly susceptible to erosion, and beaches have experienced accelerated erosion in recent decades. It is estimated that with a 1 m SLR and a conservative estimate of associated erosion, 49% of the major tourism resorts in CARICOM countries would be damaged or destroyed. Erosion associated with a 2 m SLR (or a high estimate for a 1 m SLR), would result in an additional 106 resorts (or 60% of the region's coastal resorts) being at risk. Importantly, the beach assets so critical to tourism would be affected much earlier than the erosion damages to tourism infrastructure, affecting property values and the competitiveness of many destinations. Beach nesting sites for sea turtles were also at significant risk to beach erosion associated with SLR, with 51% significantly affected by erosion from 1 m SLR and 62% by erosion associated with 2 m SLR (Simpson *et al.,* 2010).

In real terms, the threats posed to the region's development prospects are severe and it is now accepted that adaptation will require a sizeable and sustained investment of resources. Over the last decade alone, damages from intense climatic conditions have cost the region in excess of half a trillion US dollars (CCCCC, 2009).

1.1. *Climate Change Impacts on Tourism*

Direct and indirect climatic impacts: The Caribbean's tourism resources, the primary one being the climate itself, are all climate sensitive. When beaches and other natural resources undergo negative changes as a result of climate and meteorological events, this can affect the appeal of a destination – particularly if these systems are slow to recover. Further, studies indicate that a shift of attractive climatic conditions for tourism towards higher latitudes and altitudes is very likely as a result of climate change. Projected increases in the frequency or magnitude of certain weather and climate extremes (e.g. heat waves, droughts, floods, tropical cyclones) as a result of projected climate change will affect the tourism industry through increased infrastructure damage, additional emergency preparedness requirements, higher operating expenses (e.g. insurance, backup water and power systems, and evacuations), and business interruptions (Simpson *et al*., 2008).

In contrast to the varied impacts of a changed climate on tourism, the indirect effects of climate-induced environmental change are likely to be largely negative.

Impacts of mitigation policies on tourist mobility: Scientifically, there is general consensus that 'serious' climate policy will be paramount in the transformation of tourism towards becoming climatically sustainable, as significant technological innovation and behavioural change demand strong regulatory environments (e.g. Barr *et al.*, 2010; Bows *et al.*, 2009; Hickman and Banister, 2007; see also Giddens, 2009). As outlined by Scott, Peeters and Gössling (2010), "serious" policy would include the endorsement of national and international mitigation policies by tourism stakeholders, a global closed emission trading scheme for aviation and shipping, the introduction of significant and constantly rising carbon taxes on fossil fuels, incentives for low-carbon technologies and transport infrastructure, and, ultimately, the development of a vision for a fundamentally different global tourism economy. As a result, the Caribbean is likely to be a casualty of international mitigation policies that discourage long-haul travel.

Pentelow and Scott (2010) concluded that a combination of low carbon price and low oil price would have very little impact on arrivals growth to the Caribbean region through to 2020, with arrivals 1.28% to 1.84% lower than in the business as usual (BAU) scenario (the range attributed to the price elasticity chosen). The impact of a high carbon price and high oil price scenario was more substantive, with arrivals 2.97% to 4.29% lower than the 2020 BAU scenario depending on the price elasticity value used. The study concluded:

> *It is important to emphasise that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020 (Pentelow and Scott, 2010).*

Indirect societal change impacts: Climate change is believed to pose a risk to future economic growth of some nations, particularly for those where losses and damages are comparable to a country's GDP. This could reduce the means and incentive for long-haul travel and have negative implications for anticipated future growth in this sector in the Caribbean. Climate change associated security risks have been identified in a number of regions where tourism is highly important to local-national economies (e.g. Stern, 2006; Barnett and Adger, 2007; German Advisory Council, 2007; Simpson *et al*., 2008). International tourists are averse to political instability and social unrest, and negative tourism-demand repercussions for climate change security hotspots, many of which are believed to be in developing nations, are already evident (Hall *et al.*, 2004).

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and Climate*

Saint Lucia is one of the Windward Islands in the Caribbean and sits on an ancient volcanic ridge connecting Martinique to the north and St. Vincent and the Grenadines to the south. It has an area of 616 km^2 (MPDEH, 2001) and is 42 km long by 22 km wide with a largely mountainous topography. A central mountain range runs the length of the island, with peaks ranging between 305 m and 959 m in elevation (highest peak is Mount Gimie). The two towering volcanic cones on the southwest coast, Gros Piton (797 m) and Petit Piton (750 m) are one of the Caribbean's most famous landmarks(Saint Lucia Tourist Board, n.d.). The capital, Castries, is located to the northwest of the island and is the primary economic centre.

The island has a narrow coastal fringe with the mountain slopes cut by many fast-flowing streams and deep valleys. The geology is entirely volcanic with some limestone deposits from submersion in the Lower Miocene Period. Volcanic activity continues on the island with the fumaroles of the town of Sulphur Springs, in the Soufriere area, located in what is known as the Qualibou Caldera. This depression, which is 6 km in diameter, is believed to have been formed following the collapse of a large volcanic cone(MPDEH, 2001). These sites provide visitors with an opportunity to visit a "drive-in volcano" and take a dip in the reputed therapeutic springs (Saint Lucia Tourist Board, n.d.).

A significant portion of Saint Lucia is covered in natural forests, although land continues to be cleared for agriculture and construction (MPDEH, 2001). Coral reef systems along the west coast are more diverse than those on the east coast. In general, fringing reefs are located mainly along the southeast, central west, and northwest coasts with the healthiest and most diverse reefs along the central west coast off Soufriere (MPDEH, 2001). Agricultural lands are found primarily in the fertile valleys and to the south of the island, but there are some land management issues where agriculture is taking place in unsuitable locations (MOAFF, 2000).

The tropical climate of Saint Lucia is heavily influenced by marine conditions; located in the north east Trade Wind belt it is normally under an easterly flow of moist warm air. The annual range in humidity is very small with a mean of about 77% (MPDEH, 2001). Mean daily temperatures vary between 23.3°C and 30.9°C with the coolest months between December and March and the warmest months between May and September (World Meteorological Organization, n.d.). Saint Lucia's mountainous nature can cause significant temperature variation between high and low lying regions (about 2 – 5°C) (MPDEH, 2001).

The rainy season is from June to November when the island is influenced by tropical weather disturbances such as waves, depressions, storms and hurricanes. These systems account for the majority of the recorded rainfall during that period (MPDEH, 2001), which can be as high as 199 mm in a month (nearly 8 inches) (World Meteorological Organization, n.d.). The drier period occurs between December and May when rainfall is more typically 64 mm in a month (about 2.5 inches) (World Meteorological Organization, n.d.). The influence of topography on rainfall is quite pronounced with total annual rainfall varying from about 1265 mm in the relatively flat coastal regions to about 3420 mm in the elevated interior region (MPDEH, 2001).

Wind speeds are highest (24 km/h) during the months of January to July, corresponding roughly with the dry season. They drop to approximately 16 km/h during August to December. Higher gusts are occasionally experienced with the passage of tropical disturbances and cyclones (MPDEH, 2001). Recent hurricanes that have impacted Saint Lucia include Hurricane Allen (1980), Tropical Storm Debby (1994), Hurricane Lenny (1999), Hurricane Dean (2007) (GFDRR, 2010) and most recently Hurricane Tomas (2010) (ECLAC, 2011).

2.2. *Socio-Economic Profile*

Saint Lucia is classified as a middle-income small island developing state (MPDEH, 2001) with estimated population of 165,595 in 2010 (Research and Policy Unit, 2011). In 2007 the population was evenly distributed in terms of gender (The Central Statistical Office of Saint Lucia, 2008). Table 2.2.1 shows that the GDP for Saint Lucia declined between 2000 and 2002, before gradually increasing in 2010.

Table 2.2.1: Gross Domestic Product for Saint Lucia 2000-2010

YEAR	(Rebased) Gross Domestic Product Production Approach In Constant Prices, 2006 = 100 EC $ (Millions)
2000	2,025.90
2001	1,941.10
2002	1,907.47
2003	1,998.49
2004	2,117.52
2005	2,062.24
2006	2,216.74
2007	2,247.56
2008	2,377.54
2009	2,346.21
2010 (preliminary)	2,449.67

(Source: Research and Policy Unit, 2011)

Traditionally, Saint Lucia has been supported by the export "tripod" of bananas, light manufacturing and tourism (Kairi Consultants Ltd., 2007). However, the North American Free Trade Area (NAFTA) and the push by a number of Central American countries and the Dominican Republic to take advantage of the Caribbean Basin Initiative, reduced the competitiveness of the Eastern Caribbean for labour intensive manufacturing. This was swiftly followed by a decline in the Saint Lucian manufacturing sector in the mid-1990s. At the same time, banana exports were being hit by a removal of the preferential treatment given to Windward Island producers in the EU and then by challenges to the tariff-quota system through the World Trade Organization. As a result, Saint Lucia banana exports dwindled from over 130,000 tonnes in 1992 to 34,420 tonnes in 2003 (Kairi Consultants Ltd., 2007). Exports have remained close to this level of production to 2009 (Research and Policy Unit, 2011).

With the decline experienced in both manufacturing and banana exports, tourism has become the main foreign exchange earner for Saint Lucia. The services sector (of which tourism is a major component) makes up 62% of the national GDP (GFDRR, 2010) and the contribution from agriculture, 4.3% in 2009, has shrunk by approximately 30% from 2000-2009(Research and Policy Unit, 2011). The contribution from manufacturing has shown a slight increase in recent years, contributing 6.7% of GDP in 2009. These patterns of growth and decline can be seen in Figure 2.2.1. The role of tourism is discussed further in Section 2.3.

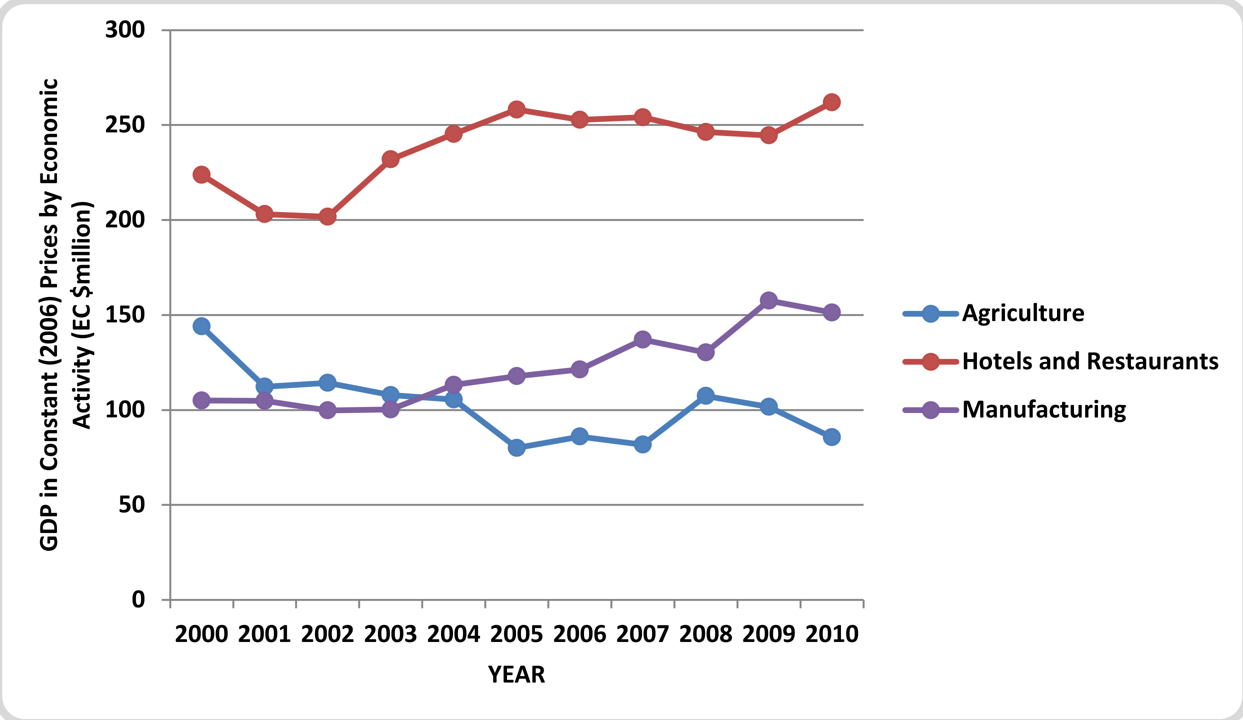


Figure 2.2.1: Gross Domestic Product in Constant Prices (2006) by Economic Activity in Saint Lucia: 2000-2010
(Source: Research and Policy Unit, 2011)

Other important contributors to GDP include construction (9.3% in 2009), transport (11.7% in 2009), real estate, renting and business (13.1% in 2009) (Research and Policy Unit, 2011). The construction sector is being considered by government to be an important avenue for economic recovery given its high labour intensity. Saint Lucia's Government budget (2010/2011) was titled "The Road to Recovery" (RLB, 2010). After showing a steep decline in 2009 with a number of projects remaining on hold or slowing down because of financing issues, the preliminary figures for 2010 show some improvement (10.7% of GDP) (Research and Policy Unit, 2011). This has been a result of increased activity by the central government and the private sector, largely associated with rehabilitation works on damaged infrastructure caused by Hurricane Tomas. Central government projects have included intensified work on the EU funded new national hospital, continuation of work on road infrastructure, and a number of other smaller scale projects. Private sector projects included the completion of the Bay Walk Mall and the Daher building, continuation of work on the Bank of Saint Lucia and the Johnson's superstore buildings (Research and Policy Unit, 2011).

The distribution of the population is heavily skewed towards the north west of the island, with the capital city Castries accounting for 39.6% of the population and Gros-Islet accounting for 15.2% of the population. The other major population centres are Vieux Fort and Micoud, both accounting for 9.8% of the total population (Research and Policy Unit, 2011). Unemployment rates are high and have increased in 2010 to 20.6% (Research and Policy Unit, 2011) reflecting the contraction of the industries as indicated above. A detailed breakdown of the labour force statistics is available for 2007, when the unemployment rate stood at 14.6%. The rate at that time was highest amongst females (18% compared to 12% for males) and in the regions of Dennery (18.4%), Anse-La-Raye (19.2%) and Vieux Fort (30.6%) (The Central Statistical Office of Saint Lucia, 2008). In terms of sector distribution, Table 2.2.2 shows the percentage of the male and female labour force by key employment sectors (i.e. those sectors that employ more than 10% of the total workforce). The statistics show that there is a considerable gender bias, with men dominantly employed in the agricultural and construction sectors and women in the wholesale and retail trade, and hotels and restaurants. It is anticipated that in 2011 tourism will employ 17.5% of the labour force directly and 45.4% total contribution (WTTC, 2011), a substantial increase on the 2007 data presented in Table 2.2.2.

Table 2.2.2: Percentage of Labour Force by Gender and Industry, 3rd Quarter 2007

	MALE% (N=38,750)	FEMALE% (N=31,650)
Agriculture Hunting and Forestry	18.61	7.46
Construction	24.03	1.55
Wholesale and Retail Trade	7.90	22.40
Hotels and Restaurants	8.77	14.85
Public Administration and Social Security	12.39	18.58

(Source: The Central Statistical Office of Saint Lucia, 2008)

The official language spoken in Saint Lucia is English, although many Saint Lucians also speak a French dialect, Creole (Kwéyòl). Creole is not just a patois or broken French, but a language in its own right, with its own rules of grammar and syntax. The language is being preserved by its everyday use in day-to-day affairs and by special radio programmes and news read entirely in Creole. In October, Saint Lucians celebrate their Creole heritage and language during the staging of the annual Jounen Kwéyòl Festival (Saint Lucia Tourist Board, n.d.).

2.3. *Importance of Tourism to the National Economy*

Caribbean tourism is based on the natural environment, and the region's countries are known primarily as beach destinations. The tourism product therefore depends on favourable weather conditions, as well as on an attractive and healthy natural environment, particularly in the coastal zone. Both of these are threatened by climate change. The Caribbean is the most tourism-dependent region in the world, with few options to develop alternative economic sectors, and is one of the most vulnerable regions in the world to the impacts of climate change including SLR, coastal erosion, flooding, biodiversity loss and impacts on human health.

As described above, tourism has become the main foreign exchange earner for Saint Lucia following the decline of the agriculture and manufacturing sectors. According to the Economic and Social Review, in 2010 the sector "registered a record contribution to Saint Lucia's foreign exchange earnings, remaining the engine of domestic economic activity" (Research and Policy Unit, 2011). It should be noted that the increased reliance on tourism presents a significant economic risk to the country since disaster losses in this sector include reputational risks that can affect tourism travel well beyond the disaster recovery period (GFDRR, 2010). It is predicted by the Word Travel and Tourism Council (WTTC) that direct contribution to GDP will be 15.4% in 2011 and total contribution will be 45.8% (WTTC, 2011).

The key markets for Saint Lucia are the United States (35.4%), United Kingdom (25.8%) and Canada (10.3%) according to 2009 figures (Caribbean Tourism Organisation, n.d.). Growth in the US and Canadian markets has been seen in 2010 as a result of increased airlift to these countries and the filming of ABC Network show 'The Bachelor' in Saint Lucia. Arrivals from France and Germany also increased, whereas arrivals from the UK declined following the imposition of the Air Passenger Duty and the problems with the volcanic ash in Iceland. All markets were affected in November and into December by the temporary closure of some hotels following Hurricane Tomas (Research and Policy Unit, 2011).

Table 2.3.1: Visitor Arrivals to Saint Lucia 2001-2010

Year	Stopovers	Cruise Ship Passengers	Cruise Ship calls
2001	250,132	489,912	378
2002	253,463	387,180	245
2003	276,948	393,948	262
2004	298,431	481,279	328
2005	317,939	394,364	258
2006	302,510	359,593	267
2007	287,518	610,343	314
2008	295,761	622,680	315
2009	278,491	699,306	397
2010	305,937	670,043	380

(Source: Caribbean Tourism Organisation, n.d.; Research and Policy Unit, 2011)

This information is shown graphically in Figure 2.3.1, where it can be clearly seen that since 2007 there has been a considerable increase in cruise ship arrivals, whereas stopovers peaked in 2005 before dropping off again and only now beginning to recover in 2010. The pattern of change in cruise ship arrivals is obviously related to the number of cruise ships calling in Saint Lucia, which highlights the vulnerability of the sector to external forces.

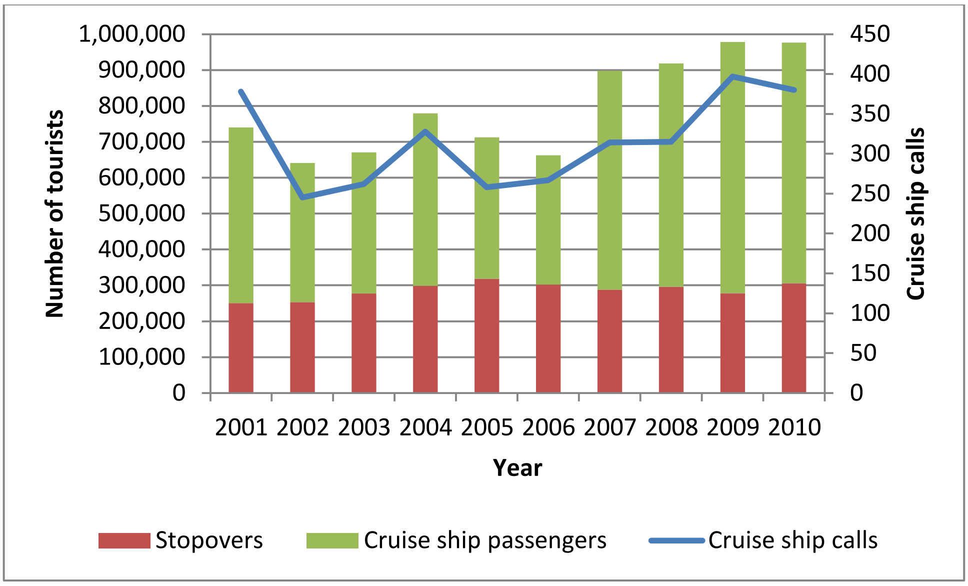


Figure 2.3.1: Tourist Arrivals 2001-2010

Cruise ship arrivals declined in 2010 as a result of the re-deployment of some lines (e.g. Ocean Village, Norwegian and Aida Vita) to other Caribbean destinations. As a result, the expenditure from cruise ship passengers also fell to EC $58.0 million. Expenditure by stay-over visitors in 2010 increased over the previous record in 2007 to EC $1,442.5 million, based on increased arrivals, increased average daily spending and a recovery of hotel room rates following discounts applied in response to the global financial crisis (Research and Policy Unit, 2011). The tourist expenditure information shown in Table 2.3.2 shows how income from the tourism sector has grown rapidly over the last decade. There was a considerable jump in stopover revenue from 2006 to 2007, which is not matched by an increase in stopover arrivals. The Cricket World Cup was held in 2007, so this could possibly be a contributing factor in the increased tourist expenditure, but it is not clear at this stage.

Table 2.3.2: Tourist Expenditure 2001-2010 (EC $Millions)

Year	Stopover	Cruise	All Visitors
2001	560	69	629
2002	522	45	567
2003	706	55	761
2004	817	62	879
2005	864	55	919
2006	725	44	768
2007	1,365	82	1,447
2008	1,175	58	1,233
2009	1,059	63	1,122
2010	1,443	58	1,500

(Source: Research and Policy Unit, 2011)

As indicated above, the tourism sector is one of the key contributors to GDP, but is also a key source of employment, employing 12% of the labour force in the hotel and restaurant sector alone in 2007 (The Central Statistical Office of Saint Lucia, 2008). The total number of people employed in additional service industries that support tourism, such as travel agents, internal transport operators and water sports operators, is much greater (34% in 2007 and 32% in 2010) (WTTC, 2011).

3. CLIMATE MODELLING

3.1. *Introduction to Climate Modelling Results*

This summary of climate change information for Saint Lucia is derived from a combination of recently observed climate data sources, and climate model projections of future scenarios using both a General Circulation Model (GCM) ensemble of 15 models and the Regional Climate Model (RCM), *PRECIS*.

General Circulation Models (GCMs) provide global simulations of future climate under prescribed greenhouse gas scenarios. These models are proficient in simulating the large scale circulation patterns and seasonal cycles of the world's climate, but operate at coarse spatial resolution (grid boxes are typically around 2.5 degrees latitude and longitude). This limited resolution hinders the ability for the model to represent the finer scale characteristics of a region's topography, and many of the key climatic processes which determine its weather and climate characteristics. Over the Caribbean, this presents significant problems as most of the small islands are too small to feature as a land mass at GCM resolution.

Regional Climate Models (RCMS) are often nested in GCMs to simulate the climate at a finer spatial scale over a small region of the world, acting to 'downscale' the GCM projections and provide a better physical representation of the local climate of that region. RCMs enable the investigation of climate changes at a sub-GCM-grid scale, as such changes in the dynamic climate processes at a community scale or tourist destination can be projected.

For each of a number of climate variables (average temperature, average rainfall, average wind speed, relative humidity, sea-surface temperature, sunshine hours, extreme temperatures, and extreme rainfalls) the results of GCM multi-model projections under three emissions scenarios at the country scale, and RCM simulations from single model driven by two different GCMs for a single emissions scenario at the destination scale, are examined. Where available, observational data sources are drawn upon to identify changes that are already occurring in the climates at both the country and destination scale.

In this study, RCM simulations from PRECIS, driven by two different GCMs (ECHAM4 and HadCM3) are used to look at projected climate for each country and at the community level. Combining the results of GCM and RCM experiments allows the use of high-resolution RCM projections in the context of the uncertainty margins that the 15-model GCM ensemble provides.

The following projections are based on the IPCC standard 'marker' scenarios – A2 (a 'high' emissions scenario), A1B (a medium high scenario, where emissions increase rapidly in the earlier part of the century but then plateau in the second half) and B1 (a 'low' emissions scenario). Climate projections are examined under all three scenarios from the multi-model GCM ensemble, but at present, results from the regional models are only available for scenario A2. Table 3.1.1 outlines the time line on which various temperature thresholds are projected to be reached under the various scenarios according to the IPCC.

Table 3.1.1: Earliest and latest years respectively at which the threshold temperatures are exceeded in the 41 projections*

SRES Scenario	1.5°C Threshold		2.0°C Threshold		2.5°C Threshold	
	Earliest	Latest	Earliest	Latest	Earliest	Latest
A1B	2023	2050	2038	2070	2053	Later than 2100
A2	2024	2043	2043	2060	2056	2077
B1	2027	2073	2049	Later than 2100	2068	Later than 2100

*NB: In some cases the threshold is not reached prior to 2100, the latest date for which the projections are available.

The potential changes in hurricane and tropical storm frequency and intensity, sea-level rise (SLR), and storm surge incidence are also examined for the Caribbean region. For these variables, existing material in the literature is examined in order to assess the potential changes affecting the tourist destinations.

3.2. *Temperature*

Observations from the gridded temperature datasets indicate that mean annual temperatures over Saint Lucia have increased at an average rate of 0.16˚C per decade over the period 1960-2006. The observed increases have been more rapid in the seasons JJA and SON at the rate of 0.19˚C and 0.18˚C per decade respectively.

General Circulation Model (GCM) projections from a 15-model ensemble indicate that Saint Lucia can be expected to warm by 0.6˚C to 1.8˚C by the 2050s and 0.9˚C to 3.1˚C by the 2080s, relative to the 1970-1999 mean. The range of projections across the 15 models for any one emissions scenario spans around 1-1.5˚C. Projected mean temperature increase is similar throughout the year.

Regional Climate Model (RCM) projections indicate much more rapid increases in temperatures over Saint Lucia compared to the GCM ensemble median projections for the A2 scenario. In particular, RCM simulations driven by ECHAM4 indicate temperature increases that are higher than any of the models in the GCM ensemble in all seasons. RCM projections indicate increases of 3.3˚C and 2.4˚C in mean annual temperatures by the 2080s, when driven by the ECHAM4 and HadCM3 respectively, compared with GCM ensemble projections of 1.8-3.1˚C for that period.

The improved spatial resolution in the RCM allows the land mass of the larger Caribbean islands to be represented, whilst the region is represented only by 'ocean' grid boxes at GCM resolution. Land surfaces warm more rapidly than ocean due to their lower capacity to absorb heat energy, and hence more rapid warming over Saint Lucia in RCM projections than in GCMs.

Table 3.2.1: Observed and GCM Projected Changes in Temperature for Saint Lucia.

Saint Lucia: Country Scale Changes in Temperature												
	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2020s			Projected changes by the 2050s			Projected changes by the 2080s		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
	(˚C)	(change in˚C per decade)		Change in ˚C			Change in ˚C			Change in ˚C		
			A2	0.3	0.7	0.8	0.9	1.4	1.7	1.8	2.3	3.1
Annual	26.4	0.16*	A1B	0.3	0.7	1	1	1.4	1.8	1.2	2.1	2.9
			B1	0.3	0.7	0.8	0.6	1.1	1.2	0.9	1.4	2
			A2	0.4	0.7	0.8	1	1.4	1.8	1.7	2.4	3.2
DJF	25.3	0.13*	A1B	0.3	0.7	1.1	0.9	1.4	1.8	1.3	2.1	2.9
			B1	0.4	0.7	0.8	0.5	1.1	1.3	0.9	1.4	2
			A2	0.2	0.6	0.8	0.8	1.3	1.7	1.6	2.3	3.1
MAM	26	0.14*	A1B	0.2	0.6	1	1	1.4	1.8	1.1	2	2.6
			B1	0.2	0.6	0.9	0.5	1	1.2	0.7	1.3	1.8
			A2	0.2	0.7	0.8	0.9	1.4	1.8	1.6	2.4	3
JJA	27.2	0.19*	A1B	0.3	0.7	0.9	1	1.3	1.8	1.1	2	3
			B1	0.3	0.7	0.8	0.5	1	1.3	0.9	1.4	2.1
			A2	0.4	0.8	0.9	0.9	1.4	1.9	1.8	2.4	3.2
SON	27	0.18*	A1B	0.3	0.7	1.1	1.1	1.4	1.9	1.5	2	3
			B1	0.4	0.7	0.9	0.7	1.1	1.3	1.1	1.4	2

Table 3.2.2: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	Median	Max
			Change in ˚C	
	GCM Ensemble Range	1.8	2.3	3.1
Annual	RCM (ECHAM4)		3.3	
	RCM (HadCM3)		2.4	
	GCM Ensemble Range	1.7	2.4	3.2
DJF	RCM (ECHAM4)		3.4	
	RCM (HadCM3)		2.6	
	GCM Ensemble Range	1.6	2.3	3.1
MAM	RCM (ECHAM4)		3.2	
	RCM (HadCM3)		2.5	
	GCM Ensemble Range	1.6	2.4	3
JJA	RCM (ECHAM4)		3.2	
	RCM (HadCM3)		2.4	
	GCM Ensemble Range	1.8	2.4	3.2
SON	RCM (ECHAM4)		3.4	
	RCM (HadCM3)		2.4	

3.3. *Precipitation*

Gridded observations of rainfall over Saint Lucia do not show statistically significant trends over the period 1960-2006. Long-term trends are difficult to identify due to the large inter-annual variability in rainfall in Saint Lucia.

GCM projections of future rainfall for Saint Lucia span both overall increases and decreases with wide variations, but tend towards decreases in more models. Projected rainfall changes in annual rainfall range from -37 to +7 mm per month (-66% to +14%) by the 2080s across three emissions scenarios. The overall decreases in annual rainfall projected by GCMs occur largely through decreased JJA and SON rainfall, but these changes are less consistent between models.

RCM projections of rainfall for Saint Lucia are strongly influenced by the driving GCM providing boundary conditions. Changes projected by the RCM driven by HadCM3 are generally greater than ECHAM4-driven simulations. Driven by ECHAM4, RCM rainfall projections indicate a moderate decrease of -7 mm (-11%) in total annual rainfall. When driven by HadCM3, RCM projects large decreases in rainfall in all seasons except SON resulting in a large decrease in total annual rainfall (-32%).

Table 3.3.1: Observed and GCM Projected Changes in Precipitation for Saint Lucia.

Saint Lucia: Country Scale Changes in Precipitation												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(mm per month)	*(change in mm per decade)*		*Change in mm per month*			*Change in mm per month*			*Change in mm per month*		
			A2	-15	-2	4	-19	-4	4	-37	-16	6
Annual	179.2	0.1	*A1B*	-10	-2	9	-18	-6	6	-29	-8	5
			B1	-11	-3	13	-18	-2	3	-21	-4	7
			A2	-3	0	11	-8	-1	1	-10	-4	3
DJF	125.6	1.9	*A1B*	-6	0	4	-8	-1	6	-12	-3	3
			B1	-7	-1	14	-9	-1	7	-8	0	6
			A2	-15	0	8	-20	0	17	-27	-1	9
MAM	105.3	-0.9	*A1B*	-8	1	8	-20	-1	8	-26	0	8
			B1	-10	0	10	-16	0	2	-17	0	5
			A2	-32	-7	10	-36	-18	12	-72	-27	14
JJA	219.3	-6.7	*A1B*	-25	-7	6	-34	-19	14	-45	-19	4
			B1	-26	-10	31	-36	-12	5	-40	-15	21
			A2	-29	-4	17	-40	-4	8	-57	-12	8
SON	265.4	5.7	*A1B*	-30	-2	23	-35	-7	21	-59	-11	15
			B1	-24	-2	12	-39	-1	16	-45	-6	9

Table 3.3.2: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
			Change in mm	
	GCM Ensemble Range	-37	-16	6
Annual	*RCM (ECHAM4)*		-7	
	RCM (HadCM3)		-32	
	GCM Ensemble Range	-10	-4	3
DJF	*RCM (ECHAM4)*		-3	
	RCM (HadCM3)		-22	
	GCM Ensemble Range	-27	-1	9
MAM	*RCM (ECHAM4)*		2	
	RCM (HadCM3)		-30	
	GCM Ensemble Range	-72	-27	14
JJA	*RCM (ECHAM4)*		-26	
	RCM (HadCM3)		-74	
	GCM Ensemble Range	-57	-12	8
SON	*RCM (ECHAM4)*		-1	
	RCM (HadCM3)		-1	

Table 3.3.3: Observed and GCM Projected Changes in Precipitation (%) for Saint Lucia.

Saint Lucia: Country Scale Changes in Precipitation													
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(mm per month)	*(change in % per decade)*			*% Change*			*% Change*			*% Change*	
			A2	-28	-5	8	-35	-9	7	-66	-23	12
Annual	179.2	0	*A1B*	-19	-4	10	-33	-10	6	-52	-15	10
			B1	-20	-5	14	-34	-5	3	-38	-9	14
			A2	-17	0	37	-26	-5	2	-38	-12	10
DJF	125.6	1.5	*A1B*	-22	0	19	-25	-2	22	-30	-9	16
			B1	-18	-4	46	-21	-3	25	-21	-2	19
			A2	-33	0	41	-47	-5	85	-73	-8	12
MAM	105.3	-0.8	*A1B*	-20	2	21	-52	-3	18	-61	0	13
			B1	-24	1	23	-49	-3	9	-42	0	22
			A2	-46	-8	8	-51	-15	17	-77	-35	21
JJA	219.3	-3.1	*A1B*	-35	-6	3	-48	-13	21	-62	-18	6
			B1	-37	-11	16	-50	-14	9	-57	-12	31
			A2	-30	-3	14	-42	-4	9	-67	-12	8
SON	265.4	2.1	*A1B*	-26	-1	19	-36	-7	14	-62	-14	16
			B1	-31	-2	8	-41	-1	11	-47	-5	9

Table 3.3.4: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
			% Change	
	GCM Ensemble Range	-66	-23	12
Annual	*RCM (ECHAM4)*		-11	
	RCM (HadCM3)		-32	
	GCM Ensemble Range	-38	-12	10
DJF	*RCM (ECHAM4)*		-9	
	RCM (HadCM3)		-32	
	GCM Ensemble Range	-73	-8	12
MAM	*RCM (ECHAM4)*		1	
	RCM (HadCM3)		-48	
	GCM Ensemble Range	-77	-35	21
JJA	*RCM (ECHAM4)*		-35	
	RCM (HadCM3)		-46	
	GCM Ensemble Range	-67	-12	8
SON	*RCM (ECHAM4)*		-1	
	RCM (HadCM3)		-1	

3.4. *Wind Speed*

Observed mean wind speeds from the ICOADS mean monthly marine surface wind dataset demonstrate increasing trends around Saint Lucia in all seasons over the period 1960-2006. The increasing trend in mean annual wind speed is 0.3 ms^{-1} per decade. It is greatest in DJF at the rate of 0.51 ms^{-1} per decade.

Mean wind speeds over Saint Lucia generally show a very small increase or no change in GCM projections. Projected changes in annual average wind speed range between -0.2 and +0.5 ms^{-1} by the 2080s across the three emission scenarios. Both increases and decreases are seen in all seasons across the 15-model ensemble.

RCM projections based on two driving GCMs are comparable to changes indicated by the GCM ensemble. Both RCM simulations project an increase in wind speed in JJA and SON. Driven by ECHAM4, the RCM indicates a very small change in wind speeds in all seasons. Driven by HadCM3, the RCM projects relatively large increases in wind speeds in JJA (+1.1 ms^{-1}) and SON (+1.0 ms^{-1}) by the 2080s.

Table 3.4.1: Observed and GCM Projected Changes in Wind Speed for Saint Lucia.

Saint Lucia: Country Scale Changes in Wind Speed												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(ms^{-1})	*(change in ms^{-1} per decade)*		*Change in ms^{-1}*			*Change in ms^{-1}*			*Change in ms^{-1}*		
			A2	-0.2	0.1	0.1	-0.2	0	0.2	0	0.1	0.5
Annual	7.4	0.30*	*A1B*	-0.3	0	0.1	-0.2	0	0.3	-0.1	0	0.4
			B1	-0.4	0.1	0.1	0	0.1	0.2	-0.2	0.2	0.2
			A2	-0.2	0.1	0.3	-0.4	0	0.2	-0.2	0	0.4
DJF	8.1	0.51*	*A1B*	-0.2	0	0.1	-0.1	0.1	0.3	-0.2	0.1	0.5
			B1	-0.3	0	0.2	-0.1	0.1	0.2	-0.4	0	0.4
			A2	-0.2	0	0.2	-0.5	0.1	0.3	-0.3	0.2	0.5
MAM	7.4	0.30*	*A1B*	-0.3	0	0.2	-0.2	0	0.2	-0.5	0	0.3
			B1	-0.5	0	0.2	-0.2	0.1	0.2	-0.1	0.1	0.4
			A2	-0.2	0	0.2	-0.2	0	0.2	-0.2	0.4	0.7
JJA	7.7	0.18*	*A1B*	-0.5	0	0.1	-0.2	0	0.3	-0.3	0.2	0.6
			B1	-0.3	0.1	0.3	-0.1	0.1	0.4	-0.2	0.1	0.2
			A2	-0.4	0	0.3	-0.3	0	0.3	-0.4	0.1	0.8
SON	6.6	0.25*	*A1B*	-0.6	0	0.3	-0.5	0.1	0.5	-0.3	0	0.6
			B1	-0.4	0.1	0.3	-0.3	0	0.3	-0.4	0.2	0.5

Table 3.4.2: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
		Change in ms^{-1}		
	GCM Ensemble Range	0	0.1	0.5
Annual	*RCM (ECHAM4)*		0	
	RCM (HadCM3)		0.7	
	GCM Ensemble Range	-0.2	0	0.4
DJF	*RCM (ECHAM4)*		-0.4	
	RCM (HadCM3)		0.2	
	GCM Ensemble Range	-0.3	0.2	0.5
MAM	*RCM (ECHAM4)*		-0.1	
	RCM (HadCM3)		0.3	
	GCM Ensemble Range	-0.2	0.4	0.7
JJA	*RCM (ECHAM4)*		0.3	
	RCM (HadCM3)		1.1	
	GCM Ensemble Range	-0.4	0.1	0.8
SON	*RCM (ECHAM4)*		0.2	
	RCM (HadCM3)		1	

3.5. *Relative Humidity*

Observations from the HadCRUH show statistically significant decreasing trend (-0.21% per decade) in relative humidity (RH) over the period 1973-2003 in Saint Lucia. The strongest decreasing trend of 0.34% per decade is seen in SON.

RH data has not been made available for all models in the 15-model ensemble. From the available data, the GCM projections indicate a small increase in RH in all seasons. The ensemble sub-sample range does span both increases and decreases in RH in all seasons.

RCM projections generally show decreases in RH over Saint Lucia in all seasons except for SON. A small increase in RH in SON is predicted by both the RCM and GCM simulations.

The representation of the land surface in climate models becomes very important when considering changes in RH under a warmer climate. This factor is reflected when GCMs and RCMs projections are compared.

Table 3.5.1: Observed and GCM Projected Changes in Relative Humidity for Saint Lucia.

Saint Lucia: Country Scale Changes in Relative Humidity												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
	(%)	*(% change per decade)*		*Change in %*			*Change in %*			*Change in %*		
			A2		0.3			0.2			0.8	
Annual	79.2	-0.21*	*A1B*	-0.5	0.1	1.1	-0.7	0.3	0.7	-0.9	0.4	1.2
			B1	-0.5	0.2	0.9	-0.5	0.5	0.6	-0.7	0.6	0.9
			A2		0.2			0.1			0.8	
DJF	78.1	-0.14	*A1B*	-0.5	0.1	1	-0.4	0.6	0.9	-0.6	0.5	1.9
			B1	-0.7	0	1.5	-0.3	0.5	1	-0.4	0.8	1.2
			A2		0.4			0.3			1	
MAM	78.4	-0.16	*A1B*	-0.3	0	1.7	-0.2	0.5	1.1	-0.4	0.9	1
			B1	-0.4	0.3	1.1	-0.1	0.5	0.9	-0.6	0.7	1.2
			A2		0.2			0.3			0.6	
JJA	80.2	-0.18	*A1B*	-0.8	0.1	1	-1.1	0.3	0.4	-1.3	0.2	1
			B1	-0.9	0	0.8	-0.9	0.2	0.5	-1.2	0.3	0.6
			A2		0.3			0			0.6	
SON	80.1	-0.34*	*A1B*	-0.7	0.1	0.6	-1.1	0.1	0.9	-1.3	0.1	2
			B1	-0.9	0.1	0.9	-1	0.2	1.1	-0.9	0.4	1.2

Table 3.5.2: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s (SRES A2)		
		Min	*Median*	*Max*
			Change in %	
	GCM Ensemble Range		0.8	
Annual	*RCM (ECHAM4)*		-0.1	
	RCM (HadCM3)		-0.4	
	GCM Ensemble Range		0.8	
DJF	*RCM (ECHAM4)*		-0.2	
	RCM (HadCM3)		-0.6	
	GCM Ensemble Range		1	
MAM	*RCM (ECHAM4)*		0.3	
	RCM (HadCM3)		-0.8	
	GCM Ensemble Range		0.6	
JJA	*RCM (ECHAM4)*		-0.8	
	RCM (HadCM3)		-0.6	
	GCM Ensemble Range		0.6	
SON	*RCM (ECHAM4)*		0.3	
	RCM (HadCM3)		0.2	

3.6. *Sunshine Hours*

The number of 'sunshine hours' per day are calculated by applying the average clear-sky fraction from cloud observations to the number of daylight hours for the latitude of the location and the time of the year. The observed number of sunshine hours, based on ISCCP satellite observations of cloud coverage, indicates statistically significant increases in annual sunshine hours in Saint Lucia by 1.51 hours per decade over the period 1983-2001. The strongest increase is seen In JJA at the rate of 1.91 hours per decade.

The number of sunshine hours is projected to increase slightly into the 21st Century in Saint Lucia by most GCMs, particularly in wet season reflecting reduction in average cloud fractions. The model ensemble, however, spans both increases and decreases in all seasons and across emissions scenarios. Changes in annual average sunshine hours span -0.9 to +0.8 hours per day by the 2080s under scenario A2. The median increases projected by the GCM ensemble are large in JJA and SON, but with changes spanning -1.2 to +1.3 and -0.4 to +1.2 hours per day respectively.

Comparison between GCM and RCM projections of sunshine hours for Saint Lucia shows that the RCM projections generally lie toward the higher end of the range of changes projected by the GCM ensemble. RCM projections indicate increases of roughly an hour per day in mean annual sunshine hours by the 2080s. Both RCM simulations indicate large increases in sunshine hours in JJA (1.4-1.9 hours per day) and in SON (1.2-1.3 hours per day), which is in agreement with the GCM projections.

Table 3.6.1: Observed and GCM Projected Changes in Sunshine Hours for Saint Lucia.

Saint Lucia: Country Scale Changes in Sunshine Hours												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(hrs)	*(change in hrs per decade)*		*Change in hrs*			*Change in hrs*			*Change in hrs*		
			A2	-0.2	0	0.3	-0.5	0.1	0.5	-0.9	0.2	0.7
Annual	5.1	1.51*	*A1B*	-0.3	0	0.3	-0.6	0.1	0.6	-0.6	0.2	0.8
			B1	-0.3	0	0.3	-0.3	0	0.3	-0.5	0	0.4
			A2	-0.4	0	0.3	-0.5	0.1	0.5	-1	0.2	0.4
DJF	5.9	1.05*	*A1B*	-0.3	0	0.3	-0.4	0	0.5	-0.5	0.1	0.4
			B1	-0.3	0.1	0.4	-0.4	0	0.5	-0.5	0	0.5
			A2	-0.6	0.1	0.4	-0.9	-0.1	0.5	-1.3	0	0.7
MAM	5.2	1.17*	*A1B*	-0.8	-0.1	0.2	-1.1	0	0.4	-1.3	0	0.6
			B1	-0.6	0	0.3	-0.5	-0.1	0.1	-1.2	-0.2	0.5
			A2	-0.4	0	0.5	-0.6	0.2	1.1	-1.2	0.4	1.3
JJA	4.8	1.91*	*A1B*	-0.5	0.1	0.7	-0.9	0.2	1.3	-0.8	0.3	1.3
			B1	-0.5	0.2	0.6	-0.4	0.2	0.7	-0.8	0.3	1.2
			A2	-0.2	0	0.4	-0.4	0.3	0.7	-0.3	0.4	1.2
SON	4.5	1.30*	*A1B*	-0.2	0	0.6	-0.3	0.2	0.9	-0.4	0.3	1.2
			B1	-0.3	0.1	0.4	-0.2	0.1	0.6	-0.4	0.1	0.7

Table 3.6.2: GCM and RCM Projected Changes in Saint Lucia under the A2 Scenario.

		Projected changes by the 2080s SRES A2 Min	Median	Max
		Change in hrs		
	GCM Ensemble Range	-0.9	0.2	0.7
Annual	*RCM (ECHAM4)*		0.9	
	RCM (HadCM3)		1.1	
	GCM Ensemble Range	-1	0.2	0.4
DJF	*RCM (ECHAM4)*		1.2	
	RCM (HadCM3)		0.9	
	GCM Ensemble Range	-1.3	0	0.7
MAM	*RCM (ECHAM4)*		0	
	RCM (HadCM3)		0.3	
	GCM Ensemble Range	-1.2	0.4	1.3
JJA	*RCM (ECHAM4)*		1.4	
	RCM (HadCM3)		1.9	
	GCM Ensemble Range	-0.3	0.4	1.2
SON	*RCM (ECHAM4)*		1.2	
	RCM (HadCM3)		1.3	

3.7. *Sea Surface Temperatures*

The HadSST2 gridded dataset indicate statistically significant increasing trend of 0.07˚C per decade in mean annual surface air temperatures around Saint Lucia. In particular, large increasing trends of 0.1˚C per decade are observed in JJA and SON in the waters surrounding Saint Lucia.

GCM projections indicate increases in sea-surface temperatures (SSTs) throughout the year. Projected increases range between +0.8˚C and +3.0˚C by the 2080s across all three emissions scenarios. The range of projections under any single emissions scenario spans roughly around 1.0 to 1.5˚C.

Table 3.7.1: Observed and GCM Projected Changes in Sea Surface Temperature for Saint Lucia.

Saint Lucia: Country Scale Changes in Sea Surface Temperature												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(˚C)	*(change in˚C per decade)*		*Change in ˚C*			*Change in ˚C*			*Change in ˚C*		
			A2	0.5	0.7	0.8	0.9	1.3	1.7	1.6	2.3	3
Annual	27.4	0.07*	*A1B*	0.2	0.6	1	0.9	1.4	1.7	1.1	2.2	2.6
			B1	0.3	0.6	0.8	0.5	1	1.2	0.8	1.4	1.8
			A2	0.5	0.7	0.8	1	1.2	1.8	1.6	2.2	3.1
DJF	26.6	0.04	*A1B*	0.2	0.6	1	0.8	1.3	1.8	1.2	2	2.6
			B1	0.3	0.6	0.8	0.4	0.9	1.2	0.8	1.5	1.8
			A2	0.6	0.6	0.8	0.9	1.1	1.6	1.5	2.1	3
MAM	26.7	0.04	*A1B*	0.2	0.6	1	0.9	1.3	1.7	1	2.1	2.4
			B1	0.3	0.7	0.9	0.5	0.9	1.1	0.7	1.4	1.7
			A2	0.5	0.7	0.8	0.9	1.3	1.5	1.5	2.1	2.8
JJA	27.9	0.10*	*A1B*	0.2	0.7	1	0.8	1.3	1.7	1	2.2	2.7
			B1	0.2	0.6	0.7	0.5	1.1	1.1	0.8	1.3	1.9
			A2	0.4	0.7	0.9	1	1.3	1.8	1.7	2.4	3.1
SON	28.3	0.10*	*A1B*	0.3	0.7	1.1	1	1.4	1.9	1.3	2.4	2.7
			B1	0.3	0.7	0.8	0.6	1.1	1.3	1	1.3	1.7

3.8. *Temperature Extremes*

Extreme hot and cold values are defined by the temperatures that are exceeded on 10% of days in the ‘current’ climate or reference period. This allows us to define ‘hot’ and ‘cold’ relative to the particular climate of a specific region or season, and determine relative changes in extreme events.

There is insufficient daily observational data to identify trends in daily temperature extremes in Saint Lucia.

GCM projections indicate increases in the frequency of ‘hot’ days by 35-97% of days and ‘hot’ nights by 35-97% of nights annually by the 2080s. The rate of increase varies substantially between models for each scenario, but is very similar throughout the year. ‘Cold’ days and nights do not occur at all in most models by the 2080s.

Table 3.8.1: Observed and GCM Projected Changes in Temperature Extremes for Saint Lucia.

Saint Lucia: Country scale changes in Temperature Extremes												
		Observed Mean 1970-99	Observed Trend 1960-2006	*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
		% Frequency	***Change in frequency per decade***				***Future % frequency***			***Future % frequency***		
Frequency of Hot Days (TX90p)												
	A2						38	54	64	55	83	97
Annual	*A1B*						39	59	64	45	77	88
	B1						30	43	49	35	48	68
	A2						61	74	95	94	98	99
DJF	*A1B*						51	79	92	75	96	99
	B1						29	50	71	47	71	91
	A2						59	77	98	92	98	99
MAM	*A1B*						55	75	97	74	96	99
	B1						31	51	82	50	71	94
	A2						58	84	93	86	99	100
JJA	*A1B*						60	88	93	71	99	99
	B1						41	64	81	49	77	96
	A2						77	89	99	97	99	99
SON	*A1B*						80	92	99	91	99	99
	B1						57	73	93	73	89	99
Frequency of Hot Nights (TN90p)												
	A2						38	56	67	55	84	97
Annual	*A1B*						40	61	64	46	80	85
	B1						30	43	54	35	47	72
	A2						61	71	95	94	97	100
DJF	*A1B*						50	75	91	72	95	99
	B1						28	49	69	47	64	93
	A2						58	77	97	91	98	99
MAM	*A1B*						57	75	96	73	96	99
	B1						31	49	82	51	76	93
	A2						58	83	95	86	97	100
JJA	*A1B*						60	89	95	72	97	99
	B1						37	67	86	50	78	95
	A2						77	91	99	98	99	100
SON	*A1B*						82	93	99	92	99	100
	B1						60	78	96	73	92	99
Frequency of Cold Days (TX10p)												
	A2						0	0	0	0	0	0
Annual	*A1B*						0	0	0	0	0	0
	B1						0	0	1	0	0	0
	A2						0	0	0	0	0	0
DJF	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0
	A2						0	0	0	0	0	0
MAM	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0
	A2						0	0	0	0	0	0
JJA	*A1B*						0	0	0	0	0	0
	B1						0	0	5	0	0	0
	A2						0	0	0	0	0	0
SON	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0
Frequency of Cold Nights (TN10p)												
	A2						0	0	0	0	0	0
Annual	*A1B*						0	0	0	0	0	0

Saint Lucia: Country scale changes in Temperature Extremes												
		Observed Mean 1970-99	Observed Trend 1960-2006	*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
		% Frequency	***Change in frequency per decade***				***Future % frequency***			***Future % frequency***		
	B1						0	0	1	0	0	0
	A2						0	0	0	0	0	0
DJF	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0
	A2						0	0	0	0	0	0
MAM	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0
	A2						0	0	0	0	0	0
JJA	*A1B*						0	0	0	0	0	0
	B1						0	0	5	0	0	0
	A2						0	0	0	0	0	0
SON	*A1B*						0	0	0	0	0	0
	B1						0	0	0	0	0	0

3.9. *Rainfall Extremes*

Changes in rainfall extremes, based on 1- and 5-day rainfall totals, as well as exceedance of a relative threshold for 'heavy' rain, were examined. 'Heavy' rain is determined by the daily rainfall totals that are exceeded on 5% of wet days in the 'current' climate or reference period, relative to the particular climate of a specific region or season.

There is insufficient daily observational data to identify trends in rainfall extremes in Saint Lucia.

GCM projections of rainfall extremes are mixed across the ensemble of models, ranging from both decreases and increases of all measures of extreme rainfall. The proportion of total rainfall that falls in heavy events decreases in most model projections, changing by -26% to +7% by the 2080s.

Maximum 1-day rainfall shows very little or no change by the 2080s, but maximum 5-day rainfall tends to decrease in model projections ranging from -33 to +8 mm annually by the 2080s.

Table 3.9.1: Observed and GCM Projected Changes in Rainfall Extremes for Saint Lucia.

Saint Lucia: Country scale changes in Rainfall Extremes												
	Observed Mean 1970-99	Observed Trend 1960-2006		*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
% total rainfall falling in Heavy Events (R95pct)												
	%	*Change in % per decade*					*Change in %*			*Change in %*		
			A2				-19	-1	2	-25	-3	2
Annual			*A1B*				-17	-1	4	-26	-3	1
			B1				-20	0	3	-21	-1	7
			A2				-11	-1	1	-12	-3	4
DJF			*A1B*				-6	-1	2	-10	-4	4
			B1				-13	0	3	-9	-2	9
			A2				-9	-1	6	-26	-3	8
MAM			*A1B*				-9	-2	5	-15	-4	5
			B1				-13	-1	3	-12	-4	15
			A2				-23	-2	5	-27	-1	10
JJA			*A1B*				-22	-3	2	-25	0	3
			B1				-25	0	4	-24	-1	7
			A2				-14	0	6	-16	-2	2
SON			*A1B*				-21	-2	8	-18	-2	7
			B1				-15	0	6	-16	1	5
Maximum 1-day rainfall (RX1day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2				-6	0	2	-10	-1	3
Annual			*A1B*				-6	0	5	-11	-1	6
			B1				-6	0	7	-7	0	7
			A2				-2	0	0	-1	0	4
DJF			*A1B*				-1	0	0	-1	0	1
			B1				-2	0	2	-2	0	2
			A2				-1	0	2	-8	0	1
MAM			*A1B*				-2	0	5	-3	0	1
			B1				-5	0	2	-1	0	2
			A2				-10	0	2	-14	-2	3
JJA			*A1B*				-9	-1	1	-13	0	3
			B1				-12	0	2	-12	0	1
			A2				-3	0	2	-6	0	3
SON			*A1B*				-4	-1	8	-8	-1	2
			B1				-3	0	6	-3	0	8
Maximum 5-day Rainfall (RX5day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2				-16	-1	4	-28	-7	4
Annual			*A1B*				-16	-3	7	-33	-4	6
			B1				-20	0	10	-20	1	8
			A2				-6	0	0	-7	-1	7
DJF			*A1B*				-6	0	3	-7	-2	3
			B1				-6	0	8	-6	-1	6
			A2				-4	0	7	-15	0	2
MAM			*A1B*				-4	0	13	-7	-1	1
			B1				-10	0	0	-3	0	8
			A2				-25	-4	7	-31	-9	12
JJA			*A1B*				-22	-5	6	-30	-6	3
			B1				-27	-2	4	-29	0	9
			A2				-12	-1	4	-23	-2	5
SON			*A1B*				-13	-4	19	-29	-6	6
			B1				-15	-1	9	-16	1	17

3.10. *Hurricanes and Tropical Storms*

Historical and future changes in tropical storm and hurricane activity have been a topic of heated debate in the climate science community. Drawing robust conclusions with regards to changes in climate extremes is continually hampered by issues of data quality in our observations, the difficulties in separating natural variability from long-term trends and the limitations imposed by spatial resolution of climate models.

Tropical storms and hurricanes form from pre-existing weather disturbances where SSTs exceed 26˚C. Whilst SSTs are a key factor in determining the formation, development and intensity of tropical storms, a number of other factors are also critical, such as subsidence, wind shear and static stability. This means that whilst observed and projected increases in SSTs under a warmer climate potentially expand the regions and periods of time when tropical storms may form, the critical conditions for storm formation may not necessarily be met (e.g. Vecchi and Soden, 2007; Trenberth *et al.,* 2007), and increasing SSTs may not necessarily be accompanied by an increase in the frequency of tropical storm incidences.

Several analyses of global (e.g. Webster *et al.*, 2005) and more specifically North Atlantic (e.g. Holland and Webster, 2007; Kossin *et al.,* 2007; Elsner *et al.,* 2008) hurricanes have indicated increases in the observed record of tropical storms over the last 30 years. It is not yet certain to what degree this trend arises as part of a long-term climate change signal or shorter-term inter-decadal variability. The available longer term records are riddled with in homogeneities (i.e. inconsistencies in recording methods through time) - most significantly, the advent of satellite observations, before which storms were only recorded when making landfall or observed by ships (Kossin *et al.,* 2007). Recently, a longer-term study of variations in hurricane frequency in the last 1500 years based on proxy reconstructions from regional sedimentary evidence indicate recent levels of Atlantic hurricane activity are anomalously high relative to those of the last one-and -a -half millennia (Mann *et al.,* 2009).

Climate models are still relatively primitive with respect to representing tropical storms, and this restricts our ability to determine future changes in frequency or intensity. We can analyse the changes in background conditions that are conducive to storm formation (boundary conditions) (e.g. Tapiador, 2008), or apply them to embedded high-resolution models which can credibly simulate tropical storms (e.g. Knutson and Tuleya, 2004; Emanuel *et al.*, 2008). RCMs are able to simulate weak 'cyclone-like' storm systems that are broadly representative of a storm or hurricane system but are still considered coarse in scale with respect to modelling hurricanes.

The IPCC AR4 (Meehl *et al.,* 2007) concludes that models are broadly consistent in indicating increases in precipitation intensity associated with tropical storms (e.g. Knutson and Tuleya, 2004; Knutson *et al.,* 2008; Chauvin *et al.,* 2006; Hasegawa and Emori, 2005; Tsutsui, 2002). The higher resolution models that simulate storms more credibly are also broadly consistent in indicating increases in associated peak wind intensities and mean rainfall (Knutson and Tuleya, 2004; Oouchi *et al.,* 2006). We summarise the projected changes in wind and precipitation intensities from a selection of these modelling experiments in Table 3.10.1 to give an indication of the magnitude of these changes.

With regards to the *frequency* of tropical storms in future climate, models are strongly divergent. Several recent studies (e.g. Vecchi and Sodon, 2007; Bengtssen *et al.,* 2007; Emanuel *et al.,* 2008, Knutson *et al.,* 2008) have indicated that the frequency of storms may decrease due to decreases in vertical wind shear in a warmer climate. In several of these studies, the intensity of hurricanes still increases despite decreases in frequency (Emanuel *et al.,* 2008; Knutson *et al.,* 2008). In a recent study of the PRECIS regional climate model simulations for Central America and the Caribbean, Bezanilla *et al.,* (2009) found that the frequency of 'Tropical -Cyclone-Like –Vortices' increases on the Pacific coast of Central America, but decreases on the Atlantic coast and in the Caribbean.

When interpreting the modelling experiments we should remember that our models remain relatively primitive with respect to the complex atmospheric processes that are involved in hurricane formation and development. Hurricanes are particularly sensitive to some of the elements of climate physics that these models are weakest at representing, and are often only included by statistical parameterisations. Comparison studies have demonstrated that the choice of parameterisation scheme can exert a strong influence on the results of the study (e.g. Yoshimura *et al.,* 2006). We should also recognise that the El Niño Southern Oscillation (ENSO) is a strong and well established influence on Tropical Storm frequency in the North Atlantic, and explains a large proportion of inter-annual variability in hurricane frequency. This means that the future frequency of hurricanes in the North Atlantic is likely to be strongly dependent on whether the climate state becomes more 'El-Niño-Like', or more 'La-Niña-like' – an issue upon which models are still strongly divided and suffer from significant deficiencies in simulating the fundamental features of ENSO variability (e.g. Collins *et al.,* 2005).

Table 3.10.1: Changes in Near-Storm Rainfall and Wind Intensity Associated with Tropical Storms in under Global Warming Scenarios.

Reference	GHG scenario	Type of Model	Domain	Change in near-storm rainfall intensity	Change in peak wind intensity
Knutson *et al.* (2008)	A1B	Regional Climate Model	Atlantic	(+37, 23, 10)% when averaged within 50, 100 and 400 km of the storm centre	+2.9%
Knutson and Tuleya (2004)	1% per year CO_2 increase	9 GCMs + nested regional model with 4 different moist convection schemes.	Global	+12-33%	+5-7%
Oouchi *et al* (2006)	A1B	High Resolution GCM	Global	N/A	+14%
			North Atlantic		+20%

3.11. *Sea Level Rise*

Observed records of sea level from tidal gauges and satellite altimeter readings indicate a global mean SLR of 1.8 (+/- 0.5) mm yr^{-1} over the period 1961-2003 (Bindoff *et al.,* 2007). Acceleration in this rate of increase over the course of the 20^{th} Century has been detected in most regions (Woodworth *et al.,* 2009; Church and White, 2006).

There are large regional variations superimposed on the mean global SLR rate. Observations from tidal gauges surrounding the Caribbean basin (Table 3.11.1) indicate that SLR in the Caribbean is broadly consistent with the global trend (Table 3.11.2).

Table 3.11.1: Sea level Rise Rates at Observation Stations Surrounding the Caribbean Basin

Tidal Gauge Station	Observed trend **(mm yr^{-1})**	Observation period
Bermuda	2.04 (+/- 0.47)	1932-2006
San Juan, Puerto Rico	1.65 (+/- 0.52)	1962-2006
Guantanamo Bay, Cuba	1.64 (+/- 0.80)	1973-1971
Miami Beach, Florida	2.39 (+/1 0.43)	1931-1981
Vaca Key, Florida	2.78 (+/- 0.60)	1971-2006

(Source: NOAA, 2009)

Projections of future SLR associated with climate change have recently become a topic of heated debate in scientific research. The IPCC's AR4 report summarised a range of SLR projections under each of its standard scenarios, for which the combined range spans 0.18-0.59 m by 2100 relative to 1980-1999 levels (see ranges for each scenario in Table 3.11.2). These estimates have since been challenged for being too conservative, with a number of studies (e.g. Rahmstorf, 2007; Rignot and Kanargaratnam, 2006; Horton *et al.,* 2008) providing evidence to suggest that their uncertainty range should include a much larger upper limit.

Total SLR associated with atmospheric warming appear largely through the combined effects of two main mechanisms: (i) thermal expansion (the physical response of the water mass of the oceans to atmospheric warming) and (ii) ice-sheet, ice-cap and glacier melt. Whilst the rate of thermal expansion of the oceans in response to a given rate of temperature increase is projected relatively consistently between GCMs, the rate of ice melt is much more difficult to predict due to our incomplete understanding of ice-sheet dynamics. The IPCC total SLR projections comprise of 70-75% (Meehl *et al.,* 2007a) contribution from thermal expansion, with only a conservative estimate of the contribution from ice sheet melt (Rahmstorf, 2007).

Recent studies that observed acceleration in ice discharge (e.g. Rignot and Kanargaratnam, 2006) and observed rates of SLR in response to global warming (Rahmstorf, 2007), suggest that ice sheets respond highly-non linearly to atmospheric warming. We might therefore expect continued acceleration of the large ice sheets resulting in considerably more rapid rates of SLR. Rahmstorf (2007) is perhaps the most well cited example of such a study and suggests that future SLR might be in the order of twice the maximum level that the IPCC, indicating up to 1.4 m by 2100.

Table 3.11.2: Projected Increases in Sea Level Rise from the IPCC AR4

Scenario	Global Mean Sea Level Rise by 2100 relative to 1980-1999.	Caribbean Mean Sea Level Rise by 2100 relative to 1980-1999 (+/ 0.05 m relative to global mean)
IPCC B1	0.18-0.38	0.13-0.43
IPCC A1B	0.21-0.48	0.16-0.53
IPCC A2	0.23-0.51	0.18- 0.56
Rahmstorf, 2007	Up to 1.4 m	Up to 1.45 m

(Source: Meehl *et al.,* 2007 contrasted with those of Rahmstorf, 2007).

3.12. *Storm surge*

Changes to the frequency or magnitude of storm surge experienced at coastal locations in Saint Lucia are likely to occur as a result of the combined effects of:

(a) Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed

(b) Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms

(c) Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm.

Sections 3.10 and 3.11 discuss the potential changes in sea level and hurricane intensity that might be experienced in the region under (global) warming scenarios. The high degree of uncertainty in both of these contributing factors creates difficulties in estimating future changes in storm surge height or frequency.

Further impacts on storm surge flood return period may include:

- Potential changes in storm frequency: some model simulations indicate a future reduction in storm frequency, either globally or at the regional level. If such decreases occur they may offset these increases in flood frequency at a given elevation.

- Potential increases in storm intensity: evidence suggests overall increases in the intensity of storms (lower pressure, higher near storm rainfall and wind speeds) which would cause increases in the storm surges associated with such events, and contribute further to increases in flood frequency at a given elevation.

4. VULNERABILITY AND IMPACTS PROFILE FOR SAINT LUCIA

Vulnerability is defined as the “inherent characteristics or qualities of social systems that create the potential for harm. Vulnerability is a function of exposure… and sensitivity of [the] system” (Adger, 2006; Cutter, 1996 cited in Cutter et al. 2008, p. 599). Climate change is projected to be a progressive process and therefore vulnerability will arise at different time and spatial scales affecting communities and sectors in distinct ways. Participatory approaches to data collection were implemented in Soufriere to provide additional community-level data and field surveys in the Rodney Bay area enabled the creation of sea level rise impact data and maps. To help in the identification and analysis of vulnerability, the following sections discuss the implications and impacts of climate change on key sectors as they relate to tourism in Saint Lucia.

Saint Lucia is already experiencing some of the effects of climate variability through damages from severe weather systems and the decline of some coastal tourism attractions. The Government of Saint Lucia is aware of the risks posed by climate change and these are identified to be intensification of hurricanes, SLR, increased atmospheric temperatures and more heavy precipitation (Government of Saint Lucia, 2011). The government has also recognised that a coordinated approach to adaptation is required if any efforts are to be effective. This has been the approach in the completion of the Saint Lucia Strategic Programme for Climate Resilience (SPCR) as well as this assessment.

4.1. *Water Quality and Availability*

4.1.1. Background

Water supplies in Saint Lucia mainly come from surface run-off sources such as rivers, wetlands, streams and springs. There are 37 watersheds along with corresponding water courses (MPDEH, 2001), with the most important catchment being the Roseau. Water is abstracted from the Roseau river to the capital Roseau and environs which accounts for 65% of the population of the island (MPDEH, 2006). Owing to the volcanic geology of the island and its impermeable rocks, groundwater sources are very few and are used primarily for irrigation (MPDEH, 2001).

Water production is approximately 18.9 million cubic metres per year (MCM/yr) however this figure is actually closer to 16.55 MCM/yr due to water losses in the distribution (Springer, 2005). During the dry season estimated water production can be as much as 25% less than the wet season (CEHI, 2006). The John Compton Dam in the Roseau Catchment was constructed in 1995 and is the island’s main water source. This dam and the Millet Reservoir development serve the northern half of the island and together have a total capacity of 3,182 million litres. The Water and Sewerage Corporation is charged with the responsibility of providing water to approximately 42,000 customers from both the north and south of Saint Lucia (Springer, 2005). Table 4.1.1 shows the main watersheds in Saint Lucia and their area.

Table 4.1.1: Watersheds and Main Rivers in Saint Lucia

Name	Area (km^2)	Main River
Roseau	49.1	Roseau River
Fond D'Or	41.0	Fond D'Or River
Cul De Sac	40.9	Cul De Sac River
Troumassee	31.7	Troumassee River
Marquis	31.0	Marquis River
Vieux Fort	28.8	Vieux Fort River
Canelles	17.3	Canelle River

(Taken from MPDEH, 2006: Original source Government of Saint Lucia, Saint Lucia Environmental Profile 1991)

Saint Lucia has a number of different types of freshwater wetlands, which perform the important functions of filtering pollutants and sediment from water and therefore have a key role in maintaining good water quality in river courses. For instance, in the 2006 GEO State of the Environment report notes that the John Compton Reservoir Dam occupies 16.2 ha of forest land which is protected reserve lands (MPDEH, 2006). The Saint Lucia Initial National Communication to the UNFCCC also states that 'watershed protection and management was the leading concern in the establishment of Forest Reserves' which is under the Department of Forestry and is protected by the Forest, Soil and Water Conservation Act (1946; amendments 1957 and 1983) (MPDEH, 2001, 2006).

The quality, quantity and availability of water supplied by a given watershed and its associated water course is dependent on the level of human activities carried out, particularly those occurring upstream (Geoghegan, 2002). As is often the case in Saint Lucia, downstream areas tend to be more affected by contaminants. The main contaminants that pollute water quality include sediments, sewage and agro-chemicals, which is partly attributable to the unregulated development of river banks (MPDEH, 2006). For instance, it is estimated that approximately 60% of housing settlements are unplanned, a great percentage of which occurs in sloped areas (Anderson, 2002).

Other factors that compromise water quality and supply are unregulated and poor land management practices associated with unsustainable agriculture, commercial and industrial development (CEHI, 2006) and the conversion of forests on steep slopes for banana plantation and other crops and for grazing (Geoghegan, 2002). Added to this are the issues of population growth, rapid urbanisation and developments in the tourism sector (CEHI, 2006). Due to increasing levels these are becoming a challenge for treatment plants to adequately address. Another threat to water quality is solid waste (MPDEH, 2006) and the inadequate septic tank infrastructure, the use of pit latrines and the use of rivers for bathing and washing (Geoghegan, 2002).

Table 4.1.2: Demand Distribution Among Sectors

Description	Percentage	Projected Percentage
	1987	2010
Domestic/minor commercial	48.6	53.0
Hotels	9.6	10.0
Government/Institutional	7.0	6.7
Industrial	2.5	5.3
New commercial	0	2.0
Unaccounted for water	32.3	23.0

(Source: Springer, 2005)

Table 4.1.2, shows the water demand in various sectors. The unaccounted water value has been estimated to actually be nearer to 47% (Springer, 2005) and more recently the figure has been found to average between 40 – 60% (Mr Sealey, personal communication, May 26, 2011). The high water losses are due to a number of problems, among them the mountainous terrain and long distances water has to be transported via aged infrastructure from water source to treatment plants and then finally to the consumers (Mr Nichols, personal communication, May 6, 2011). Water in the agriculture sector is not specifically mentioned in Table 4.1.2, however its importance to the sector will be discussed further in the irrigation section. While the industrial sector only accounts for 5.3% of the water demand, water use is considerable in this sector, especially in terms of manufacturing. Some of the manufacturing industries that require significant volumes of water are bottled water, beer, soft drink, as well as construction, sand mining and concrete making (Springer, 2005). In the tourism sector, the water demand is concentrated in the north of the island. Saint Lucia has approximately 5,000-room capacity, however, the actual visitor arrivals is far higher, with some 982,764 visitors recorded in Saint Lucia in 2009 (mainly due to cruise ship arrivals) (Caribbean Tourism Organisation, n.d). Finally, with respect to the domestic water consumption, from the 2001 Saint Lucia Census, 82% of the population had access to pipe-borne water at home (MPDEH, 2006) with this figure now closer to 98% (ECLAC, 2009).

The cost of water in Saint Lucia was last revised in 1999/2000, partly to address debt incurred by the predecessor of the Water and Sewerage Cooperation (WASCO), which was the Water and Sewerage Authority (WASA). While the increase was 100% of previous tariffs, it was able to cover less than 50% of the required costs for producing, treating and distributing raw water. Table 4.1.3 shows the cost of water in Saint Lucia, it is half the cost of electricity in the country (Springer, 2005) and is therefore considered cheap in comparison to other utilities on the island (Mr Nichols, personal communication, May 6, 2011). MPDEH (2005) has stated that there is a need to determine the economic cost of water consumers pay due to this very perception that it is cheap. WASCO pays the full rate for power for production of water, leaving it at a deficit since it does not receive this in full from water revenues – thus there is a need to revamp tariffs (Mr Sealey, personal communication, May 6, 2011). The vast majority of water customers are in the residential/domestic category (90%), paying the cheapest water rate, which contributes the least to the overall revenues of the WASCO. The agriculture and industrial (construction and mining) sectors can also abstract water easily, with near limitless access to rivers (Mr Issac, personal communication, May 6, 2011). This raises the question of how much water is being abstracted outside of the water that the government measures.

Table 4.1.3: Water Tariffs in Saint Lucia

Sector	Usage limits	Price EC $ (US $)
Domestic	less than 3,000 gallons	7.35 (2.70)
Domestic	more than 3,000 gallons	15.00 (5.50)
Commercial		20.00 (7.30)
Government		14.00 (5.10)
Ships		40.00 (14.70)
Hotels		22.00 (8.00)

(Source: Springer, 2005)

In addition, water production costs that consumers pay do not reflect the true cost of water as subsidies from the government for its production are very high and, further, “users are not being encouraged to value water” since “there is no incentive for consumers to use water efficiently, and no clear strategy or criterion by which to establish allocation priorities” (Springer, 2005). In addition, 1,000 gallons of water costs EC $18 to produce, while a domestic consumer only pays EC $7 per 1,000 gallons (Mr Sealey, personal communication, May 6, 2011). Thus, Springer (2005) have made three recommendations:

(d) Charging the full cost of water, including the cost of building and operating water supply systems.
(e) Reduce losses in distribution.
(f) Protect forests, watersheds, and other ecosystems required to regulate and maintain water quality.

WASCO and WASA is one of the main actors in the water cycle and has been mentioned a number of times in the previous paragraphs. Figure 4.1.1 below summarises the main management actors in the water cycle in Saint Lucia and relevant legislation.

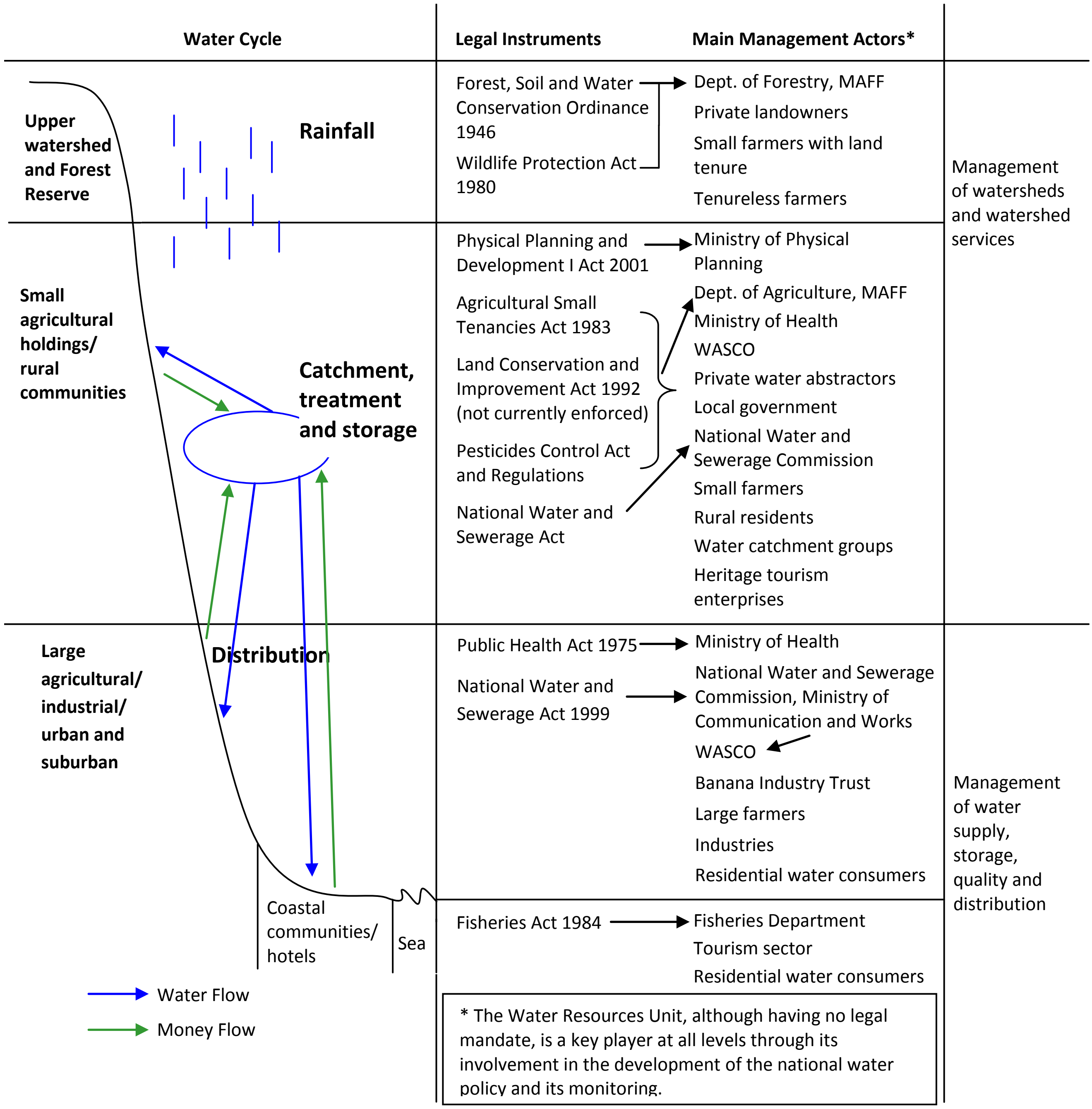


Figure 4.1.1: Saint Lucia's Water Cycle, Associated Legal Instruments and Main Actors

(Source: Geoghegan, 2002)

4.1.2. Vulnerability of Water Availability and Quality Sector to Climate Change

Rivers are prone to pollution, especially from sewage and agrochemicals (e.g. approximately 55% of land is used in agriculture), with 5 of the 7 main rivers believed to be at risk from contamination (MPDEH, 2006). As listed in the Saint Lucia Initial National Communication to the UNFCCC, the islands' freshwater resources are affected by housing, agriculture, indiscriminate abstraction, sewage disposal, solid waste disposal, tourism, fishing, river sand mining, manufacturing, river bathing and picnicking, and river alterations (MPDEH, 2001).

The problem of siltation is especially critical to Saint Lucia's water management concerns because sedimentation and the inability of treatment plants to treat water after heavy rains means that some communities do not have access to water for as much as 3 to 4 days while the plant operators wait for water turbidity in river courses to clear up (Mr Nichols, personal communication, May 6, 2011). Land degradation due to unsustainable practices in the upper watershed and the severe extent of soil erosion during the wet season significantly affects intakes that supply various communities throughout Saint Lucia. This is especially the case in rural communities as the "facilities for the treatment and storage of raw water, as well as treated water, are inadequate to meet the growing demand for freshwater, especially during the dry season" (Springer, 2005).

Aside from water quality and quantity concerns, the current infrastructure on the island that currently exists is aged and therefore cannot supply increasing demands of the public sector (Government of Saint Lucia, 2009b; Springer, 2005). Furthermore, as the Saint Lucia Water Management Plan for Drought Conditions describes, "only a small proportion of the consuming public receives a 24-hour supply of potable water. Water outages occur on a regular basis, and most consumers have installed water storage tanks" (Government of Saint Lucia, 2009b).

Drought

Decreases in precipitation are projected for many sub-tropical areas including the Caribbean region, which is also likely to experience shorter rainy seasons and precipitation in shorter duration, with intense events interspersed with longer periods of relatively dry conditions (Bates *et al.*, 2008). A significant increase in the number of consecutive dry days has been found for the Caribbean region (Bates *et al.*, 2008), indicating that periods of drought are becoming increasingly common. As a result, drought management will become a progressively large challenge, requiring a multifocal approach due to its non-structural nature and complex spatial patterns. This makes it a difficult task to find suitable solutions to adapt to the problems created by drought conditions (e.g. Campbell *et al.*, 2010). Good management of the water supply system is critical for drought mitigation, requiring a careful operation of water supply infrastructure to be effective (e.g. Fang *et al.*, 2011; Hyde *et al.*,1994; Shih and Revelle, 1994). Measures taken to mitigate the effects of drought conditions in the Caribbean region have included the use of truck water for in-country redistribution, the rotation of water supply, increased desalination, and the importation of water from other countries using barges.

In the Saint Lucia Initial National Communication to the UNFCCC, it is stated that "freshwater supplies are highly susceptible to normal climate variability such as natural disasters. During the dry season, water levels fall drastically" (MPDEH, 2001). Aged infrastructure in certain communities contributes to water distribution problems in the dry season (December to April). This period also coincides with a time when there is a high influx of tourists to the island, which increases demand on already limited water supplies (CEHI, 2006).

As defined in the Saint Lucia Water Resources Management Plan for Drought Conditions, drought is a "relative term and is most often a consequence of rainfall deficiency, resulting in a lack of water for some activity or group"(Government of Saint Lucia, 2009b). Three types of drought are noted in the plan – agricultural drought (reduction in available water at critical times, for crop or pasture production), meteorological drought (lack of rainfall) and hydrological drought (reduction in available water from the surface such as streams, dams and rivers and sub-surface from groundwater sources). Saint Lucia most commonly experiences agricultural drought conditions, "where the quantity and timing of rains throughout the growing season determines their effectiveness and value to dry land agricultural producers" (Government of Saint Lucia, 2009b). However, rural areas are prone to water-stress as distribution to remote communities is unequal (Springer, 2005). This is because during dry spells and their occurrence in vulnerable drier areas of the country, reliable access to water is not always achievable in all areas of the country (Geoghegan, 2002).

In 2001, Saint Lucia experienced severe drought conditions which set in motion the processes of preparing for further drought conditions. The Saint Lucia Water Resource Management Plan for Drought Conditions was approved by cabinet in 2009. Later in the same year, beginning from October and continuing until March 2010, Saint Lucia experienced one of its most serious drought periods, believed to be more severe than the 2001 drought event. From October to December 2009, rainfall was 40% of normal monthly values due to abnormal weather patterns (Bishop, 2010). Drought conditions during the dry season of 2010 were so severe that the Government of Saint Lucia issued a state of emergency on February 24, 2010 in accordance with the Water and Sewerage Act No. 14 of 2005 (Joseph, 2010).

To ameliorate this problem of 'chronic' water shortages, rationing is utilised to conserve water supplies. Water distribution tends to favour critical sectors; in Saint Lucia these include the health and tourism sectors (Geoghegan, 2002). However, during national disasters, alternative emergency measures are required. For instance, after Hurricane Tomas in November 2010, as much as 80% or around 140,000 people were without potable water for two weeks (MEAEPND, 2009). Some were without water for up to a month, which was partly due to heavy siltation of the John Compton dam as land and flow slides entered the reservoirs and also damaged the backup generator and pump house (MEAEPND, 2009). This meant that bottled water had to be utilised for cooking, bathing and all other water requiring activities.

Drought conditions could become more frequent resulting in decrease river base flows from river courses if temperatures were to increase. Observed temperature data for Saint Lucia have shown increases of about 0.16°C per decade from the period 1960 – 2006, with RCM data also projecting increases. Additionally, while RCM projections are indicating possible increases and decreases in rainfall, overall decreases are expected, which may increase the frequency of periods of dry spells (See section 3 Climate Modelling). Some sectors of the Saint Lucian society use predominantly stored rainwater. If they have to utilise increased quantities of piped water, this incurs extra expense to them and to the demand placed on the water authority. This will also require upgrading of current infrastructure, and in some cases the creation of new infrastructure to cater to these demands especially during the dry season.

Figure 4.1.2 shows a drought susceptibility map for Saint Lucia, which was taken from the Saint Lucia Water Management Plans for Drought Conditions (Government of Saint Lucia, 2009b). The map was generated based on the annual water balance, flow accumulation, mean annual temperature, soil drainage and moisture supply capacity. Areas with highest susceptibility are predominantly along the coast. Areas of lowest susceptibility coincide with forest reserves in the central ridge of the island (MPDEH, 2006).

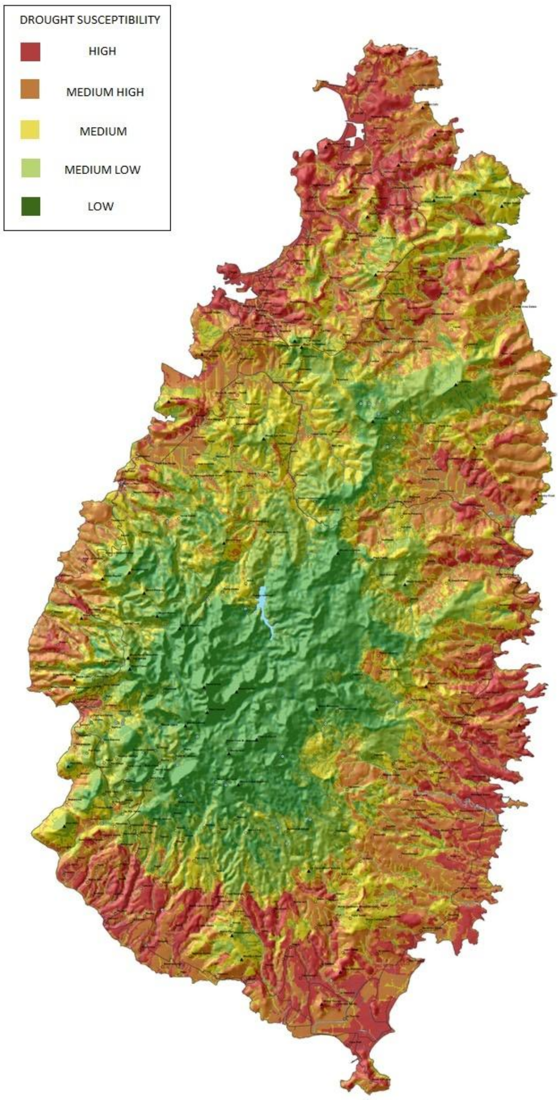


Figure 4.1.2: Drought Susceptibility in Saint Lucia
(Adapted from: DRM, 2011; Government of Saint Lucia, 2009b, Original Source: Cox, 2003)

Irrigation Efficiency in the Agriculture Sector

Globally, agricultural water use comprises around 70% of total water extractions (Wisser *et al.*, 2008). In the drier, warmer environment expected under climate change in the Caribbean, irrigation water demand is likely to increase, exacerbating the effects of decreases in water availability (Döll, 2002). Increased evaporative demands under climate change may lead to reductions in irrigation efficiency (Fischer *et al.*, 2007). Careful consideration will need to be given to efficient irrigation practices and technology to reduce wastage and increase the amount of water reaching the crop, estimated to be as low as 40% worldwide (Pimentel *et al.*, 1997).

During dry spells and instances of water scarcity, the agriculture sector's production outputs are affected due to a decrease in water supply. The national situation of water resources, where there is only one major storage facility (the John Compton Dam) and limited supplementary irrigation sources and infrastructure, makes the sector vulnerable in situations of lower than normal precipitation. Additionally, irrigation water management techniques on the island are considered inefficient and agricultural practices employed by farmers have negative impacts on the environment and its resources (MPDEH, 2005). There are several factors affecting the supply of water to the agriculture and food sectors, including high wastage, low operating efficiencies and poor cost recovery (may be due to the price of water being lower than its true cost) (Springer, 2005). Thus, farmers are not "induced to conserve water or to use water efficiently", leading to a situation which "is unlikely to improve as an island-wide irrigation expansion programme gathers pace" (Springer, 2005). Farmers who apply for connections from WASCO are required to pay the commercial rate (Mr Sealey, personal communication, May 26, 2011). However, greater expenses must be incurred by farmers when water must be transported via trucks and due to the associated labour cost to obtain water for irrigation (DREF, 2010). The direct abstraction of water from river courses for irrigation during dry periods contributes to low surface flows and is discouraged (Government of Saint Lucia, 2009b). Irrigation is expected to increase due to higher temperatures and resultant increases in evapo-transpiration rates in Saint Lucia.

Owing to the volcanic nature of the island, there are few groundwater resources used on the island, but when it is used, it is predominantly by the agriculture sector for irrigation (MPDEH, 2001). This provides some alternative water sources for a few farmers. During Hurricane Tomas in 2010, those farmers with access to ground springs depended on them to sustain their crops as rainfall during the period was minimal. SLR may make these groundwater resources more susceptible to saline intrusion which may affect the quality of water supplied to agricultural lands irrigated by water in coastal communities. This in term will impact on the productivity within the agricultural sector.

The Case of Flooding

Intense rainfall from storm events may only last a few hours, but can result in serious rapid-onset flooding. This is particularly true when it occurs in catchments that are small, steep or highly urbanised, as is the case in the much of the Caribbean region. Floods are a particular problem for water resources because aside from the potential for loss of life and property, they can affect water quality and have implications for sanitation and cause serious soil erosion. Flooding erodes topsoil along with animal waste, faeces, pesticides, fertilisers, sewage and garbage, which may then contaminate groundwater sources as well as marine areas. Erosion may lead to the formation and deepening of gullies which, if they develop in hillslope areas with temporary water tables, may cause enhanced drainage, leading to groundwater discharge (Poesen *et al.*, 2003).

While GCM modelling projections indicate an overall tendency for decreases in precipitation across the Caribbean region (see section 3 Climate Modelling), excluded from these projections is the potential of an increase in the frequency and intensity of storm events (including hurricanes) with associated heavy rainfall (Frei *et al.*, 1998; Min *et al.*, 2011). Research by Emanuel (2005) shows a strong correlation between hurricane size and SSTs, suggesting an upward trend in the destructive potential of hurricanes. Statistical analysis (Trenberth, 2005) and modelling (Knutson and Tuleya, 2004) suggest that hurricane intensity will increase, with the north Atlantic Ocean in particular showing an increasing trend in storm frequency (Deo *et al.*, 2011).

In the absence of sufficient observed data, model simulation data for the period 1960-2000 indicated that there was a decrease in rainfall. Additionally, decreases in extreme rainfall events (1- and 5- day annual maxima) has also occurred (See section 3 Climate Modelling). However, due to the high variability of rainfall events and rainfall extremes, it is uncertain if such predications may actually translate into a decrease in the incidence of flooding in Saint Lucia.

In Saint Lucia, heavy precipitation from more frequent storm events including hurricanes may result in an increased incidence of flooding with greater magnitude. Rivers are prone to overflowing their banks during periods of heavy precipitation (MPDEH, 2001). The hurricane period from June to November, brings the greatest quantity of rainfall which often gives rise to flooding (MPDEH, 2006). During hurricanes, the water intakes, dams and reservoirs may be damaged and this can result in decreased water supply and quality (MPDEH, 2001). Increased precipitation can result in siltation of river courses; at intakes such siltation is sometimes so severe that it takes 3 to 4 days before turbidity levels fall and raw water is at the basic quality which treatment plants can handle (Mr Nichols, personal communication, May 6, 2011). Mr Sealey of WASCO has stated that "evidence of climate change can be seen from the heavy rains that occur out of season" (Mr Sealey, personal communication, May 26, 2011).

Hurricanes Allen (1980) and Debbie (1994) caused widespread flooding and landslides which affected water supplies and related infrastructure (Springer, 2005). More recently Hurricane Tomas (2010) resulted in flooding so severe that it was realised that lands that were previously thought safe for residents and residential development no longer were. Buildings in flood plain areas were also affected. Additionally, there were tremendous siltation problems where approximately two-thirds of the John Compton Dam was filled with silt (Mr Nichols, personal communication, May 6, 2011). Behind the John Compton Dam there were 30 recorded landslides ("every other valley had a landslide") and was so significant that even virgin forests came down with the rains. It is estimated that there was 14 inches of rain in 24 hours in Saint Lucia, as Hurricane Tomas slowed as it passed over the island (Mr Sealey, personal communication, May 6, 2011). This resulted in no access to water for between two weeks to a month nationwide; in some communities, normal access to water has still not been resolved several months after the natural disaster. Mr Nichols of the Environment and Sustainable Unit of the Organisation of Eastern Caribbean States (OECS) has stated that this brings into question the prudence of total reliance on one storage unit, which has clearly demonstrated the vulnerability of the island to limited water storage which was severely impaired due to landslides and erosion polluting freshwater supplies (Mr Nichols, personal communication, May 6, 2011).

The vulnerability of the tourism sector during flooding was also clearly established after Hurricane Tomas. Water had to be trucked twice daily to some hotels to sustain hotel water needs. In situations such as natural disasters, water cannot be pumped to hotels, just as other water users did not have water supplies for two weeks to a month (Mr Nichols, personal communication, May 6, 2011). This emphasises the need for privatisation of water resources to an extent which takes the burden of all water demand off the government and encourages investment in water infrastructure.

4.2. *Energy Supply and Distribution*

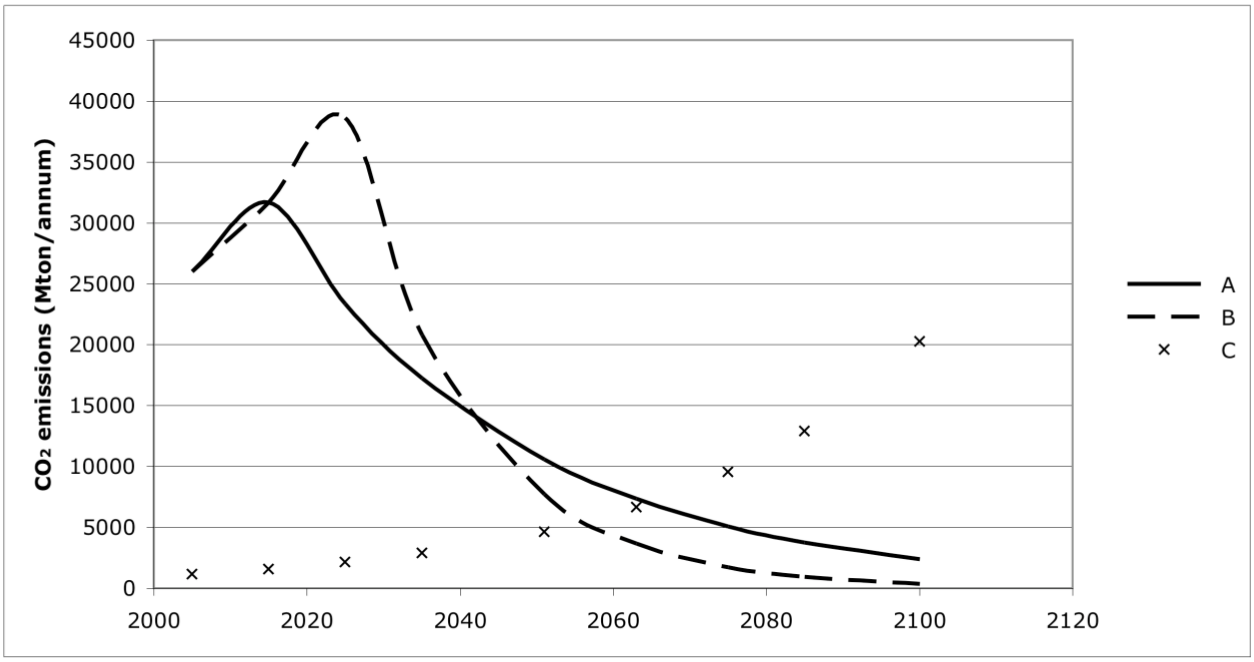
4.2.1. Background

A Global Perspective

Tourism is a significant user of energy and a concomitant contributor to emissions of GHG. In various national comparisons, tourism has been identified as one of the most energy-intense sectors, which moreover is largely dependent on fossil fuels (e.g. Gössling *et al*., 2005; Gössling, 2010). Likewise, the growing energy intensity of economies in the Caribbean has caused concern among researchers (e.g. Francis *et al*., 2007).

Globally, tourism causes 5% of emissions of CO_2, the most relevant GHG. Considering the radiative forcing of all GHG, tourism's contribution to global warming increases from 5.2% to 12.5% (Scott *et al*., 2010). The higher share is a result of emissions of nitrous oxides as well as water leading to the formation of aviation-induced clouds (AIC), which cause additional radiative forcing. The range in the estimate is primarily attributed to uncertainties regarding the role of AIC in trapping heat (Lee *et al*., 2009). Aviation is consequently the most important tourism-subsector in terms of its impact on climate change, accounting for at least 40% (CO_2) of the contribution made by tourism to climate change. This is followed by cars (32% of CO_2), accommodation (21%), activities (4%), and other transport (3%), notably cruise ships (1.5%).

Moving forward into 2050, emissions from tourism are expected to grow considerably. Based on a BAU scenario for 2035, which considers changes in travel frequency, length of stay, travel distance, and technological efficiency gains, UNWTO-UNEP-WMO (2008) estimate that emissions will increase by about 135% compared to 2005. Similar figures have been presented by the World Economic Forum (WEF, 2009). Aviation will remain the most important emissions sub-sector of the tourism system, with expected emission growth by a factor of 2-3. As global climate policy will seek to achieve considerable emission reductions in the order of 50% of 1990 emission levels by 2050, aviation, and tourism more generally, will be in stark conflict with achieving global climate goals, possibly accounting for a large share of the sustainable emissions budget (Figure 4.2.1).



Lines A and B in Figure 4.2.1 represent emission pathways for the global economy under a -3% per year (A) and -6% per year (B) emission reduction scenario, with emissions peaking in 2015 (A) and 2025 (B) respectively. Both scenarios are based on the objective of avoiding a +2°C warming threshold by 2100 (for details see Scott *et al.* 2010). As indicated, a business-as-usual scenario in tourism, considering current trends in energy efficiency gains, would lead to rapid growth in emissions from the sector (line C). By 2060, the tourism sector would account for emissions exceeding the emissions budget for the entire global economy (intersection of line C with line A or B).

Figure 4.2.1: Global CO_2 Emission Pathways versus Unrestricted Tourism Emissions Growth.
(Source : Scott *et al.* 2010)

Achieving emission reductions in tourism in line with global climate policy will consequently demand considerable changes in the tourism system, with a reduction in overall energy use, and a switch to renewable energy sources. Such efforts will have to be supported through technology change, carbon management, climate policy, behavioural change, education and research (Gössling, 2010). Carbon taxes and emissions trading are generally seen as key mechanisms to achieve emissions reductions. Destinations and tourism stakeholders consequently need to engage in planning for a low-carbon future.

The Caribbean Perspective

It is widely acknowledged that the Caribbean accounts for only 0.2% of global emissions of CO_2, with a population of 40 million (i.e. 0.6% of the world's population) (Dulal *et al.*, 2009). However, within the region, emissions are highly unequally distributed between countries (Figure 4.2.2). For instance, Trinidad and Tobago, as an oil-producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2 per capita per year). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. Saint Lucia is, so far, emitting considerably less (2.3 t CO_2) on a per capita basis than the world annual average of 4.3 t CO_2. In the future, global emissions have to decline considerably below 4.3 t CO_2 per year –IPCC suggests a decline in emissions by 20% by 2020 (IPCC, 2007), corresponding to about 3 t CO_2 per capita per year, a figure that also considers global population growth. While there is consequently room for many countries in the region to increase per capita emissions, including in particular Haiti, many of the more developed countries in the Caribbean will need to adjust per capita emissions budgets downwards (i.e. reduce national emissions in the medium-term future).

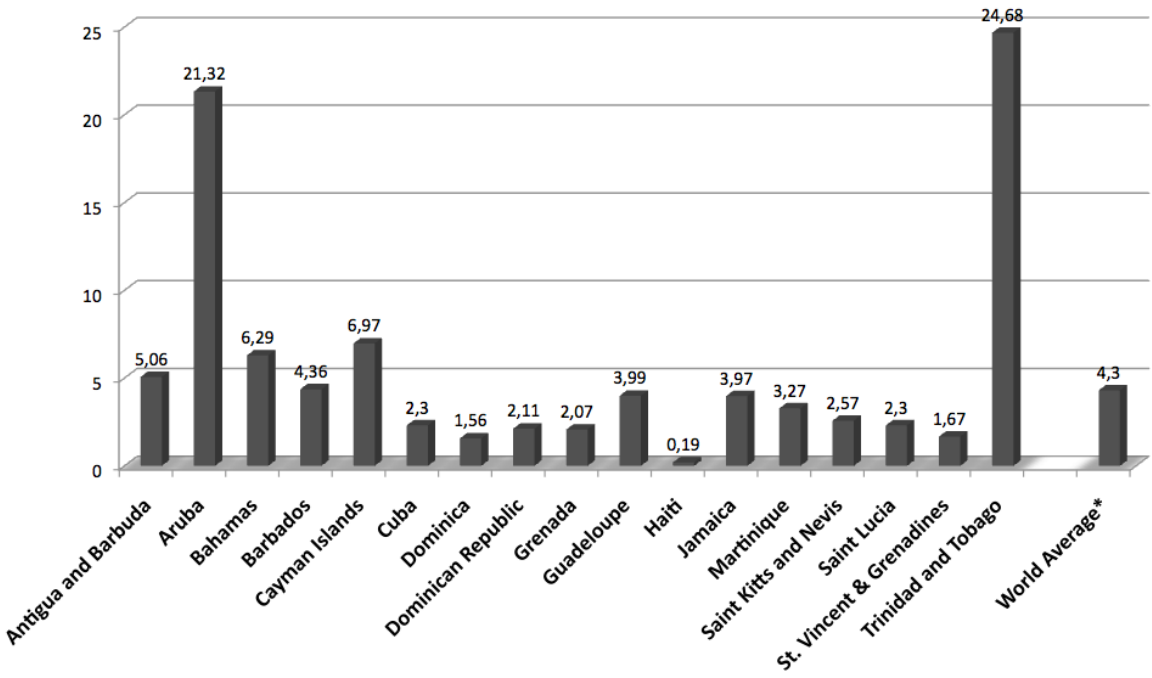


Figure 4.2.2: Per Capita Emissions of CO_2 in Selected Countries in the Caribbean, 2005

(Source: Hall *et al.* 2009)

Important in the context of this report is that in most Caribbean countries, tourism is a major contributor to emissions of GHG (Simpson *et al*., 2008). However, these emissions are not usually quantified, therefore the purpose of this assessment is to look in greater detail into energy use by sector.

Saint Lucia

Tourism is a mainstay of the Saint Lucian economy, with expenditures totalling US $311 million in 2008 (UNWTO, 2010), as compared with the estimated GDP of US $985 million in current prices (figure for 2010, CIA, 2011). Along with the growth in tourism, and the economy more generally, there is also a growth trend in energy consumption, as evident in data communicated to UNFCCC by the Government in 2001 (SDEU, 2001) (see Table 4.2.1, Table 4.2.2 and Table 4.2.3) and as outlined in recent government review documents (Research and Policy Unit, 2011).

Table 4.2.1: Growth Trends in Energy Consumption in Saint Lucia, 1995-2000

Year	1995	1996	1997	1998	1999	2000
Gasoline (IG)	9,841,517	1,139,477	11,266,099	5,728,680	11,835,765	11,771,342
Diesel (IG)	3,788,157	3,661,636	3,920,100	2,016,278	2,875,050	4,460,962
LPG (lbs)	11,768,702	13,801,072	7,868,789	17,588,144	26,654,638	14,274,342
Kerosene (IG)			70,692	72,400	114,377	103,391
AV-Jet	4,564,975	3,689,019	81,940	705,329	7,051,966	6,039,984
AV-Gas	93,288	64,350	55,170	34,523	41,926	57,326

(Source: SDEU, 2001)

Table 4.2.2: Growth Trends in Energy Consumption in Saint Lucia, 2002-2010 (Barrels of Oil Equivalent)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
Gasoline	256,607	318,867	316,360	333,590	349,264	349,261	373,605	355,073	372,416
Diesel	499,500	597,569	608,319	613,631	654,731	669,181	696,282	618,035	732,207
LPG	53,596	58,245	57,331	61,623	71,835	56,904	88,978	94,009	68,859
Kero/Avjet	72,246	119,492	169,582	200,328	165,384	212,241	227,405	141,827	213,004

(Source: Research and Policy Unit, 2011)

Electricity production, distribution and supply are administered by one company, Saint Lucia Electricity Services, which supplies approximately 98% of the population (CIPORE, n.d.). Electricity is generated using imported diesel (DOEA, 2006). In 2009, electricity consumption increased by 4.3% and in 2010 by 4.8% thanks to increased consumption in the domestic (5.5% growth), commercial (4.9% growth) and hotel (7% growth) sectors (Research and Policy Unit, 2011). Future growth is expected to occur in the same sectors by 1.52%, 1.63% and 0.85% per year respectively, up to 2020 (LUCELEC, 2009).

Table 4.2.3: Growth Trends in Electricity Consumption in Saint Lucia, 1995-2010

Year		Domestic	Commercial and hotels	Industrial	Street lighting	Total sales
1995	MWh	62,668	86,683	12,697	2,282	163,330
	%	38.4	52.5	7.8	1.4	100
1996	MWh	66,663	86,518	10,860	2,185	165,216
	%	39.7	52.4	6.6	1.3	100
1997	MWh	69,617	97,248	11,287	2,605	180,757
	%	38.5	53.8	6.2	1.4	100
1998	MWh	75,639	108,618	11,640	2,931	198,828
	%	38.0	54.6	5.9	1.5	100
1999	MWh	79,491	120,628	12,271	3,271	215,661
	%	36.8	56.9	5.7	1.5	100
2001	MWh	88,443	137,017	12,954	5,002	243,416
2002	MWh	89,084	133,996	12,673	3,634	239,387
2003	MWh	92,848	141,374	13,185	4,713	252,120
2004	MWh	96,062	151,451	12,345	6,544	266,402
2005	MWh	98,914	158,483	12,522	7,480	277,399
2006	MWh	101,635	160,895	12,982	8,886	284,398
2007	MWh	104,784	168,151	15,789	9,117	297,841
2008	MWh	103,214	170,624	18,626	9,510	301,975
2009	MWh	107,820	178,518	19,002	9,741	315,081
2010	MWh	113,757	188,640	18,373	9,959	330,729

(Source: SDEU, 2001, LUCELEC, 2011)

According to the Saint Lucia Government (SDEU, 2001), emissions of CO_2 amounted to 270,000 t CO_2 in 1994, not including emissions from international bunkers. CO_2 emissions from international bunkers for the year 1994 are reported to be in the order of 67,800 t CO_2, most of this because of aviation (60.800 t), the remainder falling on shipping (7,000 t). In total, Saint Lucia's emissions of CO_2 may thus have been in the order of 338,000 t in 1994. This value appears to have risen considerably in recent years: according to the CIA World Factbook (CIA, 2011), Saint Lucia's energy consumption is currently in the order of 3,000 bbl/day (2009 estimate) corresponding to 137,500 t, or emissions of about 440,000 t CO_2. A slightly lower estimate is presented by the US Energy Information Administration (US EIA, 2010), suggesting oil consumption of 2,880 bbl/day (i.e. 132,040 t) (in 2009). However, these figures do not compare well with data provided in the Saint Lucia Economic and Social Review (DOEA, 2006). According to the report, energy use included

61,623 bbl of liquefied petroleum gas, 333,589 bbl of gasoline, 200,328 bbl of kerosene, and 120,667 bbl of diesel in 2005, translating into 1,962 bbl/day. For comparison, the US Energy Information Administration reports fuel use of 2,631 bbl/day for 2005. Consequently, there is a considerable difference between the two sources and it is unclear whether for instance fuel bunkered by cruise ships may account for part of the difference. In the absence of detailed data on fuel use in tourism, the following section provides a bottom-up analysis to derive an estimate of emissions in this sector (Table 4.2.4).

Table 4.2.4: Assessment of CO_2 Emissions from Tourism in Saint Lucia, Data for Various Years.

Tourism sub-sector	Energy use	Emissions	%	Assumptions
Aviation[1)]	54,288 t fuel	171,000 t CO_2	56	Based on Gössling *et al*. (2008)
Road transport[2)]	6,360 t fuel	20,352 t CO_2	7	Including tourists, not day visitors
Cruise ships[3)]	1,345 t fuel	4,300 t CO_2	1	Bunkers for cruise ships
Accommodation[4)]	63 MWh	62,964 t CO_2	20	Based on energy statistics from Barbados
Activities[5)]	-	8,586 t CO_2	3	Global average
Sub-total		267,202 t CO_2	87	
Indirect energy use (factor 1.15)		40,080 t CO_2	15	To account for life-cycle emissions
Total		307,282 CO_2	100	

1) Aviation fuels: based on Gössling *et al*. (2008), fuel use in aviation (in 2005) for tourism has been in the order of 1,076 kg CO_2 per tourist (average weighted value; return flight), leading to overall emissions of 342,000 t CO_2 (including about 318,000 tourists in 2005). In a bunker-fuel approach, about half of this would fall on Saint Lucia, i.e. only the fuel bunkered in the island. Emissions are consequently in the order of 171,000 t CO_2, corresponding to a fuel use of about 54,288 t.
2) Road Transport: 318,000 international tourist arrivals in 2008 (UNWTO, 2010; slightly lower levels of about 306,000 arrivals are reported for 2010 in the Saint Lucia Economic and Social Review for 2010, (Research and Policy Unit, 2011)), with each tourist travelling an assumed 150 pkm on the island during the stay. At an assumed average of 0.133 kg CO_2 per pkm (50% occupancy rate; UNWTO-UNEP-WMO, 2008), emissions are in the order of 20 kg CO_2 (corresponding to about 8 l of diesel) per tourist, totalling 20,352 t CO_2, or about 6,360 t of fuel. Cruise tourists are not included, as these are day visitors not likely to engage in longer trips.
3) According to the Saint Lucia Government (SDEU, 2001), marine bunker fuel use resulted in emissions of 7,000 t CO_2 in 1994. It is here assumed that since 1994, there has been a 23% increase in bunker fuel use, in line with general growth in fuel use. Note that this is likely to underestimate growth in bunker fuel use, as a 22% increase in cruise passenger arrivals has taken place in the period 2004-2008 alone (UNWTO, 2010). This would correspond to 8,600 t CO_2 from shipping, out of which 4,300 t CO_2, i.e. a 50% share, corresponding to 1,345 t fuel, are here assumed to be bunkered by cruise ships. An alternative approach would be to calculate emissions that Saint Lucia would be responsible for on the basis of the number of cruise passengers it receives. At the standard per day value (global average) of 169 kg CO_2 per passenger (Eijgelaar *et al*., 2010), the 620,000 cruise passengers in 2008 (UNWTO, 2010) would have caused emissions of 104,780 t CO_2, i.e. considerably more than the 4,300 t calculated on the basis of a bunker fuel approach.
4) According to a study carried out in Barbados in 2010, hotels (n=22) used on average 22 kWh of energy per guest night. This value is also used for Saint Lucia. At an average length of stay of 9 nights in 2008 (UNWTO, 2010, note that according to the Government of Saint Lucia (Research and Policy Unit, 2011), there has been high volatility between 10.5 (2006) and 8.6 (2010) days), the 318,000 guest would have stayed 2.862 million nights, with a corresponding energy use of 63 MWh. This value compares favourably to 57 MWh of electricity used in hotels in 2005 according to the Saint Lucia Economic and Social Review 2005 (DOEA, 2006). Electricity production is assumed to be less efficient in Saint Lucia, and a value of 1 kg CO_2 per kWh is assumed here, resulting in emissions of 62,964 t CO_2. Data provided by the US Energy Information Administration (US EIA, 2010) and the Saint Lucia Economic and Social Review (DOEA, 2006) also indicates that hotels may have consumed 20.5% of electricity produced in the island. It is unknown, however, whether there is additional significant electricity production in self-sustained hotels on the basis of generators.
5) Activities are included with the global assumption of 27 kg CO_2 per tourist, as provided in UNWTO-UNEP-WMO, 2008. Given the energy-intense character of many activities in tropical environments, including boat trips, scenic drives, helicopter flights, diving, the use of jet skis, or water skiing, this value may be conservative. The 318,000 tourists would thus have caused emissions from activities corresponding to 8,586 t CO_2. As energy use for activities will be partially fossil fuel, and partly electricity based, it is difficult to translate these values into energy use.

(Source: DEFRA, 2010; UNWTO-UNEP-WMO, 2008; UNWTO, 2010)

Table 4.2.4 shows the distribution of energy use by tourism sub-sector. Note, however, that this estimate is based on data with considerable uncertainties, including extrapolations from 1994-2008. Results indicate that emissions from tourism accounted for 307,000 t CO_2 in 2008. Should the calculated value of national emissions of 440,000 t CO_2 in 2009 be correct, tourism would consequently be responsible for almost 70% of national emissions.

Trends in Energy Use in Saint Lucia

As outlined, energy use has increased considerably in recent years in Saint Lucia. It is unclear how trends will develop in the future given the plans for greater investment in renewable energy, as outlined in the next section. Table 4.2.5 shows the observed growth rate in energy consumption (based on data given in Table 4.2.3) and compares those values to the predictions provided by Saint Lucia Electricity Services Ltd in their 2009 annual report for the period up to 2020 (LUCELEC, 2009). The predicted growth rates are based on an average GDP growth of 1.5% over the same period and suggest that a plateau has been reached in terms of the continued growth in sales and mirrors the state of the economy (LUCELEC, 2009).

Table 4.2.5: Trends in Energy Use

	Domestic	Commercial and hotels	Industrial
Observed growth (1995-2010)	5.1%	7.03%	2.8%
Predicted growth rate to 2020 (LUCELEC, 2009)	1.52%	1.63% Commercial 0.85% Hotels	

Reducing Energy Use and Emissions

Saint Lucia has pursued a strategy of increasingly making use of renewable energy for several years, with the government stating in its communication to UNFCCC as far back as 2000 that:

> *There has been a concerted effort to promote the increased utilization of renewable energy on the island. This has been evident in the removal of duty and consumption tax on solar water heating units and other renewable energy technology. Feasibility studies on solar, wind and geothermal energy potential are ongoing. To this end, a comprehensive energy plan has been developed to address issues of price stability, quality, security of supply, efficiency of consumption, generation and distribution; renewable energy use and environmental impacts; utility regulations, clean energy technologies, and obligations under international agreements such as the UNFCCC. (Source: SDEU, 2001, p.11)*

More specifically, the Government of Saint Lucia set the following goals in the Sustainable Energy Plan, as reported in the Initial National Communication to the UNFCCC (SDEU, 2001). Overall, energy use has clearly increased over recent years and these targets have been amended in the National Energy Policy described in more detail below.

- Reducing projected electricity demand by 5% by 2005, resulting in a peak demand in 2005 of 51 MW, which will require an installed capacity of 75 MW.
- Reduce projected electricity demand by 15% in 2010, resulting in a peak demand in 2010 of 55.7 MW, which will require an installed capacity of 77.4 MW.
- Deliver 5 MW, or 7% of installed capacity, via renewable energy technologies by 2005.
- Deliver 17 MW, or 20% of installed capacity, via renewable energy technologies by 2010.
- As a result of reductions in demand and increased use of renewable energy resources, reduce the annual consumption of diesel fuel for electricity generation to 436,579 barrels in 2005 (12% reduction from the baseline) and 392,823 barrels in 2010 (35% reduction from the baseline.
- Reduction of annual GHG emissions from the electricity sector to 166,197 tons of carbon by 2005 and 149,539 tons of carbon by 2010.

- Reducing the consumption of gasoline and diesel fuel in the transportation sector to 122,471 barrels of diesel and 610 974 barrels of gasoline by 2005 (5% reduction) and 109,579 barrels of diesel and 546 661 barrels of gasoline (15% reduction) by 2010. These reductions are to be achieved by a combination of measures, including the increased use of public transportation, the introduction of high-efficiency vehicles, the deployment of a limited number of vehicles powered by alternative fuels, driver education and awareness to reduce fuel consumption, and improvements in road and traffic management.

Likewise, in 2000, the Government stated that in order to achieve these targets, a number of research, policy and regulatory initiatives are required. To this end, the following measures were identified:

- Renewable Energy Resource Assessment
- Assessment of Energy Efficiency and Conservation
- Reform of the Electricity Sector
- Capacity Building for Sustainable Energy
- Public Awareness
- Establishment of a Renewable-Energy Feasibility and Project Investment Fund
- Promotion of Solar Energy
- Establishment of Guidelines for Energy Efficient Practices in Government Buildings
- Improved Efficiencies in the Transport Sector
- Development of a Portfolio of Sustainable Energy

More recently, the Government of Saint Lucia has prepared a National Energy Policy (MOPDE, 2010) that acknowledges the lack of progress in implementing the Sustainable Energy Plan and seeks to "create an enabling environment, both regulatory and institutional, for the introduction of indigenous renewable energy to the national energy mix, thus achieving greater energy security and independence." The policy states the Government's commitment to making significant strides in energy sustainability, guided by the following tenets:

- Procurement of energy supplies at the least cost through liberalisation of the energy sector and broad private sector participation;
- Energy security and reliability;
- Diversification of the energy base;
- Exploitation of indigenous renewable energy resources;
- Higher efficiency in energy production, conversion and use with the overall objective of reducing energy intensity;
- Reduction of adverse environmental effects and pollution by rehabilitating existing energy sector facilities and introducing new standards for energy-related products, as well as mandating appropriate environmental impact assessments of new projects and options;
- Implementation of appropriate pricing policies to ensure that adequate energy supplies are efficiently delivered to all economic sectors, and fostering of an environment to facilitate an improved and sustained energy supply network with sufficient incentives to encourage private sector investments; and
- Establishment of an appropriate regulatory framework to set clear guidelines for investors and protect the interests of consumers.

The policy then outlines the responsibilities of the various key actors in the energy sector and commits to the establishment of an Energy Policy Advisory Committee, which includes a representative from the Saint

Lucia Hotel and Tourism Association. It also states that a Regulatory Commission will be established to oversee the licensing of power producers, tariff structures, net-metering initiatives and monitoring of the sector (MOPDE, 2010). Private enterprises may only establish non-fossil fuel power generation schemes and must do so as a Joint Venture initiative or through a Power Purchase Agreement. Co-generation is also possible for single entities where the electricity is for their own use, but capacity is not allowed to exceed 30% of their pre- co-generation consumption or 500 kW (MOPDE, 2010). Similarly, small-scale renewable systems with a maximum peak capacity of 10 kW dedicated mainly to self-supply, such as photovoltaic systems, small wind generators, or small hydro-power plants, will need approval by LUCELEC, but will not have to apply for a licence. These limitations restrict the ability for entities to contribute to the guiding policy statements outlined above.

Energy efficiency is also addressed in the National Policy, with aims to address efficiency and conservation through pricing of energy products and Demand Side Management initiatives that will require financing through tax concessions and other financial incentives. Proposals for the latter include institutional strengthening and energy-efficiency training for utility personnel, hotel developers and engineers. Energy audits will also be required for major consumers, including hotels and public sector entities that exceed a threshold to be determined. These consumers will then be required to implement energy-efficiency measures. An energy efficiency building code is also to be established and measures put in place to encourage the use of energy saving devices in new and existing buildings(MOPDE, 2010).

There is evidence that Saint Lucia is making progress in the area of renewable energy. In particular the Government is currently exploring possibilities of developing geothermal, solar and wind energy sources with the aim of reducing their unsustainable and environmentally-degrading dependence on fossil fuels, and by extension; reducing their imports of refined fuels needed for energy production. New targets for the contribution from renewable energy are 5% by 2013, 15% by 2015, and 30% by 2020 (MOPDE, 2010). However, it is acknowledged that these targets may be adjusted once national resource assessments have been conducted.

Geothermal energy is the most studied and research renewable energy source in Saint Lucia, and has been found to be have the most potential. The Government has received assistance from the Organisation of American States and the United Network of the Eastern Caribbean to establish an enabling regulatory framework and to undertake technical research.

Wind energy is also being explored, and some wind turbine projects have already commenced or are on-going. For example, a fishing village energy generation project which started in 2007 and was revisited in 2010 after some technical difficulties were encountered (DOEA, 2006; CIPORE, n.d.; Government of Saint Lucia, 2010b).

The use of solar energy will be for water heating, both for the residential and commercial sectors, and the Government is providing tax concessions to encourage greater use of solar water heater systems, and to ease the initial installation costs for dwelling and commercial units (CIPORE, n.d.). The National Energy Policy states that new large consumers of hot water such as tourist resorts will be mandated to use solar water heaters, unless hot water is provided by co-generation plants(MOPDE, 2010).

It is notable that the various measures suggested above do not specifically address shipping and in particular aviation, which is likely to be the single most relevant fuel-consuming sector in Saint Lucia.

4.2.2. Vulnerability of the Energy Sector to Climate Change

Two key impacts related to energy and emissions are of relevance for the tourism sector and the wider economy. First, energy prices have fluctuated in the past and there is evidence that the cost of oil on world markets will continue to increase. Second, if the international communities' climate objective of stabilizing temperatures at 2°C by 2100 is taken seriously, both regulation and market-based instruments will have to be implemented to cut emissions of GHG. Such measures would affect the cost of mobility, in particular, air transport, being a highly energy- and emission-intense sector. The following sections will discuss past and future energy costs, the challenges of global climate policy and how these interact to create vulnerabilities in the Saint Lucia tourism sector, as well as the vulnerabilities of the physical infrastructure for energy generation.

Energy Costs

High and rising energy costs should self-evidently lead to interest in more efficient operations, but this does not appear to be the case in tourism generally. Since the turn of the 19th Century, world oil prices only once exceeded those of the energy crisis in 1979 after the Iranian revolution. Even though oil prices declined because of the global financial crisis in 2008 (Figure 4.2.3) – for the first time since 1981 (IEA, 2009) - world oil prices have already begun to climb again in 2009, and are projected to rise further. The IEA (IEA, 2010) projects for instance, that oil prices will almost double between 2009 and 2035 (in 2009 prices). Notably, Figure 4.2.3 shows the decline in oil prices in 2009; in March 2011, Bloomberg reported Brent spot prices exceeding US $120/barrel.

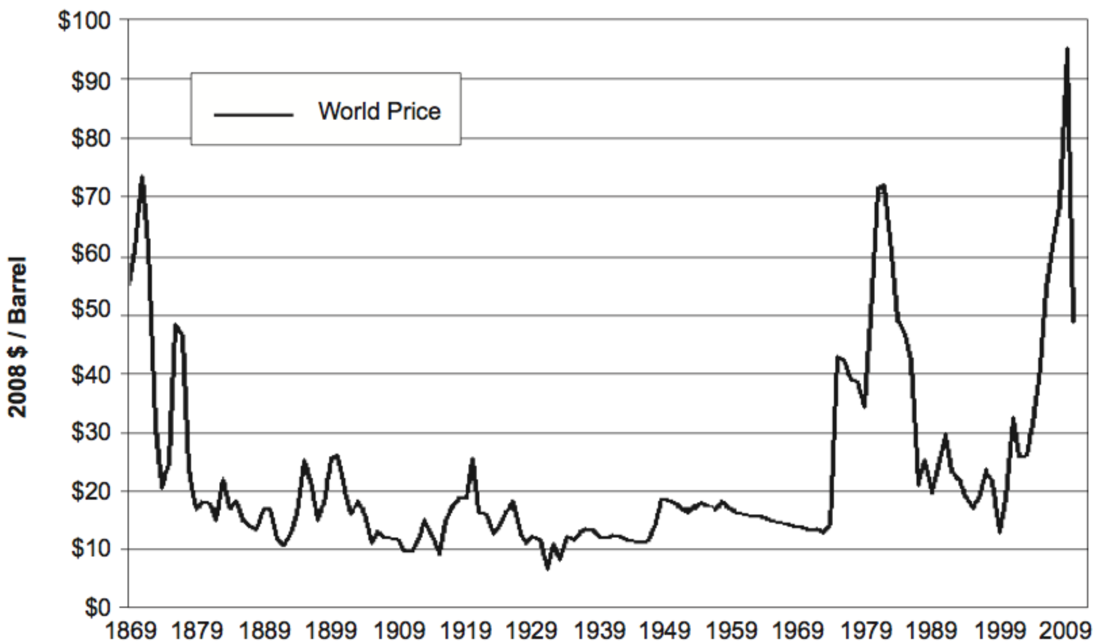


Figure 4.2.3: Crude Oil Prices, 1869-2009

(Source: after Williams, 2010)

The IEA anticipates that even under its New Policies Scenario, which favours energy efficiency and renewable energies, energy demand will be 36% higher in 2035 than in 2008, with fossil fuels continuing to dominate demand (IEA, 2010). At the same time there is reason to believe that peak oil (i.e. the maximum capacity to produce oil), may be passed in the near future. The UK Energy Research Centre, for instance, concludes in a review of studies that a global peak in oil production is likely before 2030, with a significant risk of a peak before 2020 (UKERC, 2009). Note that while there are options to develop alternative fuels, considerable uncertainties are associated with these options. For instance with regard to costs, safety, biodiversity loss, or competition with food production (e.g. Harvey and Pilgrim, 2011). Rising costs for conventional fuels will therefore become increasingly relevant, particularly for transport, the sector most dependent on fossil fuels with the least options to substitute energy sources. Within the transport sector, aviation will be most affected due to limited options to use alternative fuels, which have to meet specific demands regarding safety and energy-density (cf. Nygren *et al*., 2009; Upham *et al*., 2009). Likewise, while there are huge unconventional oil resources, including natural gas, heavy oil and tar sands, oil shales and coal, there are long lead times in development, necessitating significant investments. The development of these oil sources is also likely to lead to considerably greater environmental impacts than the development of conventional oil resources (IEA, 2009).

These findings are relevant for the tourism system as a whole because mobility is a precondition for tourism. Rising oil prices will usually be passed on to the customer, a situation evident in 2008, when many airlines added a fuel surcharge to plane tickets in order to compensate for the spike in oil prices. Increased travel costs can lead to a shift from long haul- to shorter-haul destinations. The cost of energy is one of the most important determinants in the way people travel, and the price of oil will influence travel patterns, with some evidence that in particular low-fare and long-haul flights are susceptible to changes in prices (e.g. Mayor and Tol, 2008). Moreover, it deserves mention that oil prices are not a simple function of supply and demand, but involve different parameters such as long-term contracts and hedging strategies, social and political stability in oil producing countries, as well as the global security situation generally. This is well illustrated in the volatility of oil prices in the five-year period 2002-2009, when the world market price of aviation fuel oscillated between a low of US $25 in 2002 (Doganis, 2006) and US $147 in mid-2008 (Gössling and Upham, 2009).

The huge rise in oil prices, which was not expected by most actors in tourism, had a particularly severe impact on aviation. As late as December 2007, International Air Transport Association (IATA) projected the average 2008-price of a barrel of oil at US $87, up 6% from the average price level in 2007 (IATA, 2007). In early 2008, IATA corrected its projection of fuel prices to an average of US $106 per barrel for 2008, an increase of 22% over its previous estimate. However, in July 2008, oil prices reached US $147 per barrel, and IATA corrected its forecast for average oil prices in 2008 to almost US $142 per barrel, a price 75% higher than a year ago (IATA, 2008). In autumn 2008, again seemingly unexpected by the overwhelming majority of actors in tourism, the global financial system collapsed due to speculation of financial institutions with various forms of investment. As a result, the global economy went into recession, and by the end of 2008, oil prices had reached a low of US $40 per barrel.

Fuel price volatility, in late 2008 exceeding 30% of operational costs (IATA 2009, see Figure 4.2.4), had a range of negative impacts for airlines. Before the financial crisis, it appeared as if low-fare carriers would be severely affected by high fuel prices, with even profitable airlines reporting falling profits, grounded aircraft and cancelled routes. High fuel prices had clearly affected the perception of travellers to fly at quasi-zero costs (cf. Gössling and Upham, 2009). However, when fuel costs declined because of the financial crisis, low cost carriers were apparently seen by many travellers as the only airlines still offering flights at reasonable prices; thus reversing passenger choices to the disadvantage of the flag carriers. These examples show that high and rising oil prices, as well as price volatility, can significantly affect tourism and in particular airlines, increasing destination vulnerability.

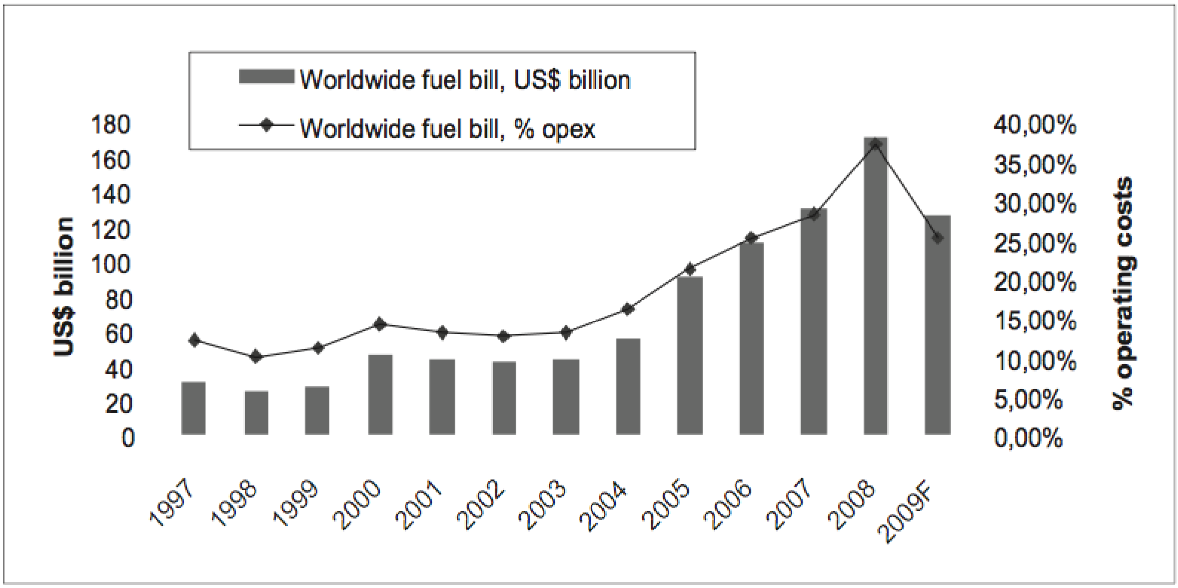


Figure 4.2.4: Fuel Costs as Part of a Worldwide Operating Cost

(Source: IATA, 2009)

Price increases have also been felt in Saint Lucia:

> *As an oil importing country, the energy and productive sectors in Saint Lucia continued to be impacted by the developments in the international petroleum market. Stronger global economic growth generated higher demand for oil, fuelled by rising consumption in emerging economies, led by China, together with developed countries such as the United States. This development coupled with the weakness of the US dollar and continued speculation about world oil supply, exerted upward pressure on crude oil prices… In 2010, the prices of West Texas Intermediate (WTI), the US benchmark, rose by 28.8% to an average of US $79.43 per barrel from US $61.69 in 2009. (Source: Research and Policy Unit, 2011, p.27)*

Oil price alone is not the only cause of vulnerability for an oil importing country like Saint Lucia. The need to diversify the source of the oil is also an area that the Government of Saint Lucia has identified as needing further investigation and discussion (MOPDE, 2010). This would make the nation less vulnerable in the event of a disruption in the supply of oil and oil derivatives.

Climate Policy

As described in the introduction, climate change is high on the global political agenda, but so far, the EU is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. While it is likely that the EU Emission Trading Scheme (ETS) will not seriously affect aviation, the only tourism sub-sector to be directly integrated in the scheme by 2012 (e.g. Mayor and Tol, 2009, see also Gössling *et al*., 2008), discussions are on-going of how to control emissions from consumption not covered by the EU ETS. This is likely to lead to the introduction of significant carbon taxes in the EU in the near future (EurActiv, 2009). Moreover, the EU ETS will set a tighter cap on emissions year-on-year, and in the medium-term future (i.e. around 2015-2025), it can be assumed that the consumption of energy-intense products and services will become perceivably more expensive. There is also evidence of greater consumer pressure to implement pro-climate policies. While climate policy is only emerging in other regions, it can be assumed that in the near future, further legislation to reduce emissions will be introduced – the new air passenger duty in the UK is a recent example, and has already been followed by Germany's departure tax (as of January 1, 2011).

As of November 1, 2009, the UK introduced a new air passenger duty (APD) for aviation, which replaced its earlier, two-tiered APD. The new APD distinguishes four geographical bands, representing one-way distances from London to the capital city of the destination country/territory, and based on two rates, one for standard class of travel, and one for other classes of travel (

Table 4.2.6).

Table 4.2.6: UK Air Passenger Duty as of November 1, 2009

Band, and approximate distance in miles from	In the lowest class of travel (reduced rate)		In other than the lowest class of travel* (Standard rate)	
	From November 1, 2009 to October 31, 2010	From November 1, 2010	From November 1, 2009 to October 31, 2010	From November 1, 2010
Band A (0-2000)	£11	£12	£22	£24
Band B (2001-4000)	£45	£60	£90	£120
Band C (4001-6000)	£50	£75	£100	£150
Band D (over 6000)	£55	£85	£110	£170

*The reduced rates apply where the passengers are carried in the lowest class of travel on any flight unless the seat pitch exceeds 1.016 metres (40 inches), in which case, whether there is one or more than one class of travel the standard rates apply.

(Source: HM Revenue and Customs, 2008)

Scientifically, there is general consensus that a "serious" climate policy approach will be paramount in the transformation of tourism towards becoming climatically sustainable, as significant technological innovation and behavioural change will demand strong regulatory environments (e.g. Barr *et al.*, 2010; Bows *et al.*, 2009; Hickman and Banister, 2007; see also Giddens, 2009). As outlined by Scott *et al.* (2010), "serious" would include the endorsement of national and international mitigation policies by tourism stakeholders, a global closed emission trading scheme for aviation and shipping, the introduction of significant and constantly rising carbon taxes on fossil fuels, incentives for low-carbon technologies and transport infrastructure, and, ultimately, the development of a vision for a fundamentally different global tourism economy.

While this would demand a rather radical change from current business models in tourism, all of these aspects of a low-carbon tourism system are embraced by business organisations in principal. For instance, the World Economic Forum (WEF, 2009) suggests as mechanisms to achieve emission reductions i) a carbon tax on non-renewable fuels, ii) economic incentives for low-carbon technologies, iii) a cap-and-trade system for developing and developed countries, and iv) the further development of carbon trading markets. Furthermore, evidence from countries seeking to implement low-carbon policies suggests that the tourism businesses themselves also call for the implementation of legislation to curb emissions, a result of the wish for "rules for all", with pro-climate oriented businesses demanding regulation and the introduction of market-based instruments to reduce emissions (cf. Ernst and Young, 2010; PricewaterhouseCoopers, 2010).

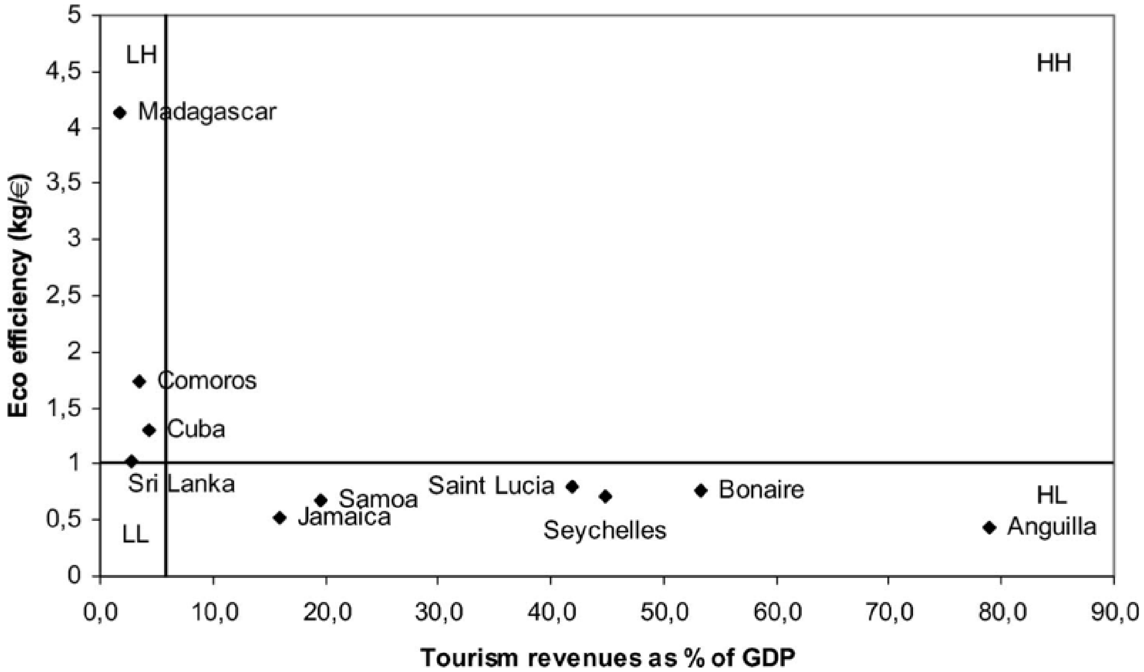
There is consequently growing consensus among business leaders and policy makers that emissions of GHG represent a market failure. The absence of a price on pollution encourages pollution, prevents innovation, and creates a market situation where there is little incentive to innovate (OECD, 2010). While governments have a wide range of environmental policy tools at their disposal to address this problem, including regulatory instruments, market-based instruments, agreements, subsidies, or information campaigns, the fairest and most efficient way of reducing emissions is increasingly seen in higher fuel prices (i.e. the introduction of a tax on fuel or emissions) (e.g. Sterner, 2007; Mayor and Tol, 2007, 2008, 2009, 2010a,b; see also OECD, 2009 and 2010; WEF, 2009; PricewaterhouseCoopers, 2010).

> *Compared to other environmental instruments, such as regulations concerning emission intensities or technology prescriptions, environmentally related taxation encourages both the lowest cost abatement across polluters and provides incentives for abatement at each unit of pollution. These taxes can also be a highly transparent policy approach, allowing citizens to clearly see if individual sectors or pollution sources are being favoured over others. (Source: OECD, 2010)*

The overall conclusion is that emerging climate policy may be felt more in the future, and tourism stakeholders should seek to prepare for this.

Vulnerabilities

A destination could generally be understood as vulnerable when it is highly dependent on tourism, and when its tourism system is energy intense with only a limited share of revenues staying in the national economy. Figure 4.2.5 shows this for various islands, expressed as a climate policy risk assessment. In the case of Saint Lucia, vulnerability is lower than in other countries, because the share of tourism in national GDP is still comparably low, while the energy intensity of the island's tourism system is also low.



Destination climate policy risk assessment: eco-efficiency and tourism revenues as share of GDP. Notes: Lines represent the weighted average values for all 10 islands; H is either high (unfavourable) eco-efficiency or high dependency on tourism, L is either low (favourable) eco-efficiency or low dependency on tourism, eco-efficiency=local spending compared to total emissions, i.e. not considering air fares.

Figure 4.2.5: Vulnerability of Selected Islands, Measured as Eco-Efficiency and Revenue Share

(Source: Gössling *et al.*, 2008)

While global climate policy affecting transportation is currently only emerging, there are already a number of publications seeking to analyse the consequences of climate policy for tourism-dependent islands. There is general consensus that current climate policy is not likely to affect mobility because international aviation is exempted from value-added tax (VAT), a situation not likely to change in the near future due to the existence of a large number of bilateral agreements. Furthermore, emissions trading as currently envisaged by the EU would, upon implementation in 2012, increase the cost of flying by just about €3 per 1,000 passenger-kilometres (pkm) at permit prices of €25 per tonne of CO_2 (Scott *et al*., 2010). Similar findings are presented by Mayor and Tol (2010b), who model that a price of €23/t CO_2 per permit will have a negligible effect on emissions developments. Other considerable increases in transport costs due to taxation are not currently apparent in any of the 45 countries studied by OECD and UNEP (2011), though such taxes may be implemented in the future. The example of the UK has been outlined above and Germany introduced a departure tax of €8, €25 and €45 for flights <2,000 km, 2,000-4,000 km and >4,000 km as of January 1, 2011.

The implications of the EU ETS for tourism in island states were modelled by Gössling *et al*. (2008). The study examined the implications of the EU-ETS for European outbound travel costs and tourism demand for ten tourism-dependent less developed island states with diverse geographic and tourism market characteristics. It confirmed that the EU-ETS would only marginally affect demand to these countries. That is, cause a slight delay in growth in arrival numbers from Europe through to 2020, when growth in arrivals would be 0.2% to 5.8% lower than in the baseline scenario (Gössling *et al*., 2008).

As the Gössling *et al*. (2008) study only looked at climate policy, omitting oil prices, Pentelow and Scott (2010) modelled the consequences of a combination of climate policy and rising oil prices. A tourist arrivals model was constructed to understand how North American and European tourist demand to the Caribbean region would be affected. A sensitivity analysis that included 18 scenarios with different combinations of three GHG mitigation policy scenarios for aviation (represented by varied carbon prices), two oil price projections, and three price elasticity estimates was conducted to examine the impact on air travel arrivals from eight outbound market nations to the Caribbean region. Pentelow and Scott (2010) concluded that a combination of low carbon price and low oil price would have very little impact on arrivals growth to the Caribbean region through to 2020, with arrivals 1.28% to 1.84% lower than in the BAU scenario (the range attributed to the price elasticity chosen). The impact of a high carbon price and high oil price scenario was more substantive, with arrivals 2.97% to 4.29% lower than the 2020 BAU scenario depending on the price elasticity value used. The study concluded:

> *It is important to emphasize that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020. (Source: Pentelow and Scott, 2010)*

A detailed case study of Jamaica further revealed the different sensitivity of market segments (package vacations) to climate policy and oil price related rises in air travel costs (Pentelow and Scott, 2010; see also Schiff and Becken, 2010 for a New Zealand study of price elasticity). Pentelow and Scott (2010) concluded that further research is required to understand the implications of oil price volatility and climate policy for tourist mobility, tour operator routing and the longer- term risks to tourism development in the Caribbean. Overall, current frameworks to mitigate GHG emissions from aviation do not seem to represent a substantial threat to tourism development (Mayor and Tol, 2007; Gössling *et al*., 2008; Rothengatter, 2009), but new regulatory regimes and market-based instruments to reduce emissions in line with global policy objectives would cause changes in the global tourism system that could affect SIDS in particular. To anticipate these changes and to prepare the vulnerable tourism economies in the Caribbean to these changes should thus be a key management goal for tourism stakeholders.

Climate Change Impacts on Energy Generation, Distribution and Infrastructure

A report on the potential impacts of climate change on the energy sector published by the U.S. Department of Energy distinguishes between direct and indirect impacts. The former are impacts that affect energy resource availability, fuel and power production, transmission and distribution processes. The latter impacts are brought on by other sectors through forward or reverse linkages with the energy sector, and may include competition for shared resources, trends in demand and supply and pricing. These impacts are not only limited to traditional (fossil fuel) based energy systems, but renewable systems as well. While direct impacts are more visible, the costs of indirect impacts can be difficult to quantify and often exceed those of direct impacts, given the inter-relationships between energy and other sectors (U.S. Department of Energy/National Energy Technology Laboratory, 2007). Similarly, Contreras-Lisperguer and de Cuba (2008) have outlined a number of potential impacts of climate change on both traditional and renewable energy systems, with varying consequences for energy production and transmission efficiency, energy prices and trends in demand and consumption.

Saint Lucia depends mainly on fossil fuels for energy production, with the aim of reducing this dependence by including various renewable energy technologies in the future. Potential physical climate change impacts specific to traditional energy production systems as well as the renewable technologies being considered by the Government of Saint Lucia are outlined here. Since Saint Lucia is at the stage of planning for and implementing renewable energy systems, special consideration should be given to the physical impacts that can affect these systems in the planning process.

An increase in the intensity (and possibly frequency) of severe low pressure systems, such as hurricanes, has the potential to affect both traditional and renewable energy production and distribution infrastructure, including generating plants, transmission lines, and pipelines. Most, if not all of the energy-based infrastructure in Saint Lucia is therefore vulnerable to impacts from tropical storms and hurricanes during any given year. Some of the more vulnerable components of the energy system include transmission lines, poles and other relatively light, above ground infrastructure, which can suffer significant damage from high winds. Lines and poles were damaged or destroyed during the passage of Hurricane Tomas in 2010 as a result of high winds, but also from erosion and landslides caused by the heavy rains associated with the system. The Union substation also suffered damage from inundation, which was previously shown to be vulnerable to flooding (UNECLAC, 2011).

In the aftermath of extreme weather, the process of restoring transmission and proper operation of generating facilities depends on road access and the amount of supplies available to replace infrastructure components that have been damaged or destroyed (see section 4.7, Comprehensive Natural Disaster Management). The vulnerability of the energy sector to extreme weather events therefore has even greater implications for increasing the recovery period and extending the loss of productivity in all other sectors within the country following an event (U.S. Department of Energy/National Energy Technology Laboratory, 2007; IPCC, 2007b; Contreras-Lisperguer and de Cuba, 2008).

Model projections for Saint Lucia suggest an increase in mean annual temperatures, as well as the number of ‘hot’ days and nights to as much as 97% of the days per year by 2080, and the virtual disappearance of ‘cold’ nights (see section 3, Climate Modelling). National energy demand and consumption for heating and cooling purposes may increase in response to extremes in diurnal temperatures. Higher temperatures have also been shown to reduce the efficiency of energy generation at thermal power plants, similar to the Cul De Sac power station in Saint Lucia. The climate modelling projections also tend towards an overall decrease in mean annual rainfall for Saint Lucia, although these predictions are more uncertain than temperature changes, which may affect water availability for non-contact cooling of power generators (Contreras-Lisperguer and de Cuba, 2008) (See section 4.1, Water Quality and Availability).

Saint Lucia is currently exploring the potential for four main sources of renewable energy: biomass, wind, solar and geothermal; the latter of which is made possible because of the volcanic nature of the island.

Alternative energy sources, while they are environmentally more sustainable, also face challenges from climate variability. For instance, the combined effects of temperature and rainfall variability will impact on sources of biofuel for biofuel production systems. For example, changes in temperature and rainfall over time, as well as changes in seasonal weather patterns, will affect the yield of dedicated energy crops (e.g. sugar cane) and result in lower biofuel production. Geothermal energy generation can be affected by climate change in much the same ways as fossil fuel generation systems. Power is generated using steam cycles and is driven by the difference in ambient and combustion temperatures. In light of this, changes in air temperature can impact the overall efficiency of the system (Contreras-Lisperguer and de Cuba, 2008; MOPDE, 2010).

Hydro power systems specifically depend on levels of precipitation, temperature and potential evapo-transpiration. Extremes in any of these variables have implications for stream flow and water availability and flow quality for hydro power generation (Contreras-Lisperguer and de Cuba, 2008). Therefore low water quantity and a low flow quality will prohibit optimum production from hydro-power systems. Conversely, excessive water levels and rapid flows from flooding may exceed the maximum capacity of hydro-power systems to operate effectively.

With regard to wind energy, wind is generated by temperature gradients which result from differential heating of the earth's surface. Based on this relationship, changes in spatial temperature gradients caused by land use change, reductions in solar incidence and changes in atmospheric circulation can be argued to result in wind pattern shifts and therefore wind energy potential. Similarly, changes in solar radiation incidence and increases in temperature can impact the effectiveness of electrical generation by photovoltaic cells and solar thermal energy collection. The projected increase in the number of sunshine hours for Saint Lucia over the next few decades, however, increases the viability of using photovoltaic technology – even if only on the basis of increasing incidence of sunshine (IPCC, 2007b; Contreras-Lisperguer and de Cuba, 2008).

With climate change, ocean-based impacts on the energy system include storm surge events and SLR. These processes are a threat primarily to infrastructure located within the coastal zone, and within the impact range of these events. Simpson *et al.* (2010) highlight that some key impact scenarios for Saint Lucia, considering its geophysical nature; include localised land erosion, beach erosion and flooding caused by storms and SLR. Power generating stations and other major infrastructure located on the coastline are therefore highly vulnerable to impacts resulting from SLR and storm induced surges.

4.3. *Human Health*

4.3.1. Background

The IPCC AR4 defines health to include "physical, social and psychological wellbeing" (Confalonieri *et al.*, 2007). An understanding of the impacts of climate change on human health is important because of the impact on the economy which ultimately impacts on people at the local, regional, national and international levels. Where diseases are endemic or where environmental and social conditions make particular populations vulnerable, climate change has the potential to impact on the quality of the environment and the resilience of the ecosystems thereby increasing the disease incidence of the area.

Health is an important issue in the tourism industry because tourists are at risk of contracting infectious In addition, air travel is responsible for a large number of diseases which are carried from tourist destinations to Europe (Gössling, 2005) and elsewhere in the world. This is highly relevant when one considers that as much as 75% of travellers become ill abroad; morbidity is most often due to diarrhoea or respiratory infections (Sanford, 2004). Serious disease outbreaks can affect tourism destination demand and negatively impact the economies of Small Island Developing States (SIDS).

The potential effects of climate change on public health can be direct or indirect (Confalonieri *et al.*, 2007; Ebi *et al.*, 2006; Patz *et al.*, 2000). Direct effects include those associated with extreme weather events such as heat stress, changes in precipitation, SLR and natural disasters, or more frequent extreme weather events. Both direct and indirect effects include the impact of climate change on the natural environment which can affect food security and the agriculture sector and increase the susceptibility of populations to respiratory diseases and food- and water-borne related diseases (Confalonieri *et al.*, 2007; Githeko and Woodward, 2003; Patz *et al.*, 2000; Taylor *et al.*, 2009).

In the Saint Lucia's Initial National Communication to the UNFCCC, health was assessed to determine the possible impacts climate change may have on the island's population (MPDEH, 2001). There is limited climate change and health research in Saint Lucia. One study was carried out by the Caribbean Environmental Health Institute (CEHI) from 2000 to 2002 to assess the links between climate variability and disease in Saint Lucia. They concluded that the time period for the study was too short to make definitive links between diseases and climatic variables and noted the difficulty in separating other factors such as socio-economic conditions and the status of public health infrastructure as contributing to disease prevalence. Among the diseases included in the study were dengue fever, malaria, leptospirosis, yellow fever, tuberculosis, asthma and other respiratory diseases and infections, schistosomaisis, cryptosporidium, cholera, staphylococcal, salmonellosis and other diarrhoeal diseases (MPDEH, 2004). Table 4.3.1 shows some statistics relevant in to the health care sector.

Table 4.3.1: Selected Statistics Relevant to the Health Sector of Saint Lucia

Population	175,700 (2008)[1]
Unemployment rate	18.8% (2004)[2]
Poverty rate	28.8% (2006)[5]
Expenditure on Public Health	8.1% of GDP (2009)[3]
Life Expectancy at Birth	72.8 yrs (2005)[2]
Birth rate (per 1,000)	13.4 (2007)[4]
Death rate (per 1,000)	6.6 (2007)[4]

(Sources: SLTB, 2011[1]; PAHO, 2007b[2]; WHO, 2011[3]; MEAEPND, 2009[4] ; ECLAC, 2011[5])

4.3.2. Direct Impacts

Weather Related Mortality and Morbidity

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes, tropical storms and floods are important considerations when assessing the vulnerability of a country to climate change. In Saint Lucia, approximately 60% of housing settlements are unplanned (Anderson *et al.*, 2011). Aside from this, at least 33.3% of Saint Lucian households are considered to be 'poor quality housing' or have been described as 'substandard housing conditions'(ECLAC, 2011) which increases the risk of injuries during natural disasters.

Approximately half of Saint Lucia's population is concentrated in the capital city of Castries which is low-lying and consists of reclaimed land prone to flooding during heavy rainfall events. For instance, during Hurricane Tomas in 2010, the greatest number of severely affected persons came were from Castries district (ECLAC, 2011). All of the island's population lives within 10 km from the coast (Burke and Maidens, 2010) and as MPDEH (2001) describes "touristic, commercial, industrial, and most agricultural development is also concentrated in the coastal belt". Another feature of the island that makes it prone to hazards and risks is its mountainous geography, which experiences landslides and erosion during rainfall events. These factors combine to make the island very vulnerable in extreme weather events.

From observed data, North Atlantic hurricanes and tropical storms appear to have increased in intensity during the last 30 years and projection models indicate that the trend is expected to continue in the future, specifically due to intensification of weather phenomenon rather than increases in frequencies (See section 3, Climate Modelling). Hurricanes, often strike Saint Lucia with the main consequences being the displacement of people.

Increased Temperature and the Effect of Heat

As a result of higher temperatures, it is expected that the population of Saint Lucia will be exposed a higher incidence of heat and stress-related illnesses (MPDEH, 2006). These events, often termed Extreme Heat Events are not very common in Saint Lucia due to the island's "geographical location within the tropical maritime north easterly Trade Wind belt. Occasionally, there are departures from this temperature cycle, resulting in elevated diurnal and nocturnal values, which may become more frequent as a result of climate change (Government of Saint Lucia, 2010c). According to observed temperature data from between 1960 to 2006, the temperature in Saint Lucia has increased by 0.16°C. Additionally, temperatures are expected to increase based on both GCM and RCM projections, but increases are higher for RCM with mean annual temperature values ranging between 3.3 and 2.4°C by the 2080s when driven by ECHAM4 and HadCM3 models, respectively (See section 3, Climate Modelling).

PAHO (2007b) indicates that pulmonary heart disease, diseases of pulmonary circulation, and other forms of heart disease were the fourth leading cause of deaths in Saint Lucia. Analysis of temperature data for Saint Lucia has shown that there has been "a slow but significant temperature increase" between 1969 and 1999 (Amarakoon *et al.*, 2004). The latter statements are relevant because increased temperatures have implications for persons prone to, or suffering from, cardiovascular diseases (Cheng and Su, 2010; Worfolk, 2000) which could be exacerbated by prolonged exposure.

In general, increased temperature may result in an increase in morbidity and mortality (Hajat *et al.*, 2010) related to heat exhaustion and dehydration (Sanford, 2004). The elderly (7.1%) and young (28.8% under 15 years) of the population in Saint Lucia in 2004 (PAHO, 2007b), are more susceptible than other groups, as well as persons chronically sick, the poor, and persons with physical disabilities and mental impairments (Government of Saint Lucia, 2010c). Persons who work outdoors for long periods of time (e.g. construction workers) are also at greater risk to these conditions. The effects of heat waves are also intensified by increased humidity and urban air pollution (Moreno, 2006). In terms of tourism, this will be an important consideration for the elderly travel enthusiasts when choosing destinations. Exposure to higher temperatures can also contribute to increase in skin diseases arising from greater exposure to ultraviolet rays (Confalonieri *et al.*, 2007). Table 4.3.2 shows skin and subcutaneous tissue disorders and malignant neoplasms of the lip, oral cavity and pharynx.

Table 4.3.2: Morbidity Data for Two Groups of Skin Conditions in Saint Lucia

Year	2000	2001	2002	2003	2004	2005
Malignant neoplasms lip, oral cavity and pharynx	6	8	10	6	6	7
Other disorders of the skin and subcutaneous tissue	8	4	-	3	3	7

(Source: Ministry of Health, 2011)

In the context of tourism, while temperature may be considered a positive determinant of visitor demands it should be noted that on one hand cooler temperate destinations tend to become more attractive as temperature increases, but warm tropical destinations become less attractive (Hamilton and Tol, 2004). However, the reverse may be also true depending on the destination. It is uncertain at what temperature threshold such scenarios will affect Caribbean destinations such as Saint Lucia.

4.3.3. Indirect Impacts

Increase in Vector Borne Diseases

Saint Lucia' tropical climate makes it suitable for the transmission of a number of vector-borne diseases and has been identified as being vulnerable to an increase in incidences of such diseases with variability and subsequent changes in climate (MPDEH, 2006). For mosquito vectors, Hales *et al*. (2002) summarises 'mosquitoes require standing water to breed, and a warm ambient temperature is critical to adult feeding behaviour and mortality, the rate of larval development, and speed of virus replication.' Of course climate is not the only important factor in the successful transmission of disease, other factors include the disease source, the vector and a human population (Hales *et al.*, 2002). However, climate change projections indicate the potential for a decrease in annual rainfall events (See Section 3, Climate Modelling), which would benefit Saint Lucia as suitable breeding sites for mosquitoes would decrease. Conversely, alternative mosquito breeding sites may arise due to greater water storage during dry spells.

Another important consideration for public health is that incurred from the tourism industry. In 2009, there were 982,764 visitors recorded in Saint Lucia due mainly to cruise ship arrivals (CTO, 2009). This influx of people from non-endemic areas represents a susceptible population to vector borne disease infections once conditions on the island are more favourable for their disease transmission.

Malaria - Malaria has been identified as one of the major diseases to be affected by climate change in the Initial National Communication to the UNFCCC (MPDEH, 2001). Indeed, the risk of importing cases is a point that is often presented due to the high number of visitors to the Caribbean region as well as the increase in vector population due to a changing climate.

In Saint Lucia, the Ministry of Health (MOH) reported 2 cases of *plasmodium vivax* from 2005 to 2011, with one case in 2005 and the other in 2011. The next reported cases were in 2010, again with 1 case of malaria. Malaria has been described as “intimately connected” with poverty because the mosquito vector breeds in standing water pools that tend to form in the streets of informal development zones lacking proper sanitation and waste removal (Gallup and Sachs, 2001). The poverty rate in Saint Lucia is very high, at approximately 28.8% of the population in 2005/2006 (ECLAC, 2011) which means that efforts to sustain the low transmission rate of Malaria need to be maintained. The transmission of malaria as a result of tourism is not as great a concern as in other Caribbean islands where the prevalence of the vector population is higher, but caution is always promoted. At least one study has found that malaria is the most common cause of fever among tourists upon returning from travel in infected areas (Wichmann *et al.*, 2003). Additionally, it should be highlighted here that malaria is the most reported cause of hospitalisations in tourists from Malaria prone destinations (Wilder-Smith and Schwartz, 2005).

Dengue Fever - Dengue fever is caused by a virus of the genus *Flavivirus* and family *Flaviviridae*, of which four serotypes exist (Gubler, 1998). As defined by Rigau-Pérez *et al*. (1998), dengue is ‘an acute mosquito-transmitted viral disease characterised by fever, headache, muscle and joint pains, rash, nausea, and vomiting. Some infections result in Dengue haemorrhagic fever, a syndrome that in its most severe form can threaten the patient’s life, primarily through increased vascular permeability and shock.’ It is the most important arboviral disease of humans, which exists in tropical and subtropical countries worldwide (Gubler, 2002; Patz *et al.*, 2000; Rigau-Pérez *et al.*, 1998). The arthropod vector for dengue is *Aedes aegypti*. Population growth, urbanisation and modern transportation are believed to have contributed to its resurgence in recent times (Gubler, 2002).

It has been shown that dengue fever transmission is altered by increases in temperature and precipitation (Hales *et al.*, 1996) and research on the association between the two and dengue transmission has been studied in Saint Lucia by Amarakoon *et al*., (2004) where they found a significant relationship between dengue and precipitation on the island. Both from modelled data and observations, it has also been found that changes in climate determine the geographical boundaries of dengue fever (Epstein, 2001; Epstein *et al*., 1998; Hales *et al*., 2002; Hsieh and Chen, 2009; Martens *et al*., 2007; Patz *et al*., 2000). This is in addition to other economical, social and environmental factors that can affect the occurrence and transmission of the disease (Hopp and Foley, 2001).

Dengue fever is a major public health problem in the Caribbean and can affect both the locals and tourists (Castle *et al.*, 1999; Pinheiro and Corber, 1997; Wichmann *et al.*, 2003). Allwinn *et al*. (2008) have found have found that the risk to travellers has been underestimated. In fact it is the second most reported disease of tourists returning from tropical destinations (Wilder-Smith and Schwartz, 2005) and air travel has been linked with its spread (Jelinek, 2000). This vector borne disease has affected the region at least as early as the 1800’s (Pinheiro and Corber, 1997).

Chen et al. (2006) demonstrated seasonal incidence of dengue in the Caribbean region. The disease is endemic in the Caribbean region and has also been identified as a vector borne disease that is sensitive to climate change and of concern in the Saint Lucia Initial National Communication to the UNFCCC (MPDEH, 2001). Table 4.3.3 and Figure 4.3.1 show dengue statistics provided by the MOH of Saint Lucia. On average there are 38 reported cases of dengue fever. All four serotypes have been identified in Saint Lucia (PAHO, 2007b) and there were 10 cases of dengue haemorrhagic fever in 2008 and 1 confirmed case in 2010; however a high number of cases are not identified by serotypes. As a result, during 2004 to 2010, over 269 cases or 77% of the total 348 cases, were unknown. Similarly, at the time of writing this report (April 2011), there were 68 unknown serotype cases of dengue fever in 2011. Higher case-reporting has also been attributed to greater surveillance efficiency. For example, between 1998 to 1999 there were on average 10 cases per year and from 2000-2005 or approximately 17 cases per year (PAHO, 2008). This data is also summarised and illustrated in Figure 4.3.1. As monthly mean rainfall increases, the number of reported dengue cases (mean monthly average from 2004 to 2010) increases up to October. The number of reported dengue cases then decreases again towards December as mean rainfall values decrease.

Table 4.3.3: Reported Cases of Dengue Fever Serotypes 1 - 4 and Dengue Haemorrhagic Fever, 2004-2010

Year	2004	2005	2006	2007	2008	2009	2010	2011*	Total
Dengue (unknown)	3	3	3	15	80	17	80	68	201
Dengue 1	-	-	-	-	-	-	10	ND	10
Dengue 2	-	-	-	9	15	-	1	ND	25
Dengue 3	-	-	-	2	-	1	-	ND	3
Dengue 4	-	1	15	9	-	-	5	ND	30
Dengue HF	-	-	-	-	10	-	1	ND	11
Total All serotypes + HF	3	4	18	35	105	18	97	68	348

**ND – No data, data from 2011 collected up to 2nd week in April*

(Source: Ministry of Health, 2011)

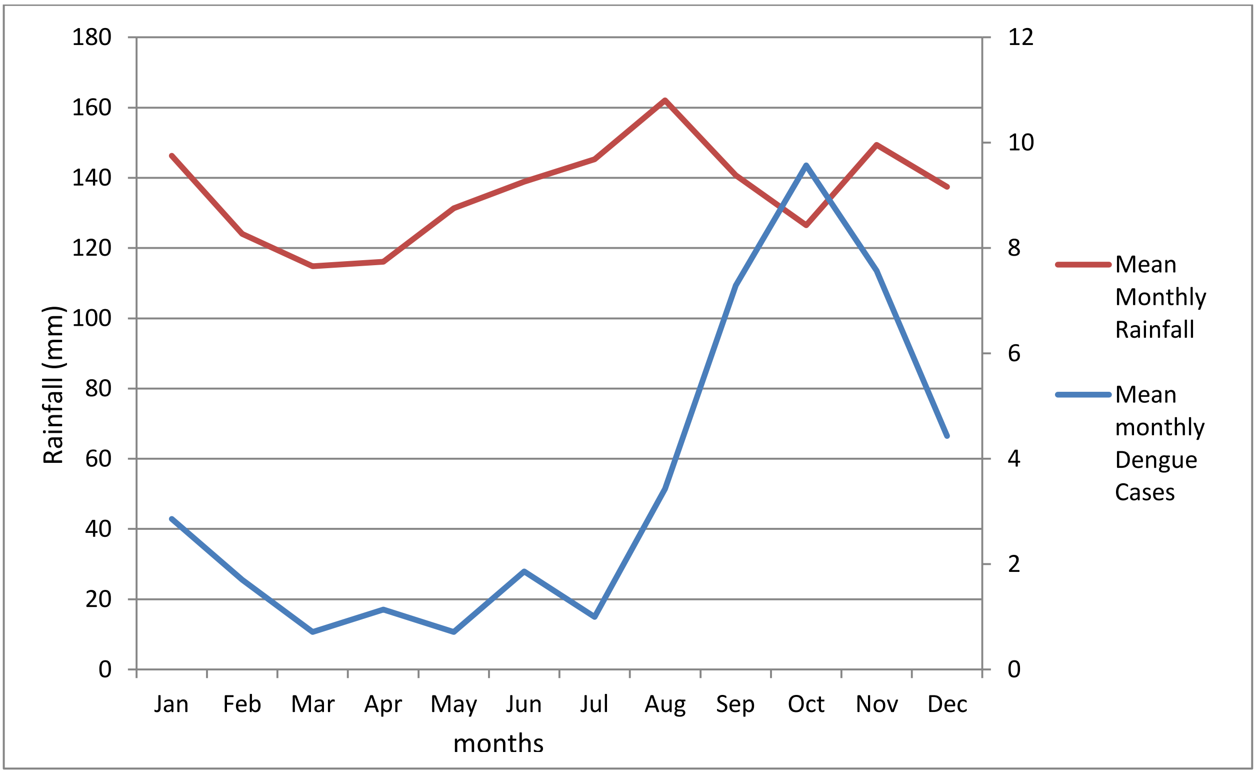


Figure 4.3.1: Average Monthly Dengue Cases in Saint Lucia and Rainfall

It is important to note that infection of one serotype does not confer immunity against another serotype. Therefore re-infection complicates the control of the virus' transmission (Gubler, 1998) and can lead to dengue haemorrhagic fever and dengue shock syndrome (Levett *et al*., 2000). Dengue is pre-dominantly an urban disease (Pinheiro and Corber, 1997) which makes highly populated areas like the west of Saint Lucia particularly vulnerable. Additionally, due to low-level of suspicion among physicians dengue fever is often under reported so the real threat that this disease poses to populations is currently under-estimated (Jelinek, 2000).

In Jamaica, Chadee *et al*. (2009) found that large storage drums were the main breeding sites of the vector, *Aedes aegypti*, accounting for a third of their breeding sites. Traditional targets of source reduction in Jamaica (i.e. small miscellaneous containers), were found to contain negligible numbers of pupae. However, if drought conditions become commonplace in the future due to climate change, the use of large water storage drums increase thus providing suitable breeding sites for the vector *Aedes aegypti.* In Saint Lucia where rain water harvesting is commonly practiced, the risk of such a situation arising is high.

Drought, Air Quality and Respiratory Illnesses

Dry spells and drought conditions can increase particular matter in the air, negatively affecting air quality. This in turn can affect persons with respiratory illnesses and result in respiratory problems. Examples of diseases that may be worsened by poor air quality are influenza and acute respiratory infections, which already are two of the main causes of morbidity in the elderly, infants and the undernourished (MPDEH, 2001). Analysis of disease data for asthma, bronchitis and respiratory infections show that there is seasonal variability in Saint Lucia (Amarakoon *et al.*, 2004). Variables that affect incidence of these diseases include temperature, relative humidity and Sahara Dust. Other diseases of relevance are chronic lower respiratory diseases and influenza and pneumonia. As Table 4.3.4 shows, these diseases have consistently contributed deaths in Saint Lucia during the period 2000-2005.

Table 4.3.4: Reported Mortality Cases of Different Types of Respiratory Disease in Saint Lucia

Year	2000	2001	2002	2003	2004	2005
Chronic lower respiratory diseases	29	29	25	28	26	36
Influenza and Pneumonia	17	37	29	21	22	43

(Source: Ministry of Health, 2011)

Air quality can also be affected by Saharan dust which annually travels across the Atlantic to the Caribbean. Saharan Dust flows may increase during warmer summer months due to atmospheric circulation patterns increasing in strength, thereby bringing greater volumes of particulate matter towards Saint Lucia (Amarakoon *et al.*, 2004). Saint Lucia is located over 4000 km from North Africa, which takes approximately one week for dust clouds to travel across the Atlantic to Caribbean (Prospero and Lamb, 2003).

If air quality can have such an effect on the local population it is likely that similar effects may be suffered by travellers (Sanford, 2004) particularly true for those with respiratory diseases, pulmonary and cardiac diseases. Furthermore, these dynamics also occur against a background of normal and expected urbanisation and industrialisation that is occurring on a global scale, which undoubtedly affects Caribbean islands such as Saint Lucia.

Water Supply, Sanitation and Associated Diseases

Despite the fact that 98% of the population has access to piped-water in their houses (PAHO, 2007b) diarrheal illnesses are a concern in Saint Lucia as they show seasonal variability and have been shown to be significantly associated with temperature and rainfall (Amarakoon *et al*., 2004). This may be explained by the reduction in domestic water supplies during drought conditions, which impacts water quality (i.e. standards of sanitation with respect to a reduction in domestic water supplies and garbage disposal) (Moreno, 2006). Annual mean precipitation is expected to decrease from -34% to -11% in HadCM3 and ECHAM4 respectively (See Section 3, Climate Modelling). Water interruptions and shortages due to flooding, but also dry spells and drought conditions, can lead to water shortages and subsequent health problems such as dengue as well as mosquito nuisance (MPDEH, 2001). As previously stated, annual mean precipitation in Saint Lucia is expected to decrease according to modelling outputs ranging from -34% to -11% in HadCM3 and ECHAM4 respectively. Therefore, emphasis on water and sanitation is critical to public health, which may become even more important because of changes in climate and the associated vulnerabilities that will be exacerbated. Examples of diseases in Saint Lucia that are associated with water and poor sanitation are cholera, shigellosis, salmonella and gastroenteritis.

Cholera is an example of a disease that proliferates in unsanitary conditions. Cholera is “an acute intestinal infection caused by the bacterium *Vibrio cholera* and is spread by contaminated water and food” (CAREC, 2008b). CAREC data does not have any reported cases of cholera for Saint Lucia between 1981 and 2005 (CAREC, 2008b) nor are there reported cases of cholera in data from the Ministry of Health. Climate change has been found to be an important factor in the spatial and temporal distribution of cholera (Confalonieri *et al*., 2007) and may result in increased incidence of the disease in instances of extreme events and above normal precipitation.

The spread of food-borne illness is also associated with unsanitary conditions and is transmitted due to poor water treatment methods. Caribbean Epidemiology Centre (CAREC) (2008b) noted that under reporting of the numerous diseases found in Saint Lucia, including salmonellosis and shigellosis (See Table 4.3.5). These cases are annually and if endemic can lead to major outbreaks given the ‘risk factor’.

Table 4.3.5: Morbidity Data for Shigellosis and Salmonellosis

Year	2004	2005	2006	2007	2008	2009	2010	2011*
Shigellosis	-	5	10	6	1	1	1	2
Salmonellosis	-	13	2	6	3	3	8	2

**Data from 2011 collected up to 2nd week in April*

(Source: Ministry of Health, 2011)

Gastroenteritis has had noteworthy morbidity statistics in the last few years, as Ministry of Health statistics indicate there were 1847 reported cases in 2008, 1814 reported cases in 2009 and 2335 reported cases in 2010 (See Table 4.3.5). Higher totals of 2010 over 2009 for gastroenteritis have been attributed to Hurricane Tomas (ECLAC, 2011), where there was an increase of 69% of cases in the < 5 years category and an increase of 57% in the > 5 years category attributed to the water shortages and poor sanitation during the period. The disease is relevant to the tourism industry because, among other places, outbreaks often occur in hotels, restaurants, cruise ships and mass gatherings (CAREC, 2008a). Additionally, other intestinal diseases do cause deaths because of their severity; Table 4.3.6 presents summarises the most recent available morbidity data from the Ministry of Health, from the period 2000 to 2005. One final disease of note is *Staphylococus aures*, which causes bacterial infections. In the last five years (2007- 2011) there has been one case reported, and in 2009 there were 9 reported cases of the bacteria.

Table 4.3.6: Syndronic Surveillance Data for Gastroenteritis

Year	2004	2005	2006	2007	2008	2009	2010	Total
Sum of Gastroenteritis < 5 yrs	218	803	1,550	910	867	856	1,453	7,091
Sum of Gastroenteritis > 5 yrs	232	707	2,343	1,329	1,343	1,389	2,186	10,799
Sum of undifferentiated fever < 5 yrs	428	674	1,210	1,288	1,372	995	1,145	7,681
Sum of undifferentiated fever > 5 yrs	369	511	1,230	1,573	2,141	1,790	1,737	10,335
Sum of Acute Respiratory Infections < 5 yrs	277	391	668	789	1,129	1,853	1,024	6,654
Sum of Fever and RS > 5 yrs	322	311	592	1,114	1,739	5,490	1,142	11,189

(Source: Ministry of Health, 2011)

Table 4.3.7: Morbidity Data for Unspecified Infectious Diseases

Year	2000	2001	2002	2003	2004	2005
Intestinal Infectious diseases	3	2	-	1	2	2
Other diseases of intestines	5	4	1	4	1	3

(Source: Ministry of Health, 2011)

Food Security and Malnutrition

Changing weather patterns in a SIDS such as Saint Lucia could have an impact on agricultural productivity if precipitation decreases because farmers depend largely on rainfall for irrigation (e.g. Saint Lucia is reliant on as much as 83%) (Trotman *et al.*, 2009). Not only will food availability and the local economy be affected by a reduction in rainfall, but this can affect facets of the national economy because as the population increases, further demands for food supply will ensue. In addition, drought and heat stress can impact the growth of crops in the field (e.g. heat stress of vegetables) (Confalonieri *et al.*, 2007; Moreno, 2006). Conversely, increased precipitation events may result in flooding, which periodically occurs during the dry season in Saint Lucia. Contamination from sewage, especially from pit latrines, may then arise if these systems become inundated. Negative health effects then follow, especially in poor and marginalised communities which not only results in diseases, but also contributes to malnutrition, under-nutrition, protein energy malnutrition, and or micronutrient deficiencies (Confalonieri *et al.*, 2007). The percentage of undernourished Saint Lucians was 3% of the total population in 2002/2004 which is significantly below the regional average of 21% (Karfakis *et al.*, 2011). Table 4.3.8 shows the few cases of malnutrition morbidity data available from the MOH. It is important to note that this small number of deaths highlights the most extreme cases of deficiencies in diet in Saint Lucia.

Table 4.3.8: Morbidity Data for Reported Cases of Malnutrition in Saint Lucia, 2000-2005

Year	2000	2001	2002	2003	2004	2005
Malnutrition	1	4	3	2	-	1

(Source: Ministry of Health, 2011)

Although agriculture accounts for only 5% of the economy's GDP output (Trotman *et al.*, 2009), it is a traditional sector in the Saint Lucian economy and employs 11.4% of the population (Trotman *et al.*, 2009). If agriculture were to be impacted by climate change, this can lead to an increase in the level of food importation. Currently, the level of importation stands at approximately 40.6%, which is double the regional average of 20.4% (Karfakis *et al.*, 2011).

Food production and fisheries stock are considered an integral part of the agricultural sector. Saint Lucia's reefs have been identified as being under high threat from shipping and marine-based pollution (Burke and Maidens, 2010). The majority of Saint Lucia's reef's – 61% - were classified as having a 'very high' Reefs at Risk Index (RRI) from human activities, while 39% have a 'high' RRI (Burke and Maidens, 2010). The most significant human activities that threatens Saint Lucia's reefs include fishing pressure, with a 'very high' value of 98%, followed by coastal development, with a 'very high' value of 67%, followed by sediment and pollution from inland sources, with a 'very high' value of 49%. Some of Saint Lucia's fish species have been summarised in the Initial National Communication to the UNFCCC as "…due to a number of reasons including over-fishing, habitat degradation, environmental stress impacting on age of maturity, spawning frequency and success, fry production and survival, resistance to disease and other possible biological conditions, some fish species have been identified as being under threat of population collapse" (MPDEH, 2001).

Greater flooding may affect turbidity levels and also introduce land based pollutants into reefs. This will affect coastal biodiversity and fisheries stocks. Hurricanes also physically batter reefs, which in the case of Saint Lucia, are recovering from other ecological threats such as the white band disease (ECLAC, 2011). Additionally, reefs maybe affected by regional ecological dynamics whereby reef fish kills occur as a result of activities outside of Saint Lucia. For example, between August and November of 1999 there was a major fish kill that can be attributed to the influx of flow from the Orinoco River which had above-normal temperatures, chlorophyll concentrations and low nocturnal oxygen levels (MPDEH, 2001).

The Reefs at Risk in the Caribbean Report states that widespread unemployment, densely populated coastal zones, easy access to the reefs, and narrow shelf areas results in a heavily consumed reef resources to provide livelihoods and sustenance. The report also links reduction in fisheries stocks with malnutrition due to a decrease in the protein content in the diet (Burke and Maidens, 2010).

Ciguatera fish poisoning – The Caribbean region is also well known for the food poisoning illness called Ciguatera Fish Poisoning (CFP) (Tester *et al.*, 2010). According to Saint Lucia's Initial National Communication to the UNFCCC, "algal blooms associated with biotoxin contamination of fish and shellfish could become more frequent resulting in the proliferation and increased transmission of Cholera and in general, seafood contamination and biotoxin poisoning" (MPDEH, 2001).

An increase in the incidence of CFP may arise as seas become warmer due to climate change, subsequently harmful algal blooms will increase, resulting in the problem of toxin bio-accumulation in fish species (Confalonieri *et al.*, 2007; Tester *et al.*, 2010). Symptoms of CFP include diarrhoea, vomiting, abdominal pain, muscular aches, nausea, reversal of temperature sensation, anxiety, sweating, numbness and tingling of the mouth and feet and hands, altered sense of smell, irregular heartbeat, lowering of blood pressure and paralysis (Friedman *et al.*, 2008). As the CAREC Annual Report 2007 states, "the occurrence of even small numbers of cases of ciguatera poisoning is of concern since it can result in severe illness, including neurological symptoms, and can also be life threatening" (CAREC, 2008a).

Changes in Precipitation and Water-Related Diseases

Increased precipitation may also result in contamination from sewage, especially from pit latrines which may consequently become inundated. This can result in an increase in water-related diseases, thereby harming the health of local populations. Malaria, schistosomiasis, typhoid, dengue fever and gastroenteritis have all been linked with water shortages after heavy rains (MPDEH, 2006). According to GCM projections, precipitation increases are projected to be 7%, although decreases are projected to be more likely at reductions of 26% by the 2080's (See Section 3, Climate Modelling). Nevertheless, an increase has the potential to affect the health sector of Saint Lucia.

Most of Saint Lucia's water resources come from surface sources such as rivers and streams which are prone to flooding given their higher than normal volumes of water. During a flood, the water intakes, dams and reservoirs may be damaged or become blocked due to debris. This can result in decreased water supply and quality (MPDEH, 2001). As MPDEH (2006) describes "most of the treatment facilities in Saint Lucia are not designed to deal with high sediment loads. Hence, raw water treatment, especially in villages and rural communities, is usually suspended after heavy rains to avoid overloading of the system. As a result, customers suffer water shortages. In many cases, they resort to using polluted river water for domestic purposes, making them vulnerable to water borne diseases". Diseases that have been reported in Saint Lucia include typhoid, with two confirmed cases in 2005 and leptospirosis and schistosomiasis, which will be described in detail below.

Leptospirosis – Gubler *et al*. (2001) define leptospirosis as 'an acute febrile infection caused by bacterial species of *Leptospira* that affect the liver and kidneys.' While rats are a known reservoir of the leptospirosis (Hales *et al.*, 2002), infection can occur from other wild or domestic animals such as dogs that come into contact with water, damp soil, vegetation or any other contaminated matter (Gubler *et al.*, 2001). Flood waters contaminated with faecal matter and urine from infected rats is often associated with and is one of the main causes of leptospirosis outbreaks and spread (Gubler *et al.*, 2001; Hales *et al.*, 2002; Moreno, 2006; Sachan and Singh, 2010). As stated in the IPCC AR4, 'there is good evidence to suggest that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human–pathogen–rodent contact' (Confalonieri *et al.*, 2007). This seasonal aspect of leptospirosis has recently been demonstrated in Trinidad by Mohan *et al.* (2009). Leptospirosis has been found to be one of the diseases of importance contracted by travellers (Jansen *et al.*, 2005) and could therefore have implications for tourists.

Table 4.3.9: Reported Cases of Leptospirosis in Saint Lucia

Year	2004	2005	2006	2007	2008	2009	2010	2011
Leptospirosis	3	8	8	6	4	4	14	6*

*Data from 2011 collected up to 2nd week in April

(Source: Ministry of Health, 2011)

Based on MOH data for Saint Lucia, between 2004 and 2010, there are on average 7 cases of leptospirosis per year. Between January and April 2011 there have already been 6 confirmed cases of the disease (See Table 4.3.9). Observation on the monthly incidence of reported cases of leptospirosis (2004-2010) revealed that the majority of cases occur from August to January, with the highest months being November (with 12 cases) and January (with 10 cases). The Saint Lucia wet season spans from June to November, coinciding with this trend of on-going transmission of the pathogen from rodent to humans. The incidence of leptospirosis may be higher (i.e. under-reporting of cases as a result of a low index of suspicion) which has been the case in neighbouring Trinidad and Tobago (Mohan *et al.*, 2009). In neighbouring Barbados, the disease is associated with adults, and sanitation and agricultural workers are groups which are at higher risks (Everard *et al*., 2005) but may not be necessarily limited to occupational groups (Mohan *et al*., 2009).

Schistosomiasis - Schistosomiasis is a water-borne disease worth mentioning as it has been identified by the IPCC in the Fourth Assessment report (Confalonieri *et al*., 2007). Spread by an aquatic snails, it is a water related parasitic disease. It exists in the Caribbean having been recorded and researched by (Bundy, 1984) and (Kurup and Hujan, 2010). PAHO (2007a) have estimated that between "20-30% of [people] living in Latin America and the Caribbean are infected with one of several intestinal helminths and/or schistosomiasis". Schistosomiasis is endemic in Saint Lucia (Kurup and Hunjan, 2010) and it is the only country that reports schistosomiasis infection cases in the Caribbean region (PAHO, 2007a). In the 1980's efforts to eliminate this parasite were conducted with great success (Jordan, 1985).

The parasite survives in soil and can be transmitted to humans through direct contact. Factors associated with transmission of the disease include walking bare foot, not washing hands before meals, trimming of nails, outdoor recreational activities with high contact with the surrounding (e.g. playing cricket), and swimming and fishing in fresh water. Poor hygiene also increases the chance of infection. Karup and Hunjan (2010) found that there was a prevalence and intensity of intestinal parasitic infection among school children in rural Saint Lucia, which included parasitic infections, helminth infections and protozoan infections. Table 4.3.10 shows the yearly incidence of schistosomiasis; on average at least 3 persons contract the disease per year. With the increased need for irrigation channels (to support agricultural production), which are suitable habitats for the snails that harbour the parasites, an increase in the incidence of schistosomiasis among farmers may also arise.

Table 4.3.10: Reported Cases of Schistosomiasis Between 2004 and 2011

Year	2004	2005	2006	2007	2008	2009	2010	2011*
Schistosomiasis	1	5	3	10	1	3	2	1

(Source: Ministry of Health, 2011)

4.4. *Agriculture and Food Security*

4.4.1. Background

Climate change related impacts on agriculture have in recent times been the focus of discussion and research on an international level. It is anticipated that climatic change will diminish agricultural potentials in some regions thereby affecting the global food system. The International Assessment of Agricultural Knowledge, Science and Technology for Development Global Report (IAASTD, 2009) stresses the need to adopt a more practical approach to agricultural research that requires participation from farmers who hold the traditional knowledge in food production.

This research examines the relationship between agriculture and tourism within the framework of climate change, and seeks to develop adaptation options to support national food security based on the experience and knowledge from local small-scale farmers and agricultural technicians. The study is exploratory in nature and the findings will be assimilated to develop national and regional projects that promote climate conscious farms and sustainable food production in the Caribbean.

4.4.2. The Importance of Agriculture to National Development

The Prime Minister and Minister of Finance, Mr Stephenson King, emphasised in the budget address for the financial year 2010/2011 the importance of the agricultural sector to the Saint Lucian economy. He acknowledged that the sector plays a significant role in the socio-economic development of the nation as a whole, through income generation, foreign exchange earnings, capital investment and food security. The budget provisions for agriculture are intended to increase the pace of economic recovery, stimulate growth, create jobs and build resilience to economic shocks in the future through expansion within the sector.

The agricultural sector in Saint Lucia is largely influenced by the performance of the banana sub-sector, which in recent years accounted for approximately 40% of total agricultural output. Figure 4.4.1 shows the relationship between GDP growth, agriculture and bananas in Saint Lucia over the period 1990 to 2004. Clearly the agriculture sector significantly influences the direction of overall economic growth, and bananas have an overwhelming impact on the national economy. According to a publication from the Saint Lucia Government Statistics Department (Charlery, 2011), agriculture's contribution to GDP in 2009 was 11.85%. The Saint Lucia Annual and Economic Review (MFEAND, 2011) reports that the sector's contribution to GDP fell to its lowest share of 3.5%, with the banana sub-sector contributing 1.5% in 2010.

The deteriorating performance of Saint Lucia's banana industry poses serious implications for national food security. Historically, the banana trade financed food imports and provided rural households with a steady income that enabled them to access their food needs. Recently, the burden to finance the food security gap has fallen on the tourism sector, which has become the major foreign exchange earner for Saint Lucia since the mid-1990s. The Saint Lucia National Review (2010) indicates that visitor arrivals grew from 100,000 in 1989 to over 650,000 in 2009, providing essential revenue for the country.

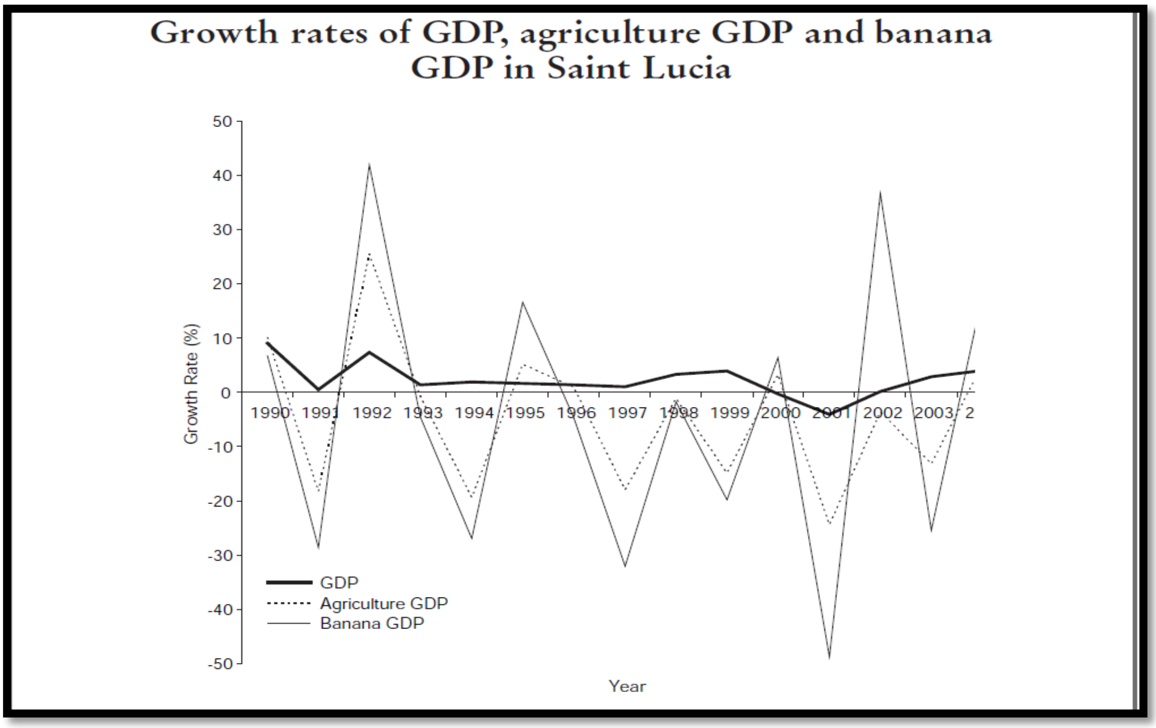


Figure 4.4.1: Relationship Between GDP Growth, Agriculture and Bananas in Saint Lucia (1990-2004)

(Source: Ford *et al.,* 2007)

However, this development model is unsustainable because the export revenue derived from tourism is used to finance imports of food for both domestic consumption and for tourists. Recognizing that the tourism sector constitutes a major leakage of foreign exchange through unrealised linkages with the domestic agriculture sector, the revitalisation and diversification of agriculture has become a primary goal of the Saint Lucia Government. Moreover, developments in international agricultural markets, including adverse price fluctuations and shortages, have underscored the importance of food security. The Government has embarked on a scheme to encourage Saint Lucians to grow more of what they consume. The intention is to reduce the reliance on banana exports, and to enhance the productivity of other existing crops.

4.4.3. Analysis of the Agricultural Sector in Saint Lucia

Traditionally, the agricultural economy in Saint Lucia was heavily dependent on the banana sector. However, the banana industry has been in decline in recent years as a result of reduced Africa, Caribbean and Pacific (ACP) banana preferential access to the EU market and rising competition from Latin American producers. The Saint Lucia Annual Agricultural Review (2010) reports that banana exports fell to 30,300 tonnes in 2005 from a peak of 132,000 tonnes in 1992. The total land under agricultural cultivation dropped from 51,328 acres in 1996 to 30,204 acres in 2007 (a decline of 41.1%) as a result of declining banana production. Despite its contraction over the years, banana production remains central to the sector, occupying 48% of all cultivated land and accounting for 41.4% of gross agricultural output.

The Government of Saint Lucia has been vigorously pursuing agricultural diversification for the past decade to reduce the reliance on one or few commodities for export and to enhance the productivity of existing crops (particularly bananas). The National Export Development Strategy (2004) identifies 9 commodities designated for increased output through government facilitation, organisation and expansion of production using land allocation within suitable agro-ecological zones. These commodities consist of breadfruit, bananas, cocoa, cut flowers, hot peppers, julie mangoes, plantain, yams and fisheries products.

The thrust towards revitalizing and diversifying national agriculture has started to produce results. In 2009, the agricultural sector grew by 3.54%, continuing its growth performance from 2008. Table 4.4.1 shows agricultural gross domestic product (EC $Million) by economic activity for the period 2005 to 2008.

Table 4.4.1: Agricultural Gross Domestic Product (EC $Million) by Economic Activity at Factor Cost (1990 Constant Prices)

Agricultural Activity and Percentage Contribution	2005	2006	2007	2008	2009
Bananas - GDP	16.84	18.76	18.12	23.56	22.13
% Contribution to Total GDP	1.26	1.34	1.3	1.69	1.57
Rate of Growth	-37.19%	11.40%	-3.41%	30.00%	-6.07%
Other Crops - GDP	8.15	8.94	10.1	12.25	12.59
% Contribution to Total GDP	0.61	0.64	0.72	0.88	0.89
Rate of Growth	-27.88%	9.69%	12.93%	21.34%	2.78%
Livestock - GDP	6.92	6.25	6.87	7.99	9.87
% Contribution to Total GDP	0.52	0.45	0.49	0.57	0.7
Rate of Growth	2.22%	-9.68%	9.92%	16.30%	23.53%
Fishing - GDP	8.48	10.52	10.76	11.94	13.22
% Contribution to Total GDP	0.64	0.75	0.77	0.85	0.94
Rate of Growth	-6.81%	24.06%	2.28%	10.97%	10.72%
Forestry - GDP	1.08	1.05	1.01	1	0.94
% Contribution to Total GDP	0.08	0.08	0.07	0.07	0.07
Rate of Growth	-3.57%	-2.78%	-3.81%	-0.99%	-6.00%
Total Agricultural GDP	**41.47**	**45.52**	**46.86**	**56.74**	**58.75**
Total Agriculture Growth Rate	**-24.74%**	**9.77%**	**2.94%**	**21.09%**	**3.54%**
% Contribution to Total GDP	**3.11**	**3.26**	**3.35**	**4.06**	**4.17**

Real growth was recorded in non-traditional crops, fisheries and livestock sub-sectors owing to the Farmer Certification Programme which led to an enhancement of agricultural production and the strengthening of marketing linkages between farmers and purchasers. In the budget address for the financial year 2010/2011 (Government of Saint Lucia, 2010a), Mr Stephenson King also outlined a number of initiatives which have helped local farmers to increase output, including provision of technical assistance in a number of areas, the establishment of the banana production management unit, reactivation of the Beausejour Agricultural Station and the completion of the Anse La Raye Fisheries Facility.

4.4.4. Women and Youth in Saint Lucian Agriculture

According to the results of the 2007 Census of Agriculture, 30% of all individual agricultural holdings were operated by women (median age of 51 years). The oldest female and male farmers are concentrated in the Choiseul district. An analysis of the gender dimensions of the agricultural sector in Saint Lucia (Paul, 2008) indicate that the share of farmers under 15 years old with holdings is on the increase. The 1996 agricultural census recorded no female farmers under 15 years old, while 7 males in that age category were recorded. However, in 2007 the agricultural census reported 37 females and 85 males under 15 years old. The emerging trend of young farmers is most prevalent in the Micoud district (25 males, 11 females) and Castries (25 males, 6 females). Significantly, there has been a marked decrease in able-bodied farmers between the ages of 20 to 34 years.

A poverty study commissioned by the Caribbean Development Bank (2007) explains that there is a significant amount of migration from some rural communities to Castries, especially by young people seeking better opportunities, employment and entertainment. Some residents have also migrated to other countries which has resulted in shifts in the composition of the rural population, and deprived some rural communities (e.g. Bouton) of valuable human resources and skills. Migration of the youthful population has serious implications for a sustainable and profitable agricultural sector in Saint Lucia.

Rambally (2005), former Minister for Social Transformation, Culture and Local Government in Saint Lucia, observed that the rural landscape in Saint Lucia is characterised by 39% female-headed households. These rural women play a major role in ensuring food security and in the development and stability of rural communities, but they lack access to vital services and the power to secure land rights. Furthermore, the loss of preferential trading arrangements for banana farmers has meant that thousands of farmers were directly affected by the restructuring and many rural women have been forced out of the industry.

The Saint Lucia Network of Rural Women Producers was formed in 2003 with support from IICA to build capacity in agricultural production, to encourage diversification in crop cultivation, and foster entrepreneurship amongst rural women. The Saint Lucia Agriculture Forum for Youth was also established in 2005 to engage young persons in the agricultural sector and to encourage them to seek careers within that industry.

4.4.5. Climate Change Related Issues and Agricultural Vulnerability in Saint Lucia

Saint Lucia's agricultural sector exhibits a high vulnerability to the existing climate, and is susceptible to extended periods of drought, unevenly distributed rainfall, and natural disasters. The Saint Lucia Economic and Social Review (2011) reports that the performance of a previously fragile agriculture sector was further affected by a prolonged drought from September 2009 to March 2010, and then by the passage of Hurricane Tomas in October 2010. The storm severely affected the banana industry through toppling, flooding and sedimentation. The estimated damage to the banana industry was about 90% of the crop, with a potential weekly income loss up to EC $2.0 million over a 6 month period. For the non-banana sub-sectors, the Ministry of Agriculture reported an estimated 80 acres under open-field vegetable production destroyed, and approximately 60% of greenhouses under production sustained major damages.

In 2009, the Saint Lucia Meteorology Office indicated that the rainfall for September was the lowest on record for Castries since 1967 and the 5th lowest for Vieux Fort Since 1973. Saint Lucia declared a Water Related Emergency on February 24, 2010 and advanced the Water Management Plan for Drought Conditions with the support of National Emergency Management Officials.

Most of the farmers in Saint Lucia depend on natural rainfall for agriculture production. The extended drought brings dire consequences including reduced outputs, increased costs of production, and higher prices for agriculture commodities for consumers. The intense rains that have followed the severe drought expose unstable slopes to the elements and the country has also experienced increased incidents of landslides as a consequence. The implications of climate change on Saint Lucian agriculture pertain to worsening of soil conditions, erosion and land degradation from flooding, and increased crop vulnerability due to high temperatures and changing rainfall patterns.

4.4.6. Vulnerability Enhancing Factors: Agriculture, Land Use and Soil Degradation in Saint Lucia

The Ministry of Agriculture, Lands, Forestry and Fisheries (2010) reports that 35% of the total land area in Saint Lucia (21,765 ha) is natural vegetation; 7550 ha are government forest reserves; and 55% (34,202 ha) of the remaining land is under agriculture. Saint Lucia's topography, which is characterised by rugged terrain and limited land space, limits agricultural potential in several parts of the island because of risks of erosion, low fertility, stoniness and acidity of soils, and dangers of land slippage. The Green Paper on National Land Policy (MPDEH, 2003a) indicates that two thirds of Saint Lucia's best agricultural lands are located in four valleys: Canelles, Cul de Sac, Mabouya and Roseau. Figure 4.4.2 gives an indication of the types of agriculture by geographical location in Saint Lucia.

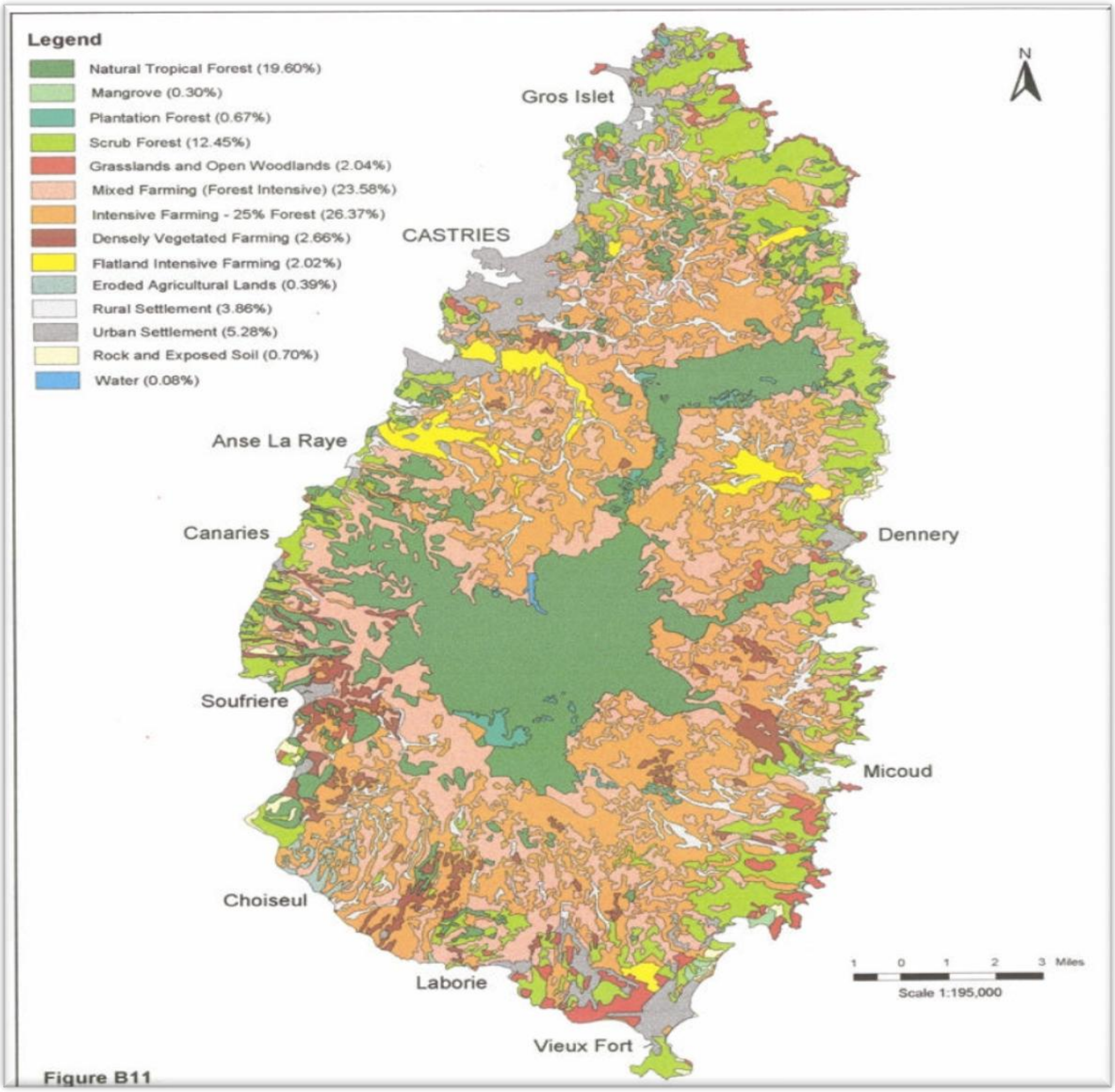


Figure 4.4.2: Saint Lucia Land Use Map

(Source: MPDEH, 2003B)

According to the 2007 Census of Saint Lucia Agriculture, the abandonment of banana plots over the last decade has contributed to the decrease in land use for permanent/medium term crops, and a simultaneous increase in land use for temporary crops. The change in agricultural production systems, which includes consistent use of slash and burn techniques, cultivation on steep slopes, and abuse and misuse of agricultural inputs, significantly contribute to land degradation, the destruction of critical habitats such as wetlands, and the removal of vegetation cover along river banks.

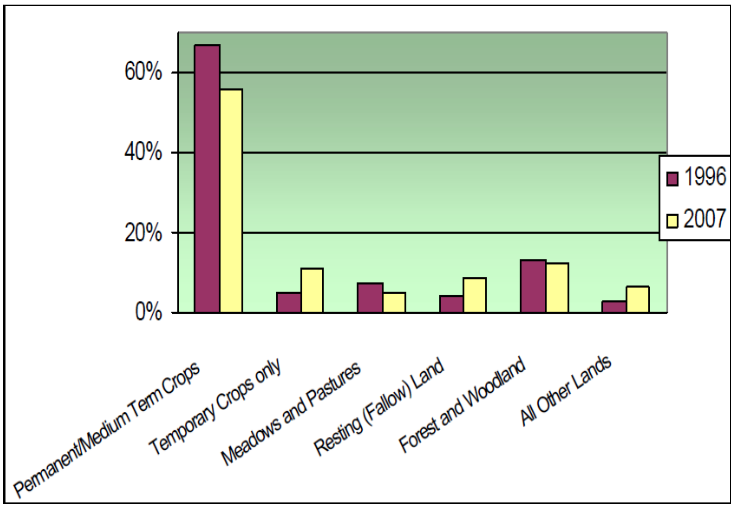


Figure 4.4.3: Land Use Structure 1996-2007

(Source: Paul, 2008)

The Green Paper on National Land Policy (MPDEH, 2003a) observes that family land, which continues to be the dominant form of agricultural land tenure, presents an obstacle to land conservation and to the use of good agricultural practices because of communal ownership. Urban development and excessive land clearing prior to housing development has provoked changes in drainage patterns, erosion, sedimentation, and increased risks of flooding.

The vulnerability enhancing factors for land use and soil degradation in Saint Lucia consists of uncontrolled agricultural intensification, poor agricultural practices and inappropriate land use. Current trends of converting of prime agricultural lands to other uses, and the radical transformation of many landscapes, threaten the country's agricultural capacity and national food security.

4.4.7. Social Vulnerability of Agricultural Communities in Saint Lucia

The social vulnerability of agricultural communities in Saint Lucia was dramatically exposed with the passing of Hurricane Tomas in October 2010. Prior to this event, the Ministry of Social Transformation, Culture and Local Government (2003) published a text which revealed that poverty in Saint Lucia is largely a rural phenomenon, with 29.6% of the rural population living in poverty, as opposed to 16.0% of the urban population. Moreover, a larger percentage of female headed households were poor (20.4%) when compared with male headed households (17.4%).

The passage of Hurricane Tomas demonstrated that rural families in Saint Lucia are in fact largely vulnerable to extreme weather events. According to an ECLAC (2011) report, rural communities in the Castries district (i.e. Guesneau-Forestiere, Fond Canie, Bexon and Marc) and in the District of Soufriere (i.e. Fond St. Jacques, Ravine Claire, Cresslands, St. Phillip and Migny) suffered severe losses due to destruction of homes and as a result of severe flooding. Road networks were severely compromised, and most road links which serve as sole access to rural communities were damaged or washed away. Consequently, this hampered search and rescue operations immediately following the passage of the hurricane.

The ECLAC assessment of the damage and losses caused by Hurricane Tomas also suggests that women who are responsible for their households are at a distinct disadvantage because they are unable to earn an income or meet their family's food needs by subsistence farming after such an episode. Many women lost crops and land through land slippage, and others lost their shops and the goods in them with the passage of the storm. Male farmers were also unable to farm in the weeks after the hurricane as their land was washed away, or they had no access to their farm lands because of blocked roads and damaged forest trails.

As far as employment is concerned, the waning of the population in agricultural communities has had a negative impact on the labour supply available to agriculture. The Saint Lucia National Review (2010) estimates that the economically active population is about one-third of the whole population; 22% are employed in agriculture, 25% in manufacturing, and 54% in tourism and other services. An FAO consultant (Paul, 2008) observes that migration of young people of both sexes from rural areas has led to a trend towards the increased prominence of female headed households that depend on agriculture for their livelihoods. Notably, the majority of both female and male farmers are over 35 years, with a significant proportion over the age of 65 years. The "aging" character of the sector limits the capacity for agricultural innovation and technological advancement.

FAO consultant, Dr. Barbara Graham (2011) asserts that the availability of food is not a problem in Saint Lucia; access to food and income for rural farmers is the challenge for sustainable livelihoods.

4.4.8. Economic Vulnerability: Climate Change and Agricultural Outputs in Saint Lucia

A primary economic vulnerability factor for the agriculture sector in Saint Lucia is the overreliance on bananas for income generation. Banana, the main export crop, dominates agricultural land use and economic life. The variability associated with drought conditions seriously affects banana exports, including fruit quality and the capacity to generate sufficient levels of production for foreign exchange earnings. Recently, farmers are getting less export income from bananas due to increased competition in the EU banana market. A significant number of farmers and labourers in rural communities have been displaced and their income source eroded (Agricultural Review, 2010). The consequence of these challenges is decreased purchasing power for agricultural workers and a heightened threat of food insecurity.

Major crops cultivated, in addition to bananas, are coconut, cocoa, and non-traditional crops grown either in monoculture or on an intercropped basis. The shift from bananas has transformed agricultural production systems and led to the cultivation of crops such as tannia, dasheen, christophene, sweet potatoes, yam, cassava, and tomatoes. A secondary vulnerability feature is the prevalence of small-scale agriculture in Saint Lucia which is characterised by many individualised production units with 2 or less acres of land. The commissioned poverty report on Saint Lucia (2007) explains that despite Government's attempts to diversify the agriculture sector, many farmers are unprepared or ill equipped to generate income from non-traditional produce. Ex-banana farmers have limited experience and training in viable agricultural diversification alternatives and reduced cash flow has further exacerbated their ability to adapt to environmental changes.

A third economic vulnerability feature in Saint Lucia is the colossal loss in agricultural investment caused by extreme weather events, especially for small farmers who have little or no insurance. Foreign exchange from export crops is also lost because crops require time to recover or to be replanted.

In terms of the food trade balance, the Saint Lucia Social and Economic Review (2011) suggest that the tourism industry drives millions of dollars' worth of food and agricultural imports. The country is a net- food importing country, with a growing trade deficit in its food bill over the last 10 years. In 2010, the level of food imports increased by 19.5% to a record value of EC $351.4 million. This upturn was to some extent influenced by higher food prices and larger import volumes of food items in the last quarter of 2010 following the passage of hurricane Tomas. During the first half of 2010, drought conditions led to a 15.3% reduction in banana exports and banana revenue fell by 25.7% (EC $41.9 million). Export volumes for non-banana crops contracted by 2.9% during the same period.

Through support from an EU-funded project, an analysis of cash crops and service plants for cultivation systems adapted to the economic needs and pedoclimatic conditions in Saint Lucia was performed. The research identifies cover crops with the potential for reducing erosion under Saint Lucia's climatic conditions. This includes herbs, which are capable of forming nodules with nitrogen fixing bacteria and forage for livestock which allows for spreading even over very heterogeneous and problematic soil patches (Reisdorff and Real, 2008). More importantly, the study identifies the commercial crops with the potential to promote agricultural diversification based on sound scientific information on Saint Lucia's soil capacity to sustain different produce (Reisdorff and Real, 2008). The following diagram shows the most important crops for Saint Lucia based on data acquired from this study and information from the Saint Lucia Annual Agricultural Review (2010).

Staple Crops: domestic use	Export Crops	Foods in demand from hotels/restaurants
• Sweet potatoes	• Bananas	• Tomato
• Cassava	• Guavas	• Cabbage
• Plantain	• Mangoes	• Cucumber
• Dasheen	• Barbados cherries	• Sweet Pepper
• Cucumber	• Papaya	• Lettuce
• Yams & coco-yams	• Ginger	• Dasheen
• Tannia	• Cocoa	• Tannia
• Tomato	• Pepper	• Plaintain
• Lettuce		• Sweet potatoes
• Potatoes		• Yams
• Beans		• Green banana
• Okra		• Herbs & spices

Figure 4.4.4: Crops in Saint Lucia

4.5. *Marine and Terrestrial Biodiversity and Fisheries*

4.5.1. Background

The small island of Saint Lucia possesses an impressive diversity of terrestrial and aquatic biological species and equally remarkable diversity of ecosystems. Approximately 35% of the land surface is forested and includes rainforest ecosystems that provide essential habitat to 1,436 species of vascular plants (1,147 of which are native) and 175 species of amphibians, birds, mammals and reptiles combined (157 species of which are native) (Daltry, 2009a). Natural resources are the foundation of the island's economic activity, food security, and livelihoods. The key economic sectors, tourism and agriculture, are heavily reliant on biodiversity. For example, hiking tours through rainforest trails filled with exotic wildlife, swimming in freshwater pools beneath cascading waterfalls, snorkelling and diving among coral reefs and shopping for souvenirs hand-crafted from local materials are all tourist experiences dependent on Saint Lucia's biodiversity and fisheries. The total annual economic benefit derived from coral reef products and services associated with tourism, fisheries and coastal protection, was estimated to be between US $240 and $350 million in Saint Lucia in 2006 (Burke *et al.*, 2008). Terrestrial and freshwater ecosystems are also vital to Saint Lucia's economy and in particular to the agricultural sector, which relies primarily on rain-fed rivers and healthy watersheds. The retention of soils and the provision of a regular and clean water supply are critical services provided by forest ecosystems.

Habitat modification and destruction have been identified as the main threats to Saint Lucia's biodiversity, stemming from the combined effects of extensive residential and tourism developments and unsustainable harvesting of natural resources (Government of Saint Lucia, 2009a). Application of international criteria in a recent study on the country's biodiversity revealed that 6 plant species and 17 animal species found in Saint Lucia qualify as globally threatened with extinction. A total of 8 species more than were previously listed on the International Union for Conservation of Nature (IUCN) Red List (Daltry, 2009a). The close relationship between people and their natural environment is particularly evident in rural areas where there are a high percentage of people who rely heavily on the environment for their survival. In many of these rural areas, increasing poverty and inadequate natural resource management have led to a vicious circle of unsustainable deforestation and fishing, leaving communities exposed to landslides and diminished fish stocks. The tragic loss of life due to landslides during the 2010 hurricane season clearly demonstrated the need for more effective land management. Saint Lucia's marine and coastal resources have been identified as being most vulnerable to climate change due to the inherently sensitive nature of these ecosystems. For instance, its fringing reefs are highly susceptible to surface run-off due to their narrow range and the steep incline of watersheds. Such vulnerability is further aggravated by existing stresses from unsustainable resource use and insufficient land-use and fisheries management. This research assesses the vulnerability and adaptive capacity of the island's biodiversity and fisheries sectors to climate change within the context of those ecosystems that are most significant to tourism and its related sectors.

Importance and Current Status of Forests

Five forest types have been described in Saint Lucia: rainforest, lower montane rainforest, montane elfin woodland, secondary forest, and dry scrub woodland. Saint Lucia's tropical rainforests boasts a high level of endemism, with 10 endemic 'higher plants', 6 endemic birds (11 sub-species.), including the vulnerable Saint Lucia Parrot, 7 endemic reptiles (5 sub-species), 1 endemic amphibian, 1 endemic mammal (1 sub-species) and more than 200 endemic beetles(Earthtrends, 2008)(Daltry, 2009a). Only 6 native plant species are listed under IUCN as globally threatened and one species, the *Pouteria semecarpifolia,* which is recognised as globally threatened, appears to still grow commonly on Saint Lucia (Daltry, 2009a). However, the general trend is a loss of species and reduction in range and size of habitat due to human encroachment on forestland in favour of socio-economic development.

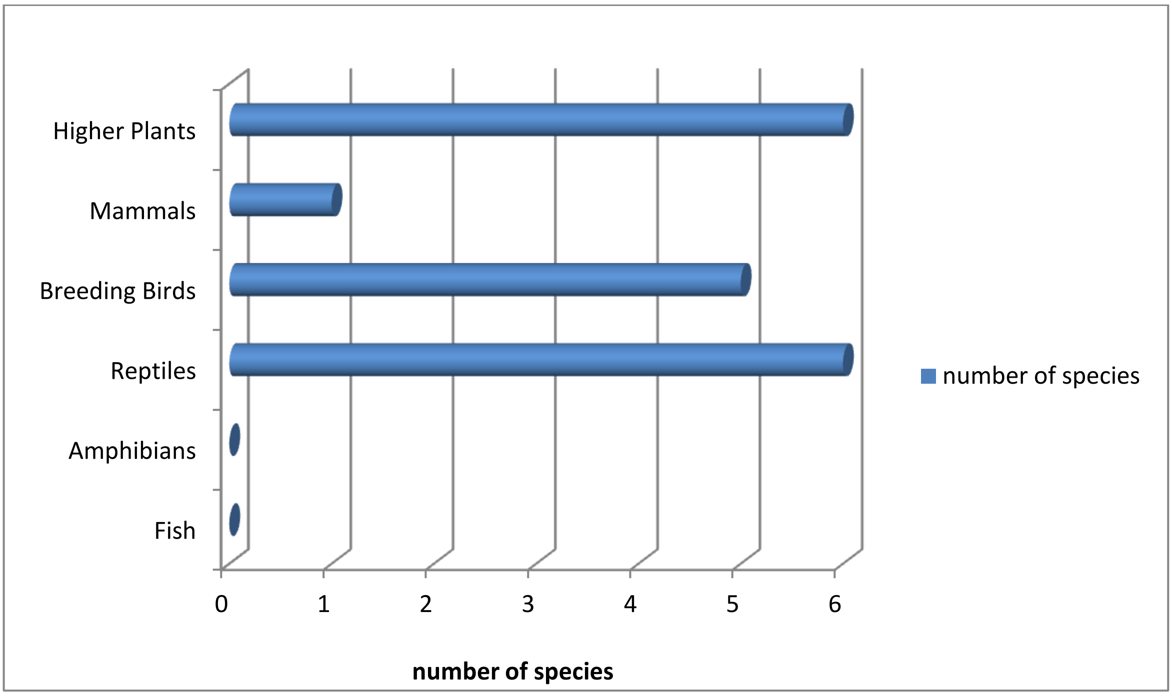


Figure 4.5.1: Threatened Species in Saint Lucia

(Source: Earthtrends 2003)

Forest biodiversity makes direct contributions to livelihoods and subsistence through the many plants and animals that are harvested and sold (Figure 4.5.2). Iguanas, crabs, opossum (manicou) and agouti are some of forest species which are harvested for food. Straw, reeds and grasses are woven into hats, baskets, floor mats and many other good that are purchased by locals and tourists. Rainforest nature trails are an important part of the Saint Lucian tourism product and provide livelihood opportunities for tour guides, tour operators, caterers, and more. Forests also play a significant role in regulating and protecting the island’s 7 most significant watersheds and in maintaining soil stability.

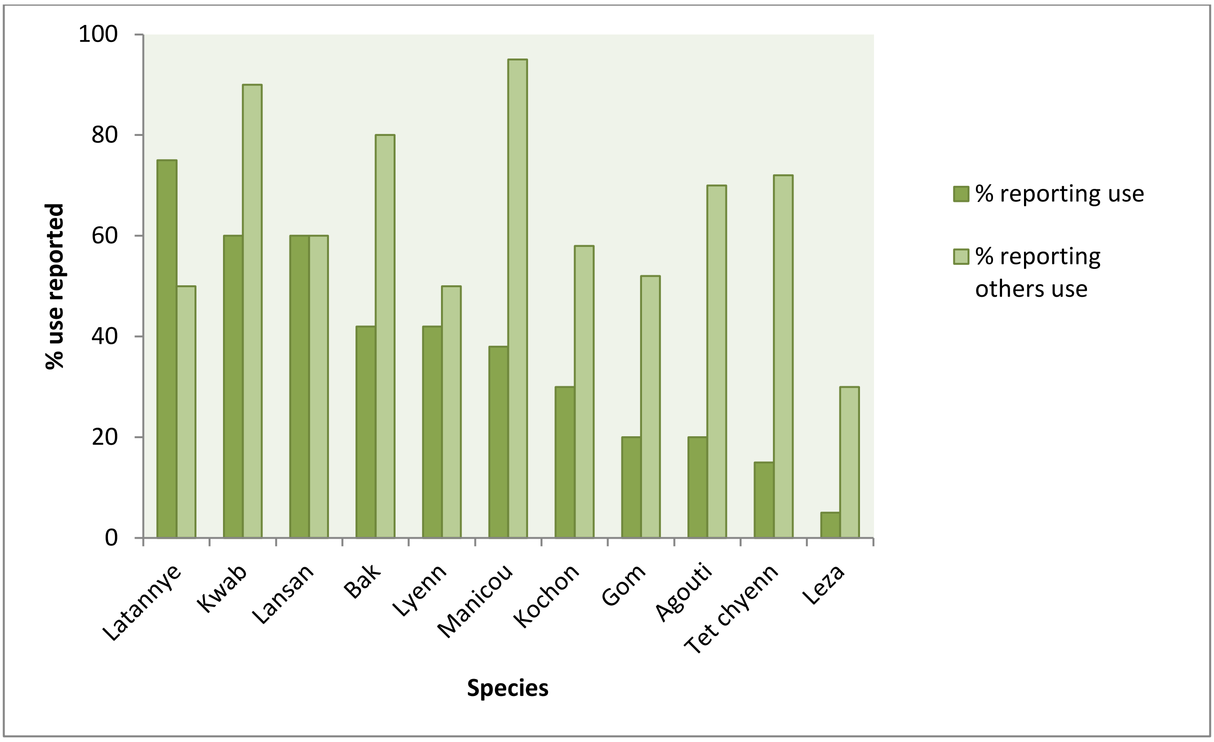


Figure 4.5.2: Forest Species Used in Saint Lucia
(Preliminary findings, National Forest Demarcation and Bio-Physical Resource inventory project, 2009)
(Source: Government of Saint Lucia 2009a)

Throughout Saint Lucia's history, forests were cleared to provide wood for construction and fuel, as well as to create agricultural lands and room for housing. As a result, only one-third of the island still has the original natural vegetation. Most of the natural forests lie within forest reserves (56%) and on private lands (43%) (Scott *et al.,* 2006). Large parcels of these privately owned forest lands have been sold or promised to developers, presenting the likelihood of a further reduction in forest cover if these developers are permitted to clear large plots (Daltry, 2009a). Combined pressures of deforestation, logging of mature trees and trade almost led to the extinction of the Saint Lucia parrot population in the 1970s(BirdLife International, 2008). Population expansion, demand for forest products, and land tenure practices in Saint Lucia continues to encroach on wildlife habitat and has accelerated the deforestation of steep slopes within forested areas in favour of agriculture and housing lands. Removal of vegetation on steep slopes promotes soil erosion, a matter of serious concern given that over 90% of land in Saint Lucia lie on slopes with inclines greater 5 degrees and is prone to land slippage. Agro-chemicals are leeched from soils and pollute water catchments, which are associated with forests, as well as coastal waters downstream. Sedimentation and chemical contamination of freshwater threatens human health, places strain on aquatic plants and animals, and damages coral reefs and other marine life. Clean water and healthy ecosystems are vital to the island's tourism industry; therefore a decline in quality of the product will negatively impact on visitor experience and willingness to return.

Invasive alien species of flora and fauna, whether accidentally or deliberately introduced, are another contributor to the loss of native forest biodiversity. Results from a study on amphibians and reptiles in Saint Lucia's forests indicated that human degradation of all forest classes was significantly associated with an increased number of alien invasive species (Daltry, 2009b). The majority of invasive plants were found in degraded forest land but appear to have had little success in invading mature forest.

Importance and Status of Freshwater Ecosystems

Freshwater habitats of Saint Lucia include 37 major rivers, streams, marshes, mangroves, underground springs, flood plains, and constructed systems such as ponds and dams. Freshwater ecosystems provide habitat to a large part of the island's biodiversity and play a significant role in water quality maintenance. Like forests, these ecosystems also help to absorb and buffer the flow of watercourses after heavy rains, providing important protection to people and other ecosystems from flood waters. Of the aforementioned natural freshwater habitats, rivers and wetlands (including mangroves) are particularly significant to the tourism industry and local livelihoods. These natural features are discussed below. More information on Saint Lucia's water resources can be found in the section 4.1, Water Quality and Availability.

Rivers

Rivers contribute to the diversity of the island's tourist attractions. These watercourses provide habitat for diverse species of insects, birds, molluscs and plants, contribute to food security and regulate the quality of coastal waters. There are 13 species of freshwater shrimp found on the island, as well as 14 species of freshwater fish(Government of Saint Lucia, 2009a). Although the harvest of these shrimp is prohibited by law, they continue to be caught for subsistence and recreation. Rivers such as the Anse-la-Raye, Roseau and Doree Rivers, have some touristic value and are used for bathing, kayaking and other recreational activities.

Mangroves and other wetlands

Very little data exists on wetland ecosystems in Saint Lucia. The remaining wetlands are small and have been reduced by about 50%, from 3.20 km^2 to 1.93 km^2. Most of Saint Lucia's mangroves (Table 4.5.1) lie along the east coast of the island within private lands and occupy only about 0.29% of the land mass(MAFF, 2001). However, mangroves have not been mapped and hence the extent of their true coverage is uncertain. Although limited, the existing mangrove stands provide essential nurseries for juvenile fish, habitat for marine species and avifauna and are part of a nutrient exchange system with associated coral reefs and seagrass beds. The vegetation reduces the impact of cyclonic winds and is valued by visiting yachtsmen, fishers and other boat owners who seek shelter for their vessels within mangrove coves during storms. In addition, mangroves play a role in the maintenance of coastal water quality, as well as in the protection of the coastline from erosion by waves and strong winds.

Historically, mangroves have been used for charcoal production, an important source of fuel for rural communities. The Mankoté Mangrove in Vieux Forte, 1 of 2 Ramsar Sites on the island, is the largest mangrove stand occupying over 40 ha and is still used by charcoal harvesters.

Table 4.5.1: Extent and Status of the Main Mangrove Wetlands in Saint Lucia

Name	Type of Mangal	Status
Bois D'orange	Basin (freshwater swamp) Species present *L. racemosa*	**Size:** 2.59 ha (1985)/only 10-15 trees, about 25 square meters(1997) **Ownership of lands:** Private **Values:** Fisheries, wildlife, large associated wet land plays an important role in flood protection. Good diversity of bird species, may be nesting site of herons and zemida dove; legally declared marine reserve **Proposed IUCN category**: IV
Cas en Bas (3 distinct patches)	Riverine (plus 2 small scrub mangals) Species present: *R. mangale, L. racemosa* and *C. erecta*	**Size:** 5.44 ha (1985)/about 1.5 ha (1997) **Ownership of Lands:** Part Crown and part private Wildlife impoverished, deforestation; legally declared marine reserve
Choc **North** **South**	Riverine basin Species present: *R. mangale*	**Size:** 12.95 ha (1985)/about eight (8) trees in the north and three (3) trees in the south (1997) Ownership of lands: Private **Other:** The northern mangal has been adopted by an environmental club of a near by school; serious problems of deforestation; legally declared marine reserve
Dennery	Riverine Species present: *R. mangale,* and *L. racemosa*	**Size:** 6.0 ha (1985)/ <0.5 ha (1997) **Ownership of lands:** Crown System severely degraded due to deforestation
Esperance	Riverine (mangrove swamp and tidal mudflats)	**Size:** 17.35 ha (1985)/about the same in 1997 as in 1985 Ownership of lands: Private **Values:** Erosion control, wildlife Low abundance of bird fauna, stopping lace for migrants; deforestation; legally declared marine reserve **Proposed IUCN category**: IV (Wild life-Reserve-like)
Fond D'Or	Riverine, Species present: *A. germinans, C. erecta,* *R. mangale,* and *L. racemosa*	**Size:** 21.0 ha (1985)/<0.5 ha (1997) **Ownership of lands:** Crown **Values**: Erosion control, fisheries Under management by the Mabouya Valley Development Committee; wild life impoverished; legally declared marine reserve **Proposed IUCN category:** IV (Wild life-Reserve-like)
Grande Anse	Basin Species present: *R. mangale,* and *L. racemosa*	**Size:** Figures for 1985 are not available/<0.5 ha (1997) **Ownership of lands**: Crown **Deforestation:** high level of sand mining on beach area; legally declared marine reserve
La Sorciere	Riverine Species present: *A. germinans, C. erecta,* *R. mangale,* and *L. racemosa*	**Size**: 5.18 ha (1985)/<1.0 ha (1997) **Ownership of land:** Crown Potential threats from deforestation
Louvet	Riverine Species present: *R. mangale,* and *L. racemosa*	**Size:** 17.35 ha (1985)/ about the same in 1997 as in 1985 **Ownership of lands:** Private Potential threats from deforestation due to uncontrolled development; wildlife impoverished; legally declared marine reserve
Mankoté	Basin Species present: *A. germinans, C. erecta,* *R. mangale,* and *L. racemosa*	**Size:** 39.37 ha (1985)/ about the same in 1997 as in 1985 **Ownership of land:** Crown **Value:** Erosion control, wildlife. Largest mangrove on the island; currently being managed through a collaborative arrangement among the DOF, a nongovernmental organization (NGO) – Caribbean Natural Resource Institute and a group of local charcoal producers who have been trained and educated on sustainable harvesting of wood from

Name	Type of Mangal	Status
		mangrove areas; lands vested in the National Development Corporation and currently being considered for hotel development; legally declared marine reserve. **Proposed IUCN category:** II (Park-like)
Marigot Bay	Fringe (mangrove swamp and lagoon), Species present: *R. mangale, A.germinans* and *L. racemosa*	**Size:** 6.22 ha (1985)/ about 0.7 ha (1997) **Ownership of lands:** Crown **Value:** Erosion control; fisheries Deforestation due to poorly controlled development; pollutants in 79 arbour; legally declared marine reserve **Proposed IUCN category:** IV (Wild life-Reserve-like)
Marquis	Riverne (mangrove swamp and lagoon), Species present: *C. erecta, R. mangale,* and *L. racemosa*	**Size:** 2.59 ha (1985)/about 1.5 ha (1997) **Ownership of land:** Private Good diversity and abundance of bird species, threats from deforestation; legally declared marine reserve **Proposed IUCN category:** IV (Wild life-Reserve-like)
Micoud	Fringe, Species present: *A. germinans, C. erecta, R. mangale,* and *L. racemosa*	**Size:** 1.29 ha (1985)/about 1.0 ha (1997) **Ownership of lands:** Private Potential threats from deforestation
Praslin	Fringe, (mangrove swamp and tidal mudflats) Species present: *A. germinans, C. erecta, R. mangale,* and *L. racemosa*	**Size:** 17.35 ha (1985)/ about the same in 1997 as in 1985 **Ownership of lands:** Private (a small section also falls on Crown lands) Deforestation due to uncontrolled development and poor agricultural practices **Proposed IUCN category**: IV (Wild life-Reserve-like)
Savannes Bay	(mangrove swamp and lagoon), Species present: *C. erecta, R. mangale,* and *L. racemosa*	**Size:** 24.61 ha (1985)/ about the same as in 1985 (1997) **Ownership of lands**: Crown **Value:** Erosion control; fisheries; wildlife Potential threats from poorly controlled development legally declared marine reserve. **Proposed IUCN category:** IV (Wild life-Reserve-like)
Trougasson	(mangrove swamp and lagoon); Species present: *R. mangale,* and *L. racemosa*	**Size:** Figures for 1985 are not available/<0.2 ha (1997) **Ownership of lands:** Crown Mangal system severely degraded due to deforestation and sand mining activities
Volet	(mangrove swamp and tidal mudflats) Species present: *R. mangale,* and *L. racemosa*	**Size**: Figures for 1985 are not available/about 1.5 ha (1997) **Ownership of lands**: Private (coastal fringe is on Crown Lands) **Value**: Erosion control; fisheries; wildlife Potential threats from uncontrolled harvesting of wood and poorly controlled development

(Source: MAFF, 2011)

Other wetlands in Saint Lucia include natural and constructed wetlands that are used for irrigation and aquaculture ponds, sewage treatment ponds and water catchments. Many of the island's wetlands are not used for freshwater extraction but they contribute to water quality since they naturally filter sediment and other pollutants.

Threats to freshwater ecosystems and biodiversity come from improper land use, poor agricultural practices and untreated effluent from domestic, agricultural and industrial sources. Demand for land has resulted in the conversion of wetlands to other uses. For example, Rodney Bay, a significant contributor to the tourism sector, was once an area of marsh land and swamp. Several other wetland areas have been lost due to clearing or filling for development purposes or as dumping grounds.

Importance and Status of Beaches

There are 102 beaches along Saint Lucia's coastline with sands ranging from black volcanic substrate to white coralline grains. From a biological perspective, these sandy beaches serve important ecological functions through the provision of habitat to many unique creatures, including endangered marine turtles and iguanas that nest on Saint Lucian shores. The vegetation that grows on beaches and sand dunes promotes shoreline stability by reducing the mobility of sand grains, increasing the resilience of beaches to erosive wave action. Beaches also have economic value, generating revenue from the recreation of locals and visitors. A valuation study of beaches in Saint Lucia roughly estimated the economic value that residents derive from using the beach. Although not a formal part of the economy, this figure was determined to range from US $52-$109 million (Burke *et al*., 2008). Economic benefit is also realised from the protection of coastal infrastructure by beaches that provide a line of defence against high waves. Saint Lucia's beaches are also an important feature in the fisheries sector, especially for artisanal fishers who launch their vessels and haul in their catches from the shores.

Despite their importance, Saint Lucia's beaches are suffering degradation as a result of human activities. Sand dunes are a reservoir for beach nourishment and provide aggregate for building construction. However, sand mining has damaged or destroyed dunes to the detriment of some of Saint Lucia's beaches (MAFF, 2001). Illegal sand mining is a serious concern considering that sand is also lost from beaches due to natural cyclonic events. Sand that is naturally washed away from a beach during a storm event is eventually recovered from the near shore deposits, but it appears that some of the island's beaches do not recover completely after storm events because of depleted sand reservoirs (SDEU, 2001).

Coastal development presents a threat to beaches in another way; hotels and restaurant facilities, which occupy approximately 26% of beaches on the west coast, can contribute to sand loss if constructed too close to the shoreline. Sea waves reflected off of their impermeable walls scour sand and gradually reduce beach width.

Status of Coral reefs

Coral reefs, "the rainforest of the sea", serve to protect an island's shoreline, maintain its marine biodiversity, contribute to tourist recreational activities, and support artisanal fisheries. About 44% of the Saint Lucia's shoreline is protected by fringing reef systems (Figure 4.5.3) (Burke *et al.*, 2004).

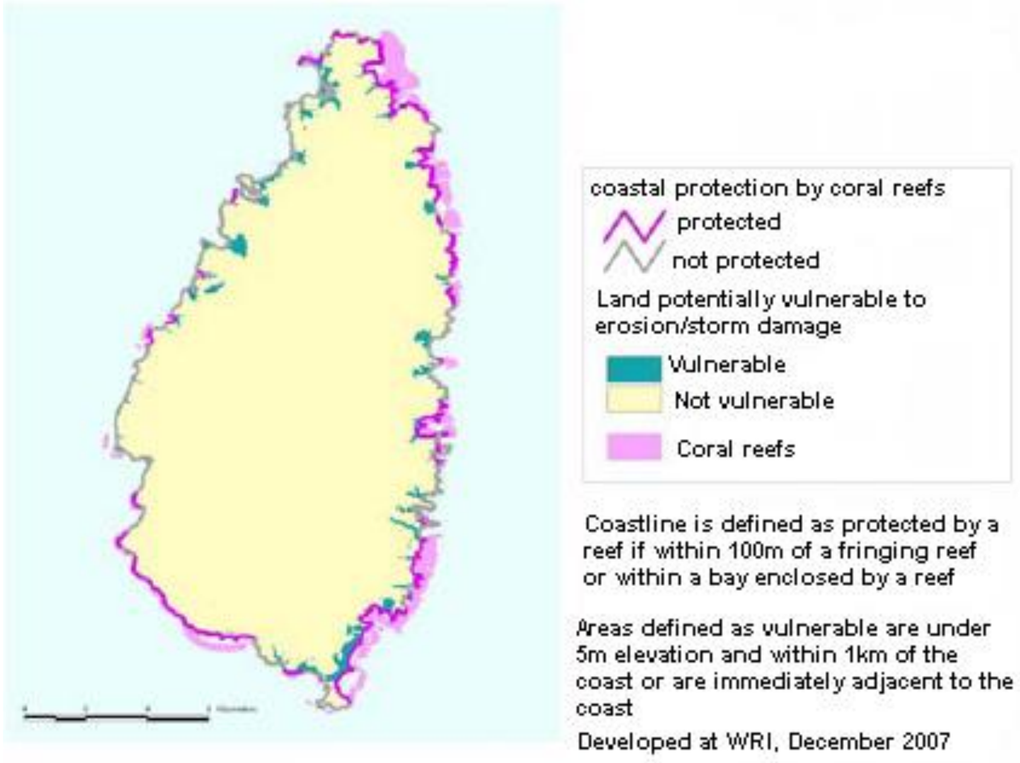


Figure 4.5.3: Coastal Protection Provided by Coral Reefs around Saint Lucia

(Source: Burke *et al.*, 2008)

The healthiest reefs are found off the coast of Soufriere, but the development of tourism in this area, a historically agricultural community, is increasing the pressures on those reefs. Furthermore Soufriere is at high risk to landslides and consequently its reefs are prone to sedimentation (see Figure 4.7.2: Landslide Hazard Map for Saint Lucia section 4.7 Comprehensive Natural Disaster Management). All 90 km of reefs around the island are at risk to human activities, in particular coastal development and over-fishing (Burke *et al.*, 2004). Unfortunately, the general trend shows that coral cover around Saint Lucia is on the decline while growth of macro-algae is increasing (Table 4.5.2).

Table 4.5.2: Change in Coral Cover and Macro-Algal Cover in Saint Lucia between 1999 and 2004

Name of reef area	Decrease in hard coral cover	Increase in macro-algae cover
Anse Chastanet Bay	62.5%	45.45%
Coral Gardens, shallow reefs	30.63%	69.35%
Coral Gardens, deep water reefs	76.71%	90.91%

(Source: Scott *et al.*, 2006)

Other reefs have also suffered damage from land-based sources of pollution and high levels of sedimentation. For example, the coastal waters off the shores of Faux a Chaux and Baron's Drive communities are being polluted by human faeces, run-off of agricultural and other chemicals, and by the dumping of garbage (Kairi Consultants Ltd, 2006).

Scuba diving is a popular activity among tourists, mostly occurring along the west coast of the island (Figure 4.5.4). A valuation study on coastal capital in Saint Lucia estimated that about 25% of tourists who visit the island do so at least in part for the coral reefs (Burke *et al.*, 2008). Approximately 45,000 total dives and 95,000 snorkelers engaged in reef based activities during 2006. The combined direct and indirect expenditures, including accommodation, glass bottom boat/snorkelling trips, diving, MPA user fees and miscellaneous expenditures on reef-related tourism and recreation in that year was estimated to be between US $160 and $194 million (Table 4.5.3).

Table 4.5.3: Coral Reef Associated Tourism Economic Impact* for Saint Lucia

Expenditure Categories	($US million)
Accommodation	64.7
Reef recreation - diving	4.9
Reef Recreation – Snorkeling and glass-bottom boats	$0.8
Marine Park Revenues	$0.05
Miscellaneous Visitor Expenses	$21.2
Total Direct Impact	**$91.6**
Indirect economic impact (from multiplier)	$68 – 102
Total Direct and Indirect Impact	**$160 – 194**
Other Values	
Consumer Surplus	$2.2 – 2.4
Local use	52-109

*Not to be confused with climate change impacts. The evaluation by Burke *et al.* (2008) uses the term "impact" to describe the economic contribution of coastal resources.

(Source: Burke *et al.*, 2008)

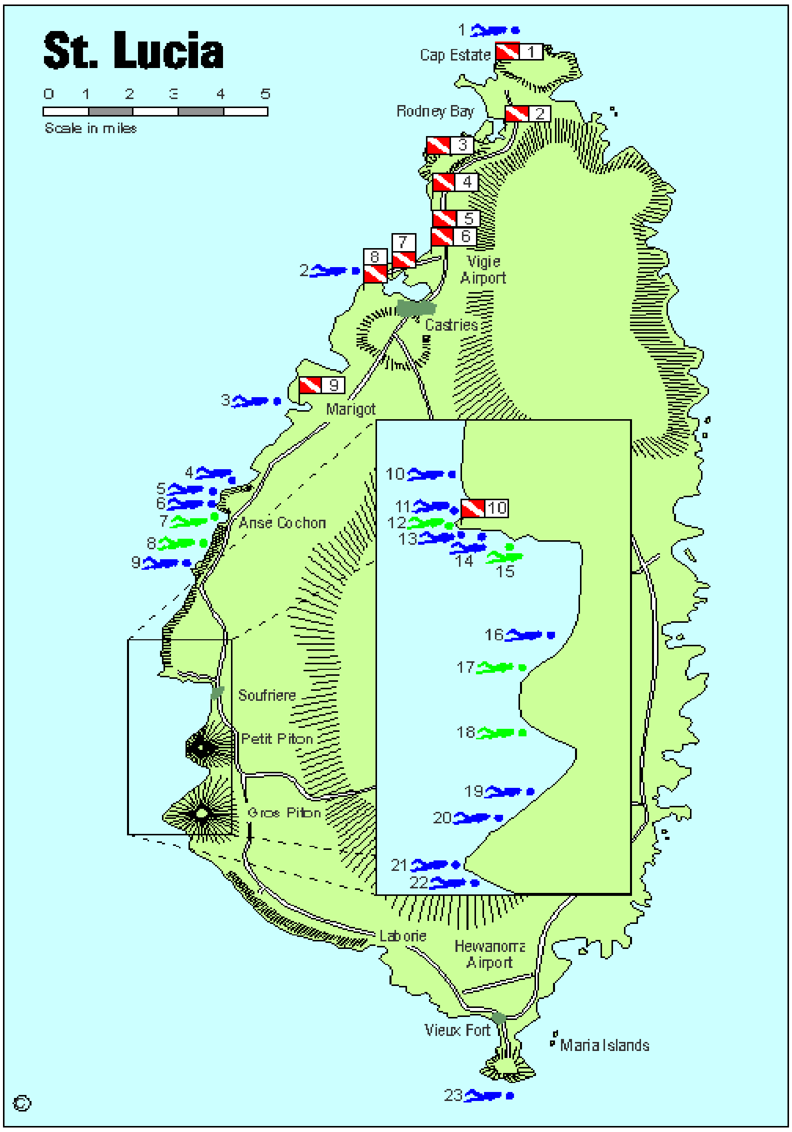


Figure 4.5.4: Dive Sites around Saint Lucia

(Source: www.caribdiveguide.com)

Coral reef fisheries, especially those along the west coast, have long been important contributors to Saint Lucian society and economy. Grunts, snappers, parrotfish and groupers are common species extracted from coral reefs and have been valued to between US $520,000 and US $841,000 annually (Burke *et al.*, 2008). The Status of Fisheries sector will be discussed in further detail on page 83.

Status of Seagrass Beds

Seagrasses are grass-like aquatic flowering plants that play an important role in the marine environment, including:

- Primary producers in the food chain of the reef community producing more than 4000 g C/m^2/yr in fixing nitrogen.
- Providing habitats, feeding, breeding, recruitment sites and nursery grounds for juveniles and adults of reef organisms including commercially important species such as sea egg (T. ventricosus), queen conch, spiny lobster and green sea turtle.
- Reducing sediment movement in near shore waters thus in stabilizing the coastline and removing sediments from the water column; decreasing turbidity of the water.

Three species of seagrass found around Saint Lucia are *Thalassia testudinum* ("turtle grass"), *Syringodium filiforme* ("manatee grass"), and *Halodule wrightii* ("shoal grass"). The major seagrass beds around the island occur in close proximity to coral reefs along the north, south, and southeast coasts at Laborie, Anse Epouge, and from Burgot Point to Saltibus Point. Increasing urbanisation, coastal development and poor agricultural practices have been damaging to Saint Lucia's seagrass beds. Healthier and denser beds can still be found along the less developed East coast of the island. Destructive fishing practices, such as dynamite-fishing, have also destroyed some seagrass plots.

Status of Fisheries

Small island communities are extremely dependent on coastal fisheries for their existence. An estimated 333 species of finfish species (Scott *et al.*, 2006) have been identified in Saint Lucia's coastal waters. This variety supports domestic and tourist consumption as well as export industry. The primary fisheries of Saint Lucia comprise demersal, coastal and off shore pelagic fisheries. The majority (70%) of catches consists of offshore migratory pelagics such as dolphinfish, wahoo, tuna and tuna-like species, shark, billfish and flying fish. Demersal fisheries, which land the most valuable species for local, tourism and export sectors, includes the spiny lobster, queen conch, grouper and snapper species. The fisheries sector is an important livelihood activity for many, employing over 2,300 fishers and some 120 fish processors (FAO, 2007). Two weekly community fish festivals - Fish Fridays at Gros Islet and at Anse-La-Raye- are highly popular street parties among tourists and locals alike. These attractions feature a wide range of freshly caught seafood including octopus, conch, lobster, whelks and a variety of fish. The events provide support for livelihood activities of cooks, vendors and entertainers. A diverse fishery is also important to the island's reputation as a dive tourism destination; a valuable sector of the industry that continues to grow in the Caribbean region.

Unsustainable levels of harvest (Figure 4.5.5), illegal fishing methods, habitat degradation and sedimentation of coastal waters are threatening Saint Lucia's fisheries. Near shore fisheries are considered overfished while the pelagic fisheries are regarded as under-utilised (FAO, 2007). Degradation of coral reef and mangrove ecosystems, which are vital nursery areas for many commercial species, has been detrimental to the status of fish stocks. Sedimentation from coastal development and from soil erosion further inland has also been shown to have significant negative impacts on the rate of fish biomass increase (Hawkins *et al.*, 2006).

Pterois volitans, the Indo-Pacific lionfish, is an invasive species that has been sighted in neighbouring territories as close as Guadeloupe and Venezuela. Lionfish have no apparent natural predators in the Caribbean and this has allowed the species to spread very rapidly throughout the region from both northern and southern ends of the Caribbean Basin. The fish feeds not only on reef fish such as parrotfish, which are important to maintaining reef health, but also on the juveniles of commercially important species. The Fisheries Division and Coastal Zone Management Unit are greatly concerned about the threat this could pose for the country's fishing industry.

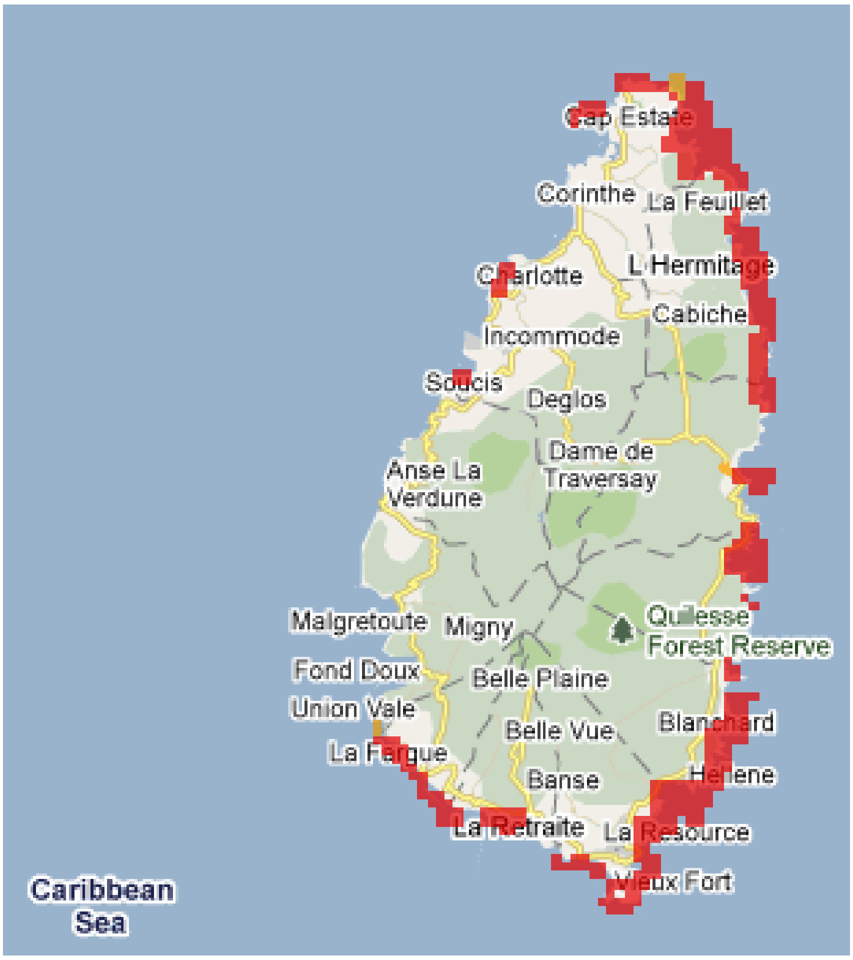


Figure 4.5.5: Areas of Over-Fishing in Saint Lucia
(Source: Adapted from IUCN and UNEP. 2009. The World Database on Protected Areas (WDPA). UNEP-WCMC. Cambridge, UK)

Other Important Species

Queen conch

Conch is targeted commercially by some fishers throughout the year, while other fishers focus their efforts on this resource during the low period of "offshore" pelagic species, for on average, 5 months (CRFM, 2004). The status of the stock appears to have worsened compared to the assessment conducted in 2006 and the abundance of the queen conch stock continues to decline (CRFM, 2008). Near shore resources have been depleted so that fishers now harvest deep water stock using scuba gear. The 2007 landings were beyond the 35 tonnes recommended by the Third Annual CRFM Scientific Meeting; hence, the stock is likely to be over fished. Catches are currently likely to be below the replacement yield, so that near shore stocks have been over exploited**;** thus most fishers harvest at deeper depths with scuba diving gear. There is a need for the collection of additional data on the density and habitat of conch in Saint Lucia to improve estimates of stock status.

Lobster

The spiny lobster is the most economically important of the lobster species found in Saint Lucia and the second most valuable fishery in terms of landings (Joseph, 2001). The lobster fishery is an important livelihood to hundreds of fishers and is a popular seafood choice among locals and tourists. As the tourism industry continues to grow, fishing pressure on this species, which is already heavily harvested, will continue to increase. Trammel nets, dynamite and spear guns are still illegally used on a small scale (CRFM 2006). Furthermore, habitat degradation from land based sources of pollution threatens the viability of this resource.

White Sea Urchin

Once a popular and sustainably harvested resource, the white sea urchin has in recent times been extracted to such an extent that the fishery had to be closed for some years. Signs of increased recruitment lead to the species being heavily harvested during a time which catches were valued at US $ 400,000 for 1995 and 2001-2004 combined (Pena *et al.*, 2010). Low levels of abundance and recruitment failure has caused the fishery to remain closed as of 2005, with little prospect of reopening.

Turtles

Three species of marine turtles are known to nest on Saint Lucia's shores. Marine turtle stocks are globally shared and are an important part of the country's marine biodiversity. The marine turtles provide an attraction for eco-tourists who can observe turtle nesting for a small fee. As of 1996, a moratorium was declared on all turtles and turtle products in Saint Lucia, however, illegal poaching and to a small extent fisheries by-catch still pose a threat to turtle population numbers. Additionally, damage to seagrass beds and beaches degrade their nesting and foraging grounds.

Marine Mammals

Various species of dolphins and whales are sighted around Saint Lucia throughout the year. Sperm whales appear to be sighted in greater numbers from the months of October to January and humpback whales are seen migrating only between January and April. The whale watching industry in Saint Lucia grew rapidly over a 10 year period from 65 whale watchers in 1998 to over 16,600 in 2008. Whale watch tours are now offered by 4 operators on the island who earned a total of US $1,577,010 in direct and indirect expenditures in 2008 (O'Connor *et al.*, 2009). The number of stay over, as well as cruise ship tourists to the region continues to increase annually, offering good prospect for expansion of the market for these tours. Cetaceans are a globally shared resource, with the continuation of whale watching tours in Saint Lucia dependent on the presence of the mammals in the Eastern Caribbean.

4.5.2. Vulnerability of Biodiversity and Fisheries to Climate Change

Climate Change Impacts on Forests

While small changes in temperature and precipitation are known to have significant effects on forest ecosystems, there has been little research focused on the projected impacts of climate change on terrestrial biodiversity in the region. Climate change related variations in average daily temperature, seasonal precipitation and extreme weather events will exacerbate the effects of existing human stressors on forest ecosystems. Alterations in the average annual temperature and precipitation patterns may affect the growth of trees and other plant species within the forest. Decreases in precipitation and increased average daily temperatures could result in a loss of rainforest zones and an associated increase in the tropical dry forest zones. The implications are a loss of habitat for endemic species, and a loss of revenue for the eco-tourism sector. Mount Gimie is the tallest peak in Saint Lucia rising to 959 m and grows a type of vegetation classified as cloud montane forest. These species require almost continual cloud coverage and are most vulnerable to climate change (Foster, 2001). Assuming a cooling rate of 1°C per 150 m of altitude, a projected increase of 1.7°C would require vegetative zones to migrate vertically by 260 m, and up to 530 m in a 3.5°C scenario (Day, 2009). The result could be a displacement of cloud forests into progressively smaller regions at the tops of mountains – possibly causing the loss of entire cloud forests if vertical migration is not possible. The famous Gros Piton (797 m) and Petit Piton (750 m) are dense with tropical rainforest and may be impacted by projected changes in humidity. Reduced moisture could result in forests becoming much drier, potentially causing the wilting and death of epiphytes, which provide important habitat for birds, insects and reptiles (Foster, 2001). Loss of forest cover will also increase the risk of soil erosion.

Caribbean forests have always suffered physical damage from storms, but there is evidence that the increasing intensity of hurricanes is causing more severe damage, with potentially longer term consequences for the integrity of the forest structure and canopy. Severe damage to trees and animal habitats may take years to return to normal. Potentially, habitats of endangered species such as the White breasted thrasher (*Ramphocinclus brachyurus*), Saint Lucia house wren (*Troglodytes aedon mesoluecos*) and the Saint Lucia Nightjar (*Caprimulgus rufous*) could be lost altogether. The mountainous slopes of Saint Lucia are prone to land slippage (Figure 4.5.6). Extreme weather events and heavy rainfall often result in massive landslides in Saint Lucia, as was recently experienced during Hurricane Tomas in 2010. As a result of Hurricane Tomas, approximately 54 km of forest trails were damaged, some of these trails were used as eco-tourist attractions and are still inaccessible to date. The repercussions on the livelihoods of those who were employed in some form or another in forest trail tours have had weighty effects on the morale of affected communities (personal communication, Soufriere community resident, April 13, 2010). Damages to the forestry sector, excluding damage to forest roads, river banks and soil structure was estimated at EC $56,046,530 (Kambon *et al.,* 2011). The cost of maintaining roads and trails across Saint Lucia's steep and rugged terrain will almost certainly increase with the projected acceleration of climate change and intensification of extreme weather events. This projected trend further justifies the strategic and economic importance of protecting and managing the integrity of the island's forests and watersheds.

Figure 4.5.6: Landslide in Saint Lucia Resulting from Hurricane Tomas in 2010

Climate Change Impacts on Beaches

Climate change, in particular SLR and extreme events, is likely to increase rates of beach erosion. As SLR gradually, shorelines retreat inland and beach area is reduced. A reduction in the width of the beach buffer zone will leave coastal infrastructure more vulnerable to erosive wave action, and possibly result in the loss of critical fish landing sites. Climate change impacts on beaches will also threaten the survival of species such as marine turtles, iguanas and shore birds. A 1 to 2 m SLR is predicted to damage 6-10% of turtle nesting sites on the island (Simpson *et al.*, 2010). Intense tropical cyclones and accompanying storm surges will also alter beach profiles and impact on nesting areas (Simpson *et al.,* 2010). Warmer average daily temperatures may skew sex ratios in developing eggs and thereby reduced the reproductive capacity of sea turtles. Such impacts will mean a loss of potential for the country's expanding ecotourism industry, disruption of marine ecosystem balance, and loss of a tourism product. As a signatory to Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES), Saint Lucia has an obligation to protect these marine reptiles.

More dramatic changes can occur to the beach profile during a single extreme weather event and although recovery occurs, it may not be to pre-hurricane conditions. During the 1990s, Saint Lucia's beaches appeared to be experiencing net erosion attributable to a series of tropical cyclones that affected that region. The frequency of events did not allow sufficient time for beaches to recover in between events (Scott *et al.,* 2006). After Tropical Storm Iris, followed by Hurricane Louis in 1995, Vigie Beach was narrowed by 11 m (Figure 4.5.7).

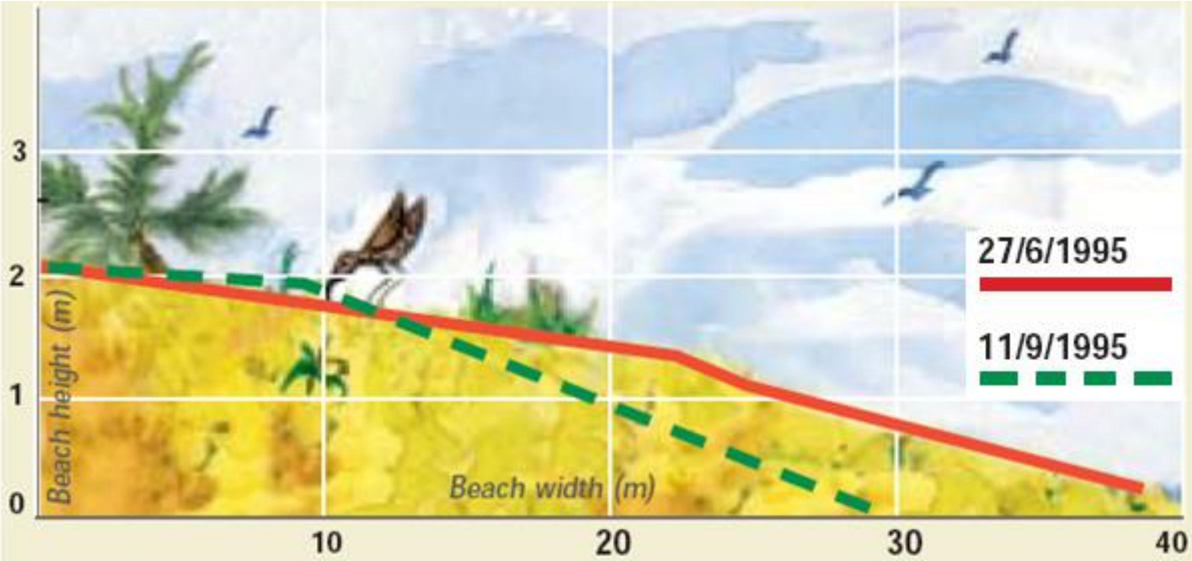


Figure 4.5.7: Beach Profile of Vigie Beach after Hurricane Louis, 1995

(Source: Fisheries Department, 2003)

Changes to the beachscape will affect recreation activities as well as the livelihoods of those employed in fisheries, water-sports operators and other such related activities. The reduced aesthetic appeal will mean reduced quality of one of the island's key tourist attractions.

Climate Change Impacts on Freshwater Ecosystems

It is anticipated that global climate change will aggravate the current human stressors on freshwater ecosystems making it even more challenging to restore and protect freshwater resources. Changes in rainfall patterns and increased temperatures will have the most obvious impacts on the island's watersheds. Protracted periods of drought will likely impact all primary river systems since these are already experiencing reduced based flows as a result of land use changes (Scott *et al.*, 2006). On the other hand, more intense rainfall increases sedimentation of rivers degrading aquatic habitat and reduces the quality of freshwater with implications for the health and tourism sectors. Protection of freshwater ecosystems is therefore vital for the island's socio-economic development. Higher temperatures and increased evaporation may constrain the country from meeting increasing water demands as the tourism sector expands.

Observed and GCM ensemble projections of temperature change in the region will not likely have adverse direct impacts on the country's mangrove forests and wetlands. However, mangroves could be indirectly impacted since increased temperatures will be damaging to coral reefs that mangroves depend on for shelter from wave action and for interchange of nutrients. SLR is expected to pose the greatest climate change threat to mangroves (McLeod and Salm, 2006). Data restrictions prohibited the calculation of the percentage of Saint Lucia's wetlands that are likely to be impacted by SLR (Simpson *et al.*, 2010). However, based on calculations for other parts of the region it is reasonable to assume that this island's wetlands may respond similarly to those in the rest of the Eastern Caribbean. SLR and salt water intrusion will increase soil salinity and may allow wetland vegetation to spread. On the other hand, if mangroves are obstructed from migrating inland due to man-made infrastructure, they may be over-come by SLR and eventually lost.

Extreme weather events have had significant impacts on Saint Lucia's wetlands in the past. For example, Tropical Storm Debbie (1994) caused heavy flooding and landslides, destruction to forests and agricultural crops. The location of mangrove stands along coastlines makes them particularly vulnerability to the impacts of hurricane-force winds and storm surge. Mangrove trees can be stripped of their leaves, suffer altered seed dispersal and seedling recruitment, and their root systems may be inundated with sediment as a result of cyclones (Rathcke and Landry, 2003). Mangrove species exhibit different responses to storm damage and a forest's community structure could thus be changed by tropical storms and hurricanes. The long term effects of extreme events on mangrove stands are uncertain but will most likely mean a loss of the many essential services provided by these ecosystems. The best approach is therefore to preserve and rebuild mangrove communities given the economic and life saving benefits they offer.

Coral reefs

Corals are sensitive to temperature changes and are stressed by changes of about 1°C above average seasonal temperature. In response to elevated SST, corals expel the symbiotic green algae (xooxanthellae) causing them to appear white, hence the term "bleached". In 2005, extensive bleaching occurred throughout the Caribbean affecting most islands, including Saint Lucia, which experienced bleaching of 50-80% of the reefs on the west coast, and 43.8% of all reefs (Wilkinson and Souther, 2008). Fortunately, coral mortality after this bleaching episode was not found to be significant nor was there significant change in hard coral cover (Reef Check, 2005). GCM projections indicate increases in SST throughout the year ranging from +0.8˚C and +3.0˚C by the 2080s across all three emissions scenarios (see section 3 Climate Modelling). Increases in SST of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals (Nicholls R. P., 2007). Increased frequency of bleaching episodes means reduced recovery time for coral polyps and greater likelihood of mortality. Of further concern is that warmer oceanic waters will facilitate the uptake of anthropogenic CO_2 which creates additional stress on coral reefs. Increased CO_2 fertilisation may change seawater pH, potentially having a negative impact on coral and other calcifying organisms since more acidic waters can dissolve and thus weaken the skeletal structure of such organisms (Hofmann *et al.,* 2010).

Other climate related impacts are expected from SLR and extreme events. Rising sea levels may reduce the amount of available light necessary for the photosynthetic processes of corals, and hurricanes can cause extensive structural damage to coral reefs. The rugged nature of a reef helps to break up waves and disperse wave energy, thereby protecting the shoreline from wave impact. However, in so doing, coral reefs can be broken apart and even uprooted from the substrate. Heavy rainfall, such as that experienced with Hurricane Debbie in 1994, washed large amounts of sediment into the sea killing almost half the reefs in Soufriere Bay and Anse La Raye (Nugues *et al.*, 2010). Climate change may increase the intensity of tropical cyclones and hinder the recovery of corals from damages experienced from previous events. The ability of coral reef ecosystems to withstand the impacts of climate change will depend on the extent of degradation from other anthropogenic pressures and the frequency of future bleaching events (Donner, 2005). Coral reefs have been shown to keep pace with rapid postglacial SLR when not subjected to environmental or anthropogenic stresses (Hallock, 2005). The cumulative impacts of climate and non-climatic stressors can take a heavy toll on Caribbean reefs. It is therefore important to reduce the impacts of those stressors over which there is a measure of control (e.g. overfishing, pollution, siltation).

Seagrass Beds

Climate change presents a relatively new threat to seagrass ecosystems and as such the impacts of climate change on seagrass beds remain largely uncertain. Potential threats may arise from SLR, changes in localised salinity, increased SST and intensity of extreme weather events. As with corals, SLR may reduce the sunlight available to sea grass beds and hence reduce their productivity. While there is no consensus amongst the models as to whether the frequencies and intensities of rainfall on the heaviest rainfall days will increase or decrease in the region, increased rainfall could mean a localised decrease in salinity and resulting decrease in productivity of sea grass habitats. On the other hand, CO_2 enrichment of the ocean may have a positive effect on photosynthesis and growth (Campbell *et al.*, 2006). Associated ocean acidification may not hamper primary productivity of sea grasses since photosynthetic activity of dense sea grass stands have been shown to increase local pH. The impact of increased SST on seagrass beds in the Caribbean is uncertain since studies have suggested that the photosynthetic mechanism of tropical seagrasses becomes damaged at temperatures of 40-45°C (Campbell *et al.*, 2006).

More intense hurricanes can uproot these delicate aquatic plants. For example, after a hurricane beaches are often strewn with mats of dead seagrass. Periods of intense rainfall are likely to cause massive sedimentation, given the steep slopes of the island, thus increasing the turbidity of waters surrounding seagrass beds, smothering plants and blocking essential light.

Fisheries

Little is known about the long-term effects of climate change on the Caribbean Sea and on its fisheries. As discussed in previous sections, climate change will generally have negative and possibly debilitating impacts on those ecosystems that are important to various life stages of commercial fish, namely coral reefs, seagrass beds and mangroves. Possible consequences are a reduction in the abundance and diversity of reef fish, with implications for livelihoods, food security and the availability of seafood for the tourism sector. According to the country's Strategic Programme for Climate Resilience (2011), it appears that this is already the case in Saint Lucia where fishers are reporting reduced fish landings.

Increased periods of precipitation will increase the quantity of freshwater outflow into estuaries causing localised desalination of coastal waters. The long-term effect on fish as well as on their critical habitats is uncertain. Pelagic fisheries, including blue marlin and sailfish, comprise the major fisheries landings in Saint Lucia and are also important game fish for a number of sport fishing charter operators. Warmer waters may drive pelagic species away from the tropics in search of cooler temperatures and could potentially alter breeding and migration patterns. Fishers in some of the Eastern Caribbean islands have reported reduced catches and have attributed this loss of revenue to recent changes in ocean currents that they believe are affecting fish distribution.

Climate change impacts on the chemical and physical characteristics of marine waters will also have negative consequences for whale watch tour operators. Information on the biology of many cetaceans is limited and this makes it difficult to predict the consequences that climate change may have on them. Nevertheless, it is likely that changes in global temperature, sea levels, sea-ice extent, ocean acidification and salinity, rainfall patterns and extreme weather events will decrease the range of many marine mammals (Elliot and Simmonds, 2007). Current evidence suggests that the migration patterns, distribution and/or abundance of cetaceans are likely to alter in response to continued changes in sea surface temperature with global climate change (Lambert *et al.,* 2010).

Of further concern to the fisheries sector is the effect that global warming will have on the incidence of vector borne diseases. Ciguatoxin infection tends to occur more frequently in northern Caribbean islands. However, there is the concern that SST increases can expand the range of the infectious algae and increase the frequency of algal blooms that can contaminate some seafood species (SDEU, 2001). Any possible correlation between human health risks, such as ciguatera poisoning and climate change, should give impetus to researching climate change impacts on regional fisheries.

4.6. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

4.6.1. Background

Small islands have much of their infrastructure and settlements located on or near the coast, including tourism, government, health, commercial and transportation facilities. With its high-density development along the coast, the tourism sector is particularly vulnerable to climate change and SLR. Saint Lucia is one of the Caribbean's most important tourism destinations, with the threat of SLR being identified as a particular concern in both the short and long-term. The areas of Pigeon Island, Pigeon Causeway, Rodney Bay and Soufriere have been identified as some the most vulnerable to SLR. This section of the report will focus on the coastal vulnerabilities associated with 'slow-onset' impacts of climate change, particularly inundation from SLR and SLR-induced beach erosion, as they relate to tourism infrastructure (e.g. resort properties), tourism attractions (e.g. sea turtle nesting sites) and related supporting tourism infrastructure (e.g. transportation networks). These vulnerabilities will be assessed at both the national (Saint Lucia) and local (Rodney Bay and Castries) scale, with adaptation and protection infrastructure options discussed. Please refer to the following section for climate change vulnerabilities and adaptation measures associated with event driven or 'fast-onset' impacts such as disasters and hazards (e.g. hurricanes, storm surges, cyclones).

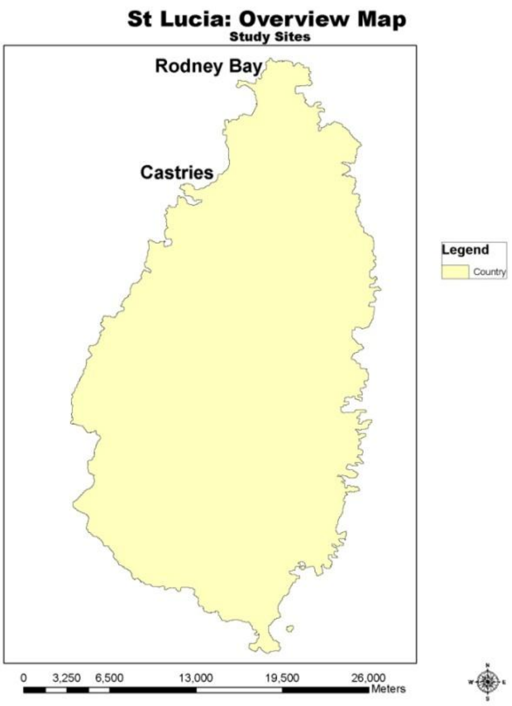


Figure 4.6.1: Saint Lucia - Overview Map

Coastal areas already face pressure from natural forces (i.e. wind, waves, tides and currents), and human activities (i.e. beach sand removal and inappropriate construction of shoreline structures). The impacts of climate change, in particular SLR, will magnify these pressures and accelerate coastal erosion. Areas at greatest risk in the Saint Lucia are in Rodney Bay, including notable resorts, ports and an airport that all lie within less than 6 m above sea level and will therefore be affected. The estimated coastline retreat due to SLR will have serious consequences for land uses along the coast (Mimura *et al.*, 2007; Simpson *et al.*, 2010) including tourism development and infrastructure. A primary design goal of coastal tourism resorts is to maintain coastal aesthetics of uninterrupted sea views and access to beach areas. As a result, tourism resort infrastructure is highly vulnerable to SLR inundation and related beach erosion. Moreover, the beaches themselves are critical assets for tourism in Saint Lucia, with a large proportion of beaches being lost to inundation and accelerated erosion even before resort infrastructure is damaged.

4.6.2. Vulnerability of Infrastructure and Settlements to Climate Change

There is overwhelming scientific evidence that SLR associated with climate change is projected to occur in the 21st Century and beyond, representing a chronic threat to the coastal zones in Saint Lucia. The sea level has risen in the Caribbean at about 3.1 mm/year from 1950-2000 (Church *et al.*, 2004). Global SLR is anticipated to increase as much as 1.5 m to 2 m above present levels in the 21st Century (Rahmstorf, 2007; Vermeer and Rahmstorf, 2009; Grinsted *et al.*, 2009; Jevrejeva *et al.* 2008; Horton *et al.*, 2008). It is also important to note that recent studies of the relative magnitude of regional SLR also suggest that because of the Caribbean's proximity to the equator, SLR will be more pronounced than in some other regions (Bamber *et al.*, 2009; Hu *et al.*, 2009).

Based on the SLR scenarios for the Caribbean (see section 3 Climate Modelling) and consistent with other assessments of the their potential impacts (e.g. Dasgupta *et al.,* 2007 for the World Bank), 1 m and 2 m SLR scenarios and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential vulnerability of major tourism resources across Saint Lucia. Saint Lucia's beaches have been monitored since 1995 by the Fisheries Department, who measure the beach slope and width at regular intervals at numerous sites around the island. Beaches change from season to season and from year to year, but the underlying trend in many locations has been a loss of beaches due to accelerated erosion. Figure 4.6.2 illustrates that the impacts of beach erosion are already being seen in Saint Lucia.

Figure 4.6.2: Choc Cemetery Flooding Vulnerability, Vigie Beach, Saint Lucia

To examine the exposure of Saint Lucia to SLR, research grade Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) data sets that were recently publically released by the National Aeronautics and Space Administration (NASA) and the Japanese Ministry of Economy, Trade and Industry, were integrated into a Geographic Information System (GIS). The ASTER GDEM was downloaded from Japan's Earth Remote Sensing Data Analysis Centre using a rough outline of the Caribbean to select the needed tiles, which were then loaded into an ArcMap document. The next step was to mosaic the tiles into a larger analysis area, followed by the creation of the SLR scenarios as binary raster layers to analyse whether an area is affected by SLR through the reclassification of the GDEM mosaics (see Simpson *et al*., 2010 for a more detailed discussion of the methodology). These assessments were used to calculate the impacts of sea level rise on the whole island.

To examine SLR-induced coastal erosion, a simplified approximation of the Bruun Rule (i.e. shoreline recession = SLR X 100) that has been used in other studies on the implications of SLR for coastal erosion was adopted for this analysis. The prediction of how SLR will reshape coastlines is influenced by a range of coastal morphological factors (i.e. coastal geology, bathymetry, waves, tidal currents, human interventions). The most widely used method of quantifying the response of sandy coastlines to rising sea levels is the Bruun Rule. This rule is appropriate for assessing shoreline retreat caused by the erosion of beach material from the higher part of the beach and deposition in the lower beach zone, re-establishing an equilibrium beach profile inland (Zhang *et al.*, 2004).

Indeed if erosion is damaging tourism infrastructure, it means the beach will have essentially disappeared. With projected 100 m erosion, 30% all the resorts in Saint Lucia would be at risk. Such impacts would transform coastal tourism in Saint Lucia, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees. Sea turtle nesting sites, a tourist attraction, are also at risk to SLR and erosion, with 30% affected by 50 m erosion scenario and half will be at risk with 100 m beach erosion. Transportation infrastructure, also of key importance to tourism, is at risk. Ports are the most threatened, with 100% of port lands in the country projected to be inundated with a 2 m SLR, followed by half of airport lands.

Saint Lucia is highly dependent on international tourism, and the country will be particularly affected with annual costs as a direct result of SLR. Despite the mountainous terrain of Saint Lucia, resorts in this study were found to be at direct risk of SLR. Saint Lucia will incur annual losses between US $41 million in 2050 to over US $144 million in 2080 (based on a mid-range scenario). Capital costs are also high, with rebuild costs for tourist resorts damaged and inundated by SLR amounting to over US $134 million in 2050 up to US $315 million in 2080. Infrastructure critical to the tourism sector will also be impacted by SLR resulting in capital costs to rebuild airport estimated to be between US $42 million by 2050 to US $98 million by 2080. Capital costs to rebuild ports are estimated to be between $57 million in 2050, to $132 million by 2080.

Table 4.6.1 identifies what tourism infrastructure would be at risk of inundation from a 1 m and 2 m SLR scenario and to erosion of 50 and 100 m. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 7% of the major tourism properties at risk, with 10% at risk with a 2 m SLR. It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure.

Table 4.6.1: Impacts Associated with 1 m and 2 m SLR and 50 m and 100 m Beach Erosion in Saint Lucia

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Road Networks	Ports
SLR	1.0 m	7%	6%	50%	0%	100%
	2.0 m	10%	10%	50%	0%	100%
Erosion	50 m	2%	30%	-	-	-
	100 m	30%	53%	-	-	-

In addition to the national assessment, the CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada), Oxford University (UK) and the Saint Lucian Department of Fisheries to complete detailed coastal profile surveying (Figure 4.6.3). The field team conducted survey transects (perpendicular to the shoreline) at sites in Rodney Bay and Castries where tourism infrastructure was present. The sites were surveyed using Trimble Geo-XT(R) satellite-based augmentation system (SBAS) differential GPS units with sub-metre accuracy in both horizontal and vertical planes.

Figure 4.6.3: High Resolution Coastal Profile Surveying with GPS
(Ryan Sim (left) and employee from the Saint Lucian Department of Fisheries (right))

Vertical measurements were adjusted according to the height of the receiver relative to the ground. The water's edge was fixed to a datum point of 0 for the field measurements, but later adjusted according to tide charts. Generally, satellite connections were very good, receiving up to 10 satellites, resulting in sub-metre accuracy. The mean vertical accuracy for all points was approximately 0.015-0.3 m while the horizontal accuracy had a mean average of 0.015-0.2 m accuracy. Each transect point measurement was averaged over 30 readings taken at 1 second intervals. At each point, the nature of the ground cover (e.g. sand, vegetation, concrete) was logged to aid in the post-processing analysis. Ground control points (GCP) were taken to anchor the GPS positions to locations that are identifiable from aerial photographs to improve horizontal accuracy. These were taken where suitable landmarks existed at each transect location and throughout the island. GCP points were measured over 60 readings at 1 second intervals.

Following the field collection, all of the GPS points were downloaded on to a Windows PC, and converted into several GIS formats. Most notably, the GPS points were converted into ESRI Shapefile format to be used with ESRI ArcGIS suite. Aerial Imagery was obtained from Google Earth, and was geo-referenced using the GCPs collected. The data was then inspected for errors and incorporated with other GIS data collected while in the field. Absolute mean sea level was determined by comparing the first GPS point (water's edge) to tide tables to determine the high tide mark. Three dimensional topographic models of each of the study sites were then produced from a raster topographic surface using the GPS elevation points as base height information. A Triangular Irregular Network (TIN) model was created to represent the beach profiles in three dimensions. Contour lines were delineated from both the TIN and raster topographic surface model. For the purpose of this study, contour lines were represented for every metre of elevation change above sea level. Using the topographic elevation data, flood lines were delineated in one metre intervals. In an effort to share the data with a wider audience, all GIS data will be compatible with several software applications, including Google Earth.

Figure 4.6.4: Total Land Loss, Sandals Grande, Saint Lucia

The high resolution imagery provided by this technique is essential to assess the vulnerability of infrastructure and settlements to future SLR, but its ability to identify individual properties also makes it a very powerful risk communication tool. Having this information available for community level dialogue on potential adaptation strategies is highly valuable. Results for the popular Sandals Grande resort area found that a 3.5 m flood scenario resulted in a total loss of more than 17,690 m^2 of beach area, Figure 4.6.4. Similar results were found for The Landings resort in Rodney Bay and a 2.0 m flood scenario resulted in a total loss of more than 15,020 m^2 of beach area and an additional loss of 29,066 m^2 of land area, Figure 4.6.5.

Figure 4.6.5: Sea Level Rise Vulnerability at The Landings in Rodney Bay

Even under a 0.5 m SLR, 90% of the highly valued beach resource at The Landings on Rodney Bay would be inundated, as would 52% of the beach at Sandals Grande in Rodney Bay (Table 4.6.2). The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive that these beach areas along with the prevailing climate are the island's main tourism attractions.

Table 4.6.2: Beach Area Losses at Two Saint Lucian Resorts

	The Landings Rodney Bay		Sandals Grande Rodney Bay	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)
0.5 m	13,530	90%	9,171	52%
1.0 m	14,676	98%	12,750	72%
2.0 m	15,020	100%	17,597	99%
3.0 m	-	-	17,598	100%
3.5 m	-	-	-	-

4.7. *Comprehensive Natural Disaster Management*

4.7.1. History of Disaster Management Globally

Though natural hazards have been affecting populations and interrupting both natural and human processes for millennia, only in the last several decades have concerted efforts to manage and respond to their impacts on human populations and settlements become a priority. Most recently, these efforts have been informed by work at the International Strategy for Disaster Reduction (ISDR), a United Nations agency for disaster reduction created after the 1990s International Decade for Natural Disaster Reduction. After several years of reporting on hazards and impacts, the ISDR created the Hyogo Framework for Action (HFA) in 2005. This strategy aimed at preparing for and responding to disasters was adopted by many countries in order to address a growing concern over the vulnerability of humans and their settlements. The HFA took the challenges identified through disaster management research and practice and created five priorities:

> *Priority #1: Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation*
> *Priority #2: Identify, assess and monitor disaster risks and enhance early warning.*
> *Priority #3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels*
> *Priority #4: Reduce the underlying risk factors.*
> *Priority #5: Strengthen disaster preparedness for effective response at all levels.*
>
> (ISDR, 2005)

Extensive elaboration of each priority is beyond the scope of this report. However, there are some key points to discuss before moving forward to a discussion of the local disaster management context. Priority #1 of the HFA can be thought of as the foundation for hazard and disaster management.

> *Given that governance and institutions also play a critical role in reducing disaster risk,…fully engaging environmental managers in national disaster risk management mechanisms, and incorporating risk reduction criteria into environmental regulatory frameworks [are key options for improving how institutions address disaster-related issues]* (UNEP, 2007, p. 15).

The Hyogo Framework suggests strengthening effective and flexible institutions for enforcement and balancing of competing interests (UNEP, 2007).

Priority #2 focuses on spatial planning to identify inappropriate development zones, appropriate buffer zones, land uses or building codes and the use of technology to model, forecast and project risks (UNEP, 2007, p. 15). The development of technology for mapping, data analysis, modelling and measurement of hazard information offers decision makers a much better understanding of the interaction hazards have with their economy and society.

Priority #3 encourages the promotion and integration of hazard education within schools to spread awareness of the risks and vulnerability to the individuals of at-risk communities. This relates to climate change awareness as well. The countries of the Caribbean, including Saint Lucia, not only face annual hazards, but will also be directly affected by changes in sea levels, more extreme temperatures and other predicted climate changes. By educating children, hazard information will be transferred to adults and basic knowledge about threats and proper response to hazards, as well as climate change, can help improve community-level resilience. It is important that hazard and climate change awareness be promoted within the tourism sector as well, since tourists may not be familiar with the hazards in their destination and will thus require direction from their hosts.

Priority #4 of the HFA demands the synthesis of the previous three priorities: governance, education and awareness, and appropriate technologies. "To develop and implement effective plans aimed at saving lives, protecting the environment and protecting property threatened by disaster, all relevant stakeholders must be engaged: multi-stakeholder dialogue is key to successful emergency response" (UNEP, 2007). Not only is this dialogue encouraged here; Goal 8 of the Millennium Development Goals (MDGs) also advocates for participation and open communication. As climate change threatens the successful achievement of the HFA and the MDGs, simultaneous dialogue about development and risk management will ensure continued resilience in communities and countries across the Caribbean.

The final priority of the Hyogo Framework, Priority #5, is geared toward a more *proactive* plan of action, rather than the reactive disaster management that has failed to save lives on many occasions in the past. It is now commonplace to have this same *proactive* approach to disaster management. However, finding ways to implement and execute these plans has proven more difficult (Clinton, 2006). As you will note, managing disaster risks requires a cross-sectoral understanding of the interdependent pressures that create vulnerability, as well as demanding cooperation of various sectors.

4.7.2. Natural Hazards in the Caribbean and Saint Lucia

There are three broad categories of hazards, and the countries in the Caribbean Basin could face all, or most of them, at any given time.

Table 4.7.1: Types of Hazards in the Caribbean Basin

Hydro-meteorological	Hurricane
	Tropical Storm
	Flooding
	Drought
	Storm Surge
	Landslide/mud-flow
Geological	Earthquake
	Volcano
	Tsunami
Biological	Epidemic
	Wildfire/Bushfire

Saint Lucia is a volcanic island where the landscape is dominated by high peaks and lush valleys in the interior of the island and a coastal plain where surface rivers and streams empty into the ocean. This diversity of topographic features creates a complex hazard profile where the vulnerability of people, communities and infrastructure varies greatly across the island. The tropical rainforest climate means that heavy rains can often lead to flooding or landslides, but tropical storms and hurricanes also pose a serious threat to Saint Lucians, as was seen in 2010 when Hurricane Tomas caused severe damages. Furthermore, the Soufrière Volcanic Centre in the south-west of the island poses the threat of eruption, as it is the younger of the volcanic centres on the island (Lindsay *et al.*, 2002).

4.7.3. Case Study Examination of Vulnerability

To explore Saint Lucia's vulnerability to natural hazards and disasters, the following section will outline some recent disasters and their primary impacts on the island, where severe impacts are assumed to result from high levels of exposure and vulnerability.

Hurricane Tomas, October 2010: In the final days of October 2010, a strong tropical wave developed very quickly into a tropical storm before passing very close to Barbados on October 29, 2010. The storm then rapidly developed into a Category 1 Hurricane, approaching Saint Lucia moving at 17 mph before slowing and stalling over Saint Lucia in the afternoon of October 30, 2010 (Ally, 2010). Heavy rains caused major flooding and landslides that blocked roads and cut communities in Soufrière parish off from the rest of the island (CDEMA, n.d.). The hurricane affected most of the island and damages to infrastructure such as bridges, roads and homes were estimated to cost 43% of GDP (Zipperer, 2011). Deaths from Hurricane Tomas in Saint Lucia were estimated at 14 persons, with 825 houses affected and 136 houses completely destroyed by the hurricane (DIGICEL St. Lucia, 2011). To further examine climate-related hazards and climate change has impacted communities in Saint Lucia, field surveys and focus groups were conducted as part of this project. Greater discussion on the vulnerability factors and adaptive capacity at the community level is presented in sections 4.8 and 5.8, respectively.

Figure 4.7.1: Flooding Damages from Hurricane Tomas in November 2011

The impacts to public utilities from Hurricane Tomas were concerning because the country's main water supply, the Roseau Dam, was declared inaccessible following landslips (Trinidad Express Newspapers, 2010). Donations from neighbouring countries and the United States were accepted in the interim period while the domestic water supply was cut off. The maintenance of clean drinking water is critical to sanitation and health during the post-disaster time period, but is also an important factor of vulnerability. A population in good health is better able to prepare and respond to hazardous circumstances and threats. These issues are given more in-depth discussion herein; section 4.3 outlines some of the vulnerability concerns for human health in relation to climate change in Saint Lucia, while section 4.1 assesses the water sector vulnerability concerns.

The hurricane also had economic impacts, specifically as a result of interrupted service in the tourism sector. A week after the disaster, the airport was open but transportation routes to the rest of the country were still restricted to emergency vehicles only (Griffiths, 2010). A cruise ship came to the port in Saint Lucia a week following the disaster and offered a donation of water, mattresses, biscuits and furniture to assist with the disaster response, along with the usual tourist expenditures at the port of call (Griffiths, 2010). Tourists from Britain were being advised to inquire about water and electricity at their chosen hotels prior to departure, a warning that was not expected to have implications on tourist arrivals beyond the start of the primary tourism season on November 5 (Griffiths, 2010). Therefore, immediate impacts from natural hazards have detrimental impacts for vulnerable persons, but also of concern for Saint Lucia are the long term economic impacts that result from lost services and interrupted public utilities.

To support countries in their disaster response and recovery, the Caribbean Catastrophe Risk Facility (CCRIF) offers an insurance program to member states. Given the extent of the impacts and damages, Saint Lucia received a payout of US $3,241,613 from the CCRIF (Young, 2010). This payout was calculated using the CCRIF parametric insurance index that uses government loss calculations, the policy terms, and an additional index based on the hurricane wind speeds. Hurricane Tomas is said to be the worst in Saint Lucia's history (Young, 2010). The most notable losses affected the banana farmers who lost 100% of their crop; an unfortunate situation that will have impacts in future seasons as well (see Section 4.4).

Landslide Hazards in Saint Lucia

Saint Lucia, given its mountainous topography, has many communities that are exposed to high risk of landslide and debris flows[1]. During heavy rainfall the risk of these geological processes is increased and previous disasters have led to the integration of a GIS into NEMO's hazard response plan for landslides and other hazards. The GIS application allows NEMO to identify the communities and areas that are most at risk (see Figure 4.7.2). There is good information on the level of exposure to this particular hazard in Saint Lucia but full knowledge of vulnerability must also consider other socio-economic and climatological factors. Disaster risk reduction must therefore be a multi-sectoral, multi-agency effort, as should climate change adaptation. Adaptive capacity and the policy, legislative and technological factors that influence this capacity are discussed in section 5.7.

Although many coastal areas of the country are at high risk of landslides, the area with the most extreme risk is in the Parish of Soufrière, an area with a growing population. NEMO considers three types of hazard scenarios i) rapid onset (natural and manmade); ii) slow onset and iii) sink holes (NEMO Secretariat, 2008). The primary difference between these hazards is the timing of the impacts, which affects the ability of individuals and NEMO to respond. Hurricanes and tropical storms generate the conditions for both rapid and slow onset debris flows and landslides by bringing periods of sustained and/or intense rainfall. As the soil becomes saturated the gravitational pull on the soil particles can more easily cause the down-slope movement of soil and other debris. The steepness of the slope also determines the amount and speed of movement of the soil and debris. Saint Lucia has experienced many debris flows in its history but the 1999 Black Mallet/Maynard Hill Landslide is one notable example where there were significant damages to this community south-east of Castries.

In September 1999, residents of the Black Mallet and Maynard Hill reported cracking in the masonry walls and concrete floors in the community (NEMO Secretariat, 2008). These communities are located near the valley of the March and River and their homes were built on unstable, colluvial material[2]. In early October 80,000 cubic metres of colluvial material flowed toward the river, destroying several concrete structures and rupturing public utility lines that served the communities (NEMO Secretariat, 2008). A few weeks later, another slippage 70 m higher on the slope caused debris to slide over Maynard Hill Road. The reason this is considered a slow-onset landslide is because as early as June 1999, cracking was reported in parts of the

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[1] Definition: "A debris flow is a moving mass of loose mud, sand, soil, rock, water and air that travels down a slope under the influence of gravity. To be considered a debris flow the moving material must be loose and capable of "flow", and, at least 50% of the material must be sand-size particles or larger." (http://geology.com/articles/debris-flow/)

[2] Colluvium (also known as colluvial material) is sediment that has moved downhill to the bottom of the slope *without* the help of running water in streams. Gravity and sheetwash during rain storms are the predominant agents of colluvium deposition (http://soilweb.landfood.ubc.ca/landscape/colluvial-environment)

Black Mallet community (NEMO Secretariat, 2008). Over the months following, the subsoil continued to move down slope until it eventually reached the threshold when the landslide occurred in October. Fortunately, there were no deaths reported in this incident.

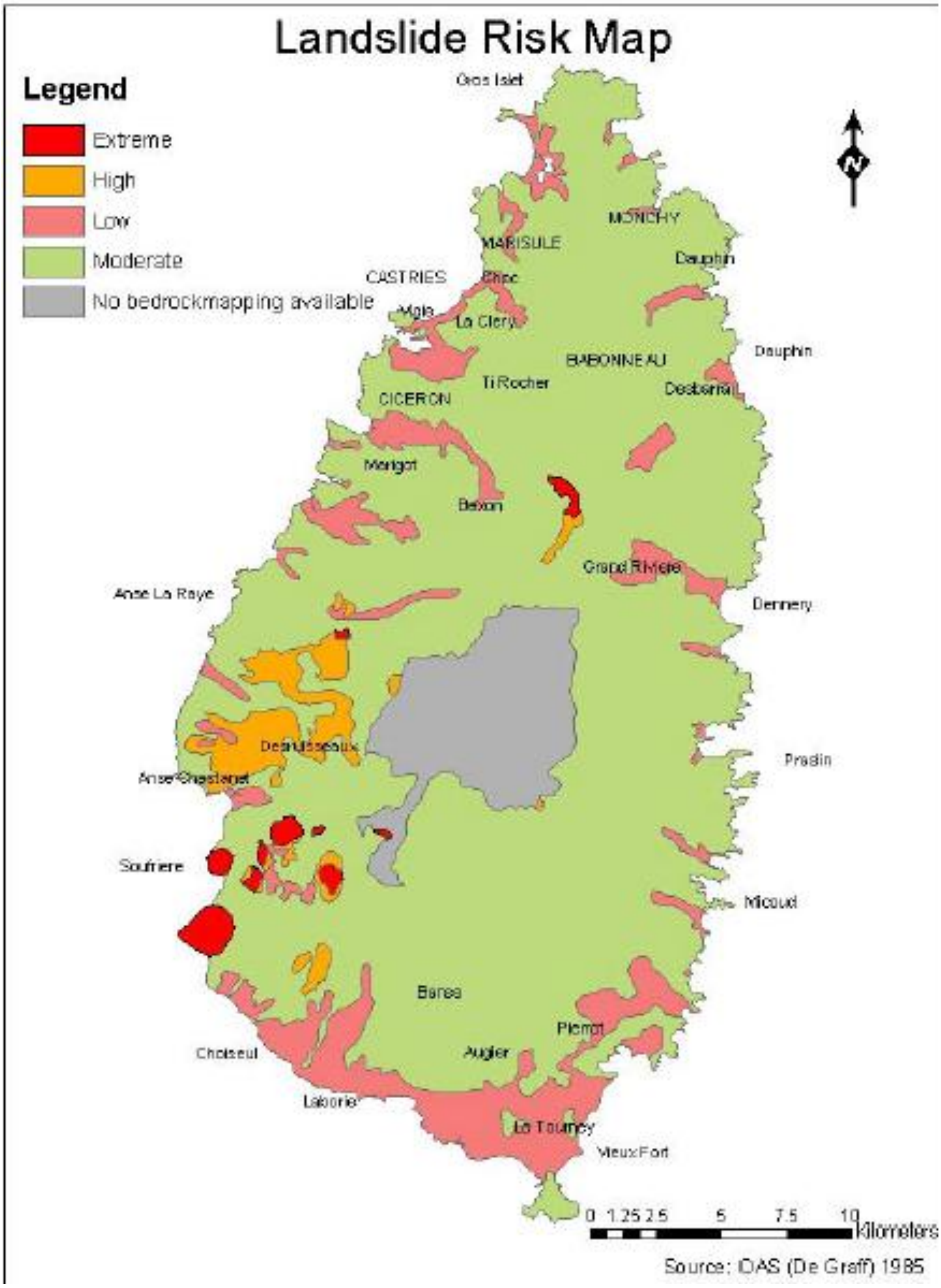

Figure 4.7.2: Landslide Hazard Map for Saint Lucia

(Source: NEMO Secretariat, 2008)

Monitoring of slope movements as well as structural protective efforts must be part of an on-going landslide and debris flow risk management strategy. NEMO has detailed many good efforts in this regard in their Landslide Response Plan (2008) and their acknowledgement of the need to include the community in planning and preparedness exercises will ensure that deaths from such events are kept to a minimum. In addition to this, the monitoring of deforestation and intensive agricultural practices on slopes is needed to minimise risks of landslide and down-slope impacts from the reduced soil stability. Furthermore, in urban and peri-urban areas, clearance of gutters and drainage canals is important for the control of the flow of rain water. NEMO acknowledges the need to conduct regular cleaning of these waterways. However, by educating the public on the link between the presence of debris and garbage and flooding, the risk can be reduced more effectively.

4.7.4. Vulnerability of the Tourism Industry in Saint Lucia

Major tourism developments in Saint Lucia are primarily located on the western coast near the capital of Castries. As noted in section 4.6, tourism infrastructure is at great risk to increasing coastal erosion and rising sea levels will slowly inundate vital beach areas. “In November 1999, surge damage in Saint Lucia associated with Hurricane Lenny was in excess of US $6 million, even though the storm was centred many kilometres offshore” (IPCC, 2007b). Because much of the tourism infrastructure is near the coast, much of that damage occurred in the tourism and hospitality industry or to housing. As a result, extreme events threaten the safety and security of tourists and locals alike. A Hospitality Industry Crisis Management Plan for Saint Lucia was developed in 1996 to provide an institutional mechanism for the management of disasters within the tourism and hospitality industry (Government of Saint Lucia, 1997). The focus of this plan on managing “crisis” indicates that it is primarily a response plan. As noted in the CDM Framework from CDEMA, movement towards integrated hazard management planning which better prepares for events and reduces risks is needed for the Saint Lucian tourism industry.

4.8. *Community Livelihoods, Gender, Poverty and Development*

Where disasters take place in societies governed by power relations based on gender, age or social class, their impact will also reflect these relations and as a result, people's experience of the disaster will vary.

Madhavi Ariyabandu (UNECLAC, UNIFEM and UNDP, 2005)

4.8.1. Background

National Context

The Trade Adjustment and Poverty report for Saint Lucia published in 2007 (Kairi Consultants Ltd., 2007a) provides a comprehensive assessment of the national poverty situation as it stood between 2005 and 2006. This report incorporated a macro-economic and social assessment, a composite survey comprised of a Survey of Living Conditions (SLC) and a Household Budgetary Survey (HBS); a Participatory Poverty Assessment (PPA); and an Institutional Analysis (IA).

The study indicated that more than a quarter (28.8%) of the country's population (at the time of the surveys) fell below the poverty line, at which time was estimated at EC $5,086 (US $1,904.87) per annum; and close to one-half of the population (40.3%) was deemed to be vulnerable to poverty (Kairi Consultants Ltd., 2007a). Members of the population who are vulnerable to poverty are those persons living below 125% of the poverty line (or 25% above the poverty line), and implies the likelihood of falling below the poverty line itself in the event of an adverse climatic or socio-economic shock(Kairi Consultants Ltd., 2007a).

Some of the major traits of poverty and poor persons in Saint Lucia include lack of education, lack of access to or ownership of resources or assets, unemployment, and labour force segmentation. These traits prevent the poor from advancing themselves to move away from poverty. Geographically, poverty appears to be more of a rural concern. At the time of the study, the highest poverty rates were recorded for rural areas in Anse-la-Raye, Soufriere, Choiseul, Laborie and Micoud (See Figure 4.8.1). However, current migration patterns (persons moving from rural areas to urban centres such as Castries) can potentially change the geography of poverty in the country over time. Additionally, approximately half of all impoverished persons were of working age, and a disproportionate percentage (39%) of persons is under the age of 15 (Kairi Consultants Ltd., 2007a).

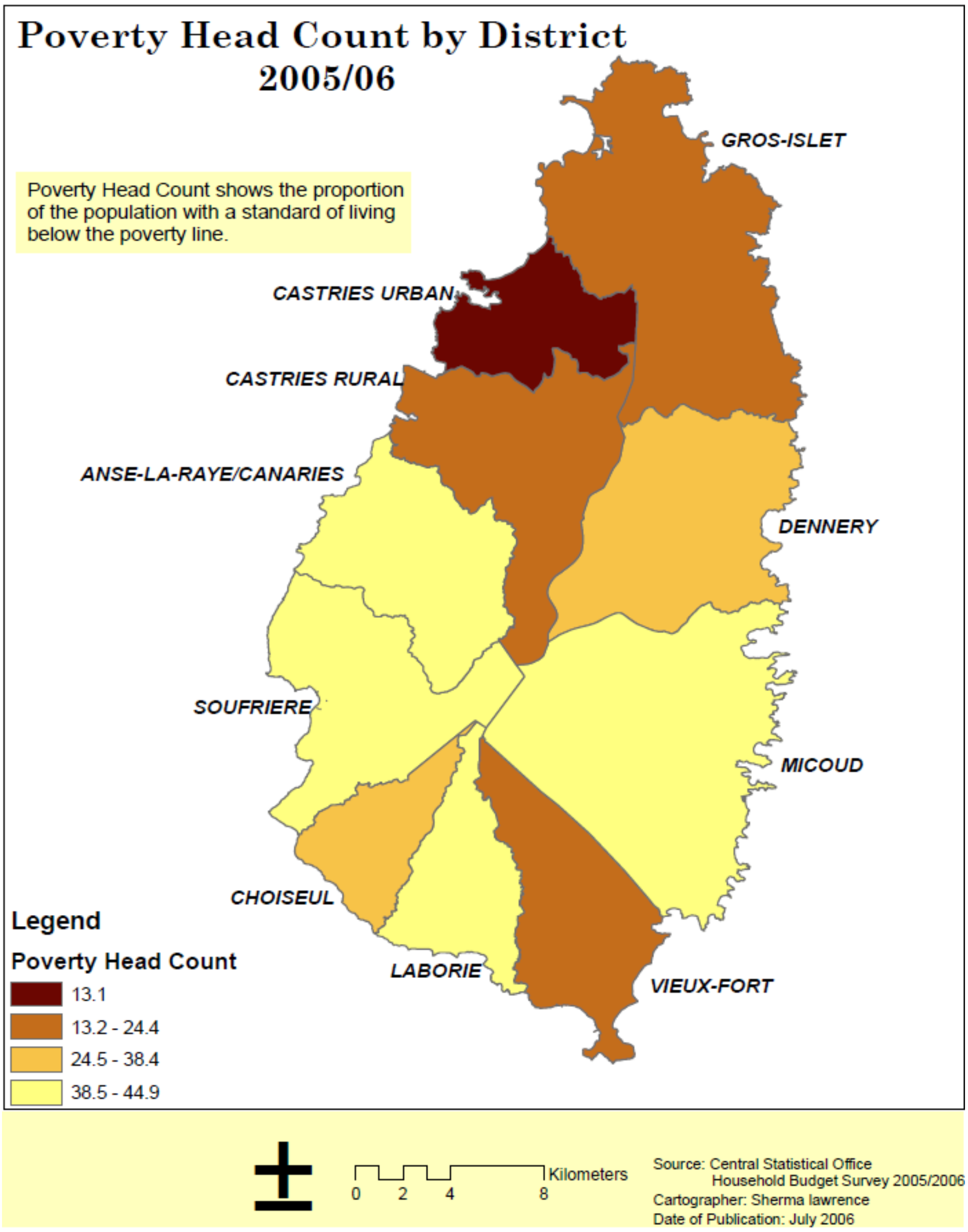

Figure 4.8.1: Poverty Levels in Saint Lucia by District: Percentage of Total Population

(Source: Kairi Consultants Ltd., 2007, adapted from the Saint Lucia Central Statistical Office)

Lack of access to data prevents any in-depth analysis of poverty and poverty vulnerability trends within the last five years. However, considering the statistics provided by the Trade Adjustment and Poverty Report (2007), the relative instability of the global economy and inherent vulnerability to hurricanes and other low pressure weather events given Saint Lucia's location within the North Atlantic Hurricane Belt; the probability of increasing poverty rates is high, barring any successful interventions to alleviate it.

The most recent statistics (2007) on employment and labour force participation indicate that the Government of Saint Lucia is the largest employer, followed closely by the wholesale and retail trade industry. Notwithstanding these two categories, a large proportion of Saint Lucia's workforce is employed by industries that are highly volatile or inconsistent in terms of economic performance. This includes construction, hotels and restaurants (tourism) and agriculture, hunting and forestry. More modest figures are recorded for other sectors that are natural resource-intensive, including fishing and energy, gas and water supply. Statistics also show that one-fifth (20.6%) of the country's labour force was unemployed in 2010, an increase of 2.5% from the previous year(Saint Lucia Central Statistics Office, 2010).

Some of the most vulnerable labour market groups include persons who are unemployed, working in the informal sector, or using commercial bank loans to establish or expand business operations (Table 4.8.1).

Table 4.8.1: High-Risk Labour Market Groups in Saint Lucia

CATEGORY	DESCRIPTION
Unemployed Persons	Unemployment in Saint Lucia remains a major concern for the Government. Unemployed persons are at risk of falling below the poverty line. Persons who have limited skills or education can be unemployed for long periods.
Informal Sector Workers	Persons in this category are deemed vulnerable owing to their lack of access to insurance and social protection. These include street vendors, fishermen, Saint Lucia's ex-farmer population and manual labourers.
Entrepreneurs	Entrepreneurs who are using credit facilities to start up or expand their business are at risk of failure and high debt if market forces do not work in their favour.
"Working Poor"	These persons, although employed; still live below the poverty line, because their income cannot sustain their needs and the needs of the household. Some of these persons work within the agriculture and manufacturing sectors.

(Source: Henry-Lee, 2004 and Kairi Consultants Ltd., 2007a)

Persons or households engaging in some of the more volatile industries stand a greater risk of impact. The tourism sector is very sensitive to many factors that operate both in origin and destination countries. This includes weather and climate, the airline industry, travel policies, economic performance and geopolitical issues. Any of these factors can encourage or hamper growth, and by extension, employment in the sector. According to the World Travel and Tourism Council (WTTC, 2011), approximately 13,000 persons are expected to be directly employed by tourism and travel in 2011, increasing to approximately 33,000 persons when indirect employment is included. These figures represent 17.5% and 45.4% of total national employment respectively, and are expected to rise over the next decade by 3.5% per annum. Figure 4.8.2 illustrates the employment trend within the tourism sector between 2001 and 2011. Employment figures have remained relatively stable within the latter five years, although they declined from the highest levels which were recorded in 2005. Barring any significant physical or economic shocks, tourism employment statistics should continue to grow, as tourism in general is predicted to develop. However, Saint Lucia's economy, like most other Caribbean territories, is still recovering from the global economic crisis and climate remains a relatively unpredictable force. Consequently, the tourism sector remains highly vulnerable.

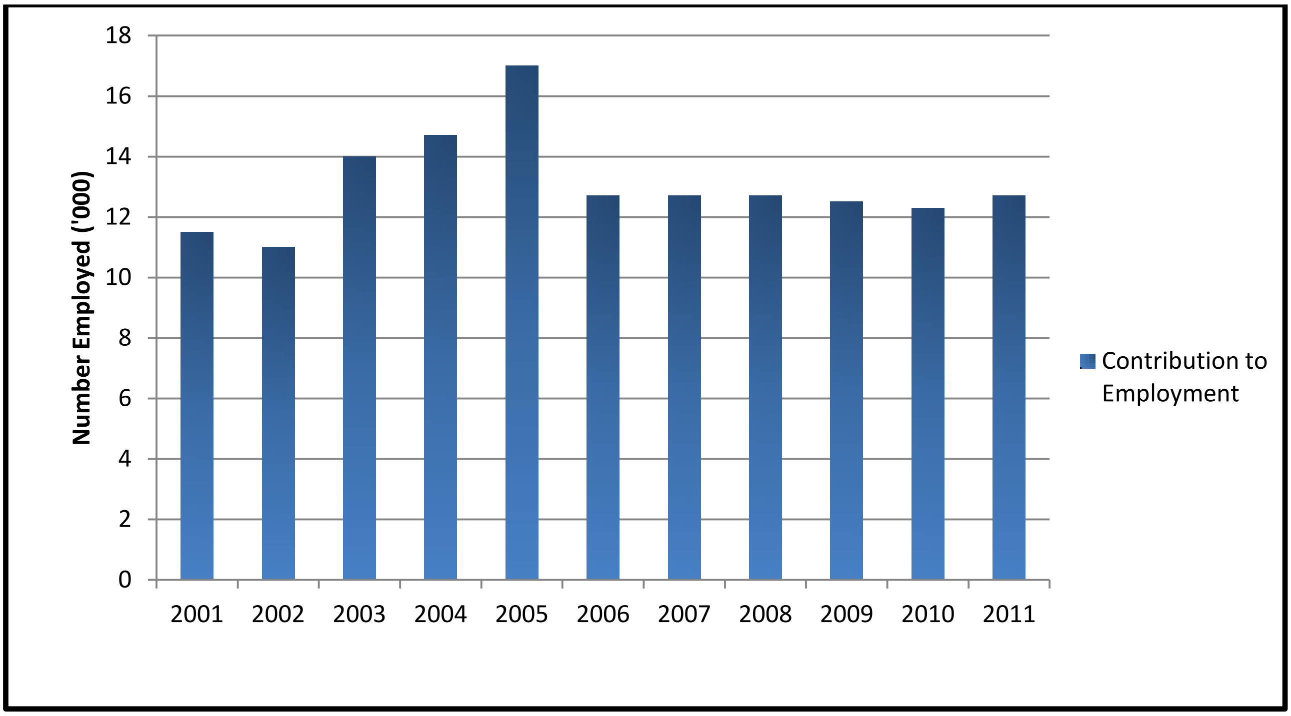

Figure 4.8.2: Saint Lucia: Direct Contribution of Travel and Tourism to Employment: 2001-2011

(Source: WTTC, 2011)

In the case of agriculture (and banana production specifically) externally designed trade systems and other economic factors severely affected farmers from the mid-1990s. Additionally, the sector has had to manage with rising input costs, poor operational practices, disease control, limited access to financing and unfavourable weather conditions; the most recent being a 7-month drought between 2009-2010 and Hurricane Tomas in 2010(Government of Saint Lucia, 2011). There had been a reduction in the number of agricultural holdings in Saint Lucia by 41% between 1986 and 2007, with 8 out of 10 administrative districts recording between 40-74% reductions in the number of holdings within this period. Overall, many farmers have had to engage in alternative livelihoods and many still are unemployed (the unemployment rate for farmers specifically is higher than the national rate) (Kairi Consultants Ltd., 2007b) (See Section 4.4, Agriculture and Food Security). These factors place local farmers and agriculture in a very vulnerable position.

4.8.2. Impacts of Weather and Climate on Community Livelihoods, Gender and Development

Livelihoods

In the face of climate change and the threat that it poses to Caribbean societies and economies, the comprehensive integration of poverty, gender and livelihood issues into climate change impact and vulnerability assessment and planning processes is essential to developing appropriate adaptation strategies and enhancing the livelihoods of households and communities in the Caribbean. Livelihood vulnerability is both hazard- and context-dependent. In the case of hazards, short-term, extreme events such as hurricanes can result in an immediate loss of earnings for workers in the tourism, forestry, fishing and agricultural sectors owing to loss of crops, land and damage to infrastructure, physical assets and facilities. Longer term, gradual changes will have less immediate but still significant impacts owing to varied physical process changes, including reductions in quality and quantity of yields and declines in fish stocks, which will result in loss of income for farmers and fishermen. Context-dependent vulnerability speaks to the existing circumstances that will place already vulnerable groups at greater risk when climate change is factored in.

Gender

One critical consideration in development is gender and gender equality, which “assesses the extent to which the country has installed institutions and programs to enforce laws and policies that promote equal access for men and women in education, health, the economy, and protection under law” (Trading Economics, 2010). This will vary by country based on cultural, political and religious practices and traditions. Data on Saint Lucia’s Gender Equality Index is only available for four years (Trading Economics, 2010), but,on a scale of 1 (poor) to 6 (high) shows a decline from 4.5 to 3.5 between 2006 and 2009.

Box 1: Gender, Poverty and Climate Change
“Women and men’s vulnerability to the impact of extreme climate events is determined by differences in their social roles and responsibilities. Among women, an expectation that they fulfil their roles and responsibilities as carers of their families often places extra burdens on them during extreme climate events. For men, their expected role as the economic provider of the family often places extra burdens on them in the aftermath of such events… As women constitute the largest percentage of the world’s poorest people, they are most affected by these changes. Children and youth – especially girls – and elderly women, are often the most vulnerable.”
(Source: WHO, 2010; adapted from Kettle, Hogan, and Saul)

While disasters create hardships for everyone, natural disasters kill, on average, more women than men or kill women at a younger age than men(WHO, 2010). Higher poverty rates and lower labour force participation and employment of women in Saint Lucia all contribute to the overall vulnerability of women in the country. Amongst the poor in particular, many women are caregivers and carry the economic burden of households, which is often meagrely supported by jobs with a low income and based in the informal sector. These factors place them, and those that they are responsible for, at greater risk to natural events than men (Buvinic *et al.*, 1999)(Kairi Consultants Ltd., 2007c).

Poverty

Climate change and poverty are inextricably linked, and the poor are, and will continue to be, the most affected. The impacts of climate change undeniably aggravate the issue of poverty in all societies, and especially where poverty is extreme and widespread (Figure 4.8.3 highlights some of these impacts). The areas where impoverished persons reside are more often at greater risk when compared to areas inhabited by stronger economic groups, particularly remote rural and coastal areas which are disconnected from essential services and resources. The impacts and aftermath of extreme weather events (e.g. flooding, drought, loss of lands and crops) and SLR (e.g. coastal erosion, salt water intrusion) deteriorate an already dire situation and leave persons in poverty with even less resources to survive (Kettle *et al.*). Conversely , climate change itself and the impacts it presents are also augmented by these same conditions of poverty, where the lack of access to resources and services almost dictates unsustainable environmental practices for survival (e.g. intense use of fossil fuels which promotes deforestation and contributes to GHG emissions, mismanagement of agricultural land and resources which encourages soil erosion, and decline in quality and output) (Kettle *et al*; UNFPA, 2007).

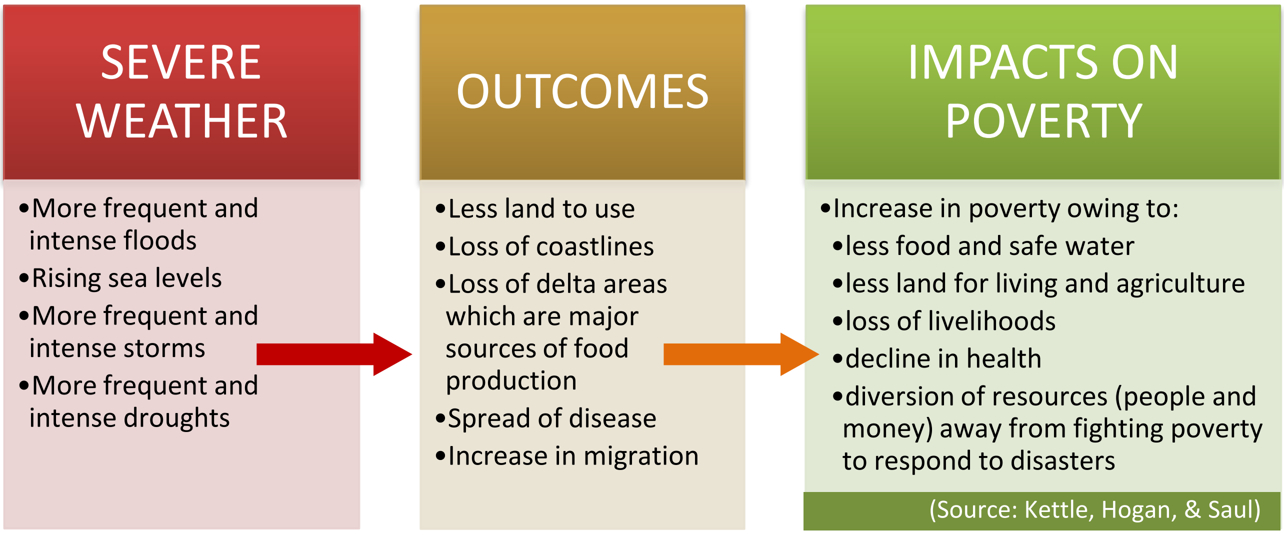

Figure 4.8.3: The Impacts of Climate Change on Poverty

The assessment conducted by UNECLAC (2011) suggests that Hurricane Tomas caused pockets of devastation in districts that are characterised by either high levels of poverty, vulnerability to falling below the poverty line and otherwise exposed to hazards and extreme events (i.e. Castries, Soufriere, Micoud). Most of the affected population resided in these three districts, and the worst affected villages were located on the interior of Soufriere and Castries (UNECLAC, 2011). Communities located in the interior, especially where houses were built on steep slopes, suffered losses as a result of landslides and other forms of soil movement. In the wake of Hurricane Tomas, poorer persons experienced more damage and destruction to houses and land. Persons with greater income and purchasing power were in a better position to access needed health care and supplies (especially water), whereas poorer persons could not and had to resort to unsafe water sources and do without essential supplies. Livelihoods were severely interrupted, and some without the likelihood of recovery in the near future, thereby leaving persons without an immediate source of income. Going by the Hurricane Tomas experience alone, future adverse weather events and the impacts of climate change will have significant consequences for the level of poverty in Saint Lucia, with the possibility of the increasing poverty (which stood at 28.8% of the population in 2005/6) and poverty vulnerability (likewise 40% of population at 2005/6) levels.

4.8.3. The Soufriere community

Soufriere was selected as the community in which to implement the *Community Vulnerability and Adaptive Capacity Assessment* methodology developed by The CARIBSAVE Partnership based on the established criteria and recommendations from the Government of Saint Lucia.

This section provides an overview of existing factors that may serve to increase the exposure and/or reduce the adaptive capacity of communities and individuals in Saint Lucia to the impacts of climate change, with special consideration of vulnerable livelihoods and socio-economic groupings (taking in account gender and the poor).

The CARIBSAVE *Community Vulnerability and Adaptive Capacity Assessment* methodology uses participatory tools to determine the context of the community's exposure to hazards, and a livelihood approach to assess adaptive capacity. All data are disaggregated by gender. The three main means of data collection are: (i) a community vulnerability mapping exercise and discussion which are the main activities in a participatory workshop; (ii) three focus groups (two single-sex; and one for those in tourism-related livelihoods; and (iii) household surveys to determine access to five livelihood assets (financial, physical, natural, social and human). Livelihood strategies (combinations of assets) are evaluated to determine the adaptive capacity of households and consequently communities. The analysis that follows, and that in other sections on *Community Livelihoods, Gender, Poverty and Development*, has been informed by a small sample of community members participating in the research. Observations may be specific to some parts within the study area but overall findings (assessments of vulnerability and adaptive capacity) are assumed to be representative for the entire community.

Soufriere is one of the rural districts in Saint Lucia with approximately 8,472 persons (4,280 males and 4,192 females) residents, representing 5.1% of the national population. Soufriere is the least densely populated district in Saint Lucia. Fishing and agriculture are significant contributors to the local economy and livelihoods of its residents, but tourism is the mainstay of the district, employing majority of the residents directly and indirectly. It is therefore branded as the "tourism capital" of Saint Lucia.

Some of the main attractions include the Sulphur Springs and geothermal system, the Pitons and the Diamond waterfall, and the district boasts a thriving tourism product. However, despite its prosperity in tourism, many of its residents cope in low socio-economic situations. Statistics for 2005-2006 indicate that close to half (42.5%) of Soufriere's population were recorded to be living below the poverty line – one of the highest poverty levels by district in Saint Lucia (See Figure 4.8.1) – and another 11.5% still are vulnerable to falling into poverty. Majority of poor labour force participants are men, most of whom are also employed, whereas less working-age poor women are employed (Kairi Consultants Ltd., 2007c), (Soufriere Regional Development Foundation, 2010a),(Soufriere Regional Development Foundation, 2010b).

The impact of Hurricane Tomas on the District of Soufriere was particularly severe. The exposure of Soufriere's population to the event was high prior to its onset, because a large proportion of its population (the largest of all districts) is characterised as poor (but not indigent), with implications for limited access to resources and limited capacity to withstand and recover from extreme weather impacts. Of the eight communities in Saint Lucia that were considered the worst affected, five of them were located in Soufriere – specifically: Fond St. Jacques, Ravine Claire, Cresslands, St. Phillip and Mingy. The district also suffered the greatest loss of/damage to housing stock as a percentage of the district's total stock, and also suffered heavy damage to its forest, agricultural holdings and marine fisheries resources. The extent of loss therefore affected the livelihoods and well-being of residents who relied heavily on these resources.

Knowledge of Climate Change and Observed Changes to the Natural Environment

Soufriere's landscape presents a diversity of natural resources which are used by residents. Agriculture, in particular, plays a significant role in Soufriere in terms of income generation, as land tenure was mainly held through inheritance, and several households are involved in agriculture. Other resources and uses presented in Table 4.8.2.

Table 4.8.2: Natural Resources and Uses/Livelihoods in Soufriere, Saint Lucia

RESOURCE	USE / LIVELIHOOD
Land	Farming/Agriculture
Waterfalls	Tours Hikes } (both locals and tourists)
Forests	Trails for hiking Tours } (both locals and tourists)
Marine Biodiversity	Fisheries

(Source: CARIBSAVE Fieldwork, 2011)

Persons who work and reside near or on the coast or at sea (working) will tend to underscore the importance of coastal and marine resources more so than inland resources and vice versa. Additionally, persons in the community were employed as hotel industry workers, care takers, teachers, health workers as well as construction and maintenance workers. There were also self-employed persons within the community, such as seamstresses and shop owners and operators.

Community residents suggested that generally, there was some degree of awareness of climate change amongst them. Knowledge of climate change concepts and details, and perceptions of risks and impacts varied.

- Residents have observed a merging of the previously distinct wet and dry seasonal patterns. The crops normally cultivated by farmers are still planted, however the growing periods appear to be changing.
- Mangoes come into season earlier than they did in the past, whereas citrus trees bear fruits later than normal.
- Despite changes in wet and dry seasons, the prolonged drought in 2010 and into 2011 resulted in losses for farmers from which they have not yet recovered. The drought also appears to have introduced a new pest, a whitefly, which has attacked tomato plants resulting in significant economic losses for tomato farmers.
- Some species of fauna have drastically decreased in size, including birds, butterflies and crayfish found in rivers; owing to pollution and destruction of habitats. Increases in vector and insect (sand flies, in particular) populations were observed prior to the passage of Hurricane Tomas, which is reported to have exacerbated the situation.
- Also reported was the incidence of coral bleaching in Saint Lucia in 2010. The Fisheries Division conducted a survey to determine the extent of coral cover affected. It was suggested that these changes in the environment, in addition to other international developments (increasing airfares, long-haul emissions taxes), have caused a decline in the local tourism sector.

Effects of Extreme Events in Soufriere – Hurricane Tomas

Hurricane Tomas represented a serious and most recent realisation of the impacts of extreme weather on Saint Lucia. According to UNECLAC (2011), outside of Castries some communities within the District of Soufriere were the hardest hit by Hurricane Tomas, and the largest group of persons in shelter was also found in Soufriere, from the community of Fond St. Jacques. Many stayed away from their homes due to fear posed by the risk of continuing landslides. It was reported during community consultations that the community took more responsibility for themselves after hurricane Allen (in 1980) than they did after Tomas. With this more recent extreme event, residents were more inclined to wait for the government to take action. This could be due to the relative scale of events (i.e. Tomas was more devastating and persons likely were immobilised by the shock). Despite the hurricane warnings, most people were unprepared because they did not expect the extent of the impact. Additionally, it was felt that that the warnings and communications from the relevant authorities prior to the passage of the hurricane were insufficient to adequately prepare residents.

Community residents received warning via text messages from the local telecommunications service provider – L.I.M.E. However, research indicates that no reports of radio or television broadcasts were made. This may have been a result of a lack of access to, or a lack of attention to broadcasts via these media prior to the event. It was also felt that the response and restoration efforts by essential and utility services were too slow following the event.

Many persons employed in the tourism industry were affected, and were out of work for at least a few days, as most of the hotel facilities were not operational for this period. However, some eco-tourism attractions were more heavily impacted through the loss of infrastructure, equipment and forest cover from landslides and flooding. For example, the Toraille Waterfall was a natural attraction that had not recovered from damages caused by Hurricane Tomas up to 6 months later. As such, employees were still unable to return to work for that period.

Lack of proper drainage was indicated as an exacerbating factor for flooding and damage to road infrastructure. Based on discussions during consultations, it was reported that inadequate drainage was a chronic issue and often resulted in worse flooding. Following Hurricane Tomas, roads were repaired temporarily to make them usable. However, residents remain concerned that unless the drainage issue is addressed, flooding will continue to affect the area and roads will be repeatedly damaged from flooding.

It was also reported that the cost of food became very high, resulting in a shift in diets as people began to rely on rice and flour. Ground provisions, plantains and green bananas became too costly.

In the aftermath of Hurricane Tomas, the community is now far more vigilant about extreme climate events compared to the lax approach that was taken in the past when warnings were issued. However, despite the new sense of vigilance, the economic crisis has forced some persons to pursue practices that essentially place the community in danger, such as undermining the natural resource base and protects eco-services for the sake of cutting costs (e.g. cutting down trees to make coal as an alternative to gas, sand mining to build less sturdy houses instead of concrete).

Additionally, the haphazard ways in which construction was completed in the community proved hazardous for residents. There is a perception within the community that the national physical planning authority severely lacks transparency in their procedures, resulting in buildings being placed in inappropriate places. The effects of this were particularly evident during Hurricane Tomas. Community members noted that many buildings were damaged or destroyed where rivers, which were previously diverted or altered to make way for physical development, reclaimed their original water courses.

Religious faith was reported as critical in allowing many persons to survive the devastation of Hurricane Tomas. One community member put it succinctly, suggesting that "*If we weren't praying, I don't know how we would have survived [...] much more would have happened*". However, the community remains concerned about their lack of capacity to collectively handle any crises similar to those that resulted from the passage of Hurricane Tomas.

Interestingly, despite a perceived decline in community spirit, it was agreed that following the passage of Tomas there was much co-operation among residents to recover. Counseling services which were offered by NEMO played a critical role in relieving some of the trauma and shock experienced by residents immediately after the hurricane. To the benefit of farmers, the Ministry of Agriculture assisted by providing subsidies and small grants (average EC $1,000) to help farmers to replant and to cover personal expenses. The international aid community was also strongly acknowledged for their rapid response to assist. Overall, non-governmental organisations, family, and friends came to the aid of residents of Soufriere, and contributed to community recovery efforts.

Gender and Community Development

Our research shows that, on average, more men (56%) are the heads of their households when compared to women, however, more females are the heads of single-parent households (poor and non-poor), and poor women in particular have been found to have higher fertility rates and generally bear more children than other more financially stable women. The labour force participation and employment rates for women have remained lower than those of men over the last decade (by as much as 20% in the case of labour force participation for some years). Conversely, the number of women that are unemployed is higher than that of men (Saint Lucia Central Statistics Office, 2010), (Kairi Consultants Ltd., 2007a),(Kairi Consultants Ltd., 2007b).

Consultations with males in the community suggest that women are more active in pursuing personal and community development, and assume leading roles in various areas. There is hardly any accountability for young men, whereas young women are more closely monitored and guided. Men may tend to voice their concerns on the football field or at the rum shop; forums which provide little means for follow up. Women attend town hall meetings more regularly and tend to be more vocal. A possible reason for this is that many men in Saint Lucia have been raised by single mothers and still look towards women to make decisions. Within formal community groups, women take the lead and are more involved in activities. It was mentioned that there is a lack of positive male role models.

Men believe that they are perhaps the more vulnerable gender with regards to climate change impacts. The majority of farmers in Soufriere (and Saint Lucia on a whole) are male, so they were directly impacted by the damages to their farmlands. If a man is unable to support his family he is looked down upon by the community. Farmers had to resort to other means to cope. They planted more short term crops while others sought employment elsewhere (e.g. as security guards). Men in Soufriere reported that they generally felt helpless and despondent, whereas the women were more quickly able to adapt by engaging in alternative livelihood activities.

On the other hand, women also perceived their own experience – specifically with Hurricane Tomas – to be far more difficult than men. Some women and single mothers reportedly lost homes and possessions, and (mothers) were unable to adequately provide for their children's school and home needs after the hurricane, noting that "the women had to send the children back to school, so it was kind of hard, getting books, getting uniforms". Women insisted that the men were better off, as "… some of them after the hurricane they went to the bar to drink." In support of their point, the example was given of a single mother who perished along with her two daughters during the passage of Hurricane Tomas while trying to protect her home.

In the aftermath of Hurricane Tomas there was a severe shortage of potable water. Generally women use streams and rivers for washing and obtaining water for other purposes. Immediately after the storm, the rivers were unsuitable for these uses, and as a result, from a health perspective women and children were perhaps more exposed to water borne illnesses. Most participating males in the consultation reported that they had not suffered any significant personal loss. They were all however affected by the shortage of potable water but felt that they had coped with the challenge well. The value of the dollar was essentially zero; they had money but there was no food (i.e. essentials such as flour, sugar, etc.) available for purchase, nor was there enough bottled water. The participants suggested that the hurricane revealed the inadequacy of government's water policy. Water catchments were not protected from contamination, and they link this issue to the national land use policy.

In response to the impacts of Hurricane Tomas, men were involved in restoring accessibility to roadways and other such physical repairs. Women were involved in this work as well, but to a lesser extent. It was felt that counselling was needed for persons in the community because of the shock of the disaster. Men tend to socialize over dominoes and at bars and may not sufficiently deal with the emotional trauma of the losses suffered.

5. ADAPTIVE CAPACITY PROFILE FOR SAINT LUCIA

Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of vulnerability to which it can cope (Nicholls *et al.,* 2007). Many small island states have low adaptive capacity and adaptation costs are high relative to GDP (Mimura *et al.,* 2007). Overall the adaptive capacity of small island states is low due to the physical size of nations, limited access to capital and technology, shortage of human resource skills and limited access to resources for construction (IPCC, 2001).

Low adaptive capacity, amongst other things, enhances vulnerability and reduces resilience to climate change (Mimura *et al.,* 2007). While even a high adaptive capacity may not translate into effective adaptation if there is no commitment to sustained action (Luers and Moser, 2006). In addition, Mimura *et al.* (2007) suggest that very little work has been done on adaptive capacity of small island states; therefore this project aims to improve data and knowledge on both vulnerability and adaptive capacity in the Caribbean small island states to improve each country's capacity to respond to climate change.

Information on the following factors was gathered, where possible to reflect adaptive capacity for each socio-economic sector:

- Resource availability (financial, human, knowledge, technical)
- Institutional and governance networks and competence
- Political leadership and commitment
- Social capital and equity
- Information technologies and communication systems
- Health of environment

The information is arranged by sector, under the headings *Policy, Management and Technology* in order to facilitate comparisons across sectors and help decision makers identify areas for potential collaboration and synergy. Some of these synergies have been included in practical Recommendations and Strategies for Action which is the following section of this report.

5.1. *Water Quality and Availability*

5.1.1. Policy

Table 5.1.1 gives an overview of the legislation related to watersheds in Saint Lucia. However, there have been a number of recent developments in the policy landscape of Saint Lucia. Directly related to climate change is the Saint Lucia National Water Policy (2004). The policy has four main objectives, which as summarised by Springer (2005), are to:

- Foster the adoption of an integrated approach to the management of water resources.
- Enable people to lead healthier and more productive lives through improved management of water resources, and increased and sustained access to water supply, sanitation, and water-based services.
- Increase and sustain the contribution made by water resources to the development of the agriculture/food and industrial sectors respectively, and to environmental sustainability.
- Ensure efficient and equitable allocation of water among competing uses.

It also recognises that special emphasis should be placed on managing water resources for irrigation in the agricultural sector because of the potential threats to food production and food security. Among the adaptation options proposed for the sector were soil conservation measures and the construction of water storage and irrigation facilities. Impacts to the tourism sector are also noted, with mention of developing strategies that take into consideration the inclusion of water conservation initiatives in the over policy direction of sustainable resource use. Also with reference to irrigation, while the agricultural sector is encouraged to increase food production through state aid, the focus is not equally placed on water use and conservation. This is believed to be linked to policy conflicts of the government (Springer, 2005).

Water sector-specific policy responses from the National Climate Change Policy as summarised by MPDEH (2006):

- Develop and/or improve the basis for sound decision making by developing the capacity to undertake research into, and analysis of relevant climate processes;
- Undertake a comprehensive inventory of all water resources;
- Promote strengthening of national water management agencies;
- Develop a national water management plan
- Encourage reforestation and other measures to increase resilience of watersheds and catchments to maximise water availability and reduce soil erosion
- Assess and address storage needs and distribution infrastructure to ensure availability during drought conditions.

Table 5.1.1: Legislation Impacting Freshwater Systems in Saint Lucia

Enabling Legislation	Scope	Agency
Forest, Soil and Water Conservation Act 1946	Management of forest resources; Establishment of forest reserves and protected forests; Protection of forest, soil, water and wild life resources; Management of water catchment	Department of Forestry (DOF)
Wildlife Protection Act 1980	Conservation of wildlife; Designation of wild life reserves	DOF
Land Development Act. 29 of 2001	Regulation of development	Development Control Authority (DCA)
Agricultural Small Tenancies Act 1983	Enforcement of regulations requiring sound soil and water conservation practices on small holdings	Department of Agriculture (DOA)
Land Conservation and Improvement Act 1992	Provision for better land drainage conservation	Ministry of Agriculture, Forestry and Fisheries (MAFF)
Pesticides Control Act 1975. Pesticides and Toxic Chemicals Control Act No. 15 of 2001	Regulation of toxic chemicals, importation and use	DOA, Pesticides and Toxic Chemicals Control Board (PCB)
Public Health Act 1975	Regulatory oversight of sewage, industries and solid waste disposal; Regulatory oversight of domestic water supply	Ministry of Health (MOH)
Saint Lucia Solid Waste Management Act 1999	Responsible for Solid Waste Disposal	Saint Lucia Solid Waste Management Authority (SLSWMA)
Water and Sewerage Act 1999	Regulation of the granting of licenses; Development and control of water supply and sewerage facilities and related matters	National Water and Sewage Authority

(Taken from MPDEH, 2006; Original Source: Government of Saint Lucia)

Special mention should be made of the Water and Sewerage Act 1999, which was devised in an effort to address management related problems in the water sector. The act allowed for the establishment of the National Water and Sewerage Commission (NWSC) and the Water Resource Management Agency (WRMA) (CANARI, 2010). The establishment of the NWSC actually came to fruition under the newer Water and Sewerage Act (2005) (CAWASA, 2009).

As described in the vulnerability subsection, there are various problems associated with water quality and quantity in Saint Lucia which have been partially blamed on “the absence of an adequate policy framework, resulting in a haphazard approach to management of this resource” and “demand for land and the absence of land use policies have had serious negative implications on the watersheds. Large areas on unstable slopes have been indiscriminately cleared for agriculture and housing settlements”(MPDEH, 2006). However, weather patterns have also become increasingly unpredictable, affecting the resilience of even virgin forests as was the case with Hurricane Tomas. Therefore, after Hurricane Tomas, a Strategic Investment Plan (2011) was devised which included considerations for extreme weather events. This plan, which has been presented to the cabinet, therefore considers climate change and the need for alternative water sources such as exploration and assessments of alluvial plains on the island (Mr Sealey, personal communication, May 26, 2011).

5.1.2. Management

The water resources in Saint Lucia are considered to be sufficient to meet current and projected demands. However, due to the vulnerabilities described in the previous subsection, future water demand requirements may not be achieved without interventions that conserve the watersheds and therefore the water resources that currently exist on the island (Geoghegan, 2002). Hydrological monitoring of precipitation levels, stream flow, ground water levels, and water usage is the responsibility of the Saint Lucia Meteorology Services and the Hydrological Department of the Ministry of Agriculture, Forestry and Fisheries (MAFF) (Government of Saint Lucia, 2009). The Water Resources Management Agency (WRMA) is the body responsible for controlling water abstraction and preventing over-abstraction.

NWSC is the economic regulator of water resources in Saint Lucia which approves fees and tariffs and has been “assigned responsibility for the orderly and co-ordinated development and use of water resources, and for the promotion of a national policy for water” (Springer, 2005). However, Mr. Justin Sealey of WASCO has stated that the commission is not currently operational and one of their objectives in the Strategic Investment Plan 2011 is to request that it becomes active again so that it can review the economic efficiency of WASCO (Mr. Sealey, personal communication, May 26, 2011). While the WASCO of the Ministry of Communications, Works, Transport and Public Utilities has the responsibility to develop and manage water supply and sewage services on the island, which includes abstraction, treatment and distribution services. Some of the programmes WASCO undertakes are “monitoring of the resource, regulation of water use, resolution of user conflicts, water allocation planning, emergency and conservation planning, information and technical assistance, and a limited role in water supply development” (Government of Saint Lucia, 2009). Additionally there is a The Water Resource Management Unit within the Ministry of Agriculture Forestry and Fisheries.

Currently, WASCO does not have a budget for the 2010/2011 financial year as the ministry under which WASCO falls, the Ministry of Communications, Works, Transport and Public Utilities was not given specific funds to conduct any water projects or cover any operating costs during the fiscal year. They depend on grants to carry out projects, which are oftentimes not entirely compatible with the objectives of WASCO and water sector needs. A budget was given to a third ministry, the Ministry of Economic Affairs, Economic Planning and National Development. This ministry has its own plan and projects for the water sector of Saint Lucia. This results in a certain degree of duplication of efforts as some projects or and target areas are similar. This problem points to the need for greater communication between two important stakeholders in the country’s water sector.

As mentioned in the vulnerability section, approximately 90% of the island uses meters, which were installed in 2006. These meters were faulty and were giving errors and incorrect data. WASCO is now undertaking a second round of metering installation exercises to replace the previous batch in a new bulk metering project via a procurement process. It also hopes to increase the meter coverage on the island with during this exercise (Mr. Sealey, personal communication, May 26, 2011).

The main water issues that consumers face is access to reliable water (Geoghegan, 2002). In the dry season, Saint Lucia is prone low surface stream flows and in the wet season landslides and erosion increased the turbidity of water courses. This creates a situation where water resources are a problem year long, varying depending on the season. To assess the state of the water resources on the island, a geophysicist has been contracted to a give a full assessment of shallow water resources in Saint Lucia. One river has been completed and two more have been carded for assessment. The choice to assess shallow water resources rather than deep water sources is linked to the shorter recharge time, which allows for a certain level of flexibility and control. Mr. Sealey of WASCO describes this option as simply a ‘smart use of water resources’ and a means by which sustainability can be achieved. There is also a report card to be completed in August 2011 on the surface water and springs of the island (Mr. Sealey, personal communication, May 26, 2011).

The Government of Saint Lucia has prepared the Saint Lucia Water Management Plan for Drought Conditions (Government of Saint Lucia, 2009) and mapped out structures to build capacity in times of drought events on the island. The plan identifies and defines five Condition and Program phases, which are Normal Conditions, Drought Water, Drought Warning, Restriction and Emergency Phases. At each phase, corresponding National Actions and relevant agencies to effect these actions are stipulated. Agencies with a role in drought management in Saint Lucia include WASCO, NEMO, and the Office of the Prime Minister, as well as water suppliers, which includes bottle water producers. Other important stakeholders in water resource management and therefore in drought management in Saint Lucia (among others) includes the Saint Lucia Meteorology Services, Hydrological Unit, Saint Lucia Hotel and Tourism Association, Manufacturing Association, the Water Resources Management Unit, the Environmental Health Department and the Agricultural Services Unit, and all related Ministries. The course of action required by various sectors are also outlined, the main vulnerable sectors in Saint Lucia include the Industrial and Manufacturing and Agricultural, Hospitality and other private sector groups (DRM, 2011).

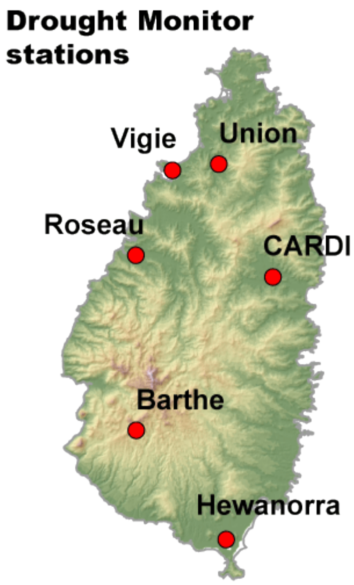

Figure 5.1.1: Drought Monitor Stations in St Lucia.

(Source: DRM, 2011)

Additionally, Saint Lucia has a number of drought monitoring stations which are also rain monitoring stations. There stations are strategically located around the island at Vigie, Union, CARDI, Hewanorra, Barthe and Roseau (DRM, 2011).

One of the ways that the WASCO copes with water shortages is through the use of rationing and by issuing Drought Rationing Schedules, stipulating the areas expected to be affected and the date and times when water will not be available. In the 2009/2010 drought period, water rationing involved water lock-offs for two day periods in various communities on the island.

During drought conditions, a contingency plan for water resource management is usually set in motion. These are more measures to mitigate rather than to adapt to water shortages, but essential to serve and protect the population in times of water scarcity and imminent drought. They include (DREF, 2010):

- Spatial water rationing initiatives
- Water transportation to areas with low pressure
- Rehabilitation of old water sources
- Education on water conservation

One final stakeholder that should be mentioned is non-governmental organisations. In Saint Lucia, there is the Trust for Management of Rivers, which was established and registered two months ago under the Not-For-Profit Act of Saint Lucia. It is a spin off from the Integrated Water and Coastal Management Project. Its general focus and emphasis is river management and watershed protection (Mr Issac, personal communication, May 6, 2011).

The Ministry of Physical Planning, currently the Ministry Of Physical Development Environment And Housing, is tasked with addressing climate change issues in Saint Lucia, including water resources which are believed to be sufficient, if properly managed for current and projected demands (Geoghegan, 2002). However, there is a lack of information necessary for proper planning, and reliability of the water supply is already a major issue faced by consumers. This is largely due to the supply that comes mainly from surface water, particularly rivers originating in the upper watersheds (Geoghegan, 2002). During dry periods, shortages have led to rationing which has tended to favour sectors such as health and tourism, but development is limited due to a lack of reliability of supply and insufficient data (Geoghegan, 2002).

The organisational structure for water resource management in Saint Lucia has been evolving and is clearly present. These organisations and governmental agencies form the institutional base so crucial to adaptation to climate change. However, it has been found that they often do not co-ordinate initiatives sufficiently to effectively manage water resources (MPDEH, 2005). For instance, Springer (2005) has commented that the institutional base of the water sector has been plagued by “fragmentation [which] exists among a multiplicity of institutions whose mandates and activities impact the water resource” (Springer, 2005). Other comments made about the water sector are that there is “…an absence of arrangements for the involvement of civil society, unsatisfactory level of understanding and awareness of management issues” and a “need for encouragement of a balance of use and watershed protection” (MPDEH, 2005).

The human resources within the sector may be part of the problem of efficient water management. Areas identified that are particularly weak are “water and wastewater management, pollution control, finance, integrated water resource planning, and the operation and maintenance of water- related infrastructure and services” (Springer, 2005). Further, Springer (2005) notes that “institutional arrangements for monitoring, collecting, researching, and evaluating water-related data and associated environmental conditions are poor”.

One area that has not been addressed in Saint Lucia’s water sector is groundwater resources. There has been no extensive exploration of the groundwater resources. As Mr Issac of the OECS notes “the government is generally unaware of what potential exists for water abstraction, where the aquifers are located on the island, the recharge dynamics or the general hydrology of the aquifer systems in the country”. He further added that “an understanding of what water resources we have is important for risk reduction, as in the case of Hurricane Tomas, everything in the country was crippled, therefore alternative and reliable water sources need to be sourced, especially to protect the health services and other important services in critical times such as during a natural disaster" (Mr Issac, personal communication, May 6, 2011).

Finally, the most recent initiative being undertaken by the Government of Saint Lucia that has a comprehensive stake in water resources and climate change is Saint Lucia's Pilot Programme for Climate Resilience (PPCR) which is part of the Strategic Programme for Climate Resilience. This report includes water related activities on a national level based on its intentions to "Pilot or Support Interventions such as Communal Rainwater Harvesting, Micro-Dams and the Establishment of Satellite Water Storage Tanks within the Forest Reserve to Feed Rural Communities'. The PPCR proposes to encourage water conservation technology use in both public and community buildings. Additionally, it emphasises the need for increasing capacity building for water monitoring and the need for rainfall stations and stream gauges in all watersheds, many of which were affected by Hurricane Tomas. This will facilitate data collection. Another means by which data collection can be managed is through the "Improved Management of Water Network and capacity in the use of GIS and related technologies". Finally, other plans that have been devised to strengthen the country's adaptive capacity include the development of a "Watershed Management Plans and Riverbank Assessment and Rehabilitation Strategy" and a "National Reforestation and Watershed Rehabilitation Programme". It would seem that water resources are extensively and comprehensively addressed in the project (MFEAND, 2011).

5.1.3. Technology

Hydrological data are critical for making informed decisions regarding the development of water resources. These data will become even more critical for observing changes in water supply and decision making regarding the provision of water resources in the future as a result of climate change related events such as droughts. While Mr Nichols of the OECS has stated that water conservation technologies exist in the market at commercially available and viable quantities, the policies to support these initiatives do not exist to encourage heavy water users, particularly in the industrial sector, to utilise them (Mr Nichols, personal communication, May 6, 2011). Additionally, Springer (2005) has found that "water conservation technologies are still rudimentary, and incentives for innovation are weak", although waste water recycling is now standard practice for many hotels, predominantly for the irrigation of gardens and lawn areas (CANARI, 2010). In industry, the Windward and Leeward Breweries has adopted water recycling by using grey water for operational tasks including cooling, washing and cleaning (CANARI, 2010). Some hotels and manufacturing plants have installed desalination plants, however the National Water Policy stipulates that, except in emergency cases or where freshwater resources are limited, licences will not be granted to produce desalinated water for public consumption (Springer, 2005).

The use of rainwater harvesting systems is practiced in Saint Lucia to varying degrees. For instance, as noted in A Programme to Promote Rainwater Harvesting in the Caribbean Region, in most affluent neighbourhoods on the island, rainwater harvesting systems have been installed in the majority of the houses using built-in cisterns (CEHI, 2006). Such rainwater harvesting systems can include technology beyond cisterns or simple polyethylene tanks and pumps by which users can be completely autonomous of the municipal water supply. Rural communities may store either piped water from WASCO or have guttering set up for rainwater harvesting. However, infrastructure is not monitored by the government through WASCO. As such, the investment is solely a private decision. There is no national training on water quality with regards to rainwater systems, which is particularly important with respect to disinfection of water and ensuring proper filtration systems are installed (Mr Issac, personal communication, May 6, 2011).

Mr Nichols of the OECS also stated that there is a need for greater awareness of the need to capture rainwater. The population should be encouraged to develop domestic supplies so as to become at least partially independent of WASCO distribution, thereby decreasing the demand on the municipal water supplies. Adaptation can further be encouraged where in "every new building, where all infrastructures should have the ability and capacity to store water" (Mr Nichols, personal communication, May 6, 2011). This is reflected in the government's objective to relieve itself of part of the capital required to invest in infrastructure in the water supply and sanitation sectors, and its drive to increase private ownership and investment in new water and sanitation technologies (Springer, 2005). Indeed, by including the private sector, the economic efficiency of water production and sewerage services can be improved as investment in infrastructure will lead to better water and sanitation technologies and better human resources.

One final consideration is the need for information. Mr Sealey notes that "there is a lack of data to do designs relevant to small island states that are efficient and economic". This has also been highlighted in a capacity assessment of GIS capabilities of the Caribbean report of the Integrated Watershed and Coastal Areas Management Project. There is limited to no digital data sets on ‘‘water bodies, hydrogeology, aquifers, rainfall, flood hazard zones, erosion…and waste management sites" on the island (CATHALAC, 2007). He also explains that there are not enough facilities to do large scale research and that there is also a problem of obsolete data. He stressed the need for data to properly inform decisions, not only in times of crisis, but all projects undertaken for the water sector, as well as in all ministries of the government.

5.2. *Energy Supply and Distribution*

5.2.1. Policy

As evident from current energy documents in many countries, both in the Caribbean and outside, tourism is not central in the consideration of wider strategies to reduce energy use (Brewster, 2005; Haraksingh, 2001). Yet, as this document has shown for Saint Lucia, its share in energy use and emissions is considerable, and likely to grow in the future. This will lead to growing vulnerabilities in a BAU scenario. At the same time, the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise island economies. The National Energy Policy has identified the tourism sector and hotels in particular as potentially large consumers that will be required to conduct energy audits and based on the results, undertake energy efficiency initiatives to reduce their consumption. New resorts will also be mandated to use solar water heaters (MOPDE, 2010).

It is vital for governments to engage in tourism climate policy, because tourism is largely a private sector activity with close relationships with the public sector at supranational, national, regional and local government levels, and through politics, there is thus an outreach to all tourism actors. Furthermore, governments are involved in creating infrastructure such as airports, roads or railways, and they also stimulate tourism development, as exemplified by marketing campaigns. The choices and preferences of governments thus create the preconditions for tourism development and low-carbon economies. Finally, there is growing consensus that climate policy has a key role to play in the transformation of tourism towards sustainability, not least because technological innovation and behavioural change will demand strong regulatory environments.

As described earlier and pointed out by OECD (2010), emissions of GHG essentially represent a market failure where there is little incentive to innovate. It has been shown that the fairest and most efficient way of reducing emissions is to consider increased fuel prices (i.e. to introduce a tax on fuel or emissions). Energy product pricing has already been identified as a key mechanism to address energy efficiency in Saint Lucia (MOPDE, 2010). Carbon taxes may be feasible for accommodation, car transport and other situations where tourism activities cause environmental problems. Taxation is generally more acceptable if taxes are earmarked for a specific use, which in this case could include incentives for the greening of tourism businesses. Tax burdens would then be cost-neutral for tourism, but would help to speed up the greening of the sector. If communicated properly, businesses as well as tourists will accept such instruments, and the economic effect can be considerable. The Maldives charge, for instance, US S10 per bed night spent in hotels, resorts, guesthouses and yachts, which accounts for 60% of government revenue (McAller *et al*., 2005).

Money collected in various ways could be re-invested in sustainable energy development. For example, there is a huge potential to use solar energy (Haraksingh, 2001). Both economical and non-economical technical solutions to reduce the energy-dependency of islands in the Caribbean could thus be implemented based on regulation, market-based approaches and incentives, as well as through financing derived from voluntary and regulatory carbon markets. Policy intervention is however needed to initiate these processes. Overall, Haraksingh (2001: 654; see also Headley, 1998) suggests that:

The Caribbean region is a virtual powerhouse of solar and other renewable sources of energy waiting to be exploited. It has the advantage of not having winters when hot water demands can increase from summer by approximately 70% in cold climates. Solar water heaters for the tourism industry and domestic and commercial usage have perhaps the greatest potential. There is a general commitment to the development of RE, but matters have not gone very far beyond this. The movement towards greater implementation of RE technologies is gaining strength, but there is a large gap between policy goals and actual achievement. Clearly, much work still needs to be done. Government fiscal incentives, greater infrastructure for policy development as well as joint venture partnerships are needed in the Caribbean region for a smooth transition.

Lorde *et al*. (2010) suggest that government policy should encourage efficiency and innovation in electricity production and distribution, noting that in particular the residential sector should be addressed in reducing electricity use. Saint Lucia has laid the ground work for future renewable energy (both large and small scale) and energy efficiency initiatives through the National Energy Policy. However, at present the plans exist in the policy document only and a great deal more effort and resources are required to develop the action plan that will lead to meaningful implementation. There must also be due consideration of the sustainability of both traditional fossil-fuel based energy infrastructure, as well as future initiatives with renewable energy technologies that may become less effective under climate change.

5.2.2. Management

Any action on reducing energy use and GHG emissions has to begin with a review of emission intensities, to ensure that action taken will lead to significant reductions. From a systems perspective, hundreds of minor actions will not yield anywhere near as much as one change in the major energy consuming sub-sectors. Aviation is thus, as outlined earlier, a key sector to focus on, followed by - in smaller to medium-sized islands - hotels, as these are comparably energy-intensive, while car-travel is not as relevant. Cruise ships will often be the third most relevant energy sub-sector. This is however dependent on whether fuels are bunkered in the respective island or not.

Tourism management is primarily concerned with revenue management, as the ultimate goal of any economic sector is to generate profits and jobs. A general critique of tourism management in this regard must be that it is too occupied with revenue, rather than profits, as well as multiplier effects in the economy. This is an important distinction because profits have been declining in many tourism sub-sectors, such as aviation, where revenues have been increasing through continuously growing tourist volumes, while profits have stagnated. This is equally relevant for average length of stay, which is falling worldwide: to maintain bed-night numbers, destinations have consequently had to permanently increase tourist numbers. For instance, in the case of Saint Lucia, average length of stay has fallen 2 full days (from 10.6 to 8.6) in the period 2001 to 2010 (with ups and downs in between; (Research and Policy Unit, 2011)). Average hotel occupancy in Saint Lucia has also been falling from 71.4% in 1997 to 54.4% in 2010. Even though occupancy rates have oscillated in recent years, these trends might be indicating critical changes in key performance indicators (Research and Policy Unit, 2011). Working pro-actively on these is consequently a highly relevant management task.

In an attempt to look at both profits and GHG emissions, a number of concepts have been developed. One of the most important overall objectives can be defined as 'reduce the average energy use/emissions per tourist'. In the case of Saint Lucia, average emissions per tourist are already comparably low (i.e. corresponding to emissions of 600 kg CO_2 per tourist for air travel) (Table 4.2.4). Table 5.2.1 illustrates the situation for a number of other islands in terms of weighted average emissions per tourist (air travel only), as well as emissions per tourist for the main market. Note that in the case of Saint Lucia, emissions per tourist for air travel are twice the amount calculated in Table 4.2.4, because this includes return-flight emissions. The table can serve as a benchmark for inter-island comparison.

Table 5.2.1: Average Weighted Emissions per Tourist by Country and Main Market, 2004

Country	Av weighted emissions per tourist, air travel (return flight; kg CO_2)*	International tourist arrivals (2005)	Total emissions air travel (1,000 tonne CO_2)	Emissions per tourist, main market (return flight; kg CO_2) and % share of total arrivals*
Anguilla	750	62,084	47	672 (USA; 67%)
Bonaire	1,302	62,550	81	803 (USA; 41%)
Comoros	1,754	17,603**	31	1,929 (France; 54%)
Cuba	1,344	2,319,334	3 117	556 (Canada; 26%)
Jamaica	635	1,478,663	939	635 (USA; 72%)
Madagascar	1,829	277,422	507	2,159 (France; 52%)
Saint Lucia	1,076	317,939	342	811 (USA; 35%)
Samoa	658	101,807	67	824 (New Zealand; 36%)
Seychelles	1,873	128,654	241	1,935 (France; 21%)
Sri Lanka	1,327	549,309	729	606 (India; 21%)

Notes:* Calculation of emissions is based on the main national markets only, using a main airport to main airport approach (in the USA: New York; Canada: Toronto; Australia: Brisbane); **Figures for 2004.

(Source: Gössling *et al.,* 2008)

A strategic approach to reduce per tourist emissions would be to focus on further analysis of markets. To this end, an indicator is the arrival-to-emission ratio, based on a comparison of the percentage of arrivals from one market to the emissions caused by this market (Table 5.2.2). For instance, tourists from the USA account for 67% of arrivals in Anguilla, but cause only 55% of overall emissions. The resultant ratio is 0.82 (55% divided by 67%). The lower the ratio, the better this market is for the destination, with ratios of <1 indicating that the market is causing lower emissions per tourist than the average tourist (and vice versa). Arrivals from source markets with a ratio of <1 should thus be increased in comparison with the overall composition of the market to decrease emissions, while arrivals from markets with a ratio of >1 should ideally decline. In the case of Anguilla, the replacement of a tourist with a ratio of >1 in favour of one tourist from the USA (ratio: 0.8) would thus, from a GHG emissions point of view, be beneficial. However, where arrivals from one market dominate, it may be relevant to discuss whether the destination becomes more vulnerable by increasing its dependence on this market.

Table 5.2.2: Arrivals to Emissions Ratios

	Anguilla	Bonaire	Jamaica	Saint Lucia
1st market	**USA**	**USA**	**USA**	**USA**
Emissions ratio	0.8	0.5	0.8	0.9
2nd market	**UK**	**Netherlands**	-	**UK**
Emissions ratio	2.5	1.6		2.0
3rd market	-	-	-	**Barbados**
Emissions ratio				0.1
4th market	-	-	-	**Canada**
Emissions ratio				1.0

(Source: Gössling *et al.* 2008)

To integrate emissions and revenue, energy intensities need to be linked to profits. An indicator in this regard can be eco-efficiencies (i.e. the amount of emissions caused by each visitor to generate one unit of revenue). This kind of analysis is generally not as yet possible for Caribbean islands due to the lack of data on tourist expenditure by country and tourist type (e.g. families, singles, wealthy-healthy-older-people, visiting friends and relatives, etc.), but Figure 5.2.1 illustrates this for the case of Amsterdam/Netherlands (Gössling *et al*., 2005). By assigning eco-efficiencies, it is possible to identify the markets that generate a high yield for the destination, while only causing marginal emissions. For instance, in the case of Amsterdam, a German tourist causes emissions of 0.16 kg CO_2 per € of revenue, while a visitor from Australia would emit 3.18 kg CO_2 to create the same revenue.

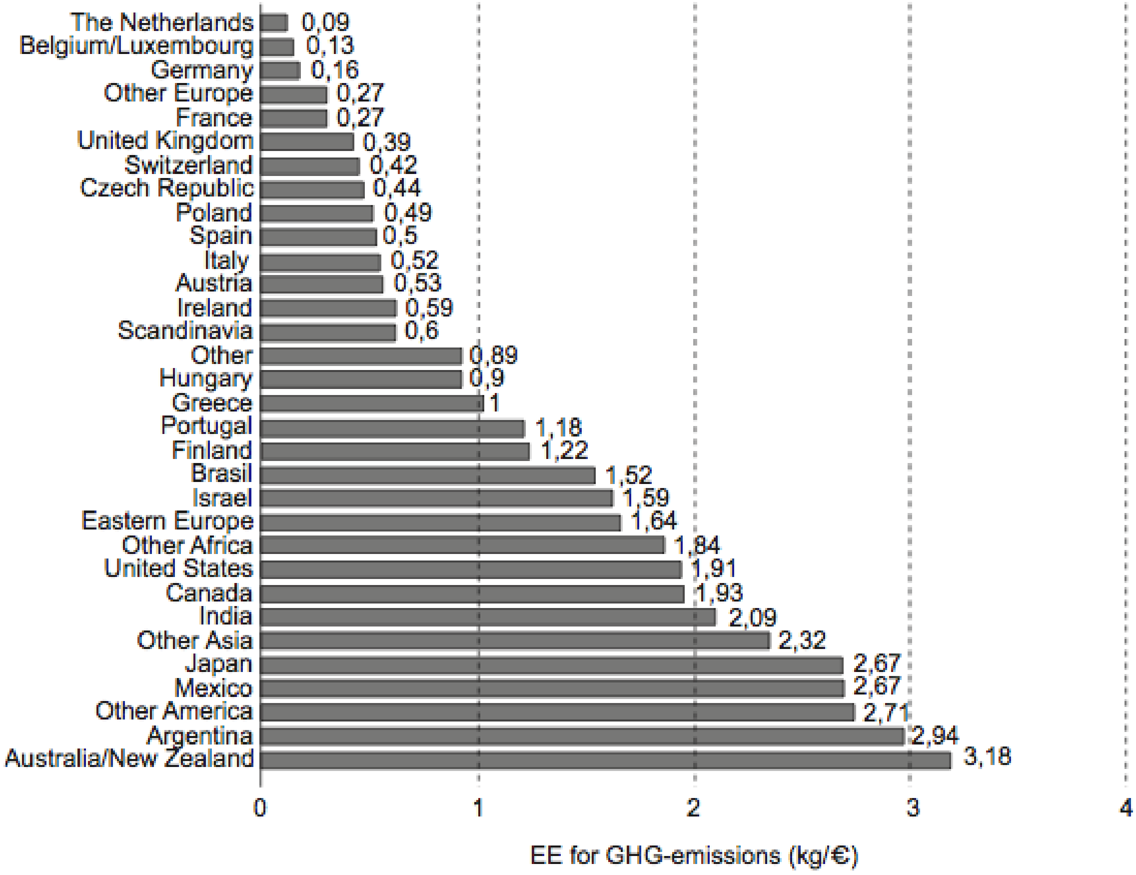

Figure 5.2.1: Eco-Efficiencies of Different Source Markets, Amsterdam

(Source: Gössling *et al*. 2005)

These indicators can serve as a basis for restructuring markets, possibly the most important single measure to reduce the energy dependence of the tourism system. However, further analysis is required to distinguish revenue/profit ratios, leakage factors/multipliers (to identify the tourist most beneficial to the regional/national economy) and to integrate market changes into an elasticity analysis (to focus on stable, price-inelastic markets) (see also Becken, 2008; Schiff and Becken, 2010). No study that integrates these factors has been carried out so far, but further developing such strategic tools for revenue and energy management would appear useful for the Caribbean.

In Barbados, a survey carried out in February 2011 to better understand tourist perspectives on spending, length of stay, climate change and mitigation, yielded some interesting results. In this regard, 71% of respondents stated that they would have liked to stay longer, and 61% stated that they had spent less money than planned. It is likely that similar results could be found throughout the region, and further research needs to be carried out to identify how this potential can be realised. For example, longer stays increase the share of money retained in the national economy, primarily in accommodation, while higher expenditure also contributes to increasing national tourism revenue, notably with a lower leakage factor, as spending for air travel will usually entail smaller profit shares and higher leakage. The Barbados study also revealed that 73% of respondents are willing to drive less by car, 70% stated willingness to use smaller cars, and 81% are positive about electric cars. With regard to air conditioning use, one of the major factors in energy use in hotels, tourists also support resource savings. For example, 71% stated that they would be willing to use fans rather than air conditioning, 90% agree that switching off air conditioning when leaving the room is acceptable, and 65% agree on using air conditioning at a 1°C higher temperature than the set room temperature actually used during the stay.

Further options to reduce energy use and emissions exist for businesses focusing on staff training. For instance, Hilton Worldwide saved energy and water costs in the order of US $16 million in the period 2005-2008, primarily through behavioural change of employees as a result of a training in resource-efficiency. These measures have to be discussed on the business level and are mostly relevant to accommodation and activities managers. As about 15% of a typical Caribbean hotel's operating cost may be attributable to energy usage (Pentelow and Scott, 2011), management-related reductions in energy use of 20% would correspond to savings of 3% on the overall economic baseline. This should represent a significant incentive to engage in energy management. For further details on energy management see Gössling (2010). Training in energy efficiency has been identified as a useful activity to reduce energy consumption in the National Energy Policy (MOPDE, 2010).

With regard to management of the existing infrastructure, it would seem that LUCELEC has performed well following recent extreme events.

> *"In general, it was clear that LUCELEC had put measures in place to ensure that it remained well insulated from the effects of events such as this. Damage and losses were low for this utility as compared with previous events and in comparison to WASCO. Recommendations made … include:*
>
> 1. *Relocation of the Union Substation to a location beside its existing position, on slightly higher land. Experience from Tropical Storm Debby in 1994 showed that this station was vulnerable to flooding.*
> 2. *Elevation of the critical infrastructure in the relocated Union Substation by approximately 1 metre above floor level.*

... It is also recommended that, if not presently so, NEMO should include representation by LUCELEC in its list of first responders after a natural hazard event." (Source: UNECLAC, 2011, p. 52)

These recommendations were made by the Managing Director of LUCELEC and indicate that the management are aware of the threats to their plant and are in the process of adapting to the changing circumstances.

5.2.3. Technology

The potential for saving energy through technological innovation has been documented for a growing number of case studies. For instance, the luxury resort chain Evason, Phuket and Six Senses Spa, Thailand, reports payback times of between 6 months and ten years for measures saving hundreds of thousands of Euros per year. Examples of the economics of resource-savings from the Caribbean include five case studies in Jamaica (Meade and Pringle, 2001). The results from this study are summarised in Table 5.2.3.

Table 5.2.3: Jamaican Case Studies for Resource Savings

Property	Sandals Negril	Couples Ocho Rios	Swept Away	Negril Cabins	Sea Splash
Number of rooms	215	172	134	80	15
Initial investment	$68,000	$50,000 ($20,000 in equipment, $30,000 in consulting fees)	$44,000	$34,670	$12,259
Water saved (m^3)	45,000	31,000	95,000	11,400	7,600
Electricity saved (MWh)	444	174	436	145	154
Fuel saved (l)	100,000 (diesel)		172,000 (LPG) 325,000 (diesel)		
Financial savings	$261,000	$134,000	$294,000	$46,000 over 2.75 years. $5,000 on laundry chemicals since August 1998	$46,000 since July 1998
Return on investment	190% over 2 years	200% over 16 months	675% over 19 months	48%	151% over 2.5 years
Payback period	10 months	6 months	4 months		

(Source: Meade and Pringle, 2001)

It is beyond the scope of this report to list all technical measures to reduce energy use, and readers are referred to Gössling (2010) for further guidance (case studies provided in this book indicate technology-based energy savings potentials of up to 90% for accommodation). The Saint Lucia Government has already determined that an energy efficiency building code will be developed that will ensure all new developments and commercial retrofits incorporate the appropriate technologies. Similarly, new tourism developments will be required to use solar water heaters (MOPDE, 2010).

Often, it is economically feasible to replace conventional, fossil-fuel based energy systems with renewable ones, with payback times of 3-7 years (e.g. Dalton *et al.*, 2009). An example study in the Caribbean is provided by Bishop and Amaratunga (2008). This study provides evidence of the economic suitability of technological innovation to generate renewable energy in Barbados. Bishop and Amaratunga (2008) propose a 10 MW wind energy scheme based on micro wind turbines of both horizontal and vertical axis configurations, and at costs as low as Bds $0.19 per kWh (US $0.096). The scheme would also lead to savings of 6,000-23,000 t CO_2 and avoided fuel costs of Bds $1.5–5.3 million (US $0.76 – 2.68 million). The authors highlighted that small wind turbines can be competitive with conventional wind farms.

Since Saint Lucia is still at the feasibility and planning stage of renewable energy initiatives, it is well placed to ensure that decisions are made with full consideration of the likely impacts climate change will have on the chosen technology.

As outlined, managers will usually be interested in any investment that has pay-back times as short as 5-7 years, while longer times are not favourable. While this would support investments into any technology with payback times of up to 7 years, it also opens up opportunities to use the Clean Development Mechanism as an instrument to finance emission reductions. The Clean Development Mechanism is one of the flexible instruments of the Kyoto Protocol with two objectives:

- To assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the convention of cost-efficient emission reductions;
- To assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments.

The Clean Development Mechanism is the most important framework for the supply of carbon credits from emission reduction projects, which are approved, validated and exchanged by the UNFCCC secretariat. Clean Development Mechanism projects can be implemented in all non-Annex I countries, and are certified by operational entities designated by UN COP (IPCC, 2007). The Clean Development Mechanism thus generates credits, typically from electricity generation from biomass, renewable energy projects, or capture of methane, often a problem in the context of waste management, which can be sold in the regulatory or the voluntary carbon markets. As such, it is a novel instrument to restructure islands towards low-carbon economies.

Discussions are already on-going in the Caribbean on how to use the Clean Development Mechanism in restructuring the energy system (e.g. MEM, 2009). It is worth noting, however, that emission reductions achieved through the Clean Development Mechanism do not apply to national economies, rather they apply to the purchaser's economy. While the Clean Development Mechanism is thus an instrument to achieve technological innovation, it is not an instrument to achieve carbon neutral status. The National Energy Policy includes a commitment by government to establish the necessary national legal and institutional systems to take advantage of Clean Development Mechanism opportunities (MOPDE, 2010).

Further funds can be derived through voluntary payments by tourists. For instance, Dalton *et al.* (2008) found that 49% of Australian tourists were willing to pay extra for renewable energy systems, out of which 92% were willing to pay a premium corresponding to 1–5% above their usual costs. In another study, Gössling and Schumacher (2010) found that 38.5% of a sample of international tourists in the Seychelles expressed willingness to pay for carbon-neutrality of their accommodation, out of which 48% stated they would be willing to pay a premium of at least €5 per night. While these values are not representative, they nevertheless indicate that there is considerable potential to involve tourists emotionally and financially in strategies to implement renewable energy schemes. Such options should be further explored.

5.2.4. Summary

Saint Lucia is vulnerable to rising oil prices and global climate policy. However, there are various tools that can be employed to reduce energy use in the country, possibly in the order of an estimated 20% within 2 years, though attention has to be paid to increasing tourist arrival numbers, which can outweigh achievements in efficiency gains. Adaptation should focus on policy, management and technology.

Policy, including regulation, taxation and incentives, is important to increase pressure on stakeholders to engage with energy management – this is an area that is generally seen as less relevant and efforts to engage significant stakeholder numbers will demand strong policy environments, as initiated through the National Energy Policy.

Vast options exist to reduce energy demand through carbon management. In particular, this includes a rethinking of markets based on their eco-efficiency, which can potentially lead to increasing turnover and declining energy costs while also bringing greater attention to the diversification of markets. Carbon management also means to address average length of stay, and measures to stimulate spending. Evidence indicates that there is considerable scope to increase both. Maintaining bed night numbers without addressing losses in average length of stay does otherwise, meaning to be stuck in logic of volume growth, which is likely to prove a problem when the cost of transport increases and when serious climate policy is introduced.

- The introduction of low-carbon technology can both reduce energy demands (energy-efficiencies) and the use of fossil fuels, which can be replaced by renewable energies. Often, restructuring existing energy systems can be cost-effective, and even lead to savings. The National Energy Policy has laid the groundwork for initiatives in this area.
- Finally, the Clean Development Mechanism and voluntary payments for carbon offsetting may be used as means to reduce energy use and to increase the share of renewable energy in national energy mixes. Again, the National Energy Policy has laid the groundwork for initiatives in this area.

5.3. *Human Health*

5.3.1. Policy

The Public Health Act of 1975 is the main legislation that governs the public health sector in Saint Lucia. Other relevant legislation includes the Hospital Ordinance Act of 1992, the Pharmacy Act of 2000, the Mental Act 1957, the Nurses and Midwives Act and the Family Practitioners Act of 1993. However, these legislative instruments pre-date the climate change agenda. The newest legislation which specifically deals with climate change is the Saint Lucia National Climate Change Policy and Adaptation Plan (MPDEH, 2003b). Among its broad policy objectives is to "foster the development of processes, plans, strategies and approaches to avoid or minimise the negative impact of climate change on human health" (MPDEH, 2003b).

With respect to the health sector and climate change in the Saint Lucia National Climate Change Policy and Adaption Plan, the general adaptation initiatives and directives included:

- Conduct the necessary health-related research and information gathering in order to strengthen the basis for sound decision-making;
- Ensure that appropriate short, medium and long-term measures to address health related climate change issues are incorporated into National Health Plans;
- Sensitise and educate health personnel and the public about climate- change related health matters;
- Ensure that to the extent possible preventive measures and curative resources such as vaccines and medications are available as needed.

The policy also focused on human settlement, and risk reduction with the following adaptation policy options (MPDEH, 2006):

- Promote the development and enforcement of appropriate building codes;
- Develop and implement plans for the relocation or protection of settlements and infrastructure at risk;
- Undertake an assessment of human settlements and infrastructure at risk from the impacts of Climate Change for inclusion in land use and development planning.

In the last decade, various internal and external factors have affected the Saint Lucian economy. With regards to natural disasters, recent examples of hurricanes that have affected the economy of the island include Hurricane Dean (2007) (MEAEPND, 2009) and Hurricane Tomas (2010) (ECLAC, 2011). Environmental health is also important to ensuring economic growth. For instance in Saint Lucia, if disease affects the banana crops, the social implications of a reduction in production are far reaching, affecting livelihoods to a subset of the 11.4% of the population that is directly involved in agriculture (Trotman *et al.*, 2009). Diseases that affect banana plantations include leaf spot disease and Moko disease (MEAEPND, 2009). In terms of external factors, most recently the deterioration of the global economy had ripple effects in Saint Lucia which affected the real economic growth of the country (MEAEPND, 2009). Other factors that also affect the economy include high oil prices, globalisation and trade liberalisation (Trotman *et al.*, 2009). Additionally, the external debt of Saint Lucia is very high, averaging at 40% of the GDP (Karfakis *et al.*, 2011). All these factors make Saint Lucia very vulnerable and necessitate greater focus and research to be placed in the development of appropriate environmental, agricultural and, trade policies (Trotman *et al.*, 2009).

These dynamics unfold against a backdrop of the high dependence of the economy on the service industry which is centred on the tourism sector. The tourism sector is the greatest foreign exchange generator in the Saint Lucian economy, providing about 77% of the country's GDP (Kairi Consultants Ltd., 2007). There have been reductions in tourist demand from traditional source markets as reported in 2008 in the Saint Lucia Social and Economic Review (2008) (MEAEPND, 2009). This ultimately affects the financial resources and capital available to the government. For example, in the health sector, expenditure on health declined by 14.9% in 2008 (MEAEPND, 2009). It also affects the foreign exchange expenditure required to purchase food and food products. In the Human Health chapter of the IPCC AR4, it notes that such financial constraints limit the ability to carry out health-impact and climate-impact adaption research in low- and middle-income countries such as Saint Lucia (Confalonieri *et al.*, 2007).

Table 5.3.1: Total Expenditure on Health as a Percentage of GDP from 1995 - 2009

Year	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
% of GDP	4.8	5.5	5.0	5.0	5.2	5.4	6.0	6.1	5.8	5.8	5.8	6.4	6.3	7.0	8.1

(Source: WHO, 2011)

Table 5.3.1 shows the health expenditure as a percentage of GDP from 1995 to 2009. It can be observed that the total expenditure on health has consistently increased during this time period, up to the current highest ever allocation of 8.1% in 2009 (WHO, 2011). EC $312.9 million (27% of the total budget) was injected in the health sector in 2008 (MOF, 2008). This clearly suggests that the government is providing resources to the health sector in keeping with international best practice.

The Government of Saint Lucia, like many other islands in the Caribbean over the last ten years, has sought to undertake Health Sector Reform. Areas identified as important priorities in the development of the health care system included "community-based health care, the improvement of existing district health teams; health sector financing; the development and efficient distribution of health care information and human resource development" (MPDEH, 2001). There was also a decision to establish National Health Service Plan, however no plan or procedure to realise this objective was found. The overall objectives of the Health Sector Reform plan also relates to the development of adaptation strategies to climate change as an overall strengthening of the health care system results in greater resilience to climate change vulnerabilities.

5.3.2. Management

One of the most relevant issues that may be affecting health in Saint Lucia is poverty, which stands at 28.8%. The Trade Adjustment and Poverty in Saint Lucia Report (2005/06) states that poorer persons are less likely to report illnesses than persons from non-poor communities (Kairi Consultants Ltd., 2007). This creates a challenge to fully address the various health problems in such communities that need the most assistance. Under-reporting distorts the relevance of strategies and action plans that the government devises and "reported health data… tend therefore to provide an inadequate basis for the formulation of health policy" (Kairi Consultants Ltd., 2007).

One means of addressing the high level of poverty has been through the development of the Saint Lucia Social Investment Fund which was born out of a merging of two other programmes, namely the Poverty Reduction Fund and the Basic Needs Trust Fund. The aim of this fund is to "serve as a delivery mechanism for the provision of basic infrastructure and services to poor and marginalised communities and groups in an efficient, responsive and accountable manner" (MOF, 2008).

There has also been the implementation of the Chilean style Puente Programme, which has four main objectives to address poverty in Saint Lucia (MOF, 2008)

1. Improve the socio economic living conditions of indigent, poor and vulnerable households;
2. Bring an end to extreme poverty in Saint Lucia (1.6% of population and 1.2% of households);
3. Reduce poverty by building sustainable livelihoods, coping strategies, the quality of human relationships and interactions; and
4. Develop opportunities in poor communities and the vulnerable population through the establishment of a targeted programme of support designed to transform household units.

As previously discussed, the agriculture sector is an important traditional sector in Saint Lucia. Combined with the dependence on importation and an environment susceptible to hurricanes and other natural disasters, Saint Lucia's ability to adapt to climate change will also depend on food security, which is important to the well-being of the population. Saint Lucia imports approximately 40.6% of its food, which is double the regional average of 20.4% according to FAOSTAT data. It also has a trade deficit with exports at 49% and imports at 67% (Karfakis *et al.*, 2011). Currently, a considerable proportion of the country is not suitable for agriculture due to factors such as steep slopes, shallow soil, stoniness, low fertility and aridity. Land suitable for intensive agriculture in Saint Lucia stands at 8,400 acres or only 5.6% of the total land area of the island (ECLAC, 2011). It should also be highlighted that other factors previously described such as disease outbreaks, natural disasters and external economic dynamics additionally impair the ability of the sector to achieve maximum output based on available land area.

A number of areas need to be strengthened which have not been specifically addressed in the Saint Lucia National Climate Change Policy and Adaptation Plan. One such area is waste disposal problems (Geoghegan, 2002; MPDEH, 2006) which requires greater awareness of health consequences of improper disposal (MPDEH, 2001).

In terms of managing vector borne diseases, limited financial resources or improper allocation of resources will impair the ability of the government to effectively address the challenges that are presented with dengue, malaria and schistosomiasis outbreaks. The Government of Saint Lucia in its 2009 National Disaster Management Plan prepared a Communicable Disease Surveillance Manual which outlines provisions to deal with any communicable diseases (Government of Saint Lucia, 2010c), but financial resources are crucial to implement surveillance effectively. As stated in the Saint Lucia Initial National Communication to the UNFCCC "dengue epidemics are costly in terms of hospitalisation, patient care, vector control efforts, national economic productivity and human suffering" (MPDEH, 2001). Some of the areas of management that require greater attention and development include:

- The prevention, treatment, limitation and suppression of disease, including the conduct of investigations and inquiries in respect thereof;
- The publishing of reports, information and advice to the government and education of the public on the preservation of health; and
- The abatement of nuisances and removal or correction of any condition that may be injurious to health.

One positive area that should be mentioned is emergency services designed to help people cope with mental health and traumatic stress in times when there are disasters and associated disruptions (MOH, 2007). Another area that seeks to protect and increase the awareness of the public is related to extreme heat events. In the National Emergency Management Plan relevant information for forecasting of Extreme Heat Events was outlined (Government of Saint Lucia, 2010c). A final example of the Government of Saint

Lucia exploring its adaption options to managing climate change in health concerns respiratory illnesses, where in the 2008 budget speech, the MOH explained the "need to be duly concerned about the prevalence of respiratory ailments in our country". It was proposed that an air quality monitoring unit be set up (MOF, 2008).

5.3.3. Summary

The newest legislation which specifically deals with climate change is the Saint Lucia National Climate Change Policy and Adaptation Plan 2003. One of its broad policy objectives is to 'foster the development of processes, plans, strategies and approaches to avoid or minimise the negative impact of climate change on human health' (MPDEH, 2003). In the last decade various internal and external factors have affected the Saint Lucian economy. For instance, once there are diseases in banana crops there will be a reduction in production that affects livelihoods/health of those in the agricultural sector that are involved in banana cultivation (11.4% of the population employed in the sector) (Trotman *et al.*, 2009). High oil prices and trade liberalization (Trotman *et al.*, 2009), as well as high external debt (averaging at 40% of the GDP (Karfakis *et al.*, 2011)) also makes Saint Lucia very vulnerable. A greater focus and more research is required for the development of appropriate environmental, agricultural and trade policies (Trotman *et al.*, 2009).

One of the most relevant issues that may be impacting health in Saint Lucia is poverty. In the Trade Adjustment and Poverty in Saint Lucia Report (2005/06) it states that poorer persons are less likely to report illnesses than persons from non-poor communities (KCL, 2007). This creates a challenge to fully address the various health problems in such communities that need the most assistance. One means of addressing the high level of poverty has been through the development of the Saint Lucia Social Investment Fund which was borne out of a merging of two other programmes, namely the Poverty Reduction Fund and the Basic Needs Trust Fund. The aim of this fund is to "serve as a delivery mechanism for the provision of basic infrastructure and services to poor and marginalized communities and groups in an efficient, responsive and accountable manner" (MOF, 2008). Combined with the dependence on importation and an environment susceptible to hurricanes and other natural disasters, the ability of Saint Lucia to adapt to climate change will also depend on food security which is an important aspect of the well-being of the population. In terms of managing vector borne diseases, limited financial resources or improper allocation of resources will impair the ability of the government to effectively address the challenges that are presented with dengue and malaria outbreaks. Positive areas of note in the health sector that add to its resilience include emergency services designed to help people cope with mental health and traumatic stress in times when there are disasters and associated disruptions (MOH, 2007), provision of information for forecasting of Extreme Heat Events (GOSL, 2010), and an air quality monitoring unit (MOF, 2008) proposed in the 2008 budget speech.

Finally, one of the most recent climate change initiatives in Saint Lucia is the Pilot Project on Climate Resilience which is part of the larger SPCR. In the health sector there are a number of climate initiatives. One such initiative outlines the need to "Facilitate (the) design and/or upgrading and implementation of national programmes for pest and disease control", which deals with the areas of vector and water borne disease monitoring as well as pest and disease monitoring inclusive of invasive species. Also related is the "Climate Change and Vector Control - Short-Term Rodent Control Project" which aims to educate the population on rodents, reduce rodent populations and transfer the responsibility of the programme to village councils to ensure its sustainability. Another project that has been proposed is the "Effective Surveillance and Control of Schistosomiasis in Saint Lucia" which specifically seeks to address the absence of active surveillance or a control programme in the country. The project will determine the prevalence of the disease on the island, map vulnerable areas and train personnel in the identification and surveillance of the vector. Another specific project has been designed to address issues related to water quality through the project entitled "Enhancing the Water Quality Surveillance Programme of the Department of Environmental Health". This will be affected through training, as well as the procurement of equipment for water testing. One final multifaceted project entitled "Mitigating the Mental Health Impacts of Climate Change and Climate Variability In Saint Lucia" aims to identify the key mental health impacts related to climate change events on the island and assess their implications, as well as to identify ways to help individuals and communities mitigate and adapt to this social problem (MFEAND, 2011).

5.4. *Agriculture and Food Security*

5.4.1. Policy

A review of the agricultural policies in Saint Lucia (MALFF, 2011) shows that the major policy provisions for the sector focuses on agricultural diversification, enhancing food security and promoting competitiveness. The Government's agricultural plans are to significantly reduce the food trade deficit, increase consumption of local produce by nationals and by the tourism sector, to introduce new crops for export, and organically grown commodities. Agricultural policy areas and objectives do not specifically address climate change issues. However, the Saint Lucia National Climate Change Policy and Adaptation Plan (MPDEH, 2003b) outline specific strategies and action plans for agriculture:

- Establish a system for improved monitoring and research of relevant agricultural processes; to determine the effects of climate change on agricultural resources.
- Develop a climate change strategy for agriculture to respond to likely impacts on agriculture.

While it is difficult to ascertain the degree to which these strategies have been implemented, the Water Management Plan for Drought Conditions, National Action Plan and the Strategic Action Plan to combat land degradation and drought, and the Saint Lucia National Land Policy Green Paper all provide a supporting framework for the achievement of these goals. The latter documents address issues that are specific to climate change adaptation and mitigation. There have also been a number of initiatives aimed at promoting land reform and making land available to poor farmers in Saint Lucia. While these measures were intended to boost agricultural production and enhance food security, many farmers have not capitalised on the terms of their lease-purchase agreements, and only a small number of intended beneficiaries have actually become owners.

5.4.2. Technology

One of the activities of the EU-funded AGIL project (2009) was to assess the training and information needs of banana and non-banana farmers. A significant result of this study is that farmers are mostly unaware of the type of soil of their farms, and a large share has no access to sustainable crop alternatives at all. Undoubtedly, this is one of the reasons why current agricultural production is at sub-optimal level, because knowledge of soil features and sustainable crop production reflects on yields. The study also suggests that about less than half of all farmers in Saint Lucia have access to current agricultural technology. The needs assessment showed that farmers need training in crop growing technologies and marketing issues, especially in the Castries Rural district and Micoud.

In compliance with the UNFCCC technology transfer framework, a technology needs assessment for Saint Lucia was developed, and a number of technical responses to support adaptation options for agriculture were identified. These are illustrated in Table 5.4.1.

Table 5.4.1: Saint Lucia Technology Needs for Agriculture

ADAPTATION OPTION	TECHNOLOGY NEEDS
Changing land topography to improve water uptake, reduce run-off, and reduce soil erosion.	GIS technologies. Earth-moving equipment (graders, bulldozers, cranes etc). Meteorological monitoring equipment. Agricultural engineering technologies (contour terracing, deep plowing, windbreaks).
Introduction of salt tolerant crops	Seed material. Propagation facilities.
Hydroponics	Hydroponic production facilities. Information technologies.
Introduction of heat and drought tolerant crops and animals.	Research facilities. Seed and propagation material. Meteorological monitoring equipment. Artificial cooling technologies (air conditioning, fans etc).
Crop research	Laboratory research facilities and equipment. Human resource development. Information technologies.
Greenhouses	Improved greenhouse Technologies. Information technologies.
Improved pest and disease management	Environmentally friendly extermination and control material and equipment.
Irrigation systems	Dams and reservoirs. Water distribution systems (pipes, pumps, treatment facilities). Drip irrigation. Environmental agricultural engineering. Information technologies.

(Source: Adapted from Climate Change Technology Needs Assessment for Saint Lucia, n.d.)

5.4.3. Farmers' Adaptation - Initiatives and Actions

According to research supported by CARDI (2003) some farmers in Saint Lucia have a good understanding of farm ecology and use good agricultural practices, while others use practices that are detrimental to their land, to other natural resources, and the sustainability of their own farming. Most of the land under cultivation is on hillsides, and soil conservation techniques are infrequently used. Saint Lucian farmers use two main techniques for soil conservation; (1) engineering structures (i.e. building of terraces, stone barriers and walls, etc.) and (2) vegetative barriers or farming practices (i.e. protecting soil through soil and vegetative management using contour or vegetable hedges, grass barriers, mulching, or other practices).

Simpson (2003) in his evaluation of erosion control methods for Saint Lucia, found hedgerows were not used to mitigate against erosion and this is a basic measure to enhance soil conservation. His study also found that there was widespread use of fertilisers and pesticides, although very few farmers had done soil chemical analyses. Results showed that many of the farmers in Saint Lucia were unaware of the environmental impacts of using agro-chemicals on their farms.

The evidence here suggests that Saint Lucian farmers are in dire need of climate change sensitisation and adaptation training in order to improve and increase national agricultural outputs.

5.5. *Marine and Terrestrial Biodiversity and Fisheries*

Adaptation requires "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007). The adaptive capacity of ecosystems then is the property of a system to adjust its characteristics or behaviour to expand its coping range under existing climate variability or future climate conditions (Brooks and Adger, 2004). Despite global action to reduce GHG, climate change impacts on biodiversity are unavoidable due to climate inertia. Natural ecosystems have long demonstrated the ability to adapt to changes in their physical environment. The rate at which climatic change occurs may exceed the rate at which ecosystems can adapt. Furthermore, natural environments that are already stressed by human activities have compromised ability to cope with and to adapt to climate change. This adaptive capacity assessment thus considers the country's ability to conserve its biodiversity through managing sustainable resource use and the capacity to implement strategies to protect its natural environment.

Many small island states generally have low adaptive capacity for some of the same reasons that they tend to be highly vulnerable to climate change (i.e. small physical size, limited access to capital and technology, shortage of human and financial resources) (Mimura *et al.*, 2007). The ability of ecosystems to adjust to projected climatic changes depends not only on their inherent resilience but also on the ability of resource users to make required adjustments. By addressing shortcomings in the above indicators adaptive capacity can be built.

Six principles for adaptation have been identified by Natural England, the UK government's advisor on the natural environment. Many elements of these principles are neither new nor climate-change specific and so may be applied within the Caribbean context. The principles, not in order of priority, are outlined in Table 5.5.1.

Table 5.5.1: Biodiversity: Six Principles for Climate Change Adaptation
Conserve existing biodiversity
Reduce sources of harm not linked to climate
Develop ecologically resilient and varied landscapes
Establish ecological networks through habitat protection, restoration and creation
Make sound decisions based on analysis
Integrate adaptation and mitigation measures into conservation management, planning and practice

(Source: Hopkins *et al.*, 2007)

5.5.1. Policy

Laws for biodiversity conservation and fisheries management in Saint Lucia are found within 28 pieces of legislation from various sectors such as the Fisheries Act, Wildlife Protection Act, Forest, Water and Soil Conservation, Forestry Management Plan, The National Trust Act, The National Conservation Authority Act and the Litter Act. In 2004, the Government produced a National Environment Policy that links the various policies and programmes in the relevant sectors of economic and social development, thus providing a broad framework for environmental management.

As expressed in the National Climate Change Policy and Adaptation Plan, the Government recognises the vulnerability of its terrestrial, coastal and marine resources to climate change impacts and by extension the livelihoods of those who depend on them. As such, the National Climate Change Committee (NCCC), in collaboration with other stakeholders, has outlined policy directives in order to address these impacts. Directives include a commitment to improving environmental monitoring and data collection, ecosystem restoration, development of a comprehensive land use management plan, and the exploration of alternative resource uses.

At the international level the country is signatory to 14 regional and international MEA that pertain to biodiversity including; CITES, Convention on Biodiversity (CBD), UN Framework on Climate Change (UNFCC), Ramsar Convention on Wetlands, Convention to Combat Desertification (CCD).

Often the failure to uphold MEAs results from a lack of supporting legislation at the national level. The Government of Saint Lucia has recognised the need to integrate biodiversity issues into the national agenda and has taken steps towards this end (Table 5.5.2).

Table 5.5.2: Extent of Integration of Biodiversity Issues into Saint Lucia's National Agenda

Policies and Strategies	Programmes and Plans	Biodiversity and Business
• Millennium Development Goals • NEP/NEMS • Climate Change Adaptation Policy • National Water Policy • National Land Policy • Saint Lucia Forest Sector Policy (draft) • Agricultural Sector Policy and Strategy • Saint Lucia Heritage Tourism Programme (SLHTP) Charter	• National Vision Plan • Systems Plan of Protected Areas (SPPA) – OPAAL project • Coastal Zone Management (CZM) Strategy and Action Plan • UNCCD National Action Plan (NAP) • Integrated Water and Coastal Zone Management Sustainable Energy Policy & Action Plan • Renewable energy in MALFF • Disaster Management Plans • Sustainable Land Management Project	• Environmental Management Systems - Green globe certification - Fair Trade, GAPs, LEAP - ISO 14000 • Sustainable Tourism Protocol under the ACS

(Source: Government of Saint Lucia, 2009)

5.5.2. Management

A nation's adaptive capacity is greater if the roles and responsibilities for implementation of adaptation strategies are well delineated by central governments and are clearly understood at national, regional, and local levels (Burton, 1996). In Saint Lucia, several inter-sectoral committees are responsible for the over-sight of national legislation with regards to environmental management as well as the various MEAs and conventions that pertain to managing biodiversity. For example, since 1995, the Department of Fisheries of the Ministry of Agriculture, Fisheries and Forestry has implemented an on-going beach profiles monitoring programme and in collaboration with NGOs the Department also monitors coral reef health. The Department of Forest and Lands oversees the management of terrestrial biota and the Conventions and Agreements Committee was established to assist the Ministry of Agriculture, Forestry and Fisheries comply with the obligations of MEAs including those that pertain to biodiversity. The Fourth National Report to the CBD states that there is a strong network between these various agencies as well as with regional and international agencies. However, coordination of efforts among said agencies needs to be improved for more effective biodiversity management.

Enforcement of regulations is at times still a constraint to protecting the island's biodiversity. For example, illegal sand mining is an on-going problem on the Grande Anse beach, although this area is part of a Marine Reserve. Similarly, illegal fishing gear is still used to harvest fish and lobster. One of the major challenges to all ecosystems in Saint Lucia results from improper land use; habitat destruction, soil erosion, sedimentation and chemical pollution are drivers of ecosystem degradation that the Ministry of Agriculture, Lands, Forestry and Fisheries is still challenged to manage.

Biodiversity is a cross-cutting theme relevant to all sectors of a country's development; therefore, the Environmental Impact Assessment (EIA) is an important tool to help decision-makers plan and implement projects in such a way so as to have minimal negative impacts on the environment and should take into consideration a projects impact on biodiversity. Under the Physical Planning and Development Act, EIAs are carried out "when deemed necessary" by the Head of the Division. The use of EIAs in Saint Lucia is increasing and the process is becoming more consultative, soliciting the participation of the public. Nevertheless, implementation of EIAs is at times insufficient due to shortcomings in resource availability, political will and overarching institutional arrangement. Furthermore, monitoring of development projects during and after activities have commenced, but is still weak (Government of Saint Lucia, 2009a).

Despite the fact that the various environmental stressors that currently exist are largely a result of human activity, there is an ethos of biological conservation and awareness among the population. This is evident by the cooperation of persons in a number of community-participation management projects. For example, co-management of mangrove stands was tested on the Mankoté mangrove swamp by entrusting management of the swamp to the charcoal harvesters, a poor group who were putting heavy pressure on the resource. These charcoal producers were involved in the development of a management plan for the swamp and were responsible for monitoring the quantity of charcoal produced, and trends in the size and abundance of mangrove trees harvested. Collaborative management has also been the approach used in the white sea urchin fishery, the Organic Farmers Association and Latanye broom makers.

Figure 5.5.1: Painting of the Saint Lucia Parrot and the Pitons.
The national bird of Saint Lucia is a symbol of resilience and success against the odds. The Pitons and the surrounding areas at Soufriere is a UNECSO World Heritage Site
(Source: Christopher Cox, http://fineartamerica.com/featured/st-lucia-parrot-and-pitons-christopher-cox.html)

Saint Lucia can also boast of its success in conserving the *Amazon versicolor,* Saint Lucia Parrot (Figure 5.5.1). Through legislative action, designated reserves, education and awareness campaigns, and a captive breeding programme, this once endangered species, although still considered vulnerable, has returned from the verge of extinction. This and the above examples attest to the effectiveness of public participation and co-management when there is wide acceptance by the government and its people. These methods should be utilised in other areas of biodiversity management and conservation and Saint Lucia can serve as a model for other SIDS. Table 5.5.3 summarises the status of the 22 programmes and projects that were outlined in the first National Biodiversity Strategic Action Plan (NBSAP).

Table 5.5.3: Summary of Projects Proposed for Implementation under the Saint Lucia NBSAP

Project/program	Status
Policy, Institutional and Legislative Review	Biodiversity, biosafety, environment and other relevant policy and legislation drafted.
Identification and selection of methods, tools, baseline variables, indicators and parameters needed for effective monitoring	Some progress was made on this under the Biodiversity Enabling Project, by analysing the ongoing monitoring programmes and making recommendations for improvements, including identification of appropriate indicators
Comprehensive inventory of terrestrial biological resources	Conducted in large part under the National Forest Demarcation and Bio-Physical Resource Inventory Project (2009).
Inventory of marine and coastal biodiversity	Some work in this area has been done under the OECS Protected Areas and Associated Livelihood (OPAAL) Project (2010), biodiversity studies conducted for the World Heritage Site 1998), and Coastal resource mapping (2009).
Assessment of the stocks of the Queen Conch (*Strombus gigas*)	This assessment was conducted to a large degree under an EU Project.
Assessment and management of wetlands	Some work in this area done under the National Forest Demarcation and Bio-Physical Resource Inventory Project (2009).
Assessment of freshwater biological resources	Freshwater biodiversity has not yet been comprehensively assessed
Inventory of biological resources of importance to agriculture	Some work has been carried by MALFF in terms of identification of biological resources of importance to agriculture and in situ conservation of germplasm.
Study and determination of the carrying capacity of critical areas used for tourism and recreation	project partially been undertaken by the Saint Lucia Nature Heritage Tourism Program with sites evaluated for tourism and recreation potential.
Design of standards and guidelines of behaviour in nature tourism sites and attractions	Standards have been developed by the Ministry of Tourism
Review of the national plan for a System of Protected Areas	Completed under the OPAAL Project.
The economics of biodiversity loss and conservation	A computer programme was developed by the World Resources Institute to determine the value of coastal and marine systems (beaches and coral reefs) for tourism and fisheries
Training	While a comprehensive approach to training for biodiversity management has not been developed, a number of relevant training exercises have been conducted.
Establishment of management programmes for the protection of the endemic and rare species of birds	Programmes exist for the Saint Lucia parrot and efforts are underway to protect other species, such as the white breasted thrasher.
Establishment of turtle monitoring programme	Turtle monitoring conducted at one site, but there is a need for expansion of this programme.
Establishment of a photographic and video graphic database on biodiversity	Done in part with the development of the national biodiversity database.
Education, public awareness and participation	Much has been done in this area, with several campaigns conducted to highlight biodiversity issues.

Project/program	Status
Upgrading of national herbarium, and creation of sub-collections	Herbarium has been updated.
Development of artificial habitats for coastal and marine resources	The Department of Fisheries is called on to examine structures as they become available for the use as artificial habitats. Procedures for examining these structures and determining appropriate sites for deployment have been developed and are being used by the Department of Fisheries
Evaluation of the medicinal and culinary properties of herbs	Under the Second Enabling Activity Project, selected commonly used herbs were surveyed to gain current knowledge of their use.
Promotion of organic farming	Organic Farmers Association established
Increasing and managing plant diversity for sustainable rural livelihoods	The Forestry Department has undertaken the propagation and cultivation of the Latanye and Mauby plants with training and technical assistance provided to community groups.

(Source: Government of Saint Lucia, 2009)

5.5.3. Protected Areas

The IUCN defines a protected area as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". Protected areas are globally recognised as one of the cornerstones of conservation because they not only protect key habitats and species, but can also be a tool for sustainable development since they preserve those natural resources that are vital to the socio-economic well-being of people (Dudley, 2008).

A number of areas in Saint Lucia have been reserved for protection and include Forest Reserves (Figure 5.5.2), Nature Reserves, Ramsar Sites, National Parks and Marine Reserves; in all a total of 104 km^2 (Triana and Acre, 2009). The Mankoté Mangrove and Savannes Bay are recognised as wetlands of International Importance, Ramsar Convention and the Pitons Management Area is a World Heritage Site. Management of reserves is entrusted to the Saint Lucia Forestry Department, Saint Lucia National Trust and the Saint Lucia Fisheries Department.

Forest reserves, particularly of rainforest ecosystems, are regarded as exceptionally well protected (Government of Saint Lucia, 2009a). An assessment of threats within these Reserves and on forested private lands revealed a lower number of major threats within the Reserve compared to the number of threats outside of the Reserve. This indicates that it is functioning well as a protected area (Daltry, 2009a). There are signs of species recovery, such as the Saint Lucia Parrot, within protected lands and as such the Government is seeking to increase the cover of Forest Reserves in attempt to redress biodiversity loss.

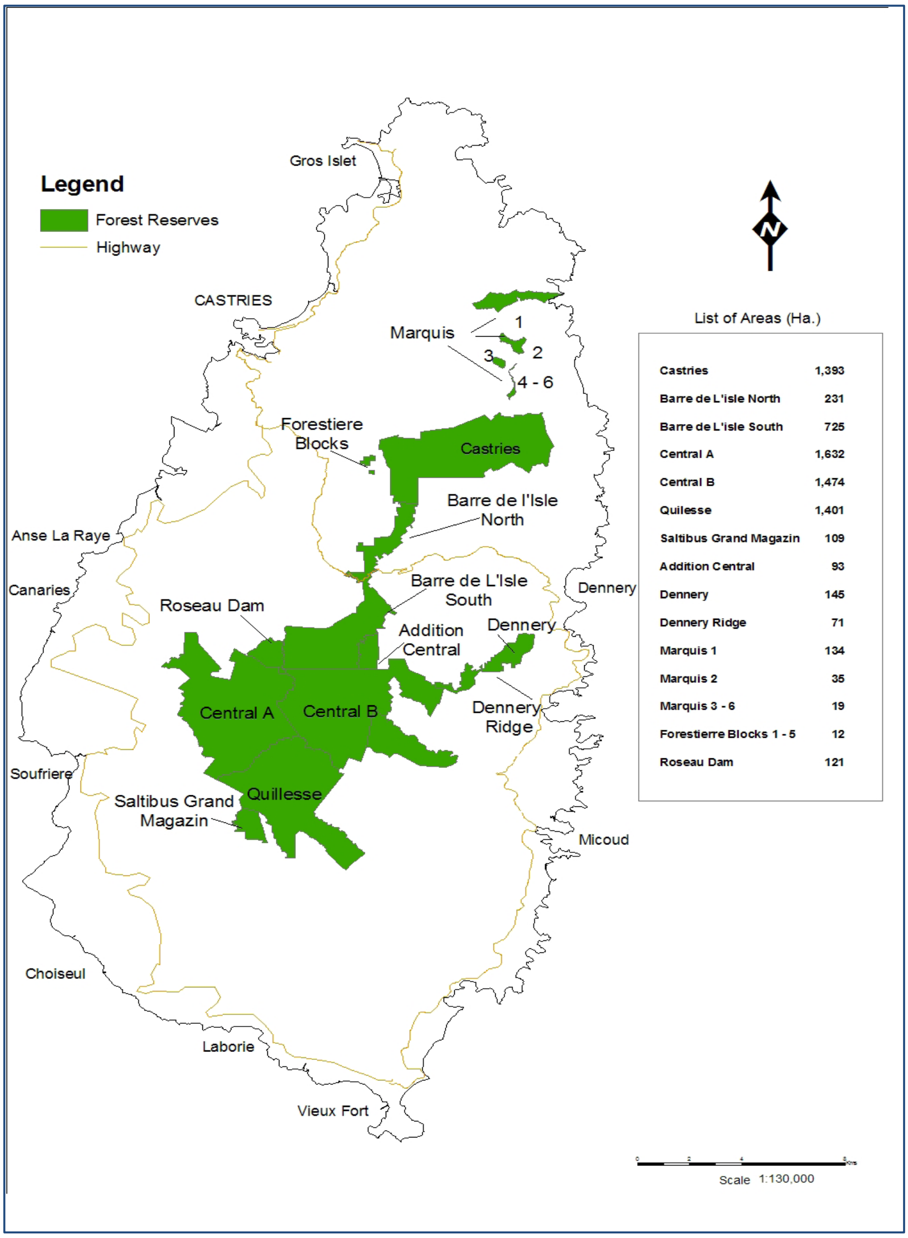

Figure 5.5.2: Forest Reserves of Saint Lucia

(Source: Forest and Lands Department 1996. Map produced by Forestry Department GIS Office)

The Soufriere Marine Management Area (SMMA) was set up in 1992 and was the first of its kind to be established in the Eastern Caribbean. Zones have been designated to protect marine life and simultaneously accommodate the activities of various resource users. Studies within Saint Lucia's SMMA have shown that no-take zones have allowed for increases in fish populations within the Marine Protected Areas (MPA), as well as on reefs outside of the MPA as a result of the "spill over effect" (Roberts *et al.*, 2001).

The Protected Area has the following designated zones:

- Marine Reserves: Areas of high ecological value set aside for the protection of all marine flora and fauna, scientific research, and the enjoyment of divers and snorkelers
- Fishing Priority Areas: Fishing takes precedence over all other activities.
- Recreational Areas: Important sites for public recreation.
- Multiple Use Areas: Fishing, diving, snorkelling, and other legitimate activities are allowed, once the general rules of the SMMA are observed.
- Yacht Mooring Areas: Moorings have been provided for visiting yachts.

Figure 5.5.3: Soufriere Marine Management Area Zonation

(Source: SMMA, 2010)

5.5.4. Technology

A high degree of access to technology at various levels (i.e. from local to national) and in all sectors may potentially play a significant role in biodiversity adaptation to climate change (Burton, 1996). To this end, the Government of Saint Lucia has established a Science and Technology Division within the government's Central Planning Unit (CPU) to encourage the study and development of different fields related to the scientific and technological areas. Available finances and human resources limit access to advanced technology for many small islands states. The Saint Lucia National Trust, an organisation responsible for the wildlife, seabirds, rare plants, and geology on Pigeon, Fregate, and Maria islands, has recruited expertise to assist in the establishment of a GIS Unit. The Unit uses geospatial technology to integrate flora and fauna biodiversity inventory, forest inventory, land survey and IKONOS satellite imagery. Mapping of the country's resources provides support to environmental managers in the decision-making process with regards to the sustainable use and conservation of those resources.

The Climate Change Technology Needs Assessment Report (2004) for Saint Lucia has identified priority technologies for the island. Most recommendations included hard and soft technologies; the following are applicable to the biodiversity and fisheries sectors:

- Integrated coastal zone management
- Human resource development
- Information technologies
- Environmental engineering tools and techniques (beach nourishment, wetland reforestation, seawalls, revetments, bulkheads)
- Coastal monitoring equipment
- Meteorological monitoring equipment
- GIS hardware and software
- Remote sensing
- Satellite imagery
- Land-use planning
- Liquid and solid waste management equipment

5.6. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

Actions need to be taken to minimise infrastructure losses in vulnerable areas of Saint Lucia. The current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in economic losses for Saint Lucia and its people. Adaptations to minimise vulnerabilities in Saint Lucia will require revisions to development plans and investment decisions. These considerations must be based on the best available information regarding the specific coastal infrastructure and ecosystem resources along the coast, in addition to the resulting economic and non-market impacts.

There are three main types of adaptation policies that can be implemented to reduce the vulnerability of the tourism sector in Saint Lucia to SLR and improve the adaptive capacity of the country: (1) Hard engineering defences and (2) soft engineering defences, which both aim to protect existing infrastructure and the land on which the infrastructure is built, as well as (3) retreat policies, which aim to establish setbacks and thereby move people and/or infrastructure away from risk. A summary of examples for each of the three types of adaptation polices are provided in Table 5.6.1, along with a summary of select advantages and disadvantages of each. Adaption options discussed in this report should be implemented in the framework of an integrated coastal zone management and all decisions need to take into account the broad range of stakeholders involved in decision-making in the coastal zone. Adaptations should benefit coastlines in light of both climate and non-climate stresses and adaptations will be promoted as a process towards an integrated coastal zone management rather than an endpoint (Linham and Nicholls, 2010).

Table 5.6.1: Summary of Adaptation Policies to Reduce the Vulnerability of Saint Lucia to SLR and SLR-Induced Beach Erosion

Protection Type	Advantages	Disadvantages
Hard Engineering Defences		
Dikes, levees, embankments[1, 2]	- Prevents inundation	- Aesthetically unpleasing - Can be breeched if improperly designed - Can create vulnerabilities in other locations (e.g. further erosion downward from the dikes) - Expensive - Requires ongoing maintenance
Groynes[3, 4]	- Prevents erosion	- Aesthetically unpleasing - Can increase erosion in other locations (e.g. stops longshore drift and traps sand) - Expensive
Revetments[3, 4]	- Prevents inundation - Less unwanted erosion than seawalls or levees	- Aesthetically unpleasing - Expensive - Requires ongoing maintenance and/or replacement (temporary)
Seawalls[3, 5]	- Prevents inundation - Good for densely developed areas that cannot retreat	- Aesthetically unpleasing - Can be breeched if improperly designed - Can create vulnerabilities in other locations (e.g. further erosion adjacent from seawalls, reflect waves causing turbulence and undercutting) - Expensive - Requires ongoing maintenance - Scouring at the base of the seawall can cause beach loss in front of the wall
Structure Redesign (e.g. elevate buildings, enforce foundations)[6, 7]	- Less environmentally damaging compared to large scale defenses - Can be completed independently of centralised management plans	- May be technologically unfeasible and expensive for larger buildings and resorts - Only protects the individual structure (not surrounding infrastructures such as roads)
Soft Engineering Defences		
Beach nourishment and replanting of coastal vegetation[2, 3, 8]	- Enhances slope stability - Reduces erosion - Preserves natural beach aesthetics - Provides protection for structures behind beach - Improves biodiversity and ecological health	- Can ruin visitor experience while nourishment is occurring (e.g. restrict beach access) - Can lead to conflict between resorts - Differential grain size causing differing rates of erosion (e.g. new sand vs. natural sand) - Difficult to maintain (e.g. nourishment needs to be repeated/replenished, unsuccessful plantings) - Will not work on open coastlines (i.e. requires locations where vegetation already exists)
Replant, restructure and reshape sand dunes[3, 8]	- Enhances slope stability - Reduces erosion	- Conflict among resort managers (e.g, 'sand wars') - Temporary (waves will continually move sand)
Retreat Policies		
Relocate settlements and relevant infrastructure[2, 9, 10, 11, 12]	- Guaranteed to reduce SLR vulnerability - Less environmental damage to coastline if no development takes place - Retains aesthetic value	- Economic costs (e.g. relocation, compensation) - Social concerns (e.g. property rights, land use, loss of heritage, displacement) - Coordination of implementation is challenging (e.g. timing of relocation is problematic) - Concerns with abandoned buildings

(Source: [1]Silvester and Hsu, 1993; [2]Nicholls and Mimura, 1998; [3]French, 2001; [4]El Raey *et al.*, 1999; [5]Krauss and McDougal, 1996; [6]Boateng, 2008; [7]Lasco *et al.*, 2006; [8]Hamm *et al.*, 2002; [9]Frankhauser, 1995; [10]Orlove, 2005; [11]Patel, 2005; [12]Barnett, 2005)

5.6.1. Technology – HARD Engineering

Hard engineering structures are manmade, such as dikes, levees, revetments and sea walls, which are used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. The capital investment needed for engineered protection is expensive and not ideal in sparsely populated areas. Unfortunately, the effectiveness of this approach may not withstand the test of time nor withstand against extreme events. Protective infrastructure not only requires expensive maintenance, which can have long-term implications for sustainability, but adaptations that are successful in one location may create further vulnerabilities in other locations(IPCC, 2007b). For example, sea walls can be an effective form of flood protection from SLR, but scouring at the base of the seawall can cause beach loss, a crucial tourism asset, at the front of the wall (Krauss and McDougal, 1996). Moreover, hard engineering solutions are of particular concern for the tourism sector because even if the structures do not cause beach loss, they are not aesthetically pleasing, diminishing visitor experience. It is important for tourists that sight lines to the beach not only be clear, but that access to the beach is direct and convenient (i.e. to not have to walk over or around a long protective barrier). Smaller scale hard engineering adaptations offer an alternative solution to large scale protection. Options include redesigning structures to elevate buildings and strengthen foundations to minimise the impact of flooding caused by SLR.

5.6.2. Technology – SOFT Engineering

Protection can be implemented through the use of soft engineering methods which require naturally formed materials to control and redirect erosion processes. For example, beaches, wetlands and dunes have natural buffering capacity which can help reduce the adverse impacts of climate change (IPCC, 2007b). Through beach nourishment and wetland renewal programmes, the natural resilience of these areas against SLR impacts can be enhanced. Moreover, these adaptation approaches can simultaneously allow for natural coastal features to migrate inland, thereby minimizing the environmental impacts that can occur with hard engineering protection. Replenishing, restoring, replanting and reshaping sand dunes can also improve the protection of a coastal area, as well as maintain, and in some cases improve, the aesthetic value of the site. Although less expensive and less environmentally damaging, soft engineering protection is only temporary. For example, the on-going maintenance required to upkeep sand dunes, such as sand replenishment schemes, will create the periodic presence of sand moving equipment, subsequently hindering visitor experience (e.g. eye and noise pollution, limit beach access, etc.). Conflicts can also arise between resort managers resulting in ‘sand wars’, whereby sand taken to build up the beach at one given resort may lead other resorts to ‘steal’ sand and place it on their own property.

5.6.3. Policy

Managed retreat is an adaptation measure that can be implemented to protect people and new developments from SLR. Implementing setback policies and discouraging new developments in vulnerable areas will allow for future losses to be reduced. Such an adaptation strategy raises important questions by local stakeholders as to whether existing land uses, such as tourism, should remain or be relocated to adjust to changing shorelines (e.g. inundation from SLR) (IPCC, 2007b). Adaptation through retreat can have the benefit of saving on infrastructure defence costs (hard and soft engineering measures) while retaining the aesthetic value of the coast, particularly in those areas that are uninhabited (i.e. little to no infrastructure or populations along the coast). The availability of land to enable retreat is not always possible, especially in highly developed areas where roads and infrastructures can impede setbacks or on small islands where land resources are limited.

For many tourist destinations in the Saint Lucia, retreat is both difficult in terms of planning (and legally challenging) and expensive to implement. Resorts and supporting tourism infrastructure are large capital investments that cannot be easily uprooted to allow the sea to move inland. If the resorts cannot be moved, then the alternative is to leave them damaged and eventually abandoned, degrading the aesthetics of the destination coastline. It is important that the retreat policy be well organised, with plans that clearly outline the land use changes and coordinate the retreat approach for all infrastructures within the affected areas. Additional considerations of adaptation through retreat include loss of property, land, heritage, and high compensation costs that will likely be required for those business and home owners that will need to relocate. Priority should be placed on transferring property rights to lesser developed land, allowing for setback changes to be established in preparation for SLR (IPCC, 2007b).

Coastal development in Saint Lucia is overseen by the Saint Lucian Coastal Zone Management Unit (CZMU). The establishment of the CZMU was established in 2005 within the Sustainable Development Section of the Ministry of Physical, Development Environment and Housing (Walker, 2006). The role of the CZMU is to serve as the Secretariat of the Coastal Zone Management Advisory Committee responsible for, amongst other things, proposing and formulating coastal zone related policies. The CZMU provides technical input and advice to relevant planning and management agencies on matters pertaining to coastal development and management (Walker, 2006). The CZMU is also responsible for the creation and enhancement of public awareness of coastal zone management issues and programmes.

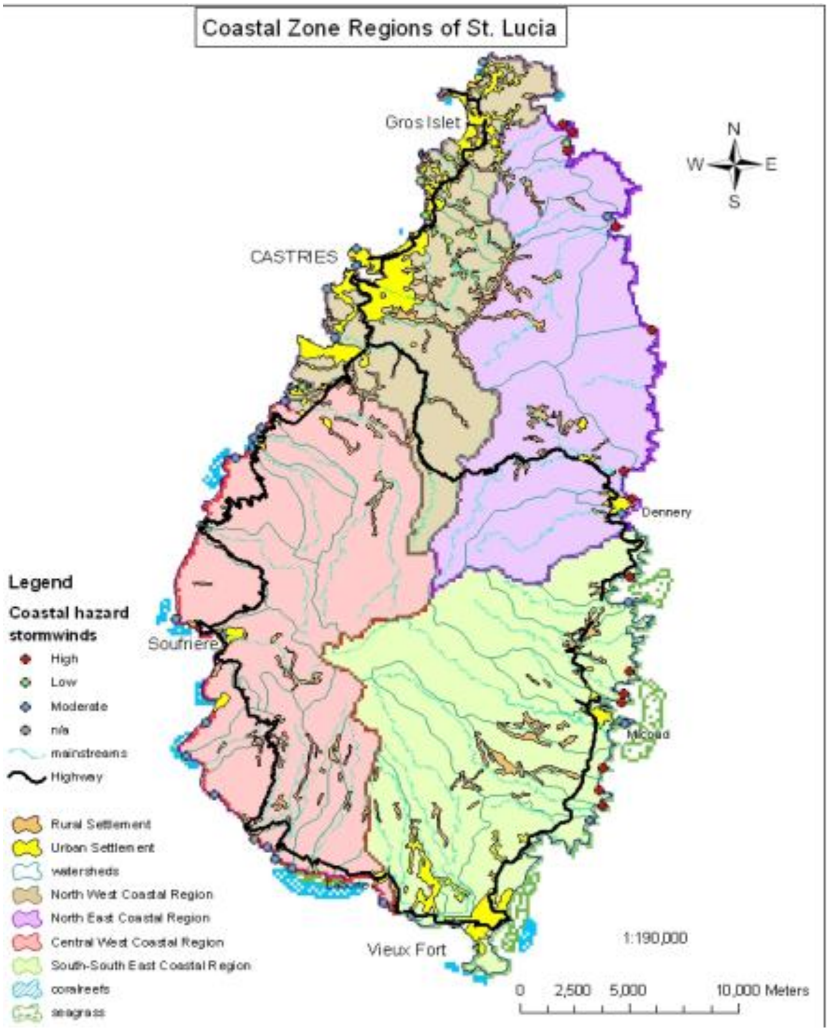

Figure 5.6.1: Coastal Zone Regions in Saint Lucia

(Source: Walker, 2006)

There are currently no institutional frameworks in place that require setbacks, nor frameworks that state what types of developments are allowed along particular areas of the coast. Despite efforts by the Saint Lucian Government to curb the deterioration of coastal and marine resources through the adoption and implementation of institutional arrangements, to date most of the development has been disorganised, unplanned and undirected (MPDEH, 2001).

The Government of Saint Lucia, through its continued commitment towards sustainable development, is working towards the development and implementation of the necessary institutional frameworks required for achieving sustainable development on the island (MPDEH, 2001). A key policy undertaken is the Saint Lucia National Climate Change Policy and Adaptation Plan, recognizing the island's vulnerability to climate change and global warming, especially with regard to SLR. This policy aims to "foster and guide a national process of addressing the short, medium and long term effects of climate change in a coordinated, holistic and participatory manner" (MPDEH, 2001).

5.7. *Comprehensive Natural Disaster Management*

Adaptive capacity can be measured through examination of policies and plans implemented for the management of disasters, as well as the actions taken following a disaster. Being able to reduce the impacts of natural disasters on a small island nation is often difficult, especially when facing major hazard threats on a regular basis. The post-disaster time period is a time when extra resources are needed to finance imports of food, energy, and inputs for the agricultural and manufacturing sectors. As a result, efforts to build resilience or adaptive capacity gets put aside while immediate survival, shelter and health needs are prioritised, along with the remedy of hazardous living conditions.

5.7.1. Management of Natural Hazards and Disasters

The disaster management system can be thought of as a cycle where preparedness, mitigation[3] and adaptation activities (disaster prevention) are the focus prior to a disaster impact. Following an impact, the management focus becomes response, recovery and reconstruction (disaster relief). These two parts of the disaster management system work together and also impact the broader social, economic, ecological and political system (see Figure 5.7.1).

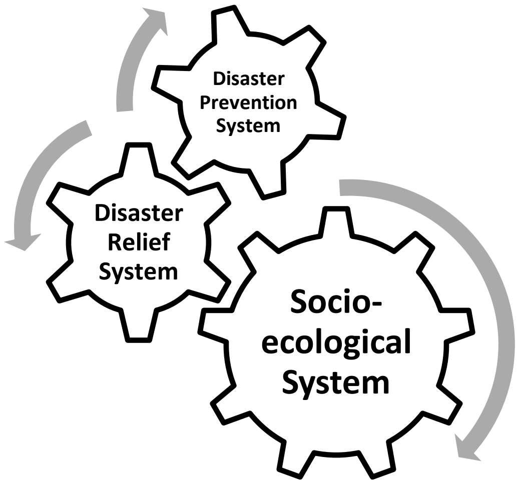

Figure 5.7.1: Relationship of the Disaster Management System and Society

Caribbean disaster management and climate change

As a region, the Caribbean has made coordinated efforts to prepare for and respond to disasters. The Caribbean Disaster Emergency Management Agency, CDEMA, (previously the Caribbean Disaster Emergency Response Agency, CDERA) was created in 1991. CDEMA plays a leadership role in disaster response, mitigation and information transfer within the region, operating the Regional Coordination Centre during major disaster impacts in any of their 18 Participating States, while also generating useful data and reports on hazards and climate change. The primary mechanism through which CDEMA has influenced national and regional risk reduction activities is the Enhanced CDM Strategy (CDEMA, 2010). The primary purpose of CDM is *to* strengthen regional, national and community level capacity for *mitigation*, *management*, and *coordinated response* to natural and technological hazards, and the effects of climate change (CDEMA, 2010) (*emphasis added*).

[3] In the disaster management literature, 'Mitigation' refers to strategies that seek to minimise loss and facilitate recovery from disaster. This is contrary to the climate change definition of mitigation, which refers to the reduction of GHG emissions.

This regional disaster management framework is designed to inform national level disaster planning and activities but also takes into consideration potential climate change impacts in its resilience building protocols. The four Priority Outcomes of the CDM framework are:

1. Institutional capacity building at national and regional levels;
2. Enhanced knowledge management;
3. Mainstreaming of disaster risk management into national and sector plans; and
4. Building community resilience.

These outcomes have been further broken down into outputs that assist in the measurement of progress towards the full implementation of CDM at the national and community level and within sectors (see Table 5.7.1). The CDM Governance Mechanism is comprised of the CDM Coordination and Harmonization Council and six (6) Sector Sub-Committees. These sectors include – *Education, Health, Civil Society, Agriculture, Tourism and Finance.* These six sectors have been prioritised in the Enhanced CDM Strategy as the focus during the period from 2007 to 2012. CDEMA facilitates the coordination of these committees (CDEMA, 2010).

To address disaster management in the Caribbean tourism sector, CDEMA, with the support of the Inter-American Development Bank (IDB) and in collaboration with the Caribbean Tourism Organization (CTO), CARICOM Regional Organization for Standards and Quality and the University of the West Indies will be implementing a Regional Disaster Risk Management (DRM) Project for Sustainable Tourism (The Regional Public Good) over the period of January 2007 to June 2010. The project aims to reduce the Caribbean tourism sector's vulnerability to natural hazards through the development of a '*Regional DRM Framework for Tourism'*. Under the Framework, a '*Regional DRM Strategy and Plan of Action'* will be developed, with a fundamental component being the development of standardised methodologies for hazard mapping, vulnerability assessment and economic valuation for risk assessment for the tourism sector (CDERA, 2007; CDERA, 2008).

Finally, the link between CDM and climate change cannot be ignored. Projections for the region suggest that more extreme temperatures and more intense rainfall in certain seasons could lead to a greater number of hydro-meteorological disasters. Many of the hazards facing Caribbean countries already pose threats to lives and livelihoods and climate-related events are regular occurrences. This has been recognised with the mention of climate change in the CDM strategy. The CCCRA report will not only offer improvements to the existing disaster management framework in the region, but will also offer pragmatic strategies for action which will build resilience in the Caribbean to the predicted impacts from climate change (see herein, sector reports on Climate Modelling, Water Quality and Availability, Marine and Terrestrial Biodiversity and Fisheries, Community Livelihoods, Gender, Poverty and Development, Human Health, Energy Supply and Distribution, Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements).

Table 5.7.1: Enhanced Comprehensive Disaster Management Programme Framework 2007-2012

<table>
<tr><td colspan="4">GOAL
Regional Sustainable Development enhanced through Comprehensive Disaster Management</td></tr>
<tr><td colspan="4">PURPOSE
To strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change.</td></tr>
<tr><td>OUTCOME 1:

Enhanced institutional support for CDM Program implementation at national and regional levels</td><td>OUTCOME 2:

An effective mechanism and programme for management of comprehensive disaster management knowledge has been established</td><td>OUTCOME 3:

Disaster Risk Management has been mainstreamed at national levels and incorporated into key sectors of national economies (including tourism, health, agriculture and nutrition)</td><td>OUTCOME 4:

Enhanced community resilience in CDERA states/ territories to mitigate and respond to the adverse effects of climate change and disasters</td></tr>
<tr><td>OUTPUTS

1.1 National Disaster Organizations are strengthened for supporting CDM implementation and a CDM program is developed for implementation at the national level

1.2 CDERA CU is strengthened and restructured for effectively supporting the adoption of CDM in member countries

1.3 Governments of participating states/ territories support CDM and have integrated CDM into national policies and strategies

1.4 Donor programming integrates CDM into related environmental, climate change and disaster management programming in the region.

1.5 Improved coordination at national and regional levels for disaster management

1.6 System for CDM monitoring, evaluation and reporting being built</td><td>OUTPUTS

2.1 Establishment of a Regional Disaster Risk Reduction Network to include a Disaster Risk Reduction Centre and other centres of excellence for knowledge acquisition sharing and management in the region

2.2 Infrastructure for fact-based policy and decision making is established /strengthened

2.3 Improved under-standing and local /community-based knowledge sharing on priority hazards

2.4 Existing educational and training materials for Comprehensive Disaster Management are standardized in the region.

2.5 A Strategy and curriculum for building a culture of safety is established in the region</td><td>OUTPUTS

3.1 CDM is recognized as the roadmap for building resilience and Decision-makers in the public and private sectors understand and take action on Disaster Risk Management

3.2 Disaster Risk Management capacity enhanced for lead sector agencies, National and regional insurance entities, and financial institutions

3.3 Hazard information and Disaster Risk Management is integrated into sectoral policies, laws, development planning and operations, and decision-making in tourism, health, agriculture and nutrition, planning and infrastructure

3.4 Prevention, Mitigation, Preparedness, Response, recovery and Rehabilitation Procedures developed and Implemented in tourism, health, agriculture and nutrition, planning and infrastructure</td><td>OUTPUTS

4.1 Preparedness, response and mitigation capacity (technical and managerial) is enhanced among public, private and civil sector entities for local level management and response

4.2 Improved coordination and collaboration between community disaster organizations and other research/data partners including climate change entities for undertaking comprehensive disaster management

4.3 Communities more aware and knowledgeable on disaster management and related procedures including safer building techniques

4.4 Standardized holistic and gender-sensitive community methodologies for natural and anthropogenic hazard identification and mapping, vulnerability and risk assessments, and recovery and rehabilitation procedures developed and applied in selected communities.

4.5 Early Warning Systems for disaster risk reduction enhanced at the community and national levels</td></tr>
</table>

(Source: CDEMA, 2010)

Climate Change and Disaster Management in Saint Lucia

In 2008 the World Bank the IDB, under the Strategic Climate Fund (SCF), approved the PPCR. This programme will pilot new development approaches in 6 of the most vulnerable islands of the Caribbean, of which Saint Lucia is included (World Bank and the Inter American Development Bank, 2011). In Saint Lucia in May 2011, there was a second Joint Mission which advised the Sustainable Development and Environment Division of the need to define goals that are in line with the broader project goals of this World Bank initiative in the country (World Bank and the Inter American Development Bank, 2011). The Government of Saint Lucia has already taken initiative in requesting participation in the Regional Disaster Vulnerability Reduction Project; a project that will allow the integration of goals and outcomes with the PPCR (World Bank and the Inter American Development Bank, 2011). This mission also identified key partners in the private sector, especially the hotel and tourism sector, recognising the great importance of involving these sectors in the design and implementation of an adaptation plan under the PPCR.

As a final outcome of the Mission in Saint Lucia, 5 strategic programme areas were identified for the Saint Lucia Strategic Program for Climate Resilience (SPCR):

1. Human Welfare and Livelihood Protection;
2. Integrated Natural Resource Protection, Conservation and Management to Promote Sustainable Development;
3. Building Resilience through Business Development, Innovation and Productivity Enhancement;
4. Capacity Development/Building and Institutional/Organisational Strengthening;
5. Reducing Risk to Climate Disasters.

(World Bank and the Inter American Development Bank, 2011, p. 4)

The parallel sectors addressed in both the SPCR and this Risk Atlas is a positive indication of the relevance of climate change work in the Caribbean at this time. Also, the recommendations from this report will be able to inform national level discussions about specific actions under the strategic programme areas.

5.7.2. Policy

Disaster management activities are guided by policies on how to work in emergency situations, environmental policies and also housing and development policies. Saint Lucia has many such policies and generally these have been reviewed and updated in recent years.

The National Disaster Management Act (2006): Across the Caribbean, policies to adapt to and manage climate change impacts are becoming more common. The strong relationship between disasters and climate change create a policy arena where both issues can be managed under similar governance mechanisms. In Saint Lucia, the Disaster Management Act outlines the roles of the Director of NEMO as well as the composition of the National Emergency Management Advisory Committee (NEMAC) (Government of Saint Lucia, 2006). The Act also sets out the guidelines for shelter operations in emergency situations and defines the roles of the persons working in the EOC and identifies the circumstances and protocol for evacuation (Government of Saint Lucia, 2006). The contents of the Act are fairly standard and are supported by many plans that were developed with assistance from consultants from the World Bank/OECS Emergency Recovery and Disaster Management Project. This assistance has proven helpful in creating disaster management policies that involve many important sectors and actors and the documents to support present decision making are well written and include many lessons learnt from major global disaster events.

In addition to this Act, Saint Lucia has enacted many policies and plans as a means to ensure hazards and disasters are well managed and to prepare the various sectors of the economy to act reasonably and responsibly during, and in preparation for, times of emergency. Table 5.7.2 highlights the national, sectoral and event-specific plans and policies that exist (as of 2006). It is notable that plans have been developed for many different types of hazards and also that different sectors have their own specific plans that address the unique conditions and challenges that face individual sectors. However, more work could be done to encourage those sectors to 'mainstream' DRR into the sector operations. For example, the Hospitality Industry Crisis Management Plan does exist and is quite well written. However, on the admission of one tourism official it was found that no real policy or plan is in operation within the sector. Furthermore, efforts made to incorporate CDM into the tourism industry has been limited to consultation during meetings, which has yet to lead to any real progress on DRR within tourism businesses (M. Andrew, personal communication, April 14, 2011). If this is a trend across all sectors, it indicates that NEMO must do more work nationally to communicate the importance of DRR with sectors. Also, NEMO and relevant sector stakeholders must examine which steps to 'mainstream' DRR into their policies, plans and operations are needed.

Nevertheless, it is an achievement that Saint Lucia has plans for hazards other than naturally occurring events, because of the prevalence of technological and human-induced emergencies is increasing globally. Also, the acknowledgement for the need to manage health concerns associated with disasters is commendable since many countries leave the detail of sanitation management out of the national policies; a decision which can lead to serious health challenges in the days, weeks and months following the disaster. For example, we are still seeing the impacts of poor sanitation management in Haiti, more than a year after their major earthquake disaster (please see Section 4.3, Human Health for more detail on health and climate change issues).

Table 5.7.2: Saint Lucia National Emergency Management Plan

Name of section	Name of Sub-section
Policies and Guidelines	
	Donations and Importation of Relief Supplies Policy
	Emergency Housing Policy
	Emergency Shelter Management Policy
	Mitigation Policy
	Travel Policy
	Management and Disposal of Dead Bodies in Disasters Policy
National Emergency Plans	
	The Saint Lucia National Hurricane Plan
	The Saint Lucia National Volcanic Eruption Response Plan
	The Saint Lucia National Mitigation Plan
	The Saint Lucia National Flood Plan
	The Saint Lucia National Earthquake Response Plan
	The Saint Lucia Oil Spill Contingency Plan
	The Saint Lucia Stress Response Team Plan
Sectoral Plans	
	The Ministry of Communications, Works, Transport and Public Utilities Plan
	The Saint Lucia National Emergency Health Sector Plan
	The Saint Lucia Private Sector Response Plan
	The Hospitality Industry Crisis Management Plan
Specific Plans	
	Mass Crowd Events Plan
	Model Plan for the District Disaster Committees in Saint Lucia
	Plan for Evacuation of Anse La Raye
	The Port Authority Cruise Line Ships Plan
	The Saint Lucia Seaports Contingency Plan
	The Saint Lucia Prison Emergency Plan

(Source: NEMAC, 2006)

Environmental Impacts and Development Planning

Separate from the policies and plans for emergency management, environmental policies and plans can also affect a country's ability to sustain impact from, and respond to, disasters. Most often in communities around the world, a 'disaster' results when natural hazard events occur in areas where there is an absence of land-use planning, or as a result of poor development planning. Saint Lucia's Hazard Mitigation Plan includes a list of 'key measures' to assist in the achievement of the goals. These key measures make reference to the need for improved information and better communication across agencies and, more specifically, to the need to have land development follow hazard maps (NEMO: National Hazard Mitigation Council, 2003). The assistance NEMO has received from expert disaster management consultants in the development of their National Hazard Mitigation Plan is evident throughout the document. This external consultation process may bring with it a concern about the on-going capacity of those working at NEMO in relation to the reduction of vulnerability. This is not to say they are incapable, but rather to emphasise the need for on-going training and capacity building to ensure that those at NEMO are kept up to date on good practices.

The Ministry of Physical Planning and the Environment has set out planning guidelines that will address some natural hazards concerns. The requirement for set-backs from the high water mark on cliffs, slopes of varying degree inclines, and the use of buffers next to rivers and ravines indicate a recognition of the risk of flooding, storm surge and slope failures (landslide, debris flow, rock fall). The National Land Policy (MPDEH, 2007) also includes a section on Environment and Natural Resource Management, including Disaster Management, indicating that the vulnerability of communities to natural hazards is real in Saint Lucia and that planning and land use must take into account the diversity of risks present in each community. Further discussion of planning concerns can be found in the Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements section, and the use of protected areas is discussed in the Marine and Terrestrial Biodiversity and Fisheries section of this report).

The key measures in the Hazard Mitigation Plan also identify the need for the development of a building code for Saint Lucia. As a region, relevant groups are working hard toward the development and application of a Caribbean Building Code or Building Standards using the International Code Council (ICC) codes as the primary base documents with additional input from the Caribbean Uniform Building Code (CUBiC) and earlier assessments on wind load and seismic considerations. The Code has already been prepared and the next step is for each of the 15 states involved to review the documents and prepare their own CAD. This document will most likely be prepared by specialists who will determine how the regional code should be applied given each country's own peculiarities, for example some countries will focus more heavily on flooding and less on seismic considerations. The CAD will then be reviewed by all of the relevant stakeholders on the National Stakeholder Subcommittee who will provide comments before it is submitted to CARICOM (J. Platt, Barbados National Standards Institute, personal communication, May 4, 2011). Saint Lucia reported having updated their national building code in 1999 and in 2001 a draft was reported as being accepted by the Development Control Authority, including 12 building inspectors employed mainly in the monitoring of residential construction (Wason, 2002).

Catastrophe Insurance Coverage

Re-insurance within the Caribbean region has generally been provided by international insurance companies. However, the classification of the region as a catastrophe zone, thus being high risk, means that insurance premiums remain very high for those who seek insurance. The Caribbean is home to the first risk pooling facility designed to limit financial impacts of catastrophic hurricanes and earthquakes in Caribbean member countries, by providing short-term liquidity when the policy is triggered (CCRIF, 2011). Originally, the insurance index was based on degree of shaking during earthquakes or wind speed for hurricane events and the member country would qualify for a pay-out based on their policy and the level of damages deemed to be associated with either wind or shaking. Recently, the need to also consider water damages has been noted. As a result, the CCRIF has continued to make progress on an 'Excess Rainfall product' which is anticipated for the beginning of the 2011-2012 policy year starting on June 1, 2011 (CCRIF, 2011). This would mean that countries would qualify for pay-out to cover damages associated with flooding and heavy rains, whether associated with hurricanes/tropical storms or not. The impacts from Hurricane Tomas in Saint Lucia were quite severe and worse than what was experienced in Barbados. However, because of the policy terms and the fact that much of the impacts in Saint Lucia were a result of flooding, Saint Lucia received US $3,241,613, considerably less than the US $8,560,247 paid to Barbados where the damages were primarily a result of high winds (Young, 2010). This is one of the most recent cases that highlighted the need to review the insurance indices and consider the possibility of other impact indices (other than wind speed and degree of shaking).

5.7.3. Management of Disasters in Saint Lucia

The management of disasters and natural hazards in Saint Lucia falls under the control of NEMO. "[NEMO's] duty is to ensure the efficient functioning of preparedness, prevention, mitigation and response actions. The main responsibility of NEMO is to ensure that Saint Lucia is in a state of readiness at all times to meet the threat or impact of any hazard" (NEMO: National Hazard Mitigation Council, 2003). As a result, NEMO has created a National Hazard Mitigation Plan built on five foundation principles (NEMO: National Hazard Mitigation Council, 2003):

1. An understanding of the economic, physical, social and cultural development of Saint Lucia;
2. Objective analysis of resources, hazard experience, and risk;
3. Review of previous mitigation efforts and capabilities;
4. An analysis of hazard exposure revealed by the most recent disasters;
5. Financial resources are needed to effect the plan.

The Hazard Mitigation Plan and the National Emergency Management Plan provide the operational guidance through which the Disaster Management Act is implemented. In the execution of the plans and policies under the Disaster Management Act (see details in section 5.7.2 Policy), the Director of NEMO also has a set of 12 National Disaster Committees and 18 District Disaster Committees (Government of Saint Lucia, 2007). The National Disaster Committees are as follows:

1. Transportation Disaster Committee
2. Supply Management Disaster Committee
3. Telecommunications Disaster Committee
4. Damage Assessment and Needs Analysis Disaster Committee
5. Information Committee
6. Wellbeing Disaster Committee
7. Stress Response Team
8. Emergency Works Committee
9. Shelter Management Disaster Committee
10. Oil Pollution Action Committee (OPAC)
11. Hospitality Crisis Management Unit
12. Hazard Mitigation Council

District Disaster Committees are community led committees that play similar organisational roles during all types of disaster. As part of the network of disaster committees, they receive information about threats and help to mobilise the general public. Though this response function is important, the District Disaster Committees also have representatives on each of the National Disaster Committees in order to facilitate collaboration (Government of Saint Lucia, 2007).

Funding Post-Disaster Activities

There is a Rapid Needs Assessment Team (RNAT), led by CDEMA, who is deployed to the impacted state to conduct a Damage Assessment and Needs Analysis (DANA) (UNDP, 2011). The skilled assessment team provides a standard assessment procedure across many of the CDEMA Participating States. However, the DANA process is only executed upon the request of the impacted state. Therefore, the assessment information is not available following *every* disaster and as such, all disaster offices should also have the capacity to execute a post-disaster assessment on their own. Making use of CDEMA's coordination activities across multiple countries builds response capacity by taking advantage of the resources and personnel from neighbouring countries and thus can also enhance the response and reconstruction efforts.

Nevertheless, the need to incorporate the principles of 'building back better' must also be a priority so that the post-disaster context becomes an opportunity for building resilience and institutionalizing disaster risk reduction goals.

5.7.4. Technology

Technology in the field of disaster management can reduce vulnerabilities through structural protective structures, by way of policies that control or guide development, or through public education that would then change the behaviours that generate vulnerability.

Coastal Protection

In the Caribbean, investments in structural protection are often used to protect coastlines. The use of groynes, breakwaters and sea walls are popular methods to control coastal erosion processes and safeguard development from damaging wave actions. Although these structures do provide some relief, they generally offer only temporary benefits and sometimes also cause negative effects in other locations along the coast. Disaster management practices have also found that structural protection is very expensive and can sometimes worsen the impacts of a disaster when the size of the structure is incongruent with an event (e.g. sea wall structures, if broken or damaged, can add debris and exacerbate flooding and erosion). Further discussion of the structural responses to climate change and SLR and storm surge can be found in the Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements section.

Technology and Public Education

The research into Saint Lucia's disaster management system has identified several strengths in their policies and plans. Much like many other Caribbean islands though, the general public are not fully aware of the real threats they face from disasters or climate change. Improvements to public education and capacity building exercises would be worthwhile in all countries. A CDEMA earthquake protocol review workshop was held in Saint Lucia in March 2011 to review and revise Saint Lucia's existing plan according to the modern earthquake contingency plan from CDEMA (Government Information Service, 2011). Following a successful workshop, CDEMA's Senior Programme Officer Dr Clerveaux "feels that the country's preparedness can be further enhanced if the National Emergency Management Office (NEMO) undertakes serious public education campaigns among schools and community groups" (Government Information Service, 2011). In addition to including more natural hazard information in school curriculum, there are many ways to engage the general public in DRR (see 6.8 Comprehensive Natural Disaster Management).

Early Warning Systems

An EWS is commonly used in conjunction with an evacuation plan to guide at-risk persons to safety and avoid losses of life from natural hazard events. The use of an EWS is an effective communication tool only when the proper instrumentation for collection of the necessary weather data is present (i.e. rain gauges, tidal gauges, weather stations etc.). Saint Lucia, through a Japan International Cooperation Agency (JICA) project in the region, erected a Prototype Telephonic Rainfall EWS prior to the 2007 Hurricane season (Caribbean360, 2007). This system is linked to the evacuation procedures of the National Emergency Management Plan so that when the water gauges rise, the Meteorological Office can trigger an alarm and the network of disaster volunteers can quickly take action (Caribbean360, 2007).

5.8. *Community Livelihoods, Gender, Poverty and Development*

As part of the CARIBSAVE *Community Vulnerability and Adaptive Capacity Assessment* methodology, household surveys were conducted in the Soufriere community to determine household and community access to five livelihood assets (financial, physical, natural, social and human). Livelihood strategies (combinations of assets) are evaluated to determine the adaptive capacity of households and consequently communities.

A total of 26 respondents were surveyed, 11 of whom were male and 14 female. One respondent did not indicate their gender. There were 14 respondents from male headed households and 10 respondents from female headed households. Two respondents did not indicate the gender of their head of household.

5.8.1. Demographic Profile of Respondents

Residency in the Community

Overwhelmingly, respondents were long-time residents of Saint Lucia, with 84% (N= 21) of the sample indicating that they had lived in their community for over 20 years. Furthermore, female and male respondents displayed a similar distribution in the length of time spent in their communities.

Table 5.8.1: Length of Residency in Parish/Community

Residency	Male		Female		Total	
Less than one year	1	9.1%	0	0.0%	1	4.0%
1 - 5 years	1	9.1%	1	7.1%	2	8.0%
11 - 15 years	0	.0%	1	7.1%	1	4.0%
Over 20 years	9	81.8%	12	85.7%	21	84.0%

Age Distribution

The sample was evenly divided across age categories. However, when disaggregated based on sex of respondent, the males were generally older than the female respondents.

Table 5.8.2: Age Distribution of Sample

Age	Male		Female		TOTAL	
Under 25	1	9.1%	4	28.6%	5	20.0%
25 - 34	1	9.1%	4	28.6%	5	20.0%
35 - 44	2	18.2%	3	21.4%	5	20.0%
45 - 54	3	27.3%	2	14.3%	5	20.0%
55 - 59	0	.0%	1	7.1%	1	4.0%
Over 60	4	36.4%	0	.0%	4	16.0%

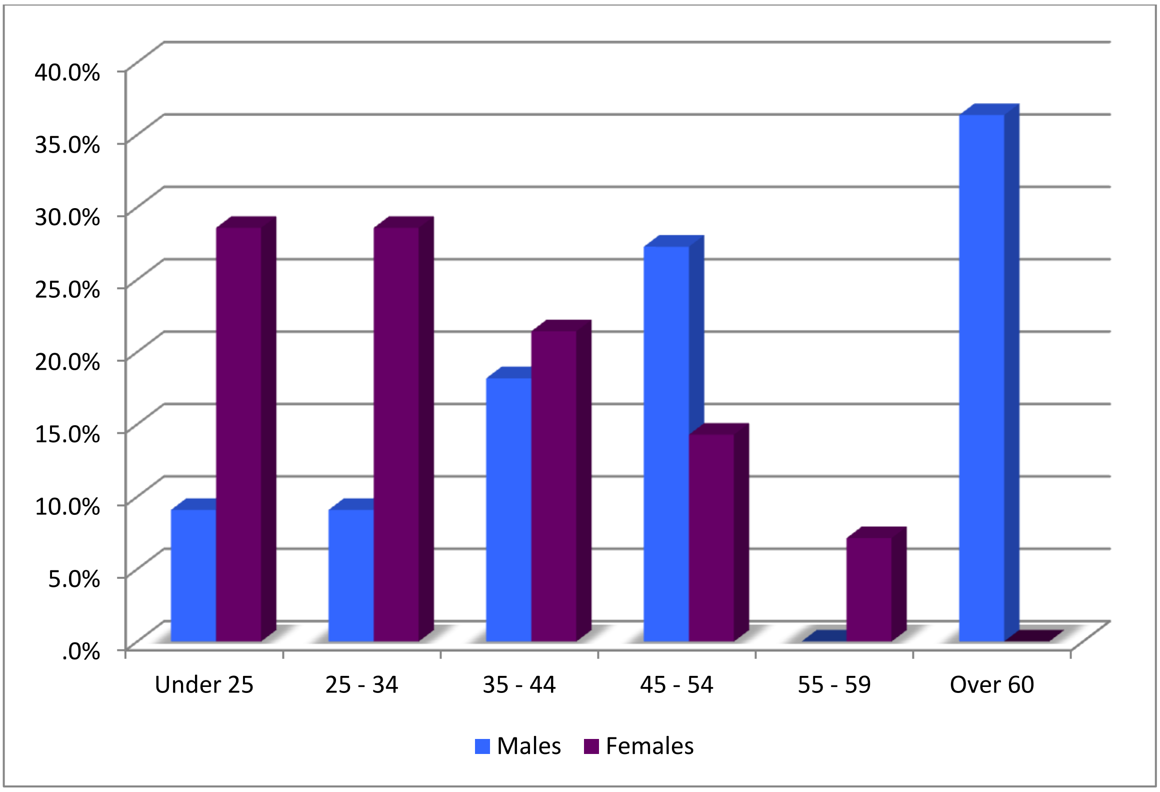

Figure 5.8.1: Age of Respondents

Household Form and Structure

Of the respondents, 32% were married and 12% were in a common-law relationship. Not surprisingly, only three males were single or divorced, with 72.7% being either married or in a common law relationship, suggesting possibly stronger support systems present for men. This is likely due to the age distribution of the sample. Only 21.4% of female respondents were married or in a common law relationship, with 64.3% of female respondents indicating that they were single. Nearly 60% of female respondents were under the age of 35, whereas less than 20% of male respondents were under the age of 35.

Table 5.8.3: Relationship Status of Respondents

Status	Male		Female		Total	
Single	2	18.2%	9	64.3%	11	44.0%
Single (Visiting Relationship)	0	0%	2	14.3%	2	8.0%
Married	6	54.5%	2	14.3%	8	32.0%
Other/Common Law	2	18.2%	1	7.1%	3	12.0%
Divorced	1	9.1%	0	.0%	1	4.0%

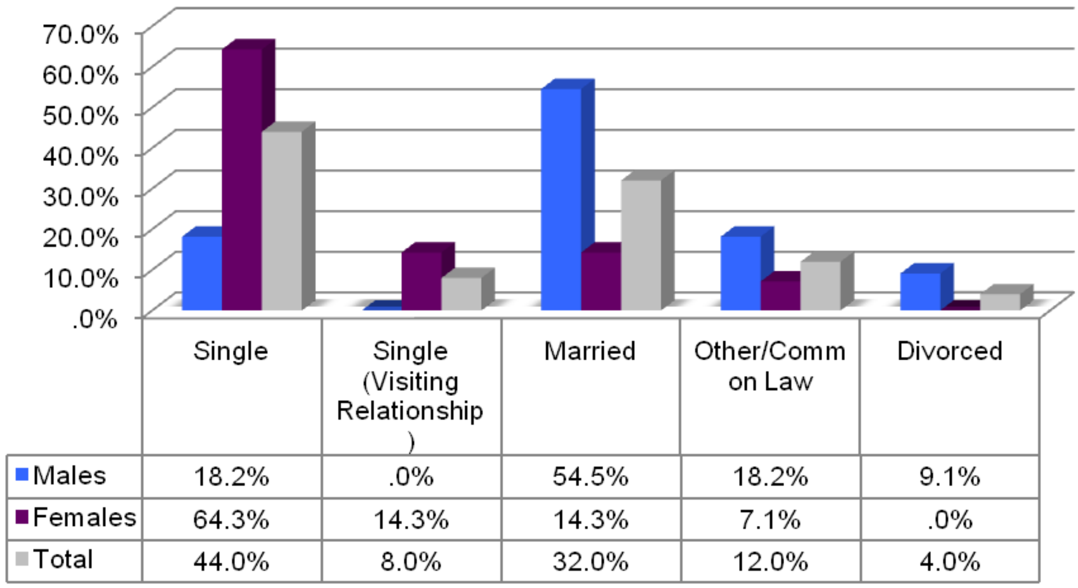

Figure 5.8.2: Relationship Status of Respondents

5.8.2. Household Headship

More than half of the respondents sampled listed themselves as the heads of their respective households (N=16/ 64%). When disaggregated by gender 72.7% of males indicated they were the heads of their households with 57.1% of females indicating this role. The ratio of male to female headed households in the community is close (42% of sampled households headed by females, 58% by males), but there is a slightly higher chance that any given household will be headed by a male (see Table 5.8.5).

Table 5.8.4: Perception of Headship of Household

Perceived as Head of Household	Sex of Respondent			
	Male		Female	
Yes	8	72.7%	8	57.1%
No	3	27.3%	6	42.9%

Table 5.8.5: Household Headship by Gender

Gender of Respondent	Male Headed Households		Female Headed Households		Sample (n=24)	
Male	10	71%	1	10%	11	46%
Female	4	29%	9	90%	13	54%
Total (% of Sample)	14	58%	10	42%	24	100%

With regards to household size, 20% (N=5) of sampled households consisted of 1 to 3 persons. Furthermore, 36% of households each had between 4 and 5 persons and between 6 and 7 persons. Two households consisted of more than 7 people. There were similar distributions based on the gender of the respondent in most categories.

Table 5.8.6: Family Size by Sex of Head of Household

Size of Household	Headship of Household					
	Male		Female		Total	
1	1	7%	1	10%	2	8%
2 - 3	1	7%	2	20%	3	12%
4 - 5	6	40%	3	30%	9	36%
6 - 7	6	40%	3	30%	9	36%
8 - 9	1	7%	0	0%	1	4%
10 and over	0	0%	1	10%	1	4%

5.8.3. Education and Livelihoods

Those who completed a secondary level of education comprised the largest portion of the sample (N=10/40.0%). Additionally, 3 respondents indicated they had completed the advanced placement secondary education level. Of note, there was a slightly higher proportion of males who had undertaken teachers college or a tertiary sector education (university, professional designation etc.), though there are also a high number of males (N=6/54.5%) who only had a primary education.

Table 5.8.7: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		Total	
Primary	6	54.5%	3	21.4%	9	36.0%
Secondary (Ordinary Level)	0	0.0%	7	50.0%	7	28.0%
Secondary (Advanced Level)	2	18.2%	1	7.1%	3	12.0%
Community College	0	0.0%	3	21.4%	3	12.0%
Technical-Vocational Institute	1	9.1%	0	0.0%	1	4.0%
Teachers College	1	9.1%	0	0.0%	1	4.0%
Tertiary	1	9.1%	0	0.0%	1	4.0%

Approximately three-quarters of the respondents reported bearing the responsibility of being the household breadwinner. There were similar percentages of male and female respondents who are breadwinners. However, there were more female breadwinners amongst the sample compared to household heads (see Table 5.8.8, c.f. Table 5.8.4).

Table 5.8.8: Sample Distribution by Main Income Earning Responsibility

Are you the main income earner?	Sex of Respondent					
	Male		Female		Total	
Yes	8	73%	11	79%	19	76%
No	3	27%	3	21%	6	24%

Most of the respondents sampled (84%) were also involved in income-generating activities. However, in terms of gender, the male employment rate is higher than the female rate, albeit the female rate is relatively high (see Table 5.8.9).

Table 5.8.9: Sample Distribution by Involvement in Income-Generating Activity

Are you involved in income generating activity?	Sex of Respondent					
	Male		Female		Total (n=24)	
Yes	10	91%	11	79%	21	84%
No	0	0%	3	21%	3	12%
1: Two respondents did not indicate an option						

In terms of household income, majority of the households sampled (approximately 60%) indicated an income of US $750 or less. Only 20-25% of households earned incomes over US $1,000. When disaggregated by gender, female headed households have a clear disadvantage compared to their male counterparts. At the time of the survey, no female headed households brought in more than US $750 per month. Conversely, while a third of the male headed households also fit into this category, another one-third recorded earning in excess of US $1,500 per month (see Figure 5.8.3). Low incomes for households, especially with a large number of members severely impairs the ability of the household to improve itself, and makes them vulnerable to harsh economic and weather impacts. Female headed households are shown here to be especially vulnerable, as they comprise the majority of the sample falling in the lowest two income ranges.

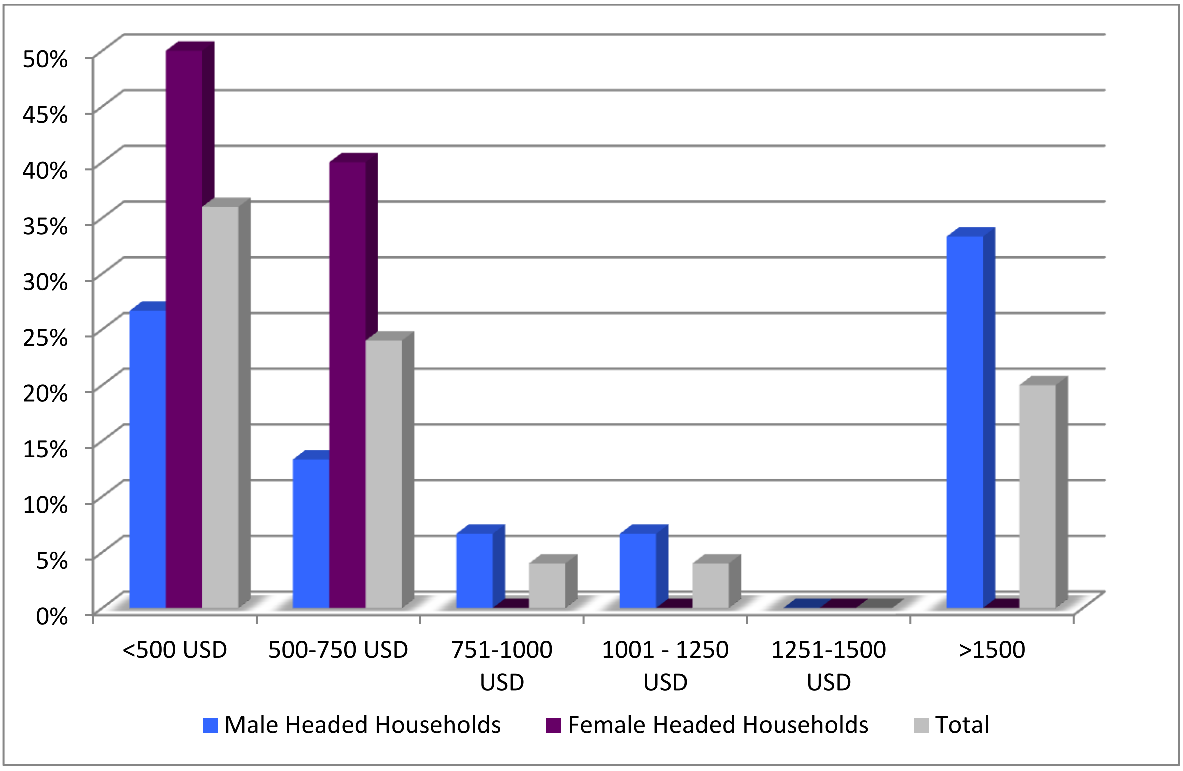

Figure 5.8.3: Sample Distribution by Average Monthly Earnings

In terms of employment in the tourism sector, the respondents generally worked in non-tourism sectors; 56% of respondents worked in the non-tourism, 24% worked in tourism and 20% of respondents refrained from answering the question.

Table 5.8.10: Labour Market Participation: Involvement in Tourism Sector

Labour Market Participation (Tourism vs. Non-Tourism Sectors)	Male		Female		Total	
Tourism	25%	3	21%	6	23%	25%
Non-Tourism	58%	8	57%	15	58%	58%
Didn't respond	17%	3	21%	5	19%	17%

Only 6 respondents were employed in the tourism sector. Of the respondents working in the tourism sector, 1 was a tour operator, 2 worked in hotels, 2 were vendors, and 1 indicated 'other'. Given the small sample, it is not possible to make conclusions based on gender.

Table 5.8.11: Labour Market Participation: Involvement in Tourism Sectors

Employment Sector	Male		Female		Total	
Taxi Driver	0	0.0%	0	0.0%	0	0.0%
Tour Operator	1	9.1%	0	0.0%	1	4.0%
Hotel Workers	1	9.1%	1	7.1%	2	8.0%
Restaurant Workers	0	0.0%	0	0.0%	0	0.0%
Craft sellers or vendors	0	0.0%	2	14.3%	2	8.0%
Informal tour guides	0	0.0%	0	0.0%	0	0.0%
Privately owned business	0	0.0%	0	0.0%	0	0.0%
Other	1	9.1%	0	0.0%	1	4.0%
Did not answer	8	72.7%	11	78.6%	19	76.0%

There were 14 respondents that indicated working in sectors other than tourism. The largest proportion of which were employed in agriculture (36%), followed by education (8%) and, lastly, retail services (8%). One respondent indicated being a government worker and 1 worked in the banking and financial sector.

Table 5.8.12: Labour Market Participation: Involvement in Non-Tourism Sectors

Employment Sector	Male		Female		Total	
Agriculture	5	45.5%	4	28.6%	9	36.0%
Banking/Financial	0	0.0%	1	7.1%	1	4.0%
Education	1	9.1%	1	7.1%	2	8.0%
Retail Sales and Services	0	0.0%	2	14.3%	2	8.0%
Government Worker	1	9.1%	0	0.0%	1	4.0%
Did not answer	3	27.3%	6	42.9%	9	36.0%

5.8.4. Food Security

Overwhelmingly, respondents (87.5%) indicated that their food supply was procured from grocery stores or super markets. Of the respondents, 87.5% also indicated that their food was grown by family. Additional sources of food included traditional markets (8.3%) and community shops (8.3%).

Table 5.8.13: Source of Food Supply

Source of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Grown by Family	9	90.0%	4	100.0%	1	100.0%	7	77.8%	21	87.5%
Grocery store/Supermarket	9	90.0%	3	75.0%	1	100.0%	8	88.9%	21	87.5%
Open air/Traditional market	0	0.0%	1	25.0%	0	0.0%	1	11.1%	2	8.3%
Community Shops	0	0.0%	0	0.0%	0	0.0%	2	22.2%	2	8.3%
Barter	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

When asked about the adequacy of the household food supply, all but 2 respondents (both female) indicated an adequate supply throughout the year. Given the small sample size, a definitive conclusion cannot be made in regards to gender and food adequacy, however, more research in this area could provide further insights.

Table 5.8.14: Adequacy of Food Supply

Adequacy of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Yes	10	100.0%	4	100.0%	1	100%	7	77.8%	22	91.7%
No	0	0.0%	0	0.0%	0	0%	2	22.2%	2	8.3%

5.8.5. Financial Security and Social Protection

Evidence of such networks is apparent, based on the ways in which differently-headed households received and offered support:

Of the respondents, 33% received financial support from relatives and 8.3% received financial support from charitable organisations. The difference between male and female respondents is negligible for this support.

Table 5.8.15: Distribution by Financial Responsibility for House (Receive support)

Source of Financial Support for Household	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Relative	3	30.0%	2	50.0%	0	0.0%	3	33.3%	8	33.3%
Family Friend	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Religious Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Charitable Organisation	2	20.0%	0	0.0%	0	0.0%	0	0.0%	2	8.3%
Government	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

A little over one-third (20.8%) of respondents gave financial support to family friends, with male headed households giving more support than female headed households. Furthermore, 1 male respondent gave support to a religious organisation, and 1 male and female gave to charitable organisations.

Table 5.8.16: Distribution by Financial Responsibility for House (Give support)

Recipient of Financial Support from Household	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Relative	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Family Friend	2	33.3%	2	40.0%	0	0.0%	1	8.3%	5	20.8%
Religious Organisation	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	4.2%
Charitable Organisation	1	16.7%	0	0.0%	0	0.0%	1	8.3%	2	8.3%
Government	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

When accessing credit, respondents were more likely to seek formal sources over non-formal sources; 58.3% accessed credit from a commercial bank or credit union, while 25% sought loans from a Sou Sou or partner.

Table 5.8.17: Distribution by Access to Credit

Source of Credit	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Commercial Bank Loan	4	40.0%	0	0.0%	0	0.0%	1	11.1%	5	20.8%
Credit Union Loan	3	30.0%	1	25.0%	0	0.0%	5	55.6%	9	37.5%
Sou Sou / Partner	1	10.0%	2	50.0%	0	0.0%	3	33.3%	6	25.0%

Over half of respondents generally believed that in the instance of job loss or the occurrence of some natural disaster, their financial reserves would last more than one year. The other half of respondents indicated that their reserves would last less than 6 months.

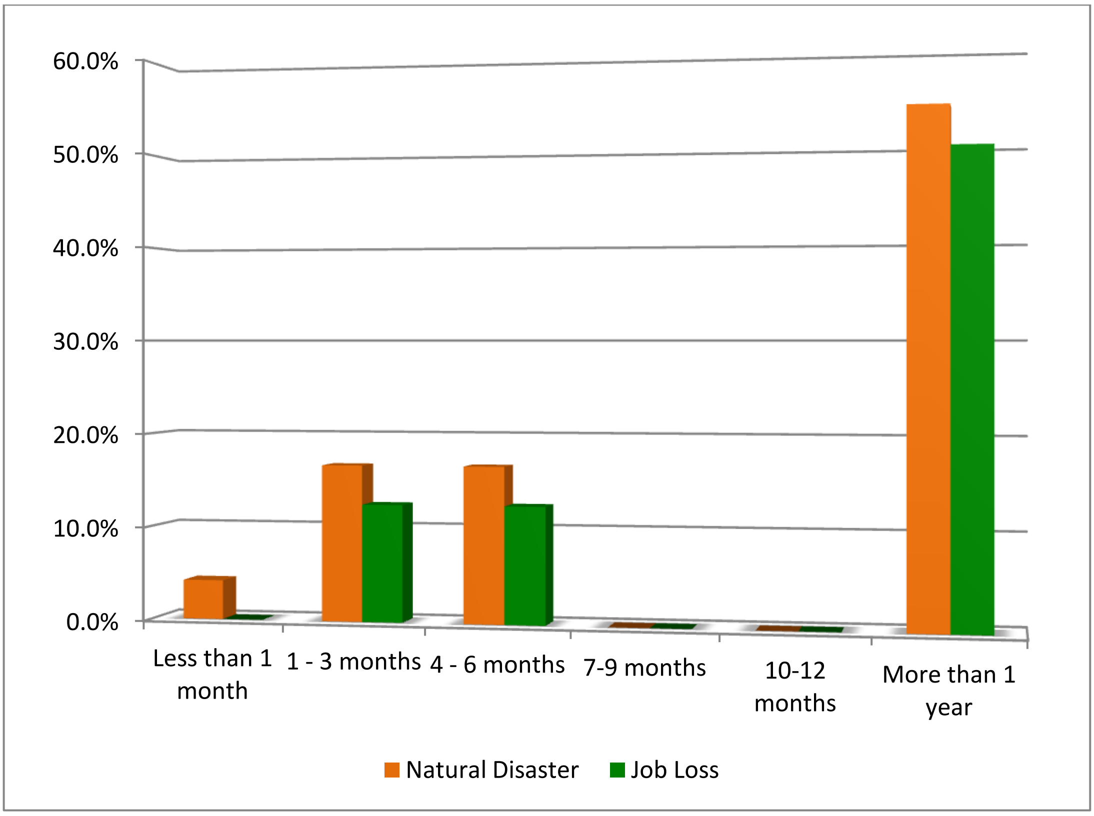

Figure 5.8.4: Financial Security: Job Loss or Natural Disaster

More specifically, when questions about job loss, 71% of respondents from male headed households indicated that they would have financial coverage for more than 1 year. Still 21.4% of respondents from male headed households indicated they would have financial reserves for between 1 and 6 months. Conversely, only 22.2% of respondents from female headed households would have financial reserves for more than 1 year.

Table 5.8.18: Sample Distribution by Financial Security: Job Loss

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
1 - 3 months	0	0.0%	1	25.0%	0	0.0%	2	22.2%	3	12.5%
4 - 6 months	2	20.0%	0	0.0%	0	0.0%	1	11.1%	3	12.5%
7 - 9 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
More than 1 year	8	80.0%	2	50.0%	0	0.0%	2	22.2%	12	50.0%
Do not know	0	0.0%	0	0.0%	1	100.0%	1	11.1%	2	8.3%

Similarly, respondents from female headed households indicated similar periods of financial coverage for a natural disaster as they had for job loss. Generally male respondents also indicated similar, though slightly longer periods of financial coverage in this instance. Again, only 20% of respondents from female headed households indicated having financial reserves that would last for more than 1 year in the event of a natural disaster.

The perception of ability to support the household is a particularly useful indicator of resilience and would be important in determining the ways in which households adapt in the face of a natural / climate related event. Given that males indicated higher incomes than females, it is not surprising that they also have larger financial reserves.

Table 5.8.19: Sample Distribution by Financial Security: Natural Disaster

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	0	0.0%	0	0.0%	0	0.0%	1	11.1%	1	4.2%
1 - 3 months	0	0.0%	0	0.0%	0	0.0%	4	44.4%	4	16.7%
4 - 6 months	2	20.0%	1	25.0%	0	0.0%	1	11.1%	4	16.7%
7 - 9 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
More than 1 year	8	80.0%	3	75.0%	0	0.0%	2	22.2%	13	54.2%
Do not know	0	0.0%	0	0.0%	1	100.0%	1	11.1%	2	8.3%

In terms of social protection provisions, respondents generally had little private social protection, with only 4 respondents having health insurance (16.7% of sample). Less than 10% of the sample had flood, fire or storm surge insurance.

- From female headed households, no respondent had flood storm, surge, fire insurance, or private pension. National insurance was the only type of insurance that female headed households were protected by (40%).
- Male headed household had a higher rate of insurance coverage for home and health insurance and almost all respondents from male headed households had national insurance (86% covered).

Table 5.8.20: Sample Distribution by Social Protection Provisions

Social Protection Provision	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Health Insurance	3	30.0%	1	25.0%	0	0.0%	0	0.0%	4	16.7%
Private Pension Savings Plan	1	10.0%	0	0.0%	0	0.0%	0	0.0%	1	4.2%
National Insurance / Government Pension	9	90.0%	3	75.0%	1	100.0%	3	33.3%	16	66.7%
Home Insurance - Hurricane Damage (water/wind)	2	20.0%	0	0.0%	0	0.0%	0	0.0%	2	8.3%
Home Insurance - Flooding	2	20.0%	0	0.0%	0	0.0%	0	0.0%	2	8.3%
Home Insurance - Storm Surge	2	20.0%	0	0.0%	0	0.0%	0	0.0%	2	8.3%
Home Insurance - Fire	2	20.0%	0	0.0%	0	0.0%	0	0.0%	2	8.3%

Asset Base

Ownership of assets, similar to provision of social protection, was generally high for respondents. The highest proportion of respondents indicated ownership of houses (70.8%), land (45.8%) and livestock (16.7%). Generally, males had higher rates of asset ownership than females.

Table 5.8.21: Sample Distribution by Ownership of Assets: Capital Assets

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
House	8	80.0%	2	50.0%	0	0.0%	7	77.8%	17	70.8%
Land	7	70.0%	2	50.0%	0	0.0%	2	22.2%	11	45.8%
Livestock	3	30.0%	1	25.0%	0	0.0%	0	0.0%	4	16.7%
Industrial/Agricultural	0	0.0%	1	25.0%	0	0.0%	0	0.0%	1	4.2%
Commercial Vehicles	1	10.0%	0	0.0%	0	0.0%	0	0.0%	1	4.2%
Private Business	1	10.0%	0	0.0%	0	0.0%	2	22.2%	3	12.5%
Other (boat)	1	10.0%	0	0.0%	0	0.0%	0	0.0%	1	4.2%

A further examination of assets revealed that respondents most often indicated having mobile phones (95.8%), television sets (91.7%), radios (87.5%) and DVD players (66.7%) in their homes. Approximately 33% of respondents indicated having a desktop computer, while 25% indicated having laptops. Of interest, there was only 1 female in female headed households in ownership of a laptop, and only 2 were in ownership of a desktop computer. Additionally, less only 16.7% of the respondents owned a cellular phone; this could have serious implications for community based warning systems in the event of a climate related event, and in the creation of any mitigation or adaptation strategy. The cost to communicate with all community members would need to be factored in as a consideration.

Table 5.8.22: Sample Distribution by Ownership of Assets: Appliances/Electronics

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Computer (Desktop)	5	50.0%	1	25.0%	0	0.0%	2	22.2%	8	33.3%
Computer (Laptop)	4	40.0%	1	25.0%	0	0.0%	1	11.1%	6	25.0%
Internet	4	40.0%	1	25.0%	0	0.0%	1	11.1%	6	25.0%
Television	9	90.0%	4	100.0%	1	100.0%	8	88.9%	22	91.7%
Video Player / Recorder	4	40.0%	2	50.0%	1	100.0%	2	22.2%	9	37.5%
DVD Player	10	100.0%	3	75.0%	1	100.0%	2	22.2%	16	66.7%
Radio	10	100.0%	4	100.0%	1	100.0%	6	66.7%	21	87.5%
Telephone (Land line)	1	10.0%	1	25.0%	0	0.0%	2	22.2%	4	16.7%
Telephone (Mobile)	10	100.0%	4	100.0%	1	100.0%	8	88.9%	23	95.8%

Effective communication in the instance of a climate related event seems more critical when measured against access to transportation. Most of the sample had access to public transportation, though members of male headed households had more access to private motorised vehicles.

Table 5.8.23: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male Headed		Female Headed		Sample	
Private motorised vehicle	3	20.0%	0	0.0%	3	12.0%
Private non-motorised vehicle	12	80.0%	10	100.0%	22	88.0%

The largest proportion of respondents (N=18/72%) indicated that their home was made of blocks and cement and 24% (N=6) indicated their house was made of wood. One respondent indicated their house was built of brick and mortar. There is little difference between male and female headed households in this regard.

Table 5.8.24: Sample Distribution by Ownership of Assets: House Material

House Material	Male Headed		Female Headed		Sample	
Brick and mortar	1	6.7%	0	0.0%	1	4.0%
Blocks and cement	10	66.7%	8	80.0%	18	72.0%
Wood	4	26.7%	2	20.0%	6	24.0%

Respondents indicated that they had some access to sanitation conveniences, with 62.5% of the respondents sampled indicating that they always had access to liquid waste disposal and 66.7% having access to indoor water-flush toilets. 95.8% of respondents had access to garbage collection. Male headed households generally had better access to sanitation conveniences compared to female headed households.

Table 5.8.25: Sample Distribution by Ownership of Assets: Access to Sanitation Conveniences

Amenity	Access	Male Headed	Female Headed	Sample
Liquid Waste Disposal	Always	71.4%	50.0%	62.5%
	Sometimes	0.0%	0.0%	0.0%
	Never	21.4%	40.0%	29.2%
Indoor water-flush toilets	Always	78.6%	50.0%	66.7%
	Sometimes	0.0%	10.0%	4.2%
	Never	21.4%	40.0%	29.2%
Garbage collection	Always	100.0%	90.0%	95.8%
	Sometimes	0.0%	10.0%	4.2%
	Never	0.0%	0.0%	0.0%

Power and Decision Making

Both female and male respondents indicated high levels of responsibility for decision making at level of the household, as well as formal and informal community levels.

Table 5.8.26: Power and Decision Making

Site of Decision Making	Males		Females	
Household	9	81.8%	10	71.4%
Informal Community	2	18.2%	1	7.1%
Formal Community	3	27.3%	2	14.3%

Table 5.8.27: Power and Decision Making: Intra Household

Site of Decision Making	Male Headed						Female Headed					
	Male		Female		Total		Male		Female		Total	
Household	9	90.0%	1	25.0%	10	71.4%	0	0.00%	8	88.9%	8	80.0%
Informal Community	2	20.0%	0	0.0%	2	14.3%	0	0.00%	1	11.1%	1	10.0%
Formal Community	3	30.0%	0	0.0%	3	21.4%	0	0.00%	2	22.2%	2	20.0%

5.8.6. Social Networks and Social Capital

Both male and female respondents were moderately active in their community; 21.4% of females and 45.5% of male respondents reported belonging to a social group within the community.

Table 5.8.28: Social Networks: Community Involvement

Membership	Male		Female	
Yes	5	45.5%	3	21.4%
No	6	54.5%	10	71.4%

With regards to support systems, male respondents tended to rely on relatives outside their households for physical help, personal advice and financial assistance. A similar trend was noticed amongst female respondents for support systems. Government agencies were not indicated as being utilised at all for male respondents, but were used for physical and financial help by some female respondents.

Table 5.8.29: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	Female	Male	Female	Male	Female
Relative (within the household)	36.4%	50.0%	18.2%	28.6%	9.1%	21.4%
Relative (outside the household)	63.6%	57.1%	54.5%	64.3%	63.6%	57.1%
Family friend	36.4%	50.0%	45.5%	42.9%	36.4%	42.9%
Religious Organisation	9.1%	7.1%	18.2%	7.1%	18.2%	0.0%
Non-religious Charity	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%
Government Agency	0.0%	7.1%	0.0%	0.0%	0.0%	14.3%

5.8.7. Use of Natural Resources

Subsistence

Agricultural land (76%) was indicated to be the most important resource for subsistence. The 2nd and 3rd most important resources were the river and the forest, with 32% of respondents indicating each resource as very important.

Livelihood

In terms of livelihoods, agricultural land was again the most important, with 72% of respondents identifying agricultural land as being very important for livelihoods. 40% of the sample indicated that rivers and forest/bush as being very important for their livelihoods.

Recreation

Generally, little importance was recorded for the importance of natural resources for recreation purposes. Three respondents (12%) indicated that the rivers, sea, coral reefs were very important for recreation.

Table 5.8.30: Use and Importance of Natural Resources

Resource	Importance	Subsistence		Livelihood		Recreation	
River / Stream	Very Important	8	32.0%	10	40.0%	3	12.0%
	Somewhat important	4	16.0%	4	16.0%	2	8.0%
	Not at all important	0	0.0%	0	0.0%	2	8.0%
	None / Do Not Use	13	52.0%	11	44.0%	18	72.0%
Sea	Very Important	1	4.0%	2	8.0%	3	12.0%
	Somewhat important	0	0.0%	0	0.0%	3	12.0%
	Not at all important	1	4.0%	1	4.0%	2	8.0%
	None / Do Not Use	23	92.0%	22	88.0%	17	68.0%
Coral Reefs	Very Important	2	8.0%	1	4.0%	3	13.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	1	4.0%	2	8.0%	1	4.3%
	None / Do Not Use	22	88.0%	22	88.0%	19	82.6%
Mangrove	Very Important	0	0.0%	0	0.0%	1	4.0%
	Somewhat important	0	0.0%	1	4.0%	1	4.0%
	Not at all important	1	4.0%	1	4.0%	1	4.0%
	None / Do Not Use	24	96.0%	23	92.0%	22	88.0%
Agricultural Land	Very Important	19	76.0%	18	72.0%	0	0.0%
	Somewhat important	2	8.0%	3	12.0%	1	4.0%
	Not at all important	0	0.0%	0	0.0%	1	4.0%
	None / Do Not Use	4	16.0%	4	16.0%	23	92.0%
Bush and Forest	Very Important	8	32.0%	10	40.0%	1	4.0%
	Somewhat important	3	12.0%	3	12.0%	2	8.0%
	Not at all important	2	8.0%	2	8.0%	0	0.0%
	None / Do Not Use	12	48.0%	10	40.0%	22	88.0%
Mountain	Very Important	1	4.0%	3	12.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	1	4.0%	1	4.0%	1	4.0%
	None / Do Not Use	23	92.0%	21	84.0%	24	96.0%
Caves	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	1	4.0%	1	4.0%	1	4.0%
	None / Do Not Use	24	96.0%	24	96.0%	24	96.0%
Wild Animals	Very Important	0	0.0%	1	4.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	1	4.0%	1	4.0%	1	4.0%
	None / Do Not Use	24	96.0%	23	92.0%	24	96.0%

When further disaggregated on the basis of gender, there was little disparity in the use of natural assets. However, a slightly larger proportion of male respondents were dependent on coastal natural resources for livelihood and subsistence.

Table 5.8.31: Use and Importance of Natural Resources, by Sex of Respondent

Resource	Importance	Subsistence		Livelihood		Recreation	
		Male	Female	Male	Female	Male	Female
River / Stream	Very Important	36.4%	28.6%	54.5%	28.6%	9.1%	14.3%
	Somewhat important	27.3%	7.1%	27.3%	7.1%	0.0%	14.3%
	Not at all important	0.0%	0.0%	0.0%	0.0%	9.1%	7.1%
	None / Do Not Use	36.4%	64.3%	18.2%	64.3%	81.8%	64.3%
Sea	Very Important	9.1%	0.0%	9.1%	7.1%	18.2%	7.1%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	18.2%	7.1%
	Not at all important	9.1%	0.0%	9.1%	0.0%	9.1%	7.1%
	None / Do Not Use	81.8%	100.0%	81.8%	92.9%	54.5%	78.6%
Coral Reefs	Very Important	9.1%	7.1%	9.1%	0.0%	22.2%	7.1%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	9.1%	0.0%	9.1%	7.1%	11.1%	0.0%
	None / Do Not Use	81.8%	92.9%	81.8%	92.9%	66.7%	92.9%
Mangrove	Very Important	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	7.1%	9.1%	0.0%
	Not at all important	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
	None / Do Not Use	90.9%	100.0%	90.9%	92.9%	72.7%	100.0%
Agricultural Land	Very Important	81.8%	71.4%	72.7%	71.4%	0.0%	0.0%
	Somewhat important	9.1%	7.1%	18.2%	7.1%	0.0%	7.1%
	Not at all important	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%
	None / Do Not Use	9.1%	21.4%	9.1%	21.4%	90.9%	92.9%
Bush and Forest	Very Important	45.5%	21.4%	54.5%	28.6%	0.0%	7.1%
	Somewhat important	18.2%	7.1%	18.2%	7.1%	9.1%	7.1%
	Not at all important	9.1%	7.1%	9.1%	7.1%	0.0%	0.0%
	None / Do Not Use	27.3%	64.3%	18.2%	57.1%	90.9%	85.7%
Mountain	Very Important	9.1%	0.0%	27.3%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
	None / Do Not Use	81.8%	100.0%	63.6%	100.0%	90.9%	100.0%
Caves	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
	None / Do Not Use	90.9%	100.0%	90.9%	100.0%	90.9%	100.0%
Wild Animals	Very Important	0.0%	0.0%	9.1%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
	None / Do Not Use	90.9%	100.0%	81.8%	100.0%	90.9%	100.0%

Agriculture

Sixteen respondents indicated they were involved in the agriculture sectors. 72.7% of male headed households always had access to water, and 18.3% sometimes had access to water. For female headed households, 60% always had access to water compared to 40% who sometimes had access to water.

Table 5.8.32: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	8	72.7%	3	60.0%	11	68.8%
Sometimes	2	18.2%	2	40.0%	4	25.0%
Never	0	0.0%	0	0.0%	0	0.0%

5.8.8. Knowledge, Exposure and Experience of Climate Related Events

Respondents indicated average levels of knowledge in relation to hurricanes (62.5%), and average or very good knowledge of flooding (average = 50% and very good = 16.7%), as well as drought (average = 54.2% and very good= 16.7%). However, knowledge was not quite as comprehensive in relation to storm surge (66.7% indicated poor knowledge).

When examined on the basis of household structure and headship, there was a small difference between male and female headed households. Females consistently showed slightly lower levels of knowledge of climate related events compared to males.

Table 5.8.33: Knowledge of Climate Related Events

Event	Knowledge	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	20.8%	20.0%	25.0%	21.4%	0.0%	22.2%	20.0%
	Average	62.5%	50.0%	75.0%	57.1%	100.0%	66.7%	70.0%
	Very Good	16.7%	30.0%	0.0%	21.4%	0.0%	11.1%	10.0%
Flooding	Poor	33.3%	40.0%	25.0%	35.7%	0.0%	33.3%	30.0%
	Average	50.0%	30.0%	75.0%	42.9%	100.0%	55.6%	60.0%
	Very Good	16.7%	30.0%	0.0%	21.4%	0.0%	11.1%	10.0%
Storm Surge	Poor	66.7%	50.0%	75.0%	57.1%	100.0%	77.8%	80.0%
	Average	16.7%	20.0%	25.0%	21.4%	0.0%	11.1%	10.0%
	Very Good	16.7%	30.0%	0.0%	21.4%	0.0%	11.1%	10.0%
Drought	Poor	29.2%	20.0%	50.0%	28.6%	0.0%	33.3%	30.0%
	Average	54.2%	40.0%	50.0%	42.9%	100.0%	66.7%	70.0%
	Very Good	16.7%	40.0%	0.0%	28.6%	0.0%	0.0%	0.0%
Landslides	Poor	20.8%	20.0%	25.0%	21.4%	0.0%	22.2%	20.0%
	Average	54.2%	40.0%	75.0%	50.0%	100.0%	55.6%	60.0%
	Very Good	25.0%	40.0%	0.0%	28.6%	0.0%	22.2%	20.0%

Despite knowledge gaps with regards to the technical aspects of the various climate related events, respondents showed various levels of awareness of the appropriate course of action to be taken in the instance such an event occurred:

- In the event of a hurricane, 79.2% of the sample was aware of what to do, without having to ask for assistance.
- In the instance of flooding, a slightly less proportion of respondents sampled (45.8%) were aware of appropriate action to take, without asking for assistance
- In the instance of a storm surge, 37.5% of respondents sampled were aware of appropriate action to take, without asking for assistance
- - In the instance of a drought, 62.5% of respondents sampled were aware of appropriate action to take, without asking for assistance
- In the event of a landslide, 54.2% of respondents were aware of what should be done.

Table 5.8.34: Knowledge of Appropriate Response to Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	79.2%	90.0%	75.0%	85.7%	0.0%	77.8%	70.0%
	No	20.8%	10.0%	25.0%	14.3%	100.0%	22.2%	30.0%
	Don't Know	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flooding	Yes	45.8%	50.0%	25.0%	42.9%	0.0%	55.6%	50.0%
	No	50.0%	40.0%	75.0%	50.0%	100.0%	44.4%	50.0%
	Don't Know	4.2%	10.0%	0.0%	7.1%	0.0%	0.0%	0.0%
Storm Surge	Yes	37.5%	50.0%	25.0%	42.9%	0.0%	33.3%	30.0%
	No	54.2%	50.0%	75.0%	57.1%	100.0%	44.4%	50.0%
	Don't Know	8.3%	0.0%	0.0%	0.0%	0.0%	22.2%	20.0%
Drought	Yes	62.5%	100.0%	25.0%	78.6%	0.0%	44.4%	40.0%
	No	33.3%	0.0%	75.0%	21.4%	100.0%	44.4%	50.0%
	Don't Know	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Landslides	Yes	54.2%	50.0%	50.0%	50.0%	0.0%	66.7%	60.0%
	No	29.2%	20.0%	50.0%	28.6%	100.0%	22.2%	30.0%
	Don't Know	16.7%	30.0%	0.0%	21.4%	0.0%	11.1%	10.0%

1: Where one or more respondents did not indicate an option, the total percentage of respondents sum up to less 100%

When questioned around the perceived risk of climate related events to their households, respondents most often indicated a high risk of hurricanes (45.8%) and landslides (41.7%), though this was slightly more so the case of respondents from female headed households (hurricanes = 60%) than those from male headed households (hurricane = 35.7%). Similarly, respondents from female headed households reported higher levels of risk for flooding (40.0%) than respondents from male headed households, where 14.3% reported high levels of risk of flooding.

Table 5.8.35: Perceived Level of Risk of Climate Related Events: Household

Event	Perception of Risk	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	4.2%	0.0%	25.0%	7.1%	0.0%	0.0%	0.0%
	Low Risk	50.0%	60.0%	50.0%	57.1%	100.0%	33.3%	40.0%
	High Risk	45.8%	40.0%	25.0%	35.7%	0.0%	66.7%	60.0%
Flooding	No Risk	20.8%	40.0%	25.0%	35.7%	0.0%	0.0%	0.0%
	Low Risk	54.2%	40.0%	75.0%	50.0%	100.0%	55.6%	60.0%
	High Risk	25.0%	20.0%	0.0%	14.3%	0.0%	44.4%	40.0%
Storm Surge	No Risk	62.5%	60.0%	100.0%	71.4%	100.0%	44.4%	50.0%
	Low Risk	33.3%	40.0%	0.0%	28.6%	0.0%	44.4%	40.0%
	High Risk	4.2%	0.0%	0.0%	0.0%	0.0%	11.1%	10.0%
Drought	No Risk	12.5%	10.0%	50.0%	21.4%	0.0%	0.0%	0.0%
	Low Risk	83.3%	90.0%	25.0%	71.4%	100.0%	100.0%	100.0%
	High Risk	4.2%	0.0%	25.0%	7.1%	0.0%	0.0%	0.0%
Landslides	No Risk	12.5%	0.0%	25.0%	7.1%	100.0%	11.1%	20.0%
	Low Risk	45.8%	50.0%	50.0%	50.0%	0.0%	44.4%	40.0%
	High Risk	41.7%	50.0%	25.0%	42.9%	0.0%	44.4%	40.0%

Of interest, respondents reported higher levels of risk to climate related event for the community than they did for their own households for all hazards. This was particularly true in regards to hurricanes, landslides and flooding.

Male and female headed households indicated similar levels of knowledge with regards to climatic hazards at the community level.

Table 5.8.36: Perceived Level of Risk of Climate Related Events: Community

Event	Knowledge	SAMPLE[1]	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low Risk	16.7%	0.0%	50.0%	14.3%	100.0%	11.1%	20.0%
	High Risk	83.3%	100.0%	50.0%	85.7%	0.0%	88.9%	80.0%
Flooding	No Risk	4.2%	0.0%	25.0%	7.1%	0.0%	0.0%	0.0%
	Low Risk	50.0%	60.0%	50.0%	57.1%	100.0%	33.3%	40.0%
	High Risk	45.8%	40.0%	25.0%	35.7%	0.0%	66.7%	60.0%
Storm Surge	No Risk	66.7%	70.0%	100.0%	78.6%	100.0%	44.4%	50.0%
	Low Risk	16.7%	20.0%	0.0%	14.3%	0.0%	22.2%	20.0%
	High Risk	12.5%	10.0%	0.0%	7.1%	0.0%	22.2%	20.0%
Drought	No Risk	4.2%	10.0%	0.0%	7.1%	0.0%	0.0%	0.0%
	Low Risk	70.8%	70.0%	50.0%	64.3%	100.0%	77.8%	80.0%
	High Risk	16.7%	20.0%	25.0%	21.4%	0.0%	11.1%	10.0%
Landslides	No Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low Risk	16.7%	0.0%	50.0%	14.3%	100.0%	11.1%	20.0%
	High Risk	83.3%	100.0%	50.0%	85.7%	0.0%	88.9%	80.0%

1: Where one or more respondents did not indicate an option, the total percentage of respondents sum up to less 100%

The disparity between perceived risk at the household and community level was greatest in the instance of hurricanes, for which 45.8% of respondents indicated a high risk for their households, compared to 83.3% of whom indicated a high risk for their respective community. There was also a disparity for flooding in which 25.0% of respondents indicated a high risk for their households, compared to 45.8% of who indicated a high risk for their respective community. Similarly, in terms of landslides, 41.7% of respondents indicated a high risk for their households, compared to 83.3% of who indicated a high risk for their respective community.

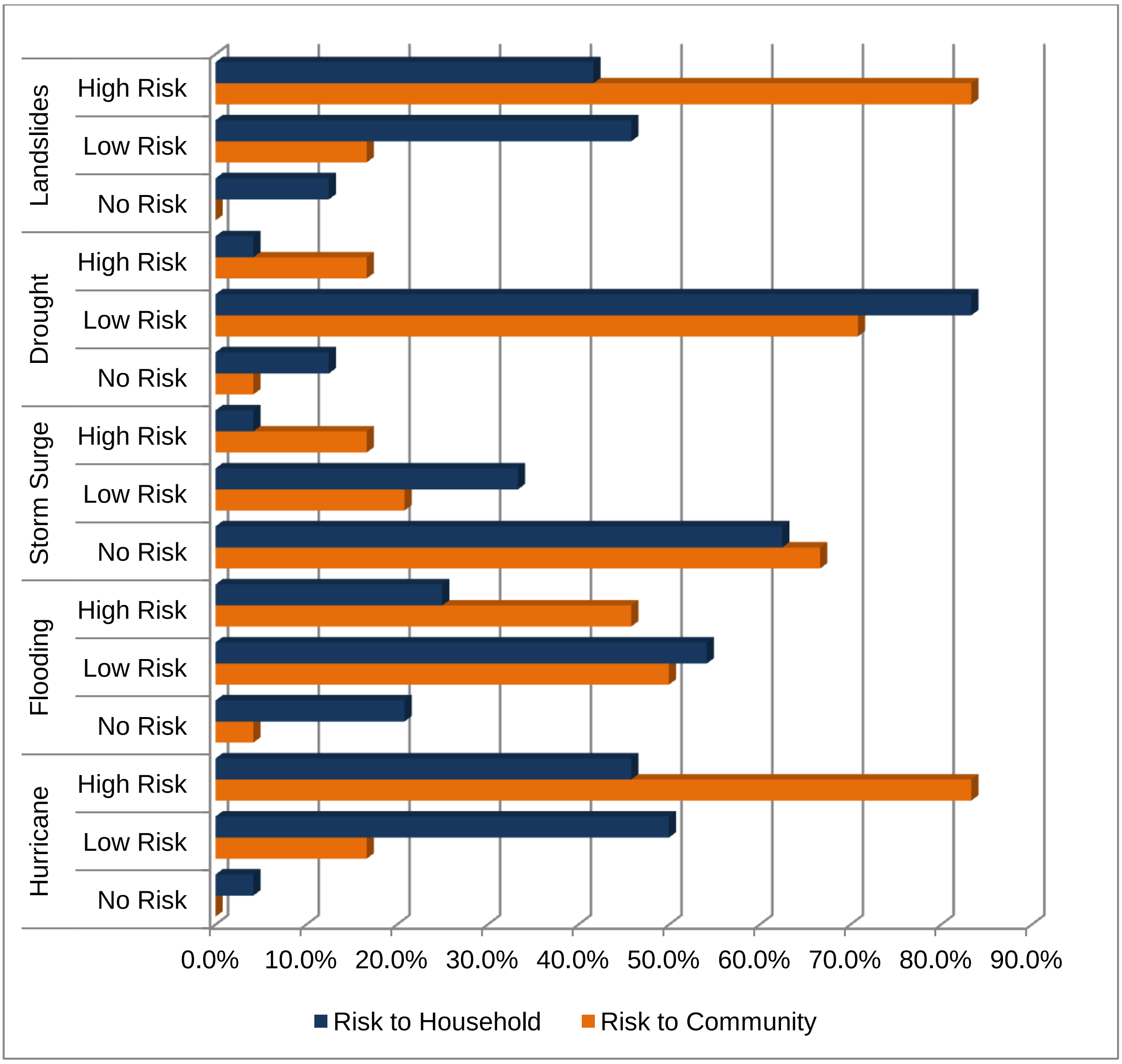

Figure 5.8.5: Perception of Risk for Climate Related Events

Similar to perceptions of risk of climate related events, respondents consistently reported higher levels of support received within the community than in their respective households during climate related events. The greatest disparity was observed in relief supplies, evacuation assistance and residence in shelter. The disparity in relief structure improvements and public education materials supplies also bears noting.

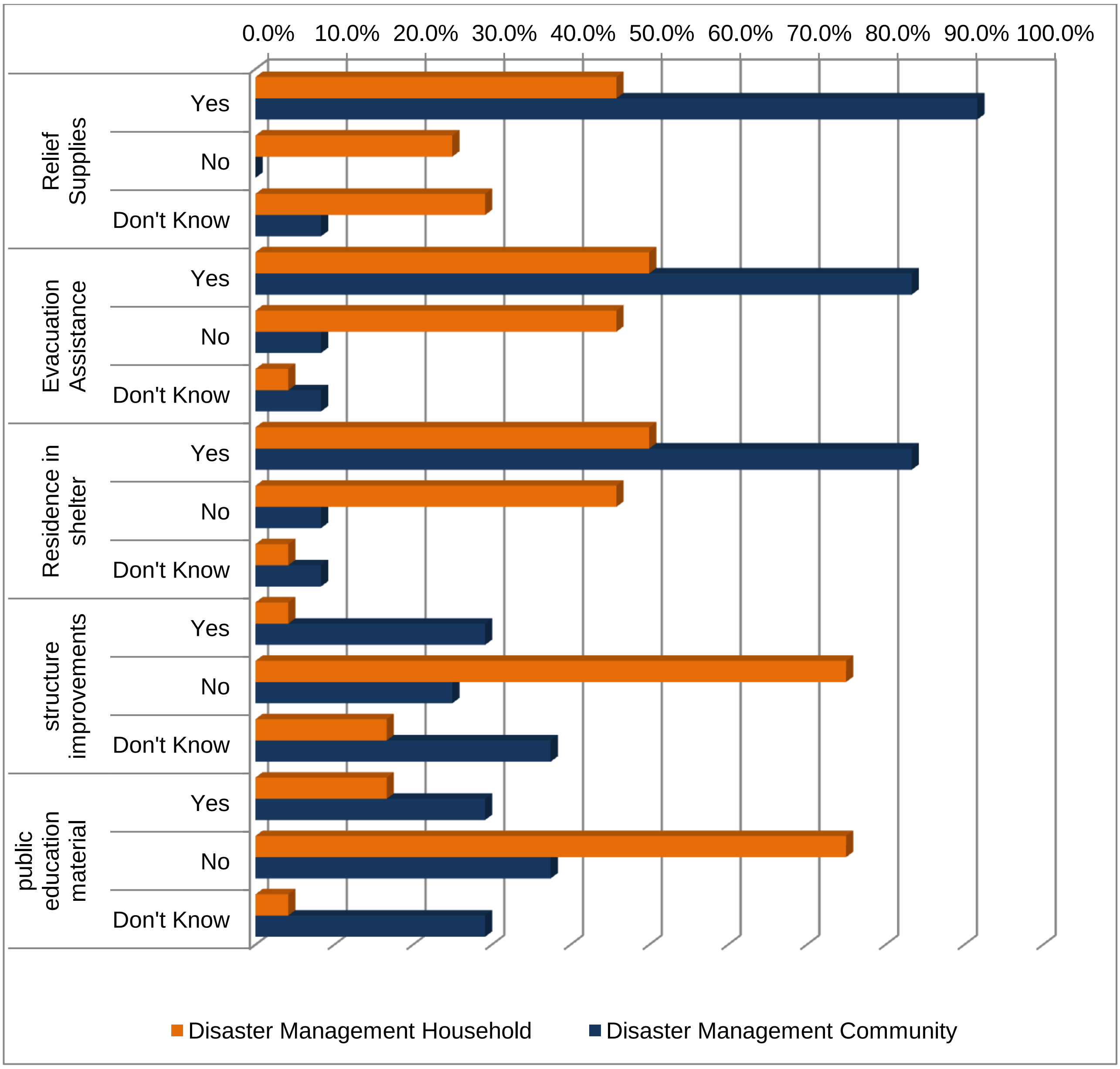

Figure 5.8.6: Support during Climate Related Events

6. RECOMMENDED STRATEGIES AND INITIAL ACTION PLAN

The following recommendations have been developed in consultation with national and community stakeholders through the use of various participatory tools. They support the main objective of the CCCRA which is to provide a scientific (physical and social) basis to support decision making, policy and planning by governments, communities and the private sector that increase resilience of economies and livelihoods to climate change. The recommendations are also consistent with the strategies and programmes identified in the *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change* endorsed by the CARICOM Heads of State.

Recommendations are presented as an initial plan of action with a brief description of the intervention, the national and/or local stakeholders involved and the expected benefits, and are categorised according to short-, medium- and long-term interventions. All recommendations are considered 'No-regret' or 'Low-regret' strategies. 'No-regret' strategies seek to maximise positive and minimise negative outcomes for communities and societies in climate-sensitive areas such as agriculture, food security, water resources and health. This means taking climate-related decisions or actions that make sense in development terms, whether or not a specific climate threat actually materialises in the future. 'Low-regret' adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components, for example installing larger diameter drains or hurricane shutters at the time of initial construction or refurbishment (World Bank, 2012).

Each one or a group of recommendations can be further developed into a concept note or project proposal with a full action plan, with much of the supporting information found in this document. Earlier sections of this report have provided the rationale for recommended interventions based on the vulnerabilities and adaptive capacity identified for key sectors.

6.1. *Cross Cutting Actions*

The following activities must be undertaken in the short-term, across a number of sectors, to ensure the success of the more specific and practical recommendations presented in later sections. These cross-cutting actions provide the necessary foundation, in terms of information and data, development policy, awareness raising and cross-sectoral linkages from which wider actions to combat the threat of climate change on future development can be legitimized. With this foundation, future actions and the allocation of resources to adaptation and mitigation activities are more easily justified because decisions can be based on current information, as well as common goals and a widespread understanding of the severity of the threat.

6.1.1. Data collection, monitoring and evaluation

It is evident in a number of sectors that the lack of data and inadequate monitoring and evaluation procedures inhibit the ability of the relevant agencies to plan and manage a number of resources. Monitoring and evaluation is essential if progress is to be demonstrated. By collecting and sharing the information gathered, Section 6.1.3, it is possible to gain even greater support amongst stakeholders.

Specific areas and suggestions for data collection, monitoring and evaluation include:

- **Conduct energy audits:** Few countries and businesses assess and monitor their tourism-related energy use and emissions. National as well as company-specific inventories to assess energy use and related emissions are a precondition for any work to reduce energy use. Companies should thus engage in energy- and carbon audits, while energy- and carbon labelling of a wide range of products and services should be policy goals for the Government of Saint Lucia.

- **Inventory existing coastal protection defences, as well as their design range and maintenance status**: The analysis of the vulnerability of tourism infrastructure in this report on Saint Lucia, and specifically Rodney Bay and Castries, was hindered by inadequate data on existing coastal structures, their type, design specifications and expected lifetime. Future assessments of the costs and benefits of coastal protection require this information to provide a more accurate estimate of the resources required for adaptation to sea level rise.

- Greater effort can be made by the Government of Saint Lucia to have their data better analysed, peer reviewed and published. As discussed in section 6.1.3, Saint Lucia has relatively good and current data. This approach to sharing and cooperation will allow for validation and developing a "culture" for systematic review. This will then result in the conversion of knowledge into policy and planning. In the Saint Lucia State of the Environment Report (2006), with reference to climate change, the Government seeks to "promote and support research at the national, regional and international levels on aspects of climate change and its impacts relevant to Saint Lucia" (MPDEH, 2006). Lessons from other countries can be identified and problems averted by using this method of peer review as it offers perspectives from persons outside the national context.

6.1.2. Mainstreaming Climate Change

Where national or sectoral policies and plans already exist there are areas that lack sufficient consideration of climate change and its impacts.

In recent years, Saint Lucia has experienced significant damages from climate-related events and disasters. The SPCR released in June 2011 (see Government of Saint Lucia, 2011) offers a few key activities that will build resilience in Saint Lucia to the impact of both climate change and future disasters. It is recommended that the projects outlined in the SPCR, especially the "Mainstreaming the Lessons of Hurricane Tomas and other Recent Climate Events", be executed; bearing in mind the direct link between vulnerability to natural hazards and climate change. Further to the implementation of the projects in the SPCR, the following recommendations are also made.

- **Work with relevant tourism stakeholders to implement existing sustainable tourism plans with the goal of mainstreaming DRR and climate change, SLR in particular, considerations into tourism development and local land use development plans.** Mainstreaming climate change in Saint Lucia requires special consideration to sea level rise as a matter of national priority for the local population and, more specifically, the tourism industry. To ensure these considerations get their due attention, it is recommended that Saint Lucia undertake national-level consultation with government ministries responsible for land use planning and tourism planning and that the broad scale results of this study, along with higher-resolution local scale studies, be used to guide reviews and updates of official land use plans. Consider the development of official SLR risk maps to accompany existing hazard maps in order to further guide future coastal development. Incorporation of coastal protection data from the inventory recommended in 6.1.1. The economic impacts of climate change may be slow to impact individual businesses, but Saint Lucia's national economy depends on tourism significantly. Therefore the incentives to protect and adapt must come from the national level in order for all stakeholders at the local level understand more fully the impacts. The importance of awareness raising and education is imperative to the success of this and many of the other recommendations herein.

- **Define national action plans for the energy sector.** Once national policy goals have been agreed upon, an action plan to avoid energy use, increase efficiency, and to use a greater share of renewable energy sources needs to be written and implemented. This plan needs to combine savings potentials (energy management; cf. Gössling 2010) as well as technological restructuring[4]. As part of the action, planning an assessment of the sustainability of Saint Lucia's energy systems should be prioritised, especially in the case of future renewable energy sources that depend on climate and priority coastal infrastructure such as power plants. These assessments should include outputs from climate change modelling scenarios (see Chapter 3) and involve energy sector authorities and national and regional specialists with support from international organisations where necessary.

6.1.3. Communication and networking

It is essential that a tri-partite approach is taken when developing the full action plans for the recommended strategies given. A number of relevant studies have been undertaken in Saint Lucia in the past, but the recommendations are frequently not implemented for a number of reasons: lack of resources being commonly cited. By establishing a framework by which government, private sector entities and civil society can work more effectively together, the probability of implementation and widespread 'buy-in' to the numerous initiatives increases. It is not possible for any one group to achieve the changes that are needed alone and government must ensure that national policy goals and challenges faced are transparent and publicly available so that solutions can be discussed and negotiated between groups. Redundant and repeated efforts by various sectors and stakeholders are counter-productive and can lead to mal-adaptation. National policy goals to reduce emissions also need to be communicated to the private sector, and challenges be outlined. Documentation of progress and improved communication will facilitate successful adaptation to climate change and address the issues identified in Saint Lucia's SPCR report. Gaining support for initiatives is also facilitated through education and awareness, Section 6.1.4.

The data and information produced through the various initiatives described in Section 6.1.1 must be communicated and made available through networks in each sector and across sectors. This is especially true for the idea of a green economy that will require the restructuring of economic systems towards establishing a low-carbon society. It is thus important to document and communicate progress to create positive opinion in large parts of society.

National level data should be made available to regional clearing houses where they exist and where they don't exist thought should be given to establishing them. Particular areas that could benefit from such a data repository include:

- The idea of a regional clearing house was noted to be of particular use in the health sector. Accessing morbidity and mortality data from the Saint Lucia MOH for this study was very easy, and their morbidity data was up-to-date to 2011. Statistics on mortality were only available up until

[4] Valuable information on the potential of wind- and solar power can for instance be found in Bishop and Amaratunga (2008), Chen *et al.* (1990), Chen *et al.* (1994), and Headley (1998).

2005. With efforts made to keep all data on diseases current, Saint Lucia could be promoted as a pilot country in the clearing house. Furthermore, the Saint Lucia State of the Environment Report (2006), states that the Government is committed to collaborating "with other states and organisations that pursue confluent agendas on climate change" (MPDEH, 2006). Once health data is current and detailed on various diseases, particularly those with climate sensitivities (e.g. dengue fever, schistosomiasis, and malaria), shared information can help other countries in the region build similar repositories. Further research and data collection is encouraged and recommended in section 6.4.

6.1.4. Education and awareness

The previous section on communication and networking relates directly to the sharing of information to assist decision making and planning. However, without education and awareness raising on climate change and the likely impacts of climate change on specific sectors the information shared will be meaningless. The research in a number of sectors highlighted specific areas that need additional efforts in education and awareness:

- Disaster risk reduction and emergency preparedness at the household level;
- Water conservation, rain water harvesting and other collection techniques for households, as well as water treatment;
- The importance of energy and the role of emissions in climate change, specifically knowledge about energy, its generation, and the economic and environmental importance of energy;
- Climate-related diseases and health promotion, particularly malaria and diarrhoea and the development of linkages with the agricultural sector to reduce malnutrition and improve food security;
- Impacts and costs of SLR to communities, but also to the public and private sectors, because of these damages have implications for livelihoods and sustainable development.

Due to the interrelated nature of some environmental issues and natural processes collaboration between different sectors can reinforce learning amongst the general public while also providing synergistic benefits for resources. Creative methods for public education and awareness have been developed. For example, the use of mobile phone technology can allow vital information to reach individuals during emergency situations. Research at the community level revealed that not all persons have cell phones, so this technique requires complementary messages to be transmitted through more traditional mediums, radio and television. In addition, building awareness of the issues mentioned above can be better embraced when the message is conveyed by a respected figure. Children and youth have been found to be good transmitters of basic environmental information. One effective communication strategy could therefore be to use Soca and Calypso music, since it has a tradition of telling stories and these styles are still popular in Saint Lucia today. By enlisting the support of a local Soca or Calypso artist, the messages can be widely made available and will be more easily remembered in a hit song.

It was reported that scientists have held discussions on climate change impacts in Saint Lucia, but not at the community level. Education on climate change and hazards is vital for the Soufriere community to foster awareness amongst all groups and to encourage residents to prepare and put measures in place to deal with likely impacts. Similarly, within the community itself, it is felt that there is a lack of knowledge/skills transfer, where older generations do not take the time to pass on the knowledge of traditional practices to younger generations, such as rainwater harvesting (previous recommendation). A regular, organised, community level forum should be established to facilitate knowledge transfer sessions between generations and for dissemination of information to the community from external sources (i.e. climate change practitioners). Such a forum could also contribute to community development and serve as an environment for mentoring the youth.

6.1.5. Legislation creation and regulation

Although deficiencies in resources, both technical and financial, are acknowledged in various agencies and sectors in Saint Lucia, legislative and regulatory frameworks that will ensure the effective and complete implementation of national climate change strategies are important to Mainstreaming Climate Change (section 6.1.2) and must be informed by current data (section 6.1.1).

Review and develop policies and legal framework to support coordinated retreat from high-risk coastal areas: The Government of Saint Lucia must review existing policy and legal frameworks to assess the responsibilities of the state and landowners for the decommissioning of coastal properties damaged by the impacts of SLR. The government should also examine the use of adaptive development permits that will allow development based on current understanding of SLR, but stipulate the conditions for longer-term coastal retreat if sea level increases to a specified level. Current coastal set-back regulations need to be reassessed in light of new SLR projections to ensure that new developments are not built in vulnerable coastal areas.

Use regulation to stimulate changes and adaptation with relation to energy use in the tourism sector: While carbon pricing is the most efficient tool to stimulate behavioural change and changes in production, market failures justify additional policy intervention (see also Francis *et al.,* 2007). Energy-intense forms of tourism and transport, as well as behavioural change, are difficult to steer through rising energy costs and can thus be addressed through other measures, such as speed limits, bans of jet skis, quads, or other motorised transport at the destination level. Moreover, regulation can include building codes and other minimum standards to reduce emissions, also with a view on adaptation (see also recommendation on building codes in section 6.9). Actual enforcement of existing environmental regulation needs to be ensured as well.

Policies should be developed to help protect existing water supplies and to support water conservation initiatives: Legislation should be developed to regulate and licence the abstraction of surface water, particularly in the construction and mining industries and in the agriculture sector. In addition, forests, watersheds, and other ecosystems which are required to regulate and maintain water quality should be protected. Water conservation technologies exist in the market at commercially available and viable quantities, but the policies to support these initiatives do not exist to encourage heavy water users, particularly in the industrial sector to utilise them.

6.2. *Water Quality and Availability*

Short term actions

WASCO pricing structures should be reassessed such that the full cost of water is charged, including the cost of water supply systems: 1,000 gallons of water costs EC $18 to produce, while a domestic consumer only pays EC $7 per 1,000 gallons, which does not encourage water use efficiency. Water pricing should be set at a level which encourages conservation, reducing water wastage and demand, and government subsidies for water production phased out in line with this.

Medium term actions

Specific training in water quality testing and filtration systems is needed in WASCO. There is no national training on water quality with regards to rainwater systems, which is particularly important to disinfection of water and the assurance that proper filtration systems are installed across Saint Lucia. Additional revenues resulting from improved price structures should therefore be allocated, at least in part, to continued training for WASCO staff.

6.3. *Energy Supply and Distribution*

Consistent with the issues and future directions outlined in the National Energy Policy, the following section suggests a set of measures to reduce energy consumption and emissions in tourism in the Caribbean.

Short term actions

Stabilise energy pricing to influence energy use and emissions: Taxes, emission trading and other economic instruments are needed to steer energy use and emissions, conveying clear, long-term market signals. It is important for these economic instruments to significantly increase the costs of fossil fuels and emissions. Price levels also need to be stable (not declining below a given level), progressive (increasing at a significant rate per year) and foreseeable (be implemented over longer time periods), to allow companies to integrate energy costs in long-term planning and decision-making.

Long term actions

Create incentives for low-carbon technology use: The introduction of low-carbon technology needs to be supported through incentive structures. An ecological tax reform, for instance, could shift tax burdens from labour to energy and natural resources, and thus "reward" users of low-carbon technology. Other incentives could include financial support, reward mechanisms or awards. There is also a range of examples of bonus-malus[5] systems in tourism and transport, rewarding those choosing to pollute less.

6.4. *Human Health*

Short term actions

Improve the use of technology in the health sector: There are various aspects of technology that can be developed in the health sector. An Early Disease Warning Systems that considers temperature signatures for vector borne diseases, however these must be validated (Chen *et al.*, 2006) and be site-specific (Ebi *et al.*, 2006). Saint Lucia could draw from the climate projections presented in Section 3 of this report, to identify temperature variability. With this data, local studies of specific vectors and vector borne diseases could then be studied as a collaborative effort between the Ministry of Health and the academic community within the Caribbean. Other signatures that require further researched include the use of the pre-seasonal treatment of vector breeding areas (Chadee, 2009). This kind of action can be a practical way to execute effective disease control in Saint Lucia (Ebi *et al.*, 2006). With respect to asthma and other respiratory diseases, a special Early Warning System is required to be able to track Sahara dust clouds arriving from the West Coast of Africa and using this information to inform local hospitals and patients of impending arrivals of dusts. When the early warning system is developed, and at the time of first release especially, a public awareness campaign would be required so that persons fully understand who is

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[5] Business arrangements which alternately reward (bonus) or penalise (malus) for specific actions.

vulnerable and what information is conveyed in the warnings. Collaboration with NEMO is recommended to make use of existing warning system communication methods and mechanisms.

Medium term actions

Conduct assessments focusing on the links between health, tourism and climate change: The literature on tourism and climate change is growing, especially with regard to the economic impacts (Hamilton and Tol, 2004). So too are the parallels between tourism and climate change with health. Therefore, further research that links the epidemiology of diseases in Saint Lucia with climate data is recommended. For instance, dengue fever is perhaps under-reported by travellers who experience the generalised symptoms of the disease and are unfamiliar with them and similarly health care professionals also under-diagnose the disease (Wilder-Smith and Schwartz, 2005). It is recommended that an on-going study of visitors leaving the island be implemented to allow the determination of the validity of this statement. To effectively monitor these diseases in visitors, another method of data monitoring could be conducted through collaboration with research units in private institutions and universities such as UWI. Many of the source markets for international tourists have national tropical diseases centres which would also have some data on these diseases. The collection of such data would be labour intensive, but by partnering with research institutions, an on-going project which aims to create a database can fostered (see also regional clearing house recommendation in section 6.1.3).

An important question to be answered in the tourism sector of Saint Lucia is whether substitution of destinations would occur if tourism related health problems increased as a result of climate change. There is a need for studies that link climate change, tourism and health in the Caribbean and by extension in the Caribbean basin. The consequences of air travel and the cost of health incurred to tourists could also be assessed to understand the implications of diseases, particularly communicable diseases to tourists entering the region. It is a delicate and complex process to consider and separate the specific contribution of climate change to the transmission on any particular disease because Saint Lucia has to find numerous ways to adapt to the range of health issues described above. Therefore the fourth recommendation coming out of this study is that research be conducted to determine the perception of tourists to health and climate change on the island.

Long term actions

With the long term goal of implementing the WHO Integrated Vector Management (IVM) programme, develop capacity within the public health sector, with specific focus on evaluation of diseases. Gubler (2002) has stated that the resurgence of diseases, particularly vector borne diseases, has been “compounded by complacency about infectious diseases in general and vector-borne diseases in particular, and a lack of public health resources for research, surveillance, prevention, and control programs”. These may be applicable in Saint Lucia, particularly in light of recent dengue outbreaks and the continued yearly reporting of schistosomiasis cases. It is, therefore, recommended that the IVM Programme approach of the WHO be adopted. Before that can be achieved, Saint Lucia must build up a supply of public health resources for the surveillance, prevention and control of vector borne diseases.

Later, in cooperation with the WHO, the Caribbean Environmental Health Institute (CEHI), the Ministry of Health will then have the ability to effectively employ the IVM approach. The items of the IVM approach, taken from the Report of WHO consultation on IVM (WHO, 2007) are:

- Advocacy, social mobilisation and legislation
- Collaboration within the health sector and with other sectors
- Integrated approach

- Evidence-based decision-making
- Capacity-building

The Caribbean region, as part of the WHO Region of the Americas has the potential to chart a course that includes IVM in diseases that have a climate change signal. Those diseases that have been highlighted for Saint Lucia include malaria and dengue fever. On-going monitoring of these diseases is encouraged and sharing findings with other sectors will be an important part as discussed in section 6.1.3.

6.5. *Agriculture and Food Security*

Short term actions

Create a "*Crop-growing for Climate Change*" project to build Saint Lucian farmers' capacity to grow produce using good agricultural practices and to introduce them to new technologies that will improve the quality and yield of their crops under existing pedoclimatic conditions: Delivery of training courses should be farm-based, practical and should target organised groups such as women farmers, youth and farmers' associations based in agricultural districts. This programme should enhance the work conducted through the EU-funded AGIL project and implement some of the recommendations for farmer education identified through the training needs assessment.

Medium term actions

Assess land use plans and policy to addresses land allocation for agriculture and employ alternative agricultural practices to improve slope stability and reduce landslide risks. Community Participants in the consultations reported that prime agricultural land is being cleared for housing and tourism. The government owns much of the flat lands, and thus these lands are not accessible to the small farmers who lack the necessary resources to purchase land away from their location on hills. There was a 41% reduction in the number of agricultural holdings in Saint Lucia between 1986 and 2007, with 8 out of 10 administrative districts recording between 40-74% reductions in the number of holdings within this period. Continued farming in the hills leaves the land increasingly vulnerable to landslides because of poor cultivation practices on the slopes and regular erosion also continually degrades the soil quality, having detrimental effects on crops.

Many of these issues have already been identified in the the National Green Paper. While community members would like to see land reforms that allow them the opportunity to buy or lease flat land, other options also exist. A Sloping Agricultural Land Technology (SALT) project is an alternate solution which would help address some of these concerns. SALT is a package technology on soil conservation and food production which has been endorsed by CARDI based on their previous practical applications and studies conducted in Belize. This project will require collaboration with the Saint Lucia Ministry of Agriculture and technical agencies such as IICA and FAO. The aim is to control soil erosion in agricultural areas, help to restore soil structure and fertility, and increase efficiency in food crop production. The SALT system should be targeted especially towards small farmers with limited financial resources and be configured to use local resources and minimal labour for cultivation. Community discussions also revealed the need for reforestation programmes that uses fruit trees as opposed to heavy mahogany trees in areas affected by landslides. This would provide an additional source of food and/or income for rural communities.

6.6. *Marine and Terrestrial Biodiversity and Fisheries*

Saint Lucia's diversity of ecosystems and species are critical to the island's main economic sectors: tourism and agriculture. The drivers of biodiversity loss have been, and continue to be, rapid tourism development and poor resource use as a result of poverty and unemployment. The inherent links between forests, freshwater ecosystems and coastal ecosystems necessitates an integrated approach to resource management. The following strategies will seek to integrate efforts between the tourism and agriculture sectors to minimise their respective stressors on terrestrial and coastal/marine biodiversity and thus build resilience of these sensitive ecosystems to climate change.

Short term actions

Review and assess standards for discharge of pollutants such as sewage and agro-chemicals with the aim to preserve water quality in both surface water and coastal areas. Sewage treated to irrigation-quality-standards at hotels has caused algal blooms in Saint Lucia (Edwards, 2008). Reduced marine water quality impacts on coral reefs, seagrasses, marine turtles, fisheries and is potentially harmful to swimmers. In 2010 the Saint Lucia Bureau of Standards (SLBS) produced new guidelines for recreational water quality. The Rodney Bay Sewage Treatment Works is operated by the WASCO and serves a portion of the population in the north of the island. Several hotels are otherwise served by privately owned package sewage treatment plants. Hotels and treatment plants should ensure that effluent meets the new standards laid out in the 2010 SLBS Guidelines.

To help motivate hotels to meet these standards, a monitoring and enforcement programme will likely be needed. Through discussions within the water sector, the most appropriate enforcement body can be identified, as well as the appropriate penalties for non-compliance determined. Concerns of agro-chemical pollutants and sedimentation of surface waters is also a concerned raised by the water sector. The issue of sedimentation can be partly remedied by the sloping agriculture (SALT) recommendation. Creation of similar penalties and regular testing of water quality will however be required. In this case, WASCO and the Ministry of Agriculture must negotiate who is best suited in terms of technical personnel and set up a system to share the responsibility and financial revenues.

Improve the management and resilience of fish sanctuaries. The Ministry of Agriculture, Forestry and Fisheries, the Ministry of Physical Development, Environment and Housing and community fisheries groups are encouraged to collaborate in the creation of a strategy for:

- establishing a more effective fish sanctuary management and enforcement system for coastal communities;
- for enhancing the capacity of resource managers and users to be more resilient to climate change; and
- establishing a sustainable finance mechanism for supporting fish sanctuary management.

The strategy should increase the involvement of the tourism sector in supporting community-based MPAs, as well as provide opportunities for alternative livelihoods and technologies for public education. It is anticipated that the financial, marketing and communication mechanisms will help promote mutually-beneficial partnerships between the tourism sector and fishing communities in Saint Lucia.

Construct/restore wastewater wetland treatment systems: Wetlands naturally act as biofilters to remove contaminants from wastewater. A study on hotel sewage package treatment plants in Saint Lucia found that the highest quality effluent was at a wetland treatment system for a medium-sized hotel (UNEP, 1998). Sewage is first pre-treated with screening and settling. The wastewater then flows into a three-tiered, free-water-surface wetland system dug into a hill. The wetland effluent passes through a filter and then is disinfected with an ultraviolet lamp. WWTS are a low maintenance, low energy and cost effective alternatives to conventional treatment options. They also provide aesthetic and habitat values.

Priority sites for constructed/restored wetlands should include hotels and tourist related operations. This strategy provides opportunity to strengthen collaboration between the tourism, planning, water and environment departments. Hotels that utilise the WWTS may benefit by gaining preferred status as eco-friendly establishments.

Medium term actions

Replant mangroves in priority areas: Maintaining vegetative buffers, such as mangroves, through regulation, enforcement and rehabilitation is a potential adaptation strategy that is suggested by the SPCR for Saint Lucia that will benefit a number of vulnerable sectors namely agriculture, water and forestry, tourism, health and social sector of vulnerable groups. The landslide risk map of Saint Lucia (Figure 4.7.2 in section 4.7.3) shows that the coastline from Anse-la-Raye to south of Soufriere are at high-extreme risk of landslides. Coral reefs in these areas are thus highly vulnerable to sedimentation and require protection. Replanting mangroves along this stretch of coastline will help protect dive sites, coral reefs and their associated fisheries from heavy sedimentation during periods of intense rainfall and extreme weather events. When used in conjunction with the alternative agricultural practice on slopes (SALT – see Section 1.5), sedimentation impacts can be significantly reduced.

A buffer of mangrove forests will also provide protection for tourism infrastructure. The SMMA will benefit from the presence of mangrove trees which filter pollutants and provide protection to fish and crustaceans allowing them to increase in size and abundance. Healthy mangrove forests will also provide better protection of the coastline, tourism infrastructure and coastal communities against natural disasters such as storm surge and hurricanes.

One method of mangrove reforestation that has proven successful in Belize is the Riley Encased Methodology. The method, which uses a small PVC pipe to protect growing saplings, is relatively inexpensive, easily implemented and causes minimal disturbance to the environment. A natural alternative is the use of bamboo wave attenuators to protect developing saplings; this will save a step in the reforestation process since the PVC piping will not have to be removed once the saplings have grown to reproductively mature trees. Mangroves reach maturity in 20-25 years so high priority should be given to establishing mangrove stands in these areas now.

Long term actions

Sea egg aquaculture in marine reserves: The sea egg industry has been a culturally and economically significant one for many years. Despite closed seasons and moratoriums, the sea egg (*T. ventricosus*) fishery has continued to face combined pressures of harvest and habitat degradation. A possible approach to mitigate the declining numbers of this species is a sea egg reseeding programme. This species grows quickly and can reach maturity within 1 year; making it a suitable candidate for aquaculture. Larvae may be reared in laboratory facilities on the island and juveniles can then be relocated to designated protected areas. Previous attempts at managing the fishery using a co-management approach primarily through the engagement of fisherfolk have proven effective and may be revisited for this strategy. Fisherfolk can be trained and employed in the relocation of sea-eggs from laboratories to protected areas and in the monitoring of these sites. Rebuilding of the sea egg population will have ecological benefits since this herbivorous species grazes on algae and helps to control its growth. This strategy builds the capacity of fisherfolk, improves the relationship between resource users and managers and addresses the lack of wardens to monitor marine reserves.

6.7. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

Due to the time scales required for the removal of GHG from the atmosphere and the thermal inertia of the oceans, the effects of prior emissions will ensure that climate change impacts will persist for more than a millennium (IPCC, 2007b; IPCC, 2007d). It is therefore vital to not only recognise the vulnerabilities to current SLR and SLR-induced erosion, but to also anticipate and prepare for future SLR implications. Successful adaptation is more than simply implementing a technology or building a structure, it is a process of awareness raising, information sharing, planning and design, implementation, and perhaps most importantly, evaluation (Linham and Nicholls, 2010). Recognizing this, the following recommendations reinforce the need for serious, comprehensive and urgent action to be taken to address the challenges of adapting to SLR in Saint Lucia.

Short term actions

Commence coastal protection adaptation planning early: The Government of Saint Lucian needs to work with local stakeholders on the development of coastal protection systems. The detailed local level planning for coastal protection needs to begin within the next 15 years if the environmental assessments, financing, land acquisition, and construction is to be completed by mid-Century, so that the economic benefits of damage prevention are optimised.

Integrate SLR into the design of all *NEW and renovated* coastal structures: Environmental assessments and construction permits for coastal structures should be required to take into account the most recent estimates of SLR from the scientific community. The Government of Saint Lucia needs to assess all projects that involve building, maintaining, or modifying infrastructure in coastal areas at risk from SLR to ensure that the new developments take SLR into account. The cost of reconstruction after flood damage is often higher than modifying structures in the design phase.

Medium term actions

Conduct a thorough cost-benefit analysis of coastal protection at a local level: Cost-benefit analysis of coastal protection will be informed by the estimated cost of damage to specific infrastructure and properties. The specific location of infrastructure is important for estimating impacts to a high level of fidelity. Similarly, property values are highly dependent on exact location – for example in some areas the most expensive property values may be on the coast, whereas in others they may be located on a hillside. A detailed analysis of property prices by location is required as part of local level studies. The Government of Saint Lucia, local resort owners and local building authorities are encouraged to collaborate with members of the research community to help develop a cost-benefit analysis for coastal protection. In addition to refining estimates of costs to rebuild infrastructure (particularly in areas with high-density coastal development), there is an important need to investigate the response of international tourists and the private sector to the impacts of coastal erosion to test adaptation strategies in the tourism sector. By completing a cost-benefit analysis, decision makers will able to identify the best adaptation options to adopt and can begin to move forward in reducing the vulnerability of settlements and infrastructures in vulnerable areas.

Assess the adaptive capacity of the tourism sector to SLR: Tourism is one of the most important sectors in Saint Lucia. Given the close proximity of the tourism infrastructure to the coast, it is highly dependent on the attractiveness of the natural coastal environment, which has been shown to be vulnerable to SLR. More detailed analysis of the impacts of SLR for major tourism resorts, critical beach assets and supporting infrastructure (e.g. transportation) is needed to accurately assess the implications for inundation and erosion protection. A necessary part of this evaluation is to identify the land that can be used for tourism infrastructure and future development under a managed retreat response to SLR.

Integrate SLR into insurance policies: Insurance policies that account for the long-term risks of SLR will enable landowners to properly assess coastal protection and retreat options. The Government of Saint Lucia needs to work with insurance companies to develop policies that take into account the unique risks faced by coastal areas. Government subsidies to insure coastal properties that suffer repeated losses or are at high risk of SLR inundation and erosion will encourage maladaptive decisions by property owners and continued expense to the national economy. The government needs to ensure that subsidies are instead provided for appropriate adaptation measures that will result in long term economic benefits for both the tourism sector as well as for the people of Saint Lucia.

Long term actions

Complete a focused analysis of the vulnerability of secondary and tertiary economies to SLR and determine the economic impacts of these damages for the tourism sector: Tourism infrastructure is vulnerable in Saint Lucia. With tourism contributing a large proportion to the national economy, the capacity of the Saint Lucian economy to absorb and recover from proportionately higher economic losses in that sector is expected to be low. Determining the secondary and tertiary economic impacts of damages to the tourism sector and possible adaptation strategies for Saint Lucia should be a priority for future research. This will enable the identification of the degree to which the economy of Saint Lucia and its citizens are economically and socially vulnerable to SLR. In the event that this study finds tourism to be economically vulnerable to the impacts of SLR, then action plans could be developed to diversify the economy and provide training and tools to help workers transition to other sectors that may be less vulnerable.

6.8. *Comprehensive Natural Disaster Management*

Due to the cross-cutting nature of the disaster management sector, and the close linkages between disaster management and climate change adaptation, the majority of recommendations from the assessment of the disaster management system have been captured in the other sector recommendations. In particular, the many recommendations are in line with results from the community work conducted in Soufriere and therefore located in the subsequent section.

Medium term action

Develop a warning system for coastal hazards that makes use of technology for the collection of accurate data and the provision of good information on at-risk coastal areas: Minimal progress can be made on vulnerability reduction efforts without proper baseline data. Saint Lucia has acknowledged the need for vulnerability assessments, but due to lack of human capacity and other resource constraints, these assessments are not being done by the responsible agencies (ISDR, 2010). "Because risk and vulnerability are dynamic, risk and vulnerability assessments must be continuous efforts" (UNEP, 2007, p. 15). A more robust vulnerability data collection will allow for the prioritisation of future projects on areas that are least able to adapt to climate change and those most at risk to damage and loss from hazards and disasters. This will require additional data from rainfall and tidal gauges. Rainfall data could also inform a new CCRIF insurance index based on rainfall accumulation over time, a consideration that is currently not possible due to poor and inconsistent data. This data management problem is also mentioned in the SPCR Project Profile 8, Events Mapping – Hurricane Tomas and Project Profile 9 – Enhancing the capacity of the Ministry of Physical Development. These SPCR recommendations are encouraging the allocation of funding to these important tasks. Greater investment in technical capacity will enhance vulnerability reduction decision making nationally (see recommendation on capacity building in NEMO in section 6.9).

6.9. *Community Livelihoods, Gender, Poverty and Development*

During the consultations, community residents highlighted various strengths and gaps in their ability to adapt to climate change, and also put forward recommendations to increase their resilience. Many of these recommendations are inter-related, so that concerted effort on one area should have a positive feedback effect in other areas.

Short term actions

Develop the Green Paper on National Land Policy into a comprehensive land use policy and plan that includes hazard assessments, hazard maps and watershed management plans will enable the Government of Saint Lucia to address various issues, including:

- Access and allocation of land and property to Saint Lucians, particularly agricultural land;
- Better integration of hazard information into land allocation decision making;
- Protection of water catchments from sedimentation and pollutants (see recommendation on water quality);
- Reduction of development (including formal and informal housing) near river banks and in high-risk areas, such as steep slopes where landslides threaten housing, agriculture and water supplies;
- Lack of transparency of decisions relating to land use;

The Ministry of Physical Development, Environment and Housing is recommended to carry forward the development of the National Land Policy and accompanying plans. Collaboration with NEMO, WASCO and the Ministry of Agriculture will be necessary to ensure related policies and plans support and inform the goals.

Review drainage and river engineering: Community members reported that Hurricane Tomas highlighted a number of weaknesses in the drainage system. Many buildings were damaged or destroyed when rivers, which were previously diverted or altered to make way for physical development, reclaimed their original water courses. Road infrastructure is also damaged during flooding and following Hurricane Tomas, roads were repaired temporarily to make them usable, but residents remain concerned that unless the drainage issue is addressed, flooding will continue to affect the area and roads will be repeatedly damaged.

Some engineering solutions were suggested by community members:

- new design for bridges as they have been repeatedly damaged by floods;
- dredging of rivers, as siltation in the river from land erosion currently increases the likelihood of flooding during heavy rains; and
- retaining walls to control soil erosion and land slippage. It was reported that previously, there were 10-12 ft banks along the rivers, but currently the water height is almost at street level.

A comprehensive review of these issues and the determination of some specific actions that could be taken to alleviate the pressure in some rivers would reduce the vulnerability of communities to damage from flooding. Identification of flood prone areas should also feed into the land use plan recommended earlier with engineering solutions such as building on stilts incorporated into building regulations.

Promote economic development in rural areas: A major challenge for the Government of Saint Lucia is to promote economic development policies that will reduce the rate of urbanisation by providing more employment opportunities in rural areas (MHURLG, 2008). Specific concerns raised in the community consultations relate to the economic prospects of people living in rural areas, include:

- Lack of access to markets for agricultural products;
- Lack of access to technology for improved agricultural practices;
- Lack of access to resources for purchasing land and technology.

Community members identified a need for greater access to markets for selling agricultural produce at fixed, profitable prices. It was reported that even though there is a farmers' co-operative, farmers often use produce for their own subsistence and give away surplus because there is a greater preference for imported goods in some cases. Agricultural land was identified as important for subsistence by 76% of respondents and 72% said it was important for livelihoods. One community recommendation was the establishment of a food processing enterprise in the area, which would serve to provide employment and present farmers with more options for the sale of their produce. The Ministry of Agriculture, along with community organisations such as the Saint Lucia Network of Rural Women Producers or Saint Lucia Agriculture Forum for Youth, are seen as the primary stakeholders to be engaged in the development and organisation of such alternative enterprises.

There has generally been wide acceptance of the use of greenhouses in agriculture, however, it is an expensive venture. Residents indicated that they need technical assistance from government to start greenhouse operations. They find that the government is unreliable in providing the necessary support and farmers feel ill-equipped to source funding from other agencies. Through larger regional bodies, such as IICA, funding of projects relating to technological development can be explored so that the Ministry of Agriculture does not have to stretch limited national funding for this kind of infrastructure.

Assess, repair and upgrade storm shelters as necessary: The largest group of persons seeking shelter during Hurricane Tomas was found in Soufriere, from the community of Fond St. Jacques, and many people stayed away from their homes due to fear posed by the risk of continuing landslides. Community members recommended that existing storm shelters need to be upgraded to better withstand storm events, and repairs are needed for those shelters that sustained damage during the passage of Hurricane Tomas. Shelters form an important part of a community's asset base when it comes to resilience and adaptive capacity. However, the shelters must be well designed and well equipped to perform the task.

Promote and support individual water harvesting and storage to reduce the pressure on the government supply and ensure supplies are available in the event of a natural disaster and drought. In the aftermath of Hurricane Tomas there was a severe shortage of potable water and participants suggested that the hurricane revealed the inadequacy of government's water policy. It was reported that in the past, residents harvested water and stored it in tanks for use in the event of water shortages. In addition, the local planning department plan for residents to use cisterns to harvest rainwater should continue to be supported nationwide.

Particular consideration for water storage installation through incentives in every new building and during renovations should be encouraged. This could possibly be considered during the review of the building code in the previous recommendation. An assessment of the viability of expanding storage facilities which would supplement the John Compton Dam should be conducted with specific concern for improving access to potable water in communities. One possible solution is the use of large scale desalination plants to help maintain distribution during periods of low supply. Correspondingly, National Water Policy which does not grant licences for small scale desalination plants to produce water for public consumption should be reviewed by WASCO in conjunction with an assessment of the use of this water production method in the energy sector. Finally, water shortages during times of drought and disaster can result from losses in the water distribution system. A study should be conducted by WASCO to ensure stored water is of good quality and that leakages are reduced through replacement of necessary pipes and infrastructure.

Update building regulations and hire building inspectors, in permanent positions, with the responsibility of reviewing all construction on the island: Across the Caribbean, housing structures are highly vulnerable to damages from disasters such as hurricanes and tropical storms. In Saint Lucia after a recent hurricane, the worst affected villages were located in the interior of Soufriere and Castries (UNECLAC, 2011). Communities located in the interior, especially where houses were built on steep slopes, suffered losses as a result of landslides and other forms of soil movement. Poverty and lack of livelihood opportunities have forced some people to pursue practices that essentially place the community in greater danger, such as undermining the natural resource base and protective ecosystem services for the sake of cutting costs (e.g. cutting down trees to make charcoal as an alternative to gas; and sand mining to build less sturdy houses instead of concrete). Very few of the people surveyed have insurance (17% health, <10% flood, fire or storm surge insurance), which makes them even more vulnerable to the impacts of climate change.

To help adapt houses located in unsafe locations, review of construction practices in Saint Lucia is recommended. The regional standard on building materials and practices aims to help to reduce losses to individual families and also take some of the pressure off of storm shelters because if designed and enforced appropriately, homes would safe to stay in during emergencies. Saint Lucia should continue to assist with the development of a regional code, however, since national regulations or building codes do exist, the issue is more one of enforcement of the building code and land use regulations. This becomes particularly important following major events, such as Tomas, where many homes can be rebuilt in a safer manner. NEMO, along with Planning (and also with contractors and builders) must collaborate to conduct a needs assessment with the objective of identifying financial resource availability, personnel requirements that would improve enforcement and physical and technical requirements for hiring more building inspectors and reviewing land use management. Capacity would need to be built within NEMO as well so that post-disaster assistance in reconstruction is appropriately allocated to housing safety.

Medium term actions

Conduct capacity building and technical training programs for NEMO employees and community assistants so that the current technical deficiencies can be remedied and skills gained. The need for training on the promotion of disaster risk reduction (DRR), including the identification of 'DRR champions' to volunteer within the DRR Network was identified during this research and in consultation with community members. This recommendation is to build capacity in the local communities and within national level agencies so as to increase community cohesion and develop linkages between communities and national stakeholders. To achieve this NEMO and their District Disaster Committees shall work together and develop complementary skills to better manage risks and improve understanding of the vulnerability in the communities across Saint Lucia.

This recommendation also aims to help build community cohesion, while at the same time increasing the community's resilience to climate-related events. As such a needs assessment must be conducted and funding for community level disaster mitigation initiatives sought. Such initiatives might take the form of tree-planting on unstable slopes, construction of gabion walls, clearing of drains, development of early warning systems and evacuation planning. It was pointed out that post-Tomas landslide excavation and waste disposal activities were outsourced, whereas persons from within the community could have been employed for these tasks, thereby building community spirit and allowing community members to benefit financially.

Further capacity will be needed in the newly constructed and Emergency Operations Centre (EOC).Provision for on-going training for staff will ensure this new facility is fully operational and that all tools and technologies are put to use during emergencies. These activities should also be supported by a strong educational component as outlined in the previous recommendation (section 6.1.3).

Long term actions

Mainstream gender and poverty into climate change and related policies: Challenges of poverty reduction and climate change need to be addressed in a coherent and synergistic way. It needs to draw on the lessons and progress in development policy and particularly the recognition of the importance of gender differences if policies are to be sustainable, effective, and benefit all sectors of the population. The gender equality index in Saint Lucia has declined between 2006 and 2009 (Trading Economics, 2010) and higher poverty rates and lower labour force participation and employment of women contribute to their overall vulnerability (Buvinic *et al.*, 1999; Kairi Consultants Ltd., 2007c). Achieving sustainable and effective responses to climate change, therefore, requires attention to the underlying power relations and gender equalities which create vulnerability both to poverty and climate hazards, and a more gender-sensitive approach which takes into account and evaluates the differing and potentially inequitable access which men and women have to economic, ecological, social and human resources, institutions, governance and infrastructure. These factors could be addressed through a project to:

- *Provide gender disaggregated data and evidence on the impacts of climate change* to show how men and women are being affected differently by climate-related changes. This could be done for direct impacts, such as extreme weather conditions or disasters, water shortages, food insecurity or changes in land use. This could also be done for indirect secondary impacts, such as access to energy, changes in employment opportunities, sectoral impacts (e.g. agriculture, tourism and fisheries), and increased migration or conflict. The survey in the Soufriere area of Saint Lucia showed that although women have higher levels of education they remain lower wage earners.

- *Conduct a gender- analysis on the social impacts of current policies on adaptation and mitigation* and how they may benefit or adversely affect men and women in different ways. Even when policies have clear gender-related statements or objectives, rarely do they have the mechanisms in place to integrate gender at a programme level or to measure the impact of the policies from a gendered perspective. Economic cost-benefit analyses often overlook the social implications and there is a lack of methodology for measuring the gendered impacts of current policies.

- *Improve institutional capacity in key agencies to implement gender sensitive policy or gather gendered data.* This is needed due to the lack of gender experts involved in policy design and implementation around climate change; the lack of awareness or gender training of key staff in ministries and statistics offices responsible for climate change data and policies; and a general disconnect between the reality of poor people’s (and particularly under-represented women’s) lives and policy makers.

7. CONCLUSION

7.1. *Climate Modelling*

Recent and future changes in climate in Saint Lucia have been explored using a combination of observations and climate model projections. Whilst this information can provide us with some very useful indications of the changes to the characteristics of regional climate that we might expect under a warmer global climate, we must interpret this information with due attention to its limitations.

- Limited spatial and temporal coverage restricts the deductions we can make regarding the changes that have already occurred. Those trends that might be inferred from a relatively short observational record may not be representative of a longer term trend, particularly where inter-annual or multi-year variability is high. Gridded datasets, from which we make our estimates of country-scale observed changes, are particularly sparse in their coverage over much of the Caribbean, because spatial averages draw on data from only a very small number of local stations combined with information from more remote stations.

- Whilst climate models have demonstrable skill in reproducing the large-scale characteristics of the global climate dynamics, there remain substantial deficiencies that arise from limitations in resolution imposed by available computing power, and deficiencies in scientific understanding of some processes. Uncertainty margins increase as we move from continental/regional scale to the local scale as we have in these studies. The limitations of climate models have been discussed in the context of tropical storms/hurricanes, and SLR in the earlier sections of this report. Other key deficiencies in climate models that will also have implications for this work include:

    - Difficulties in reproducing the characteristics of the El Niño – Southern Oscillation which exerts an influence of the inter-annual and multi-year variability in climate in the Caribbean, and on the occurrence of tropical storm and hurricanes.

    - Deficiencies in reliably simulating tropical precipitation, particularly the position of the Inter-tropical Convergence Zone which drives the seasonal rainfalls in the tropics.

    - Limited spatial resolution restricts the representation of many of the smaller Caribbean Islands, even in the relatively high resolution RCMs.

We use a combination of GCM and RCM projections in the investigations of climate change for a country and at a destination to make use of the information about uncertainty that we can gain from a multi-model ensemble together with the higher-resolution simulations that are only currently available from two sets of model simulations. Further information about model uncertainty at the local level might be drawn if additional regional model simulations based on a range of differing GCMs and RCMs were generated for the Caribbean region in the future.

7.2. *Water Quality and Availability*

Water supplies in Saint Lucia mainly come from surface run-off sources such as rivers, wetlands, streams and springs. Owing to the volcanic geology of the island, and its impermeable rocks, groundwater sources are very few and are used primarily for irrigation (MPDEH, 2001). Water production is approximately 18.9

MCM/yr, however this figure is actually closer to 16.55 MCM/yr due to water losses in the distribution (Springer, 2005). During the dry season, estimated water production can be as much as 25% less than the wet season (CEHI, 2006). Unaccounted water is estimated to be between 40 – 60% (Mr Sealey, personal communication, May 26, 2011). The high water losses are due to a number of problems, among them the mountainous terrain and long distances water was to be transported via aged infrastructure from water source to treatment plants and then finally to the consumers (Mr Nichols, personal communication, May 6, 2011).

The cost of water in Saint Lucia was last revised in 1999/2000, partly to address debt incurred by the predecessor of the WASCO. Water production costs that consumers pay do not reflect the true cost of water as subsidies from the government for its production are very high and, further, "users are not being encouraged to value water" since "there is no incentive for consumers to use water efficiently, and no clear strategy or criterion by which to establish allocation priorities" (Springer, 2005).

Rivers are prone to pollution, especially from sewage and agrochemicals, particularly because 55% of land is used in agriculture according to the 1998 Biodiversity Country Study Report and 5 of the 7 main rivers are believed to be at risk from contamination (MPDEH, 2006). The problem of siltation is especially critical to Saint Lucia's water management concerns because sedimentation and the inability of treatment plants to treat water after heavy rains means that some communities do not have access to water for as much as 3 to 4 days while plant operators wait for water turbidity in river courses to clear up (Mr Nichols, personal communication, May 6, 2011). Land degradation due to unsustainable practices in the upper watershed and the severe extent of soil erosion during the wet season significantly affects intakes that supply various communities throughout Saint Lucia. Aside from water quality and quantity concerns, the current infrastructure on the island that currently exists is aged and therefore cannot supply increasing demands of the public sector (Government of Saint Lucia, 2009b; Springer, 2005).

In the Saint Lucia Initial National Communication to the UNFCCC, it is stated that "freshwater supplies are highly susceptible to normal climate variability such as natural disasters. During the dry season, water levels fall drastically" (MPDEH, 2001). Aged infrastructure in certain communities contributes to water distribution problems in the dry season (December to April). This period also coincides with a time when there is a high influx of tourists to the island, which increases demand on already limited water supplies (CEHI, 2006). Rural areas are prone to water-stress as distribution to remote communities is unequal (Springer, 2005). This is because during dry spells and their occurrence in vulnerable drier areas of the country, reliable access to water is not always achievable in all areas of the country (Geoghegan, 2002). To ameliorate this problem of 'chronic' water shortages, rationing is utilised to conserve water supplies.

During dry spells and instances of water scarcity, the agriculture sector's production outputs are affected due to decrease in water supply. The national situation of water resources, where there is only one major storage facility (the John Compton Dam) and limited supplementary irrigation sources and infrastructure, makes the sector vulnerable in situations of lower than normal precipitation. Additionally, irrigation water management techniques on the island are considered inefficient and agricultural practices employed by farmers have negative impacts on the environment and its resources (MPDEH, 2005).

Water resources in Saint Lucia are considered sufficient for current and projected demands, but severe vulnerabilities exist, particularly from (i) severe storms and hurricanes which have previously damaged water infrastructure and led to communities being cut off from normal water supplies, (ii) pollution of water supplies due to erosion of hill slopes during storm events as a result of poor planning of building developments, and (iii) an insufficient water storage capacity to deal with periods of drought which has led to water distribution rationing. Improved land management policies and assessment of the water pricing structure are among recommended actions to enhance the water sector and its resilience to climate change.

7.3. *Energy Supply and Distribution*

There can be little doubt that tourism is an important and growing energy-consuming sector in the Caribbean. If this growth continues, vulnerabilities associated with higher energy prices as well as global climate policy will grow concomitantly.

Any Caribbean nation's ambition should thus be to reduce its energy use and to increasingly use renewable energy produced in the region. In practice, this appears to be hampered by the lack of detailed databases on energy use by sub-sectors, which is a precondition for restructuring energy systems. To this end, Francis *et al*. (2007: 1231) suggest that:

> *Finally, given the absence of a more detailed database on energy consumption and GDP in Haiti, Barbados, and Trinidad and Tobago, further research can be directed at two important issues. First, with wider data on energy consumption and GDP (total and sectoral), a decomposition analysis could be undertaken, which can add value by identifying the main drivers, a useful approach to the formulation of effective policies.*

These insights also apply for other islands. While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of GHG, it also appears clear that energy demand in all islands could be substantially reduced at no cost, simply because the tourism sector in particular is wasteful of energy, and because carbon management allows for the restructuring of markets. Furthermore, technological options to develop renewable energy sources exist, and can be backed up financially by involving carbon markets as well as voluntary payments by tourists. In order to move the tourism sector forward to make use of these potentials, it appears essential that policy frameworks focusing on regulation, market-based instruments and incentives be implemented.

7.4. *Human Health*

The vulnerabilities of the health sector to climate include weather related morbidity and mortality and the diseases that are affected by changes in temperature, as well as a number of emerging and re-emerging communicable diseases (i.e. dengue, schistosomiasis, leptospirosis) and food and water borne illnesses. Based on the combination of hard data and grey data used to inform the vulnerability and adaptive capacity sections of this report, it is very difficult to make definitive statements about the health sector of Saint Lucia. However, the data suggests a number of trends that indicate the population is vulnerable in a number of ways. This includes vector borne diseases, sanitation and potable and accessible water supply related issues especially during the rainy season and the spread of food- and water- borne illnesses. It is further evident that these factors impact on multiple sectors, such as the tourism, water and agricultural sectors. Foreign exchange revenues generated from the tourism industry will be important to sustaining Saint Lucia's economy and by extension the progress and development of its various sectors, including the health sector. Therefore the impact of health on the tourism sector should be fully evaluated and addressed which will benefit the economy and society of Saint Lucia. Increased research and validation of data (e.g. with diseases of low but consistent prevalence such as schistosomiasis) should be given greater attention. Such research will pave the way for a sound platform from which to inform policy and planning for the future as the climate changes.

7.5. *Agriculture and Food Security*

The state of agriculture and food security in Saint Lucia as they relate to climate change revolves around several key priorities which include:

- Diversification of the agricultural economy as a means of reducing reliance on banana revenue;
- Building local farmers' capacity to increase food production under existing climatic conditions;
- Developing and implementing adaptation options for agriculture using tested scientific research to assist farmers to respond to and quickly recover from the effects of extreme weather events, particularly hurricanes.

The Government of Saint Lucia has demonstrated its commitment to agricultural diversification and through its policies has sought to create an enabling environment for dealing with climate change issues. Although Saint Lucia's farmers have begun to grow new crops instead of strictly bananas, there is an opportunity to earn export revenue from some non-traditional crops that are currently used for domestic consumption. The challenge is to cultivate these crops with some measure of consistency and in sufficient quantities using critical knowledge of local pedoclimatic factors.

7.6. *Marine and Terrestrial Biodiversity and Fisheries*

Saint Lucia's rich biological diversity is highly vulnerable to climate change due to the inherent fragile nature of some of the ecosystems, especially coral reefs, and the various threats to environment that have resulted from rapid economic development and poverty driven resource consumption. Like many SIDS, Saint Lucia is challenged to address gaps in environmental management because of insufficient finances and lack of available technology and/or technically trained personnel. While political will is at times contrary to sustainable natural resource management, the island has generally demonstrated a positive response towards addressing biodiversity issues. Saint Lucia is also internationally recognised for the early success of the SMMA, which pioneered co-management in the Eastern Caribbean and demonstrated the benefits that no-take areas can produce for reef fisheries. The island is also famous for the success of its conservation efforts that brought the endemic Saint Lucia parrot from the edge of extinction. It can therefore be expected that with an intensified education and awareness campaign geared towards climate change sensitisation, and its pending impacts on biodiversity, that the responsible agencies will take more rapid action to ensure completion of outstanding projects, programmes and policy amendments for climate change adaptation, such as those outlined in the original NBSAP.

Projects such as a fish sanctuaries management initiative can serve as a catalyst in the paradigm shift from a BAU approach to biodiversity consumption to that of an eco-system based approach to adaptation. It also presents opportunities to harness the evident willingness of communities, the private sector and the Government of Saint Lucia to conserve its biodiversity, and it also provides an opportunity to channel the particular interests of these stakeholders towards achieving a common goal and resolving traditional conflicts among resource users. Strengthening the adaptive capacity of the country's ecosystems in the face of climate change can only be achieved within the context of collaboration. Ultimately, sustainable use and effective management of the island's natural resources lies within the hands of its people; the CARIBSAVE Partnership is an impartial agent that can serve as mediator between various stakeholders and provide the right framework within which the adaptive process may be honed.

7.7. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

With its development along the coast and reliance on coastal resources, the tourism sector in Saint Lucia is vulnerable to climate change and SLR. Tourism, a very large and important sector of the economy, is also the key activity taking place in the island's coastal areas. Given the importance of tourism, Saint Lucia will be particularly affected with annual costs as a direct result of SLR. Fortunately, the mountainous topography of Saint Lucia provides a great deal of protection to many development, yet there are still very important tourism developments that are incredibly vulnerable. If action is not taken, the current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in significant economic losses for the country and its people. Adaptations to minimise the vulnerabilities of Saint Lucia will require revisions to development plans and major investment and policy decisions. These considerations must be based on the best available information regarding the specific coastal infrastructure and ecosystem resources along the coast, in addition to the resulting economic and non-market impacts. Decisions regarding where retreat policies should be implemented versus what should be protected needs to be a priority if Saint Lucia is to help curb development in vulnerable areas and protect vulnerable tourism assets.

The Government of the Saint Lucia needs to implement policies to regulate coastal development and to identify and inventory vulnerabilities of coastal lands and infrastructure to weather and climate related hazards. This work needs to be advanced to include in greater detail the implications of and application of climate change adaptation measures and strategies, to ensure that Saint Lucian coastal resources and infrastructure do not suffer from the consequences of SLR. Continued development and an increasing reliance on the tourism sector will only magnify the vulnerabilities faced, placing additional assets and people at risk, while simultaneously raising the damage estimates and the costs to protect the coastline. It is vital to recognise the vulnerabilities from current SLR and SLR-induced erosion, as well as to anticipate and prepare for future SLR implications. There is an urgent need for serious, comprehensive and urgent action to be taken to address the challenges of adapting to SLR in Saint Lucia.

7.8. *Comprehensive Natural Disaster Management*

Saint Lucia is a country with tropical climate, mountainous topography and valleys with lush vegetation. The geography and topography of the island has created a diversity of natural hazards that have the potential to cause damage and losses to Saint Lucians. Changes in climate are likely to create more disasters as changes in seasonal precipitation cause more droughts and also more heavy rainfall events. Furthermore, due to historic development processes, the location of settlements near steep slopes and in valleys puts many communities at risk to damage and loss. In 2010, the impact of Hurricane Tomas reminded Saint Lucians of their vulnerability to natural hazards as flooding and high winds damaged many homes, roadways, bridges and public utilities. This hurricane challenged the emergency response capacity on the island, while also encouraging support networks to help one another cope with the impact.

NEMO leads the country's emergency management and hazard mitigation efforts with a mixture of policy and technological instruments. Support from consultants under the World Bank/OECS Emergency Recovery and Disaster Management Project led to the creation of several comprehensive hazard mitigation plans for all of the likely hazards and plans specific to the primary economic sectors in Saint Lucia. The Disaster Management Act has also recently been updated to include recent amendments to emergency management practices. These documents indicate a strong understanding of the CDM Strategy and Plan at

NEMO and a willingness to apply the regional standards within Saint Lucia. Nevertheless, more effort is needed in the promotion of these hazard mitigation plans throughout all of the sectors and the general public. Further ‘mainstreaming’ of DRR within Saint Lucia efforts will only lead to a stronger, more resilient Saint Lucia.

7.9. *Community Livelihoods, Gender, Poverty and Development*

It is well documented, that women and men are differently affected by the effects of climate variability and change. Reasons include the different responsibilities men and women assume in relation to care work, income generating work, as well as their different levels of dependency on natural resources, knowledge and capacities to cope with the effects because of differences in the access to education and information systems.

Research findings indicate that community residents agree that men and women are affected differently by weather-induced hazards and disasters. Men believe that they are perhaps the more vulnerable gender with regards to climate change impacts, citing the fact that the majority of farmers in Soufriere (and Saint Lucia on a whole) are male, so they were directly impacted by the damages to their farmlands following Hurricane Tomas. Conversely, women perceived their own experience to be far more difficult than men since some women and single mothers lost homes and possessions, and were unable to adequately provide for their children’s school and home needs after the hurricane.

Additionally, poorer residents and depleted environments are hit the hardest by disasters because of the debilitating combination of existing vulnerabilities, risks and the degree of impact by events or hazards; whereas stronger communities and balanced ecosystems tend to be more resilient. In the wake of Hurricane Tomas, poorer persons experienced more damage and destruction to houses and land. Persons with greater income and purchasing power were in a better position to access needed health care and supplies (especially water), whereas poorer persons could not and had to resort to unsafe water sources and do without essential supplies.

Social roles and responsibilities of women and men lead to different degrees of dependency on the natural environment. As indicated, most farmers and fishermen are men, thereby suffering loss of livelihoods in the aftermath of Hurricane Tomas. Women use the streams and rivers for washing and collecting water and were therefore exposed to a greater risk of water-borne disease when water quality deteriorated after the event. The use of a ‘gender lens’ can help to better understand social processes, thereby ensuring that adaptation projects consider gendered differences and do not inadvertently perpetuate inequality.

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