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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 Vincent and the Grenadines

Prepared by The CARIBSAVE Partnership with funding from UKaid from the Department for International Development (DFID) and the Australian Agency for International Development (AusAID)

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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.

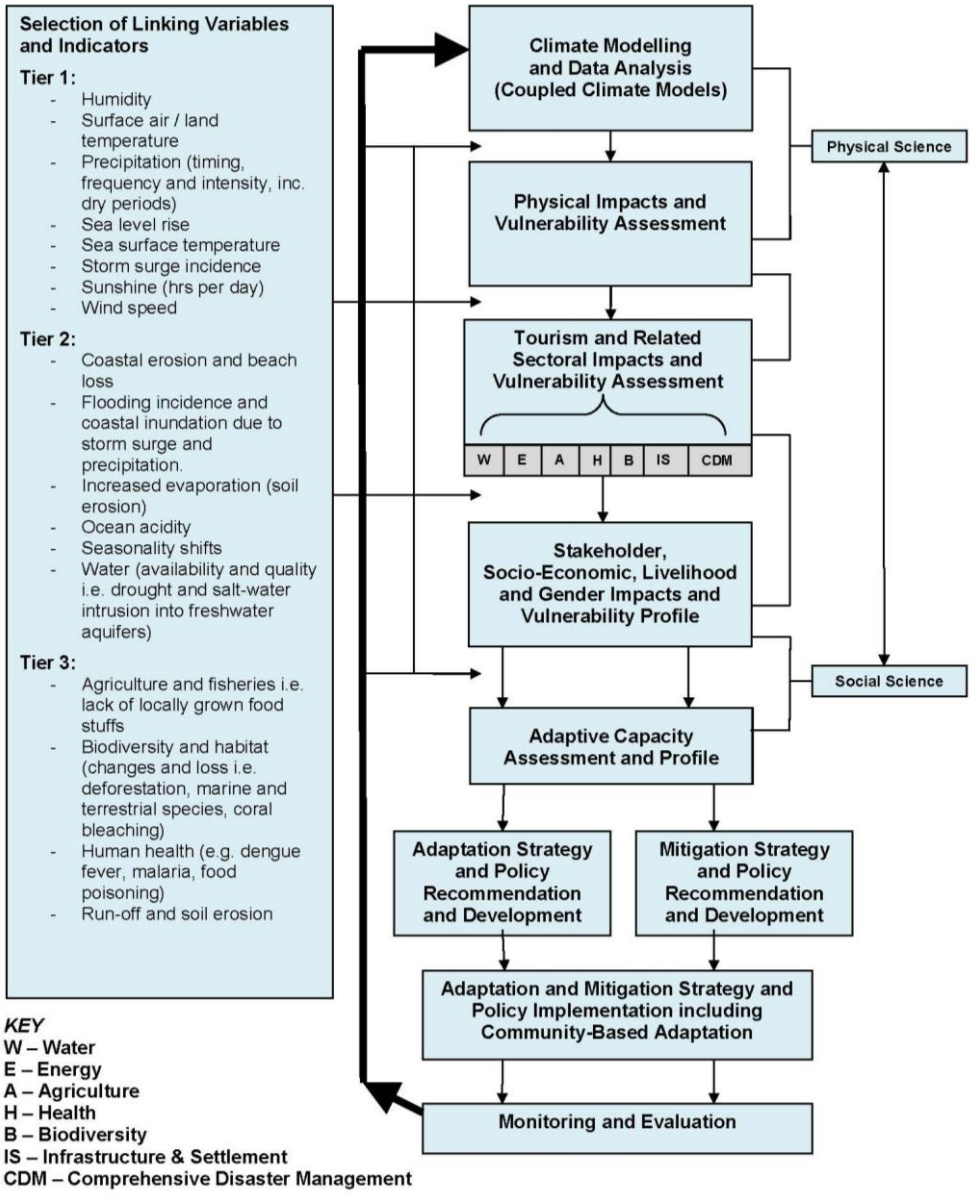
The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change, 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 CCCRA Flow chart below) 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.

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.



CCCRA Profiling Flow Chart

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

AGE---------- Acute Gastroenteritis
AIC---------- Aviation-induced clouds
AOSIS ---------- Alliance of Small Island States
APD---------- Air Passenger Duty
AR4---------- Fourth Assessment Report (IPCC)
ASTER ---------- Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ---------- Business as Usual
CAD---------- Caribbean Application Document
CARDI ---------- Caribbean Agricultural Research and Development Institute
CAREC ---------- Caribbean Epidemiology Centre
CARICOM ---------- Caribbean Community
CBA---------- Community Based Adaptation
CCCCC---------- Caribbean Community Climate Change Centre
CCCRA ---------- CARIBSAVE Climate Change Risk Atlas
CCRIF---------- Caribbean Catastrophe Risk Insurance Facility
CDB---------- Caribbean Development Bank
CDC---------- Centre for Disease Control and Prevention
CDEMA ---------- Caribbean Disaster Emergency Management Agency
CDM---------- Clean Development Mechanism (in the context of energy and emissions)
CDM---------- Comprehensive Disaster Management
CEHI ---------- Caribbean Environmental Health Institute
CEP ---------- Caribbean Event Programme
CITES ---------- Convention on International Trade in Endangered Species
COP---------- Conference of Parties
CPACC ---------- Caribbean Planning for Adaptation to Climate Change
CRFM ---------- Caribbean Regional Fisheries Mechanism
CRI ---------- Climate Risk Index
CRID ---------- Regional Disaster Center – Latin America and the Caribbean
CROSQ---------- CARICOM Regional Organisation for Standards Quality
CSGM ---------- Climate Studies Group Mona
CTO---------- Caribbean Tourism Organization
CUBiC ---------- Caribbean Uniform Building Code
CWSA ---------- Central Water and Sewage Authority
CZM ---------- Coastal Zone Management
DANA ---------- Damage and Needs Assessment
DF---------- Dengue Fever
DFID ---------- Department for International Development
DHF---------- Dengue Hemorrhagic Fever
DJF---------- Seasonal period of December, January, February
DMC---------- Disaster Management Committee
DRM---------- Disaster Risk Management
DRR---------- Disaster Risk Reduction
ECE ---------- Energy Conservation and Efficiency
ECLAC ---------- Economic Commission for Latin America and the Caribbean
EIA ---------- Environmental Impacts Assessment
EM-DAT ---------- The International Disaster Database
ENSO ---------- El Niño Southern Oscillation
EOC---------- Emergency Operations Centre
EU ETS ---------- European Union Emissions Trading System
EU---------- European Union
EWS ---------- Early Warning System

FAO---------- Food and Agriculture Organization
GCM ---------- Global Circulation Model
GCP---------- Ground Control Point
GDEM---------- Global Digital Elevation Model
GDP ---------- Gross Domestic Product
GECCU ---------- General Employees Corporative Credit Union
GGCA ---------- Global Gender and Climate Alliance
GHG ---------- Greenhouse Gas
GIS ---------- Geographic Information System (GIS)
GPF ---------- Grenadines Partnership Fund
GPS ---------- Global Positioning System
HFA ---------- Hyogo Framework for Action
ICC ---------- International Code Council
ICZM ---------- Integrated Coastal Zone Management
IDB---------- Inter American Development Bank
IEA ---------- International Energy Agency
IICA ---------- Inter-American Institute for Co-operation on Agriculture
INSMET ---------- Meteorological Institute of the Republic of Cuba
IPCC ---------- InterGovernmental Panel on Climate Change
ISDR ---------- International Strategy for Disaster Reduction
ITCZ---------- Inter-tropical Convergence Zone
IWRM ---------- Integrated Water Resources Management
MDGs ---------- Millennium Development Goals
MOHE ---------- Ministry of Health and the Environment
NASA ---------- National Aeronautics and Space Administration
NEAB ---------- National Environmental Advisory Board
NEMO---------- National Emergency Management Office
NHC ---------- National Hurricane Center
NOAA ---------- National Oceanic and Atmospheric Administration
OE ---------- Operational Entities
PAHO ---------- Pan-American Health Organization
RCM ---------- Regional Circulation Model
RNAT ---------- Regional Needs Assessment Team
RTK ---------- Real Time Kinematic
SLR ---------- Sea Level Rise
SPCR---------- Strategic Programme for Climate Resilience
SVG ---------- St. Vincent and the Grenadines
TIN ---------- Triangular Irregular Network
UNCCD ---------- United Nations Convention to Combat Desertification
UNDP ---------- United Nations Development Programme
UNECLAC---------- United Nations Economic Commission for Latin America and the Caribbean
UNFCCC ---------- United Nations Framework Convention on Climate Change
UNFPA ---------- United Nations Population Fund
UNIFEM ---------- United Nations Development Fund for Women
USACE ---------- United States Army Corps of Engineers
VINLEC ---------- St. Vincent Electricity Services
WAAS ---------- Wide Area Augmentation System
WHO ---------- World Health Organization

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 St. Vincent and the Grenadines

St. Vincent & the Grenadines (SVG) is already experiencing some of the effects of climate variability and change through damage from severe weather systems and other extreme events, as well as more subtle changes in temperature and rainfall patterns.

Detailed climate modelling projections for St. Vincent & the Grenadines 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 analysed to:

1. assess the vulnerability of the livelihoods of community residents in the **Georgetown** area to climate change; and
2. project sea level rise and storm surge impacts on **Belmont Walkway, Bequia and Canash Beach, Indian Bay, Johnson Point and Villa Beach**.

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

- Household incomes, financial support and security and insurance coverage rates are low.
- One-third of the households surveyed have food shortages, with a high dependence on an external food supply.
- Many precursor conditions exist undermine the community's ability to respond to impacts of climate-related hazards.
- The 2009 drought resulted in significant losses to farmers; food prices rose and produce had to be imported from other islands to supplement the limited supply in St. Vincent.

Vulnerable coastlines

- 1 m SLR places 10% of the major tourism properties at risk, along with 1% of road networks, 50% and 67% of airport and sea port lands respectively.
- With 2 m SLR, 24% of major tourism resorts will be impacted and 75% of airport lands.
- With 100 m of erosion (resulting from approx. 1 m SLR), 76% of the major tourism resorts will be impacted.
- Annual losses in tourism resulting from the reduced amenity value from beach loss is estimated to be between US $46 million by 2050 to US $174 million by 2080 for a mid-range SLR scenario.

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 St. Vincent and the Grenadines

Four primary variables were considered in determining the vulnerability of SVG to climate change. The projections of *temperature, precipitation, sea surface temperatures* and *tropical storms and hurricanes* 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.

Box 1: Climate Modelling Projections for St. Vincent and the Grenadines

Temperature: Regional Climate Model (RCM) projections indicate an increase spanning 2.4-3.1˚C in mean annual temperatures by the 2080s in the higher emissions scenario.

Precipitation: General Circulation Model (GCM) projections of rainfall span both overall increases and decreases, ranging from -34 to +6 mm per month by the 2080s across 3 scenarios. Most projections tend toward decreases. Both RCM projections indicate large decreases in total annual rainfall (-30% when driven by HadCM3 boundary conditions and -22% based on ECHAM4).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.9˚C and +3.0˚C by the 2080s across all three emissions scenarios.

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

Figure 1: Beach erosion at Indian Bay Beach, St. Vincent

The majority of infrastructure and settlements in SVG, like most SIDS, are located on, or near the coast, including government, health, commercial and transportation facilities. High-density tourism development on the coast is particularly vulnerable to climate change and SLR and tends to increase the degradation of coastal and marine biodiversity, thereby reducing resilience to climate change impacts such as SLR and storm surge.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and staff from the National Parks, Rivers and Beach Authority to complete detailed coastal profile surveying at five study sites: Belmont Walkway, Bequia; and Canash Beach, Indian Bay, Johnson Point and Villa Beach in St. Vincent. One metre and two metre SLR scenarios and beach erosion scenarios of 50 m and 100 m, were used to assess the potential vulnerability of major tourism resources.

Results of these surveys indicate that 1 m SLR places 10% of the major tourism properties at risk, along with 1% of road networks, 50% of airports and 67% of sea ports. With 2 m SLR, 24% of major tourism resorts will

be impacted and 75% of airports. Critical beach assets will be affected much earlier than SLR-induced erosion damages to infrastructure; indeed, once erosion is damaging infrastructure, it means the beach, a vital tourism asset, has essentially disappeared.

With 100 m of erosion (resulting from approx. 1 m SLR), 76% of the major tourism resorts will be impacted and 47% of sea turtle nesting sites will be impacted (see Table 1, Figure 2 and Figure 3). Engineered structures and natural environments (e.g. mangroves) can protect against some of these impacts to coastal regions, but the dynamics of these erosion processes will demand some adaptation of coastal infrastructure and settlements.

Table 1: Impacts associated with 1 m and 2 m SLR and 50m and 100m beach erosion in SVG

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Port Lands
SLR	1.0m	10%	11%	50%	1%	67%
	2.0m	24%	16%	75%	1%	67%
Erosion	50m	38%	34%	-	-	-
	100m	76%	47%	-	-	-

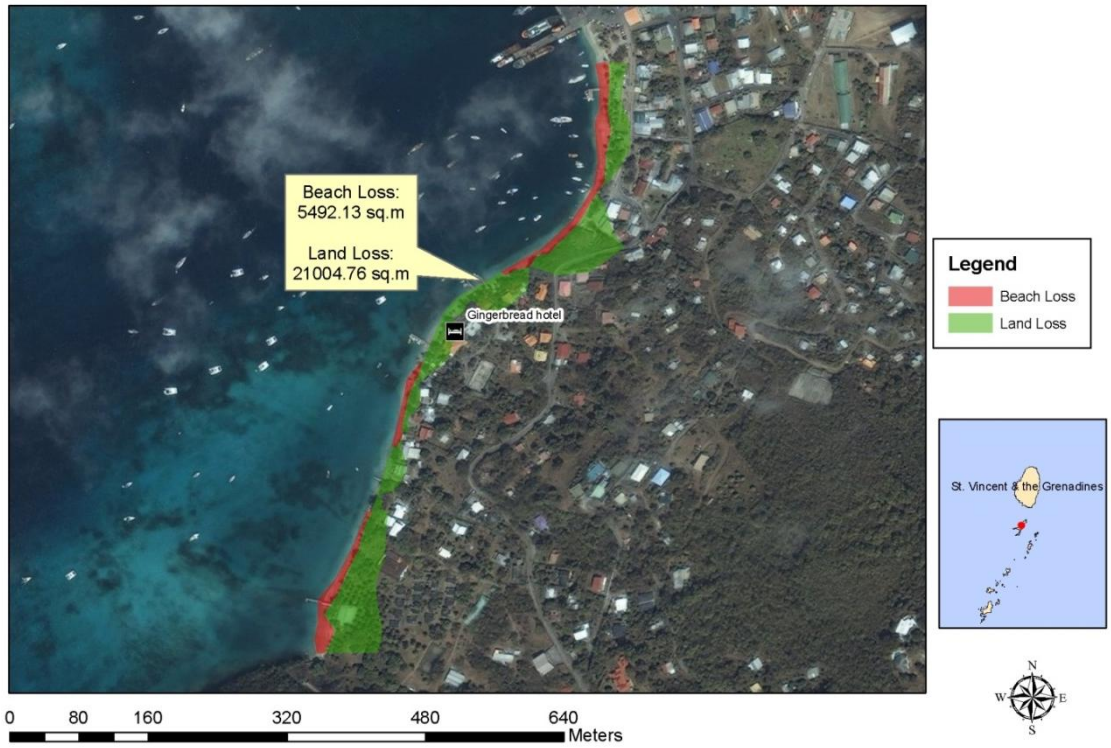


Figure 2: Land and beach loss at Belmont Walkway, Bequia

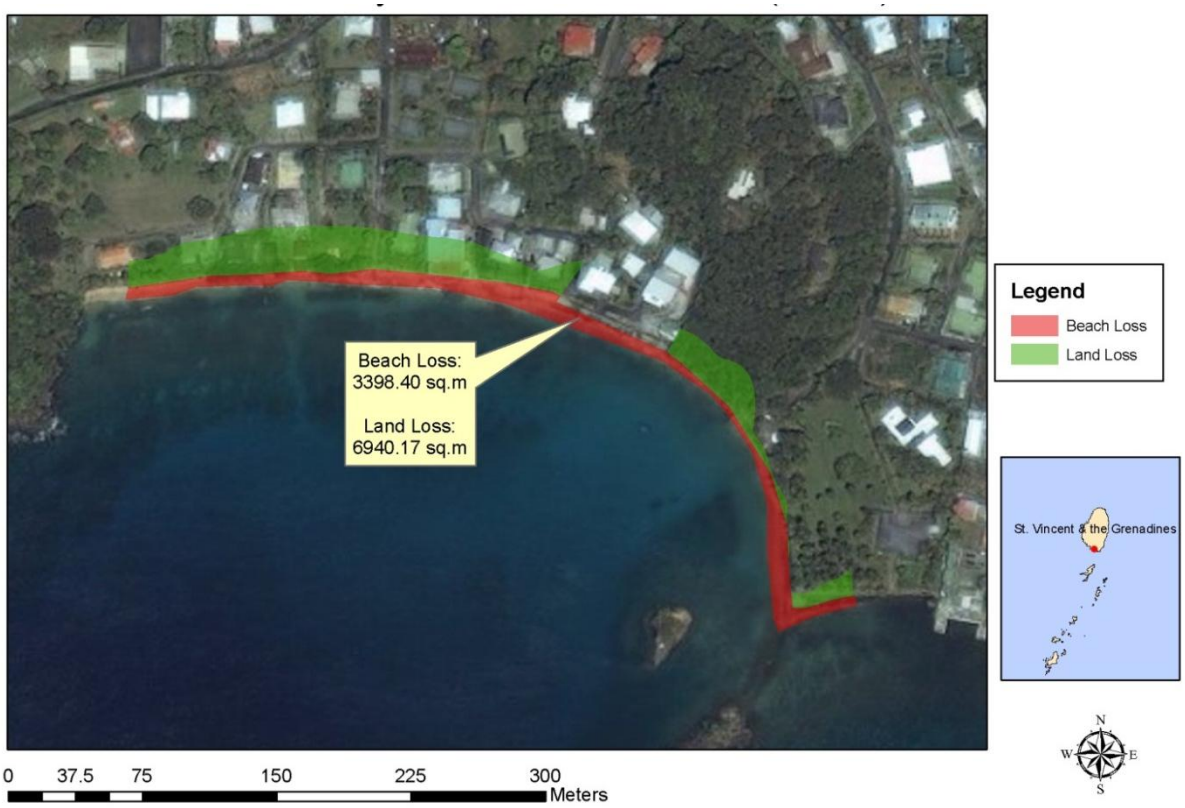


Figure 3: Land and beach loss at Indian Bay Beach, St. Vincent

This study therefore reinforces that serious, comprehensive and urgent action that addresses the challenges of adapting to SLR is needed in SVG. One priority area is to build a full inventory of existing coastal protective defences so that structural protection can be optimised now and into the future, for example, existing seawalls that are in disrepair do not serve their anticipated erosion protection purpose. Only when the current conditions are known can adaptation planning begin in earnest with SLR integrated into government insurance policies, design of coastal structures and most importantly land use development plans and Tourism Master plans.

This study revealed the geographic areas that will be impacted by SLR, but the calculation of actual costs associated with this inundation must include impacts on insurance costs, destination competitiveness and the spill-over impacts that lost coastal activities/industries will have in other sectors, for example changes in agriculture and energy demand or fluctuations in employment in construction etc. Annual reductions in the contribution of tourism to SVG's GDP as a result of the reduced amenity value from beach loss is estimated to be between US $46 million by 2050 to US $174 million by 2080 for a mid-range SLR scenario. The cost of rebuilding the infrastructure in 2050 is estimated to be over US $134 million to rebuild major tourism resorts and an additional US $81 million to rebuild airports and US $54 million to rebuild ports[i]. As the CCCRA reveals, projected impacts from climate change involve much more than SLR impacts and therefore losses to national economies will also be greater than the figures mentioned.

This SLR work provides SVG with new, high resolution geospatial data of coastal areas and a quantification of the extent of SLR impacts projected for the islands. The involvement of staff from the National Parks,

[i] 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.

Rivers and Beach Authority in the coastal profile surveying has also contributed to capacity building in SVG with regard to coastal survey methodology and survey equipment.

Community Livelihoods, Gender, Poverty and Development

Figure 4: Residents create a vulnerability map of their community, Georgetown

More than 50 residents and workers in Georgetown (the capital city) participated in CARIBSAVE's research which included vulnerability mapping, focus-groups and household surveys which were developed according to a sustainable livelihoods framework. The activities aimed to provide understanding of: how the community livelihoods are dependent on the natural resources and how they have been affected by climate-related events; the community's adaptive capacity; the complex factors that influence their livelihood choices; and the differences in the vulnerability of men and women.

Community Characteristics and Experiences

Rivers and the land support a number of livelihoods in the community outside of public or private sector employment, mainly in agriculture and fisheries. Although tourism is relatively small-scale in the community, some residents work as craft-makers and vendors and are patronised by tourists.

Within the community, households are relatively small to moderate in size, although a few households are large. Access to most types of physical assets and social capital are moderate as well. However, there are gaps in other important areas. Household incomes, financial support and security and insurance coverage rates are fairly low. One-third of the households have food shortages, with a high dependence on an external food supply. These gaps limit a household's ability to sustain themselves under normal circumstances and will ultimately undermine its ability to respond to impacts of climate-related hazards.

Georgetown residents are generally aware of climate change and have already observed some changes in climate patterns, such as:

- An increase in atmospheric temperature, which has been one of the most distinct changes
- Hurricanes appear to be more intense
- Wet and dry seasons are no longer clearly defined
- More frequent sea swells and increased coastal erosion
- Pest and diseases are also more common, which have several implications for human health and agricultural production, respectively.

Given the coastal location of the community, residents are concerned that SLR and storm surge impacts pose a significant threat to livelihoods and property.

Three major events over a span of three years highlighted the vulnerability of the community to climate impacts and in 2009, there was a water shortage resulting from drought conditions. Many residents in Georgetown practice agriculture and farmers suffered losses from reduced crop production that year. Food

prices rose and produce had to be imported from other islands to supplement the limited supply in St. Vincent.

Hurricane Tomas then affected the island at the beginning of November 2010, bringing heavy rains and high winds which caused flooding, loss and destruction to several buildings, agricultural plots, livestock and the natural landscape. Persons were displaced from their homes. The impact of the hurricane on the community was exacerbated because most residents did not initially expect the system to affect the country and failed to prepare adequately. Before most residents recovered fully from the impact of Hurricane Tomas, a severe flash flood occurred in April 2011. The flood damaged homes and water pipes. Georgetown was without a piped water supply for about one month. Consequently rainwater harvesting is practiced in some households, but needs to be further promoted and integrated in the community, perhaps with appropriate financial assistance mechanisms.

Figure 5: Debris from flood washed onto a beach in Georgetown as a result of torrential rains, April 2011

Based on previous experiences, the impact of extreme events is greater on women in some ways, especially in relation to public shelter situations and household responsibilities. The absence of a piped water supply following Hurricane Tomas and the April, 2011 flood also affected women significantly, as they are the primary care givers of households and are responsible for domestic duties which require water (washing, food preparation). Female headed households in the community are generally more disadvantaged than male headed households. They are more likely to be earning lower incomes, have lower financial security, insurance coverage (no female headed household surveyed had home insurance) and ownership/access to assets. Consequently, there are also greater implications for female headed households in terms of adaptive capacity.

In Georgetown, the psychological impacts of disasters are very evident, especially in men. Some men are unable to manage the burden of recovering and providing for their family or families. Men who have responsibility for their families felt a greater strain than those who did not and suffered a weakened sense of pride when they were unable to fulfil their duties. It has been reported that as a result they resort to heavy drinking and becoming intoxicated. The flash flood also affected older persons more seriously than younger ones, as they also found it harder to recover.

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 community-specific adaptation strategies. Achieving this, in part requires attention to the underlying power relations and gender equalities and the evaluation of the differing and potentially inequitable access which men and women have to economic, ecological, social and human resources, institutions, governance and infrastructure.

Notwithstanding the threat of climate change, careless human activities (dumping, deforestation) also increase the community's vulnerability to climate impacts. Illegal dumping, burning of waste, deforestation have contributed to erosion and pollution in the community. When drains are clogged with excessive solid waste, flooding is significantly exacerbated and this was blamed in part for contributing to the severity of the April 2011 flood event. More prudence in solid waste disposal is needed to reduce the impact of

flooding. Drains and water courses also need to be cleared regularly (moreso during the wet season) to ensure that drainage is most effective during severe weather. Community residents should consider organising a group and designating time at regular intervals to clear drainage channels.

Complacency is also considered major issue. Some residents do not take enough precautions or prepare adequately when a storm approaches, mainly because up until recently, severe weather impacts have been infrequent. Disaster education and response training activities are needed in the area to engender more proactive attitudes towards storm preparation and hazard mitigation; more important within the younger generations of the community who have little experience with severe weather impacts.

Agriculture and Food Security

Agriculture is one of the major economic activities on St. Vincent and is based largely on banana production, with additional output of arrowroot, sweet potatoes, eddoes, tannias, yams and coconuts. In recent years the erosion of preferential trade agreements and increased competition in the EU banana market have led to declining exports and income. The reliance on just one crop and the small-scale of the farms leaves the sector economically vulnerable.

Figure 6: Banana farming in St. Vincent

Uncontrolled agricultural intensification, poor agricultural practices and inappropriate land use contribute to the vulnerability of the sector through soil erosion and land degradation. When combined with the current trend of converting prime agricultural lands to other uses, agricultural capacity and national food security is threatened. The gap between agricultural exports and imports has been widening making SVG vulnerable as a net food importing country. In 2007, the value of agricultural exports was EC $46.9 million compared to an estimated import bill of EC $157.5 million. In 2008, exports declined to EC $35.8 million while the food import bill increased to EC $198.5 million.

In the Grenadines, geological and environmental conditions prevent much involvement in agriculture. However, small ruminants and marine fisheries make additional, significant contributions to the economy, food security and employment. Although the contribution of agriculture to the GDP has declined from 21.2% in 1990 to 9.6% in 2006, the industry employs more than 40% of the workforce. This decline in agricultural production is a contributing factor in the increasing unemployment situation in the country and as young people migrate to urban areas the available labour for farming in rural areas is depleted. A community-based "*Youth in Agriculture*" project involving young people between the ages of 15 to 25 to help them learn about agriculture through practical work cultivating and harvesting crops using basic low cost technologies would help to promote agriculture as a viable livelihood.

St. Vincent's agricultural sector is high vulnerability to the existing climate, especially extended periods of drought, unevenly distributed rainfall and natural disasters. During the second week of April 2011 heavy rainfall caused rivers to overflow and landslides in the north-eastern section of Saint Vincent in a major agricultural area. This occurred while the sector was still recovering from damages totalling EC $35 million in 2010 caused by hurricane Tomas (primarily in banana and plantain production). Small farmers typically have little or no insurance and are ill-equipped to deal with the impacts of climate change. A programme to build Vincentian 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 and future climate would be of great benefit.

Energy and Tourism

Current tourism related energy use and associated emissions in SVG are estimated to be the equivalent of 81% of estimated national emissions of CO_2, though there are uncertainties regarding current national emissions. SVG is emitting considerably less CO_2 than the global annual average of 4.3 t CO_2 per capita (1.7 t CO_2). Energy audits will help to identify major energy consuming sub-sectors and to develop appropriate strategies for energy and emissions reductions. Aviation (34%), cruise ships (28%) and accommodation (22%) were identified as the major direct consumers of energy and emissions in the tourism sector.

Figure 7: St. Vincent Electricity Services Limited – Hydrometric Network

Source: www.stewartengineeringsvg.com

St. Vincent and the Grenadines is largely dependent on imported fossil fuels for power, with just 5% of consumption provided by hydropower (5.7 MW) which is located entirely on St. Vincent at 3 separate locations and consumption has increased by 40% in just 6 years. Most of the capacity is located on St. Vincent with additional diesel-powered units on Bequia, Union Island, Canouan and Mayreau. The other Grenadines islands are supplied by privately owned electricity systems on the basis of diesel plants. Most of the generators are old and inefficient.

A National Energy Policy and Plan that cover planning and management, the power sector, renewable energy, the petroleum sector, the transport sector and energy efficiency have been developed. Even tough very little direct action is proposed for the tourism sector other than highlighting the benefit of investing in renewable energy in smaller, remote islands with high dependency on tourism, the majority of actions put forward are equally applicable to tourism facilities or will impact tourism facilities. Implementing the Energy Policy and Action Plan should be a high priority.

Climate change can have both direct and indirect impacts on energy generation, distribution and transmission infrastructure, with implications for existing traditional (fossil fuel based) energy systems, as well as proposed renewable energy initiatives. Hurricanes impact transmission lines, poles and other infrastructure and Hurricane Tomas resulted in an island-wide power outage in SVG due to broken lines, fallen trees and damaged poles. Power generating stations and other major infrastructure located on the coastline are highly vulnerable to damage from flooding and inundation resulting from SLR and storm induced surges.

Temperature increases reduce the efficiency of energy generation at thermal power plants and reduced precipitation may affect water availability for non-contact cooling. Alternative energy sources, while they are environmentally more sustainable, also face challenges from physical climate change impacts and these

must be considered in energy sector planning. For example hydro-power facilities can be impacted by reduced flows in periods of drought.

The anticipation of continued rising oil prices, as well as international emissions reduction polices, will make both the tourism sector and the wider economy of SVG highly vulnerable. A one year period of government price regulation in SVG cost EC $6 million and in 2008 almost 17% of GDP was spent on imported fossil fuels. Rising oil prices will affect tourism in particular since aviation has limited options for using alternative fuels and increases in fuel costs will inevitably be passed on to the passengers. In order to ensure that fuel imports are maintained at an affordable and sustainable level, demand side management, technological innovation and politics that allow restructuring of tourism systems will be needed. Carbon pricing is the most efficient tool to stimulate behaviour change and change in production, thus while it will be difficult at first, such a price structure will encourage the creation of a more sustainable energy sector; and by extension, a more sustainable tourism sector in SVG. In SVG, a fuel surcharge is already applied to electricity consumption per kWh, which varies monthly depending on fuel costs and a number of incentives and tax schemes have been identified for further consideration to encourage energy efficiency and use of renewable energy. The introduction of many technologies is economically feasible in tourism, while new financing mechanisms such as the Clean Development Mechanism and voluntary carbon offsetting schemes can make contributions to implementing new and innovative, but not economical technical solutions.

A number of tourism management models that focus on market structure and average length of stay are available and can be used to address the high emissions associated with international travel. Some markets are economically more beneficial because of higher spending, while having lower emissions because of proximity to the destination. Similarly, it is preferable to increase the length of stay of a few visitors rather than increase the number of short stays by many visitors. St. Vincent and the Grenadines has recently witnessed a massive decline in arrivals, so considerable effort should be focussed on marketing for longer stays in order to increase spending. Evidence from a case study in Barbados suggests that this is indeed feasible.

Water Quality and Availability

The island of St. Vincent is generally not considered to be water-stressed, with average annual rainfall ranging from 1,500 mm on the coast to 3,800 mm in the central mountains[ii]; in the Grenadines, by contrast, average annual rainfall is lower at around 1000 mm and severe water shortages are experienced[iii]. The 13 watersheds on the island of St. Vincent, many of which are within forest reserves, generate most of the country's supply of fresh water (approximately 120 million m^3/yr of surface water), meeting the demands

[ii] FAO. (2000). FAO's Information System on Water and Agriculture - St. Vincent and the Grenadines. *Aquastat* Retrieved 16/11/2011, from http://www.fao.org/nr/water/aquastat/countries_regions/st_vincent/index.stm

[iii] NEAB. (2000). Initial National Communication on Climate Change: St. Vincent and the Grenadines: National Environmental Advisory Board and Ministry of Health and the Environment, Government of St. Vincent and the Grenadines.

of the island's population and various sectors, including the generation of hydroelectricity[iv]. In the Grenadines, due to the small size of the islands, the drier climate and the absence of perennial steams, there is limited surface water and an adequate supply of water is highly dependent on the timely arrival of the rainy season[v]. A Sea Water Reverse Osmosis Desalination Plant with a Production Capacity of at least 5 Cubic Meter per Hour was recently installed in Paget Farms, Bequia. This has been operational since September 2011 and is one of the outputs of the Special Programme for Adaptation to Climate Change (SPACC) executed by the Caribbean Community Climate Change Centre. Previously, most residents collected water transported by barge from mainland St. Vincent.

During the period 2009-2010, the Caribbean experienced one of the most severe droughts in recent years. In St. Vincent and the Grenadines, the rains ceased in October 2009 and did not return until July 2010. Considered the worst drought to affect the country since 1987, the Central Water and Sewage Authority (CWSA) was required to shut off the water supply in some parts of the country at various times of the day and activate emergency response teams. St. Vincent and the Grenadines has not devised a National Water Policy or Water Management Plan[vi] but there is a Draft Road Map toward Integrated Water Resources Management (IWRM) Planning for Union Island, St. Vincent and the Grenadines. The CWSA is the statutory body that oversees all aspects related to production of water and the provision of sewage services. The CWSA, St. Vincent Electricity Company (VINLEC) and the Ministry of Agriculture are the main water resource institutions. Co-ordination between these three entities had been found to be lacking[vii]. Furthermore, the CWSA faces financial and human resource constraints, as well as deficiencies in technical staff particularly water engineers[viii].

As part of the IWRM implementation, improved coordination will be a necessary starting point, along with the strengthening of institutional and legislative frameworks and development of a platform for collaboration across all stakeholder groups, especially government agencies. A working IWRM framework

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[iv] CEHI. (2001). National Report Integrating Management of Watersheds & Coastal Areas in SIDS of the Caribbean - The Vincentian Perspectives: Caribbean Environmental Health Institute; John, L. (2006). From Growing Ganja to Planting Trees: Stimulating Legal Livelihoods and Watershed in Saint Vincent Through Payment from Public Utilities, A report on the Integrated Forest Management and Development Programme (IFMDP) and Forest User Groups of St. Vincent and the Grenadines. Laventille: Caribbean Natural Resources Institute; John, N. A. (2009). Assessment of the Climate Change Impact on Streamflow of the Montreal Watershed, St. Vincent, International Master Program for Environment Sustainable Development. Taiwan, Republic of China: National Central University

[v] Culzac-Wilson, L. (2003). St. Vincent and the Grenadines - Report to the Regional Consultation on SIDS Specific Issues: Regional Office for Latin America and the Caribbean. Kingstown: Government of St. Vincent & the Grenadines; Peters, E. J. (2003). Sizing of Rainwater Cisterns for Domestic Water Supply in the Grenadines. *The St Vincent and the Grenadines Country Conference, May 22-24, 2003* Retrieved 16/11/2011, from http://www.cavehill.uwi.edu/BNCCde/svg/conference/papers/peters.html

[vi] CEHI. (2007). Draft Road Map toward Integrated Water Resources Management Planning for Union Island, St. Vincent and the Grenadines. Castries: Caribbean Environmental Health Institute/United Nations Environment Programme Collaborating Centre for Water and Environment/ the GEF-funded Integrating Watershed and Coastal Areas Management Project; ECLAC. (2003). *Chapter 11: St. Vincent and the Grenadines. In Review of the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing State (SIDS POA) in the Caribbean Subregion 1994-2003/4.* Economic Commission for Latin America and the Caribbean. Port of Spain, Trinidad and Tobago; Peters, E. J. (2003). Sizing of Rainwater Cisterns for Domestic Water Supply in the Grenadines. *The St Vincent and the Grenadines Country Conference, May 22-24, 2003* Retrieved 16/11/2011, from http://www.cavehill.uwi.edu/BNCCde/svg/conference/papers/peters.html

[vii] Culzac-Wilson, L. (2003). St. Vincent and the Grenadines - Report to the Regional Consultation on SIDS Specific Issues: Regional Office for Latin America and the Caribbean. Kingstown: Government of St. Vincent & the Grenadines.

[viii] Kairi Consultants Limited. (2008b). Final Report St. Vincent and the Grenadines Country Poverty Assessment 2007/2008 Living Conditions in Small Island Developing States, Volume 3 Report on the Institutional Assessment. Tunapuna: Kairi Consultants Limited

should enable SVG to better respond and adapt to changing rainfall patterns and make individuals more resilient to decreases in precipitation.

Although St. Vincent and the Grenadines lie to the south of the main hurricane storm track, the islands are occasionally impacted by tropical storms, hurricanes and heavy rainfall events. Most recently, heavy rainfall during April 11-12, 2011 caused rivers to overflow and landslides in the north-eastern section of St. Vincent. An assessment by the National Emergency Management Office (NEMO) revealed that the sectors which were most affected were water and agriculture. The potable water infrastructure in Georgetown was severely damaged, including the main catchments and pipes which deliver water to households, as well as the treatment and filtration plants. It is estimated that 20,000 persons depend on these catchments and pipes for their primary source of water[ix].

Accelerated sea level rise is expected to increase the likelihood of the inundation of low-lying coastal areas, increase the salinity of surface and ground water and result in higher water tables[iii].

The Country Poverty Assessment 2007/2008 noted that the cost of water parallels the cost in production however, other operational costs are met through subsidies. Although the water resources on St. Vincent adequately meet domestic consumption, competing uses have substantially reduced streamflow and aged or insufficient water infrastructure also contributes to the vulnerability of the water supply in SVG. Therefore, water infrastructure should be expanded to reduce vulnerability, particularly during drought events and after major storms and hurricanes. There is specific need for additional storage and treatment facilities, so viable options for SVG must be examined to allow for adequate access to water supply in all communities during all seasons. Additional public water supply networks are needed to reach areas, such as Bequia, where they do not currently exist. Maintenance of this infrastructure must be planned and budgeted for so that climate change impacts do not further hinder water supply in SVG.

SVG is highly dependent on surface water to meet its demand but this need not necessarily be the case, particularly on the island of St. Vincent where groundwater sources are not utilised. While the surface systems are reasonably well known, the groundwater resources have not been adequately studied and, while their true potential is not known, resources are expected to be adequate[x]. Aquifers act as large reservoirs of fresh water which reduce vulnerability during periods of drought. The status of aquifers should be assessed in St. Vincent and, if possible, developed to supplement the existing surface water resources.

Comprehensive Natural Disaster Management

The natural hazards facing SVG are numerous and unpredictable, therefore investments in preparedness and capacity building have and will continue to improve the country's overall resistance and resilience to impacts when they do occur. A strong disaster and emergency management system is important not only to safety and security but also to the socio-economic performance of the country. Historic development trends in SVG, given the limited availability of flat land, have resulted in the construction of homes, roads and public spaces in areas that are at risk to natural hazards. Development planning must also consider

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[ix] IFRC. (2011). Saint Vincent and the Grenadines: Floods: Disaster Relief Emergency Fund Operation, International Federation of Red Cross and Red Crescent

[x] Robins, N. S., & Lawrence, A. R. (2000). Some Hydrogeological Peculiar to Various Types of Problems Small Islands. *Water and Environment Journal, 14*(5), 341-346.

construction techniques and although National Building Code legislation has been passed the guiding regulations have yet to be fully adopted by practitioners. This must be remedied by integrating resilient practices into building designs and hiring building inspectors, in permanent positions, with the responsibility of reviewing all construction on the island.

During storms, the mountainous topography combined with construction on steep slopes creates a context where high winds and heavy rains have the potential to generate serious damages from flash flooding and slope destabilisation (e.g. landslides or mudslides). Hurricane Tomas in 2010 resulted in losses to the banana and plantain crops, damages to roofs and severe flooding that prompted 1,200 Vincentians to relocate to public shelters. Transportation routes, electricity and communication were impacted for extended periods and following the storm, emergency assistance funds were received from various governments, development banks and the Caribbean Catastrophe Risk Insurance Facility (CCRIF).

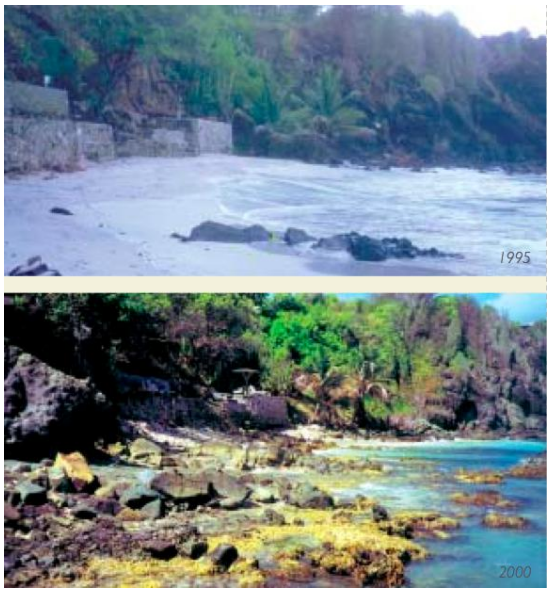

Figure 8: Beach profile of Honor Bay, Mustique before and after Hurricane Lenny

Source: http://www.unesco.org/csi/act/cosalc/vinb.pdf

The Meteorological Service issues warnings with information from the National Hurricane Center (NHC) in the United States of America and the Ministry of Agriculture maintains a system of stream gauges and meteorological stations on the island, but the system is not automated. This is a good start on an EWS, but it demands good cooperation and strong information sharing systems. The system for monitoring hydro-meteorological stations should be automated so that data can quickly be updated and the early warning system becomes more effective. In contrast, the seasonal nature of rainfall creates drought conditions, particularly in the Grenadines where rainwater harvesting is the primary source of water.

The most recent eruption of La Soufrière volcano was from April – June 1979. There was no permanent monitoring, but reports seem to indicate that there was a continuous strong steam emission from the crater and powerful vertical explosions that produced ash clouds reaching 8 km high[xi]. The largest pyroclastic flow that was observed descended the Larikai valley to the west of the crater and out to sea, while other pyroclastic flows followed the Wallibou and Rabacca river valleys. The populated areas of northern St Vincent were evacuated to the south as the eruption started and although impacts were generally limited to the island of St. Vincent, Barbados, which is 180 km east of St. Vincent, reported ash plumes on April 13 and 14[xii]. While there were no deaths reported as a direct result of the eruption, some traffic accidents occurred during evacuation and there were multiple reports of respiratory problems as a result of the ash. Major eruptions can impact global climate, however, there is no evidence that a changing climate will cause volcanic eruptions. Seismic monitoring is done by the regional University of the West Indies Seismic Research Centre through the Soufrière Monitoring Unit located in the SVG Ministry of Agriculture. The monitoring unit should be automated so that data can be updated faster and therefore

xi Shepherd, J. B., Aspinall, W. P., Rowley, K. C., Pereira, J., Sigurdsson, H., Fiske, R. S., et al. (1979). The eruption of Soufriere volcano, St Vincent April-June 1979. Nature, 282, 24-28.

xii PAHO. (n.d.). Disaster Reports Number 2: Jamaica, St. Vincent and Dominica. Pan American Health Organization.

improve the efficiency of the early warning system. Hazard mapping has been done in SVG for volcanic risk and basic geographic information is available in a geographic information system (GIS) format. The next step is to improve the mapping coverage for other hazards so that environmental and land use planning can better identify and enforce areas of high risk.

National Emergency Management Office (NEMO) has responsibility for emergency management and preparedness in SVG and the system includes district disaster committees and 40 local community disaster committees that have received training in damage assessment, shelter management, relief supplies management, first aid and related activities. This provides a strong basis for disaster management, especially when coupled with the regular public awareness campaigns issued by NEMO and the Prime Minister. Many technologies have been employed in education and awareness building in schools and for the general public.

However, the current national curriculum is deficient on climate change and disaster risk reduction and teachers require better training and text books with Caribbean specific information[xiii]. An interactive and innovative community education and capacity building initiative designed to reach all levels of Vincentian society would enable individuals to manage their own risk levels and also build resilience to natural hazard events. Also, capacity building and technical training programmes for NEMO employees are still required so that the current technical deficiencies can be remedied and skills gained. Also,

The recent Strategic Programme for Climate Resilience (SPCR) proposed work in many areas where climate change adaptation and disaster risk management overlap. Of particular importance to management activities is the issue of technical training and information management. Civil Servants in various government ministries participated in a training workshop with NEMO in 2011 in order to promote collaboration of the comprehensive disaster management (CDM) strategies within the country. The SPCR also led to a project that will create information packages for families and communities in the "Red Zone" and will take an "all hazards" approach to community-based disaster risk reduction, delivering talks, leader training and advocacy training, for those living in high risk areas[xiii].

Human Health

Health is an important issue in the tourism industry because tourists are susceptible to acquiring diseases whilst travelling, but they are just as likely to act as carriers of diseases. The potential effects of climate change on public health can be direct or indirect: direct effects include those associated with extreme weather events such as heat stress, changes in precipitation, sea-level rise and natural disasters; indirect effects are associated with changes in ecosystems and various sectors such as water, agriculture and the wider economy. The acquisition of an infection can have consequences for persons visiting a destination which can significantly affect the economies of Small Island Developing States (SIDS) because of a loss of reputation and avoidance of these destinations by tourists.

The health sector was not specifically mentioned in the Initial National Communication to the UNFCCC, but one recommended adaptation measure recognises the need for “An expansion of the country’s environmental education programme that speaks to climate change, vulnerability, sustainability, human

xiii Government of Saint Vincent and the Grenadines. (2011a). Strategic Programme for Climate Resilience - Saint Vincent and the Grenadines Phase One, Part Two: Proposed Investment Program, Components for PPCR Funding. Kingstown: Government of Saint Vincent and the Grenadines.

health and safety" and "The strengthening and equipping of the local vector-control unit to respond to expanding insect populations and the emergence or re-emergence of vector-borne diseases"[iii].

Vector borne diseases that threaten the health sector include dengue, leptospirosis and infrequent cases of malaria. It has been shown that dengue fever transmission is altered by increases in temperature and rainfall. In SVG, there were 37 cases per year for the last decade with 58% of cases occurring in 2010. This may be due to either drought conditions between October 2009 and January 2010 or episodes of high precipitation such as severe floods in April 2010 or Hurricane Tomas in October 2010. Definitive statements can only be made with monthly data.

Leptospirosis is endemic with poor disposal habits and improper disposal infrastructure contributing to conditions that encourage the proliferation of rats in the country. It is recommended that the World Health Organisation (WHO) Integrated Vector Management Programme be adopted and further research undertaken that links the epidemiology of diseases with climate data in SVG. This research must be based on improved, peer reviewed data potentially collected and disseminated through a Caribbean data information centre or Clearing House that includes temporal, environmental and climatological data.

In addition to the direct threat of injury or death from a particular natural disaster such as floods, physical and capital damage to health facilities may also arise. Displacement of persons and loss of shelter are important because of the associated mental and physical impacts and increasing temperatures can result in heat stress; heat wave events have been found to be associated with short-term increases in mortality globally as well as morbidity related to heat exhaustion and dehydration. Both locals and visitors should be provided with continued health education and promotion campaigns which will be crucial in sustainable disease prevention and may save lives during and after natural disasters.

A lack of potable water supply and adequate sanitation facilities can result in the spread of a number of diseases and in SVG these include dengue, malaria, cholera and leptospirosis. Diarrheal diseases (e.g. salmonellosis, shigellosis and campylobacterosis) and gastroenteritis are also diseases of importance due to the high number of cases and the economic and social burden to the country. Over one third of the population in the Grenadines do not have access to continuously supplied public water and almost 30% of the population of SVG are using either pit-latrines, ventilated pit latrines or have no sanitation facilities. Improved water storage and sanitation infrastructure must therefore be prioritised. An early disease warning system could also be established so that people can take the necessary precautions in their day-to-day activities.

Dry spells can affect air quality and increase diseases like acute respiratory infections, influenza-like illnesses and asthma which are quite common among residents of SVG, but there has been a decline in reported cases of acute respiratory infections in the last decade. The climate related impacts on the agricultural sector as well as invasive pests have affected productivity which in turn could affect the availability and cost of food. In SVG the prevalence of babies being born underweight and under-nutrition in children less than five years of age is 5.7%[viii]. This situation combined with the lower percentage expenditure on the health sector contributes to the vulnerability of the population. Emergency services only exist in St. Vincent; patients from the Grenadines Islands must be flown or shipped to St. Vincent for emergency treatment and some services are not even offered in St. Vincent and must therefore be sought abroad. It has been suggested that a more business-like approach be taken which includes considerations for health insurance[viii]. The main challenges to addressing climate change impacts on the health sector of SVG are the lack of financial and technical resources with staff shortages in the sector partially filled by Cuban medical practitioners.

Marine and Terrestrial Biodiversity and Fisheries

The islands of St Vincent and the Grenadines are home to globally important biodiversity and ecosystems including the Central Mountain Range, which represents one of the largest remaining tracts of wet forest in the Lesser Antilles and one of the few forests that maintains a full altitudinal corridor from sea level to 1,200 meters. The islands of the Grenadines encompass a large area of biologically diverse marine and terrestrial habitats, with extensive coral formations and important fisheries.

The impacts of climate change are likely to exacerbate the damage caused by existing anthropogenic impacts, such as deforestation, poor land-use practices, sedimentation, coastal pollution and over-fishing. Improving the management of biodiversity and fisheries will become increasingly important to the welfare of Vincentians and to the sustainability of the country's main economic activities – fishing, tourism and agriculture.

Figure 9: Pristine white sand on the west coast of Union Island

Source: O. Day, 2007

Beaches and mangroves are particularly vulnerable to SLR and more intense storms and coral reefs are at risk from more frequent bleaching events, increasing coastal siltation and sedimentation. In the small islands of the Grenadines, protecting fisheries will be important for maintaining healthy populations of herbivores and hence the resilience of coral reefs, as well as for safeguarding the sustainability of artisanal fisheries.

Education and awareness projects for residents and in-bound tourists could be developed. Short videos that encourage residents and visitors to be more conscious of their impacts on ecosystems can be shown on national TV networks and during in-bound international flights. The films should focus on positive actions that individuals can take to minimise their impact on the environment by decreasing energy and water consumption, wastage and precautions to be taken during marine based recreation (diving, snorkelling, boating). They should also explain the importance of preserving and managing ecosystem services in order to protect the livelihoods of communities.

In keeping with SVG's commitment to expand protected areas and its participation in The OECS Sustainable Financing and Management of Eastern Caribbean Marine Ecosystems Project, a strategy should be created for:

- establishing a more effective fish sanctuary management and enforcement system for coastal communities;
- 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.

Reforestation of the mangrove stands will improve the size and health of fish nurseries thus benefitting both the resilience of coastal ecosystems and the livelihoods of those engaged in marine-based activities. Proposed MPAs will benefit from the presence of mangrove trees, which filter pollutants, stabilise

sediments and provide important habitat to juvenile fish and crustaceans. However, reforestation projects will not be effective if development projects are allowed to continue removing and damaging mangrove stands. Restoration efforts would be particularly relevant to the mangrove stands in Union Island where recent developments have caused extensive damage to existing mangroves.

The projected increase in temperature and decrease in precipitation could have dramatic consequences for the forests and overall biodiversity of SVG. Reduced moisture will result in forests becoming much drier, potentially causing the wilting and death of epiphytes, which provide important habitat for birds, insects and reptiles. The Central Mountain Range includes large areas above 1,000 m and grows a type of vegetation classified as cloud montane forest that requires almost continual cloud coverage and is therefore most vulnerable to climate change. The projected warming could result in a displacement of cloud forests into progressively smaller regions at the tops of mountains ultimately resulting in complete loss if vertical migration is not possible. The increasing intensity of hurricanes is causing more severe damage and potentially longer-term consequences for the integrity of the forest structure and canopy.

Although SVG is a signatory to several Multilateral Environmental Agreements and has developed national legislation for the management of natural resources, the laws need updating and harmonising. Component 3 of the newly developed Pilot Project for Climate Resilience (PPCR) addresses strengthening the policy, legal and institutional framework of SVG for climate change and includes a range of proposed activities. Of particular relevance is the "revamping of the land use or spatial planning legislation in the Caribbean to incorporate climate change resilience and the development of new land codes/practices and guidelines"[xiv].

Various departments and divisions share responsibility for coastal zone management, natural resource management, biodiversity and physical infrastructure, often leading to a lack of coordination and integration and therefore inefficient management. A lack of human, technical and financial resources also limits effectiveness in the public sector of SVG. Strengthening the capacity to manage the network of protected areas must be seen as a priority for the long-term protection of the nation's biodiversity, especially the important mountain forest reserves on St Vincent and marine protected areas in the Grenadines.

The education sector was identified as one of four specific areas that are high priorities for intervention under Component 2 of the Strategic Programme for Climate Resilience (SPCR). Incorporation of climate change and biodiversity issues into school curricula starting at the primary level will help to improve public awareness, while building adaptive capacity through knowledge and training. Doing so at the primary, secondary and tertiary levels will encourage students to view environmental management as a viable career choice and address the lack of trained personnel in this field.

The government recognises the deficiencies and has recommended that a Geographical Information System (GIS) database for biodiversity information be created to improve the effectiveness of biodiversity management, however, progress has been limited. The Grenadines Marine Resource Space-use Information System (MarSIS) project has compiled information on marine space-use on the Grenada Bank that can be used to identify areas for special management attention, and other more localised inventories and assessments have been undertaken either as a single event or on a more regular basis, such as inventories in the Tobago Cays Marine Park and bi-annual Parrot Census by the Forestry Division.

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xiv Mendoza P. (2011a). Strategic Programme for Climate Resilience. Saint Vincent And The Grenadines Phase One. Part Two Proposed Investment Program Components for PPCR Funding

Conclusion

Recent and future changes in climate in St. Vincent and the Grenadines have been explored 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 can provide very useful indications of the changes in the characteristics of regional climate that one might expect under a warmer global climate. 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.

SVG has a history of damages and losses from natural disasters. Disasters not only interrupt development progress at the national level, but they also cause individuals to invest time and resources into rebuilding their homes and livelihoods after an impact. Since it is predicted that under climate change hurricanes may increase in intensity and, extreme rainfall events may increase in intensity preparedness for disasters (e.g. flooding or drought) and climate change adaptation become common goals.

It is clear that the Government and people of SVG are aware of climate change, as evidenced by some policy responses and planned actions, particularly the SPCR. However, resource users with little or no awareness of alternative courses of action, continue to degrade or over-extract from marine and terrestrial ecosystems including groundwater aquifers, in an effort to sustain themselves or even for recreation. Poorly planned land development and population expansion degrades habitats and introduces pollutants into the environment, thereby decreasing the resilience of plant and animal species and increasing the risk of damages from flooding. Climate change driven impacts will pose even greater threats to ecosystems and populations in SVG as SLR, increased intensity of extreme weather events, oceanic and atmospheric temperature increases and altered patterns of precipitation interfere with their functions and livelihoods.

1. GLOBAL AND REGIONAL 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 emissions and changes in the global climate system (IPCC, Summary for Policymakers. , 2007a). Notably, climate change is ongoing, with "observational evidence from all continents and oceans … that many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC, 2007b, p. 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, p. 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 (increased runoff and earlier spring peak discharge, warming of lakes and rivers affecting thermal structure and water quality), terrestrial ecosystems (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 (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 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, p. 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, Herzfeld, Stanton, & Ackerman, 2008). This should be seen in the light of (Dulal, Shah, & Ahmad, 2009, p. 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 Intergovernmental Panel on Climate Change's 4th Assessment Report (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 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 is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. Some individual countries are taking action, such as the Australian Government's comprehensive long-term plan for tackling climate change and securing a clean energy future. The plan outlines the existing policies already underway to address climate change and cut carbon pollution and introduces several critical new initiatives and has four pillars: a carbon price; renewable energy; energy efficiency; and action on land. As a group, AOSIS member states account for less than 1% of global greenhouse gas 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 CARICOM nations to SLR and associated storm surge by The CARIBSAVE Partnership in 2010 found that large areas of the coastlines in the Caribbean 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 M. C., 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 negatives 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, Gossling, & Scott, 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, Shaw, Coles, & Prillwitz, 2010; Bows anderson, & Footitt, 2009; Hickman & Banister, 2007; see also Giddens, 2009). As outlined by (Scott, Peeters, & Gössling, 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. 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 elasticities 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 & 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 and national economies (e.g. Stern, 2006; Barnett & Adger, 2007; German Advisory Council, 2007; Simpson, Gossling, & Scott, 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, Waugh, Haine, Robbins, & Khatiwala, 2004).

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and climate*

Forming part of the Windward Islands, SVG is a multiple island nation consisting of the mainland of St. Vincent (345 km^2) and approximately 32 islands and cays in the northern Grenadines (about 44 km^2). The majority of the Grenadine islands are uninhabited, with only Bequia, Mustique, Union Island, Canouan, Palm Island, Mayreau and Petit St. Vincent being populated. St. Vincent is about 28.97 km long and 17.70 km at its widest point. The capital of Kingstown is located on the southwest coast of the island and the Government and main commercial centre are situated there (UNCCD, 2000; MOHE, 2004).

SVG is of volcanic origins and was formed during the Miocene period after two major volcanic eruptions. The mainland, St. Vincent, has a very mountainous and deeply divided interior. The Central North South mountain range (the Soufriere mountains) reaches peaks of 1,234 m and culminates at the cone of the active volcano La Soufriere (which has had five major eruptions, the most recent of which was in 1979) (UNCCD, 2000; UNCCD, 2002). At the southern end of the island, the Morne Garou Mountains, Grand Bonhomme, Petit Bonhomme and Mount St. Andrew can be found (MOHE, 2004). The rugged terrain of St. Vincent has lent itself to the formation of wet upland forests and several steam filled valleys.

In contrast, the Grenadines, which are ecologically older than St. Vincent, have a much gentler relief with hills reaching elevations no higher than 150 m to 300 m. Due to their formation and geology, the Grenadines also lack the streams which are found on the mainland. An underwater volcano, known as Kick 'em Jenny, is located in the lower Grenadines, above Grenada. (NEAB and MOHE, 2000; MOHE, 2004).

SVG has a tropical climate with temperatures typically ranging between 18.0˚C to 33.0˚C. As a result of its mountainous terrain, St. Vincent has a range of microclimates that vary greatly with elevation, location and orientation (for instance, temperatures are cooler at higher elevations in the interior of the island). In St. Vincent, annual precipitation varies from 150 cm on the coast in the extreme south to 381 cm in the interior; whereas the Grenadines may receive as little as 46 cm of rain per year. There are two distinct seasons: a wet season (between June and December) and a dry season (between January and May) and the main wind system which affects the islands is the Northeast Trade winds (Mills, 2001; MOHE, 2004; MOHE, 2010). Although SVG lies to the south of the main storm track, the islands are occasionally struck by tropical storms and hurricanes (UNCCD, 2002). Below is a list of the tropical storms and hurricanes which affected SVG within the past decade:

- Tropical Storm Chantal (August 17, 2001)
- Tropical Storm Jerry (October, 8 2001)
- Tropical Storm Lily (September 23, 2002)
- Tropical Storm Claudette (July 8, 2003)
- Hurricane Tomas (October 31, 2010)

(Source: StormCARIB, 2011)

St. Vincent has approximately 105 km of coastline which is characterised by black volcanic sand beaches, except along its southern tip where coralline sand beaches exist. Conversely the Grenadines, which are surrounded by fringing reefs, boast mainly white sandy beaches (UNCCD, 2000; Mills, 2001: 1211; MOHE, 2004). The natural variations in the geology, topography and climate of SVG have created a diverse range of

ecosystems, habitats and species. Current data suggest that the islands are home to over 1,150 species of flowering plants, 163 species of ferns, 4 species of amphibians, 111 species of birds and 15 species of mammals. St. Vincent has significant vegetation cover which includes tropical rain forests (some of which are primary forests that provide habitat for the endangered St. Vincent parrot), palm brakes, elfin woodlands, deciduous seasonal forests/cactus scrubs, littoral woodlands and mangroves (UNCCD, 2000; UNCCD, 2002).

Included in the 30 territories and countries which comprise the Caribbean Islands Biodiversity Hotspot, SVG was identified as having seven areas with a significant number of globally threatened species and/or where there is the occurrence of restricted range species and congregatory species (CEPF, 2010). In particular, St. Vincent's Central Mountain Range Corridor was selected as one of the seven conservation corridors in the region. Conservation corridors are groupings of key biodiversity areas of high priority due to their contribution to ecosystem resilience, the provision of eco-system services and the promotion of the health and richness of the hotspot's biological diversity (CEPF, 2010, p. 15). The before mentioned seven key biodiversity areas are found contiguous with each other along the Central Mountain Range Corridor and collectively form the proposed Central Forest Reserve under the System of Protected Areas and Heritage Sites (SPAHS). The corridor is home to four globally threatened species and its watersheds provide all of St. Vincent's freshwater (CEPF, 2010, p. 18).

The marine eco-system is also important and over 500 marine species have been identified in SVG. These include at least 450 species of fin-fish, 4 species of turtles, 9 species of gastropods, 11 species of seaweed and 30 species of coral (MOHE, 2010, p. 3). Twelve species of cetaceans (marine mammals) can also be found in the waters of SVG, some of which include humpback whales, sperm whales, pilot whales, bottlenose dolphins and spinner dolphins. Bequia is actually one of the few locations where whale hunting is still permitted by the International Whaling Commission due to aboriginal subsistence hunting (Mills, 2001, p. 1212).

2.2. *Socio-economic profile*

SVG is described as having a small lower middle income, open economy which is highly susceptible to exogenous shocks (external economic events and natural disasters) (European Commission, n.d.-a; European Commission, n.d.-b). The 2001 Population and Housing Census[1] placed the population, which is predominately of African descent, at approximately 106,253 persons (53, 626 males and 52,627 females); of which roughly 91.9% live on the mainland and the remaining 8.1% on the Grenadine islands. This estimate indicates that the country experienced a population decline of 0.2% (possibly due to migration) since the last census in 1991, where the period 1980 - 1991 was marked by an 8.8% increase in population (Statistical Office, 2001). The mountainous interior of St. Vincent forces most of the population and developmental activities to occupy a narrow coastal strip. However, in recent times housing settlements have been constructed on the slopes of the Central Mountain Range – to the detriment of the environment. As a result of the impermeable concrete and galvanised iron used in such developments, rain water penetration into the soil has been reduced. Also, construction on the steep slopes has caused more rapid run-off and sedimentation and pollution of streams (especially during the dry season) (UNCCD, 2002).

[1] The Statistical Office is also currently in the process of preparing for the 2011 Population and Housing Census (Government of St. Vincent & the Grenadines, 2011c).

The 2001 census also indicated that approximately 5.4% of the population have attained tertiary level education. While the size of the labour force increased to 43,528 (an increase of 1,846 persons since the 1991 census), the unemployment rate have also increased by 1.3 percentage points to stand at 21.1%. This upward movement in unemployment was attributed to an increase in unemployed males (Statistical Office, 2001). Social indicators suggest that SVG is the poorest country in the Eastern Caribbean, with an annual per capita income of US $1,730 (European Commission, n.d.-b; MOHE, 2004). Many persons are only seasonally employed and often migrate to other Caribbean countries or industrial nations seeking employment in order to send remittances home to their families. In 2001, the Government administratively established the National Economic and Social Development Council (NESDEC) to oversee and guide the country's Interim Poverty Reduction Strategy Paper (European Commission, n.d.-b).

Agriculture is one of the largest economic activities on St. Vincent and is generally concentrated in the middle basin where the land is relatively flat. However, due to limited prime agricultural land, activity has been encroaching onto the slopes at higher elevations, contributing to landslides and increased sediment transport (NEAB and MOHE, 2000; Mills, 2001; MOHE, 2004). Production is centred on a narrow range of crops (such as sweet potatoes, eddoes, tannias, yams and coconuts) of which most is exported, while the country relies heavily on imports to meet internal demands (European Commission, n.d.-a; UNCCD, 2000). In spite of the 'Banana Wars' in which the United States of America and a few Latin American countries challenged the preferential arrangement between the European Community and the African, Caribbean and Pacific (ACP) states under the banana protocol of the Lomé Convention (1975), banana still dominates most of the agricultural production of St. Vincent (Williams & Darius, 1998; Mills, 2001; Myers, 2004). After an eight year standoff, in 2001 the World Trade Organisation (WTO) ruled against the preferential terms of access on bananas, finding them to be discriminatory and in violation of WTO rules (Williams & Darius, 1998; Myers, 2004). In response to the uncertainty surrounding the continuation of the preferential treatment for bananas on the European market beyond 2006, the Government of SVG was prompted to take action towards restructuring the banana industry and diversifying the economy to include services, such as tourism. (ECLAC, 2003). Besides banana, another economically important agricultural output is arrowroot (Mills, 2001; ECLAC, 2003). Although the contribution of agriculture to the GDP has declined from 21.2% in 1990 to 9.6% in 2006, the industry employs more than 40% of the workforce (UNCCD, 2000; UNCCD, 2002; European Commission, n.d.-b). This decline in agricultural production is a contributing factor in the increasing unemployment situation in the country.

In the Grenadines, on the other hand, because of their drier climate and the calciferous nature of the soil, very little agricultural activity occurs; although some persons engage in small-scale husbandry (cattle and goat rearing). As a result, these islands are almost entirely dependent upon the coastal environment for their existence – tourism being their main economic activity (Mills, 2001; UNCCD, 2002).

The offshore fishery is an important economic sector for SVG (Mills, 2001, p. 1212). The fisheries are predominately small scale and artisanal and contributed approximately 2.02% of GDP in 1997. The main fisheries include shallow reef species, small coastal pelagic species, large pelagic species, non-fish species (lobster, conch and sea urchin) and a small traditional whaling fishery. Marine turtle fishing has been observed in SVG since the 17th Century and the fishery is based mainly on the green and the hawksbill turtles (Mills, 2001; Mohammed, Straker, & Jardine, 2003). Through a Japanese Grant Aid Programme, significant progress has been made to upgrade the fisheries sector (Mohammed, Straker, & Jardine, 2003).

The services sector, based largely on a growing tourism industry, is also important to SVG's economy (Government of Saint Vincent & the Grenadines, 2011). Real economic growth was averaged at 4.4% per annum during the period 2002 - 2006 and this growth was attributed largely to strong activity in the

construction sector for tourism, low income housing, road maintenance and the development of new highways (European Commission, n.d.-b; Government of Saint Vincent & the Grenadines, 2011). However, a downside to the growth in the construction sector is that it also led to an increase in the extraction of sand and aggregate from coastal stocks. This has required Government to introduce initiatives and incentives to dissuade developers from engaging in sand mining (e.g. tax concessions are given to developers who use imported sand) (CEHI, 2011). Table 2.2.1 provides a breakdown of GDP for the period 2001 - 2010 and shows that the slight growth in the economy continued up to 2009, after which there was a decline of about 4.06% in 2010. Similarly, Table 2.2.2 shows that most industries experienced some growth (albeit with minor fluctuations) for the years 2003 - 2009. The only industries to exhibit growth in 2010 were manufacturing, construction, communications and real estate and business activities; that is to say, the services sector. Figure 2.2.1 illustrates the percentage contribution of the sectors to GDP.

Table 2.2.1: GDP in current prices (US $million) 2001-2010

YEAR	Gross Domestic Product in Current Prices (US $ millions)
2001	349.46
2002	370.06
2003	386.95
2004	386.95
2005	445.57
2006	497.90
2007	555.28
2008	583.87
2009	585.38
2010	561.61

(Source: World Bank, 2011)

Table 2.2.2: Sector GDP in constant 2006 prices (EC $million) 2001-2010

Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010‡
Agriculture, Livestock & Forestry	74.67	84.94	79.15	76.06	77.60	80.54	88.47	87.74	99.11	80.70
Fishing	5.92	4.92	6.17	6.08	6.37	6.38	7.99	4.78	7.45	6.06
Mining & Quarrying	2.17	2.09	2.37	3.85	3.98	4.18	4.76	5.00	4.58	4.48
Manufacturing	64.70	63.07	67.66	66.00	71.01	71.01	67.82	68.37	62.47	65.22
Electricity & Water	45.47	46.72	49.30	51.92	55.49	56.78	59.03	58.10	59.98	57.25
Construction	88.13	96.15	116.00	127.09	137.99	155.98	139.89	128.27	125.43	144.24
Wholesale & Retail	162.56	168.19	180.96	196.51	205.37	215.42	235.05	244.22	223.43	222.31
Hotels & Restaurants	25.43	24.44	32.27	36.65	39.56	49.45	49.33	46.62	36.31	29.05
Transport & Storage	97.82	115.38	124.93	133.66	133.95	145.82	153.05	154.81	154.96	153.91
Communication	26.62	37.27	59.63	60.53	63.62	72.19	61.14	62.24	58.85	59.74
Financial Intermediation	89.41	96.56	100.08	105.50	104.99	110.04	105.76	104.36	105.79	97.34
Real Estate & Business Activities	203.57	205.89	207.53	212.72	215.81	227.52	229.16	233.98	230.13	230.61

*Estimates; ‡Preliminary

(Source: ECCB, 2011)

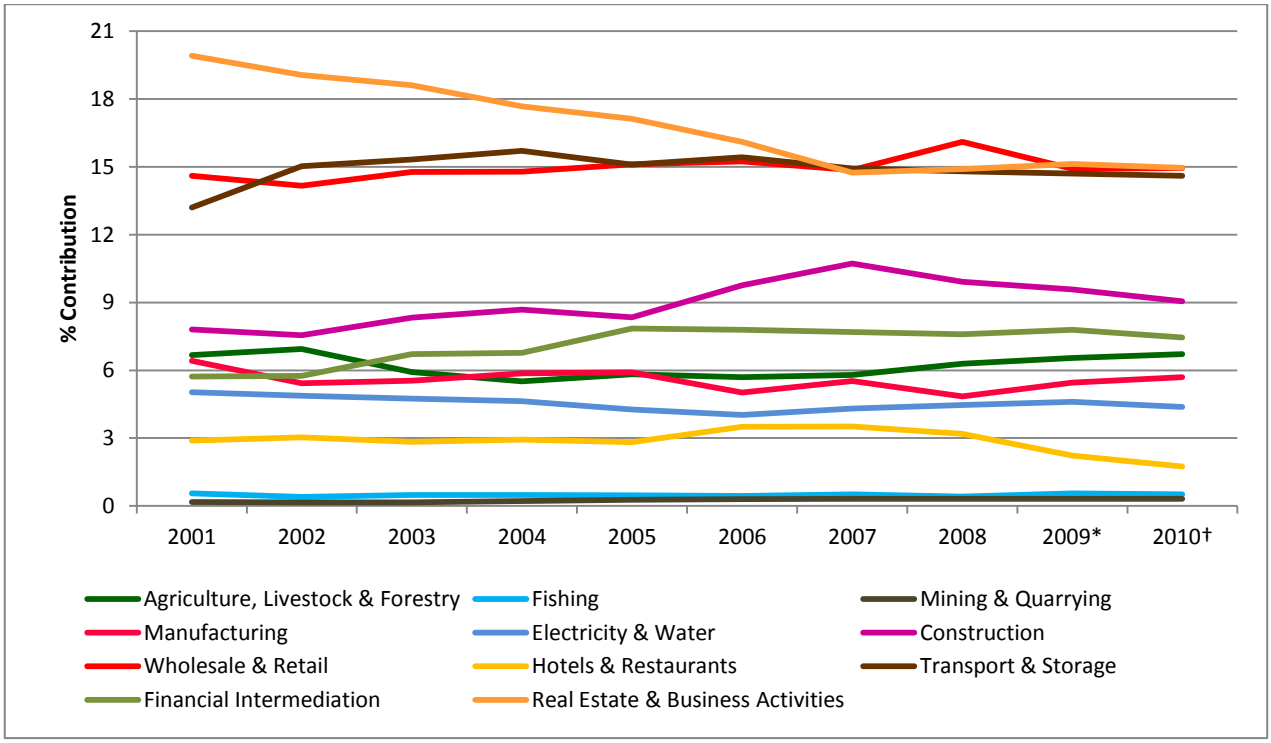


Figure 2.2.1 Percentage contribution to GDP by sector 2001-2010

(Source: ECCB, 2011)

To support economic growth and stability, the Government drafted a Medium Term Economic Strategy Paper 2002 - 2004, to review the islands' socio-economic and environmental issues and the broad

parameters of its socio-economic policies and implementation framework (Homer & Shim, St. Vincent & the Grenadines Environmental Management Strategy and Action Plan 2004-2006, 2004; European Commission, n.d.-b). In 2007, VAT and modern Excise tax were introduced in SVG. VAT is charged at a rate of 15%, with a reduced rate of 10% for hotel accommodations, diving tours and other tourism related services; while Excise Tax is levied at varying rates on items such as cars, petroleum products, alcohol and cigarettes. In addition, the 2006 agreement with Italy to write off existing debt has lead to a reduction of SVG's public debt; and by the end of 2009 it was estimated at 73.2% of GDP (FCO, 2011).

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.

SVG has been classified as an emerging tourist destination. St. Vincent's tourism industry is considered to be relatively new and has generally been developed around ecotourism and culture. However, as there are only a few tourist attractions, it does not attract many stay-over tourists. The island has, however, become a popular cruise destination after the opening of the deepwater cruise terminal on the eastern side of Kingstown harbour. In contrast, tourism in the Grenadines is far more established and centres mainly on the marine environment. The islands are known for their excellent yachting, sailing, scuba diving and water sports. While the exclusive island resorts of Mustique, Petit St. Vincent and Palm Island add a further element of luxury (Mills, 2001, p. 1213; ECLAC, 2003).

It is unknown how many persons are employed in the tourism industry; however, as of 2000, there were 169 properties registered as hotels and guesthouses which provide direct employment for more than 1,000 people (Homer & Shim, p. 8). In general, the tourism sector contributes 2-3% of GDP (UNCCD, 2000). While there has been a steady average annual increase in tourist arrivals in the Caribbean over the past decade, SVG has fallen behind in regional trends and accounts for less than 3% of the region's tourism market (ECLAC, 2003). The main tourist markets to SVG are the United States, Europe, Canada and Other. In 2007, the percentage shares of those markets were as follows: United States (29.7%); Other Caribbean (23.8%); United Kingdom (18.7%); Trinidad and Tobago (9.6%); Canada (7.5%); Other Europe (7.5%); and Rest of World (3.2%) (CTO, n.d.). Table 2.3.1 indicates that the total number of stopover visitors has been steadily decreasing from 2007, while the number of cruise ship passengers has fluctuated markedly over the last ten years. See also Table 2.3.2 and Figure 2.3.1 for an overview of total tourist arrivals and expenditure.

Table 2.3.1: Visitor Arrivals to St. Vincent and the Grenadines 2001-2010

Year	Stopovers	Cruise Ship Passengers
2001	69454	76,500
2002	77463	70,314
2003	78,535	64,765
2004	86,727	74,657
2005	95,505	69,391
2006	97,432	106,474
2007	89,637	144,555
2008	89,397	116,613
2009	75,446	149,464
2010	72,478	110,955

(Source: OECS, 2009; CTO, 2011)

Table 2.3.2: Visitor expenditure 2001-2010 (EC $million)

Year	All Visitor Expenditures
2001	216.45
2002	223.74
2003	246.22
2004	250.00
2005	245.73
2006	246.22
2007	258.00
2008	281.10
2009	236.35
2010	234.30

(Source: OECS, 2009; MOTI, 2011)

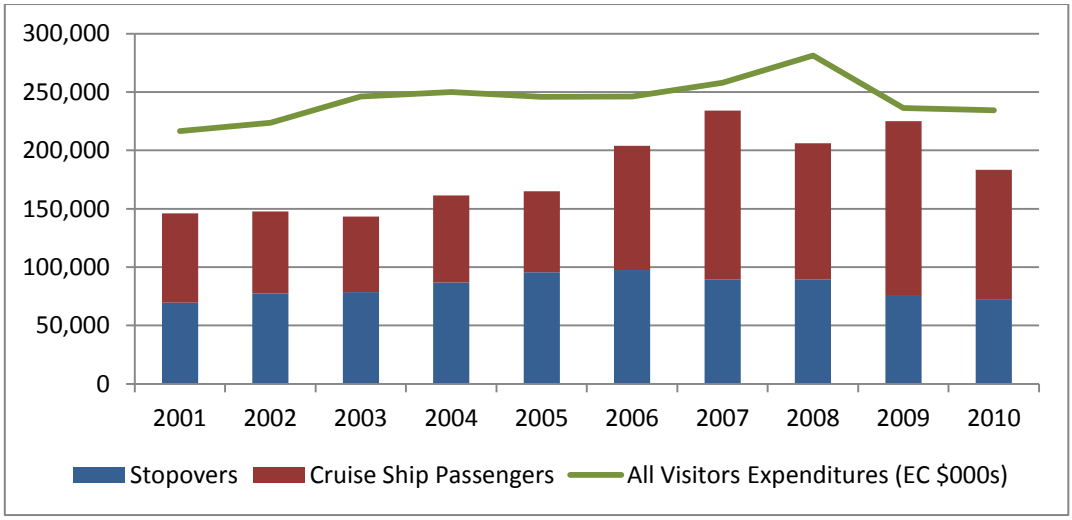


Figure 2.3.1: Tourist arrivals and expenditure

(Source: OECS, 2009; MOTI, 2011)

Some of the factors which have been attributed to the slow growth of SVG's tourism sector are limited availability of and access to capital; increased competition from other destinations; increased awareness of

the need for environmental protection; lack of a well defined tourism product; and lack of white sandy beaches, especially on St. Vincent (ECLAC, 2003). The absence of an international airport has also been identified as one of the limitations of SVG's tourism industry. However, to address this, the Government has set up the International Airport Development Company Ltd. (IADC), a wholly Government owned private limited liability company, to oversee the arrangement for the financing and construction of the Argyle International Airport (IADC, 2011). This initiative can be seen as an indication of the Government's commitment to promoting and developing the sector. In addition, a five year Tourism Development Plan has been established to help enhance the industry and the Ministry of Tourism and Industry has reported that a National Tourism Policy is currently being updated (European Commission, n.d.-a; MOTI, 2011).

3. CLIMATE MODELLING

3.1. *Introduction to Climate Modelling Results*

This summary of climate change information for SVG 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, 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 SVG have increased at an average rate of 0.15˚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 0.17˚C per decade.

General Circulation Model (GCM) projections from a 15 model ensemble indicate that SVG can be expected to warm by 0.6˚C to 2.0˚C by the 2050s and 0.9˚C to 3.4˚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 similar or greater increases in temperatures compared to the GCM ensemble median projections for the A2 scenario over SVG. In particular, RCM simulations driven by ECHAM4 indicate temperature increases that are higher than GCM ensemble median projections in all seasons. RCM projections indicate increases of 3.1˚C and 2.4˚C in mean annual temperatures by the 2080s, when driven by the ECHAM4 and HadCM3 respectively, compared with the GCM ensemble projections of 1.9-3.4˚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 we therefore see more rapid warming over SVG in RCM projections than in GCMs.

Table 3.2.1: Observed and GCM projected changes in temperature for St Vincent and the Grenadines.

St Vincent and the Grenadines: 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	0.4	**0.7**	0.9	1.1	**1.4**	2	1.9	**2.5**	3.4
Annual	26.6	0.15*	*A1B*	0.3	**0.7**	1.1	1	**1.4**	2	1.3	**2.1**	2.9
			B1	0.3	**0.7**	0.9	0.6	**1.1**	1.3	0.9	**1.5**	2
			A2	0.4	**0.7**	0.8	1.1	**1.4**	2	1.8	**2.5**	3.5
DJF	25.6	0.13*	*A1B*	0.3	**0.7**	1.1	1	**1.4**	2	1.3	**2.2**	2.9
			B1	0.4	**0.7**	0.9	0.5	**1.1**	1.3	0.9	**1.5**	2
			A2	0.3	**0.7**	0.9	0.9	**1.3**	1.8	1.7	**2.3**	3.3
MAM	26.4	0.15*	*A1B*	0.3	**0.7**	1.1	1	**1.4**	1.9	1.2	**2.1**	2.6
			B1	0.3	**0.6**	0.9	0.6	**1**	1.2	0.7	**1.4**	1.9
			A2	0.3	**0.8**	0.8	1.1	**1.4**	1.9	1.9	**2.5**	3.2
JJA	27.3	0.17*	*A1B*	0.3	**0.7**	1.1	1	**1.4**	1.9	1.3	**2.1**	3
			B1	0.3	**0.7**	0.9	0.7	**1.1**	1.3	1	**1.5**	2.1
			A2	0.5	**0.8**	0.9	1.1	**1.5**	2.2	2	**2.6**	3.6
SON	27.2	0.17*	*A1B*	0.3	**0.7**	1.2	1.2	**1.5**	2.2	1.5	**2.1**	3
			B1	0.4	**0.8**	1	0.8	**1.2**	1.4	1.1	**1.5**	2

Table 3.2.2: GCM and RCM projected changes in St Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in ˚C	
	GCM Ensemble Range	1.9	**2.5**	3.4
Annual	*RCM (ECHAM4)*		**3.1**	
	RCM (HadCM3)		**2.4**	
	GCM Ensemble Range	1.8	**2.5**	3.5
DJF	*RCM (ECHAM4)*		**3.2**	
	RCM (HadCM3)		**2.4**	
	GCM Ensemble Range	1.7	**2.3**	3.3
MAM	*RCM (ECHAM4)*		**3**	
	RCM (HadCM3)		**2.3**	
	GCM Ensemble Range	1.9	**2.5**	3.2
JJA	*RCM (ECHAM4)*		**3**	
	RCM (HadCM3)		**2.3**	
	GCM Ensemble Range	2	**2.6**	3.6
SON	*RCM (ECHAM4)*		**3.3**	
	RCM (HadCM3)		**2.4**	

3.3. *Precipitation*

Gridded observations of rainfall over SVG show statistically significant decreasing trends in all seasons over the period 1960 - 2006. The trend in annual rainfall is -7.7 mm per decade with strongest decreasing trends seen in the wet season; i.e. in JJA (-12 mm per decade) and SON (-12.4 mm per decade).

GCM projections of future rainfall for SVG span both overall increases and decreases with wide variations, but tend towards decreases in more models. Projected rainfall changes in annual rainfall range from -34 to +6 mm per month (-66% to +13%) 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 SVG are strongly influenced by the driving GCM providing boundary conditions, but both RCM project a decrease in rainfall by the 2080s under the A2 scenario. Changes projected by the RCM driven by HadCM3 are greater than ECHAM4-driven simulations expect in the SON season. Driven by ECHAM4, RCM projections indicate decreases in rainfall in all seasons with -13 mm (-22%) change in total annual rainfall. When driven by HadCM3, the RCM projects large decreases in rainfall in all seasons except SON resulting in a large decrease in total annual rainfall (-30%).

Table 3.3.1: Observed and GCM projected changes in precipitation for St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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	-17	**-3**	6	-23	**-7**	5	-34	**-14**	2
Annual	142.7	-7.7*	*A1B*	-10	**-4**	9	-20	**-7**	4	-33	**-8**	1
			B1	-12	**-2**	11	-22	**-4**	3	-26	**-4**	6
			A2	-2	**0**	9	-8	**-2**	0	-9	**-4**	1
DJF	89.6	-3.2	*A1B*	-5	**0**	4	-7	**-3**	7	-8	**-5**	1
			B1	-7	**0**	13	-6	**-2**	5	-6	**-1**	4
			A2	-17	**0**	10	-14	**-1**	18	-20	**-2**	8
MAM	76.3	-3.2	*A1B*	-6	**0**	5	-14	**0**	7	-19	**0**	5
			B1	-8	**0**	9	-14	**0**	2	-14	**0**	5
			A2	-46	**-7**	10	-53	**-18**	6	-69	**-28**	8
JJA	190.2	-12.0*	*A1B*	-30	**-6**	7	-44	**-16**	4	-68	**-22**	8
			B1	-34	**-8**	26	-50	**-12**	16	-61	**-15**	17
			A2	-22	**-3**	17	-36	**-6**	11	-58	**-11**	0
SON	214.1	-12.4*	*A1B*	-30	**-3**	26	-32	**-7**	16	-58	**-13**	5
			B1	-22	**-2**	10	-35	**-2**	14	-43	**-6**	5

Table 3.3.2: GCM and RCM projected changes in St. Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in mm	
	GCM Ensemble Range	-34	**-14**	2
Annual	*RCM (ECHAM4)*		**-13**	
	RCM (HadCM3)		**-28**	
	GCM Ensemble Range	-9	**-4**	1
DJF	*RCM (ECHAM4)*		**-7**	
	RCM (HadCM3)		**-34**	
	GCM Ensemble Range	-20	**-2**	8
MAM	*RCM (ECHAM4)*		**-3**	
	RCM (HadCM3)		**-34**	
	GCM Ensemble Range	-69	**-28**	8
JJA	*RCM (ECHAM4)*		**-36**	
	RCM (HadCM3)		**-45**	
	GCM Ensemble Range	-58	**-11**	0
SON	*RCM (ECHAM4)*		**-6**	
	RCM (HadCM3)		**0**	

Table 3.3.3: Observed and GCM projected changes in precipitation (%) for St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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	-26	**-5**	10	-36	**-9**	9	-66	**-18**	6
Annual	142.7	-5.4*	*A1B*	-19	**-6**	8	-31	**-12**	5	-53	**-16**	3
			B1	-18	**-5**	11	-34	**-7**	3	-41	**-10**	13
			A2	-18	**1**	33	-25	**-7**	0	-43	**-17**	6
DJF	89.6	-3.6	*A1B*	-20	**-1**	19	-25	**-7**	26	-31	**-13**	8
			B1	-23	**-1**	49	-20	**-7**	19	-22	**-5**	17
			A2	-28	**0**	60	-45	**-4**	103	-73	**-6**	17
MAM	76.3	-4.2	*A1B*	-21	**1**	24	-51	**0**	11	-60	**0**	12
			B1	-28	**-1**	15	-53	**-1**	8	-53	**-1**	34
			A2	-47	**-9**	9	-55	**-17**	7	-74	**-30**	12
JJA	190.2	-6.3*	*A1B*	-31	**-9**	3	-45	**-18**	5	-70	**-16**	7
			B1	-35	**-9**	12	-51	**-12**	8	-62	**-17**	25
			A2	-29	**-4**	14	-36	**-9**	15	-67	**-17**	1
SON	214.1	-5.8*	*A1B*	-31	**-4**	19	-29	**-10**	13	-52	**-17**	8
			B1	-22	**-3**	9	-32	**-2**	12	-42	**-4**	6

Table 3.3.4: GCM and RCM projected changes in St. Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			% Change	
	GCM Ensemble Range	-66	**-18**	6
Annual	*RCM (ECHAM4)*		**-22**	
	RCM (HadCM3)		**-30**	
	GCM Ensemble Range	-43	**-17**	6
DJF	*RCM (ECHAM4)*		**-21**	
	RCM (HadCM3)		**-42**	
	GCM Ensemble Range	-73	**-6**	17
MAM	*RCM (ECHAM4)*		**-17**	
	RCM (HadCM3)		**-49**	
	GCM Ensemble Range	-74	**-30**	12
JJA	*RCM (ECHAM4)*		**-41**	
	RCM (HadCM3)		**-30**	
	GCM Ensemble Range	-67	**-17**	1
SON	*RCM (ECHAM4)*		**-9**	
	RCM (HadCM3)		**0**	

3.4. *Wind Speed*

Observed mean wind speeds from the ICOADS mean monthly marine surface wind dataset demonstrate increasing trends around SVG in all seasons over the period 1960 - 2006. The increasing trend in mean annual wind speed is 0.42 ms^{-1} per decade. It is greatest in MAM at the rate of 0.45 ms^{-1} per decade.

Mean wind speeds over SVG generally show a very small increase 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 indicate both increases and decreases in wind speeds under the A2 scenario. Driven by ECHAM4, the RCM indicates very small changes in wind speeds in all seasons. Driven by HadCM3, the RCM projects relatively large increases in wind speeds in JJA (+1.2 ms^{-1}) and SON (+1.2 ms^{-1}) by the 2080s.

Table 3.4.1: Observed and GCM projected changes in wind speed for St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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	-0.1	**0.1**	0.1	-0.2	**0.1**	0.2	0	**0.2**	0.5
Annual	7.3	0.42*	*A1B*	-0.3	**0**	0.1	-0.2	**0.1**	0.3	-0.1	**0**	0.4
			B1	-0.3	**0.1**	0.2	0	**0.1**	0.2	-0.2	**0.2**	0.3
			A2	-0.2	**0.1**	0.2	-0.3	**0**	0.2	-0.1	**0.1**	0.4
DJF	7.8	0.36*	*A1B*	-0.1	**0.1**	0.2	-0.1	**0.1**	0.3	-0.2	**0.1**	0.4
			B1	-0.3	**0.1**	0.1	-0.1	**0.1**	0.2	-0.3	**0**	0.4
			A2	-0.2	**0**	0.1	-0.5	**0**	0.2	-0.2	**0.2**	0.4
MAM	7.5	0.45*	*A1B*	-0.2	**0**	0.1	-0.2	**0**	0.2	-0.4	**0**	0.2
			B1	-0.4	**0**	0.2	-0.1	**0.1**	0.2	-0.1	**0.1**	0.3
			A2	-0.2	**0**	0.2	-0.2	**0.1**	0.2	-0.1	**0.4**	0.8
JJA	7.5	0.30*	*A1B*	-0.4	**0**	0.1	-0.2	**0**	0.3	-0.2	**0.2**	0.6
			B1	-0.3	**0.1**	0.3	-0.1	**0.1**	0.4	-0.2	**0.2**	0.3
			A2	-0.4	**0**	0.2	-0.2	**0**	0.3	-0.3	**0.1**	0.8
SON	6.4	0.33*	*A1B*	-0.6	**0**	0.3	-0.4	**0.1**	0.5	-0.3	**0.1**	0.7
			B1	-0.4	**0.1**	0.3	-0.2	**0.1**	0.3	-0.3	**0.1**	0.5

Table 3.4.2: GCM and RCM projected changes in St. Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in ms^{-1}	
	GCM Ensemble Range	0	**0.2**	0.5
Annual	*RCM (ECHAM4)*		**0.1**	
	RCM (HadCM3)		**0.8**	
	GCM Ensemble Range	-0.1	**0.1**	0.4
DJF	*RCM (ECHAM4)*		**-0.3**	
	RCM (HadCM3)		**0.3**	
	GCM Ensemble Range	-0.2	**0.2**	0.4
MAM	*RCM (ECHAM4)*		**-0.1**	
	RCM (HadCM3)		**0.3**	
	GCM Ensemble Range	-0.1	**0.4**	0.8
JJA	*RCM (ECHAM4)*		**0.4**	
	RCM (HadCM3)		**1.2**	
	GCM Ensemble Range	-0.3	**0.1**	0.8
SON	*RCM (ECHAM4)*		**0.3**	
	RCM (HadCM3)		**1.2**	

3.5. *Relative Humidity*

Observations from the HadCRUH show a statistically significant decreasing trend in annual relative humidity at the rate of 0.26% per decade over the period 1973 - 2003 in SVG. The decreasing trend is strongest in SON (-0.38% per decade) and is statistically significant.

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

RCM projections indicate small increases in RH over SVG in all seasons under the A2 scenario, whereas the GCM projects small decreases. The increases are roughly around 1% in all seasons by the 2080s and are generally larger in the RCM simulation driven by ECHAM4 than the one driven by HadCM3.

The representation of the land surface in climate models becomes very important when considering changes in relative humidity 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 St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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 in % per decade)*		*Change in %*			*Change in %*			*Change in %*		
			A2		**0.1**			**-0.2**			**-0.1**	
Annual	79.5	-0.26*	*A1B*	-0.6	**0.1**	1.7	-0.5	**0.1**	1.4	-0.6	**0.3**	1.1
			B1	-0.4	**-0.1**	1.5	-0.3	**0.2**	1.2	-0.5	**0.2**	1.5
			A2		**0.2**			**-0.1**			**-0.3**	
DJF	78.4	-0.26	*A1B*	-0.5	**0.1**	1.9	-0.4	**0.5**	1.7	-0.5	**0.7**	1.5
			B1	-0.6	**-0.2**	1.7	-0.3	**0.2**	1.4	-0.3	**0.5**	2.1
			A2		**0.3**			**-0.2**			**0.6**	
MAM	78.6	-0.2	*A1B*	-0.2	**0**	2.4	-0.1	**0.4**	1.9	-0.1	**0.8**	1.8
			B1	-0.3	**0.2**	1.7	0.1	**0.5**	1.7	-0.6	**0.5**	1.9
			A2		**-0.1**			**-0.4**			**-0.6**	
JJA	80.6	-0.17	*A1B*	-0.6	**0**	1.5	-0.9	**0.1**	0.7	-0.9	**-0.2**	0.9
			B1	-0.8	**-0.1**	1.3	-0.6	**0**	0.6	-0.9	**-0.2**	0.9
			A2		**0.2**			**-0.1**			**-0.3**	
SON	80.3	-0.38*	*A1B*	-1.1	**0**	1.2	-0.7	**-0.2**	1.5	-1.1	**-0.1**	1.2
			B1	-1	**-0.2**	1.4	-1.2	**0.1**	1.2	-0.9	**0.3**	1.2

Table 3.5.2: GCM and RCM projected changes in St. Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in %	
	GCM Ensemble Range		**-0.1**	
Annual	*RCM (ECHAM4)*		**1**	
	RCM (HadCM3)		**0.8**	
	GCM Ensemble Range		**-0.3**	
DJF	*RCM (ECHAM4)*		**0.6**	
	RCM (HadCM3)		**0.5**	
	GCM Ensemble Range		**0.6**	
MAM	*RCM (ECHAM4)*		**1**	
	RCM (HadCM3)		**0.7**	
	GCM Ensemble Range		**-0.6**	
JJA	*RCM (ECHAM4)*		**1.1**	
	RCM (HadCM3)		**0.9**	
	GCM Ensemble Range		**-0.3**	
SON	*RCM (ECHAM4)*		**1.4**	
	RCM (HadCM3)		**0.9**	

3.6. *Sunshine Hours*

The number of 'sunshine hours' per day is 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 SVG by 1.42 hours per decade over the period 1983-2001. The strongest increase is seen In JJA at the rate of 1.81 hours per decade.

The number of sunshine hours is projected to increase slightly into the 21st Century in SVG by most GCMs, particularly in the 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 -0.8 to +0.7 hours per day by the 2080s under scenario A2. The median increases projected by the GCM ensemble are higher in JJA and SON but with changes spanning -1.0 to +1.4 and -0.3 to +1.1 hours per day respectively.

Comparison between GCM and RCM projections of sunshine hours for SVG shows that the RCM projections are higher than the end of the range of changes projected by the GCM ensemble except for MAM. 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 (1.6-1.9 hours per day) and in SON (1.3 hours per day).

Table 3.6.1: Observed and GCM projected changes in sunshine hours for St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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**	0.2	-0.4	**0.2**	0.5	-0.8	**0.3**	0.7
Annual	5	1.42*	*A1B*	-0.3	**0**	0.3	-0.5	**0.1**	0.5	-0.5	**0.2**	0.7
			B1	-0.3	**0.1**	0.3	-0.3	**0.1**	0.3	-0.4	**0**	0.4
			A2	-0.4	**0**	0.3	-0.5	**0**	0.5	-0.9	**0.3**	0.5
DJF	5.9	1.07*	*A1B*	-0.3	**0.1**	0.3	-0.3	**0.1**	0.5	-0.5	**0.2**	0.5
			B1	-0.3	**0.1**	0.5	-0.3	**0.1**	0.5	-0.5	**0.1**	0.5
			A2	-0.6	**0**	0.4	-0.9	**-0.1**	0.5	-1.4	**0.1**	0.6
MAM	5.1	0.99	*A1B*	-0.7	**-0.1**	0.3	-1	**0**	0.6	-1.2	**0**	0.6
			B1	-0.5	**0**	0.2	-0.5	**-0.2**	0.1	-1	**0**	0.5
			A2	-0.3	**0.1**	0.5	-0.5	**0.2**	1.1	-1	**0.4**	1.4
JJA	4.8	1.81*	*A1B*	-0.3	**0.2**	0.7	-0.6	**0.4**	1.2	-0.6	**0.3**	1.2
			B1	-0.3	**0.2**	0.7	-0.3	**0.3**	0.7	-0.7	**0.4**	1.1
			A2	-0.1	**0**	0.4	-0.3	**0.3**	0.6	-0.3	**0.4**	1
SON	4.3	1.30*	*A1B*	-0.3	**0**	0.5	-0.2	**0.2**	0.8	-0.3	**0.5**	1.1
			B1	-0.3	**0.1**	0.4	-0.2	**0.2**	0.6	-0.3	**0.1**	0.7

Table 3.6.2: GCM and RCM projected changes in St. Vincent and the Grenadines under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in hours	
	GCM Ensemble Range	-0.8	**0.3**	0.7
Annual	*RCM (ECHAM4)*		**1.1**	
	RCM (HadCM3)		**1.1**	
	GCM Ensemble Range	-0.9	**0.3**	0.5
DJF	*RCM (ECHAM4)*		**1.3**	
	RCM (HadCM3)		**1.1**	
	GCM Ensemble Range	-1.4	**0.1**	0.6
MAM	*RCM (ECHAM4)*		**0**	
	RCM (HadCM3)		**0**	
	GCM Ensemble Range	-1	**0.4**	1.4
JJA	*RCM (ECHAM4)*		**1.6**	
	RCM (HadCM3)		**1.9**	
	GCM Ensemble Range	-0.3	**0.4**	1
SON	*RCM (ECHAM4)*		**1.3**	
	RCM (HadCM3)		**1.3**	

3.7. *Sea Surface Temperatures*

The HadSST2 gridded dataset does not indicate a statistically significant trend in mean annual sea surface temperatures around SVG. However, statistically increasing trends are observed in JJA (0.09˚C per decade) and in SON (0.09˚C per decade) in the waters surrounding SVG.

GCM projections indicate increases in sea surface temperatures throughout the year. Projected increases range between +0.9˚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 St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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	0.8	**1.3**	1.7	1.6	**2.3**	3
Annual	27.4	0.06	*A1B*	0.3	**0.6**	1	0.9	**1.4**	1.7	1.2	**2.3**	2.6
			B1	0.3	**0.6**	0.8	0.6	**1**	1.2	0.9	**1.4**	1.8
			A2	0.5	**0.7**	0.8	0.9	**1.2**	1.8	1.6	**2.2**	3.2
DJF	26.7	0.03	*A1B*	0.3	**0.6**	1	0.9	**1.3**	1.8	1.2	**2.1**	2.6
			B1	0.3	**0.5**	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	1.6	**2.2**	3
MAM	26.8	0.03	*A1B*	0.2	**0.6**	1	1	**1.3**	1.7	1.1	**2.1**	2.5
			B1	0.3	**0.6**	0.9	0.5	**0.9**	1.1	0.8	**1.5**	1.8
			A2	0.5	**0.7**	0.8	1	**1.3**	1.5	1.5	**2.2**	2.8
JJA	27.8	0.09*	*A1B*	0.3	**0.7**	1	0.9	**1.4**	1.7	1.1	**2.2**	2.7
			B1	0.3	**0.7**	0.7	0.6	**1.1**	1.1	0.9	**1.3**	1.9
			A2	0.4	**0.7**	0.9	1	**1.3**	1.8	1.6	**2.5**	3.1
SON	28.3	0.09*	*A1B*	0.3	**0.7**	1.1	1	**1.3**	1.8	1.3	**2.4**	2.6
			B1	0.3	**0.7**	0.9	0.7	**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 SVG.

GCM projections indicate increases in the frequency of 'hot' days by 36-93% of days and 'hot' nights by 37-97% 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 St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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*	*Mx*
	% Frequency	***Change in frequency per decade***				***Future % frequency***			***Future % frequency***		
Frequency of Hot Days (TX90p)											
		A2				40	**55**	62	61	**85**	93
Annual		*A1B*				42	**58**	63	49	**77**	84
		B1				32	**41**	49	36	**50**	66
		A2				61	**76**	93	91	**97**	99
DJF		*A1B*				55	**79**	90	80	**95**	98
		B1				33	**51**	70	55	**75**	84
		A2				61	**75**	93	89	**97**	99
MAM		*A1B*				60	**73**	92	76	**93**	98
		B1				35	**54**	79	53	**71**	89
		A2				58	**81**	92	88	**96**	99
JJA		*A1B*				63	**83**	92	75	**91**	99
		B1				44	**59**	79	49	**73**	95
		A2				70	**88**	95	90	**98**	99
SON		*A1B*				73	**87**	95	85	**95**	99
		B1				49	**73**	90	72	**84**	95
Frequency of Hot Nights (TN90p)											
		A2				42	**58**	74	62	**87**	97
Annual		*A1B*				43	**64**	72	49	**85**	88
		B1				32	**46**	61	37	**52**	79
		A2				61	**73**	95	96	**98**	100
DJF		*A1B*				53	**76**	93	77	**96**	99
		B1				31	**51**	71	53	**67**	95
		A2				59	**80**	95	93	**98**	99
MAM		*A1B*				61	**75**	95	76	**95**	99
		B1				33	**55**	82	54	**79**	90
		A2				67	**87**	96	91	**98**	100
JJA		*A1B*				68	**89**	96	79	**98**	99
		B1				49	**66**	89	58	**78**	95
		A2				78	**91**	99	98	**99**	100
SON		*A1B*				82	**93**	99	93	**99**	100
		B1				62	**79**	96	72	**90**	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**	2	0	**0**	0
MAM		*A1B*				0	**0**	1	0	**0**	0
		B1				0	**0**	1	0	**0**	1
		A2				0	**0**	0	0	**0**	0

St Vincent and the Grenadines: 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*	*Mx*	
	% Frequency	***Change in frequency per decade***				***Future % frequency***			***Future % frequency***			
JJA		*A1B*				0	**0**	0	0	**0**	0	
		B1				0	**0**	3	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	
		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**	4	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 SVG.

GCM projections of rainfall extremes are mixed across the ensemble of models, ranging from both decreases and increases in all measures of extreme rainfall. The proportion of total rainfall that falls in heavy events decreases in most model projections which range between -19% to +8% by the 2080s.

Maximum 1 day rainfall shows no change by the 2080s but maximum 5 day rainfall tends to decrease in model projections ranging from -29 to +8 mm annually by the 2080s.

Table 3.9.1: Observed and GCM projected changes in rainfall extremes for St. Vincent and the Grenadines.

St Vincent and the Grenadines: 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			-14	**0**	4	-19	**-4**	1	
Annual		*A1B*			-14	**-2**	5	-19	**-1**	3	
		B1			-15	**0**	4	-16	**0**	8	
		A2			-10	**-2**	2	-12	**-4**	3	
DJF		*A1B*			-7	**-2**	3	-12	**-5**	3	
		B1			-12	**0**	1	-10	**-2**	7	
		A2			-6	**-4**	8	-26	**-3**	8	
MAM		*A1B*			-8	**0**	7	-14	**-2**	4	
		B1			-13	**-2**	6	-15	**-3**	16	
		A2			-17	**0**	3	-21	**-1**	6	
JJA		*A1B*			-14	**-3**	3	-18	**-1**	5	
		B1			-18	**0**	4	-19	**0**	8	
		A2			-11	**-3**	6	-17	**-4**	3	
SON		*A1B*			-16	**-3**	6	-17	**-3**	3	
		B1			-10	**-2**	6	-10	**0**	5	
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***	
Maximum 1-day rainfall (RX1day)											
mm	*Change in mm per decade*				*Change in mm*			*Change in mm*			
		A2			-6	**0**	2	-8	**-1**	3	
Annual		*A1B*			-7	**0**	5	-9	**0**	7	
		B1			-5	**0**	6	-4	**0**	6	
		A2			-2	**0**	0	-1	**0**	4	
DJF		*A1B*			-2	**0**	0	-2	**0**	0	
		B1			-1	**0**	1	-3	**0**	2	
		A2			-1	**0**	3	-8	**0**	2	
MAM		*A1B*			-2	**0**	5	-2	**0**	2	
		B1			-4	**0**	4	-2	**0**	2	
		A2			-9	**0**	2	-13	**-1**	2	
JJA		*A1B*			-7	**0**	2	-11	**0**	2	
		B1			-10	**0**	1	-11	**0**	2	
		A2			-3	**0**	2	-3	**-1**	4	
SON		*A1B*			-4	**-1**	6	-4	**-1**	2	
		B1			-3	**0**	5	-4	**0**	6	

St Vincent and the Grenadines: 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*	
Maximum 5-day Rainfall (RX5day)												
	mm	*Change in mm per decade*				*Change in mm*			*Change in mm*			
		A2				-13	**-1**	3	-25	**-6**	4	
Annual		*A1B*				-14	**-3**	7	-29	**-3**	3	
		B1				-18	**0**	8	-15	**1**	8	
		A2				-5	**-1**	0	-6	**-1**	6	
DJF		*A1B*				-5	**-1**	2	-8	**-2**	2	
		B1				-5	**-1**	7	-6	**-1**	5	
		A2				-3	**0**	7	-15	**0**	5	
MAM		*A1B*				-3	**0**	15	-7	**0**	0	
		B1				-11	**0**	2	-5	**0**	8	
		A2				-26	**-2**	4	-35	**-9**	7	
JJA		*A1B*				-21	**-3**	1	-33	**-7**	3	
		B1				-27	**-2**	3	-31	**0**	9	
		A2				-10	**-1**	6	-18	**-5**	8	
SON		*A1B*				-12	**-4**	13	-22	**-6**	2	
		B1				-12	**-1**	9	-9	**0**	11	

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 sea surface temperatures (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. Veccchi 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 (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 1,500 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). Regional Climate Models 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, 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 20th Century has been detected in most regions (Woodworth *et al.,* 2009; Church and White, 2006).

There are large regional variations super-imposed 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 and a number of studies (e.g. Rahmstorf, 2007; Rignot and Kanargaratnam, 2006; Horton *et al.,* 2008) have provided evidence to suggest that their uncertainty range should include a much larger upper limit.

Total sea level rises associated with atmospheric warming appear largely through the combined effects of two main mechanisms: (a) thermal expansion (the physical response of the water mass of the oceans to atmospheric warming) and (b) 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 (+/ 0.05m 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 1.4m	Up to 1.45m

(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 SVG are likely to occur as a result of the combined effects of:

1. Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed.
2. Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms.
3. 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 3.11 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 ST. VINCENT AND THE GRENADINES

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 Georgetown to provide additional community-level data. Field surveys in Belmont Walkway, Bequia and Canash Beach, Indian Bay, Johnson Point and Villa Beach in St. Vincent 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 SVG.

SVG is already experiencing some of the effects of climate variability through damages from severe weather systems and the decline of some coastal tourism attractions. According to the Government of SVG, the major issues of climate change are SLR and the likelihood of more intense weather systems and periods of drought. The Maritime Administration is one of the Government agencies responsible for the implementation and regulation of the coastal zone, as well as the protection of coastal eco-systems and habitats.

4.1. *Water Quality and Availability*

4.1.1. Background

The island of St. Vincent is generally not considered to be water-stressed (NEAB, 2000), with average annual rainfall ranging from 1,500 mm on the coast to 3,800 mm in the central mountains (FAO, 2000). St. Vincent's mountainous interior, high vegetative cover and climate has resulted in an abundance of surface water in the form of both perennial and ephemeral rivers and streams (John, 2009; NEAB, 2000). The 13 watersheds on the island, many of which are within forest reserves, generate most of the country's supply of fresh water (CEHI, 2001; John, 2006; John, 2009); the major watersheds of Colonarie, Richmond, Cumberland and Montreal are shown in Figure 4.1.1.

In the Grenadines, by contrast, average annual rainfall is lower at around 1,000 mm and severe water shortages are experienced (NEAB, 2000). Due to the islands' small sizes, drier climate and absence of perennial steams, an adequate supply of water is highly dependent on the timely arrival of the rainy season (Culzac-Wilson, 2003; Peters, 2003). For example, Bequia and Union Islands do not have any surface water sources which results in high demand for water from external sources (World Bank, 2006) which increases during the Christmas, Carnival, Easter and regular regatta periods due to increases in households of between 2 and 6 persons for between one and three weeks (Peters, 2003). Freshwater is obtained mainly from rainwater runoff (private and public catchment systems), groundwater sources (wells and springs), importation and desalination (MOHE, 2007; NEAB, 2000; Peters, 2003). Hotels in the Grenadines depend mostly on desalination plants for water (Kairi Consultants Limited, 2008b). Union Island is the driest island is of the Grenadine Islands and as a result 80% of properties have underground tanks for storing water in the rainy season (World Bank, 2006). Centralised public water supply networks do not extend to all parts of the Grenadines; most residents in Bequia, for example, are dependent solely on rainwater collected and

stored in tanks and deliveries to the island during extended dry periods (Durrant *et al*., 2008). In the 2010 budget speech, the Minister indicated that one of the main capital investments for the Grenadines will be for the improvement of the country's water supply (Government of St. Vincent and the Grenadines, 2010a).

The key watersheds of St. Vincent produce approximately 120 million m^3/yr of surface water, meeting the demands of the island's population and various sectors, including the generation of hydroelectricity which, depending on the season, meets 14-26% of the nation's electricity demand. The island has also been able to occasionally supply cruise ships with water without affecting local demand (ECLAC, 2003). In 2002, there were 20 water abstraction areas in St. Vincent (with major sites located at Dalaway, Hermitage, Majorca and Montreal); and the total production of water was approximately 2 billion gallons, with an estimated GDP of EC $12.6 million (current prices) (Homer and Shim, 2004).

The water supply diminishes during the dry season (January to May), with reserve water supplies dwindling to as low as one or two days' supply (John, 2006). While there is no official record of water usage by sectors (FAO, 2000), Table 4.1.1 provides the estimates of the water consumption patterns for SVG. The most recent data suggest that 96% of households have access to safe, disinfected piped water, while most other persons live within one mile of standpipes, but this figure is most reflective of St. Vincent, accounting for approximately 30,000 households (Kairi Consutlants Limited, 2008a). The topography of St. Vincent does not favour the construction of large reservoirs (Bons and McL Simon, 2000), however, the need for additional storage and treatment facilities has been recognised (ECLAC, 2003; MOHE, 2007). Indeed only 57.4% of the population have public water piped into their homes, with another 14.7 having piped public water piped into their yard. 4.3% depend on standpipes and 10.1% source water from private sources and 7.8% from private catchments either piped or not piped (Kairi Consutlants Limited, 2008a). 69% of households in St. Vincent have access to public water seven days a week, whereas in the Grenadines, just 36% of the population has access to water on a daily basis. Further, as much as 30% of the population still utilize pit latrines, ventilated pit latrines or none (Kairi Consultants Limited, 2008a).

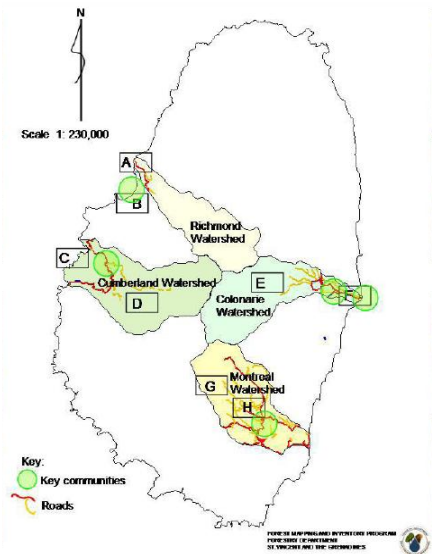


Figure 4.1.1: Major Watersheds in St. Vincent

(Source: John, 2006)

Table 4.1.1: Water statistics for St. Vincent and the Grenadines

	Million US gallons (million m^3)
Total surface water	31,701 (120)
Storage capacity	1,321 (5)
Consumption patterns	
Government institutions	423 (1.6)
Domestic	1,400 (5.3)
Unaccounted for water	476 (1.8)
Leakages	132 (0.5)

(Source: John, 2006)

The illegal clearing of land for agriculture is one of the largest threats to watersheds in St. Vincent. As agricultural practices are generally characterised by high use of agrochemicals, farming in watershed areas not only reduces the quantity of surface water available but also the quality. It is estimated that approximately 20% of all chemicals used in agriculture in St. Vincent between the months of July and December ends up in the rivers and streams (CEHI, 2001). The island's growing ecotourism industry is also a threat to watersheds, since most of the watersheds are located in forest or wildlife reserves where paths are being cleared to facilitate nature trails. Repeated use of these paths can lead to the further erosion of the loose volcanic soil resulting in gullies (CEHI, 2001). In 2009, there were 75,446 tourist arrivals by air and 149,464 cruise ship passengers arrivals to SVG. While this figure is at its lowest in five years (CTO, 2010) it still represents a threat not only to the natural landscape but also to water resources in the country.

The management of SVG' water resource is shared between the Central Water and Sewage Authority (CSWA) (a statutory body responsible for the conservation and production of potable water and the provision of sewage services) and the Forestry Department (which is charged with the management of watersheds) (John, 2009; MOHE, 2007). Table 4.1.2 shows CSWA's water service charges for metered connections by type and the environmental fees charged to customers on the mainland of St. Vincent and those for the Grenadines.

Table 4.1.2: Monthly service charges and environmental fees for metered, domestic and commercial customers

Water Charges			
Consumption Bands (US gallons)	Rates per 1000 US gallons, EC $ (US $)		
0 to 2,500	5.50 (2.04)		
2,501 to 5,000	6.50 (2.41)		
5,001 to 10,000	11.00 (4.07)		
10,001 to 15,000	15.00 (5.56)		
Over 15,000	20.00 (7.41)		
Basic Charges	Standing charge, EC $ (US $)		
Domestic	12.00 (4.44)		
Commercial	15.00 (5.56)		
Environmental Fees – St. Vincent			
Domestic	8.00 (2.96)		
Commercial	Small	Medium	Large
	20.00 (7.41)	40.00 (14.81)	70.00 (25.93)
Environmental Fees – Grenadines			
Domestic	5.00 (1.85)		
Commercial	Small	Medium	Large
	10.00 (3.70)	50.00 (18.52)	300.00 (111.11)

(Source: CWSA, 2011)

Exchange rate used: EC $2.70 = US $1

The Country Poverty Assessment 2007/2008 noted that the cost of water parallels the cost in production however, other operational costs are met through subsidies (Kairi Consultants Limited, 2008a). Rainwater storage buffers the actual cost required to be paid for water in the Grenadines. Water storage vessels have different capacities. For example "underground and above ground concrete cisterns (average 30,000 litres), metal tanks with capacity of (760-1900 litres), plastic tanks (760-3000 litres), drums (170 litres), wood barrels (130-150 litres)" (Peters, 2003).Further, it should be noted that "storage facilities are sized according to the rainfall in the area, the roof construction material and size, the expected water demand in the house the cistern serves, the cost of constructing the cistern and the degree of reliability the owner desires" (Peters, 2003).

Although the water resources on St. Vincent adequately meet domestic consumption, competing uses have substantially reduced streamflow (NEAB, 2000). The priority uses of water on the island include:

- **Domestic demand**: Domestic water use has increased with changes in lifestyle and housing patterns (larger homes with lawns).
- **Agricultural demand**: Use of crop irrigation systems, particularly during the dry season.
- **Hydro-electricity demand:** The St. Vincent Electricity Services (VINLEC) operates two hydro-electric plants at South Rivers and Cumberland River. In order to meet the demands of the Cumberland plant, water is diverted from a river in Richmond which, as a consequence, remains dry for most of the year negating any water related activity in that area.
- **Industrial demands:** Although there are no large industrial operations in St. Vincent, there are several operations which are water dependent. These include Bottlers St. Vincent Limited, Hairoun Brewery Limited, the East Caribbean Group of Companies, concrete block makers and a number of cottage industries.

- **Tourism demand:** The tourism sector is a heavy consumer of water and it is estimated that the per capita demand for fresh water by the sector is about four times that demanded by domestic households.

(Bons and McL Simon, 2000; CEHI, 2001; Chase, 2008; NEAB, 2000).

Aged or insufficient water infrastructure presents vulnerabilities in the supply of water in SVG (St. Vincent and the Grenadines 2010b). While there is no scarcity of fresh surface water in St. Vincent, there is limited surface water in the Grenadines (CEHI, 2001), making it particularly vulnerable. Groundwater reserves in St. Vincent have not been fully explored or developed (CEHI, 2001), although are expected to be adequate in terms of both recharge and storage (Robins and Lawrence, 2000). The decline of forest reserves in St. Vincent is considered to be a large threat to watersheds and the water supply (CEHI, 2001).

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

Climate models suggest that SVG will experience drying throughout the year (even during the wet season); with maximum possible changes of up to 24% less rainfall by the 2030s, 41% less rainfall by the 2060s and 58% less rainfall by the 2090s (CIF, 2010). However, an increase in the intensity of rainfall in fewer rain days is also expected, which means that not only is SVG vulnerable to droughts, but also to the secondary effects of torrential rains such as landslides and the contamination of water supplies (CIF, 2010). Such projections would severely impact the water supply of rivers and streams in St. Vincent and are of particular concern for the Grenadine islands, whose small sizes and topography necessitate a very high dependence on rainwater for freshwater supply. Watersheds have also been affected by land degradation due to "squatting, mono-cropping with poor agricultural techniques, global weather patterns (changes in rainfall distribution, drought and elevated atmospheric temperatures), deforestation and excessive use of agrochemicals" (World Bank, 2006).

Drought, water supply and irrigation in St. Vincent and the Grenadines

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, 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, needing 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.

Prolonged dry spells and lack of rainfall have resulted in significantly lower stream flows on many of the major rivers in St. Vincent, particularly the Vermont/Buccament River and the Montreal system of rivers and springs. Such shortages have affected the production of treated water at some of the main water sources and forced the CWSA to initiate a number of measures to ensure a satisfactory and equitable distribution of water to the residents of SVG (CWSA, n.d.). While the CWSA does have some small reservoirs for everyday distribution, these provide only limited security in cases of emergency (CEHI, 2001).

The Grenadines Islands depend on water from St. Vincent. In Union Island water is barged across, but the quality is often poor due to contamination from dirty water-transportation vessels (CEHI, 2007).

During the period 2009 - 2010, the Caribbean experienced one of the most severe droughts in recent years. In SVG, the rains ceased in October 2009 and did not return until July 2010. Considered the worst drought to affect the country since 1987, the CWSA was required to shut off the water supply in some parts of the country at various times of the day (I-Witness News, 2011). The CWSA activated its emergency response teams by January 2010 (CWSA, 2010). The CWSA responded to the drought by: (i) raising public awareness of the drought, particularly the need for conservation measures and the reduction in bush fires, through media visits to affected intakes, the creation of a video documentary, advertisements and news releases; (ii) increasing monitoring and control of all systems and interconnecting of affected systems enabling the utilisation of excess capacity on other systems; (iii) trucking water to higher elevation areas with water outages lasting longer than 6 hours; (iv) identifying and repairing leaks in public buildings and facilities; and (v) temporarily disconnecting most public standpipes. The drought affected particularly severely the islands of the Grenadines and as a result the CWSA also shipped a total of 224,000 US gallons of water to Union Island, Mayreau, Canouan and Bequia (CWSA, n.d.), utilising a newly acquired water tender (CWSA, 2010).

Flooding in St. Vincent and the Grenadines

Intense rainfall from storm events may only last a few hours but can result in serious rapid onset flooding, particularly when they occur 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 lead to enhanced drainage leading to groundwater discharge (Poesen *et al*., 2003).

While GCM modelling projections indicate an overall tendency for decreases in overall 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 with associated heavy rainfall (Frei *et al*., 1998; Min *et al*., 2011), including those associated with hurricanes. Research by Emanuel (2005) shows a strong correlation between hurricane size and sea surface temperature, suggesting an upward trend in hurricane destructive potential. 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).

Although SVG lies to the south of the main hurricane storm track, the islands are occasionally impacted by tropical storms, hurricanes and heavy rainfall events. Most recently, heavy rainfall during April 11-12, 2011 caused rivers to overflow and landslides in the north-eastern section of St. Vincent (IFRC, 2011a). The majority of the damage was seen in Georgetown, where landslides displaced fallen trees from the mountains, blocking rivers and causing further flooding in nearby areas. Four bridges were flooded, leading to the isolation of some communities for a few days. Infrastructural damage was also sustained to 55 homes and 73 people were forced to seek refuge in shelters or with relatives and friends. An assessment by the National Emergency Management Office revealed that the sectors which were most affected were water and agriculture. The potable water infrastructure in Georgetown was severely damaged, including the main catchments and pipes which deliver water to households, as well as the treatment and filtration plants. It is estimated that 20,000 persons depend on these catchments and pipes for their primary source of water, however, the local water authorities indicated that it could take up to three months to have the

infrastructure repaired and full services restored (IFRC, 2011a). Another area that floods frequently is the Spring Village Community, "located on the slopes and in the flood plain of the Mongoroo River…is under constant threat from the upstream floodwaters during heavy rains" (World Bank, 2006). Kingstown and Arnos Vale watersheds also experience flooding due to poor drainage (Government of St. Vincent and the Grenadines, 2010b).

Seawater Intrusion of Ground Water Resources

Coastal aquifers are threatened by seawater intrusion with rising sea levels, exacerbated by a decrease in groundwater recharge through overabstraction and decreasing precipitation (Bates *et al*., 2008; Lewsey *et al*., 2004; Werner and Simmons). A rise in sea level as low as 0.1 m may cause a decreases in aquifer thickness of more than 10 m (Bobba *et al*., 2002), leading to substantial declines in freshwater availability. Reductions in groundwater recharge to inland aquifers can also lead to seawater intrusion if they are next to saline aquifers (Chen *et al*., 2004) indicating a potential knock-on effect where coastal aquifers become saline due to SLR, then neighbouring aquifers experience saltwater intrusion during dry periods with low groundwater recharge. With global average sea levels found to be rising at a rate of 1.8 ± 0.3 mm per year (White *et al*., 2005) and with rates increasing (Church and White, 2006), coastal aquifers may be severely impacted by saltwater intrusion and many countries may lose vital water resources. Storm surges from hurricanes can cause extensive damage to aquifers (Anderson, 2002), the risk of which will increase as higher sea levels reduce the level of the storm surge required for contamination to occur. In the Caribbean, sea levels have been observed to have risen between 1.5 and 3 mm per year (see Section 3: CLIMATE MODELLING). Factors which increase the vulnerability of aquifers to saline intrusion include (i) their proximity to the sea, (ii) increasing abstractions due to rising demand from domestic, agricultural and industrial uses (Karanjac, 2004) and (iii) declining groundwater recharge through reduced precipitation or an increased proportion of surface runoff through precipitation occurring in higher intensity, shorter duration events (Bates *et al*., 2008) or decreased infiltration of water through land cover changes agriculture (Scanlon *et al*., 2005; Zhang and Schilling, 2006).

In SVG, accelerated SLR is expected to increase the likelihood of the inundation of low lying coastal areas, increase the salinity of surface and ground water and result in higher water tables (NEAB, 2000). However, because the watersheds in St. Vincent are above 300 m in elevation they have not yet been impacted by SLR. In the Grenadines, the islands have high water tables due to size and low elevation (Kairi Consultants Limited, 2008a) and some supplies are obtained from groundwater abstraction, although groundwater has been found previously to be limited (BGS, 1991) and there have been some unconfirmed reports of saltwater intrusion into aquifers in the Grenadines due to over abstraction (CEHI, 2001). However, Bequia and Union Island do not have any known groundwater (World Bank, 2006). Unlike the Grenadines, groundwater sources are not utilised in St. Vincent. While the surface systems are reasonably well known, the groundwater resources have not been adequately studied and while their true potential is not known, resources are expected to be adequate (Robins and Lawrence, 2000). Saline water contamination should not be a major concern as most lenses are expected to be fully charged (CEHI, 2001). A baseline assessment of coastal erosion conducted by the Sea Grants Project estimated a 0.3m/year rate and as high as 1.6 m/year in the north eastern (windward) coast (World Bank, 2006). Some areas have shown higher erosion rates such as Richmond and Sand Bay where loss of land was in excess of 15 m between 1995 and 2000 (World Bank, 2006).

Irrigation efficiency in the agricultural sector

Globally, agricultural water use comprises around 70% of total water extractions (Wisser *et al*., 2008) yet, 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).

St. Vincent exhibits conditions which are conducive to drip irrigation systems, namely the soil, slope and lack of mechanisation (Bons and McL Simon, 2000). The domestic and agricultural irrigation system which has been development in St. Vincent uses mini sprinklers or drippers and is driven by surface water abstraction schemes (Bons and McL Simon, 2000; CEHI, 2001). This method is considered to be highly water efficient and there is no drainage associated with the system (CEHI, 2001). Since the irrigation scheme in St. Vincent is still relatively new, issues of salinity has not yet been observed. However, since the surface water in St. Vincent is almost devoid of salts and the major water table is low, it is doubtful that salinity will be an issue (CEHI, 2001).

According to 2000 Census data "60% of the population is involved in agriculture occupying 43% of the land mass" (World Bank, 2006). If conditions become drier in SVG, agricultural productivity could decrease by as much as 20% due to the dependence on rain water for irrigation (Sem, 2007).

4.2. *Energy Supply and Distribution*

4.2.1. Background

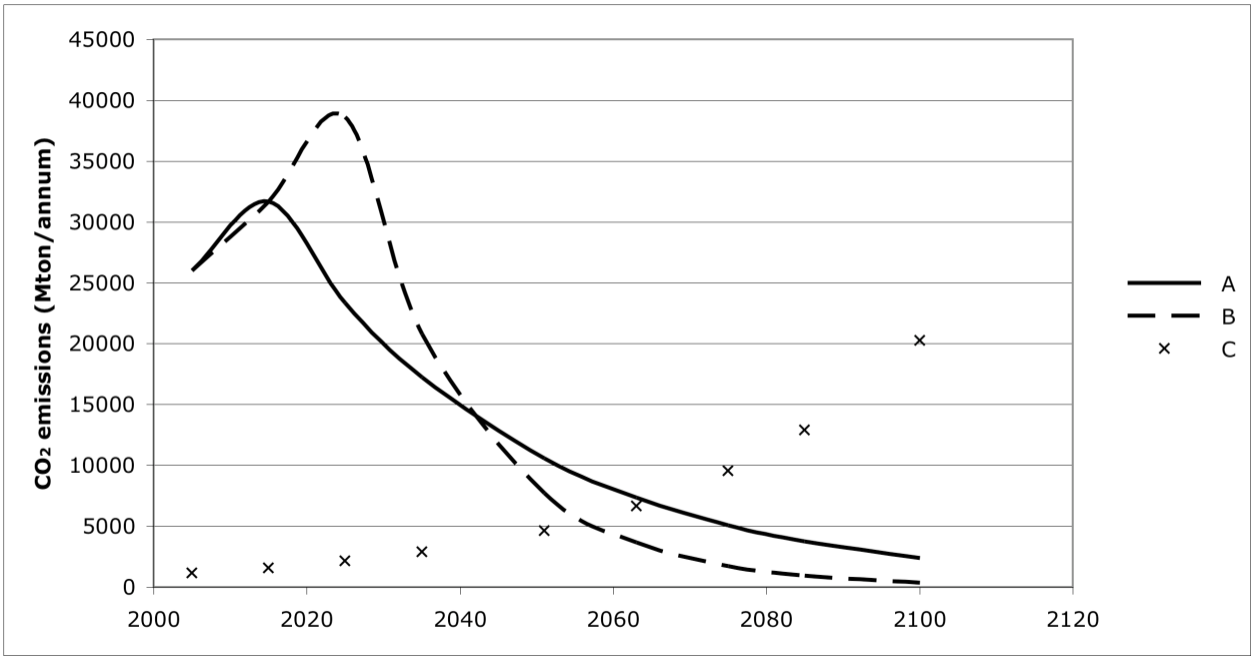
A global perspective

Tourism is a significant user of energy and a concomitant contributor to emissions of greenhouse gases. 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 greenhouse gas. Considering the radiative forcing of all greenhouse gases, tourism's contribution to global warming increases to 5.2-12.5% (Scott *et al*., 2010). The higher share is a result of emissions of nitrous oxides (NO_x) 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%).

In the future to 2050, emissions from tourism are expected to grow considerably. Based on a business as usual 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 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). Within the region, emissions are however highly unequally distributed between countries, Figure 4.2.2. For instance, Trinidad & Tobago, as an oil producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. SVG is currently emitting considerably less (an estimated 1.7 t CO_2; Figure 4.2.2) on a per capita basis than the world annual average of 4.3 t CO_2. There is thus potential room for further growth in emissions, though the figure does not include bunker fuels (for discussion see following sections).

In the future, global emissions have to decline considerably below 4.3 t CO_2 per year, the Intergovernmental Panel on Climate Change (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.

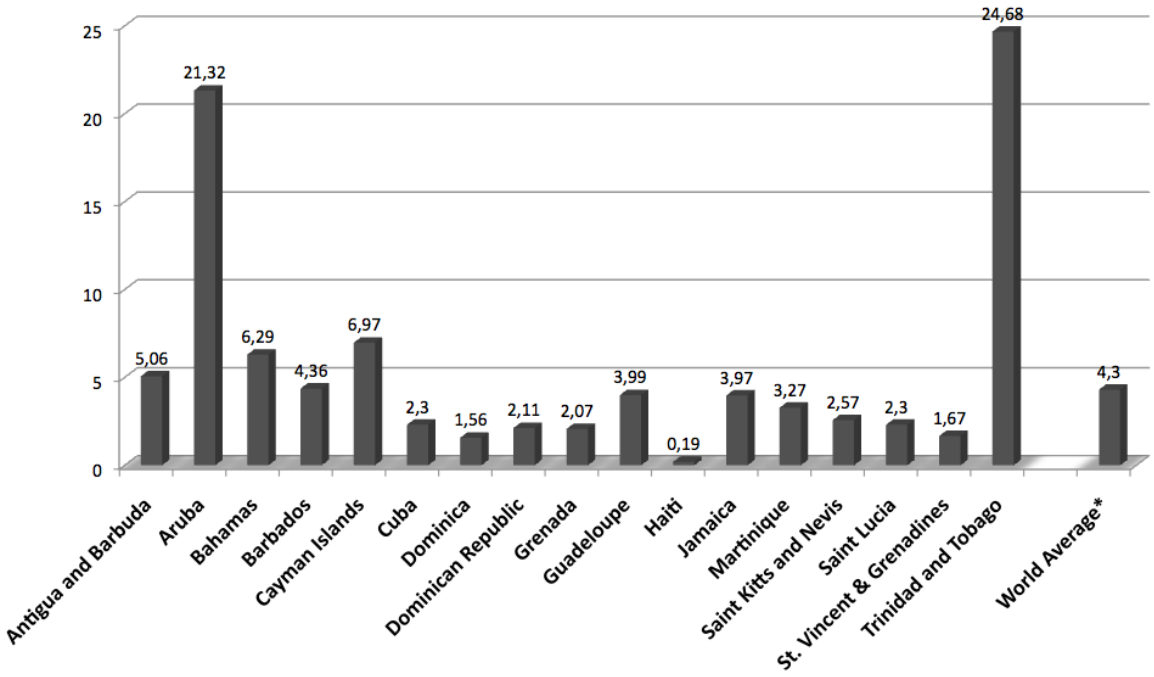


Figure 4.2.2: Per capita emissions of CO_2 in selected countries in the Caribbean, 2005

(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 greenhouse gases (Simpson *et al.*, 2008; see also country reports in the Risk Atlas). As these emissions are not usually quantified, however, the purpose of this assessment is to look in greater detail into energy use by sector.

4.2.2. St. Vincent and the Grenadines

SVG is currently almost completely dependent on imported petroleum products like gasoline (for transport), diesel (transport and electricity generation), kerosene (cooking) and butane/LPG (cooking, water heating and industry). Only St. Vincent has developed hydropower, which contributes about 5% to total primary energy consumption (Table 4.2.1; Figure 4.2.3). Overall, electricity is produced mainly by the SVG state-owned utility VINLEC, which has almost 49 MW installed capacity (11.5% is hydro).The majority of capacity (40.5 MW) is on the main island of Saint Vincent with two diesel generating facilities, Cane Hall (26.2 MW) and Lowman's Bay (8.7 MW) and three hydro power stations (Cumberland3.7 MW, Richmond 1.1 MW and South Rivers 0.9 MW). The remaining diesel fuelled units are distributed among Bequia (2.9 MW), Union Island (1.3 MW), Canouan (3.1MW) and Mayreau (180 kW). The other Grenadines islands are supplied by privately owned electricity systems on the basis of diesel plants. Bequia, Union Island, Canouan and Mayreau are also completely reliant on diesel power. According to VINLEC's 2007 report, Saint Vincent has some 5.6 MW (constant in the last 10 years) of available hydro power and diesel power plants evolved from 20.8 MW in 1998 up to 35 MW in 2007, an almost 70% increase in diesel power capacity. As the Government notes, "Most of VINLEC's diesel generators are old, inefficient and in need of replacement by newer engines or other means of electricity generation. This represents an opportunity to move towards new sources of energy." (St. Vincent and the Grenadines, 2010: 15).

Table 4.2.1: Energy matrix, tonnes of oil equivalent (TOE) 2008

Fuel	TOE
Diesel (VINLEC)	25,549
Aviation spirit	5
Kerosene	598
Hydro	1,953
Propane	0.78
Butane	3,074
Diesel (transport etc)	38,430
Gasoline (transport etc)	23,299
Total	92,909

(Source: St. Vincent and the Grenadines 2010)

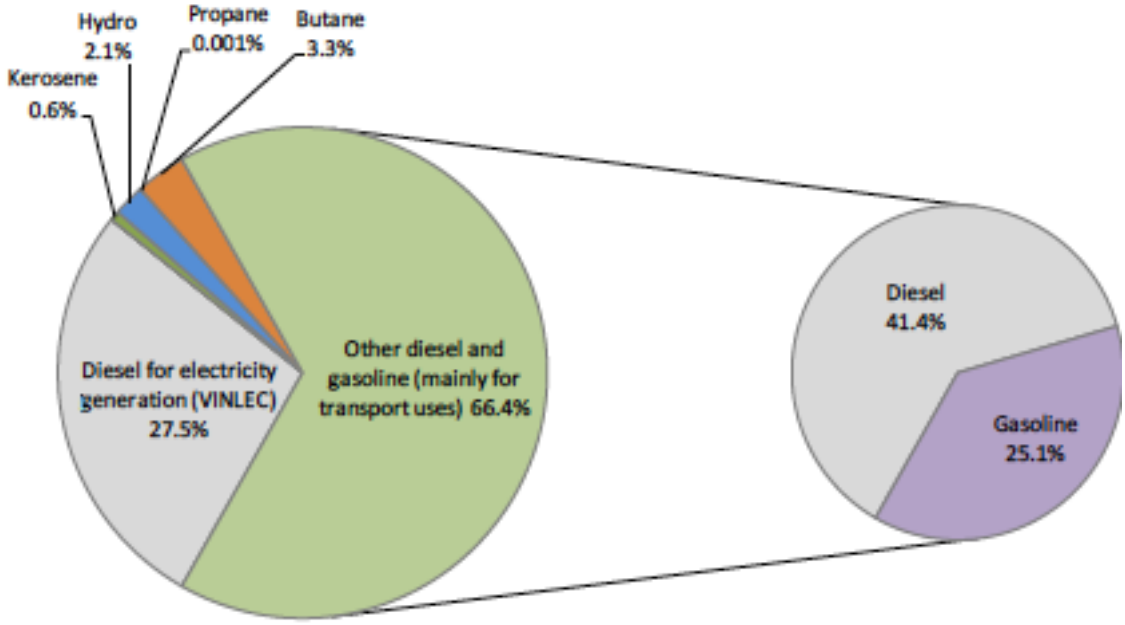


Figure 4.2.3: Energy consumption by energy source, percentages 2008

(Source: St. Vincent and the Grenadines 2010)

Most of the electricity produced is used in the residential and commercial sectors, including the Government (Figure 4.2.4), though no detailed information on end users (sub-sectors) is available.

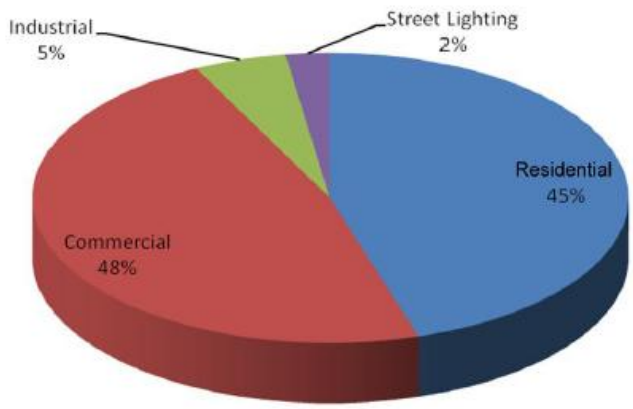


Figure 4.2.4: Electricity consumption by sector, 2008

(Source: St. Vincent and the Grenadines, 2010)

Finally, Figure 4.2.5 shows trends in energy use in the period 2002 - 2008, indicating that energy consumption increased from 64,840 TOE in 2002 to about 91,000 TOE in 2008, i.e. representing a growth of more than 40% in just six years (St. Vincent and the Grenadines, 2010).

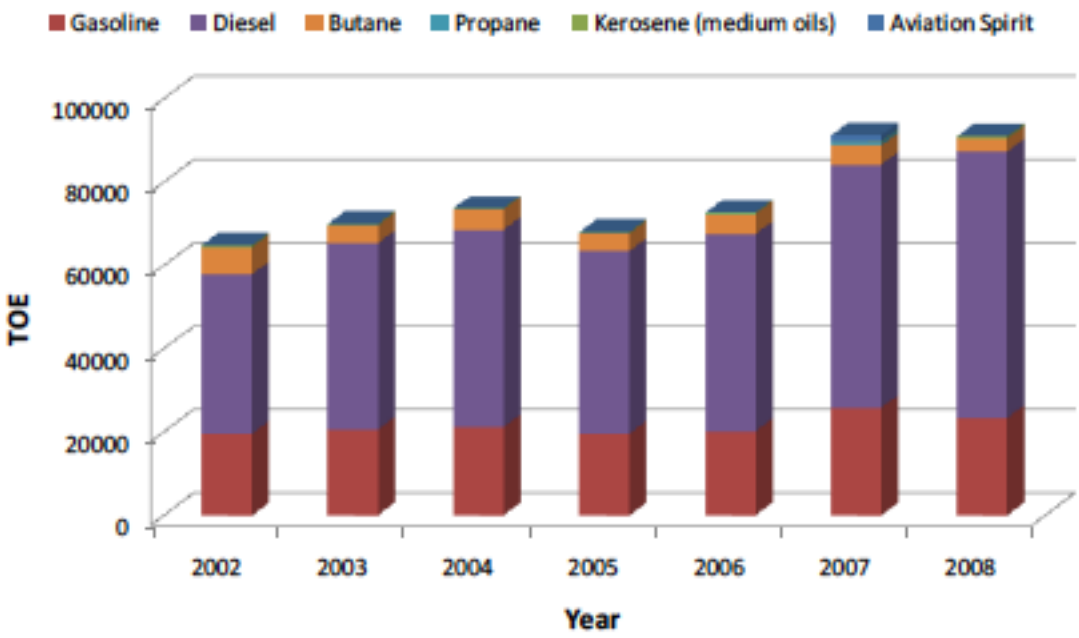


Figure 4.2.5: Growth trends in energy consumption, 2002 - 2008

(Source: St. Vincent and the Grenadines, 2010)

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 4.2.2).

Table 4.2.2: Assessment of CO_2 emissions from tourism in St. Vincent and the Grenadines, 2007

Tourism sub-sector	Energy use	Emissions	%	Assumptions
Aviation[1)]	9,677 t fuel	30,482 t CO_2	34	Bottom-up analysis
Road transport[2)]	314t fuel	1,003 t CO_2	1	Including tourists, not day visitors
Cruise ships[3)]	7,890 t fuel	25,259 t CO_2	28	Bunkers for cruise ships
Accommodation[4)]	19.4GWh	19,420 t CO_2	22	Based on energy statistics from Barbados
Activities[5)]	-	2,037 t CO_2	2	Global average
Sub-total		78,201 t CO_2	87	
Indirect energy use (factor 1.15)		11,730 t CO_2	15	To account for life-cycle emissions
Total		89,931 t CO_2	100	

1) Aviation fuels: there were 75,446 tourist arrivals in 2009 (CTO, n.d.), with major markets including the USA (26%) Caribbean (26%), UK (18%), Trinidad & Tobago (10%), Canada (9%) and Other Europe 8% (CTO, n.d.). Consequently, aviation would have consumed (bunker fuel approach, i.e. only including fuels for travelling from St. Vincent and the Grenadines to country of origin): USA(20,159 tourists x 3,349pkm (New York) x 0.120 kg CO_2 = 8,102t CO_2), Caribbean (19,489 tourists x 500pkm x 0.120 kg CO_2 = 1,169 t CO_2), UK (13,347 tourists x 6,919pkm(London) x 0.120 kg CO_2 = 11,082 t CO_2), Trinidad & Tobago (7,346 x 300 pkm x 0.120 kg CO_2 = 264 t CO_2), Canada (6,820 tourists x 3,862pkm (Toronto) x 0.120 kg CO_2 = 3,160 t CO_2), Other Europe countries (5,750 tourists x 7,513pkm(Frankfurt) x 0.120 kg CO_2 = 5,184 t CO_2), plus Rest of the World (3%; 2,535 tourists x 5,000pkm x 0.120 kg CO_2 = 1,521 t CO_2), i.e. totaling 30,482t CO_2.
2) Road Transport: 75,446 international tourist arrivals in 2009, with each tourist travelling an assumed 100 pkm 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 13.3 kg CO_2 (corresponding to about 4 l of diesel) per tourist, totalling 1,003 t CO_2, or about 314 t of fuel. Cruise tourists and their potential travel on the island are not included.
3) There were 149,464 cruise passengers in 2009 (CTO, n.d.; note that there were also 40,859 yacht passengers, which are not considered in the following calculations). At the standard per day value (global average) of 169 kg CO_2 per passenger (Eijgelaar *et al*., 2010), the 149,464 cruise passengers would have caused emissions of 25,259 t CO_2, or about 7,890 t fuel.
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 St. Vincent and the Grenadines. At an assumed average length of stay of 11.7 nights in 2009 (no data on average length of stay available), the 75,446 guests would have stayed 882,718 nights, with a corresponding energy use of 19.4GWh. Electricity production is assumed to be less efficient and a value of 1 kg CO_2 per kWh is assumed here, resulting in emissions of 19,420 t CO_2.
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 75,446 tourists would thus have caused emissions from activities corresponding to 2,037t 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: CTO, n.d.; DEFRA, 2010; UNWTO-UNEP-WMO, 2008; UNWTO, 2010)

Table 4.2.2 shows the distribution of energy use by tourism sub-sectors. Note that this estimate is based on data with considerable uncertainties. Results indicate that emissions from tourism accounted for 89,931t CO_2 in 2009 (excluding flights to St. Vincent and the Grenadines). These figures reflect the energy intensity of the tourism system, i.e. even if a considerable share of these emissions do occur outside the jurisdiction of SVG, these emissions are "needed" to maintain the tourism system of the islands. Compared to national emissions of greenhouse gases in the order of 110,421 t CO_2 in 1997 (UNFCCC, 2000), i.e. the latest year for which an emissions inventory was found, tourism would have caused the equivalent of about 81% of national emissions. There is considerable uncertainty regarding this estimate, however, as it is unknown what the country's current emissions actually are and they are likely to be considerably higher based on the increased electricity consumption shown in Figure 4.2.5.

Reducing energy use and emissions

In order to reduce energy consumption and emissions in SVG, the Government has provided a list of guiding principles in its National Energy Policy (St. Vincent and Grenadines, 2009). Though none of these is specific to tourism, several are still of relevance to the sector:

- Guarantee a clean, reliable and affordable energy supply to customers;
- Strengthen the national economy by reducing the dependence on import of fossil fuels;
- Stabilise and possibly reduce the energy consumption per capita in the medium and long term;
- Reduce the dependence on import of energy through continued and expanded exploitation of indigenous resources and improvement of energy efficiency and/or conservation of energy use;
- Liberalise the energy market by encouraging and accommodating private sector participation in energy development and energy services, thereby enhancing competitiveness and engendering lower prices;
- Take advantage of renewable, local energy resources, wherever this is possible from the aspects of availability (potential), energy demand, technical and social implications, economic feasibility, ecological harmony and sustainability;
- To always encourage and stimulate the efficient use of all energy resources, keeping in mind that all types of energy are either scarce or need significant amounts of capital to be tapped or transposed into applicable forms of energy use;
- In all its decision making with respect to energy services development, the Government will strongly promote the active participation of the energy sector, the general public, NGOs, etc.
- In delivering energy services, Government will minimise subsidies to consumers and set prices and tariffs in such in way that they timely reflect full cost but taking into account ways to relieve the price burden on the lowest income households;
- Take advantage of national expertise and know-how as far as possible for the development and delivery of energy services. Where importation of resources is required, provide incentives for the use of the most available technology;
- Ensure that the measures taken in pursuing this energy policy is in line with the requirements and legal implications of the Caribbean Single Market Economy.

More specifically, strategies and policies to reduce energy use and emissions are outlined in the Government's Energy Action Plan (St. Vincent and the Grenadines, 2010), which should be consulted for details – the following sections list only the main policy goals:

Planning and Management **-** Consolidate well-coordinated planning and management programmes to achieve sustainable supply and use of energy by 2015.

Power Sector **-** Reduce projected increase in peak demand by 5% by 2015 and 10% by 2020 and strive to reduce power losses down to a total of 7% by 2015 and 5% by 2020.

Renewable Energy - Deliver 30% of projected total electricity output from renewable energy sources by 2015 and 60% by 2020.

Petroleum Sector - Increase energy security and diversify the energy portfolio.

Transport Sector - Reduce projected consumption of fossil fuels in the transport sector by 10% by 2015 and 15% by 2020.

Energy Efficiency- Reduce projected electricity generation by 5% by 2015 and 15% by 2020.

Specific reference is made to the value of tourism in some of the smaller islands and therefore the need to investigate clean, competitively priced energy alternatives. These islands have an excellent potential for wind and solar resources (St. Vincent and the Grenadines, 2010).

4.2.3. 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 of all, energy prices have fluctuated in the past and there is evidence that the cost of oil on world markets will continue to increase. Secondly, 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 greenhouse gases. 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 SVG' tourism sector and the vulnerabilities of the energy infrastructure.

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 4.2.6) – 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 International Energy Agency (IEA) (IEA, 2010) projects for instance, that oil prices will almost double between 2009 - 2035 (in 2009 prices). Notably, Figure 4.2.6 shows the decline in oil prices in 2009; in March 2011, Bloomberg reported Brent spot prices exceeding US $120/barrel.

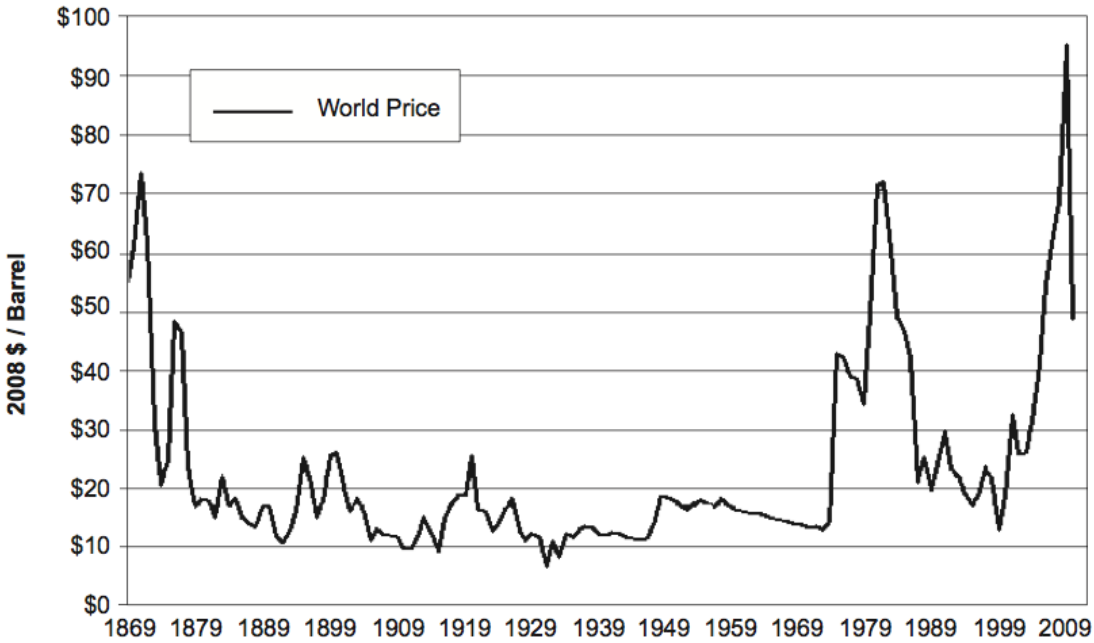


Figure 4.2.6: Crude oil prices 1869 - 2009

(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). In SVG, the Government regulated prices for one year (January 2005-January 2006) resulting in subsidies of EC $6 million and in 2008, almost 17% of the country's GDP was spent on fossil fuel imports. A fuel surcharge is applied to electricity consumption per kWh, which varies monthly depending on fuel costs (St. Vincent and the Grenadines, 2010). 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 pre-condition 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, involving 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 severe impact particularly on aviation. As late as December 2007, IATA projected the average 2008 price of a barrel of oil at US $87, up 6 per cent 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 4.2.7), 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, 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.

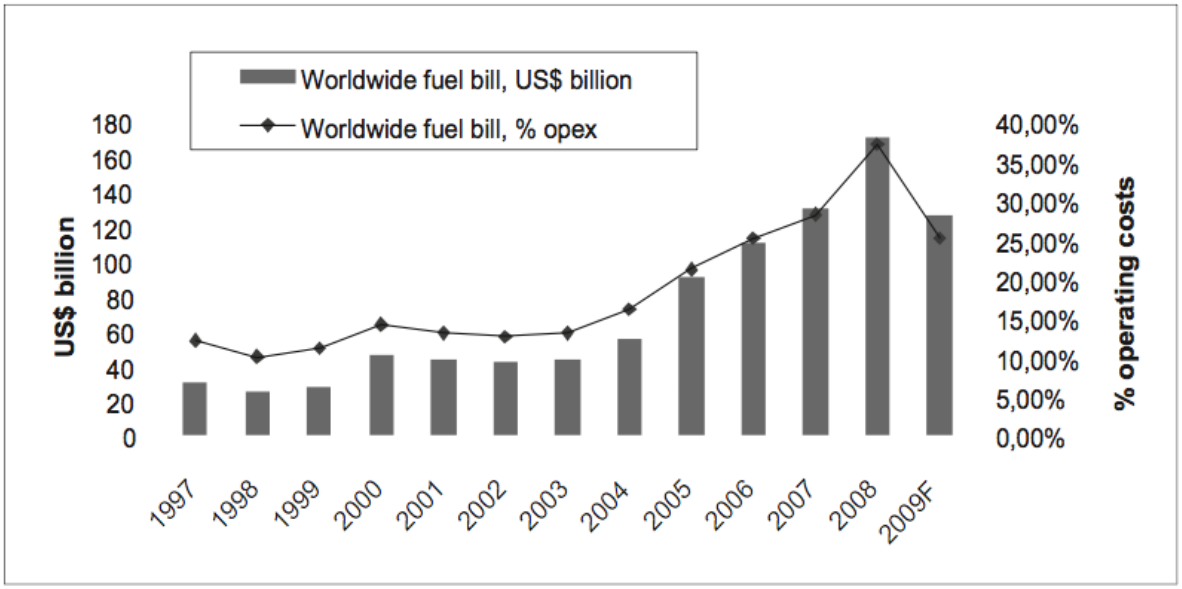


Figure 4.2.7: Fuel costs as part of a worldwide operating cost

(Source: IATA, 2009)

Climate policy

As described in the introduction climate change is high on the global political agenda but so far the European Union 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 ongoing 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; this tax will be abandoned in 2012, however, when the EU-ETS will include aviation).

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 4.2.3).

Table 4.2.3: 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 & 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 principally embraced by business organisations. 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 & Young, 2010; PricewaterhouseCoopers, 2010).

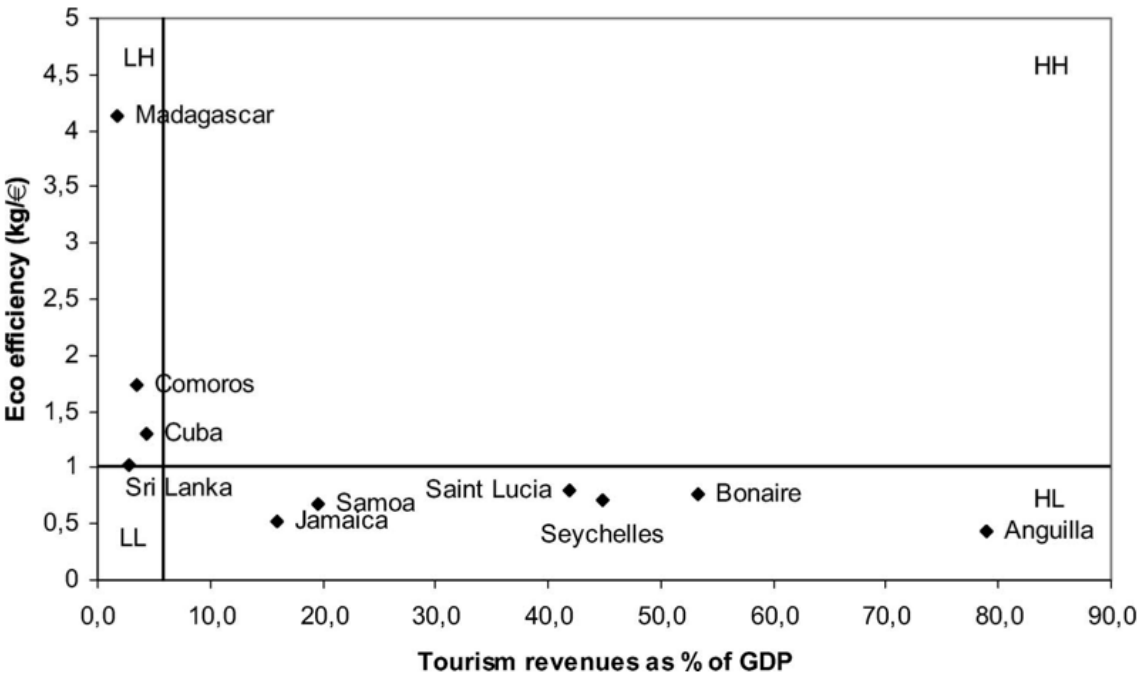
There is consequently growing consensus among business leaders and policy makers that emissions of greenhouse gases represent a market failure. The absence of a price on pollution encourages pollution, prevents innovation and creates a market situation where there is little incentive to innovate (OECD, 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. One of the guiding principles in the National Energy Plan (St. Vincent and Grenadines, 2009) is to "minimise subsidies to consumers and set prices and tariffs in such in way that they timely reflect full cost but taking into account ways to relieve the price burden on the lowest income households". Compact fluorescent lamps already benefit from tax exemption including VAT and Action 9 of the Energy Action Plan calls for the Ministry of Finance and Economic Planning to create a list of items (for energy efficiency or use of renewable energy) that will be completely or partially exempted from import or consumption taxes, while higher taxes may be imposed on energy inefficient devices. The Ministry is to also investigate establishing a tax credit scheme for investments in energy efficiency or renewable energy sources and reconsider the current exemption of electricity, gasoline, kerosene, diesel and LPG from VAT (St. Vincent and Grenadines, 2010).

Vulnerabilities

Generally, a destination could 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 4.2.8 shows this for various islands, expressed as a climate policy risk assessment.



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 4.2.8: 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 bi-lateral 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 & 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 <2000km, 2000-4000km and >4,000 km as of 1 January 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, i.e. causing 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 but omitted 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 elasticities 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 (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 elasticities). 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 in particular SIDS. 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 impacts: which affect energy resource availability, fuel and power production, transmission and distribution processes; and indirect impacts which 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.

SVG's electricity production is almost entirely based on diesel driven plants with a small contribution from hydro-electric facilities and the use of solar water heaters, primarily at the domestic level. Additional potential exists for expansion of the hydro-power sector as well as investing in wind, solar, geothermal and biomass energy (St. Vincent and the Grenadines, 2010). Potential physical climate change impacts specific to traditional energy production systems as well as the identified renewable technologies being considered are outlined below. Special consideration should be given to the physical impacts of climate change 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. The energy based infrastructure in SVG 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. Hurricane Tomas in 2010 brought an island wide power outage due to broken lines, fallen trees and damaged poles (IFRC, 2011b) (see Section 4.7: Comprehensive Natural Disaster Management).

Modern wind turbines stop rotating when wind speed exceeds approximately 55 mph to protect the equipment and the structures are typically designed to withstand winds in excess of 150 mph. Other installations are designed to be winched down in the event of an approaching hurricane. These types of problems should be carefully considered during the planning of any wind farm developments. 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. The vulnerability of the 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 & de Cuba, 2008).

Model projections for SVG 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 a possible disappearance of 'cold' nights (see Section 3: CLIMATE MODELLING). National energy demand and consumption for 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 those in SVG. The climate modelling projections also indicate a decrease in mean annual rainfall, (although these predictions are more uncertain than temperature changes) which may affect water availability for non-contact cooling of power generators (Contreras-Lisperguer & de Cuba, 2008), Section 4.1: Water Quality and Availability. Similar impacts are likely to apply to biomass systems.

SVG already has some hydropower capacity and is investigating renewable energy projects utilising, geothermal, wind and solar power. Alternative energy sources, while they are environmentally more sustainable, also face challenges from climate variability. 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, water availability and flow quality for hydro power generation (Contreras-Lisperguer & 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. 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& de Cuba, 2008).

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. Climate models project seasonal increases in wind speed for SVG (Section 3: CLIMATE MODELLING). 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 SVG 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 & de Cuba, 2008).

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 SVG, considering their geophysical nature; include erosion and flooding caused by storms and SLR, salt water intrusion, localised landslides and coral bleaching. Power generating stations and other major infrastructure located on the coastline are therefore highly vulnerable to impacts resulting from SLR and storm induced surges.

The likelihood of climate change impacting on energy systems will vary. However, an assessment of the vulnerability of SVG's systems should be prioritised, especially in the case of renewable energy sources that are being planned and which depend on specific climate parameters and priority coastal infrastructure such as power plants.

4.3. *Agriculture and Food Security*

4.3.1. 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 IAASTD Global Report (International Assessment of Agricultural Knowledge, Science and Technology for Development, 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 adaptations options to support national food security based on experience and knowledge gained 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.

4.3.2. The Importance of Agriculture to National Development

Prime Minister of St. Vincent and the Grenadines, Dr. Ralph Gonsalves (2011), confirms that the Government accords high priority to agriculture. It is the economic mainstay and it contributes significantly to economic and social development, particularly as it relates to the livelihoods of rural peoples. In 2009, its share of GDP increased slightly to 9.6% compared with 9.0% in 2008.

Recognizing the importance of agriculture to the economy the administration in SVG has made several interventions to enhance agriculture's competitiveness and productivity. Among these strategies is support for small scale farmers in production technologies, agri-business management, good agricultural practices and pest and disease control; policy initiatives to address climate change issues, environmental protection, risk mitigation and fisheries development; and a national plan for dealing with food security.

To this end, the Government of SVG has allocated in the 2011 budget estimates the sum of EC $31.6 million to agriculture, of which $12.7 million will be expended on capital investment and $18.9 million on recurrent expenditure, with a commitment to steer national agricultural outputs upward.

4.3.3. An Analysis of the Agricultural Sector in St. Vincent & the Grenadines

Banana dominates the agricultural economy in St. Vincent and the Grenadine; the performance of the agricultural sector is directly linked to the economic fortunes of the banana industry. With the erosion of preferences and increased competition in the EU banana market, Windward Island producers have in recent years witnessed declining exports and income. As a consequence, banana production is being abandoned with many producers exiting the industry. With respect to other industries, arrowroot, root crops, small ruminant and marine fishery all make significant contributions to economy, food security and employment. Root crop production includes sweet potatoes, yams, eddoes and dasheen. Other crops include plantain, vegetables and fruits (Singh *et al*., 2005).

The gap between agricultural exports and imports has been widening making SVG vulnerable as a net food importing country. In 2007, the value of agricultural exports was EC $46.9 million compared to an

estimated import bill of EC $157.5 million. In 2008, exports declined to EC $35.8 million while the food import bill increased to EC $198.5 million.

According to Gonsalves (2011), the agriculture sector is faced with numerous challenges. Moko, Leaf spot and Black Sigatoka diseases persistently affect production. In addition, farmers have had to contend with the requirements of Global GAP and Fairtrade certification standards. Also, there is the perennial problem of praedial larceny and stray dogs which continue to plague the agricultural sector.

In response to some of these challenges, the Ministry of Agriculture has intensified its programme of treatment of bananas, plantains and other affected crops. The industry has demonstrated resilience and there has been some stability. For example, during 2009, over 120,000 banana plantlets were produced and hardened at the Orange Hill Tissue Culture Laboratory and the Rivulet and Wallilabou Agricultural Stations. Consequently, an estimated 384 acres were replanted, with 198 acres using tissue cultured bananas. Also, an estimated 543 acres of bananas were rehabilitated.

The performance of the root crop sub-sector in 2009 was much improved compared with 2008. The export value of dasheen increased from EC $4.4 million in 2008 to $5.4 million in 2009. Eddoes increased from EC $2.8 million to $4.7 million, sweet potatoes from EC $1.9 million to $2.6 million. Yams and tannias though smaller in volume and value also showed steady increases.

This improved performance of the root crops sub-sector can be attributed to a shift of over 500 farmers from banana production and significant improvement in the marketing and purchasing arrangements of fruit crops led by Vincy Fresh and Eastern Caribbean Trading Co. Ltd (ECTAD).

4.3.4. Women and Youth in Vincentian Agriculture

Kairi (2008) reports that may women in SVG work in the informal agriculture sector clearing the undergrowth around marijuana plantations, earning more than a regular day's pay if they were to work in the formal agri-sector. With the dearth of institutional structures needed to manage the shift from bananas to alternative crops, some female agricultural workers have resorted to the informal sector.

In the case of artisanal fisheries, females partner with males and mostly do the selling of catch and deal with the finances. Research by Grossman (2000) shows that in the traditional banana economy in St. Vincent & the Grenadines, women are primarily concerned with production and sale of local food crops while the men own prime lands for banana cultivation. The women who work on banana plantations engage in much of the labour such as planting, weeding and harvesting.

Conway and Glesne (2008) observe that agricultural labour is increasingly shunned by young Vincentians unless there have no other options to acquire money. Nevertheless, there is evidence that some young people are embracing agriculture as a means for earning sustainable incomes. Hand2Earth (2011) launched an innovative project to turn abandoned land into a model for sustainable living and farming systems in St Vincent. The aim of the project, which has links to local primary and secondary schools, is to teach young people about organic agriculture, environmental art and creative land use. The project on almost 1 ha of land in the fertile Vermont Valley and young people have been planting banana, plantain, papaya, pineapple, avocado and other fruit trees, digging ponds for fish farming and building bamboo and earth structures for workshops.

4.3.5. Climate Change Related Issues and Agricultural Vulnerability in St. Vincent & the Grenadines

St. Vincent'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. During the second week of April 2011 heavy rainfall caused landslides and rivers to overflow in the north eastern section of Saint Vincent. The majority of damage was in the Georgetown area where landslides washed fallen trees from the mountains, blocking rivers and causing flooding in nearby areas. The affected geographical area is one of the main agricultural zones of the island and overflowing rivers caused crop damage and loss of livestock (IFRC, 2011).

Similarly, in 2010 hurricane Tomas, the nineteenth named storm and the twelfth hurricane of the Atlantic hurricane season wreaked havoc on the agriculture sector with estimated damages totalling EC $35 million. The major losses were recorded in banana and plantain production.

Most of the farmers in Saint Vincent and the Grenadines 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 Vincentian 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.

4.3.6. Vulnerability Enhancing Factors: Agriculture, Land Use and Soil Degradation in St. Vincent and the Grenadines

FAO (2008) reveals that the bulk of agricultural activities in SVG are carried out on small farmer holdings. The 2000 population estimate revealed that just over 27% of the total number of farms were under 0.2 ha, 23% between 0.4 and 1.0 ha, 14.9 percent between 1 and 2 ha while only 0.25% and 0.12% were between 20.2 to 40.5 ha and over 40.5 ha, respectively. A proportion of 73% of farm area was privately owned, while about 22% was rented and a small percentage came under other agreements.

The abandonment of banana plots over the last decade has contributed to the decrease in land used 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.

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 SVG therefore 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.

4.3.7. Social Vulnerability of Agricultural Communities in St. Vincent & the Grenadines

The social vulnerability of agricultural communities in SVG is typified by the major generation gap between the older farmers and the young generation who have tendencies to migrate out of the rural areas. The result is shrinking rural communities consisting of mostly older folks and a dearth of labour to support agricultural development. The reason for this is that agriculture in the country is still mostly centred on bananas (Kairi, 2008). Culzac-Wilson argues that the impact of the banana fall out has had a great effect on rural communities, leading to loss of employment. Rural communities have deteriorated drastically over the past few years as a result of this fallout and thus the incidence of poverty has increased significantly.

4.3.8. Economic Vulnerability: Climate Change & Agricultural Outputs in St. Vincent & the Grenadines

A primary economic vulnerability factor for the agriculture sector in SVG is the over-reliance 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 (Kairi, 2008). The consequence of these challenges is decreased purchasing power for agricultural workers and a heightened threat of food insecurity.

A secondary vulnerability feature is the prevalence of small-scale agriculture in SVG which is characterised by many individualised production units with two or less acres of land. 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 SVG 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.

The following figure shows the most important crops for food security SVG based on data acquired from FAO (2008).

Figure 4.3.1 List of major crops for food security in St. Vincent & the Grenadines

Fruits	Vegetables	Legumes
•Banana	•Dasheen	•String bean
•Plantain	•Sweet Potato	•Peanut
•Watermelon	•Cauliflower	•Pigeon pea
•Soursop	•Brocolli	•Black eye pea
•Papaya	•Tannia	
•Mango	•Cassava	
•Citrus	•Eddo	
•Coconut	•Raddish	
•Passion fruit	•Pakchoi	
•Pineapple	•Maize	
•Advocado	•Tomato	
•Guava	•Lettuce	
•Wax apple	•Cabbage	
•Plum rose	•Breadfruit	
•Sugar apple	•Pumpkin	
•Golden apple	•Carrot	
	•Eggplant	
	•Ochra	
	•Cucumber	

4.4. *Human Health*

4.4.1. Background

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) defines health as "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 eco-systems thereby increasing the disease incidence of the area.

Health is an important issue for the tourism industry because tourists are at risk of contracting infectious diseases transmitted by insect vectors. 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, the agriculture sector and increase the susceptibility of populations to respiratory diseases and food- and water-borne diseases (Confalonieri, *et al*., 2007; Ebi, Lewis, & Corvalan, 2006; Patz *et al*., 2000).

The health sector was not specifically mentioned in the Initial National Communication to the UNFCCC. However, health was among the adaptation measures in the communication; and the need was recognised for "An expansion of the country's environmental education programme that speaks to climate change, vulnerability, sustainability, human health and safety" and "The strengthening and equipping of the local vector-control unit to respond to expanding insect populations and the emergence or re-emergence of vector-borne diseases"(NEAB, 2000). In 2009, there were 75,446 tourist arrivals by air and 149,464 cruise ship passenger arrivals to SVG. The average length of stay per visitor was 11.7 days (CTO, 2010). This high number of persons to the country constitutes a susceptible population to communicable diseases, the most prevalent of which are highlighted in the following subsection.

Table 4.4.1: Selected statistics relevant to the Health Sector of St. Vincent and the Grenadines

Population	109,000 (2009)[1]
Unemployment rate	18.8%(2008)[2]
Poverty rate (poverty headcount index)	30.2%(2008)[2]
Expenditure on Public Health	5.6% (2009)[3]
Life Expectancy at Birth (yrs)	71.8 (2009)[1]
Crude birth rate (per 1,000)	17.4 (2009)[1]
Crude death rate (per 1,000)	6.1(2001)[4]

(Source: (PAHO, 2009)1,(Government of St. Vincent and the Limited, 2008a)2,(WHO, 2011)3,(PAHO, 2007)4)

4.4.2. Direct Impacts

Weather Related Mortality and Morbidity

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes and tropical storms can affect the vulnerability of SVG to climate change. There were five fatalities as a result of 9 natural disasters between 1970 and 1999; however in 2004 alone, there were 15 deaths (Kairi Consultants Limited, 2008b). Landslides are the most common natural disaster and floods occur frequently (Kairi Consultants Limited, 2008b). Hurricane Ivan in 2004 also devastated the island (Kairi Consultants Limited, 2008b). Weather systems can also affect health infrastructure and SVG is also prone to the displacement of persons and loss of shelter. For example, the National Emergency Management Office (NEMO) estimates that as much as 40% of the country live in houses that are not of an adequate standard to withstand natural disasters (Kairi Consultants Limited, 2008b). If hurricanes become more intense, but not accompanied by suitable mitigation and adaptation measures in SVG, this could further impact the health sector of the country (CIF, 2010).

4.4.3. Indirect Impacts

Increase in Vector Borne Diseases

Vector borne diseases may increase due to increased precipitation and temperatures in SVG (CIF, 2010). In the SVG Strategic Plan For Health 2007 – 2012 it was stated that "National household and Breteaux indices continue to be above and beyond internationally accepted levels" (Government of St. Vincent and the Grenadines, 2007). Dengue is specifically mentioned (Government of St. Vincent and the Grenadines, 2007) but malaria cases have also been reported. Data obtained from the Ministry of Health reported 1 imported case of malaria in 2008 and another in 2010. CEHI (2007) has also stated that "There are serious issues related to availability of water, health and sanitation in the context of vector control". Poor environmental

conditions also contribute to the breeding of rats, the vector for leptospirosis which will be discussed briefly below.

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 *Aedesaegypti*. 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 rainfall (Hales *et al*., 1996) and research on the association between these two factors and dengue transmission has been studied in the neighbouring island of 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, Wet, Maindonald, & Woodward, 2002; Hsieh and Chen, 2009; Martens, Jetten, & Focks, 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) and is relevant to SVG as well (CEHI, 2007).

Dengue fever is endemic to the Caribbean region and is thus a major public health problem which can affect both locals and tourists (Castle *et al*., 1999; Pinheiro and Corber, 1997; Wichmann, Mühlberger, & Jelinek, 2003). Allwinn *et al*., (2008) 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).

While the St. Vincent and the Grenadines Initial National Communication does not specifically mention dengue, it identifies the need for further vector control. Table 4.4.2 below shows the number of dengue cases reported to the Ministry of Health between 2001 and 2010. There have been 374 cases in the last ten years or 37 cases per year. The year 2010 had the most cases, or 58% of cases for the decade. The country was particularly affected by droughts that spanned October 2009 to January 2010 (IFRC, 2010). This encouraged greater water storage during and after this period, which in turn may have provided suitable habitats for mosquitoes to breed. For instance, in Jamaica, Chadee *et al*., (2009) found that large storage drums used during dry spells and drought conditions were the main breeding sites of the vector, *Aedesaegypti*, 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. Similar occurrences could contribute to dengue fever transmission in SVG.

Conversely, the country experienced severe floods in April of 2010 (IFRC, 2011) and Hurricane Tomas in October which also brought heavy rains to the islands. These events may have also provided suitable habitats for mosquitoes to breed particularly because many areas of SVG have poor drainage (Kairi Consultants Limited, 2008b). However, definitive statements can only be made with monthly data. Nonetheless, it should be noted that Chen *et al.*, (2006) have demonstrated seasonal incidence of dengue in the Caribbean region.

Table 4.4.2: Dengue Fever Cases in St. Vincent and the Grenadines between 2001 and 2010

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Female	1	N/A	N/A	2	0	1	11	2	4	129
Male	2	N/A	N/A	2	3	1	9	8	6	89
Total	3	100	4	4	3	2	20	10	10	218

(Source: Ministry of Health, 2011)

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). Further, as stated in the IPPC Fourth Assessment report '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) and the seasonal aspect of leptospirosis has recently been demonstrated in Trinidad by Mohan *et al*., (2009). Leptospirosis has also been found to be one of the diseases of importance contracted by travellers (Jansen *et al.*, 2005) and could therefore have implications for tourists.

In SVG leptospirosis is endemic and cases continue to be reported (Government of St. Vincent and the Grenadines, 2007). Poor disposal habits as well as improper disposal infrastructure contribute to conditions which encourage the proliferation of rats in the country (Kairi Consultants Limited, 2008a). Table 4.4.3 shows the number of cases of leptospirosis between 2001 and 2010. There were 130 cases during the period, or 13 cases per year. The number of cases has shown an increasing trend, with 2010 having the highest incidence of the disease in the last decade. The flooding in April or Hurricane Tomas or both may have contributed to the rise in cases.

Table 4.4.3: Leptospirosis Cases in St. Vincent and the Grenadines between 2001 and 2010

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Female	N/A	2	N/A	0	0	N/A	2	2	2	5	13
Male	N/A	13	N/A	07	07	N/A	13	13	13	21	117
Total	**10**	**15**	**10**	**07**	**07**	**19**	**15**	**15**	**15**	**26**	**130**

(Source: Ministry of Health, 2011)

In the past, SVG' rat infestation problems were so severe that they resulted in the development and implementation of a Rodent Control Programme (Culzac-Wilson, 2003). Some issues that have encouraged rodent populations include release of waste into drains, financial constraints, improper practices by farmers such as leaving excess crops to rot in the field, squatting settlement and disregard for rules established by the Public Health Department (Government of St. Vincent and the Grenadines, 2007; Culzac-Wilson, 2003). Farmers have been identified as the biggest contributors to rodent infestation in SVG (Culzac-Wilson, 2003). This perhaps explains why there were 9 times more cases reported by men than by

women. If precipitation events continue to increase, encouraging flooding episodes, leptospirosis cases may further rise.

Drought, air quality and respiratory illnesses

The quality of the air may also be affected by expected drier spells due to climate change (Confalonieri *et al*., 2007). Diseases of importance include acute respiratory infections, influenza like illnesses and asthma. Many clinical visits were due to asthma between 2001 and 2005 (PAHO, 2007).

Figure 4.4.1 and Table 4.4.4 show the number of reported cases of acute respiratory infection between 2001 and 2010. Cases have shown an overall decline in the last ten years. Cases have also been low despite severe drought conditions in 2010. Further research is needed to determine the relationship between weather conditions and cases of acute respiratory infections in the country.

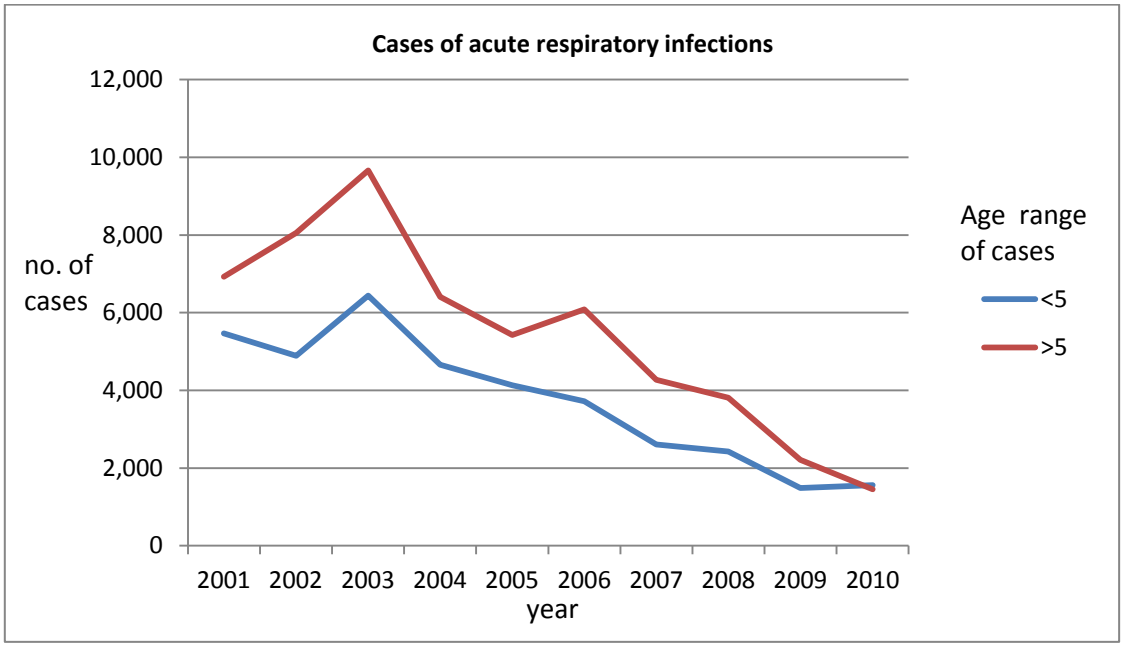


Figure 4.4.1: Cases of acute respiratory infections in St. Vincent and the Grenadines between 2001 and 2010

Table 4.4.4: Acute Respiratory Infections cases in St. Vincent and the Grenadines between 2001 and 2010

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Female <5	2,477	2,297	2,959	2,163	1,832	1,626	1,222	1,190	683	722
Male <5	2,992	2,588	3,478	2,499	2,299	2,095	1,388	1,238	798	839
Total <5	**5,469**	**4,885**	**6,437**	**4,662**	**4,131**	**3,721**	**2,610**	**2,428**	**1,481**	**1,561**
Female >5	4,075	4,649	5,572	3,918	3,274	3,557	2,550	2,400	1,385	675
Male >5	2,852	3,408	4,091	2,488	2,152	2,523	1,723	1,407	829	781
Total >5	**6,927**	**8,057**	**9,663**	**6,406**	**5,426**	**6,080**	**4,273**	**3,807**	**2,214**	**1,456**

(Source: Ministry of Health, 2011)

Influenza cases have also been reported in the last decade. As Table 4.4.5 shows the number of cases has declined over this time period.

Table 4.4.5: Influenza cases in St. Vincent and the Grenadines between 2001 and 2010

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Female	1, 669	3, 242	2, 117	1, 218	1, 019	440	615	858	842	500
Male	1, 368	2, 940	1, 962	1, 009	762	401	536	651	691	460
Total	**3, 037**	**6, 182**	**4, 079**	**2, 227**	**1, 781**	**841**	**1, 151**	**1, 409**	**1, 533**	**960**

(Source: Ministry of Health, 2011)

If air quality can have a significant impact on the health of the local population then, it is reasonable to expect similar effects on vulnerable travellers (Sanford, 2004) particularly those with respiratory diseases and those with pulmonary and cardiac diseases.

Water Supply, sanitation and associated diseases

Emphases on water quantity and quality, proper water treatment and sanitation are critical to public health in a country. This is of relevance to St. Vincent and the Grenadines where only 57.4% of the population have public water piped into their homes and 14.7% have piped public water piped into their yard. Another 4.3% depend on standpipes, 10.1% source water from private sources and 7.8% from private catchments either piped or not piped (Kairi Consutlants Limited, 2008a). However, adequate sanitation may be more of a concern in the Grenadine Islands. This is because while 69% of households in St. Vincent have access to public water seven days a week, in the Grenadines, this figure drops to 36% of the population. Aside from access to safe drinking water, sanitation facilities present other threats to health because as much as 30% of the population still utilize pit latrines, ventilated pit latrines or none (Kairi Consultants Limited, 2008a).

A lack of potable water supply can result in the spread of a number of diseases. In SVG these include dengue, malaria, cholera and leptospirosis (CIF, 2010). Diarrheal diseases (e.g. salmonellosis, shigellosis and campylobacterosis (CAREC, 2010; PAHO, 2007)) and gastroenteritis are also diseases of importance due to the high number of cases and the economic and social burden they place on the country. Diarrheal diseases exist in part due to under-developed water infrastructure and poor management. Water supply to some communities is often inconsistent; invariably poor persons are most affected (CEHI, 2007; Kairi Consultants Limited, 2008b). Where water infrastructure is lacking, sanitation infrastructure is also a problem (Kairi Consutlants Limited, 2008b). In Union Island, water scarcity presents challenges for health and sanitation, for increases in water demand further create stresses on water supplies during drought conditions (CEHI, 2007). In areas where squatting communities exist, potable water and proper sanitary facilities are often absent. Overcrowding also facilitates the spread of communicable diseases (Government of St. Vincent and the Grenadines, 2007; PAHO, 2007).

With respect to gastroenteritis in the 2007 CAREC Annual Report, it was stated that "Acute gastroenteritis in children under 5 years of age represented 13% of all outpatient visits and 17% of all hospital admissions in St Vincent and the Grenadines" (CAREC, 2008). In addition, in the past acute diseases such as gastroenteritis resulted in a high incidence of infant deaths (Culzac-Wilson, 2003). Figure 4.4.2 and Table 4.4.6 show gastroenteritis cases have decreased in recent years. Gastroenteritis as well as other gastrointestinal diseases are important diseases which can negatively impact the tourism industry as outbreaks are often associated with environments with tourism in the region, such as hotels, restaurants, cruise ships and mass gatherings (CAREC, 2008).

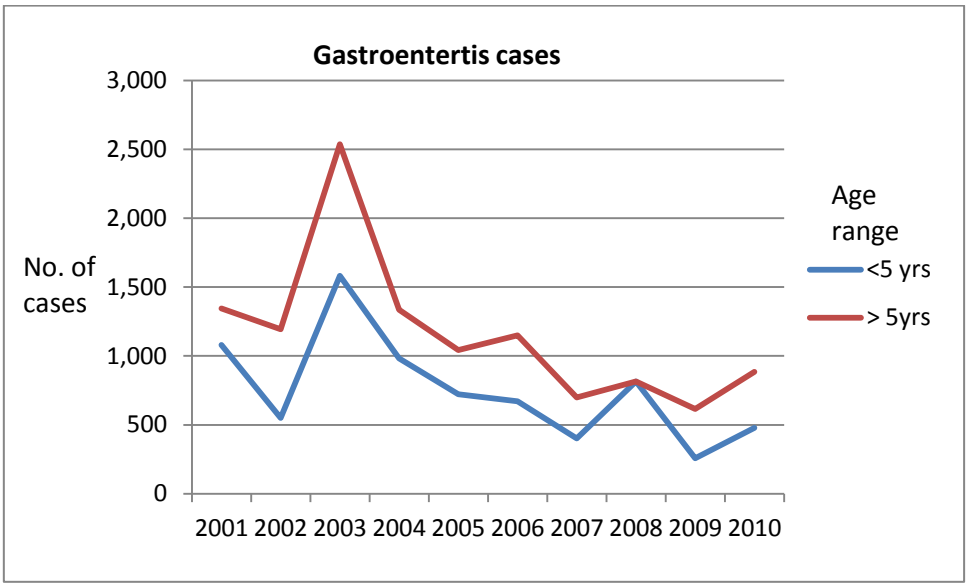


Figure 4.4.2: Gastroenteritis cases in St. Vincent and the Grenadines between 2001 and 2010

Table 4.4.6: Gastroenteritis cases in St. Vincent and the Grenadines between 2001 and 2010

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Female<5	525	266	706	457	311	310	205	529	126	227
Male<5	554	284	877	526	411	362	197	287	131	251
Total<5	**1,079**	**550**	**1,583**	**983**	**722**	**672**	**402**	**816**	**257**	**478**
Female >5	769	678	1,407	727	564	634	356	529	351	511
Male >5	575	516	1,130	608	478	516	342	287	265	373
Total >5	**1,344**	**1,194**	**2,537**	**1,335**	**1,042**	**1,150**	**698**	**816**	**616**	**884**

(Source: Ministry of Health, 2011)

Food security and Malnutrition

The 2010 Budget Speech makes the statement that "The gap between agricultural exports and imports has been widening making SVG vulnerable as a net food importing country" (Government of St. Vincent and the Grenadines, 2010a). It also notes that the poor and the indigent are most likely to be affected by increases in imported goods. Drought conditions and resultant heat stress could further impact the ability of the agriculture sector to meet local demands (Confalonieri, *et al.*, 2007).

Babies being born underweight and undernutrition in children under five years of age, at a prevalence rate of 5.7% have been reported (Kairi Consultants Limited, 2008b). Cases of underweight children have higher prevalence rates in certain communities (e.g. in March 2008, in Owia and Sion Hill 18% and 2.4% of children respectively were found to be underweight (Kairi Consultants Limited, 2008b)). A study was also conducted in 1996, that showed that 19% of primary school children and 41% of pre-schoolers had some degree of iron deficiency (Kairi Consultants Limited, 2008b). The IPCC Fourth Assessment Report states that under-nutrition, protein energy malnutrition and or micronutrient deficiencies are cause for concern in terms of climate changes and its possible impacts (Confalonieri, *et al.*, 2007). Part of the challenge of attaining a

balanced diet is tied to the cost of food, which poorer groups in society cannot afford (Kairi Consultants Limited, 2008a).

Aside from the impact of droughts, which affect agricultural productivity in the Grenadines more severely (Kairi Consultants Limited, 2008b), pests can also affect the productivity of the agriculture sector which in turn could affect the availability and cost of food crops (Kairi Consultants Limited, 2008a). For instance the moko disease has affected the agriculture sector (Kairi Consultants Limited, 2008b). Fortunately food inflation has been relatively low for SVG in 2010 (Government of St. Vincent and the Grenadines, 2010).

Increased precipitation and water related diseases

Poor drainage or absence of drainage entirely, affects both richer and poorer communities (Kairi Consultants Limited, 2008b). When there is high precipitation this may result in flooding and further environmental problems. In the more northern country of Antigua and Barbuda, water storage devices and rainwater harvesting is heavily utilised. Contamination of water resources through improper filtration and treatment of rainwater is a concern (CEHI, 2008). Similar occurrences may be experienced by residents of the Grenadines and should also be considered with respect to water quality and the implications for health. The diseases of importance related to water and sanitation include those already discussed - dengue and gastroenteritis. Their prevalence could increaseduring the rainy and hurricane seasons.

4.5. *Marine and Terrestrial Biodiversity and Fisheries*

4.5.1. Background

SVG is a 389 km^2 archipelagic state that consists of the main island of St Vincent and the northern twothirds of the Grenadines, which are a chain of smaller islands stretching south from St. Vincent to Grenada. St. Vincent has a central spine of volcanic mountains that stretch from north to south along the entire length of the island with steep watersheds falling down to both the east and west coast. The main island of Saint Vincent is very rugged with 50% of the slopes 30 degrees or more and 20% less than 20 degrees (Barker, 1981 cited in Caribbean Conservation Association (CCA), 1991). The topography and population dynamics of the islands result in most towns and villages being established on the flat coastal regions and are thus very vulnerable to SLR as a result of climate change. The highest point on this mountain range is the La Soufriere volcano to the north that rises to approximately 1,246 m (4,048 ft) above mean sea level. It is one of the world's largest active volcanoes. Other mountain peaks south of La Soufriere include the Richmond Peak, Mount Brisbane, Grand Bonhomme, Petite Bonhomme and Mount Saint Andrew.

The Grenadines are geologically older than Saint Vincent and have a much gentler relief with no point higher than 1,000 ft. The Grenadines are surrounded by fringing reefs and white sandy beaches and are an important tourism destination, especially for yachts.

The principal eco-systems on SVG are dry and humid tropical forests, wetlands and tidal flats, sandy and rocky beaches, coral reefs, sea grass beds, mangroves, offshore islets. The reef, sea grass and mangrove systems of this area are recognised as among the most productive in the world. There are more than 1,150 species of flowering plants, 163 species of ferns, 4 species of amphibians, 16 species of reptiles, 111 species of birds and 15 species of mammals have been identified on SVG. In terms of marine biodiversity, over 500 species have been identified. Among these are at least 450 species of fin-fish, 12 species of whales and dolphins, 4 species of turtles, 9 of gastropods, 11 seaweeds and 30 different coral species (MHE, 2010).

Forest

The country is about 29% forested (Culzac-Wilson, 2008) and the forest vegetation with elevation, geology and rainfall and includes rainforest (mostly between 300 m (1,150 ft) and 500 m (1,640 ft)), elfin woodland and montane forest (above 500 m), palm break (between the rainforest and montane forest and in disturbed areas) and mangrove (of which there is just about 50 ha left in the country, most of which is on Union Island with some on Mustique).

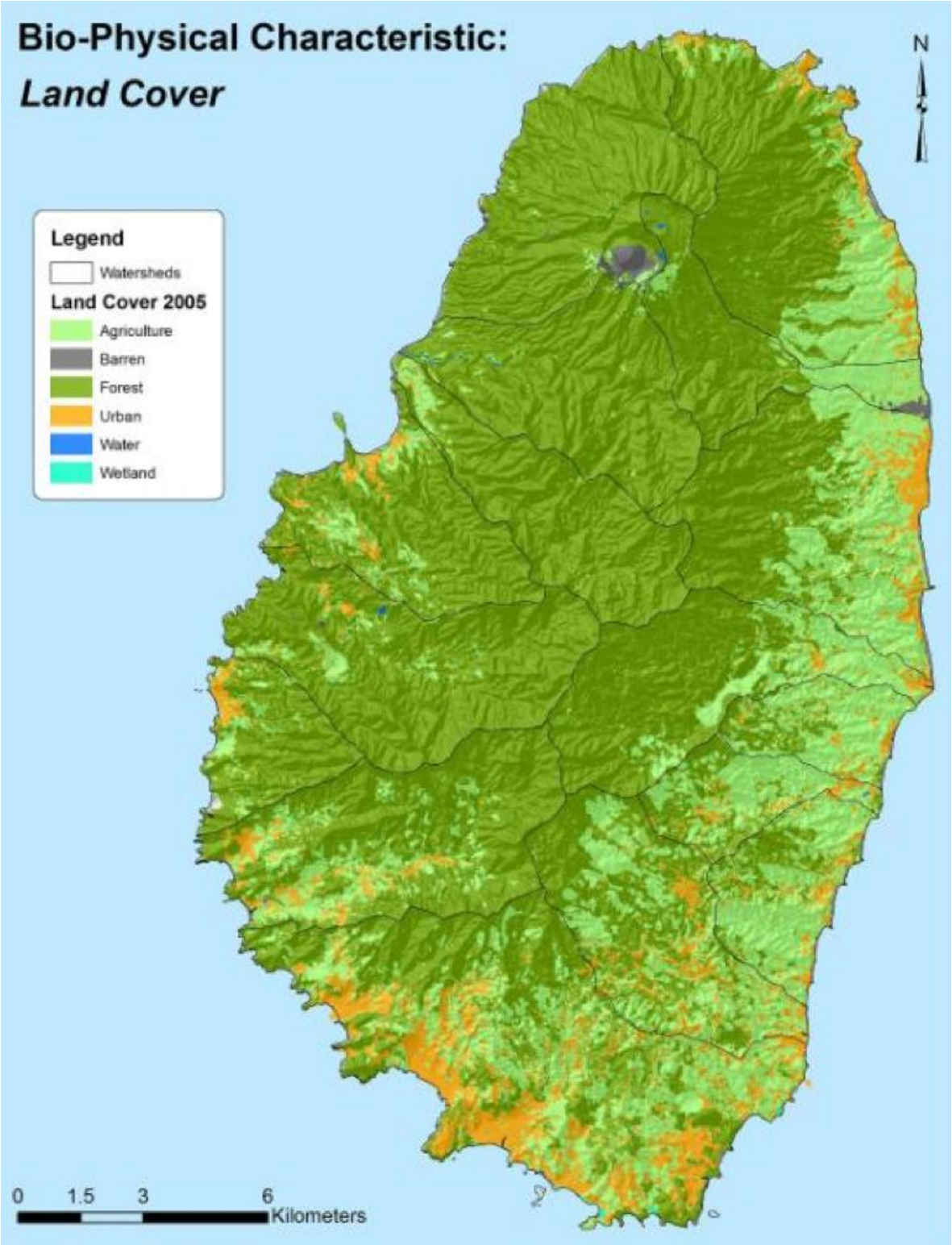


Figure 4.5.1: Land Cover Map of St. Vincent in 2005.

(Source: Mendoza P, 2011b)

The most important contiguous area of forest in SVG occurs in the Central Mountain Range. This encompasses the following key biodiversity areas: the Colonaire, Cumberland, Dalaway and (the proposed) Kingstown Forest Reserves; the La Soufriere National Park, Mount Pleasant and Richmond Forest Reserves. St Vincent's Central Mountain Range represents one of the largest remaining tracts of wet forest in the Lesser Antilles and one of the few that maintains the full altitudinal corridor from sea level to 1,200 meters

(CEPF, 2009). The forest supports populations of four globally threatened species and comprises all of the island's key watersheds, which provide all of the island's freshwater supply.

The Central Mountain Range is ear-marked for listing as a protected area (the Central Mountain Range Corridor) under the System of National Parks and Protected Areas. This is significant because, although it was traditionally protected from developmental pressures due to the rugged terrain, the area is now threatened by illegal marijuana cultivation and proposed infrastructural development, most notably, the construction of the roads.

The forest is home to the Vincy Parrot (*Amazona guildingi*), which is the national bird of SVG; a symbol of enormous cultural importance. It is listed both under Appendix 1 of the Convention from the International Trade in Endangered Species (CITES) and as a 'vulnerable' species on the IUCN Red list. The Vincy Parrot is one of the four remaining Amazon parrots in the Lesser Antilles and is largely confined to the Rainforest (Moist Montane Forest) and Secondary Rainforest (Cloud transitional forest) types. Culzac-Wilson (2005) explains that the bird's small population, limited range, the threat of hurricane and volcanic activities, coupled with the threats of continued loss and fragmentation of habitat and the illegal trade in the species, put it in great danger of extinction. Poaching has been identified as one of the main threats to *A. guildingii*, with birds removed to (illegally) supply the international pet trade. Hunting parrots as a source of food is an ongoing (although declining) threat. The forestry department conducts a biennial parrot census to keep track of the wild populations. The population of parrots in the wild is considered to be stable or possibly even increasing. There is a successful ex- situ breeding programme at the Nichol's Wildlife Complex in the St. Vincent Botanical Gardens, which has produced at least one new bird per year since its inception in 1990.

Primary and secondary rainforests are also rich in many other national and regional endemic species. These include the Whistling Warbler, *Catharopeza bishop* (endemic); the Black Snake, *Chinorinus Vincenti* (endemic); the St. Vincent House Wren, *Trologlodytes aedon* (endemic); Rufous-throated Solitaire, *Myadestes genibarbis* (endemic sub-species), Hooded Tanger, *Tangara cucullata* (regional endemic shared with Grenada); the Congo snake, *Mastigodryas bruesi* (regional endemic) and the Piping frog, *Eleutherodactylus shrevei* (endemic). Although little research has been done to determine the actual levels of endemism of the herbaceous plants associated with the primary and secondary rainforests, it is well known that many forest plants are utilized for traditional medicinal purposes and in handicrafts.

Forests provide critical habitat for wildlife and many products and services, including water conservation, amelioration of climate, production of timber and non-timber products, prevention of soil erosion and flood control. SVG currently depends entirely on surface water for its domestic, agricultural and industrial supply and all catchment areas are located within forest reserves (Cottle, Koester, Providence, & Renard, 2002).

The establishment of mono-culture bananas plantations used to be a primary threat to forest biodiversity due to encroachment on forest boundaries. However, these threats have been reduced in recent times due to the influence of European agricultural standards such as EUREPGAP (Good Agricultural Practices), which stipulate strict environmental standards for agricultural crop production. Various initiatives undertaken by the Caribbean Agricultural Research and Development Institute (CARDI) and the Inter-American Institute for Co-operation on Agriculture (IICA) have also contributed to the improvements. Nonetheless, similar and even more pervasive problems are now being created by illegal marijuana (*Cannabis sativa*) cultivation deep inside key watersheds.

Habitat loss and fragmentation due to squatting for housing and development are now also major factors threatening forest biodiversity in SVG. The proposed "cross-country road" that would bisect the centre of the Vincy parrot's range (and primary rainforest habitats) would result in a new axis for deforestation across the centre of St Vincent.

Invasive species are also on the rise, presenting much challenge to forest biodiversity. One example of this is the Cattle Egret (*Bubulcus ibis*) whose roosting habits have been linked to loss of Mangrove at the Brighton beach area. It appears that toxins caused by build up of faecal deposits have polluted wetland soil, destroying plant roots. Another example is that of the introduced Armadillo (*Dasypus novemcinctus*) which has done considerable damage to the ecosystem in the Vermont watershed, undermining trees, accelerating erosion and thereby threatening native biological resources. (InERT, 2006: 33).

In 1991, it was estimated that in some watersheds, deforestation rates were as much as sixty to seventy acres per year (CCA, 1991). Table 4.5.1 compares the amount of area covered by the various forest types as well as total forest cover over 1949, 1984 and 1993. It can be seen that between 1949 and 1993, total forest cover declined by almost 10%. The current rate of deforestation is estimated to be between 3-5% per annum. Natural threats to the forest ecosystems include volcanic eruptions, tropical cyclones, extended drought and landslides. However, observations have confirmed that the long term effect of such events on forest biodiversity is minimal and normal patterns re-emerge soon afterwards. However, the increased frequency of extreme hydrometrological events expected to be caused by Climate Change will likely increase the impact of these threats.

Squatting and agricultural encroachment has resulted in a trend in deforestation (L. FitzGerald Providence, 2000); initially during the years of European colonisation and more recently development of the banana industry in the 1980s and 90s, brought in a new wave of deforestation (Cottle, Koester, Providence, & Renard, 2002). Estimates of deforestation in some watershed areas were estimated to approach 400-500 acres/year (FMIP 2007).

Table 4.5.1: Forest Types and Coverage in St. Vincent between 1949 and 1993

Type	1949	1984	1993
Rainforest	8,218	9,208	7,759
Dry Scrub Woodland	1,491	1,326	2,179
Elfin Woodland	207	952	457
Palm Brake	4,122	1,734	518
Regeneration			1,776
Total Forest Area	***14,038***	***13,220***	***12,689***

(Source: Edwards, 2008)

Mangroves

Approximately 50 ha of mangrove may be found in SVG, most of which is on Union Island with some on Mustique (MHE, 2010) and a very tiny area on St. Vincent's south coast (See Table 4.5.2). Four distinct species can be found; the red (*Rhizophora mangle L.*), black (*Avicennia germinans* L.), white (*Laguncularia racemosa* (L) Gaertn.f.) and button, (*Cococarpus erecta*). Interestingly, all four species are found together in an area of less than 6Ha at Richmond Beach on Union Island.

Spanning the intersection of land and sea, mangroves support a variety of life from fish to human. Mangrove stands buffer the impacts of storm surge and high energy winds; their root networks trap fine sediments and suspended particles thus contributing to the maintenance and stabilization of shorelines. This function also serves to filter tidal waters reducing their turbidity and improving water quality.

Mangrove habitats provide a unique and effective shelter and breeding ground for a host of economically important marine organisms such as conch, lobster and fish. The forest canopy provides extensive habitat and breeding areas for birds and reptiles. Their high biological productivity provides a source for available nutrients and forms a critical link between terrestrial and marine ecosystems, most notably coral reefs and seagrass beds. However, indiscriminate coastal development has resulted in the destruction of many of the mangroves throughout the country, most notably the construction of the Ashton Marina in Union Island which caused severe damage to the country's largest remaining mangrove forest.

Table 4.5.2: Distribution and Composition of Mangrove Forests in St. Vincent and the Grenadines

Location	Size (Ha)	Compositions
St. Vincent	0.16	White mangrove
Mustique (Lagoon Bay)	8.09	*7.69 ha Black mangrove 65%, Red mangrove 25%, Manshineel (Hippomane mancinella L.), Kashee-Acacia spp., Mimosacea spp. 10%* *0.4 ha of Red Mangrove belt.*
Mustique (north corner of airport)	4.05	*Black mangrove with small clumps of button mangrove (tree and shrub form)*
Union (Ashton harbor)	20.24	*0.81 ha red mangrove belt, 19.43 ha black mangrove (tree and shrub form)*
Union (Richmond beach)	5.67	*Red, black, white and button mangrove*
Union (Clifton Bay Reserve)	1.25	*Red and black mangrove*

(Source: MHE, 2010)

Beaches

Beaches are important tourist attractions that are frequented by thousands of visitors and residents annually. They are also a line of defence protecting the coastline from erosive wave action and provide landing sites for small fishing boats. Common vegetation growing on sand dunes help to stabilise the shore, encourage the build up of sand into dunes, which form an important reservoir of sand and natural wind-break. Beaches are dynamic eco-systems that support biodiversity by providing habitat for shore birds, crustaceans and at least two species of endangered marine turtles: the hawksbill and green turtle that return annually to the beaches on SVG to nest (see section on Marine Turtles).

Beaches are also very vulnerable to hurricanes and tropical storms, which cause dramatic changes that usually result in serious beach erosion. Seasonal "high waves" during the winter months from storms in the North Atlantic Ocean and known as swell waves, or locally as 'groundseas', can also dramatically affect beach profiles. On top of these impacts, SLR, is a long term factor, that takes place very slowly over decades and causes shorelines to retreat inland.

Beaches are also vulnerable to anthropogenic activities. Removing sand and other materials from beaches and dunes for construction purposes causes erosion and the loss of beaches and dunes. Building too close to the beach interferes with the natural sand movement and may impede beach recovery after a serious storm or hurricane. Badly planned sea defences may cause the loss of the beach and of neighbouring

beaches. Pollution from human activities on the land may damage coral reefs and seagrass beds; these biological systems protect and provide sand to the beaches. Removing vegetation from coastal areas destabilises beaches and clearing sites inland may result in soil erosion and siltation of the coral reef systems.

In order to monitor the changes that are being observed on the beaches of SVG, several beaches in Bequia and the Tobago Cays have been monitored since 2000 by students from the Bequia Community High School, who measure beach slope and width on a regular basis. Beaches in Mustique are also monitored by the Mustique Company. The tropical storms and hurricanes that have been unusually frequent since 1995 and while there is some beach recovery after the event, this is often not to pre-hurricane levels.

Figure 4.5.2: Pristine white sand beach on the West Coast of Union Island, 2007

(Source: Owen Day, 2007)

Coral Reefs

There are approximately 140 sq km of coral reefs around SVG. Coastal and marine based activities are a major revenue stream for many Vincentians, particularly in the Grenadines, where tourism and fishing are especially important. Coral reefs support livelihoods directly and indirectly in fisheries and marine tourism. They are a significant source of beach sand and provide stability for beaches. Reefs serve as habitat, feeding and nursery grounds for juvenile fish such as snappers and groupers as well as commercially important molluscs (e.g. conch) and crustaceans (e.g. lobster). Coral reefs also have value in terms of their historic, cultural, medicinal and ecological significance. An even more valuable service provided by coral reefs is their role as a natural coastal defence, protecting the shoreline and coastal infrastructure from the erosive action of waves and storm surges.

But, unplanned development and the unregulated use of the marine resources have already led to significant degradation in many areas. Overfishing, coastal habitat destruction, sedimentation, solid waste and sewage disposal from land-based sources and yachts, as well as the damage from anchors have been cited as causative factors for this deterioration (Baldwin *et al*., 2009).

To assist in long term planning and management of the marine resources around the Grenadines, extensive mapping of the biological and physical features in both the Southern Grenadines (which are part of Grenada) and Northern Grenadines (part of SVG) was carried out under the Marsis project (2011). Maps and resources are available to download at www.grenadinesmarsis.com.

Seagrasses

Seagrass beds are found along the shoreline in shallow water where sunlight penetration is adequate to allow photosynthesis. There has been very little mapping and monitoring of these eco-systems on the main island of St Vincent. Some maps are available on the Marsis website (see above) for the Grenadines and these seagrass beds tend to be relatively small and isolated. Seagrasses play an important role:

- As primary producers in the food chain of the reef community producing more than 4000 g C/m^2/yr;
- In fixing nitrogen.
- In providing habitats, feeding, breeding, recruitment sites and nursery grounds for juveniles and adults of reef organisms including the major commercial species and the culturally important sea egg (*T. ventricosus*);
- In reducing sediment movement in nearshore waters and removing sediments from the water column;
- In decreasing turbidity of the water;
- In stabilising the coastline.

Seagrass beds are usually found close to shore and this makes them highly susceptible to run-off from land based activities and to stressors arising from watersports activities. The increasing levels of soil erosion and sedimentation on the main island of St Vincent (see Figure 4.5.4), is very likely to be causing damage to these important habitats.

Fisheries

Demersal fish

Fisheries on the deep slopes around SVG are targeting mainly species including snappers (Lutjanidae) and groupers (Serranidae), which are taken on handlines. Bottom set longlines with about 100 hooks are also used. In St Vincent, these demersal species are fished more heavily in the off season for large pelagics. In the Grenadines, they are harvested all year round and a large proportion of the catch is delivered direct to trading vessels for export. Anecdotal evidence suggests that this fishery is underexploited. Potential yield estimates range from 32 to 144 t/year (Source: FAO Fisheries Technical Paper, No. 313). A precautionary approach is warranted since foreign effort cannot be quantified and some species (e.g. groupers) are extremely vulnerable to overexploitation while they aggregate for spawning.

Coastal pelagic fish

The coastal pelagics are nearshore fish found in mid-water or surface waters close to beach areas. The main target species are jack, herring, silverside, anchovy, ballyhoo, robin/scad and small tunas. These species account for approximately 45 to 60% of the total estimated landings. This fishery is one of the most important in SVG. Anecdotal evidence from fishers suggests that stocks are moderately exploited but lack of data precludes the estimation of potential yield.

Large pelagic fish resources

The large pelagic fish resources are fast swimming migratory fish that inhabit the deep sea. The target species include tunas (*Scombroidei*), billfishes (*Stiophoridae*), dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium Solandri*), sharks (*Elasmobranchii*), swordfish (*Xiphus gladius*), whales and porpoises (*Cetaceae*). The regional large pelagics (dolphinfish, kingfish, etc.) are mainly caught by trolling from pirogues and canoes east of the Grenadines Bank. Most of the catch is landed in Kingstown. In the Grenadines, catches of regional large pelagics are primarily incidental to fishing for shallow shelf reef and deep-slope fishes. Ocean-wide pelagics (yellowfin tuna, billfishes and swordfish) are targeted primarily by multipurpose vessels. The large pelagics make up 25% (214 t) of the estimated average annual landings in SVG (St. Vincent and the Grenadines Fisheries Statistics 2000). There are no regulations controlling the harvest of large pelagics in the Eastern Caribbean.

The Caribbean Spiny Lobster

The Spiny lobster (*Panulirus argus*) fishery is a very valuable fishery for SVG. Approximately 25 t are exported annually to neighbouring islands such as Martinique, St Lucia and Barbados. An estimated 10–20% of the lobster catch is consumed locally. Since SVG and Grenada share the same shelf, joint management of the fishery is necessary. The lobster population is considered to be overexploited in nearshore areas. The potential yield is 90 t/year (FAO Fisheries Technical Paper, No. 313). The current regulations stipulate a closed season for lobster (1 May – 31 August) as well as minimum size limits, restrictions on fishing gear and restrictions on taking berried females or moulting individuals.

The Conch

The conch fishery of SVG is a moderately important commercial activity. Conch is harvested primarily by a number of lobster fishermen during the close season for lobster. There are also specialised free-diving conch teams operating out of Union Island, who harvest the resource all year round. Approximately 500 fishermen and 160 fishing vessels are involved in the conch fishery. An estimated 10.5 t of conch is landed annually in SVG and, of this figure, approximately 4 t are exported to neighbouring islands. The current regulations stipulate a size restriction (minimum shell length and meat weight) and harvesting of conch with a flared lip.

Table 4.5.3: Fisheries Production and Landings for St. Vincent (lbs), 2005-2007

Product	2003	2004	2005	2006	2007
Fish (all types inc. Sharks)	1,699,715	1,625,167	1,651,590	1,655,349	2,109,302
Conch	19,601	37,950	14,221	7,907	23,668
Lobster	61,676	84,339	46,193	31,774	19,365
Turtles(Green & Hawksbill)	1,478	0	2,224	1,501	2,118
Whales (Pilot)	1,090	1,720	1,410	900	9,900
Whelks	1,935	0	0	300	0
Total	***1,784,405***	***1,749,176***	***1,715,638***	***1,697,731***	***2,164,353***

(Source: Fisheries Division, SVG)

Cetaceans

Several species of whale have been recorded in the waters of SVG, including humpback whales, sperm whales and pilot whales. The best time to see them is usually between the months of December to April though it is possible to encounter them all year round. SVG is now actively marketing whale watching as an eco-tourism attraction and while whale watching tours do not guarantee sightings but the chances of seeing dolphins are high. Dolphin species in SVG waters include spinner dolphins, bottlenose dolphins and common dolphins. Experience from other countries suggests that, if carefully marketed and managed, whale and dolphin watching present an attractive and economically viable, non-extractive use of marine resources.

SVG is also a whaling nation and two humpback whale species are taken in the Grenadines, usually in the vicinity of Bequia between January and May. Blackfish or pilot whales and other small whales and porpoises are also harvested for meet in St Vincent, mainly from Barrouallie.

Cetaceans are a globally shared resource therefore the continuation of whale watching tours in SVG is dependent on the presence of the mammals in the Eastern Caribbean. 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 (Elliott & 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, Hunter, Pierce, & MacLeod, 2010).

Marine Turtles

Marine turtles are still harvested by fishermen in SVG – see Table 4.5.3 above. Visitors can see turtles and learn about turtle conservation at the Old Hegg Turtle Sanctuary on Bequia (http://turtles.bequia.net). Turtles can also be seen in the wild in the Tobago Cays at the Tobago Cays Marine Park, where Green turtles are often seen while swimming or snorkelling in this protected environment.

Damage to seagrass beds and beaches degrade their nesting and foraging grounds. Compounding these existing threats is impact that climate change. Intense tropical cyclones and accompanying storm surge will also alter beachfront and impact on nesting areas (Simpson, *et al.*, 2010). Warmer average daily temperatures may skew sex ratios in developing eggs and thereby reduce the reproductive capacity of sea turtles. Such impacts will mean a loss of potential for the country's expanding ecotourism industry, disruption of marine eco-system balance and loss of a tourism product. As a signatory to the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), SVG has an obligation to protect these endangered marine reptiles.

4.5.2. Vulnerability of Biodiversity and Fisheries to Climate Change

Forest

Climate changes projections for SVG suggest that annual changes in temperature by the 2080 will increase by 0.9 - 3.4˚C. These changes, combined with projected decreases in precipitation could have dramatic consequences for the forests and overall biodiversity of SVG. GCM projections of future rainfall for SVG span both overall increases and decreases, but tend towards decreases in most models. GCM projections of rainfall over SVG indicate decreases in annual rainfall of -34 to +6 mm per month by 2080 under scenario A2. The range is higher during JJA and SON seasons. The changes in seasonal precipitation simulated by the

RCM vary considerably depending on the driving GCM. Both the RCM simulations indicate large decreases in total annual rainfall with the projected change of -22% when driven by ECHAM4 and -30% when driven by HadCM3.

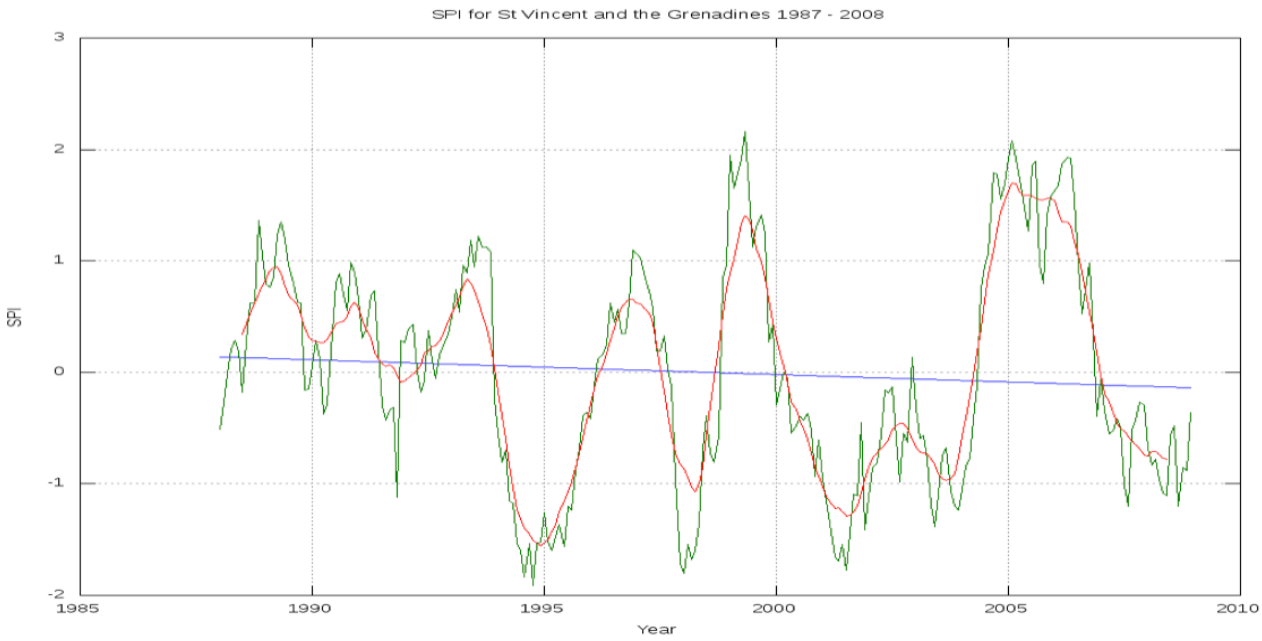


Figure 4.5.3: Standardised Precipitation Index (SPI) for SVG over the period 1987-2008

The Green line is SPI, the Blue line is the trend line and the Red is the running mean. [The SPI is a drought index that is used to describe drought conditions important for a range of meteorological, agricultural and hydrological applications. For example, soil moisture conditions respond to precipitation deficits occurring on a relatively short time scale, whereas groundwater, streamflow and reservoir storage respond to precipitation deficits arising over many months.]

(Source: MHE, 2010)

SVG's tropical rainforest is likely to be impacted by projected changes in humidity. Reduced moisture will 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). Major droughts in Saint Vincent and the Grenadines have occurred three times in the 21 year period spanning 1987-2008, each lasting more than six months. The Standardized Precipitation Index (SPI) graph above shows that the longest drought lasted around 2 years between 2001 and 2004. Also noticeable is a cyclical pattern of drought and heavy rainfall. Since the country's economy depends on agriculture, a meteorological drought can have adverse effects. For example, the ECLAC report of 2001-2002 states that banana production was down by 27% due partly to leaf spot disease and drought conditions.

While small changes in temperature and precipitation are known to have significant effects on forest eco-systems, 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. Regional Climate Model (RCM) projections driven by ECHAM4 and HadCM3 indicate more rapid increase in temperature over SVG than the median change projected by the GCM ensemble under higher emissions scenario A2.

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, a loss of revenue for the eco-tourism sector and a loss of other important eco-system products and services.

The Central Mountain Range includes large areas above 1,000 m in altitude 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^{o}C would require vegetative zones to migrate vertically by 260 m and up to 530 m in a 3.5^{o}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.

In the recent past, few hurricanes have made landfall on SVG. Nonetheless, the islands' location at the southern edge of the Atlantic hurricane belt makes them prone to the effect of tropical storm activity. The islands have been impacted by tropical storms such as Lenny (1999) which caused US $142,000 (EC $386,250) in damages (UNFCCC, 2000) and Tomas (2010) which caused landslides, devastated crops and displaced many citizens from their homes. In 2002, Tropical Storm Lili caused damage estimated at EC $978,000. Damages from Hurricane Ivan in 2004 amounted to EC $100 million. In 2005, Hurricane Emily caused an estimated EC $10 million dollars worth of damages, while Hurricane Dean caused EC $2.2 million worth of damages in 2007. In 2008, Hurricane Omar caused damages at an estimated cost of EC $5.6 million. In 2010, Hurricane Tomas caused extensive damage to the forest and virtually destroyed the entire banana harvest in St Vincent, (Data, from NEMO, 2011).

Caribbean forests have always suffered physical damage from storms and 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. The cost of maintaining roads and trails 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.

Two of the main areas of concern for the population of St Vincent are soil erosion and landslides, which in recent years have been increasing. Any damage inflicted on the forest, either by extreme weather events (hurricanes, droughts) or man (deforestation, road construction, fires) will greatly exacerbate the likelyhood of landslides and soil erosion. The areas that are most susceptible to landslides are shown in Figure 4.5.4.

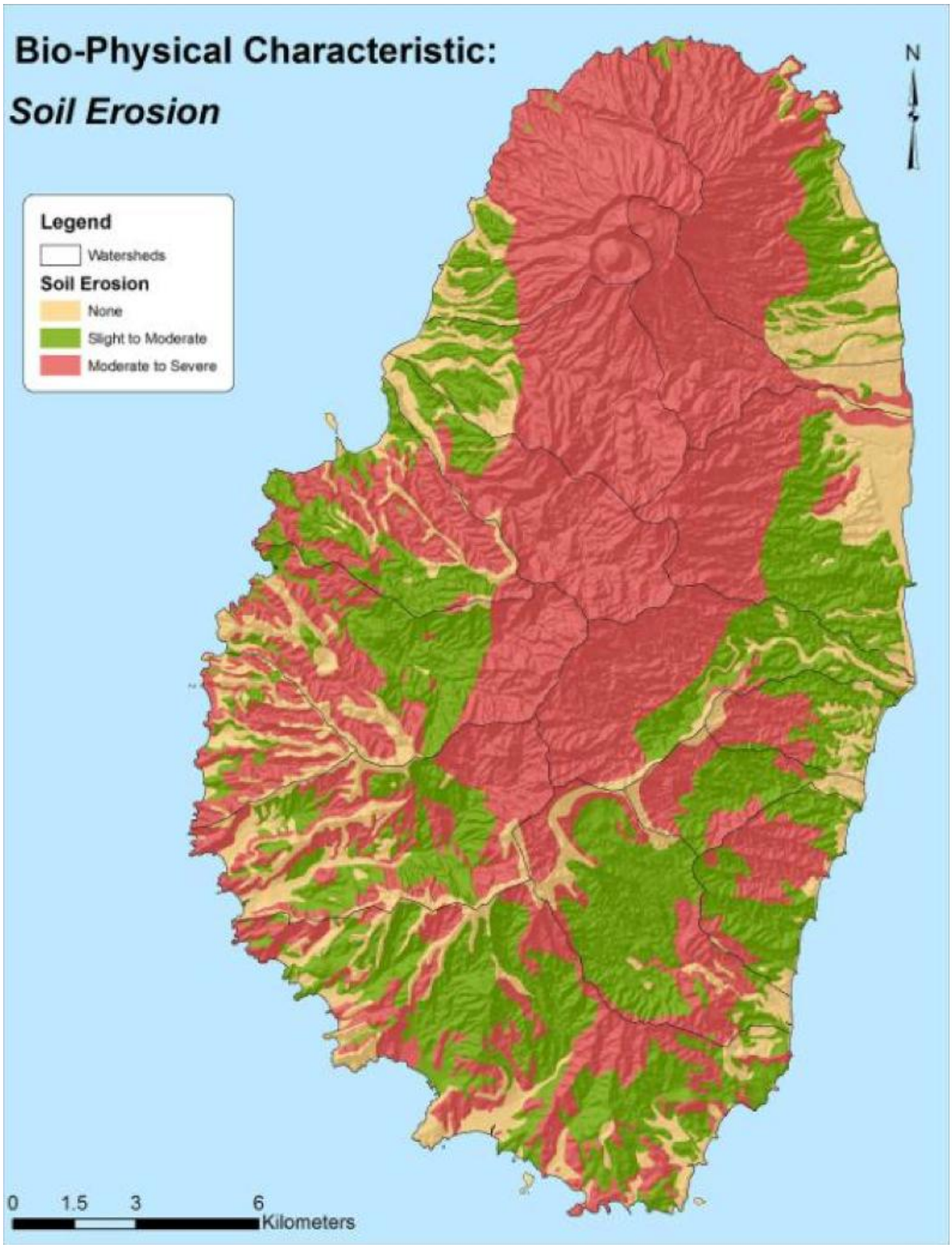


Figure 4.5.4: Map of Soil Erosion Index for St. Vincent

(Source: SVG Strategic Programme for Climate Resilience PPCR, 2011)

Mangroves

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 & Salm, 2006).

The location of mangrove stands along coastlines makes them particularly vulnerability to the impacts of hurricane force winds and storm surge. Extreme cyclonic events strip trees of their leaves, alter seed dispersal and seedling recruitment and inundated root systems with sediment (Rathcke & 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 eco-systems.

Due to the size, location and limited coastline of the islands, SVGs mangroves are also highly vulnerable to SLR. The capacity of mangrove forests (small pockets only remaining in the Grenadines) to cope with SLR is higher where the rate of sedimentation approximates or exceeds the rate of local SLR. Snedaker (1993) argues that mangroves in the Caribbean are more likely to be affected by changes in precipitation than by higher temperatures and rising sea levels because they require large amounts of fresh water to reach full growth potential. SLR and salt water intrusion will increase soil salinity and may allow wetland vegetation to spread inland. On the other hand, if mangroves are obstructed from migrating inland due to man-made infrastructure or the topography of the land, then they will eventually be over-come by SLR and lost.

According to Simpson *et al*., (2010) reports, SVG is projected to lose 2% of agricultural lands, 67% of sea port lands and nearly half of airport lands under a 1 m rise in sea levels. Being heavily dependent on the agricultural industry and the export of these products, such losses would devastate the economy of SVG. Under a 1 m rise scenario, a 1 in 100 year storm surge event would also cause severe damages to infrastructure and livelihood, since such an event could bring with it surges of 4.5 m and loss of 3% of the population and 7% of agricultural lands. Under a mid-range rise scenario, capital costs of infrastructure and land losses could approach US $445 million in 2050. By 2080 that cost could increase to US $1,290 million. Also associated with SLR is an exacerbation of any tsunamis or sea waves that may result from an eruption of the active submarine volcano Kick 'em Jenny, which is located south of the Grenadines. Mangroves have been shown tom provide important coastal defences against tsunamis and storm surges and should be conserved and even replanted in order to protect communities and valuable coastal infrastructure in suitable low lying areas of SVG.

Beaches

Climate change, in particular the projected increase in SLR and extreme weather events, is likely to increase rates of beach erosion across the Caribbean. As sea levels rise 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 habitat and fish landing sites. Climate change impacts on beaches will also threaten the survival of species such as marine turtles, iguanas and shore birds. Dramatic changes can occur to beach profile during a single extreme weather event and although recovery occurs, it may not be to pre-hurricane conditions (see Figure 4.5.5)

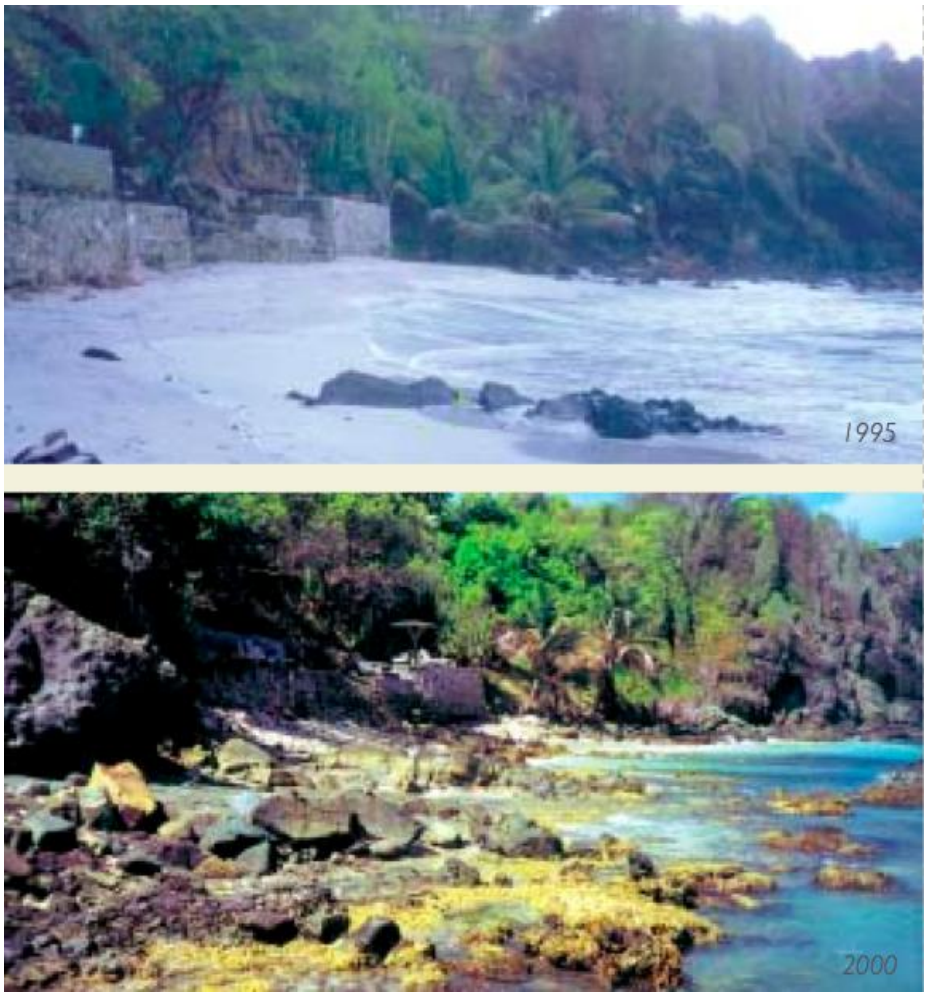


Figure 4.5.5: Beach Profile of Honor Bay in Mustique before (1995) and after (2000) Hurricane Lenny (1999)

(Source: http://www.unesco.org/csi/act/cosalc/vinb.pdf)

Coral reefs

SVG reefs have been subjected to a number of weather and climate related pressures from tropical cyclones and increased temperatures. 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 mass coral bleaching events occurred throughout the Caribbean region, including SVG, where average mortality rates of coral exceeded 25% (Eakin *et al*., 2010).

GCM projections indicate increases in SST throughout the year and projected increases range from +0.9˚C and +3.0˚C by the 2080s across all three emissions scenarios. 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). SVG reefs are therefore likely to bleach more frequently in the coming decades. This increased frequency of bleaching episodes will mean reduced recovery time for coral polyps, greater likelihood of mortality and increased susceptibility to disease. 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 lowers 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).

SLR and increased storm intensity also pose a particular threat to coastal populations, which will make the buffering role played by coral reefs and mangroves increasingly important as climate change intensifies.

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.

Climate change is expected to increase the intensity of tropical cyclones and this will 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). It is therefore increasingly important to reduce the impacts of those local stressors over which there is a measure of control (e.g. overfishing, pollution, siltation) in order to increase the resilience of coral reefs and hence their ability to adapt to the current and future changes in their environment.

One of the sources of pollution that needs to be addressed is from yachts. The numbers of yachts visiting the Grenadines is increasing yearly and there are still no regulations regarding the disposal of liquid waste and the emptying of sewage tanks. Many yachts anchor for extended periods in secluded anchorages where fragile ecosystems are exposed to their untreated sewage and waste water (detergents, cooking fats). The yachting industry needs to address this issue in order to reduce the impact of this pollution on already vulnerable eco-systems.

Figure 4.5.6: The Tobago Cays Marine Protected Area – A popular destination for yachts

(Source: Owen Day, 2007)

Seagrasses

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, McKenzie, & Kerville, 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, McKenzie, & Kerville, 2006).

Increasingly intense hurricanes can have severe impact on these eco-systems; 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. Key economic sectors such as fisheries and dive tourism will likely suffer losses if seagrass ecosystems are degraded. In SVG, the main threats to sea grasses in the future are likely to come not directly from the effects of climate change but from anthropogenic disturbances, such as dredging, sand mining, overfishing, water pollution, recreational boating and land reclamation. The combined effect is therefore significant (Mendoza, 2011b).

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.

Increased periods of precipitation will increase the quantity of freshwater outflow into estuaries causing localised desalination of coastal waters. The long term effect of localised desalination on fish, as well as on their critical habitats, is uncertain. Pelagic fisheries, including blue marlin and sailfish, comprise the major fisheries landings in SVG 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.

Projected increases in SSTs indicate a potential for increases in hurricane intensity meaning increased likelihood of impacts to the fisheries sector, including damage to infrastructure and key landing sites. Protecting and designing landing sites for small fishing boats will be an important adaptation activity for the fisheries sector in SVG.

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 may expand the range of the infectious algae to the southern Caribbean and increase the frequency of algal blooms that can contaminate some seafood species (Confalonieri, Menne, Akhtar, Ebi, Hauengue, & Kovats, 2007; Tester, Feldman, Naua, Kibler, & Litaker, 2010) (for further details see section on Health). Since 1980, a number of large scale mass mortalities of fish have occurred in the Caribbean Region but were poorly documented or researched (Williams & Bunkley-Williams, 2000). The unprecedented scale of impacts from climate change on the fisheries sector should give impetus to researching climate change impacts on regional fisheries and motivate immediate action to build the resilience of the natural resources which support it and the adaptive capacity of the people who depend on them.

In 2011, particularly between the months of July and August, an exceptionally large amount of Sargassum fluitans, otherwise known as 'the sargassum seaweed', was washed ashore causing concerns among visitors and residents. Although not confirmed as a climate change related event, the phenomenon is thought to be as a direct result of above average tropical storm activity in the Sargasso Sea. These floating mats of vegetation arrive in the Caribbean region annually but this year they appear to be doing so in unusually large quantities. Fishers have complained that their nets and lines become entangled in the Sargassum and this has almost shut down the entire fishing sector in neighbouring St. Andrew, Grenada. There is also concern over the risk of disease and invasive species that may accompany the seaweed. The large volume and weight of seaweed washed up on some beaches is unsightly and poses a problem for the tourism industry as well as a major expense and logistical challenge for Governments who opt to collect and dispose of the Sargassum. If this event is indeed related to cyclonic storms that have formed in the Atlantic during the 2011 hurricane season then coastal and marine environmental managers should prepare for the likelihood of these events occurring with increased frequency in the near future.

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. SVG is one of the Caribbean's most important tourism destinations where the threat of SLR has been identified as a particular concern in both the short and long term. SVG relies on its tourist industry for much of its national income and therefore the economic effects of SLR and storm induced erosion are significant. Of critical importance is the threat of beach erosion to the majority of existing and expected tourism facilities sited in areas located near the coastline (e.g. Indian Bay Beach and Villa Beach in St. Vincent). 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 (SVG) and local scale (Belmont Walkway, Canash Beach, Indian Bay, Johnson Point, Villa Beach), 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).

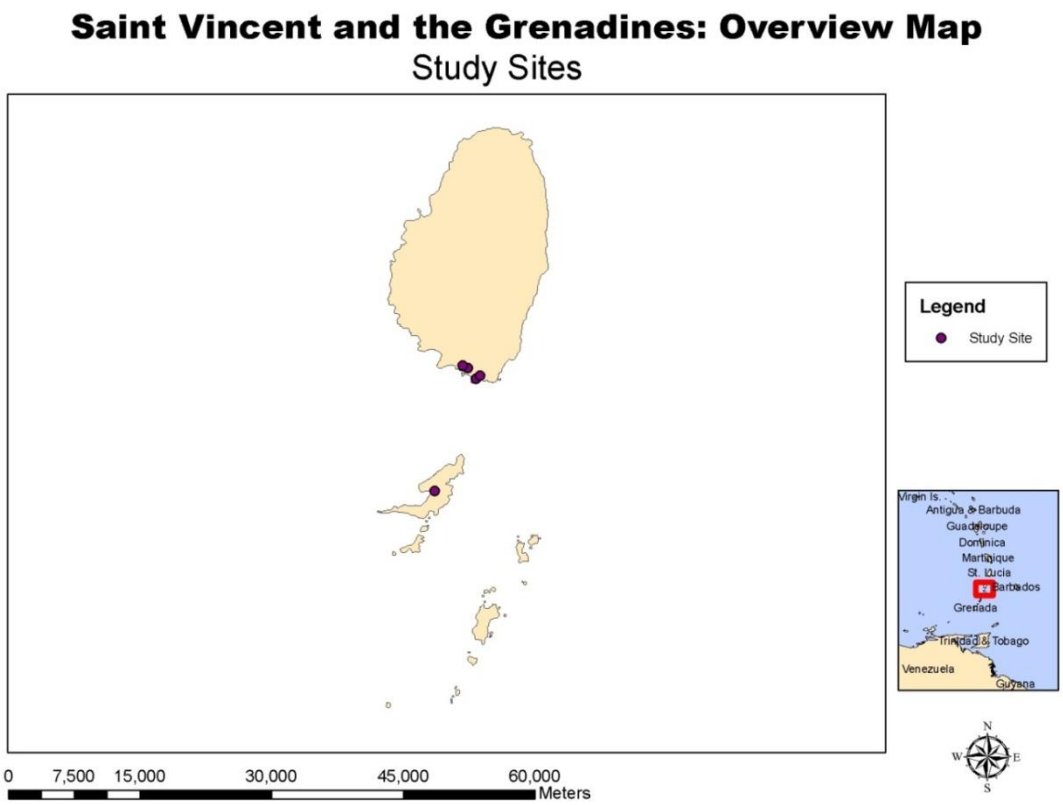


Figure 4.6.1: St. Vincent and the Grenadines - Overview Map

Coastal areas already face pressure from natural forces (wind, waves, tides and currents) and human activities, (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 SVG are Belmont Walkway, Canash Beach, Indian Bay, Johnson Point and Villa Beach including notable resorts, ports and an airport that lies at 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 M. , 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 SVG, 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

As outlined in Section 3: Climate Modelling, 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 SVG. The sea level has risen in the Caribbean at about 3.1 mm per year from 1950 to 2000 (Church, White, Coleman, Lambeck, & Mitrovica, 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 & Rahmstorf, 2009; Grinsted, Moore, & Jevrejeva, 2009; Jevrejeva, Moore, & Grinsted, 2008; Horton, Herweijer, Rosenzweig, Liu, Gornitz, & Ruane, 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 3.11: Sea Level Rise) and consistent with other assessments of the potential impacts (e.g., Dasgupta *et al.,* 2007), 1 m and 2 m SLR scenarios and beach erosion scenarios of 50 m and 100 m were calculated at the national level to assess the potential vulnerability of major tourism resources across St. Vincent and the Grenadines. The beaches in SVG 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 faced in SVG.

Figure 4.6.2: Evidence of Erosion at Indian Bay Beach (St. Vincent)

To examine the exposure of SVG 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 SLR across the islands.

To examine SLR-induced coastal erosion, a simplified approximation of the Bruun Rule (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 (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, Douglas, & Leatherman, 2004).

Results from the calculated SLR-induced erosion for a 50 m and 100 m scenario on key tourism attractions (resorts and sea turtle nesting sites) are provided in (Table 4.6.1). Indeed if erosion is damaging tourism infrastructure, it means that the beach will have essentially disappeared. With projected 50 m erosion, 38% of the resorts in SVG will be at risk, with 76% at risk with a 100 m erosion scenario. One third (34%) of the sea turtle nesting sites in SVG will be impacted with 50 m erosion, with almost half (47%) at risk with a 100 m erosion scenario. Table 4.6.1 also summarises the SLR impacts on tourist attractions and transportation infrastructure. A 1 m SLR scenario will impact 10% of the major tourism resorts on the islands, 11% of sea

turtle nesting sites, 50% of the airports, 1% of the major road networks and 67% of the ports. Such impacts would transform coastal tourism on the island, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees.

Table 4.6.1: Impacts associated with 1 m and 2 m SLR and 50m and 100m beach erosion in St. Vincent and the Grenadines

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	Major Road Networks	Port Lands
SLR	1.0m	10%	11%	50%	1%	67%
	2.0m	24%	16%	75%	1%	67%
Erosion	50m	38%	34%	-	-	-
	100m	76%	47%	-	-	-

* 47 known sea turtle nesting sites

SVG is highly dependent on international tourism and the country will be particularly affected with annual costs as a direct result of SLR. For instance, annual reductions in the contribution of tourism to SVG GDP as a result of the reduced amenity value from beach loss due to SLR is estimated to be between US $46 million to US $112 million by 2050 for a mid and high range SLR scenario, respectively (Simpson *et al.*, 2010). By 2080, this estimate increases to between US $174 million to US $328 million for a mid and high range SLR scenario, respectively (Simpson *et al.*, 2010). Infrastructure critical to the tourism sector that is impacted by SLR will result in high capital costs to rebuild the infrastructure. In 2050, capital costs are estimated to be US $81 million to rebuild airports, $54 million to rebuild ports and $134 million to rebuild tourist resorts impacted by SLR under a mid range SLR scenario. Under a high-range SLR scenario for 2080, capital costs are estimated to increase to US $677 million to rebuild airports, $332 million to rebuild ports, $2 million to rebuild major road networks and $1.586 billion to rebuild major tourism resorts (Simpson *et al.*, 2010).

In addition to the national assessment, The CARIBSAVE Partnership co-ordinated a field research team with members from the University of Waterloo (Canada) and the staff from the National Parks, Rivers and Beach Authority to complete detailed coastal profile surveying (Figure 4.6.3). Using survey grade GPS equipment CARIBSAVE field teams conducted survey transects (perpendicular to the shoreline) at five locations in SVG where tourism infrastructure was present.

Study sites closer to the equator do not support Wide Area Augmentation System (WAAS) and are better suited for Real Time Kinematic (RTK) GPS systems. This common method often used in land based and hydrographic surveys requires the setting up of a base station over a known location at each study site. Due to the unavailability of a close reference station a TOPCON RTK GPS system including base station (15 km radius), antenna, survey stick and data logger was used for data collection in SVG.

The Base Station receiver was set up in wide open areas to maximise both study site and satellite coverage. A survey stick rover unit was then sent out to survey beach elevations along transects within the 15 km base station coverage area. Finally, distances between points along transects were measured using a LeciaDisto laser distancing meter.

Figure 4.6.3: Ryan Sim (University of Waterloo) using High Resolution Coastal Profile Surveying with an RTK GPS System

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 to 0.3 m while the horizontal accuracy had a mean average of 0.015 to 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.

The high resolution imagery provided by this technique is essential to assess the vulnerability of infrastructure and settlements to future SLR in SVG. The imagery also has the ability to identify individual

properties, making it a very powerful risk communication tool. Having this information available for community level dialogue on potential adaptation strategies is highly valuable. Detailed maps from the five study locations in SVG are provided in Figure 4.6.4, Figure 4.6.5, Figure 4.6.6, Figure 4.6.7 and Figure 4.6.8, highlighting total land and beach loss due to SLR.

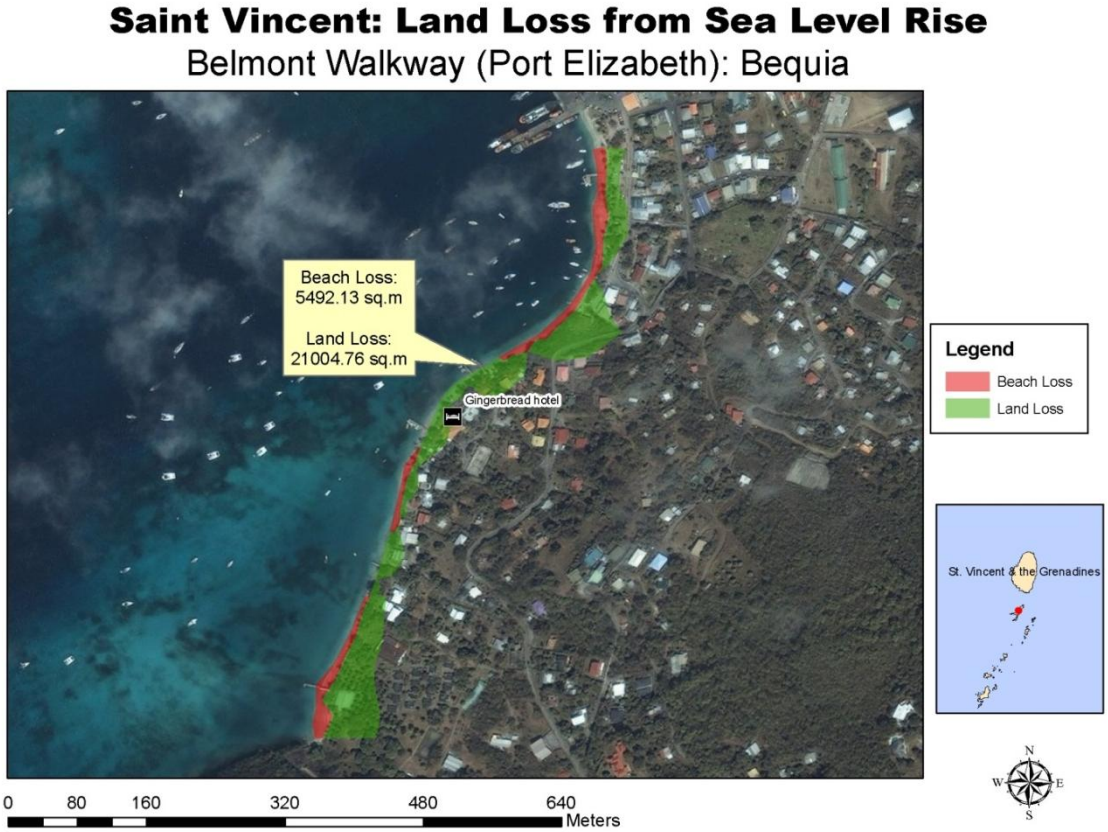


Figure 4.6.4: Total Land and Beach Loss due to SLR, Belmont Walkway (Port Elizabeth), Bequia

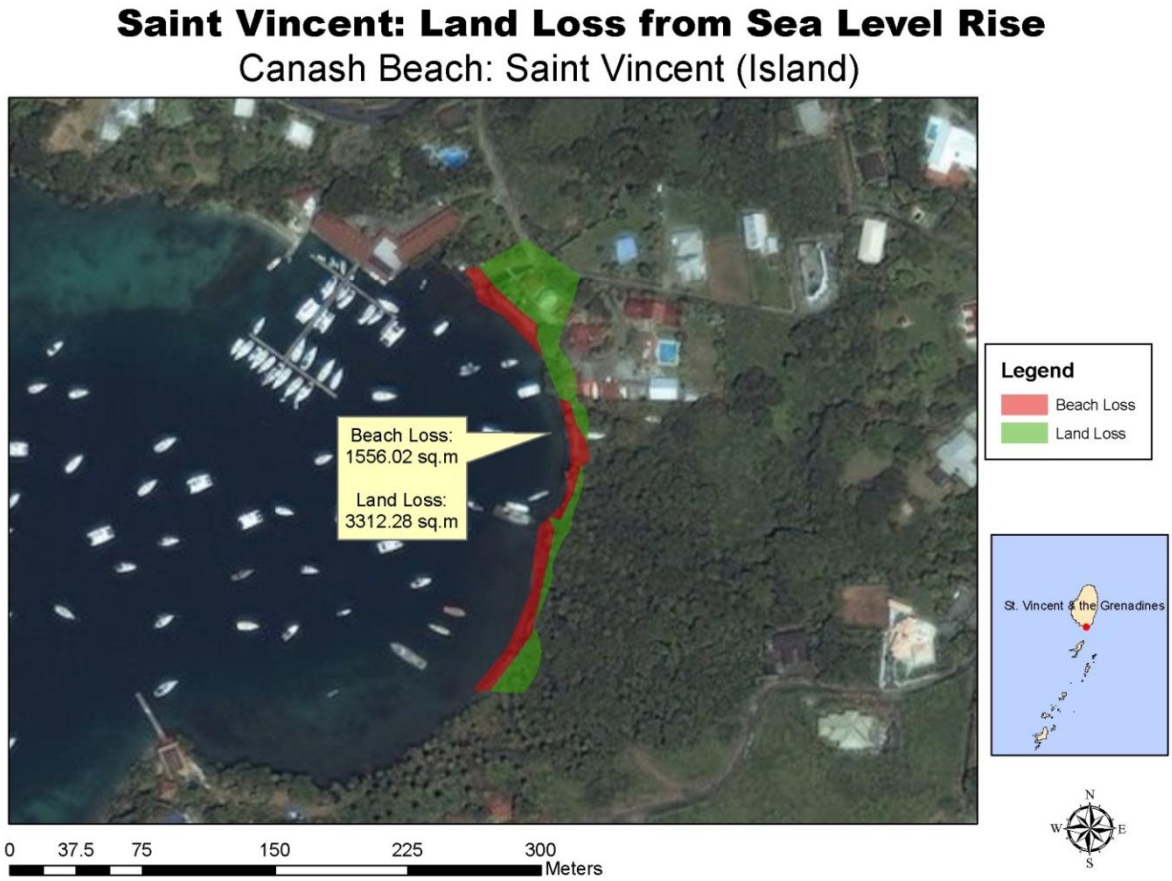


Figure 4.6.5: Total Land and Beach Loss due to SLR at Canash Beach, St. Vincent

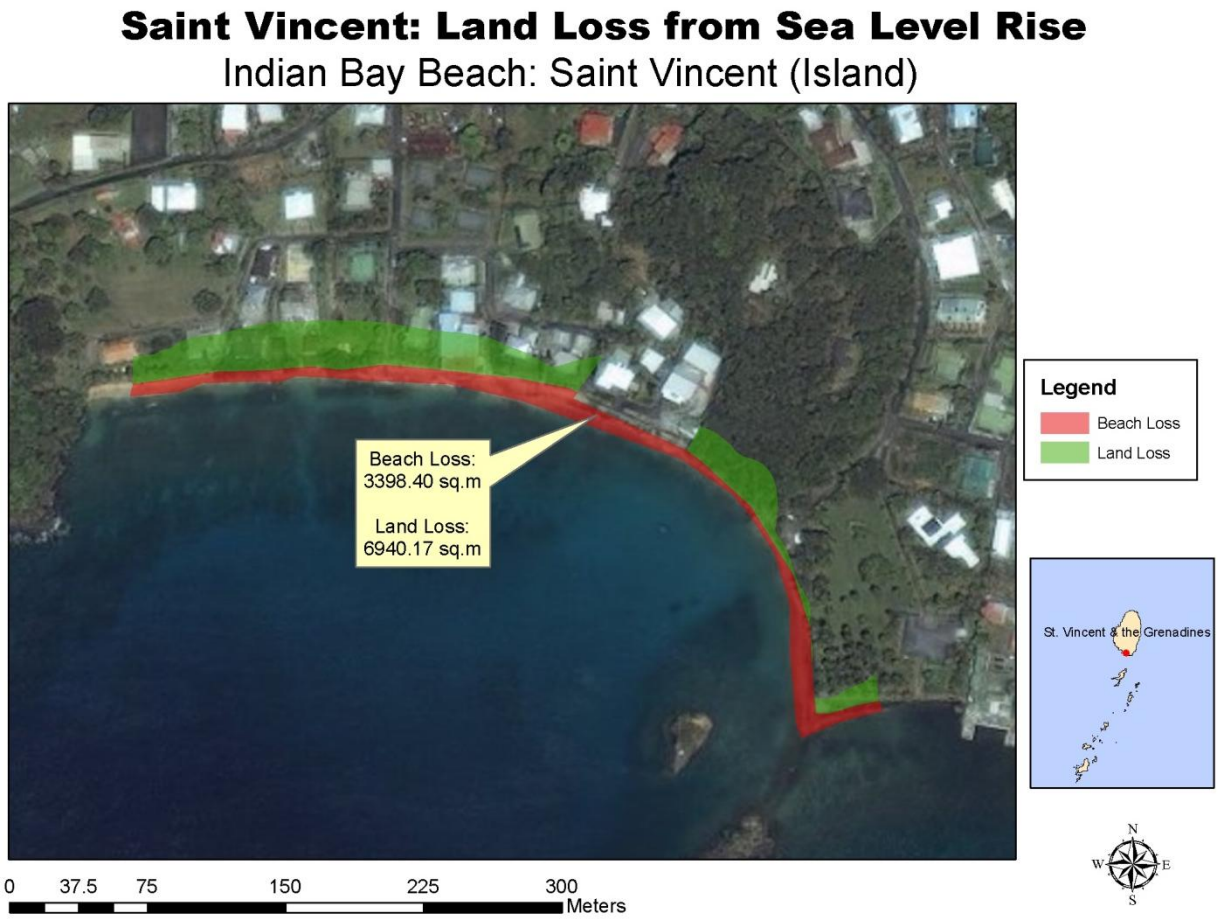


Figure 4.6.6: Total Land and Beach Loss due to SLR at Indian Bay Beach, St. Vincent

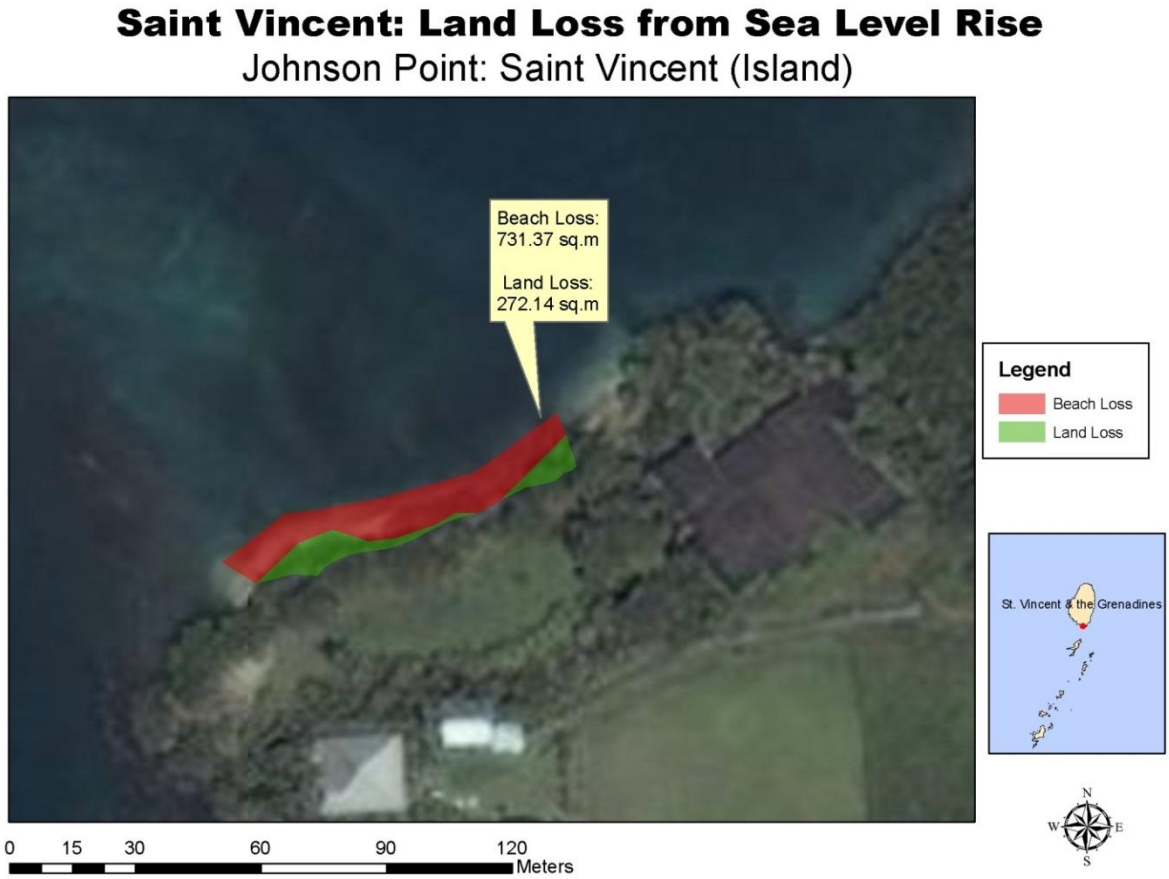


Figure 4.6.7: Total Land and Beach Loss due to SLR at Johnson Point, St. Vincent

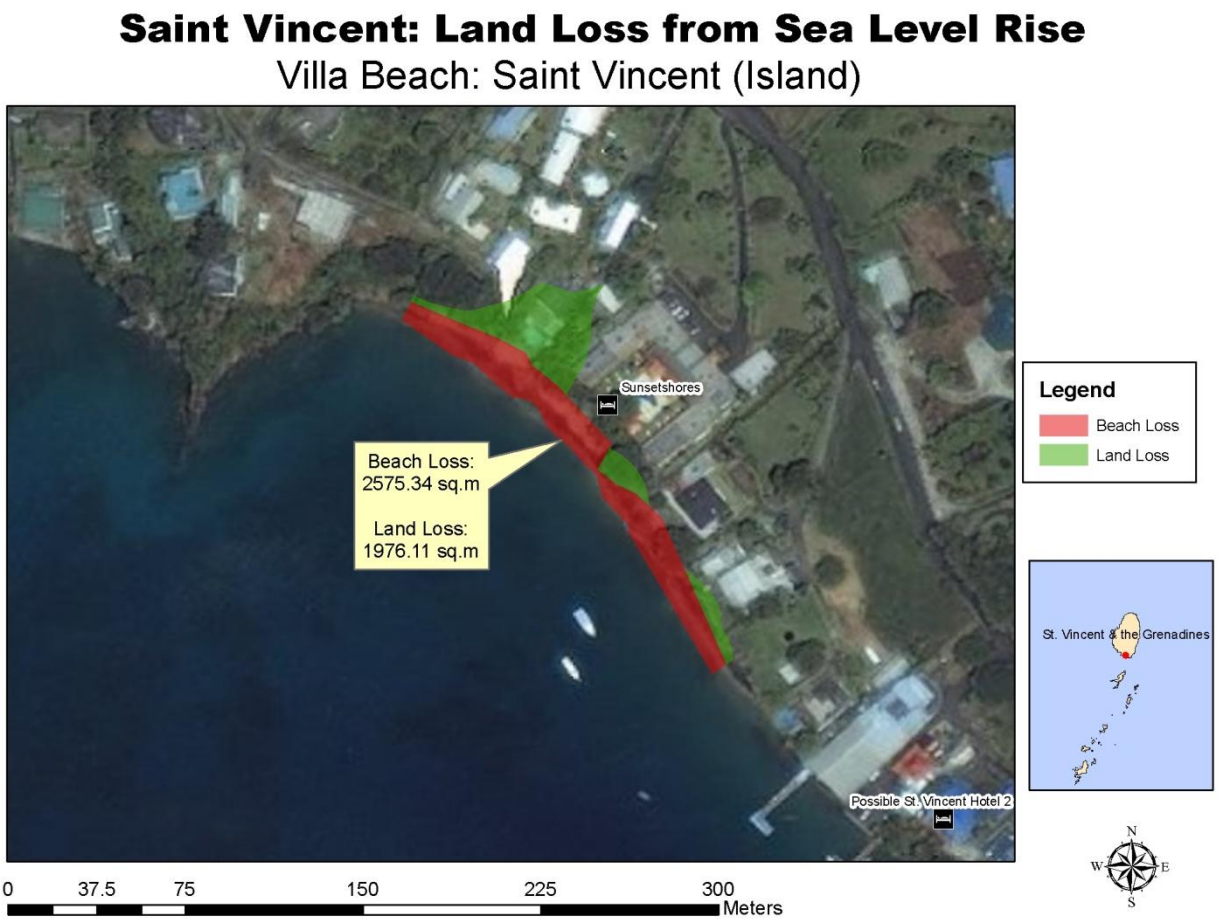


Figure 4.6.8: Total Land and Beach Loss due to SLR at Villa Beach, St. Vincent

The greatest total land and beach loss due to SLR is estimated to occur in Belmont Walkway (Bequia). Here, it is projected 21,004.76 m^2 of land will be lost, with a total beach loss of 5,492.13 m^2 as a result of SLR (Figure 4.6.4). Resorts impacted in this region include the popular Gingerbread Hotel. Indian Bay Beach (St. Vincent) is projected to have the second greatest loss of total land and beach area due to SLR, with land losses of 6,940.17 $m^2$and beach losses of 3,398.40 m^2. In Canash Beach (St. Vincent), total land loss from SLR is estimated to be 3,312.28 m^2, with total beach losses of 1,556.02 m^2 (Figure 4.6.5). Total land loss at Villa Beach (St. Vincent) is projected to be 1,976.11 m^2, with total beach losses of 2,575.34 m^2 (Figure 4.6.8). The lowest total land and beach loss due to SLR is projected to occur at Johnson Point (St. Vincent), 272.14 m^2 and 731.37 m^2, respectively (Figure 4.6.7).

Beach area losses at study sites in St. Vincent and the Grenadines were calculated for 0.5 m, 1 m, 2 m and 3 m scenarios (Table 4.6.2). At a 0.5 m SLR scenario, approximately half of the beaches will be lost at Villa Beach (45%), Belmont Walkway (48%) and Canash Beach (55%), with three quarters of the beach lost at Johnson Point (75%). At a 1 m SLR scenario, all (100%) of the beach area will be lost at Canash Beach and Villa Beach, with almost all of Indian Bay Beach lost (96%). With a 2 m SLR scenario, all but Indian Bay Beach will be completely inundated, with all of the beaches lost with a 3 m SLR. 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 Four Resorts in St. Vincent and the Grenadines

	Belmont Walkway (Bequia)		Canash Beach		Indian Bay Beach		Johnson Point		Villa Beach	
SLR Scenario	Beach Area Lost To SLR m²	Beach Area Lost (%)	Beach Area Lost To SLR m²	Beach Area Lost (%)	Beach Area Lost To SLR m²	Beach Area Lost (%)	Beach Area Lost To SLR m²	Beach Area Lost (%)	Beach Area Lost To SLR m²	Beach Area Lost To SLR (%)
0.5 m	2,643	48%	853	55%	2,533	75%	177	24%	1,157	45%
1.0 m	4,692	85%	1,556	100%	3,265	96%	531	73%	2,572	100%
2.0 m	5492	100%	-	-	3,390	99%	731	100%	-	-
3.0 m	-	-	-	-	3,398	100%	-	-	-	-

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 they 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 St. Vincent and the Grenadines, 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 co-operation of various sectors.

4.7.2. Natural Hazards in the Caribbean and St. Vincent and the Grenadines

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

SVG is a collection of 32 islands and cays that are primarily of volcanic origin with steeply sloped topography (GFDRR, 2010a). Structures and the population of SVG are vulnerable to multiple hazards. Understanding the dynamic processes that generate vulnerability is important for individuals, households, communities and the country as a whole. Historic development trends in SVG have resulted in the construction of homes, roads and public spaces in areas that are exposed to natural hazards. In addition, there are many environmental variables that influence vulnerability through time and space.

During storms, the mountainous topography and location of many of the islands' construction on steep slopes creates a context where high winds and heavy rains have the potential to generate serious damages (GFDRR, 2010a). Heavy rains are known to cause flash flooding and slope destabilisation (e.g. landslides or mudslides) in this kind of environment. Furthermore, there is little flat land in SVG for construction of either roads or other construction (GFDRR, 2010a) therefore much of this infrastructure and development is located in highly exposed, potentially hazardous areas. In contrast, seasonal rainfall variability creates some

drought conditions, particularly in the Grenadines because they do not have rivers and rainwater harvesting is the primary source of water (GFDRR, 2010a) (an more in-depth review of water quality and availability can be found in section 4.1).

SVG is at risk to geological hazards as well, including volcanic eruptions and a low -moderate seismic risk (GFDRR, 2010a). "La Soufriere has erupted five times in recorded history beginning with the eruption of 1712, the largest recorded being the eruption of 1979" (GFDRR, 2010a, p. 239). There is the potential for tsunami in SVG as a result of geological hazards. An eruption from the submarine volcano south of Grenada, Kick-'em-Jenny, could cause tsunami waves in SVG (GFDRR, 2010a). Many villages are located in low lying coastal areas where waves would have damaging impacts. A main roadway connecting the east and west coasts of Saint Vincent is also located very close to the coast and is exposed to impacts from wave action and storm surge (GFDRR, 2010a). New developments, particularly tourism infrastructure, continue to be built in coastal areas "with little attention to natural hazard risk or with little formal land use planning on some of the smaller islands" (GFDRR, 2010a, p. 239). Coastal development and protective structures around SVG have direct and indirect impacts on vulnerability to all types of hazards; a discussion of coastal infrastructure and settlements appears in sections 4.6 and 5.6.

4.7.3. Case Study Examination of Vulnerability

SVG has been hit by 8 storms since 1900; most notable are: Hurricane Allen (1980), Hurricane Lenny (1999) and Hurricane Ivan (2004) (GFDRR, 2010a). A significant proportion (41.6%) of the population is exposed to risk of mortality from 2 or more hazards as well, there is a large economic risk (41.6% of GDP) (GFDRR, 2010a). As such, vulnerability reduction is an important part of disaster management in SVG and the post-disaster time period is one where vulnerabilities can be reduced through adaptation and recovery activities aimed at 'building back better'. The following examples of recent or notable emergency situations details specific lessons and vulnerabilities.

Hurricane Tomas– 2010

Hurricane Tomas passed between Saint Lucia and St. Vincent as a Category 1 hurricane, with maximum sustained winds of 153 km/hr from 7 pm Saturday October 30, 2010 (CNN Wire Staff, 2010). The hurricane also dropped significant rainfall causing severe flooding in St. Vincent. The Prime Minister, Mr. Gonsalves, "stated that the storm was the worst storm in living memory" (GFDRR, 2010b).

Vulnerability to flooding and high winds was found to be quite significant as displayed by the impacts. Damages were wide spread in St. Vincent, with high winds and flooding affecting households and various economic sectors. The agriculture sector was the worst affected (GFDRR, 2010b). This included the destruction of the country's banana and plantation trees and significant losses to pear (avocado), breadfruit and pigeon pea trees as well as other vegetables (Chance, 2010). Initial estimates of the damages to the agriculture sector are EC $65 million, demonstrating the great vulnerability of this economic sector. Agriculture accounts for 11% of GDP in SVG and is one of the primary sectors in the country, along with tourism (GFDRR, 2010a). Further vulnerability in the agriculture sector is outlined in section 4.3.

Figure 4.7.1: Damaged banana trees after Hurricane Tomas
(Source: fairtrade.org.uk, 2010)

The hurricane impacts led to the declaration of disaster areas in SVG on both the windward, from Park Hill to Sandy Bay, and north-western side of the island from Belle Isle to Fitz Hughes (CDEMA, 2010b). In these areas and across SVG, 1,200 people were forced to seek shelter in schools and public buildings and 600 homes suffered damages including lost roofs (GFDRR, 2010b). The ability of individuals to protect themselves from such impacts is affected by various factors including socio-economic status and access to various types of resource. A community level assessment of these factors was conducted in Georgetown (see sections 4.8 and 5.8). This primary research identified some of the vulnerabilities of Vincentians and revealed some examples of vulnerability reduction strategies already in place. This hurricane demonstrates however, that disaster risk reduction efforts must be strengthened at the household and national level in order to ensure progress on sustainable development goals is not stifled by climate-related hazards.

Figure 4.7.2: Damaged house in St. Vincent following the passage of Hurricane Tomas
(Source: NationNews.com, 2010)

Hurricane Tomas was not a strong storm in terms of the wind speeds but the rains that accompanied the storm, along with the risk profile of SVG led to significant impacts. Emergency assistance funds were received from various Governments and development banks and also the Caribbean Catastrophe Risk

Insurance Facility (CCRIF) (Chance, 2010). Some vulnerability may be able to be reduced in the reconstruction process, but topography is a major limiting factor that will likely result in the rebuilding of risk; especially since none of these funds specifically stipulate that the country must 'build back better' or enforce building codes. Examination of existing policies, regulations and plans relating to risk reduction and disaster management are included under the adaptive capacity assessment in section 5.7.

La Soufrière Volcano – 1979

La Soufrière volcano is located on the island of St. Vincent and occupies much of the island. The cone is 4,000 ft (1,219 m) high and reaches 1 mile (1,609 m) in diameter (PAHO, n.d.). The volcano demonstrated some signs of changing activity in the years prior to its largest eruption in 1979. Between 1972 and 1979 the temperature of the lake in the crater fluctuated above ambient temperatures, peaking after the Soufriere eruption in Guadaloupe in 1976 (PAHO, n.d.). There was no permanent monitoring but reports indicate that there was a continuous strong steam emission from the crater and powerful vertical explosions that produced ash clouds reaching 8 km high (Shepherd, et al., 1979). The largest pyroclastic flow that was observed descended the Larikai valley to the west of the crater and out to sea, while other pyroclastic flows followed the Wallibou and Rabacca river valleys (Shepherd, et al., 1979) – see Figure 4.7.3.

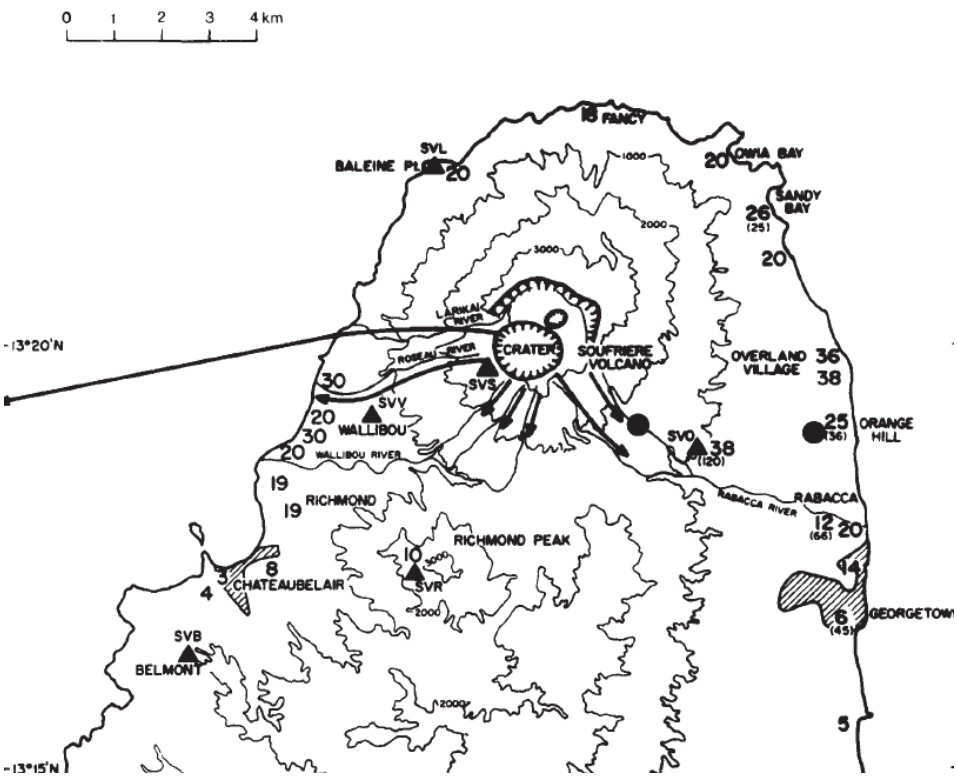


Figure 4.7.3: Northern St. Vincent and Soufrière volcano
NB: Arrows indicate the direction of pyroclastic flow, ash thickness (mm) is given by numerals

In 1979, the populated areas of northern St. Vincent were evacuated as the eruption started and persons were safely in the southern part of the island within 12 hours (PAHO, n.d.). This clearly indicates that the exposure and vulnerability were acknowledged and effective disaster response protocols have been in place for many years in SVG.

The links between climate and volcanic activity are part of an ongoing debate. Scientists suggest that "large scale volcanic activity may last only a few days, but the massive outpouring of gases and ash can influence climate patterns for years" (Wolfe, 2000). However, La Soufrière's eruption in 1979 is not said to be a large scale eruption. The Mount Pinatubo eruption in The Philippines in 1991, in contrast, ejected gases and

solids into the stratosphere that circulated the globe for three weeks (Wolfe, 2000). “Volcanic eruptions of this magnitude can impact global climate, reducing the amount of solar radiation reaching the Earth's surface, lowering temperatures in the troposphere and changing atmospheric circulation patterns” (Wolfe, 2000). The Caribbean region has several active volcanoes that could produce similar impacts. While such an eruption could impact on climate patterns for years, there is no evidence to show that climate change causes volcanic eruptions.

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 (ECLAC, UNIFEM and UNDP, 2005)

4.8.1. Climate Change Vulnerability: Implications of Community Livelihoods, Gender, Poverty and Development

Vulnerability in the context of climate change is a function of the level of exposure to climate change related or induced events, the level of sensitivity to these events and the capacity to adapt. Climate and hydrological variability have both short and long term manifestations at the global scale and is more often compounded by micro and meso scale human activities and impacts. The observed and predicted impacts of climate change are widely acknowledged in science and non-science circles, including communities who depend on natural resources.

Climate sensitive or natural resource intensive livelihoods are very vulnerable to climate change impacts because they depend so much on the stability of climate conditions or resources. As indicated previously, groups predisposed to vulnerability include women, children and the poor, owing to their lack of access to resources and opportunities which translates into low resilience and exposes them more to climate change impacts than other groups. The impacts of climate change undeniably aggravate poverty in all societies and especially where poverty is extreme and widespread (Figure 4.8.1 highlights some of these impacts). The areas where impoverished people 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, Hogan, & Saul, n.d.; UNFPA, 2007).

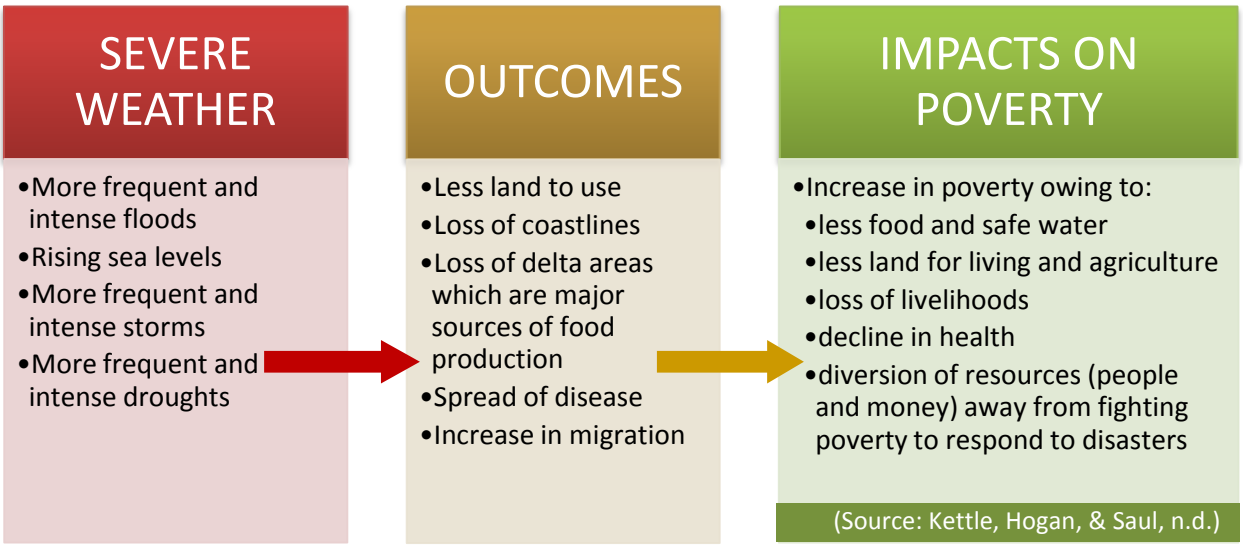


Figure 4.8.1: The Impacts of Climate Change on Poverty

Gender is given special consideration in assessing human vulnerability owing to the different roles and circumstances associated with men and women in society and especially in disaster preparation and response. The Training Manual on Gender and Climate Change developed by the Global Gender and Climate Alliance (GGCA) highlights that gender based vulnerability is not influenced by a single factor but takes into account a number of factors, especially in the case of women who tend to have less or limited access to assets when compared to men. These factors have been identified as determinant factors of vulnerability and adaptive capacity and include physical location, resources, knowledge, technology, power, decision making, potential, education, health care and food (GGCA, 2009). The size and composition of an individual or social group's asset base (natural, physical, social, human and financial) will determine to what extent they will be affected by and respond to climate change impacts. A larger quantity and/or diversity of assets imply greater resilience and adaptive capacity. Conversely, a lack of assets will pre-dispose individuals to increased vulnerability.

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). In the Caribbean specifically, Kambon (2005) highlighted the varied responses of gender to all stages of a natural disaster (pre-dominantly hurricanes) based on the observed social impacts of disasters following the 2004 Tropical Atlantic Hurricane season. Some of these differences are highlighted in Table 4.8.1.

Table 4.8.1: Examples of Gender Differences in Response to Natural Disasters in the Caribbean

PHASE	ISSUES	FEMALE	MALE
PRE-DISASTER			
	Differing Vulnerabilities		
	- Biological	Reproductive health needs	No special restrictions
	- Social	Restricted skill base	Mobile skills
	- Cultural	Exclusion from home construction	Exclusion from child care responsibilities
	- Attitudinal (risk perception)	Low level of risk tolerance	High level of risk tolerance
EMERGENCY			
	Different coping mechanisms	Suffer higher incidence of depression (crying and suicide ideation)	Alcoholism, gambling and dysfunctional behaviour
		Organising community sing-alongs and storytelling	Rescuing villagers and clearing roads
TRANSITION (REHABILITATION AND RECOVERY)			
	Needs Social Composition	Weak access to wage earning possibilities	Easier access to wages/income
		Women prepared one-pot meals for the community	Men engaged in 'marooning' teams for house rebuilding
		Devoted more time to community and reproductive work	Spend more time in productive work; abandonment of families and domestic and/or other responsibilities
RECONSTRUCTION			
	Differing priorities	Priorities for shelter, economic activity, food security and health care	Priorities for agriculture, infrastructural development and economic activity
	Differing access to resources;	Women slower to return to labour market	Men had easy access to the labour market
		Reconstruction programmes that embark on development without the inclusion of gender analysis tools	Reconstruction programmes in construction and agricultural development that favour male participation
	Differing access to power in the public sphere	Women's lack of involvement in governance mechanisms	Gender neutral governance mechanisms that do not recognise changing gender roles and relationships and favour male participation

(Source: Kambon, 2005; adapted from ECLAC, UNIFEM and UNDP, 2005)

Outlined in the Climate Modelling Section of this document are the changes likely to occur for given climate and ocean variables for SVG over the next few decades. The outputs produced for SVG by both the RCMs and GCMs are very similar to those of other Caribbean territories. Some of the more outstanding similarities include:

1. An increase in the mean annual temperature and the number of 'hot' days and nights.
2. The likelihood of more intense cyclones resulting from warmer sea surface temperatures, although this is not conclusive.
3. The likelihood of a decline in mean annual rainfall and the total rainfall experienced during heavy rainfall events.
4. The relative disappearance of 'cold' days and nights by the 2080s.

These projections are associated with different degrees of certainty, based on the availability of observed (recorded) data, the outputs from model simulations and the fact that some physical processes are too

complex to be represented by these models. In light of this, current projections and the future reality may be different. However, some of the trends indicated in these projections (up to 2080) are currently being observed and therefore the likelihood of these projections taking effect should not be discounted. Based on these projections, farmers in particular will face challenges in crop yields and outputs, having to deal with drier conditions and variable rainfall. Hotter overall temperatures will also impact on general wellbeing and comfort of citizens and variable rainfall will have implications for groundwater catchment and availability if a decline prevails.

SLR and storm surge impacts also pose significant threats. Some of the country's key vulnerabilities include coastal erosion and inundation from SLR and storms. The Grenadine islands are also faced with the threat of salt water intrusion of ground water resources. A 2 m SLR scenario could likely affect at least 24% major tourism resorts, as well as local airport, seaport and energy infrastructure. When storm surge impacts are superimposed on SLR effects, the consequences are much greater (Simpson *et al.,* 2010).

The projections for climate and oceanic change have serious implications for tourism infrastructure (a large part of which is coastal), the natural environment which supports tourism and fisheries activities and the preferred climate for tourists, who may seek alternate destinations if conditions are continually less than favourable. Gradual weather changes, SLR and the potential for increasing intensity of extreme weather events will have substantial effects on livelihood assets and activities, in particular – tourism, agriculture and fisheries, sector contributions to GDP, employment, existing poverty levels and other facets of economic and social development (Alcamo, et al., 2007; Wilbanks, et al., 2007)

4.8.2. Case Study: Georgetown, St. Vincent and the Grenadines

Overview

Georgetown 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 St. Vincent and the Grenadines.

The CARIBSAVE *Community Vulnerability and Adaptive Capacity Assessment* methodology employed participatory tools to determine the context of these communities' exposure to hazards and a sustainable livelihoods framework to assess their adaptive capacity. All data were disaggregated by gender and the three main means of data collection were: (i) a community vulnerability mapping exercise and discussion which were the main activities in a participatory workshop; (ii) 3 focus groups (2 single-sex; and 1 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) were evaluated to determine the adaptive capacity of households and consequently the entire community. Even though observations were specific to some parts within the study area, overall findings (assessments of vulnerability and adaptive capacity) are assumed to be representative for the entire community.

Leadership and development in the community

The Government of St. Vincent and the Grenadines, through the constituency representative (Member of Parliament) determines the way the community is run. The police maintain law and order and churches have a strong influence on the community. There is currently no local governing body but there are some organisations that are trying to revive a local Government. Some residents have ideas for community development but do not have the support or access to the proper channels to realise them. Local events and festivals, such as 'Nine Mornings', are planned and implemented by CBOs. There is a community

centre, maintained by local residents, which provides adult learning, library and information technology services for the benefit of the community.

Despite available resources, a number of socially and economically disadvantaged people reside in the area. An indigent family or group resides near Drip. They live under tarpaulin shelters, do not have any amenities and are highly vulnerable to weather impacts. There are also living quarters on either side of road near coastal areas where blind people and other vulnerable persons reside. Previous opportunities for farmers to acquire their own land were turned down because they did not have sufficient capital or training at the time the offers were made.

Men dominate the political platform, as with most other Caribbean territories but women are not restricted from entering politics. Women are more vocal and active in addressing social issues in the community than men and tend to be the main agents for community development.

Natural resources and community livelihoods

Rivers and the land are the most important natural resources in the community, because they support a number of livelihoods. From the land and rivers, other resources are obtained, including food (agricultural produce and fish), sand and fibres.

In Georgetown most people have just one livelihood, a few may have more than one. Several residents of Georgetown are involved in agriculture and construction. Farmers cultivate fruits and vegetables and most of the food grown is sold in markets (e.g. coconuts, bananas, breadfruits, potatoes, mangoes, grapefruits, golden apples and citrus fruits). Fishermen use the Owia river for catching 'tri-tri' and freshwater lobster and sand is dredged from the Owia river for construction. Community residents also work as public servants in education, law enforcement, health and administration.

Tourism supports a few livelihoods, although tourism is not a major part of the community. Tourists pass through the area periodically, as tourist attractions like the salt pond and Soufriere are accessed via the Colonarie to Sandy Bay area. There is a plan to establish a restaurant and a craft shop in the community. Some residents are engaged in craft making and products are sold to both locals and tourists but it is becoming more difficult to source the necessary raw material.

Community knowledge of climate change and observed changes to the natural environment

The community considers their knowledge of climate change to be average, with no outstanding differences between male or female perceptions. Similar to other case studies, residents have started to observe a number of changes in climate but they are less aware of the technical and scientific aspects of the phenomenon. Definitions of climate change include "changes within the environment, such as weather changes, decrease in rainfall, increase in storms" and "disruptions in climatic conditions of a region that may have adverse affects on the people and the environment of that area".

For residents, a rise in temperature has been one of the most distinct changes. Some attribute the temperature rise to the increase in paved areas, concrete buildings and large areas of development but it is mainly perceived to be purely climatic. Hurricanes appear to be more intense. Wet and dry seasons are no longer clearly defined; parts of St. Vincent flooded as a result of heavy rains in April, 2011 (i.e. during the dry season). There are more frequent sea swells and increased coastal erosion. Pest and diseases are also more common, including mosquitoes, plant diseases such as the white Sigatoka and invasive species such as the giant African snail, which have several implications for human health and agricultural production, respectively. A freak hailstorm that occurred in St. Kitts a few years ago also opened the eyes of residents

to the threat of climate change. Despite some of the negative impacts of climate change, the community presented some positive outcomes of recent impacts. There is more gravel and sand for construction (brought downstream by flash floods) and tree trunks brought downstream are used for crafts and fuelwood.

Other changes have also been noticed in the natural environment and human activities are blamed for most of these changes. Illegal dumping, burning of waste, deforestation have contributed to erosion and pollution in the community. These activities increase the community's vulnerability to events. When drains are clogged with excessive solid waste, flooding is significantly exacerbated. Seagrape trees were removed in Black Point for tourism development, which resulted in beach destabilisation and the beach eroded. A vegetation replanting project has subsequently begun in Black Point in attempt to restore stability to the coastline.

Despite the observations that have been made and the apparent increase in severe weather impacts, the community's greatest concern lies with the possible eruption of La Soufrière Volcano, which would affect the Georgetown community sitting on the south eastern base of the dome (See Vulnerability Section for Comprehensive Natural Disaster Management).

Impacts of weather and climate on community livelihoods and development

Desirable or productive weather conditions vary depending on an individual's livelihood activities. Vegetable farmers require both rain and a period of dry weather. However very heavy rainfall events after a long dry spell is problematic for banana farmers as plants become brittle during the dry season and collapse and break when heavy rains come. Erosion is also greater if the soil is parched. Dry weather is generally preferred by all others (e.g. construction, tourism). Residents are accustomed to intermittent rain and would expect heavy rainfall events during the wet season. However, out of season events or extremes in temperature or rainfall are offsetting and can even be detrimental.

Drought, 2009: In 2009, there was a water shortage resulting from drought conditions. Many residents in Georgetown practice agriculture and farmers suffered losses from reduced crop production that year. Food prices rose and produce had to be imported from other islands to supplement the limited supply in St. Vincent. An irrigation system has been set up in one area to assist with water shortages. Few homes harvest rain water. Tanks are often uncovered and the concern of creating breeding grounds for mosquitoes may deter persons from obtaining tanks. More residents are beginning to store water in drums instead.

Hurricane Tomas, November 2010: Hurricane Tomas affected the island at the beginning of November 2010, bringing heavy rains and high winds which caused flooding, loss and destruction to several buildings, agricultural plots, livestock and the natural landscape. The impact of the hurricane on the community was exacerbated because most residents did not initially expect the system to affect the country and failed to prepare adequately. Persons were displaced from their homes. A primary school was used as a shelter and school was disrupted for two weeks as a number of shelter occupants remained after the hurricane passed (also see Vulnerability Section for Comprehensive Natural Disaster Management).

The impact of extreme events such as Hurricane Tomas is greater on women in some ways. Women have difficulty in using public shelters because of the lack of privacy or personal space. A woman is less keen on depending on others for personal items such as clothing. Men tend to be less conscious or bothered by such things. Some women, especially those who head single parent homes lost some authority over their homes. Men who have responsibility for their families felt a greater strain than those who did not and

suffered a damaged sense of pride when they were unable to fulfil their duties. Some men have more than one family to care for, so the level of despair amongst these men was significantly higher.

Flash Floods, April 2011: St. Vincent experienced a severe flash flood in April 2011, similar to the floods which affected Guyana in 2005. There was no defined dry season in 2011 and while the torrential rains were unusual at that time of year (as April falls within the dry season), two major reasons were cited for contributing to the severity of the flood (i) the passage of Hurricane Tomas 6-7 months prior, which disturbed the stability of the land and vegetation and their capacity to absorb water efficiently; and (ii) poor drainage as a result of improper garbage disposal in Georgetown. Clearing of land for agriculture also created unstable soils contributing to the extent of erosion by the river during the flood. Large quantities of sand were also eroded from rivers and deposited in low lying areas of the community and along the coast.

Figure 4.8.2: Debris from flood washed onto a beach in Georgetown as a result of torrential rains, April 2011

Flood waters carved in road channels in Morris Village and felled large trees which were washed down onto a beach. Large trees that had been felled by Hurricane Tomas in November 2010 were washed down from the mountains during the heavy rains. The flood damaged water pipes and Georgetown was without a piped water supply for about one month. During this time, trucks delivered water to the community. The absence of a piped water supply affected women significantly, as they are the primary care givers of households and are responsible for domestic duties which require water (washing, food preparation). In the aftermath, women had to carry water into households to cook, clean, wash and to provide freshwater for children. The flash flood also affected older persons more seriously than younger ones as they found it harder to recover.

Other impacts and vulnerabilities: The area from Colonarie to the local clinic is generally vulnerable to flooding and storm surge impacts and both residential and commercial infrastructure are located along the coast. More frequent and higher sea swells are blamed for destroying berths at Kingston and Layou and damaging several fishing boats.

In the Bentink-Sandy Bay area houses and land have collapsed and property was lost. Boulders are now used to protect the area from further erosion. People have had to be relocated from coastal areas because of increasing instability of the foundation which their houses are on. However some community residents

were reluctant to relocate and preferred to return to their regular way of life, even after suffering damage from the hurricane.

Heavy rains sometimes obstruct the road with debris from the river banks, making transportation and commuting difficult. Georgetown itself can be accessed by a number of roads but it can be easily separated from the rest of the country if the major/main road used is damaged or flooded. The other roads are too steep and narrow, making them unsafe for frequent travelling.

The removal of vegetation for various reasons (development, agriculture) and subsequently destabilisation of soils increasing the occurrence of landslides and slippages, which have affected a number of farmers. Some areas that were once vegetation are now exposed rock.

Coping strategies and disaster management in the community

At the national level, the National Emergency Management Organisation (NEMO) is responsible for disaster and emergency management activities. NEMO has a community arm which consists of a network of 40 District Committees that implement training and awareness activities in communities throughout SVG (see Adaptive Capacity section for Comprehensive Natural Disaster Management).

When a hurricane approaches, men and women will assume different responsibilities for preparation. Men generally look after more labour-intensive tasks such as securing the house (putting up shutters, securing the roof), whereas women tend to more domestic details (ensuring enough food and water supplies are in the house, make preparations to move to a shelter if required). The Church and schools in the community are used as hurricane shelters but these are not in the best of conditions and are also subject to flooding. Additionally, some people have remained in the shelters for extended periods of times, using them as homes well after the event has passed.

In the aftermath of severe weather, the psychological impacts are very evident, especially in men. Some men are unable to manage the burden of recovering and providing for their family or families. As a result, they resort to drinking and intoxication as a way of dealing with the pressure (also see coping strategies highlighted in Table 4.8.1; Kambon, 2005). After Hurricane Tomas, some residents received housing and materials which were of greater value than what they had previously owned. Families worked together to rebuild livelihoods: fathers and sons farmed together to restore agricultural output, while mothers and daughters sold juices and confectionaries to earn income. More residents (who can afford it) have also acquired water storage tanks, in preparation for any future situations where the regular water supply may be interrupted.

In terms of agriculture, farmers now do ‘mixed-cropping’ i.e. plant various plots with different crops, to diversify their output. The Ministry of Agriculture has established an irrigation system in Georgetown that is functioning well, which will help during the dry season. KaribKable has also started a tree-planting initiative to create green spaces and to help stabilise the soil in some areas.

Despite the seriousness of disaster preparedness and knowledge of experiences on other islands, complacency is a major issue. Some residents do not take enough precautions or prepare adequately when a storm approaches, mainly because up until recently, severe weather impacts have been infrequent. Community members lament that even with the lessons learnt from Hurricane Tomas and the April 2011 floods, given enough time, those lessons will be forgotten. Complacency is also common amongst the younger adult generation, who may not have experienced severe weather previously and underestimate the devastation that can result. Residents also consider the community too dependent on external help, especially from the Government; to improve living situations and to recover from disasters.

5. ADAPTIVE CAPACITY PROFILE FOR ST. VINCENT AND THE GRENADINES

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

The Central Water & Sewerage Act of 1992 "makes provision for conservation, control, apportionment and use of water resources" and for the designation of protected areas for water conservation (World Bank, 2006). The Waste Management Act, No. 31 of 2000 dictates the approach for solid waste management in the country. Other legislations that have a role in water resources management include the Environmental Health Services Act, (No. 14 of 1991), Forest Resource Conservation Act of 1992 which allows for the creation of crown lands into conservation areas for the purpose of water production as well as the Pesticides Control Act (No. 23, 1973) regulates all issues related to pesticides and their usage in the country (Simmons and Associates Inc., 2000). The Forest Resources Conservation Act (1992) provided for the creation of the forest management agency which specifically deals with watershed management issues (Simmons and Associates Inc., 2000).

The country has not devised a National Water Policy or Water Management Plan (CEHI, 2007; ECLAC, 2003; Peters, 2003). In terms of water resource management, the Draft Road Map toward Integrated Water Resources Management (IWRM) Planning for Union Island, St. Vincent and the Grenadines is one of the most recent developments in St. Vincent and the Grenadines. With respect to Union Islands, a number of policy limitations were identified. These included:

- "Water is not mainstreamed into national development frameworks and therefore afforded relatively low priority;
- Low level presence and intervention of mainland Government in addressing pressing needs; largely related to the geographic distance between the mainland and Union Island;
- Low level of knowledge and awareness on the concept of IWRM;
- Existing legislative and regulatory provisions are not explicit in addressing issues in the Grenadines context;
- Unregulated land use (has implications for water management)" (CEHI, 2007).

In Component two (Implementation of selected adaptation measures designed to address climate impacts on biodiversity and land degradation (total cost $2.35 million, GEF funding $1.5 million)) of the GEF funded project contains seven sub-components. Sub-component 6 - Integrated Ecosystem Approach to Climate Change in Bequia and Union Islands (St. Vincent and the Grenadines) was geared towards the introduction of adaption measures to increase water supply on Bequia and also to remediate coastal vulnerabilities in Bequia and Union Island (World Bank, 2006). With respect to flooding and flood mitigation, sub-component seven sought to implement "mitigation and adaptation measures to reduce the risk of landslides and flash flooding" in Spring Village, St. Vincent (World Bank, 2006).

5.1.2. Management

The Central Water and Sewerage (CWSA) is the statutory body that oversees all aspects related to production of water and the provision of sewage services. It operates semi-autonomously under the Ministry of Health and the Environment, but its activities are regulated by the Public Health Department, which is the legal responsibility of the department (MOHE, 2007). The main functions of the CWSA are:

- "Water supply - treatment, transmission and distribution of potable water to domestic, commercial, shipping and Government customers
- Sewerage - management and operation of two sewerage systems that serve the central business district (CDB) of Kingstown and the Arnos Vale Housing Scheme respectively
- Solid waste - CWSA assumed responsibility for the Solid Waste Management Unit (SWMU) from April 1998. The Unit became fully operational in 2002" (CWSA, 2011).

Other institutions with a role in water resource management include the St. Vincent Electricity Company (VINLEC), Environmental Health Unit, the Physical Planning Department of the Ministry of Finance, Planning and Development, the Ministry of Communications and Works and the Pesticides control Board. In the Ministry of Agriculture, it is the Forestry Department as well as the Soil and Water Conservation Unit which addresses erosion issues and the Extension and Advisory Services Division assists in rainfall measurement (Simmons and Associates Inc., 2000). Of these institutions, the CWSA, VINLEC and the Ministry of Agriculture are the main water resource institutions. Co-ordination between these three entities had been found to be lacking (Culzac-Wilson, 2003). The CWSA faces financial and human resource constraints as well as deficiencies in technical staff particularly water engineers (Kairi Consultants Limited, 2008b).

NGO's are also active in water resource initiatives. For example, the Grenadines Partnership Fund (GPF) which is a North Carolina based NGO in the USA is currently executing a water project in St. Vincent and the Grenadines. The Water Project is a drought mitigation initiative and aims to source water for distribution from a well that was sunken in Port Elizabeth, Bequia, in the past. The project which has cost $40,000.00 so far, will involve pumping the water and storing it in a 20,000 gallon storage facility until required (Gurley, 2011).

5.1.3. Technology

Hydrological data is critical for making informed decisions regarding the development of water resources. This data will become even more critical for observing changes in water supply and decision making regarding the provision of water resources in future as a result of climate change related events such as droughts.

In St. Vincent and the Grenadines, there are deficiencies in hydrological data collection, for example of aquifers (Peters, 2003). The Environmental Health Division is responsible for testing water quality, which is carried out through the Water Testing and Monitoring programme. This involves testing for residual chlorine on a weekly basis. These tests are only carried out on St. Vincent and in hotels in the other islands (Kairi Consultants Limited, 2008b).

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 St. Vincent and the Grenadines, it would make sense to address energy use and emissions in tourism because the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise its economy.

Generally, 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 greenhouse gases 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. 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 for instance include incentives for the greening of tourism businesses. Tax burdens would then be cost neutral for tourism, but 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 $10 per bednight 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. Haraksingh (2001), for instance, outlines that there is a huge potential to use solar energy. 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. The incentives highlighted in Section 4.2.3: Vulnerability of the Energy Sector to Climate Change, are aimed at making efficient and alternative energies more affordable. Should the decision be made to apply VAT to fuel, the additional cost should also encourage greater efficiency. The Ministry of Finance and Economic Planning are also to look at revising the existing taxation on vehicles so that the system is based on fuel efficiency rather than engine size (St. Vincent and the Grenadines, 2010).

5.2.2. Management

Any action on reducing energy use and emissions of greenhouse gases 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 hotels, as these are comparably energy intense, 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 country 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 bednight numbers, destinations have consequently had to permanently increase tourist numbers. Working pro-actively on these is consequently a highly relevant management task.

In an attempt to look at both profits and emissions of greenhouse gases, 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'. Table 5.2.1 illustrates the situation for a number of islands in terms of weighted average emissions per tourist (air travel only), as well as emissions per tourist for the main market. The table can serve as a benchmark for inter-country 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	1302	62 550	81	803 (USA; 41%)
Comoros	1754	17 603**	31	1929 (France; 54%)
Cuba	1344	2 319 334	3 117	556 (Canada; 26%)
Jamaica	635	1 478 663	939	635 (USA; 72%)
Madagascar	1829	277 422	507	2 159 (France; 52%)
Saint Lucia	1076	317 939	342	811 (USA; 35%)
Samoa	658	101 807	67	824 (New Zealand; 36%)
Seychelles	1873	128 654	241	1935 (France; 21%)
Sri Lanka	1327	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 now 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 in order 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
Primary market Emissions ratio	USA 0.8	USA 0.5	USA 0.8	USA 0.9
Secondary market Emissions ratio	UK 2.5	Netherlands 1.6	-	UK 2.0
Third market Emissions ratio	-	-	-	Barbados 0.1
Fourth market Emissions ratio	-	-	-	Canada 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 countries 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.

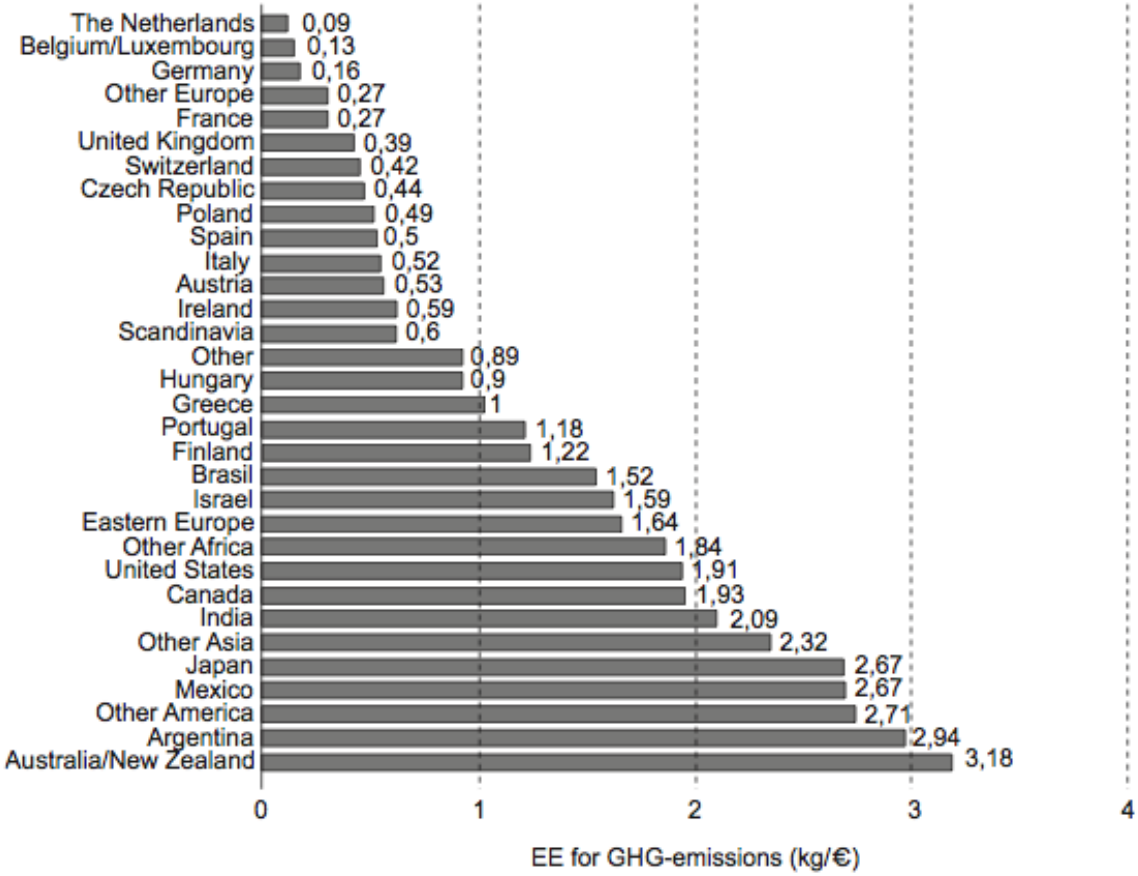


Figure 5.2.1: Eco-efficiencies of different source markets, Amsterdam

(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; 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.

A survey carried out in February 2011 in Barbados 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: 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 A/C use, one of the major factors in energy use in hotels,

tourists also support resource savings: 71% stated to 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).

Two of the actions of critical relevance here are the investigation of the energy consumption sector to see how it is structured and what potentials exist for improving energy efficiency; and the provision of an energy auditing service at low/no cost for large energy consumers. The agencies identified to carry out these tasks are VINLEC and the Ministry with responsibility for energy (St. Vincent and the Grenadines, 2010).

5.2.3. Technology

The potential for saving energy through technological innovation has been documented for a growing number of case studies. For instance, luxury resort chain Evason Phuket & 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.

Often, it is also 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 on the economic suitability of technological innovation to generate renewable energy in Barbados. Bishop and Amaratunga (2008) propose a 10MW 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. 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. The authors highlight that small wind turbines can be competitive with conventional wind farms.

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 (CDM) as an instrument to finance emission reductions. The CDM is one of the flexible instruments of the Kyoto Protocol with two objectives:

1. 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;
2. To assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments.

The CDM 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. CDM projects can be implemented in all non-Annex I countries and are certified by operational entities (OE) designated by UN

COP (IPCC, 2007). The CDM thus generates credits, typically from electricity generation from biomass, renewable energy projects, or capture of CH_4, 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 ongoing in the Caribbean on how to use the CDM in restructuring the energy system. It is worth noting, however, that emission reductions achieved through the CDM do not apply to national economies, rather they apply to the purchaser's economy. The CDM has been identified as a potential source of international funding in the Energy Plan (St. Vincent and the Grenadines, 2010). While the CDM is thus an instrument to achieve technological innovation, it is not an instrument to achieve carbon neutral status.

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

St. Vincent and the Grenadines is vulnerable to rising oil prices. However, there are various tools that can be employed to reduce energy use in the country's tourism sector, possibly in the order of an estimated 20% within two 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.
- Vast options exist to reduce energy demand through carbon management. In particular, this includes a re-thinking of markets based on their eco-efficiency, this 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 bednight numbers without addressing losses in average length of stay does otherwise, meaning to be stuck in a 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.
- 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.

5.3. *Agriculture and Food Security*

5.3.1. Policy

Due to the decline in the banana industry, the main policy position of the Government has been to "diversify around banana" and to increase production and exports of root crops, fruits and vegetables. The major components of St. Vincent's Agricultural Policy Framework are as follows:

i. Export development based on selected commodities including fisheries to generate higher levels of foreign exchange earnings.
ii. Food and nutrition security through the production of selected commodities including fish and fish products. Affordable food prices, self-sufficiency and environmental sustainability.
iii. Import substitution which involves production of special commodities for import replacement, saving foreign exchange, increasing linkages particularly the tourism sector and development of export based agro-industries.
iv. Employment creation for the rural population with particular emphasis on the fisheries sub-sector
v. Protection and preservation of the environment.

While the agricultural policy does not speak specifically to climate change adaptation measures, recent Government interventions in agriculture address climate change issues in the sector, particularly as they relate to environmental protection, risk mitigation and fisheries development.

5.3.2. Technology

Francis (2010) notes that although the banana sector in St. Vincent and the Grenadines faced several challenges, which included pests and disease, low soil fertility and low yielding varieties, local farmers and Government agencies have been slow in responding to these problems through the use of modern agro-technology. It is evident that less than half of all farmers in St. Vincent have access to current agricultural technology. Farmers need training in crop growing technologies and sustainable agricultural methods.

5.3.3. Farmers' Adaptation - Initiatives and Actions

Research conducted by Titus *et al*., (2009) reveals that local farmer innovation was either not evident or not adopted in the banana industry. The farmers still, for the most part, operate as they did more than two decades ago. The need to innovate for sustainability of the industry is crucial for all agricultural outputs. This finding is substantiated by FAO (2008) which found no outstanding measures taken to adapt to climate change impacts at the farm level. Moreover, Francis (2010) found that Vincentian farmers introduced new banana cultivars and tissue culture plantlets but did not adopt the irrigation and improved fertilisation techniques required to achieve the projected yields.

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

5.4. *Human Health*

5.4.1. Policy

Environmental Health Services Act (1977) "makes provisions for the protection of human health, harmful vector and disease control" (CEHI, 2007). A National Policy on Wellness was announced in the 2010 Budget Speech. Among other areas it will focus attention on primary health care, water and sanitation and public health (Government of St. Vincent and the Grenadines, 2010). The National Nutritional Policy also addresses food security concerns in the society.

As early as 2002, the Ministry of Health and the Environment submitted a draft policy on Climate Change to the cabinet (Culzac-Wilson, 2003). The draft National Climate Change Adaptation Policy has been developed and while it addresses health, the Minister of Health in Commonwealth Health Ministers' Update 2009 stated that there is a "lack of direct policy to address climate change and health (Commonwealth Secretariat, 2009). The adaptive capacity section of the draft National Economic and Social Development Plan also addresses health (Commonwealth Secretariat, 2009). The country is in the process of preparing its second national communication to the UNFCCC (CIF, 2010). A more detailed assessment of health compared to the initial communication is required. Most recently, the Saint Vincent and the Grenadines Pilot Program for Climate Resilience (PPCR) was prepared. This also identifies health as a vulnerable sector and briefly mentions sanitation concerns and vector borne diseases. The programme seeks to increase climate resistance in all vulnerable sectors (CIF, 2010).

In 2007, the Ministry of Health and the Environment prepared the National Strategic Health Plan 2007 - 2012. It identifies a number of key areas requiring attention, one of which is communicable diseases. Some of the strategies to address communicable diseases include the need to increase communicable disease surveillance, launching a communicable disease awareness programme and improve "surveillance for the prevention of "exotic" vectors entering" the country. It also acknowledges the weakness created in the health sector due to staff deficiencies and proposes the development of a Human Resource Plan for the health sector (St. Vincent and the Grenadines, 2007).

The Draft Road Map toward Integrated Water Resources Management Planning for Union Island, St. Vincent and the Grenadines focuses on water resources but also makes the link between water scarcity, health and sanitation issues. It focuses on Union Island, one of the Grenadine Islands which has serious water challenges. One of the areas requiring further research to develop the final Integrated Water Resources Management Plan is to "Determine water quality and environmental health of community and household RWH systems, establish health and sanitation risk and propose appropriate vector control measures" (CEHI, 2007).

Table 5.4.1: Total expenditure on health as a % of GDP from 1995 – 2009 in St. Vincent and the Grenadines

Year	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
% of GDP	5.7	5.6	6.1	5.6	5.6	6.0	5.9	5.9	5.8	5.9	5.8	5.9	5.3	5.2	5.6
***GGEH as % of GGE**	13.1	12.1	9.2	8.5	8.5	10.8	10.1	10.7	11.0	9.8	10.4	11.2	9.5	9.5	9.5

(Source: WHO, 2011)

** General Government Expenditure on Health (GGEH) as a % of General Government Expenditure (GGE)*

Table 5.4.1 shows the total expenditure on health as a percentage of GPD between 1995 and 2009. The total expenditure on health has remained fairly constant in the last fifteen years while the general Government expenditure on health as a percentage of general governmental expenditure has declined. In 2010, approximately EC $82.8 million (EC $61.2 million in recurrent expenditure and EC $21.6 million in capital expenditure) was allocated to the Ministry of Health and the Environment (Government of St. Vincent and the Grenadines, 2010). Specific estimates for health could not be determined. It has been suggested to help address the many challenges in the health sector, that a more business like approach be taken which includes considerations for health insurance (Kairi Consultants Limited, 2008b).

The main challenges to addressing climate change impacts on the health sector of SVG are the lack of financial and technical resources (CIF, 2010). The country is depending on support from external sources, through projects that can increase the resilience at the community level (Commonwealth Secretariat, 2009). The disparity between imports and exports is continually growing; a situation which contributes to the vulnerability of not only the economy, but the social sector and health of citizens. For instance in 2007 while the food import bill was estimated at EC $157.5 million the food export bill was only EC $46.9 million. This situation was more extreme in 2008 with figures of EC $198.5 million and EC $35.8 million respectively (Government of St. Vincent and the Grenadines, 2010). This will have an effect on the health of the population as non-communicable lifestyle diseases rise in the country.

5.4.2. Management

There are a number of important agencies and institutions with a role in health in SVG. In the Ministry of Health and the Environment there is the Public Health Department and the Health Services Department. The Health Information Unit is involved in education and report writing. However, no reports have been published in recent years (Kairi Consultants Limited, 2008b). The Environmental Health Division has the responsibility "to monitor, regulate, improve, maintain and safe guard the environmental health of the state" (Kairi Consultants Limited, 2008b). Within the division, operates the semi-autonomous Vector Control Unit. The Nutrition Unit provides services for new born babies, hospitals, the public at large and other Government agencies (Kairi Consultants Limited, 2008b). The Environmental Management Department is the focal point for the UNFCCC activities at the national level (Commonwealth Secretariat, 2009).

There is one main hospital in Kingstown, St. Vincent, five other public hospitals and five private hospital throughout the country (Culzac-Wilson, 2003; PAHO, 2007). The 211 bed Milton Cato Memorial Hospital in Kingston is the only referral hospital in the country (PAHO, 2007). These facilities are distributed throughout eleven health districts in the country. In each district there is at least one doctor and in the Grenadines there is one doctor in Bequia, Canouan and Union Island and Myreau is serviced by the Union Island's doctor (Kairi Consultants Limited, 2008b). There are a total of 39 health centres throughout the

country (CEHI, 2007). The Primary Health Care Approach of the Ministry of Health and the Environment ensured that in locating health centres, all citizens were within 2 miles from a primary health care (Culzac-Wilson, 2003). A more recent estimate is 3 miles (PAHO, 2007).

Union Island has one health clinic in Clifton (CEHI, 2007). Each can provide services to up to 3,000 persons (Culzac-Wilson, 2003). Emergency services only exist in St. Vincent; patients from the Grenadines Islands must be flown or shipped to St. Vincent for emergency treatment (Kairi Consultants Limited, 2008b). During natural disasters or other situations requiring emergency services to the Grenadines, this leaves people vulnerable. Some services are not even offered in St. Vincent, for example cardiology, oncology and endocrinology which must be sought in other islands such as Barbados, Trinidad and Tobago and Cuba (Kairi Consultants Limited, 2008b).

With respect to strengthening the services aspect, of the Ministry of Health, initiatives are undertaken every year. In 2010, two new facilities, a Health Centre at Evesham funded by the Basic Needs Trust Fund and the Stubbs Polyclinic will add to the health network of the country. Other initiatives include refurbishment of the Milton Cato Memorial Hospital and the Modern Medical Complex in Georgetown (Government of St. Vincent and the Grenadines, 2010). There are 3 hospital beds per 1,000 of the population in the period 2005 to 2008 (PAHO, 2009).

88.5% regard the service at public health facilities as satisfactory (44.2% satisfied and 44.3% very satisfied with the quality of treatment). Public health clinics (50.4%) and public hospitals (16.2%) are the preferred institutions for people seeking health care in SVG. However, 21.4% indicated that a private doctor/dentist would be the first place they would visit if they require medical treatment (Kairi Consultants Limited, 2008a). Primary health care is free for persons 15 years and under and 65 years and over. The rest of the population has to pay a base fee of $5 with exemptions for indigent persons (Government of St. Vincent and the Grenadines, 2010).

In an institutional assessment carried out for the Country Poverty Assessment for SVG it was observed that there were “a number of critical health issues” in the country (Kairi Consultants Limited, 2008a). For example, like many other Caribbean nations, the country suffers staff attrition of physicians and nurses to other countries such as the British Virgin Islands, Turks and Caicos, the Cayman Islands and to the North Atlantic (Kairi Consultants Limited, 2008a; Kairi Consultants Limited, 2008b). Professionals from Cuba assist in filling vacancies and supporting of the health sector of SVG (Government of St. Vincent and the Grenadines, 2010; Kairi Consultants Limited, 2008a). The Environmental Health Division is also understaffed (Kairi Consultants Limited, 2008b). The 2010 Budget Speech has stated the Government’s intention to create a number of new posts – 13 in the area of laboratory and nursing personnel at the Milton Cato Memorial Hospital and 32 at the Modern Medical Complex at Georgetown (Government of St. Vincent and the Grenadines, 2010).

In SVG, from the perspective of respondents to the Country Poverty Assessment 2007/2008, ill-health was due to the “inability to afford to eat a proper diet on a regular basis, the stress and worry of how to survive and provide for their families and the lack of money to afford good medical care and medication” (Kairi Consultants Limited, 2008a).

Water security should be high on the agenda in the Grenadines given water scarcity concerns. Ways to ensure a reliable supply of water are being developed in different communities with different needs. For instance, one of the initiatives of the Draft Road Map toward Integrated Water Resources Management Planning for Union Island, SVG, was an assessment of the water quality standard of harvested rain water and rain water harvesting systems. This project, which cost US $4,000, also sought to determine

environmental health at the community level (CEHI, 2007). NGOs also have a role in strengthening the adaptive capacity of communities in SVG. After being devastated by floods in April, 2010, the Red Cross delivered safe potable water (through the use of chlorination tablets) to 200 families to reduce and prevent the spread of water borne and related diseases and damage water infrastructure was repaired (IFRC, 2011). Reliable water supplies are also important for health facilities, for example in Union Island, the Celina Clouden Hospital/Clifton Health Centre has its own storage facilitate capable of storing 36,370 litres of water. Excess water may be utilised by residents (CEHI, 2007).

With respect to nutrition, the Nutrition Support Programme, which consists of the School Feeding Programme and a Supplemental Feeding Programme which targets maternal and child care clinics (Kairi Consultants Limited, 2008b), is important in fighting the various forms of nutrition. With respect to water resources, the Environmental Health Division is responsible for monitoring water quality testing and monitoring the level of residual chlorine present in water throughout all health districts in the country. However, residual chlorine testing is not carried out in the Grenadines outside of the hotels which occurs sporadically (Kairi Consultants Limited, 2008b). The Central Water and Sewage Authority conducts water quality monitoring in Union Island if needed (CEHI, 2007).

Ineffective vector control, especially of mosquitoes, is a problem that has its roots in poor management. This has been linked to the high prevalence of *Adesegypti* mosquito, the dengue fever vector present in SVG (CEHI, 2007). This may stem from the functioning of the Vector Control Unit. In terms of the treatment of cases of vector borne diseases, in the Commonwealth Health Ministers' Update 2009, the Minister of Health for St. Vincent and the Grenadines summarised that "the hospital is adequately equipped and staffed to address normal levels of vector borne diseases, however, increased incidences would create a challenge as a result of limited human and financial resources" (Commonwealth Secretariat, 2009).

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, in order to expand its coping range under existing climate variability, or future climate conditions (Brooks & Adger, 2004). Despite global action to reduce greenhouse gases, 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, which 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 are as follows (not in order of priority):

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, Allison, Walmsley, Gaywood, & Thurgate, 2007)

5.5.1. Policy

The capacity of countries to implement climate change adaptation strategies will be enhanced by policies that take advantage of linkages between socio-economic and environmental sectors. The Government of SVG recognises the importance of conserving biodiversity and has established legislation and programmes to reflect this viewpoint. The Government of SVG is a signatory to several Multilateral Environmental Agreements. These are listed in the Table 5.5.1 below with the dates of ratification.

Table 5.5.1: St. Vincent and the Grenadines – Multi-lateral Environmental Agreements and Year of Ratification

Multilateral Environmental Agreements	Year of Ratification
SPAW Protocol	1991
United Nations CBD	1996
UNFCCC	1996
UNCCD	1998
Cartagena Convention	1999

In the national legislation, the main laws that pertain to the management of natural resources are:

- The Fisheries Act (1986) provides for the management and development of fisheries as well as the protection of special areas designated as Marine reserves.
- The Wildlife Protection Act (1987) provides for the protection and management of the Nation's wildlife and authorises the establishment of wildlife reserves for that purpose. It is under this Act that the SVG's 24 wildlife reserves have been established.
- The Forests Resources Conservation Act (1992).
- St. Vincent and the Grenadines National Trust Act, 1969.
- Environmental Health Services Act, No. 14 of 1991.
- The Town and Country Planning Act, 1992.

The Town and Country Planning Act, 1992 provides a mechanism for consideration to be given to environmental consequences of national projects, by requiring EIAs required for projects likely to have adverse effects on the environment. The Act gives the Physical Planning and Development Board the authority to require EIAs for projects likely to cause pollution or have adverse effects on the environment. Nonetheless, EIA requirements in the Town and Country Planning Act do not guarantee adequate consideration of environmental impacts of development projects and current actions to minimise adverse impacts on biodiversity are inadequate. (MHE, 2010).

In May 2009, the Caribbean agreed to be one of two Regional Track pilot programs for climate resilience as part of a World Bank funded initiative (PPCR – *Pilot Program for Climate Resilience*). The Regional approach addresses i) country investments in six vulnerable nations and ii) region-wide activities addressing climate risks and vulnerabilities common to all Caribbean countries. SVG was selected as one of the 6 pilot countries. Following consultations in SVG in 2010 and 2011, a national Strategic Programme for Climate Resilience (SPCR) was developed (Mendoza, 2011). Component 3 of the SPCR addresses strengthening the policy, legal and institutional framework to address climate change. This includes a range of proposed activities but the one that is specifically relevant to biodiversity and fisheries is a proposal to expand the policy/legal framework to deal with issues related to climate change, in particular a "revamping of the land use or spatial planning legislation in the Caribbean to incorporate climate change resilience; development of new land codes/practices and guidelines". A summary of the PPCR investment for SVG is shown in Table 5.5.2.

Table 5.5.2: Summary of the PPCR Investment Programme for St. Vincent and the Grenadines

PPCR Investment Programme – St. Vincent and the Grenadines		
Project Component 1	Component 1: Climate Vulnerability, Risk Assessments and Risk Reduction	$6,130,500
Project Component 2	Component 2: Data Collection, Analysis and Information Management	$953,910
Project Component 3	Component 3: Strengthening of existing policy, Legal and Institutional Framework to address Climate Change	$1,165,00
Project Component 4	Component 4: Design and implementation of a Public Education and Capacity Building Programme	$805,000
	Primary Total	**$9,054,410**
	Project Management 10%	$905,441
	Secondary Total	**$9,959,851**
	Contingency	$40,149
	GRAND TOTAL	**$10,000,000**

(Source: Mendoza, 2011)

5.5.2. Management

Successful implementation of international and national policies depends on related institutional arrangement. 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). The responsibility for managing biodiversity falls mainly under the Ministry of Health, Wellness; the Environment and the Ministry of Agriculture, Rural Transformation, Forestry and Fisheries; and the Ministry of Housing, informal Human Settlements, Physical Planning and Lands and Surveys. Spread across these 3 ministries are various departments and divisions that often share responsibility for coastal zone management, natural resource management, biodiversity and physical infrastructure.

Capacity for management is often limited by a lack of co-ordination and integration between the various Ministries. It is also limited by a lack of human and technical capacity, due to a lack of financial resources.

For instance, most of the forests in St. Vincent and the Grenadines are located on Government lands. Management therefore, is done primarily through the Forestry Department. Direct national spending on the forestry sector stands at only 2.1 million Eastern Caribbean dollars (US $770,000) annually. The Forest Resource Conservation Act, 1992 make provision for the conservation, management and proper use of the forest and watersheds. This includes the declaration of forest reserves, protected areas within forest reserves, demarcation of forest boundaries, forest management plans etc. The organisational structure of the Department also includes the management of the upper watersheds. The Watershed Unit is headed by a forestry supervisor and one assistant who performs more of a co-ordinating function.

Strengthening protected area networks is one way of adopting an eco-system based approach to adaptation, i.e. one that integrates biodiversity, eco-system services and people into an overall strategy to build resilience and reduce exposure to the adverse impacts of climate change (Colls, Ash, & Ikkala, 2009). Strengthening the capacity to manage the network of protected areas on the main island of St. Vincent must be seen as a priority for the long term management of the nations biodiversity. St. Vincent has several globally important forest reserves. These are listed below and are shown on Figure 5.5.1:

- The Cumberland Forest Reserve
- The Dalaway Forest Reserve
- The Kingstown Forest Reserve
- La Soufrière National Park Reserve
- The Mount Pleasant Forest Reserve
- The Richmond Forest
- The Colonarie Forest Reserve

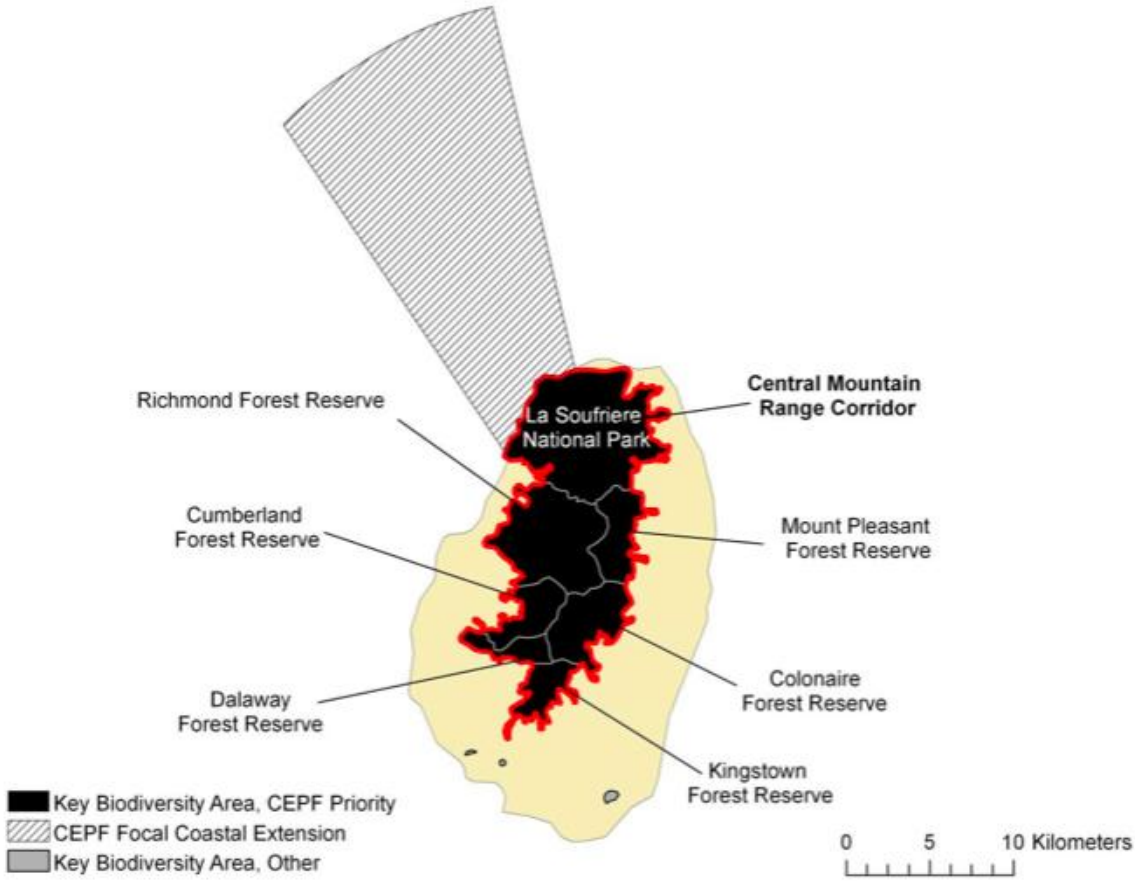


Figure 5.5.1: Map of Forest Reserves and Key Biodiversity Areas

(Source: CEPF, 2009)

The Fisheries Division operates under the Ministry of Agriculture, Forestry & Fisheries and is responsible for the overall management and development of the Fisheries sector. It is comprised of six units: Biology and Research, Extension, Public Education, Data, Quality Control/Product Development, Conservation. Each unit is headed by a Fisheries Officer, with the other supporting staff being Senior Fisheries Assistants, Fisheries Assistants, Data Collectors, Typist, Junior Clerk, Boat Captain and Driver. The Chief Fisheries Office is the Head of the Division and reports directly to the Chief Agricultural Officer.

The Tobago Cays Marine Reserve is a collection of five small islands, sheltered lagoons and coral reefs to the east of Mayreau, that is now considered a successful marine protected area. While progress has been made with the establishment of the Tobago Cays Marine Park, this is just a start. Protection of the marine environment must be a priority set of actions that are locally owned and implemented, with strong Government support. The Sustainable Grenadines Project (SusGren) is seeking World Heritage Site listing under the UNESCO World Heritage Convention. Amongst numerous conditions to be satisfied for such

listing, a comprehensive Plan of Management must be in place and operational. Such a Plan of Management could provide a firm basis of long term protection from climate change impacts in the fragile eco-systems of the Grenadines and for coastal St. Vincent.

The Grenadines Network of Marine Protected Areas Established is developing a partnership between Grenada and SVG to build capacity and public support for new marine protected areas. The network will aim to share experiences across national borders and encourage communication between staff and board members of the three marine parks. Representatives of the Governments of both St. Vincent and the Grenadines and Grenada recently attended this first networking meeting. Also represented were St. George's University, the University of the West Indies, the Caribbean Marine Protected Areas Management Network and Forum (CaMPAM), SusGren and the Environmental Law Institute. Mr Roland Baldeo, Marine Protected Area Co-ordinator from the Fisheries Division of the Ministry of Agriculture and Fisheries in Grenada explained "As our reefs and oceans face increasing threats from overfishing, pollution and climate change we need to join forces. The three marine protected areas have undertaken to share information and collaborate together to promote the conservation and sustainable use of our marine resources." This initiative is a joint effort made possible with support from the US National Fish and Wildlife Service and the UNEP-Caribbean Environment Program through the Small Grant Program coordinated by CaMPAM and GCFI with funding from the Italian Ministry of Foreign Affairs to support the Caribbean Challenge initiative.

The Government of SVG should be praised for its willingness to enter into partnership with neighbouring countries, NGOs and CBOs to ensure effective management of its protected areas. At the 7th Conference of the Parties (COP7) of the Convention on Biological Diversity (CBD) in 2004, the Nature Conservancy, CERMES and RARE signed a Memorandum of Understanding with the Government of St. Vincent and the Grenadines, in which parties committed to work together in the implementation of a program of Work on Protected Areas. This MOU is commonly known as the Protected Areas National Implementation Support Partnership (NISP). The NISP committee of St. Vincent and the Grenadines undertook an initial Gap Analysis in 2005 to identify priorities. The priorities for St. Vincent and the Grenadines included baseline environmental surveys, conducting and completing a management effectiveness assessment, a sustainable finance plan, a capacity development plan and an ecological gap analysis for the protected area system.

The objective of the Ecological Gap Analysis conducted in 2005 was to determine how the current system of protected areas represents St. Vincent's biodiversity and to identify actions that could be taken to ensure good representation of that biodiversity. The analysis indicates that Moist Forest, Dry Forest, Freshwater Systems and Marine Ecosystems are currently represented within established protected areas. Sites were prioritised based on ecological importance, overall threat level to the biodiversity and feasibility of establishing effective management at the site level. A timeline has been created to achieve the CBD commitment to protect 10% of terrestrial resources by 2010 and 10% of marine resources by 2012. Highest priority was given to Soufriere. High priority sites included the Southern Grenadines Management Unit, Buccament/Vermont Corridors, Leeward Coast MPA and the Fenton Corridors. Medium priority was assigned to the Northern Grenadines Management Unit, Cumberland Corridors and Owia and Fancy.

5.5.3. Technology

A high degree of access to and training with, relevant technologies at various levels (i.e. from local to national) and across sectors, will play a significant role in biodiversity adaptation to climate change (Burton, 1996). Successful implementation of MEAs hinges on the use of both scientific and traditional knowledge.

As a general rule, access to and use of, environmental technologies for biodiversity conservation and fisheries has been limited in SVG due to a lack of resources. The Government recognises this deficiency and has recommended that a *Geographical Information System (GIS)* database for biodiversity information be created to improve the effectiveness of biodiversity management. The activities surrounding the implementation of this strategy involve

- Establishment of a committee to guide general GIS Development Policy within the state.
- Establishment of a set of broad goals and long term objectives for the establishment of the Biodiversity GIS.
- Establishment of a national Biodiversity database inclusive of data formats and standards for accuracy and detail of all data to be incorporated in any national GIS System.
- Facilitation of data transfer between the various institutions responsible for biodiversity and natural resource management.

Progress in implementing this strategy has been limited. A National GIS Unit has been set up within the Physical Planning Department and there is limited GIS Capability within the Forestry Department, Fisheries Division and the National Parks Authority. However, none of these set ups are specifically focused on biodiversity. Furthermore, although the National GIS Unit has primary responsibility for GIS in the country, it faces significant resource constraints in terms of acquiring sufficient hardware and current software licenses. However, the Unit is set to receive assistance under the UNDP/GEF Capacity Building and Mainstreaming of Sustainable Land Management project, to acquire licenses for 5 years and to update some of its equipment. Memoranda of Understanding between various departments will also be set up to improve data transfer and information sharing between different agencies involved in natural resource management (MHE, 2010).

Over the past few years there have not been any systematic efforts to expand, revise and enhance biodiversity research and inventorying in SVG. Nonetheless, there have been a number of one-off projects that have, in some way, contributed to improving knowledge on various aspects of SVGs biodiversity. Among these initiatives are:

- The Grenadines Marine Resource Space-use Information System (MarSIS) project implemented by CERMES and the Sustainable Grenadines Project complied information on marine space-use in the Grenada Bank that can be used to identify areas for special management attention such as critical habitats; representative marine ecosystems, areas of high aesthetic value and cultural importance; areas important for livelihoods, fishing grounds and marine based tourism; areas of highest human threat and space use conflict. An innovative, participatory approach was utilised by Dr. Kim Baldwin of CERMES, involving a range of stakeholders in the information gathering and research processes to create the GIS database.
- Under the OECS PERB Project, a biodiversity inventory and assessment was conducted for the Kingshill Forest Reserve. The information collected will be entered into a web based OECS database that will be periodically updated with the help of the OECS Environment and Sustainable Development Unit (ESDU).
- Fisheries Survey for the South Coast of St. Vincent was conducted in late 2009 by the Fisheries Division in conjunction with the Nature Conservancy. The final report will contain important information on the health of the marine habitat and fisheries stock in the area.
- The Tobago Cays Marine Park regularly conducts inventories of the sea grass beds, fish, coral and marine vertebrates found within the Park. Regular assessments are also done on Mustique Island, organised by the Mustique Company

- The Forestry Division conducts a bi-annual Parrot Census as well as regular inventorying of the population of the endemic Black Snake and Endemic Frog. Bird Life International and Avian Eyes conduct inventories from time to time on important bird areas / species found in SVG.

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

Based on the above evaluation, actions need to be taken to minimise infrastructure losses in vulnerable areas of St. Vincent and the Grenadines. The current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in economic losses for St. Vincent and the Grenadines and its people. Adaptations to minimise vulnerabilities in St. Vincent and the Grenadines 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.

Given the historical damage caused by event driven coastal erosion, as well as slow onset SLR, the need to design and implement better strategies for mitigating their impacts is becoming apparent. There are a number of solutions that can be used to tackle beach erosion. Unfortunately, most of the common solutions such as beach replenishment and groynes are only temporary and their cost makes them unaffordable. There are three main types of adaptation policies that can be implemented to reduce the vulnerability of the tourism sector in St. Vincent and the Grenadines to SLR and improve the adaptive capacity of the country: (i) Hard engineering defences and (ii) soft engineering defences, which both aim to protect existing infrastructure and the land on which the infrastructure is built, as well as (iii) 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 ICZM 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 ICZM rather than an endpoint (Linham & Nicholls, 2010).

Table 5.6.1: Summary of Adaptation Policies to reduce the vulnerability of SVG to SLR/ 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 sea walls, reflect waves causing turbulence and undercutting) - Expensive - Requires ongoing maintenance - Scouring at the base of the sea wall 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 defences - 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

(Sources: [1] (Silvester & Hsu, 1993)[2] (Nicholls & Mimura, 1998)[3] (French, 2001) [4] (El Raey, Dewidar, & El Hattab, 1999)[5] (Krauss & McDougal, 1996)[6] (Boateng, 2008)[7] (Lasco, Cruz, Pulhin, & Pulhin, 2006)[8] (Hamm, Capobiancob, Dettec, Lechugad, Spanhoffe, & Stivef, 2002) [9] (Fankhauser, 1995)[10] (Orlove, 2005)[11] (Patel, 2006)[12] (Barnett J. , 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. For densely populated cities, a sea wall may be worth the investment when the costs of the protected lands are taken into account.

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 sea wall can cause beach loss, a crucial tourism asset, at the front of the wall (Krauss & 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 minimising 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 ongoing 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). 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 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).

There are a variety of agencies that are involved in coastal zone management (CZM) in St. Vincent and the Grenadines, many of which take part in climate change risk assessment, as well as policy and regulatory measures. Agencies include the Ministry of Physical Development and the Environment; Ministry of Agriculture, Lands, Forestry and Fisheries; Meteorological Office; and the Ministry of Health, Wellness and the Environment (St. Vincent and the Grenadines 2011, UNESCO 2003). Given the number of agencies that are all responsible for managing development and fostering stakeholder participation in environmental management, the approach to CZM becomes highly disintegrated. Given the onset of climate impacts on coastal areas, as well as projected long term impacts of climate change, a fundamental shift in governance toward a more integrated coastal zone management (ICZM) approach is required.

St. Vincent and the Grenadines is part of the Pilot Program for Climate Resilience (PPCR) which is funded by the Strategic Climate Fund (Climate Investment Funds, 2011). The purpose of PPCR is to exhibit ways that developing countries can include climate risk and adaptation as part of their development planning process. This includes providing technical and financial assistance to aid St. Vincent and the Grenadines with integrating climate resilience into their national and sectoral development plans (Climate Investment Funds, 2011). As members of PPCR, St. Vincent and the Grenadines is committed to proposing and formulating coastal zone related policies (St. Vincent and the Grenadines, 2011). A pilot project has begun on Union Island to assess the benefit of ICZM and to allow for a review of ICZM elements, adjusting those components of ICZM that are not in keeping with the local context. Results from this evaluation will be used to guide ICZM for all other islands in St. Vincent and the Grenadines (Saint Vincent and the Grenadines, 2011). While this is a positive step, as of yet, there remains no comprehensive plan to deal with the impacts of climate change, with no ICZM plan for St. Vincent and the Grenadines adopted. Previous planning controls have also not included much attention of coastal ecosystem protection for climate resilience (Saint Vincent and the Grenadines, 2011).

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 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[2] 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).

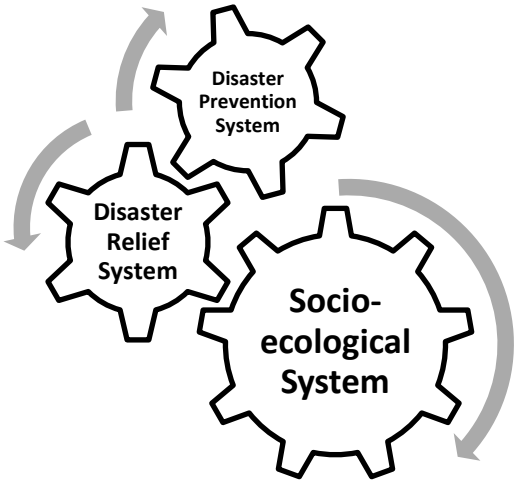


Figure 5.7.1: Relationship of the Disaster Management System and Society

Caribbean disaster management and climate change

As a region, the Caribbean has made co-ordinated 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, 2010a). The primary purpose of CDM is to strengthen regional, national and community level capacity for *mitigation*, *management* and *co-ordinated response* to natural and technological hazards and the effects of climate change (CDEMA, 2010a) (*emphasis added*).

[2] 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 Harmonisation 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, 2010a).

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 practical strategies for action which will build resilience in the Caribbean to the predicted impacts from climate change.

Table 5.7.1: Enhanced Comprehensive Disaster Management Programme Framework 2007-2012

GOAL Regional Sustainable Development enhanced through Comprehensive Disaster Management			
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.**			
OUTCOME 1: Enhanced institutional support for CDM Program implementation at national and regional levels	**OUTCOME 2:** An effective mechanism and programme for management of comprehensive disaster management knowledge has been established	**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)	**OUTCOME 4:** Enhanced community resilience in CDERA states/ territories to mitigate and respond to the adverse effects of climate change and disasters
OUTPUTS *1.1 National Disaster Organisations 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*	***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*	***OUTPUTS*** *3.1 CDM is recognised 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*	***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 organisations 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 Standardised 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*

(Source: CDEMA, 2010)

5.7.2. Management of Disasters in St. Vincent and the Grenadines

Disaster management in SVG is lead by the National Emergency Management Office (NEMO). They offer various services including:

- Informing and information dissemination
- Warning, analysis and forecasting
- Coordinating resource distribution during emergencies
- Providing and maintaining extraordinary resources as well as the diversion of regular resources to meet emergency needs
- Evaluating the performance of the organisation with the view to its improvement (NEMO, 2011a)

There are two policy documents, the Disaster and Emergency Management Act and the National Disaster Plan, which have created a disaster management system with three levels of disaster response and planning. National committees consist of representatives from various sectors and the committees determine the management planning framework. District committees have been created as a mechanism for de-centralisation of power and at the lowest level, there are now 40 community level committees that have received training in damage assessment, shelter management, relief supplies management, first aid and related activities (GFDRR, 2010a). This provides a strong basis for disaster management, especially when coupled with the regular public awareness campaigns issued by NEMO and the Prime Minister.

NEMO is housed under the Ministry of National Security, Air & Sea Port Development and as such has more of a reactive mandate, as is seen in the services they provide in SVG. These are important activities but there is a need for a more holistic approach to disaster management that focuses on all stages of the disaster management cycle. In acknowledgement of the changing disaster management field, NEMO has recently embarked on more proactive approaches to disaster and emergency management. For example, the recent "CDM training for the Public Service was officially launched on October 10, 2011 at the Services Commissions Department Training Room, followed by a two day training workshop for thirty-two liaison officers to increase collaboration with NEMO and key agencies in CDM and in keeping with the National Emergency and Disaster Management Act No. 15 of 2006 section 26.1" (NEMO, 2011b). While NEMO plays a lead role in disaster management in SVG, the organisation cannot be successful without the support and sensitisation of other Senior Civil Servants.

Successful disaster management demands a thorough understanding of environmental processes and natural hazards. In SVG, there is recognition of the importance of disaster management to environmental management as well. In the National Environmental Management Strategy and Action Plan, Principle 9 is to "Prevent And Manage the Causes and Impacts of Disaster" (Homer & Shim, St. Vincent & the Grenadines Environmental Management Strategy and Action Plan, 2004). Two strategies, with specific activities, are therefore designed to help NEMO achieve this part of the environmental management plan.

Strategy 29: *Establish at the community and national levels, appropriate and relevant integrated frameworks to prevent, prepare for, respond to, recover from and mitigate the causes and impacts of natural phenomena on the environment and to prevent manmade disasters.*

Activities:

i. *Develop and promote the National Disaster Plan to communities throughout SVG. [National Emergency Management Organisation]*
ii. *Train local agencies at the district/village level to help coordinate local level activities in response to a disaster. [National Emergency Management Organisation]*
iii. *Participate in the Comprehensive Disaster Management programme in the Caribbean. [National Emergency Management Organisation]*

Strategy 30: *Exchange information with other States or agencies, relating to the experiences and lessons to be learnt from the causes and impacts of natural and manmade hazards and phenomena on its environment.*

Activities:

i. *Participate in activities of the Caribbean Disaster Emergency Response Agency and other disaster management activities; and share local disaster management information with other agencies in the Caribbean as appropriate. [National Emergency Management Organisation]*

These strategies were developed in 2004 and efforts to achieve them are already visible in SVG. There are community level disaster committees and NEMO is part of CDEMA activities. It is important that the link between environmental management and disaster management be made, although by only outlining activities for NEMO to conduct, synergies and linkages may be missed. For example, better integration of NEMO, the Environmental Services Unit and the Central Planning Division (as is visible in other strategies) would demonstrate a more integrated strategy of managing risks from natural hazards and planning development in SVG in a way that keeps risks and vulnerability to a minimum.

Climate change adaptation and disaster risk management

NEMO has been identified as a national institution with good placement to act as the lead on climate change adaptation. This work under the Strategic Program for Climate Resilience (SPCR) is complementary to disaster management activities. The SPCR has designed one of the objectives to optimise this link. The strategy aims "to improve the institutional capacity of NEMO to guide the national programmes both of the public and private sectors in building resilience in support of climate change adaptation using public education as a vehicle" (Government of Saint Vincent and the Grenadines, 2011b). Since vulnerability to climate change has many similarities to the natural hazard vulnerabilities facing SVG, this is a logical action that will improve resilience in both areas.

NEMO is thought to be a good lead organisation but their limitations in generating all the necessary climate change resources are acknowledged and support from other agencies and community groups will be needed (Government of Saint Vincent and the Grenadines, 2011a, p. 74). As such, the enhancement of local Community Disaster Management Committees is also suggested as part of the SPCR. Community disaster committees would therefore need training, equipment and resources for public education. Furthermore, the SPCR proposes funding various projects under the institutional strengthening of NEMO, including training technical staff and community "champions" for climate change resilience building (Government of Saint Vincent and the Grenadines, 2011a, p. 74).

Funding Post-disaster Activities

The Eastern Caribbean Donor Group (ECDG) is a mechanism for co-operation between development agencies in Barbados and the Eastern Caribbean. Operating under the UNDP, the Eastern Caribbean Donor Group for Disaster Management (ECDGDM) facilitates disaster and emergency response activities at the request of the affected Member State (UNDP , 2011). In conjunction with CDEMA, the ECDGDM provide funds for initial damage assessments following an impact and assist the national Government in co-ordinating the response. 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). This kind of 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. Co-ordinating activities across multiple countries builds response capacity by taking advantage of the resources and personnel from neighbouring countries and thus enhancing 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 institutionalising disaster risk reduction goals.

5.7.3. 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 SLR section.

Technology and Public Education

Technology can enhance disaster management at all stages of the disaster management cycle. One central area where information about hazards, preparedness and response can be disseminated is through the education system. The current national curriculum is deficient in detail on climate change and disaster risk reduction. Teachers require better training and high school curriculum must include materials appropriate for the age groups, including text books with Caribbean specific information (Government of Saint Vincent and the Grenadines, 2011a, p. 18).

The geography of coastal communities in SVG creates a unique opportunity for community level DRR. It has been proven worldwide, that community DRR is the most effective method to address vulnerability and risk because of the teamwork and cohesion that often results in small communities (Government of Saint

Vincent and the Grenadines, 2011a, p. 88). Due to the disconnected nature of coastal communities in SVG collective disaster and climate change resilience goals can be enhanced through independent efforts in each community. Co-operation and teamwork at a local scale can allow national level agencies to focus on co-ordination and response in the worst affected areas, which should lead to better response during an emergency.

More recently, as a component of the SPCR, the "Development of information packages for families and communities in the "Red Zone" project was developed. This project will take an "all hazards" approach to community-based disaster risk reduction, coastal eco-systems information etc. and will deliver talks, leader training and advocacy training, for those living in high risk areas or the "Red Zone"" (Government of Saint Vincent and the Grenadines, 2011a, p. 19).

Annually the International Day for Disaster Risk Reduction occurs in October. Many countries use this day as a day to remind people of the importance of DRR, hazard identification and preparedness activities. SVG has also made use of this day to target children and youth education. On October 13th the Teachers Co-operative Credit Union Youth Group was invited to participate in a workshop under the theme "the role of youths in disaster risk reduction in St. Vincent and the Grenadines" (NEMO, 2011c; NEMO, 2011a).

Figure 5.7.2: Step Up for Disaster Risk Reduction Day October 13, 2011

(Source: NEMO Facebook page, 2011)

Early Warning Systems (EWS)

An EWS is commonly used in conjunction with an evacuation plan to guide at risk people 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.). In SVG, the Meteorological Service issues warnings with information from the National Oceanic and Atmospheric Administration (NOAA) and the National Hurricane Center (NHC) in the United States of America. The Ministry of Agriculture does maintain a system of stream gauges and meteorological stations in SVG, but it is not automated (GFDRR, 2010a). Seismic monitoring is done by

the University of the West Indies Seismic Research Centre, which is a regional system including 5 stations coupled with 8 GPS (Global Positioning System) in SVG (GFDRR, 2010a). The Soufrière Monitoring Unit is located in the SVG Ministry of Agriculture to maintain the stations and information is then relayed to the UWI Seismic Research Centre for analysis and reporting.

While these monitoring and data collection stations are good evidence of efforts to collect data which informs decision making on disaster risk management and climate change adaptation, there are some challenges in SVG. For example, the

"fragmented approach to data management … has its challenges, including gaps, duplication and limited institutional capacity to capture and share information within and between Ministries and agencies. There is need for data collection and analysis on various aspects of resilience to climate change in affected sectors and dissemination to the potential beneficiaries." (Government of Saint Vincent and the Grenadines, 2011a, p. 6).

This challenge was identified during the development of the SPCR and so there is now an opportunity to address this problem going forward. Decision making is optimised with all possible data sources and are shared and available to inform decisions. Furthermore, promoting co-operation and finding synergies allows all agencies to make the most of their limited budgets.

5.7.4. Policy

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.

The National Emergency and Disaster Management Act No. 15 was made in 2006 to establish NEMO and its operational authorities, particularly for disaster planning and response (GFDRR, 2010a). Along with this policy document, the National Disaster Plan assigns responsibilities to various Government and private sector organisations for a variety of hazard situations. However, national development plans do not yet mandate disaster risk management as an objective (GFDRR, 2010a). Until there is specific legislation that governs multiple ministries to consider disaster risk in their activities, national level vulnerability and capacity will remain somewhat limited. Mainstreaming of disaster risk reduction has been identified as the best way for countries exposed to multiple hazards to achieve development and reduce losses from natural processes. In SVG, there has been active co-operation between different ministries and non-Governmental organisations in the areas of preparedness and response; therefore better risk reduction planning and risk avoidance strategies must now become the focus (GFDRR, 2010a).

In the SPCR, it is recommended that the Disaster Management Act be reviewed in an effort to improve the quality of governance and support the mainstreaming of climate change resilience into development planning (PPCR, 2011). "The current National Emergency Plan is outdated and does not address climate resilience issues or some other key disaster management issues. The new National Emergency Plan will be prepared to address key issues in disaster management" (Government of Saint Vincent and the Grenadines, 2011b, p. 71).

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.

In the First National Communication to the IPCC (NEAB and MOHE, 2000), a project to develop a National Environmental Management Plan identified the development of a "disaster management plan that addresses the training of local disaster committees, the preparation of disaster plans at the national and community levels, the development of mitigation plans and the establishment of early warning systems". This has now been accomplished since the creation of NEMO in 2006 and ongoing efforts are in place for training and NEMO has an active public awareness campaign schedule.

Environmental Impact Assessments (EIAs) are not legislated in SVG, except for waste management facilities (Trotz, Rogers, de Romilly, & Clarke, 2004). Apart from waste management facilities, EIAs are conducted on a case by case basis and guidelines for undertaking such a study are determined by the person or organisation making the application (Trotz, Rogers, de Romilly, & Clarke, 2004). In the absence of a required EIA that includes a natural hazard assessment, planning and development can generate risk. While some hazard mapping has been conducted for SVG, there are many areas where hazard information is not available to either NEMO or the Ministry of Planning. NEMO supports only limited geographic information system (GIS) mapping capacity and current GIS based maps have only basic information (roads, contours, rivers, coastline, agricultural and urban land use) (GFDRR, 2010a, p. 242). Volcanic risks have been mapped but other hazards pose greater risk in terms of the frequency of conditions during which they are possible (i.e. landslides occurring from heavy rainfall). Environmental and land use planning have specific interests in understanding the nature and geography of hazards in SVG and more work is needed in this area so that development in the islands is done with good awareness of the risk levels.

Building Codes

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 Caribbean Application Document (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 Sub-committee who will provide comments before it is submitted to CARICOM (Personal communication - Jonathan Platt, Barbados National Standards Institute. May 4, 2011). In SVG "the passage of the National Building Code legislation has provided the legal framework for advances in this area and regulations are to be issued during 2009; however, the integration of resilient practices and designs for vulnerability reduction are not yet mainstreamed" (GFDRR, 2010a, p. 243).

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 (Kambon, et al., 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). The benefits of this insurance scheme been seen in SVG when in 2010 Hurricane Tomas caused serious damages to the country. That said, an index that considered excess rainfall would have led to greater assistance being provided to SVG after Tomas.

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 Georgetown 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 30 respondents were surveyed, 8 of whom were male and 22 female. There were 16 respondents from male headed households and 12 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 St. Vincent and the Grenadines, with 63% (N= 19) 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 Community

Residency	Male		Female		Total	
Less than 1 year	0	0%	2	9%	2	7%
1 - 5 years	1	13%	1	5%	2	7%
6 - 10 years	1	13%	1	5%	2	7%
11 - 15 years	1	13%	0	0%	1	3%
16 - 20 years	1	13%	3	14%	4	13%
Over 20 years	4	50%	15	68%	19	63%

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	13%	3	14%	4	13%
25 - 34	0	0%	5	23%	5	17%
35 - 44	0	0%	6	27%	6	20%
45 - 54	3	38%	4	18%	7	23%
55 - 59	1	13%	0	0%	1	3%
Over 60	3	38%	4	18%	7	23%

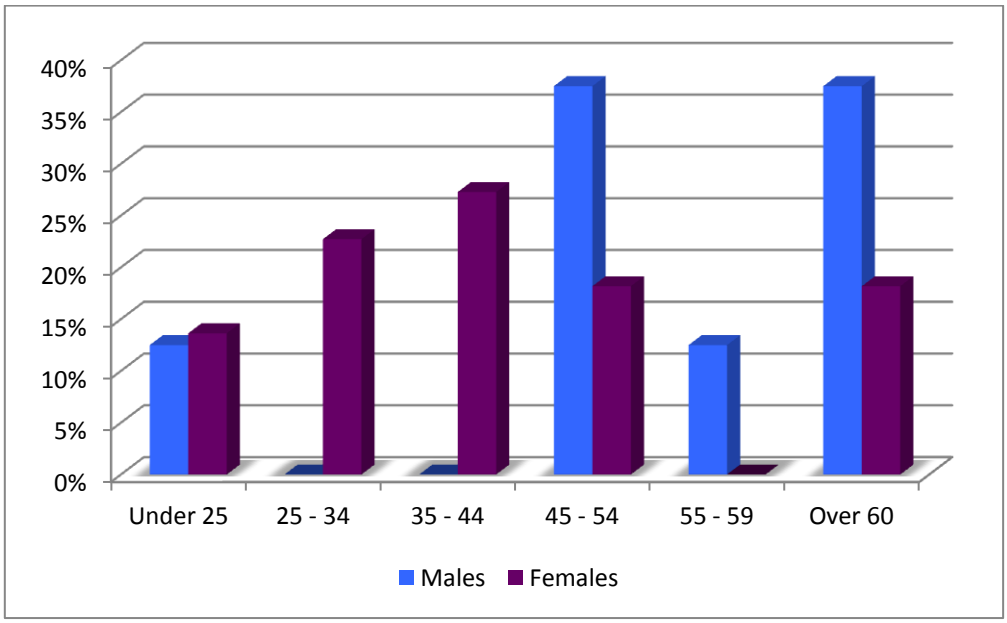


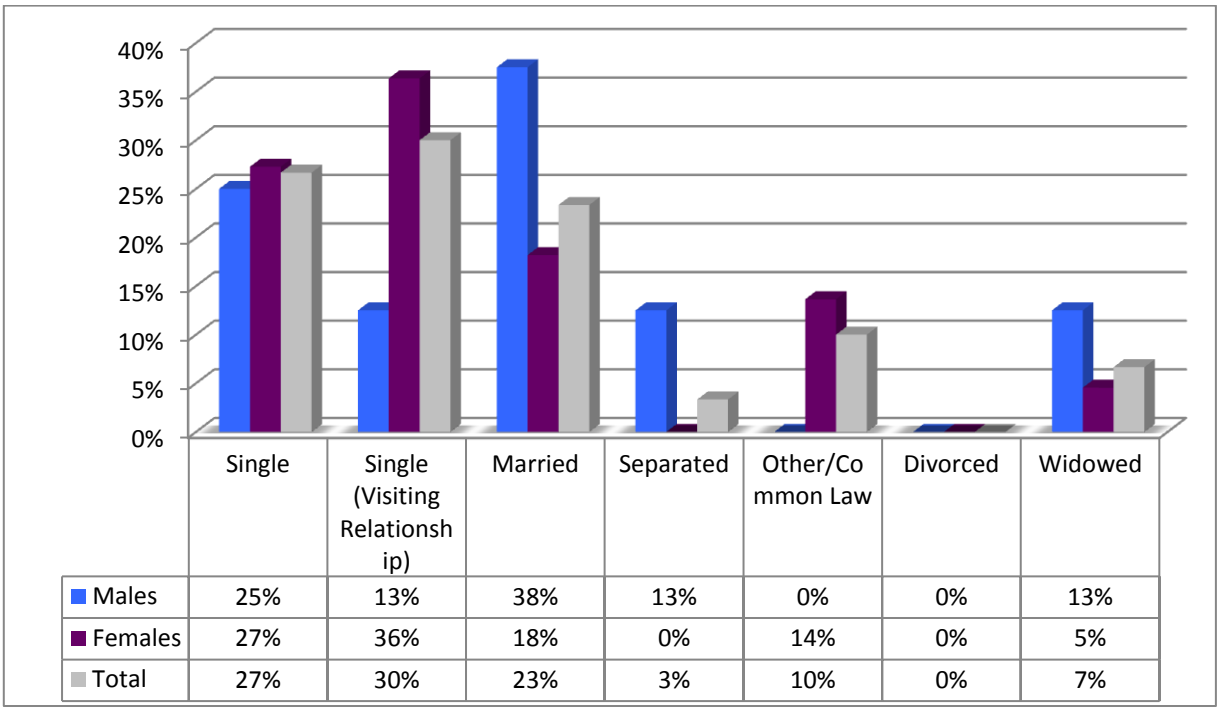
Figure 5.8.1: Age of Respondents

Household Form and Structure

Only 23% of the respondents were married and 27% were single. Another 30% of respondents indicated being involved in visiting relationships. One male respondent and one female respondent were widowed and one person was divorced.

Table 5.8.3: Relationship Status of Respondents

Status	Male		Female		Total	
Single	2	25%	6	27%	8	27%
Single (Visiting Relationship)	1	13%	8	36%	9	30%
Married	3	38%	4	18%	7	23%
Separated	1	13%	0	0%	1	3%
Other/ Common Law	0	0%	3	14%	3	10%
Divorced	0	0%	0	0%	0	0%
Widowed	1	13%	1	5%	2	7%



	Single	Single (Visiting Relationship)	Married	Separated	Other/Common Law	Divorced	Widowed
Males	25%	13%	38%	13%	0%	0%	13%
Females	27%	36%	18%	0%	14%	0%	5%
Total	27%	30%	23%	3%	10%	0%	7%

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. When disaggregated by gender 88% of males respondents indicated they were the heads of their households with only 41% of females indicating this role. There were slightly more male headed households comprising the sample, compared to female headed households.

Table 5.8.4: Perception of Headship of Household

Perceived as Head of Household	Sex of Respondent			
	Male		Female	
Yes	7	88%	9	41%
No	1	13%	13	59%

Table 5.8.5: Household Headship by Gender

Gender of Respondent	Male Headed Household		Female Headed Household		Sample	
Male	7	43.8%	1	8.3%	8	28.6%
Female	9	56.2%	11	91.7%	20	71.4%
Total (% of sample)	16	57.1%	12	42.9%	28	100%

With regards to household size, 14% (N=4) of respondents indicated that they lived in households of one persons and 32% lived in households of two or three persons. Furthermore, 36% of respondents belonged to households with between four and five persons, 14% belonged to households with six or seven persons. Only one respondent (in a female headed household) indicated living in a household with more than 10 people. There were similar distributions based on the gender of the respondent.

Table 5.8.6: Family Size by Sex of Head of Household

Size of Household	Headship of Household					
	Male		Female		Total	
1	3	19%	1	8%	4	14%
2 - 3	5	31%	4	33%	9	32%
4 - 5	5	31%	5	42%	10	36%
6 - 7	3	19%	1	8%	4	14%
8 - 9	0	0%	0	0%	0	0%
10 and over	0	0%	1	8%	1	4%

5.8.3. Education and Livelihoods

Those who completed a primary level of education comprised the largest portion of the sample (N=15/41%), followed by 27% who had completed ordinary level secondary studies. One female went to community college and two attended a teachers college. Two respondents have completed tertiary level studies. The percentage of residents who have not completed any studies beyond primary level education are severely constrained in the job market, and may be restricted mostly to low-paying or minimal wage jobs. Education and employment are two significant factors in facilitating improvement and social mobility. The lack of basic required qualifications (e.g. secondary school education) amongst residents is therefore one area of capacity that needs to be addressed.

Table 5.8.7: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		Total	
Primary	3	38%	12	55%	15	50%
Secondary (Ordinary Level)	3	38%	5	23%	8	27%
Secondary (Advanced Level)	0	0%	0	0%	0	0%
Community College	0	0%	1	5%	1	3%
Technical-Vocational Institute	0	0%	0	0%	0	0%
Teachers College	1	13%	1	5%	2	7%
Tertiary	1	13%	1	5%	2	7%

Based on Figure 5.8.3, most households reported an income of less than US $1,000 per month. No household reported an income that was greater than US $1,500. When disaggregated by gender, the graphy shows that while 40% of female headed households recorded earning less than US $500 per month, none of them earned more than US $1,000. Male headed households overall earned marginally more income than female headed households. It is previously noted that the lack of further education of some residents may be prohibiting them from working in better-paid positions. To facilitate any improvements in the income situations of households, interventions will first need to focus on promoting further education and skills training amongst residents.

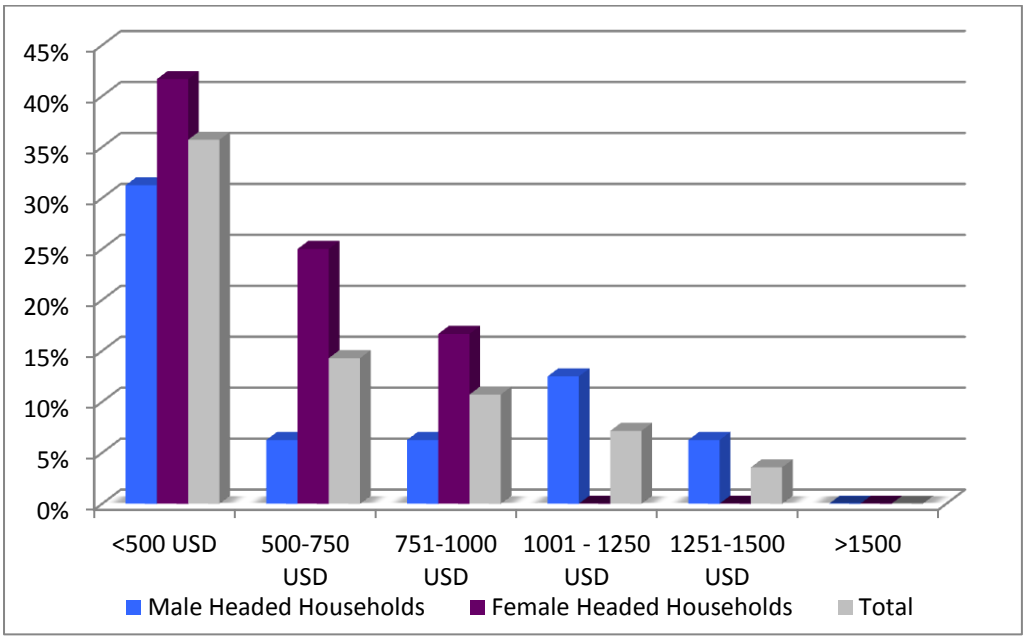


Figure 5.8.3: Sample Distribution by Average Monthly Earnings

In terms of employment in the tourism sector, the respondents generally worked in non-tourism sectors; 70% of respondents worked in the non-tourism, 3% worked in tourism and 27% of respondents refrained from answering the question.

Table 5.8.8: Labour Market Participation: Involvement in Tourism Sector

Involvement in Tourism Sector	Male		Female		Total	
Yes	1	13%	0	0%	1	3%
No	6	75%	15	68%	21	70%
Didn't respond	1	13%	7	32%	8	27%

Table 5.8.9: Labour Market Participation: Involvement in Tourism Sectors

Employment Sector	Male		Female		Total	
Taxi Driver	0	0.00%	0	0.00%	0	0.00%
Tour Operator	0	0.00%	0	0.00%	0	0.00%
Hotel Workers	0	0.00%	0	0.00%	0	0.00%
Restaurant Workers	0	0.00%	0	0.00%	0	0.00%
Craft sellers or vendors	1	12.50%	0	0.00%	1	3.33%
Informal tour guides	0	0.00%	0	0.00%	0	0.00%
Privately owned business	0	0.00%	0	0.00%	0	0.00%
Other	0	0.00%	0	0.00%	0	0.00%
Did not answer	7	87.50%	22	100.0%	29	96.67%

Only one respondent was employed in the tourism sector, working as a craft vendor. There were 15 respondents that indicated working in sectors other than tourism. The largest proportion of which were self employed (13.3%), followed by mechanical/technical (10%).

Table 5.8.10: Labour Market Participation: Involvement in Non-Tourism Sectors

Employment Sector	Male		Female		Total	
Administration	0	0.0%	0	0.0%	0	0.0%
Agriculture	1	12.5%	1	4.5%	2	6.7%
Banking/Financial	0	0.0%	0	0.0%	0	0.0%
Building/Construction	0	0.0%	0	0.0%	0	0.0%
Domestic worker	0	0.0%	2	9.1%	2	6.7%
Education	0	0.0%	2	9.1%	2	6.7%
Manufacturing	0	0.0%	0	0.0%	0	0.0%
Mechanical/Technical	3	37.5%	0	0.0%	3	10.0%
Retail Sales and Services	0	0.0%	1	4.5%	1	3.3%
Health Services	0	0.0%	0	0.0%	0	0.0%
Government Worker	1	12.5%	0	0.0%	1	3.3%
Information Technology	0	0.0%	0	0.0%	0	0.0%
Science/Technology	0	0.0%	0	0.0%	0	0.0%
Self Employed	2	25.0%	2	9.1%	4	13.3%
Student	0	0.0%	0	0.0%	0	0.0%
Transportation	0	0.0%	0	0.0%	0	0.0%
Other	1	12.5%	6	27.3%	7	23.3%
Did not answer	0	0.0%	8	36.4%	8	26.7%

5.8.4. Food Security

Overwhelmingly, respondents (78.6%) indicated that their food supply was procured from grocery stores or super markets. Additionally, 17.9% of respondents also indicated that their food was grown by family. Other sources of food included Traditional Markets (17.9%) and Community Shops (39.3%).

Table 5.8.11: Source of Food Supply

Source of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Grown by Family	1	14.3%	2	22.2%	0	0.0%	2	18.2%	5	17.9%
Grocery store/Super market	6	85.7%	8	88.9%	1	100.0%	7	63.6%	22	78.6%
Open air/Traditional market	1	14.3%	2	22.2%	0	0.0%	2	18.2%	5	17.9%
Community Shops	2	28.6%	5	55.6%	1	100.0%	3	27.3%	11	39.3%
Barter	0	0.0%	0	0.0%	0	0.0%	2	18.2%	2	7.1%
Other	0	0.0%	0	0.0%	0	0.0%	1	9.1%	1	3.6%

When asked about the adequacy of the household food supply, only 64.3% 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 5.8.12: Adequacy of Food Supply

Adequacy of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Yes	5	71.4%	6	66.7%	1	100%	6	54.5%	18	64.3%
No	2	28.6%	3	33.3%	0	0%	5	45.5%	10	35.7%

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 as 13.8% of respondents received financial support from relatives inside the household. No other form of support was indicated.

Table 5.8.13: Distribution by Financial Responsibility for House (Receive support)

Source of Financial Support for Household	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Relative	2	28.6%	2	22.2%	1	100%	5	45.5%	10	35.7%
Family Friend	0	0.0%	0	0.0%	0	0.0%	2	18.2%	2	7.1%
Religious Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Charitable Organisation	1	14.3%	0	0.0%	0	0.0%	0	0.0%	1	3.6%
Government	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	1	14.3%	2	22.2%	0	0.0%	2	18.2%	5	17.9%

Of the sample, 25.0% of respondents gave financial support to family friends, with male headed households giving more support than female headed households. Furthermore, one respondent gave support to a religious organisation and three respondents gave to charitable organisations.

Table 5.8.14: 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	4	57.1%	1	11.1%	0	0.0%	2	18.2%	7	25.0%
Religious Organisation	0	0.0%	1	11.1%	0	0.0%	0	0.0%	1	3.6%
Charitable Organisation	0	0.0%	3	33.3%	0	0.0%	0	0.0%	3	10.7%
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; 25.0% accessed credit from a commercial bank and 10.7% from credit union, while 7.1% sought loans from a “Sou-Sou” or partner.

Table 5.8.15: Distribution by Access to Credit

Source of Credit	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Commercial Bank Loan	1	14.3%	2	22.2%	0	0.0%	4	36.4%	7	25.0%
Credit Union Loan	0	0.0%	1	11.1%	1	100.0%	1	9.1%	3	10.7%
Sou Sou / Partner	0	0.0%	0	0.0%	0	0.0%	2	18.2%	2	7.1%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

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 less than one month. The other half of respondents indicated that their reserves would last more than one month.

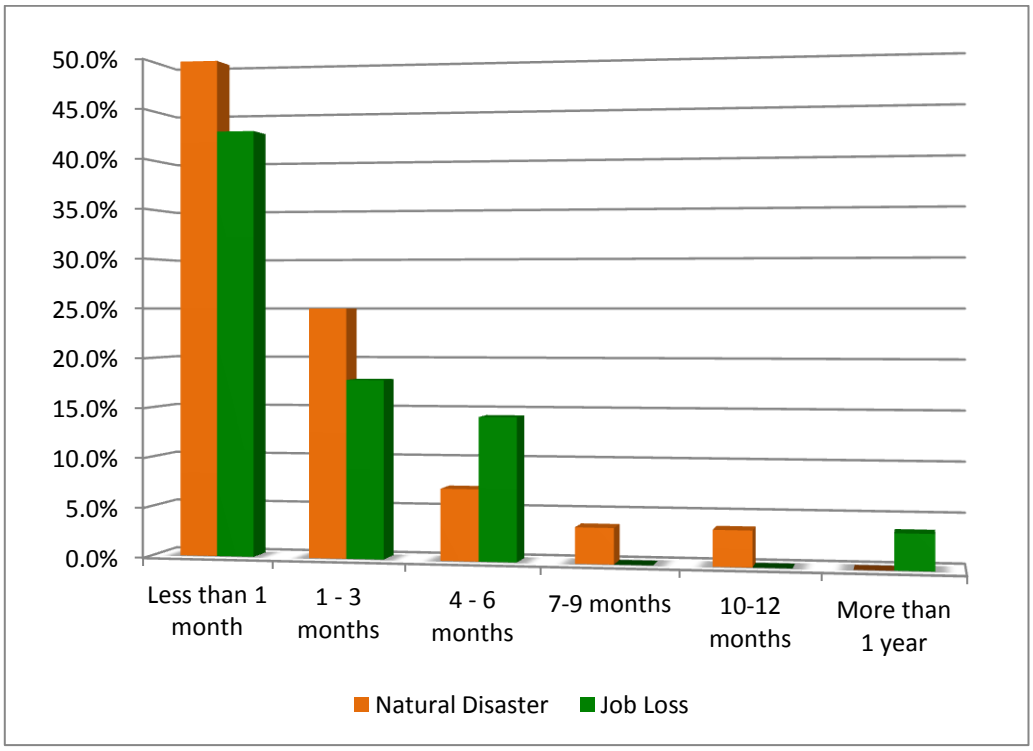


Figure 5.8.4: Financial Security: Job Loss or Natural Disaster

In relation to Job Loss, 42.9% of respondents indicated that they would have financial coverage for less than one month. Another 17.9% of respondents indicated they would have reserves for between one and three months, 14.3% of respondents indicated they would have reserves for between four and six months and only one respondent indicated they would have financial reserves for more than one year.

Table 5.8.16: Sample Distribution by Financial Security: Job Loss

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	3	42.9%	5	55.6%	0	0.0%	4	36.4%	12	42.9%
1 - 3 months	1	14.3%	1	11.1%	1	100.0	2	18.2%	5	17.9%
4 - 6 months	1	14.3%	1	11.1%	0	0.0%	2	18.2%	4	14.3%
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	1	14.3%	0	0.0%	0	0.0%	0	0.0%	1	3.6%
Do not know	1	14.3%	0	0.0%	0	0.0%	0	0.0%	1	3.6%

Female respondents indicated similar, yet slightly shorter periods of financial coverage for a natural disaster as they had for job loss. Generally male respondents also indicated the similar, though slightly shorter periods of financial coverage.

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.

Table 5.8.17: Sample Distribution by Financial Security: Natural Disaster

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	3	42.9%	6	66.7%	0	0.0%	5	45.5%	14	50.0%
1 - 3 months	2	28.6%	2	22.2%	1	100.0	2	18.2%	7	25.0%
4 - 6 months	0	0.0%	0	0.0%	0	0.0%	2	18.2%	2	7.1%
7 - 9 months	1	14.3%	0	0.0%	0	0.0%	0	0.0%	1	3.6%
10 - 12 months	0	0.0%	1	11.1%	0	0.0%	0	0.0%	1	3.6%
More than 1 year	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Do not know	1	14.3%	0	0.0%	0	0.0%	1	9.1%	2	7.1%

In terms of social protection provisions, respondents generally had little private social protection, with only three respondents having health insurance (10.7% of sample). Less than 10% of the sample had flood, fire or storm surge insurance.

Table 5.8.18: Sample Distribution by Social Protection Provisions

Social Protection Provision	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Health Insurance	2	28.6%	0	0.0%	0	0.0%	1	9.1%	3	10.7%
Private Pension Savings Plan	1	14.3%	0	0.0%	0	0.0%	2	18.2%	3	10.7%
National Insurance/Government Pension	2	28.6%	5	55.6%	0	0.0%	6	54.5%	13	46.4%
Home Insurance - Hurricane Damage (water/wind)	1	14.3%	1	11.1%	0	0.0%	0	0.0%	2	7.1%
Home Insurance - Flooding	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Home Insurance - Storm Surge	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Home Insurance - Fire	0	0.0%	1	11.1%	0	0.0%	0	0.0%	1	3.6%

5.8.6. Physical Asset Base

Ownership of assets, similar to provision of social protection, was moderate for respondents. The highest proportion of respondents indicated ownership of houses (64.3%), land (50.0%) and livestock (7.1%).

Table 5.8.19: Sample Distribution by Ownership of Assets: Capital Assets

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
House	4	57.1%	8	88.9%	0	0.0%	6	54.5%	18	64.3%
Land	3	42.9%	7	77.8%	0	0.0%	4	36.4%	14	50.0%
Livestock	1	14.3%	1	11.1%	0	0.0%	0	0.0%	2	7.1%
Industrial/Agricultural	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Commercial Vehicles	0	0.0%	1	11.1%	0	0.0%	0	0.0%	1	3.6%
Private Business	0	0.0%	3	33.3%	0	0.0%	3	27.3%	6	21.4%
Other (boat)	2	28.6%	1	11.1%	1	100.0%	1	9.1%	5	17.9%

A further examination of assets revealed that respondents most often indicated owning television sets (85.7%), radios (75.0%) and/or mobile phones (67.9%). 21.4% of respondents indicated having a desktop computer, while 17.4% indicated having lap tops.

Table 5.8.20: Sample Distribution by Ownership of Assets: Appliances / Electronics

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Computer (Desktop)	1	14.3%	3	33.3%	1	100.0%	1	9.1%	6	21.4%
Computer (Laptop)	1	14.3%	2	22.2%	0	0.0%	2	18.2%	5	17.9%
Internet	1	14.3%	2	22.2%	1	100.0%	2	18.2%	6	21.4%
Television	6	85.7%	8	88.9%	1	100.0%	9	81.8%	24	85.7%
Video Player / Recorder	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
DVD Player	1	14.3%	0	0.0%	0	0.0%	2	18.2%	3	10.7%
Radio	6	85.7%	6	66.7%	1	100.0%	8	72.7%	21	75.0%
Telephone (Land line)	3	42.9%	4	44.4%	1	100.0%	5	45.5%	13	46.4%
Telephone (Mobile)	5	71.4%	6	66.7%	1	100.0%	7	63.6%	19	67.9%

Effective communication in the instance of a climate related event seems more critical when measured against access to transportation. Pre-dominantly the sample most normally had access to non-motorised vehicles or 'other' transportation, though it was only members of male headed households who had access to private non-motorised vehicles.

Table 5.8.21: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male		Female		Sample	
Private motorised vehicle	0	0%	0	0%	0	0%
Private non-motorised vehicle	8	100%	0	0%	8	27%
Public transit	0	0%	0	0%	0	0%
None	0	0%	0	0%	0	0%
Other	4	50%	0	0%	4	13%

The largest proportion of respondents (N=21/70%) indicated that their home was made of blocks and cement and 23% (N=7) indicated their house was made of bricks and mortar. Two respondents indicated their house was built of wood. There is little difference between male and female headed households in this regard.

Table 5.8.22: Sample Distribution by Ownership of Assets: House Material

House Material	Male		Female		Sample	
Brick and Mortar	1	13%	6	27%	7	23%
Blocks and Cement	7	88%	14	64%	21	70%
Mud	0	0%	0	0%	0	0%
Wood	0	0%	2	9%	2	7%
Other	0	0%	0	0%	0	0%

Respondents indicated that they had some access to sanitation conveniences, with 42.9% of the respondents sampled indicating that they always had access to liquid waste disposal and 78.6% having access to indoor water-flush toilets. 89.3% of respondents had access to garbage collection. Male headed households generally had better access to sanitation conveniences compared to female headed households.

Table 5.8.23: Sample Distribution by Ownership of Assets: Access to Sanitation Conveniences

Amenity	Access	Male Headed	Female Headed	Sample
Liquid waste disposal	Always	37.5%	50.0%	42.9%
	Sometimes	6.3%	8.3%	7.1%
	Never	50.0%	25.0%	39.3%
Indoor water-flush toilets	Always	81.3%	75.0%	78.6%
	Sometimes	6.3%	8.3%	7.1%
	Never	12.5%	16.7%	14.3%
Garbage collection	Always	93.8%	83.3%	89.3%
	Sometimes	6.3%	0.0%	3.6%
	Never	0.0%	0.0%	0.0%

5.8.7. 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 5.8.24: Power and Decision Making

Site of Decision Making	Males		Females	
Household	7	87.5%	15	68.2%
Informal Community	1	12.5%	4	18.2%
Formal Community	0	0.0%	2	9.1%

Table 5.8.25: Power and Decision Making: Intra Household

Site of Decision Making	Male Headed						Female Headed					
	Male		Female		Total		Male		Female		Total	
Household	6	85.7%	5	55.6%	11	68.8%	1	100%	10	90.9%	11	91.7%
Informal	1	14.3%	0	0.0%	1	6.3%	0	0.00%	4	36.4%	4	33.3%
Formal	0	0.0%	1	11.1%	1	6.3%	0	0.00%	1	9.1%	1	8.3%

5.8.8. Social Networks and Social Capital

Both male and female respondents were moderately active in their community; 22.7% of females and 12.5% of male respondents reported belonging to a social group within the community.

Table 5.8.26: Social Networks: Community Involvement

Membership	Male		Female	
Yes	1	12.5%	5	22.7%
No	7	87.5%	16	72.7%

With regards to support systems, respondents tended to rely on relatives inside and outside their households and family friends for physical help, personal advice and financial assistance. Other opportunities for support were rarely used.

Table 5.8.27: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	Female	Male	Female	Male	Female
Relative (within the household)	75.0%	50.0%	37.5%	40.9%	37.5%	36.4%
Relative (outside the household)	37.5%	31.8%	0.0%	36.4%	12.5%	27.3%
Family friend	50.0%	36.4%	25.0%	27.3%	25.0%	18.2%
Religious Organisation	0.0%	9.1%	25.0%	4.5%	12.5%	0.0%
Non-religious Charity	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Government Agency	0.0%	13.6%	0.0%	9.1%	0.0%	22.7%

5.8.9. Use of Natural Resources

Subsistence

Agricultural land (16.7%) was indicated to be the most important resource for subsistence. The second and third most important resources were the river (10.0%) and the sea with 3.3% of respondents indicating each resource as very important.

Livelihood

In terms of livelihoods, the river the most important with 10% of respondents identifying the river land as being very important for livelihoods. 3.3% of the sample indicated agricultural land as being very important for their livelihoods.

Recreation

Generally, little importance was recorded for the importance of natural resources for recreation purposes.

Table 5.8.28: Use and Importance of Natural Resources

Resource	Importance	Subsistence		Livelihood		Recreation	
River / Stream	Very Important	3	10.0%	3	10.0%	3	10.0%
	Somewhat important	3	10.0%	5	16.7%	5	16.7%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	24	80.0%	22	73.3%	22	73.3%
Sea	Very Important	1	3.3%	0	0.0%	1	3.3%
	Somewhat important	1	3.3%	3	10.0%	7	23.3%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	28	93.3%	27	90.0%	22	73.3%
Coral Reefs	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	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	30	100.0%	30	100.0%
Mangrove	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	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	30	100.0%	30	100.0%
Agricultural Land	Very Important	5	16.7%	1	3.3%	0	0.0%
	Somewhat important	2	6.7%	4	13.3%	2	6.7%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	23	76.7%	25	83.3%	28	93.3%
Bush and Forest	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	1	3.3%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	30	100.0%	29	96.7%
Mountain	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	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	30	100.0%	30	100.0%
Caves	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	1	3.3%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	29	96.7%	30	100.0%
Wild Animals	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	1	3.3%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	30	100.0%	30	100.0%	29	96.7%

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 5.8.29: 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	12.5%	9.1%	12.5%	9.1%	12.5%	9.1%
	Somewhat important	0.0%	13.6%	12.5%	18.2%	0.0%	22.7%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	87.5%	77.3%	75.0%	72.7%	87.5%	68.2%
Sea	Very Important	0.0%	4.5%	0.0%	0.0%	0.0%	4.5%
	Somewhat important	0.0%	4.5%	12.5%	9.1%	0.0%	31.8%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	90.9%	87.5%	90.9%	100.0%	63.6%
Coral Reefs	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	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Mangrove	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	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Agricultural Land	Very Important	25.0%	13.6%	0.0%	4.5%	0.0%	0.0%
	Somewhat important	0.0%	9.1%	25.0%	9.1%	0.0%	9.1%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	75.0%	77.3%	75.0%	86.4%	100.0%	90.9%
Bush and Forest	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%	4.5%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	95.5%
Mountain	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	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Caves	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	12.5%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	87.5%	100.0%	100.0%	100.0%
Wild Animals	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%	4.5%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	95.5%

Agriculture

Seven respondents indicated they were involved in the agriculture sectors. 18.8% of male headed households always had access to water and 6.3% sometimes had access to water. For female headed households, 0% always had access to water compared to 8.3% who sometimes had access to water.

Table 5.8.30: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	3	18.8%	0	0.0%	3	10.7%
Sometimes	1	6.3%	1	8.3%	2	7.1%
Never	1	6.3%	1	8.3%	2	7.1%

5.8.10. Knowledge, Exposure and Experience of Climate Related Events

Respondents indicated average levels of knowledge in relation to hurricanes (50.0%) and average or very good knowledge of flooding (average = 50% and very good = 7.1%) as well as drought (average = 35.7% and very good= 3.6%).

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 5.8.31: Knowledge of Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	35.7%	42.9%	55.6%	50.0%	0.0%	18.2%	16.7%
	Average	50.0%	42.9%	33.3%	37.5%	100.0%	63.6%	66.7%
	Very Good	14.3%	14.3%	11.1%	12.5%	0.0%	18.2%	16.7%
Flooding	Poor	42.9%	57.1%	44.4%	50.0%	0.0%	36.4%	33.3%
	Average	50.0%	28.6%	55.6%	43.8%	100.0%	54.5%	58.3%
	Very Good	7.1%	14.3%	0.0%	6.3%	0.0%	9.1%	8.3%
Storm Surge	Poor	53.6%	57.1%	66.7%	62.5%	0.0%	45.5%	41.7%
	Average	39.3%	28.6%	33.3%	31.3%	100.0%	45.5%	50.0%
	Very Good	7.1%	14.3%	0.0%	6.3%	0.0%	9.1%	8.3%
Drought	Poor	57.1%	100.0%	44.4%	68.8%	0.0%	45.5%	41.7%
	Average	35.7%	0.0%	55.6%	31.3%	100.0%	36.4%	41.7%
	Very Good	3.6%	0.0%	0.0%	0.0%	0.0%	9.1%	8.3%
Landslides	Poor	32.1%	42.9%	22.2%	31.3%	0.0%	36.4%	33.3%
	Average	39.3%	0.0%	66.7%	37.5%	100.0%	36.4%	41.7%
	Very Good	28.6%	57.1%	11.1%	31.3%	0.0%	27.3%	25.0%

1: Where respondents did not indicate an option, the total percentage of respondents sum up to less than 100%

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, 92.9% 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 (46.4%) were aware of appropriate action to take, without asking for assistance.

- In the instance of a storm surge, 32.1% of respondents sampled were aware of appropriate action to take, without asking for assistance.
- In the instance of a drought, 53.6% of respondents sampled were aware of appropriate action to take, without asking for assistance.
- In the event of a landslide, 28.6% of respondents were aware of what should be done.

Table 5.8.32: Knowledge of Appropriate Response to Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	92.9%	100.0%	77.8%	87.5%	100.0%	100.0%	100.0%
	No	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Don't Know	7.1%	0.0%	22.2%	12.5%	0.0%	0.0%	0.0%
Flooding	Yes	46.4%	57.1%	44.4%	50.0%	0.0%	45.5%	41.7%
	No	28.6%	42.9%	22.2%	31.3%	0.0%	27.3%	25.0%
	Don't Know	25.0%	0.0%	33.3%	18.8%	100.0%	27.3%	33.3%
Storm Surge	Yes	32.1%	28.6%	22.2%	25.0%	0.0%	45.5%	41.7%
	No	32.1%	42.9%	33.3%	37.5%	0.0%	27.3%	25.0%
	Don't Know	32.1%	28.6%	44.4%	37.5%	100.0%	18.2%	25.0%
Drought	Yes	53.6%	42.9%	55.6%	50.0%	0.0%	63.6%	58.3%
	No	17.9%	28.6%	22.2%	25.0%	0.0%	9.1%	8.3%
	Don't Know	21.4%	28.6%	22.2%	25.0%	100.0%	9.1%	16.7%
Landslides	Yes	28.6%	42.9%	33.3%	37.5%	0.0%	18.2%	16.7%
	No	35.7%	28.6%	33.3%	31.3%	0.0%	45.5%	41.7%
	Don't Know	28.6%	28.6%	33.3%	31.3%	0.0%	27.3%	25.0%

1: Where respondents did not indicate an option, the total percentage of respondents sum up to less than 100%

When questioned around the perceived risk of climate related events to their households, respondents most often indicated a high risk of hurricanes (57.1%) and storm surges (35.7%).

Table 5.8.33: Perceived Level of Risk of Climate Related Events: Household

Event	Perception of Risk	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	10.7%	28.6%	11.1%	18.8%	0.0%	0.0%	0.0%
	Low Risk	25.0%	14.3%	55.6%	37.5%	0.0%	9.1%	8.3%
	High Risk	57.1%	57.1%	33.3%	43.8%	100.0%	72.7%	75.0%
Flooding	No Risk	21.4%	14.3%	0.0%	6.3%	0.0%	45.5%	41.7%
	Low Risk	50.0%	71.4%	55.6%	62.5%	100.0%	27.3%	33.3%
	High Risk	28.6%	14.3%	44.4%	31.3%	0.0%	27.3%	25.0%
Storm Surge	No Risk	28.6%	14.3%	22.2%	18.8%	0.0%	45.5%	41.7%
	Low Risk	35.7%	28.6%	44.4%	37.5%	0.0%	36.4%	33.3%
	High Risk	35.7%	57.1%	33.3%	43.8%	100.0%	18.2%	25.0%
Drought	No Risk	17.9%	42.9%	11.1%	25.0%	0.0%	9.1%	8.3%
	Low Risk	64.3%	42.9%	66.7%	56.3%	100.0%	72.7%	75.0%
	High Risk	17.9%	14.3%	22.2%	18.8%	0.0%	18.2%	16.7%
Landslides	No Risk	67.9%	42.9%	77.8%	62.5%	100.0%	72.7%	75.0%
	Low Risk	25.0%	42.9%	11.1%	25.0%	0.0%	27.3%	25.0%
	High Risk	7.1%	14.3%	11.1%	12.5%	0.0%	0.0%	0.0%

1: Where respondents did not indicate an option, the total percentage of respondents sum up to less than 100%

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. Male and female headed households indicated similar levels of knowledge with regards to climatic hazards at the community level.

Table 5.8.34: Perceived Level of Risk of Climate Related Events: Community

Event	Perception of Risk	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	10.7%	14.3%	11.1%	12.5%	0.0%	9.1%	8.3%
	High Risk	82.1%	71.4%	88.9%	81.3%	100.0%	81.8%	83.3%
Flooding	No Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low Risk	42.9%	57.1%	33.3%	43.8%	100.0%	36.4%	41.7%
	High Risk	50.0%	28.6%	66.7%	50.0%	0.0%	54.5%	50.0%
Storm Surge	No Risk	10.7%	28.6%	0.0%	12.5%	0.0%	9.1%	8.3%
	Low Risk	32.1%	28.6%	55.6%	43.8%	0.0%	18.2%	16.7%
	High Risk	42.9%	0.0%	44.4%	25.0%	100.0%	63.6%	66.7%
Drought	No Risk	14.3%	28.6%	11.1%	18.8%	0.0%	9.1%	8.3%
	Low Risk	39.3%	57.1%	22.2%	37.5%	100.0%	36.4%	41.7%
	High Risk	42.9%	0.0%	66.7%	37.5%	0.0%	54.5%	50.0%
Landslides	No Risk	21.4%	14.3%	22.2%	18.8%	0.0%	27.3%	25.0%
	Low Risk	60.7%	57.1%	66.7%	62.5%	100.0%	54.5%	58.3%
	High Risk	10.7%	14.3%	11.1%	12.5%	0.0%	9.1%	8.3%

1: Where respondents did not indicate an option, the total percentage of respondents sum to less than 100%

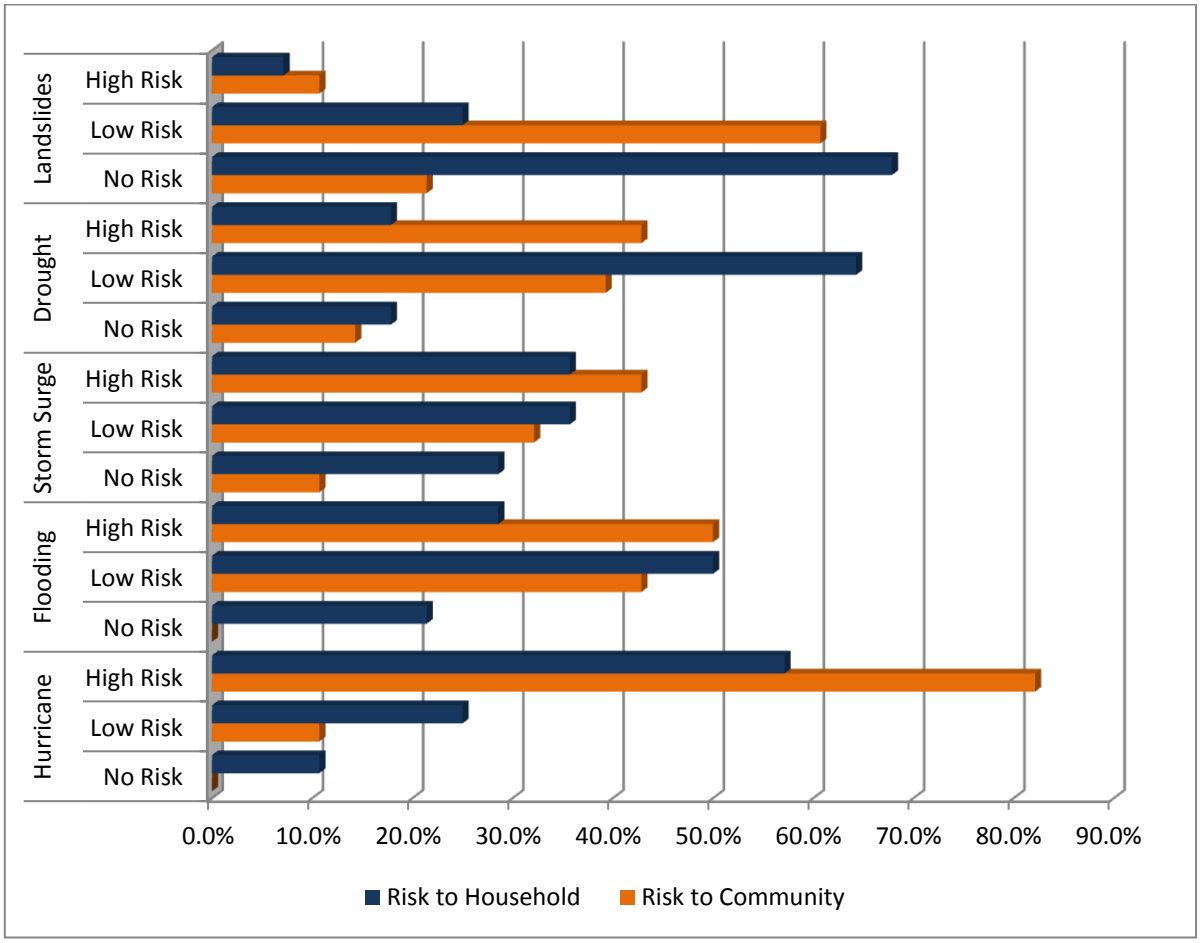


Figure 5.8.5: Perception of Risk for Climate Related Events

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.

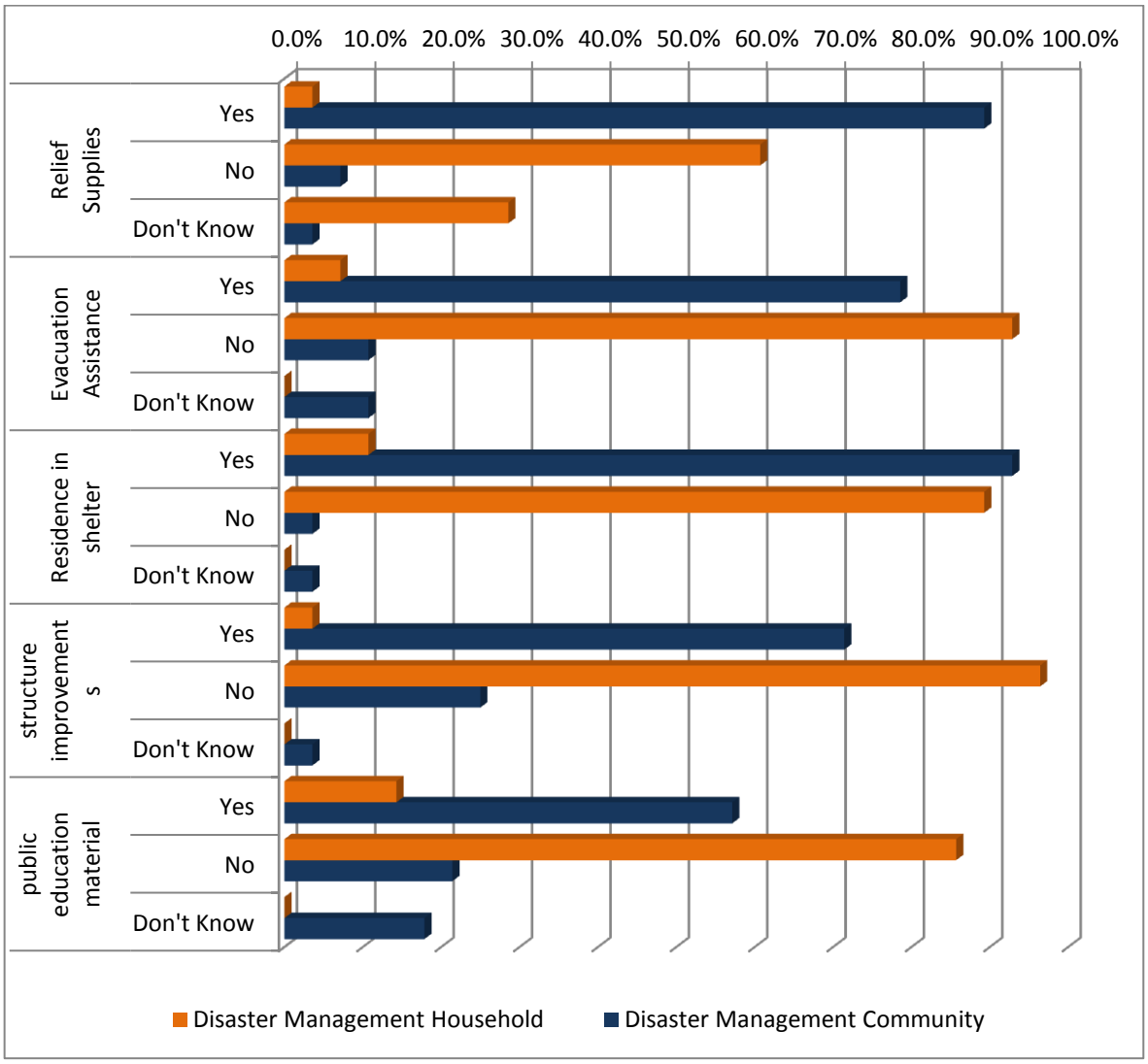


Figure 5.8.6: Support during Climate Related Events

5.8.11. Adaptation and Mitigation Strategies

Some respondents indicated that they were employing strategies at the household level to protect themselves, their households and their livelihoods against impacts of extreme weather. The most popular strategies included seeking assistance, borrowing money and reducing expenses, which were mainly in response to hurricanes or flooding. Response actions for storm surge events, drought events and landslides were not indicated by any of the respondents. When disaggregated by gender, more response actions were indicated by male headed households. There is concern for those households (a large number from the sample) that have not adopted any adaptation and mitigation actions, as it has implications for household and overall community vulnerability to future weather and climate change impacts.

Table 5.8.35: Household Adaptation and Mitigation Strategies

STRATEGY	Event	Sample	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
SELLING ASSETS	Hurricane	-	-	-	-	-	-	-
	Flooding	-	-	-	-	-	-	-
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
BORROWING MONEY	Hurricane	5	1	2	3	-	2	2
	Flooding	3	-	-	2	-	1	1
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
SEEKING ASSISTANCE	Hurricane	6	2	2	4	-	2	2
	Flooding	5	2	2	4	-	1	1
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
REDUCING EXPENSES	Hurricane	5	-	2	2	-	3	3
	Flooding	2	-	1	1	-	1	1
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
STARTING A NEW LIVELIHOOD ACTIVITY	Hurricane	1	1	-	-	-	-	-
	Flooding	-	-	-	-	-	-	-
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
DECREASING HOUSEHOLD SIZE	Hurricane	-	-	-	-	-	-	-
	Flooding	-	-	-	-	-	-	-
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
OTHER ACTIVITY	Hurricane	2	2	-	2	-	-	-
	Flooding	1	1	-	1	-	-	-
	Storm Surge	-	-	-	-	-	-	-
	Drought	-	-	-	-	-	-	-
	Landslide	-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-

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 legitimised. 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:

- **Energy audits:** National as well as company-specific inventories to assess energy use and related emissions by sector are a precondition for any work to reduce energy use. Companies should thus engage in energy- and carbon audits. As Meade and Pringle (2001) have shown, engaging in environmental management systems can have a significant cost-saving impact and be an avenue to engage stakeholders, Section 5.2.3. This is a no-regret option since the cost of fuel and therefore electricity is unlikely to decrease, regardless of the climate outcome. Additional training may be needed to ensure that personnel are available in SVG to undertake the audits.
- **Epidemiology data with climate signals:** Further research is needed to link the epidemiology of diseases in SVG with climate data. More detailed information, especially presenting temporal, environmental and climatological data, is needed.
- **Monitoring and evaluation in the Health Sector:** Greater effort is needed to have data analysed, peer reviewed and published. In many cases, as with health, the data may be gathered by a public sector agency that lacks the technical or human capacity to carry out this type of evaluation. Therefore it might be beneficial to establish a partnership with a tertiary education or research institution to enable continued monitoring and evaluation of the collected data. This approach will allow for validation and for developing a "culture" for systematic review and the conversion of knowledge into policy and planning.
- **Conduct inventory assessments of the existing coastal protection defences, as well as their design range and maintenance status, making the information publicly available**. This study was hindered by inadequate data on existing coastal structures, including 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 SLR adaptation.
- **Automate the system for monitoring hydro-meteorological stations and seismic stations so that data can quickly be updated and the early warning system becomes more effective:** Stream gauges and seismic gauges for SVG have to be manually monitored and are maintained by the Ministry of Agriculture. The stream gauge information has great relevance to agriculture in SVG, but there are other areas where the data would be useful. As such, a Memorandum of Understanding needs to be developed with all relevant Government agencies and possibly some private sector actors, so that needs can be evaluated and the system upgraded to become automated. The technology available for data collection and storage may also need review so that hazards and disasters can be identified in a timely manner and broadcast through the early warning system.

6.1.2. Mainstreaming Climate Change

Where policies and plans already exist there are areas that lack sufficient consideration of climate change and its impacts.

- **Building code:** The building code in SVG, although relatively recent, has not been fully mainstreamed, Section 5.7.4. Efforts should be made to ensure that resilient building practices are used and the code itself should be reviewed to ensure that adequate attention is given to climate change concerns. This is especially true in relation to reducing energy use and energy efficiency, considering potential impacts and risk of flooding from SLR and ensuring that new buildings have infrastructure for storing water.
- **Integrate SLR into the design of all coastal structures:** The Environmental Assessments that are currently required on a case by case basis, should be made mandatory for coastal structures and

take into account the most recent estimates of SLR from the scientific community. The Physical Planning and Development Board needs to assess all projects that involve building, maintaining, or modifying infrastructure in coastal areas at risk of SLR to ensure that the new developments take into account SLR. The cost of reconstruction after flood damage is often higher than modifying structures in the design phase.

- **Integrate SLR into Government 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 SVG 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 be a continued expense to the 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 SVG.
- **Incorporate SLR and climate change impacts into local and national land use development plans.** Undertake national-level consultation with Government ministries responsible for land use planning to utilise the broad scale results of this study and higher-resolution local scale studies to develop and review existing land use plans. The development of official SLR risk maps should also be considered to further guide future coastal development and the development of stringent setback policies. The PPCR has already identified the need for improved spatial planning including considerations for building resilience to climate change. In particular, there needs to be work in the following areas:
    - Develop robust land management policies to reduce the discharge of pollutants including sediments, sewage and agro-chemicals into water systems. In particular, (i) unplanned housing settlements should be avoided, particularly in hill slope areas; (ii) permanent paths for eco-tourism should be established, with no new paths subsequently permitted, minimising erosion; and (iii) unplanned and unsustainable agriculture should not be practiced and the use of agro-chemicals be controlled. In addition, penalties should be made for discharging pollutants into drainage systems, sensitive potable water zones and marine areas.
    - Ensure the protection of existing mangrove forests.
    - Community members also recommended that 'green spaces' need to be incorporated in future developments, Section 6.9.

Incorporate SLR and climate change impacts into sustainable tourism plans, with a focus on disaster risk reduction. Work with relevant tourism stakeholders to further develop and implement the existing sustainable tourism sector plan. A draft DRR plan has been prepared for the tourism sector (GFDRR, 2010a), however more work is needed to reduce risks in this industry. Tourism infrastructure is currently concentrated in the coastal zone where the risk of storm surge, tsunami and coastal erosion is greatest. These hazards will degrade the tourism product (e.g. beach, coral reef) and also expose tourists to higher risks than would occur if they were staying at a place of accommodation in the interior of the islands. Climate change threatens to degrade and possibly destroy the Caribbean tourism industry and impacts on a single island may be transferred to other islands since tourists often view the region as one destination. With a sustainable tourism development plan that corresponds with national land use development plans the financial contributions from tourism can be maintained no matter the changes that occur in the coastal zone. NEMO, the Ministry of Tourism and the Physical Planning and

Development Board should collaborate on this project with the private sector to create a sustainable tourism plan that is in line with other sustainable development goals in SVG.

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 St. Vincent and the Grenadines in the past and others are underway or starting under the PPCR, but the recommendations are frequently not implemented for a number of reasons, lack of resources (both financial and technical) 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. 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, Section 6.3. It is thus important to document and communicate progress to create positive opinion in large parts of society. A number of the sectors have identified recommendations that will require cross-sectoral collaboration in order to be successful, Integrated Water Resources Management and Integrated Coastal Zone Management are two examples. The community also identified the need for collaborative projects on disaster management between NEMO, the District Committee and the local community, Section 6.9.

National level data should also be made available to regional clearing houses where they exist and, where they don't exist, thought should be given to establishing them. One particular area that could benefit from such a data repository is:

- **Epidemiology data with climate signals:** Moreno (2006) has suggested the establishment of a central clearing house containing information on diseases whose transmission is modified by climate change as well as relevant environmental data. The Caribbean Epidemiology Centre (CAREC) is one regional institution that has summarised such statistics, but it is noted that such statistics might be politically sensitive, resulting in some resistance to this recommendation, Moreno (2006). Other regional institutions that might be suited to housing such a repository include CEHI, CCCCC and UWI.

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, which has also been identified as a priority for action under the PPCR:

- Climate change issues in general;

- Water conservation at the household level to alleviate pressure on water supply.
- The proper use of rainwater harvesting systems including quality control measures and the use of easily obtainable home water test kits (Michael, 2008);
- Energy conservation and alternative energy – without better knowledge about energy, its generation, and its economic and environmental importance, few stakeholders in tourism are likely to engage with energy management. Energy- and carbon labelling of a wide range of products and services should be adopted.
- There are a number of areas in the health sector that could benefit from increased and continued information dissemination and awareness campaigns.
    - Some diseases such as malaria and gastrointestinal diseases are entirely preventable therefore both locals and tourists should be provided with continued health education as a crucial element in sustainable disease prevention.
    - Health education can also be used to prevent malnutrition with inputs from the agricultural sector and community development, Section 6.4.
- Incorporate climate change and biodiversity conservation into the primary, secondary and tertiary school curricula. The education sector was identified as a high priority for intervention under the SPCR (Disaster Vulnerability and Climate Risk Reduction Project). SVG, like many other islands of the region, is challenged to meet commitments to MEAs, sustainably manage biodiversity and monitor, mitigate and adapt to climate change because of a lack of expertise. Incorporation of climate change and biodiversity issues into school curricula will help to improve public awareness, while building adaptive capacity through knowledge and training. Doing so at the primary, secondary and tertiary levels will encourage students to view environmental management as a viable career choice and address the lack of trained personnel in this field.
- The level of awareness of SLR impacts and costs needs to be raised for all levels of the SVG Government and administration to better inform decision makers within the tourism sector including operators, investors, planners, developers, policy makers, architects and communities.
- Formulate an interactive and innovative community education and capacity building initiative for all levels of society to enable individuals to manage their own risk levels and build resilience to natural hazard events.

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. In addition, building awareness of the issues mentioned above can be better embraced when the message is conveyed by a respected figure. NEMO can work with the Red Cross to develop a culturally appropriate communication plan that will not only communicate the vital information Vincentians need to reduce their vulnerability to natural hazards, but be in a format that individuals will listen to and take note. 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. By enlisting the voluntary support of a local Soca or Calypso artist, the messages can be made widely available and will be more easily remembered in a hit song (for example, Jimmy Buffett and his song 'Volcano' or Kid Site and 'Hurricane Hit We').

In terms of educating visitors to SVG and the Caribbean in general, short educational films can be shown as part of the In-flight Entertainment (IFE) to encourage visitors to be more conscious of their impacts on the fragile ecosystems of the islands. Films can be effective tools in influencing human behaviour and a number of suitable films have already been produced and are available on YouTube. The films should focus on

positive actions that visitors can take to minimise negative impacts on the environment by decreasing energy and water consumption and wastage, and by taking precautions during marine based recreation (diving, snorkelling, boating). By reducing anthropogenic stresses on the environment, ecosystem health will improve and become better able to cope with climate change.

6.2. *Water Quality and Availability*

All of the recommendations for the water sector given below should become components of a national level Integrated Water Resource Management (IWRM) Plan. SVG has already developed a Draft Road Map toward IWRM for Union Island and related work in both Bequia and Union Island has been started under a GEF funded Integrated Ecosystem Approach to Climate Change. While these are both positive strides towards integrated resource management, institutional and legislative frameworks at all stages of water planning and management should be revisited, assessed and, if necessary, amended to allow the full implementation of IWRM nationally. IWRM encourages a move away from a uni-sectoral water management approach to one which allows participatory decision-making including different user groups. Such an approach allows an equitable management of water resources, which will be particularly important with declining water resources under climate change.

Short term

Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes. In particular, (i) although the topography of St. Vincent does not favour the construction of large reservoirs (Bons and McL Simon, 2000), the need for additional storage and treatment facilities has been recognised (ECLAC, 2003; MOHE, 2007) and the viability of additional storage facilities should be assessed, allowing improved access to potable water in different communities; (ii) losses in water distribution should be reduced through pipe replacement; and (iii) centralised public supply networks should be established in areas where they do not currently exist, such as Bequia (Durrant *et al*., 2008). This last development has been cited by Durrant *et al*., (2008) as one the most serious concerns of the residents of Bequia, since it would reduce vulnerability to water scarcity by providing a backup facility when rooftop harvesting fails to meet demand. The need for more reliable water storage and distribution was also identified as a priority by the health sector to avoid problems with sanitation and vector borne diseases. Further developments in sewerage infrastructure and waste management will help to protect against water borne diseases especially those spread during periods of heavy rainfall when flooding occurs. These actions should be led by CWSA in collaboration with the Physical Planning Department to help in the identification of suitable rainwater catchment areas. This no-regret option will help reduce vulnerability to droughts that are already occurring and build resilience regardless of the outcomes of climate change.

Medium term

Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation: Reducing the required fresh water for household and hotel use would alleviate pressure on water supply. The tourism industry, especially cruise ships and golf courses (there is one course on Canouan), is a high water consumer. Waste water from the domestic and tourism sectors can be recycled to produce irrigation water, either for agriculture or golf courses. This no-regret action would alleviate the pressure on water resources, particularly in the Grenadines and reduce the need for desalination. A number of agencies would need to collaborate on this recommendation: CWSA, Ministry of Health, Environmental Health Division and the Ministry of Agriculture.

Long term

Investigate the feasibility of using renewable energy for desalination and water generation for water-stressed islands in the Grenadines: Saltwater reverse osmosis systems using renewable energy should be assessed as an option for more remote islands with limited rainwater catchment opportunities (Kalogirou, 2005). Alternative water generation technologies such as atmospheric water generation (water from air) systems should also be investigated (see Wahlgren, 2001). The smaller islands have already been identified as excellent candidates for wind and solar energy investments in the National Energy Action Plan, Section 4.2.2.

Assess and develop groundwater resources in St. Vincent: Groundwater sources are not utilised in St. Vincent. While the surface systems are reasonably well known, the groundwater resources have not been adequately studied, but are expected to be adequate (Robins and Lawrence, 2000). Aquifers act as large reservoirs of fresh water which reduce vulnerability during periods of drought. The status of aquifers should be assessed in St. Vincent and, if possible, developed to supplement the existing surface water resources. CWSA with the help of private consultants and/or tertiary research institutions should assess the capacity of the groundwater supply and develop a management plan for sustainable use of the resource.

6.3. *Energy Supply and Distribution*

The National Energy Policy and Action Plan for SVG already captures the activities that must be undertaken to improve efficiency and reduce dependency on imported fuel. Therefore the priority must be on implementing the plan through public-private partnerships and initiatives. The need to undertake energy audits, incorporate energy efficiency in the building code and raise awareness of energy issues has also been mentioned in Section 6.1. The remaining areas for consideration are:

Short term

Undertake an assessment of the sustainability of SVG's energy systems under climate change: This should be prioritised, especially in the case of future renewable energy sources that depend on climate and priority coastal infrastructure such as power plants that might be vulnerable to SLR. These assessments should include outputs from climate change modelling scenarios and involve energy sector authorities and national and regional specialists with support from international organisations where necessary.

Medium term

Use regulation to stimulate changes and adaptation: 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 can 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. Actual enforcement of existing environmental regulations needs to be ensured.

Pursue the concept of a 'Green Economy': The benefits of these efforts will be immense: there is a very low likelihood of energy prices decreasing over the longer-term, and a very high likelihood that these will in fact increase. Building a green tourism economy is likely to lead to a renewed cycle of growth, while making the islands less dependent on imports of resources, and in particular oil. Many of the principles of a Green Economy will already have been addressed in the existing Energy Policy even though it is not presented as

such. However, a Green Economy reaches beyond energy considerations alone and includes efforts to adjust procurement procedures, level the playing field for greener products, removal of counter-productive subsidies etc.

6.4. *Agriculture and Food Security*

Medium Term

CARIBSAVE recommends a ***"Crop-growing for Climate Change"*** programme to build Vincentian 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 pedo-climatic conditions. Delivery of training courses could be facilitated by the St. Vincent Technical College under the existing Agriculture Programme - in conjunction with the Ministry of Agriculture, and should be farm based, practical and should target organised groups such as women farmers, youth and farmers' associations based in agricultural districts.

A second recommendation is a ***"Youth in Agriculture"*** project. The project should be community based and located in key agricultural areas. Experienced farmers, agriculture extension officers and technical agencies will collaboratively establish community gardens with a view to helping young people learn about and practice agriculture and environmental stewardship. Young people between the ages of 15 and 25 will be encouraged to join the after school and summer programs which will offer interactive farm classes and involve practical work cultivating and harvesting crops using basic low cost technologies.

6.5. *Human Health*

Short Term

Conduct Assessments focusing on the links between health, tourism and climate change: The literature on tourism and climate change is growing as the economic importance of the latter on the former is more and more being realised and emphasised (Hamilton & Tol, 2004). So too are the parallels between tourism and climate change with health. No assessment have been conducted in the health sector to determine the vulnerability to climate change (CIF, 2010). 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 a study of visitors leaving country be conducted to determine the validity of this statement.

An important question to be answered in the tourism sector of SVG is "Would substitution of destinations 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 of any particular disease because SVG has find numerous ways to adapt to the range of health issues described above. Therefore another recommendation coming out of this study is that research be conducted to determine the perception of tourists of health and climate change in SVG. The data collection process and following analysis could be undertaken by tertiary institutions within SVG and

others throughout the region, which will need to work with the Ministry of Health, Wellness and the Environment, the Ministry of Tourism and Industry and the St. Vincent and the Grenadines Meteorological Service. Potential collaboration with CEHI, CCCCC, CAREC and PAHO should also be explored.

Medium Term

Build up a supply of public health resources for the surveillance, prevention and control of Vector Borne Diseases: Vector control falls under the domain of the Ministry of Health, Wellness and the Environment. Gubler(2002) has stated that the resurgence of diseases and 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." Rawlins *et al*., (2008) have also made the salient point that it is "important for us to record in detail the Malaria situation in the Caribbean region, so that health decision makers may be aware of how acute the situation really is and how much emphasis should be rightly placed at preventing the re-occurrence of the disease in the region". It is therefore recommended that the Integrated Vector Management (IVM) Programme approach of the WHO be adopted. The Caribbean region can plan a course that includes IVM which contains a climate change component. Those that have been highlighted for SVG include dengue and leptospirosis. In this region limited human capacity and attention to evaluation are two major challenges to the utilisation of IVM.

Long Term

Develop Early Warning Systems for diseases: As data becomes available and an improved level of understanding is reached regarding climate signals and disease outbreaks, it might be possible to establish an Early Disease Warning System which considers temperature signatures for vector borne diseases as a practical way to execute effective disease control (Ebi *et al*., 2006). However these must be validated (Chen, *et al*., 2006) and be site-specific (Ebi, *et al*., 2006). Other strategies can be utilised such as the use of the pre-seasonal treatment (Chadee, 2009). With respect to asthma and other respiratory diseases, a special Early Warning System could be developed that would involve tracking Sahara dust clouds arriving from the West Coast of Africa. Hospitals and patients can then be made aware of their impending arrival. The state of a person's health is their own responsibility, or in the case of children, the parents' responsibility. However the government can utilise its resources to put things into place for response during peak dust periods.

6.6. *Marine and Terrestrial Biodiversity and Fisheries*

Medium Term

Mangrove Restoration and Protection: Reforestation of the mangrove stands will improve the size and health of fish nurseries thus benefitting both the resilience of coastal ecosystems and the livelihoods of those engaged in marine based activities. Proposed MPAs will benefit from the presence of mangrove trees, which filter pollutants, stabilise sediments and provide important habitat to juvenile fish and crustaceans. However, reforestation projects will not be effective if development projects are allowed to continue removing and damaging mangrove stands. This would be particularly relevant to the mangroves stands in Union Island where recent developments have caused extensive damage to existing mangroves.

One method of mangrove reforestation that has proven successful in Belize is the Riley Encased Methodology (REM). 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 local Caribbean

Coastal Area Management Foundation (C-CAM) representative (in Jamaica) would like to explore the option of using water-proofed paper tubing that will biodegrade over time. This adaptation from the REM methodology will save a step in the process since the piping will not have to be removed once the saplings have grown to reproductively mature trees. A natural alternatively is the use of bamboo wave attenuators to protect developing saplings. The Ministry of Health and the Environment can promote restoration initiatives at the community level with CBOs who are willing to implement a restoration project within their area, and aim to establish a network of small restoration projects that will collectively have a major impact.

Long Term

Improve the management and resilience of fish sanctuaries and MPAs: While fish sanctuaries can facilitate the sustainability of fisheries and fisheries-based livelihoods, management of MPAs and fish sanctuaries in the Caribbean often suffers from a severe lack of funds. A needs assessment conducted by The Nature Conservancy showed a significant gap in available finances. In Jamaica for instance, where a number of sanctuaries are well-established, the Financial Needs Assessment conducted for the Sustainable Financing Plan for Jamaica's System of Protected Areas 2010 - 2020 estimated that between US $267,000 and US $358,000 would be needed annually for the management of each sanctuary. In keeping with SVG's commitment to expand protected areas and its participation in The OECS Sustainable Financing and Management of Eastern Caribbean Marine Ecosystems Project, there is a need for the public sector, private sector and hte NGO community to collaborate in creating 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. Key players from the public sector would include the Fisheries Division, the Ministry of Tourism and Industry and the Physical Planning Unit. However, to ensure that such an initiative remains effective and sustainable, community buy-in is critical, and therefore most of the thrust come from the community or a community-based organisation with active interest in the upkeep and development of the sanctuary; with support from private and public sector entities.

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

Short Term

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 St. Vincent and the Grenadines (in particular, the Physical Planning Unit, the Land and Surveys Department, and the Ministry of Health and the Environment), local resort owners and local building

authorities are encouraged to collaborate with members of the research community to help develop a cost benefit analysis of 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 be 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.

Medium Term

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 St. Vincent and the Grenadines. With tourism contributing a large proportion to the national economy, the capacity of the 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 St. Vincent and the Grenadines should be a priority for future research. Research can be undertaken by a tertiary institution or consultancy firm under the direction of the Ministries of Tourism and Finance and Economic Planning. This will enable the identification of the degree to which the economy of St. Vincent and the Grenadines 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.

Assess the adaptive capacity of the tourism sector to SLR: 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.

Commence coastal protection adaptation planning early: The Government of St. Vincent and the Grenadines needs to work with local stakeholders on the development of coastal projection 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.

Long Term

Review and develop policies and legal framework to support co-ordinated retreat from high risk coastal areas: The Government of St. Vincent and the Grenadines must review existing policy and legal frameworks to assess the responsibilities of the state and landowners for the de-commissioning of coastal properties damaged by the impacts of SLR. Government should also examine the utilisation 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 re-assessed in light of new SLR projections to ensure that new developments are not built in vulnerable coastal areas.

6.8. *Comprehensive Natural Disaster Management*

Following the national review of progress on the HFA goals NEMO identified many strengths and weaknesses. The following recommendations are complementary to those and in some cases add further detail in an effort to enhance vulnerability and risk reduction efforts as well as permitting for effective climate change adaptation.

Medium Term

Conduct capacity building and technical training programs for NEMO employees so that the current technical deficiencies can be remedied and skills gained: The need for training and "technical skills in climate adaptation, resilience building and disaster risk management are limited" were revealed in the SPCR (Government of Saint Vincent and the Grenadines, 2011a, p. 12). Although some training and workshops have been conducted in other Government agencies, to achieve CDEMA's goals under the Comprehensive Disaster Management Strategy and Plan, the prioritisation of technical training within the Participating States' disaster offices is also needed. Therefore, this recommendation is to continue to build capacity at the local and national level. In this way, the NEMO and the community disaster committees can prepare themselves and manage risks better while also generating a better understanding of the vulnerability in the communities across SVG.

Long Term

Integrate resilient practices into building designs and hire building inspectors, in permanent positions, with the responsibility of reviewing all construction across the country: In SVG, the recent passage of a National Building Code is an achievement because of the steep slopes and low lying coastal areas. However, until building designs and practices consider vulnerability and have resilience as a goal, the code will have limited benefit. Implementation of a regional standard on building materials and practices would help to reduce losses to individual families and also take some of the pressure off of shelters because this would mean that some people would be able to stay in their own homes during emergencies. SVG should certainly continue to assist with the development of this regional code, however, since national regulations or building codes do exist, the problem locally is actually one of enforcement. Therefore, it is recommended that NEMO collaborate with the Ministry of Planning and other relevant ministries to conduct a needs assessment with the objective of identifying financial resource availability, personnel requirements to improve enforcement and physical and technical requirements for hiring more building inspectors.

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 a concerted effort on one area should have a positive feedback effect in other areas.

Medium Term

Establish a dedicated hurricane shelter in Georgetown and improve the structural integrity of buildings that are used as provisional shelters: Strong and durable public buildings are normally used as provisional hurricane shelters in the event that members of the public feel unsafe in their own dwellings and wish to take shelter elsewhere. This is especially the case with low to middle income households whose housing structures are perceptibly less able to withstand physical hurricane impacts.

School and church buildings in the Georgetown community are used as public shelters. However, owing to the inadequate state of these facilities and previous experiences where the school in particular was used as a shelter beyond the period of time initially planned for, residents have suggested that there is a need for a dedicated hurricane shelter, which would not otherwise impact on the resumption of academic or religious activities housed in the buildings which are used as provisional shelters.

Church buildings that are currently used as provisional shelters were also not originally designed with this purpose in mind. Therefore, they lack important facilities and amenities that are needed in hurricane shelters that are likely to be in service for a long period of time after a hurricane. Although people are encouraged to travel with the supplies they will need, a number of provisional shelters can still be inadequate to meet certain needs and this is especially the case for gender sensitive needs (e.g. privacy for pregnant or nursing women, the needs of physically challenged members of the community).

Strong consideration should be given to erect a dedicated hurricane shelter in Georgetown, which may also function as another community centre outside of the hurricane and during the hurricane season when no immediate storm threat exists. Additionally, structural assessments and repairs should be conducted on buildings used as hurricane shelters in the area to improve their integrity and minimise possible damage and discomfort of occupants during a hurricane, including the local school and church buildings.

Encourage proper waste management and cleaning activities to reduce severity of flood events: Parts of the Georgetown area are particularly vulnerable to flooding and water settling for various reasons and floods may occur with extreme events such as hurricanes or a short but torrential rainfall event. Flooding is made worse however, because of clogged drains and culverts. More prudence in solid waste disposal is needed to reduce the impact of flooding. Drains and water courses also need to be cleared regularly (more so during the wet season) to ensure that drainage is most effective during severe weather. While this responsibility falls on Government to some degree, resources may not always be available to follow through with this action regularly. Community residents should consider organising a group and designating time at regular intervals to clear drainage channels. Stringent measures and repercussions can be put in place to deter illegal dumping activity, but this requires the support of the entire community in order to be effective.

Skills training and development in the community: The multi-purpose centre in the community has night classes in woodwork, technical drawing, electrical insulation and plumbing in residents are encouraged to participate. Residents are also interested in other areas (e.g. hospitality, food and beverage training). Training in these areas is provided in other locations in St. Vincent (e.g. the SVG Community College and the SVG Technical College) but the distance to travel to and from the training facility is a major constraint and deters residents from pursuing classes. Trainers in other livelihood areas which residents are interested in could be sourced, who would be willing to provide training at the Centre in Georgetown, to provide residents with more options for development and ultimately, employment. This could be facilitated through a community development programme funded by a non-Government organisation or charity, if it is beyond the ability of the state's community development portfolio.

Further facilitate rainwater harvesting efforts: Rainwater harvesting would provide households in the community with an alternative source of water for non-potable uses (for toilets, irrigation, washing cars, etc.) and thereby reduce the demand on the public water supply. Currently, only a few homes in the community have catchment and storage systems because they are expensive to obtain and install. Some residents also believe that storage tanks will ultimately harbour mosquitoes.

The General Employees Corporative Credit Union (GECCU) is offering loans to set up water storage tanks. Other financial institutions should consider developing similar facilities which are accessible and community residents qualify without much difficulty. Ultimately, the use of collected water for non-potable uses can also help residents to save money (by spending less on the water utility). Rainwater harvesting efforts, however, should not only be limited to the household and community level but should expand to include large commercial, industrial and administrative buildings.

Provide technical resources and training for farmers in the community: Several community residents depend heavily on farming for food and for their livelihood. The natural resources required are present but farmers are in need of technical resources to improve their current mode of operation in agriculture and the outputs from their work. Several areas of need or improvement were highlighted:

1. Farmers have expressed an interesting in training on marketing and presentation of their produce to increase business potential.
2. Obtaining strains of seeds that will produce crops which are more resistant to pests, diseases and harsh (extremely wet or extremely dry) conditions.
3. Farmers have also expressed an interested in learning utilising more sustainable farming practices and techniques which will maximise yield but also minimise environmental impacts.
4. Farmers also need assistance with putting mechanisms or monitoring systems in place to deter praedial larceny, which is a serious issue for them.
5. Market research to identify crops that are in greatest demand at different times of the year, so as to guide crop cultivation patterns and minimise shortages or wastage of produce.
6. Revisit the structure and operation of the local farmers organisation, to make it more inclusive for more local farmers

The St. Vincent Coommunity College may be able to incorporate some of these areas within the Agriculture programme if they do not already exist within the curriculum, or can consider creating short evening training courses geared to farmers in these areas. Assistance in this area could also be obtained from regional organisations such as IICA and FAO.

Identify opportunities for community level disaster management activities that can be implemented through collaboration between the National Emergency Management Organisation (NEMO), the District Committee and the local community: Disaster management falls under the purview of NEMO and the District Committees which operate at the community level. The community has recommended that some disaster education and response training activities are needed in the area to engender more pro-active attitudes towards storm preparation and hazard mitigation; more important within the younger generations of the community who have little experience with severe weather impacts. Church meetings and groups are potential channels for education and awareness forums. Further to this, a needs assessment should be undertaken to determine resource gaps in the community and funding sought to support community level disaster mitigation initiatives. These 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. Outside of Government support, the community can explore options from non-Governmental and international aid organisations which sponsor overall community development programmes.

Long Term

The incorporation of 'green spaces' in future developments: 'Green spaces' or park areas are being recommended for all future residential developments which can add aesthetic qualities, provide spaces for

rest and relaxation for community residents and may, depending on the size and arrangement of buildings, help to regulate the micro-climate (temperature and humidity). Developers should strongly consider incorporating this component in future developments, with encouragement from the Physical Planning Unit and the Ministry of Health, Wellness and the Environment.

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 that draws 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. 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, whether direct impacts such as extreme weather conditions or disasters, water shortages, food insecurity or changes in land use or indirect secondary impacts such as access to energy, changes in employment opportunities, sectoral impacts (such as in agriculture, tourism and fisheries) and increased migration or conflict.

- *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 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 policies 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 SVG 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 (ENSO) 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 (ITCZ) 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 Regional Climate Models.

We use a combination of GCM and RCM projections in the investigations of climate change for a country and at a destination in order 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*

The island of St. Vincent is generally not considered to be water stressed (NEAB, 2000), with average annual rainfall ranging from 1,500 mm on the coast to 3,800 mm in the central mountains (FAO, 2000); in the Grenadines, by contrast, average annual rainfall is lower at around 1000 mm and severe water shortages are experienced (NEAB, 2000). St. Vincent's mountainous interior, high vegetative cover and climate has resulted in an abundance of surface water in the form of both perennial and ephemeral rivers and streams (John, 2009; NEAB, 2000). In the Grenadines, due to the islands' small size, drier climate and absence of perennial steams, there is limited surface water and an adequate supply of water is highly dependent on the timely arrival of the rainy season (Culzac-Wilson, 2003; Peters, 2003). The water supply in the country diminishes during the dry season (January to May), with reserve water supplies dwindling to as low as one or two days' supply (John, 2006, p.10). The need for additional storage and treatment facilities has been recognised (ECLAC, 2003; MOHE, 2007). Groundwater reserves in St. Vincent have not been fully explored or developed (CEHI, 2001), although are expected to be adequate in terms of both recharge and storage (Robins and Lawrence, 2000). Although the water resources on St. Vincent adequately meet domestic consumption, competing uses have substantially reduced streamflow (NEAB, 2000). The illegal clearing of land for agriculture is one of the largest threats to watersheds in St. Vincent. The country's growing ecotourism industry is also a threat to watersheds, since most of the watersheds are located in forest or wildlife reserves where paths are being cleared to facilitate nature trails, leading to erosion of the loose volcanic soil. The decline of forest reserves in St. Vincent is considered to be a large threat to watersheds and the water supply (CEHI, 2001).

Climate models suggest that St. Vincent and the Grenadines will experience drying throughout the year (even during the wet season); with maximum possible changes of up to 24% less rainfall by the 2030s, 41% less rainfall by the 2060s and 58% less rainfall by the 2090s (CIF, 2010). However, an increase in the intensity of rainfall in fewer rain days is also expected, which means that not only is St. Vincent and the Grenadines vulnerable to droughts, but also to the secondary effects of torrential rains such as landslides and the contamination of water supplies (CIF, 2010).Such projections would severely impact the water supply of rivers and streams in St. Vincent and are of particular concern for the Grenadine islands, whose small sizes and topography necessitates a very high dependence on rainwater for freshwater supply.

The following recommendations are made:

1. Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes.
2. Develop robust land management policies to reduce the discharge of pollutants including sediments, sewage and agro-chemicals into water systems.
3. Undertake public education in water resources.
4. Investigate the feasibility renewable energy and alternative desalination and water generation technologies for water stressed islands in the Grenadines.
5. Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation.
6. Assess and develop groundwater resources in St. Vincent.
7. Develop mechanisms to facilitate Integrated Water Resources Management (IWRM).

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 pre-condition 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 countries. While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of greenhouse gases, it also appears clear that energy demand in all countries 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. *Agriculture and Food Security*

The state of agriculture and food security in St. Vincent and the Grenadines 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 St. Vincent 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 St. Vincent'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 pedo-climatic factors.

7.5. *Human Health*

The vulnerabilities of the health sector to climate include weather related morbidity and mortality as well as a number of emerging and re-emerging communicable diseases such as dengue, leptospirosis, gastroenteritis and other food and water borne illnesses. Based on a 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 SVG. However, the data suggests a number of trends which include that the population is vulnerable in a number of ways, most notably to vector borne diseases and the spread of food and water borne illnesses. It is further demonstrated that these factors impact multiple sectors, such as the tourism, water and agricultural sectors. Therefore the impact of health on the tourism sector should be fully evaluated and addressed which will benefit the economy and society of SVG. Increased research and validation is necessary to determine the prevalence of disease with low incidence such as malaria. Such research will pave the way for a sound platform from which to inform policy and planning for the future as the climate changes.

7.6. *Marine and Terrestrial Biodiversity and Fisheries*

The largely undeveloped islands of SVG are home to globally important biodiversity and ecosystems. These include the Central Mountain Range, which represents one of the largest remaining tracts of wet forest in the Lesser Antilles and one of the few forests that maintains a full altitudinal corridor from sea level to 1,200 m. More than 1,150 species of flowering plants, 163 species of ferns, 4 species of amphibians, 16 species of reptiles, 111 species of birds and 15 species of mammals have been identified in SVG. The islands of the Grenadines encompass a large area of biologically diverse marine and terrestrial habitats, with extensive coral formations and important fisheries, with at least 450 species of fin-fish, 12 species of whales and dolphins, 4 species of turtles, 9 of gastropods, 11 seaweeds and 30 different coral species.

Like those of many other small islands, the diverse eco-systems found in SVG are vulnerable to the projected impacts of climate change. These increasing threats are likely to exacerbate the damage caused by existing anthropogenic impacts, such as deforestation, poor land use practices, sedimentation, coastal pollution and over-fishing. Improving the management of biodiversity and fisheries, will become increasingly important to the welfare of its inhabitants and to the sustainability of its main economic activities – fishing, tourism and agriculture.

Effective environmental management in SVG is hampered by limited technology and institutional capacity to undertake monitoring and research, as well as the enforcement of regulations. A lack of public awareness towards the environment and in particular a lack of understanding of the importance of biological diversity to human well-being is a major challenge for managers and a barrier to political will. This is reflected in the poor insufficient integration of biodiversity considerations in planning and decision making processes. Perhaps the greatest challenge facing SVG is poverty and population pressures, which are undermining the effectiveness of environmental interventions and the need to balance development with environmental protection.

The Government of SVG should be praised for its willingness to enter into partnership with neighbouring countries, Universities, NGOs and CBOs in order to ensure effective management of its protected areas and fisheries. Many of these collaborations have been successful and the opportunities for further success and even more ambitious projects are increasing due to the recent influx of climate change adaptation funds. The Pilot Programme for Climate Resilience (PPCR), for instance, will provide much needed resources for

improving environmental legislation and management. The Government should use these funds to build capacity and to promote more effective involvement of civil society, the private sector and scientific institutions in biodiversity conservation and natural resource management.

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 St. Vincent and the Grenadines 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 islands' coastal areas. Given the importance of tourism, SVG will be particularly affected with annual costs as a direct result of SLR. 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 the SVG 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 SVG is to help curb development in vulnerable areas and protect vulnerable tourism assets.

The Government of the St. Vincent and the Grenadines 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 coastal resources and infrastructure of SVG do not suffer from the consequences of increased 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 SVG.

7.8. *Comprehensive Natural Disaster Management*

SVG is exposed to diverse natural hazards including seismic activity and volcanoes, as well as hurricanes and tropical storms. The volcanic origins of the islands create a topography that is marked by steep slopes and low lying coastal areas. Vulnerability, therefore, is widespread in SVG as most of the population is either along the coast where erosion and waves threaten development or located in the steep slopes where exposure to landslides and high winds is great.

Recent disasters have helped identify some vulnerability. The volcanic eruption in 1979 was a reminder that the active volcano could cause impacts and damages in the northern part of St. Vincent at any time. The nearby submarine volcano, Kick-'em-Jenny, also threatens to generate a tsunami that could impact the coastal zone of SVG. Most recently, it was Hurricane Tomas that created significant damages to SVG. While only a category 1 hurricane, the heavy rainfall and winds created serious damages to homes and the agricultural sector. Reconstruction efforts following the hurricane were supported by donations and grants,

but efforts to consciously 'build back better' were not noted. As a result, much vulnerability still exists in SVG.

There is some institutional capacity in SVG to reduce hazard risks and also for climate change adaptation. While much of the activities of the National Emergency Management Organisation (NEMO) are aimed at preparedness and response, there is evidence of good public awareness raising and a desire for improved institutional capacity. Environmental planning and the newly proposed Strategic Programme for Climate Resilience (SPCR) both acknowledge the need for co-operative efforts on environmental management, disaster risk reduction and climate change adaptation. While some legislation could be strengthened and better enforced, SVG is on a path to achieving its goals where disaster management and climate change are concerned.

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

The Georgetown community profile highlights several elements of vulnerability. Weather impacts, but also of careless human activities undermine the natural resource base that is so important for several community livelihoods. Low income levels and financial and social protection compromise the ability of residents to respond adequately when faced with a hazard. The impacts of Hurricane Tomas in 2010 and the subsequent April 2011 floods have exemplified that women in particular are more vulnerable than men, owing to their circumstances in households and the community as carers with heavy domestic responsibilities.

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. Preparation and adaptation therefore need to be prioritised for these groups to minimise future impacts on stability and development. Recommendations put forward to address vulnerability and adaptive capacity concerns include resource conservation and incorporation of green areas in new developments, training and awareness, infrastructural assessments and developments, disaster management activities and policy reform to incorporate gender and poverty lenses. These are only some of the activities that can be implemented in the short and long term and will require efforts at all levels and across sectors to build the resilience of the Georgetown community to the impacts of climate change.

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