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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 St. Kitts

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PROJECT BACKGROUND AND APPROACH

Contribution to climate change knowledge and understanding

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

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

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

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

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

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

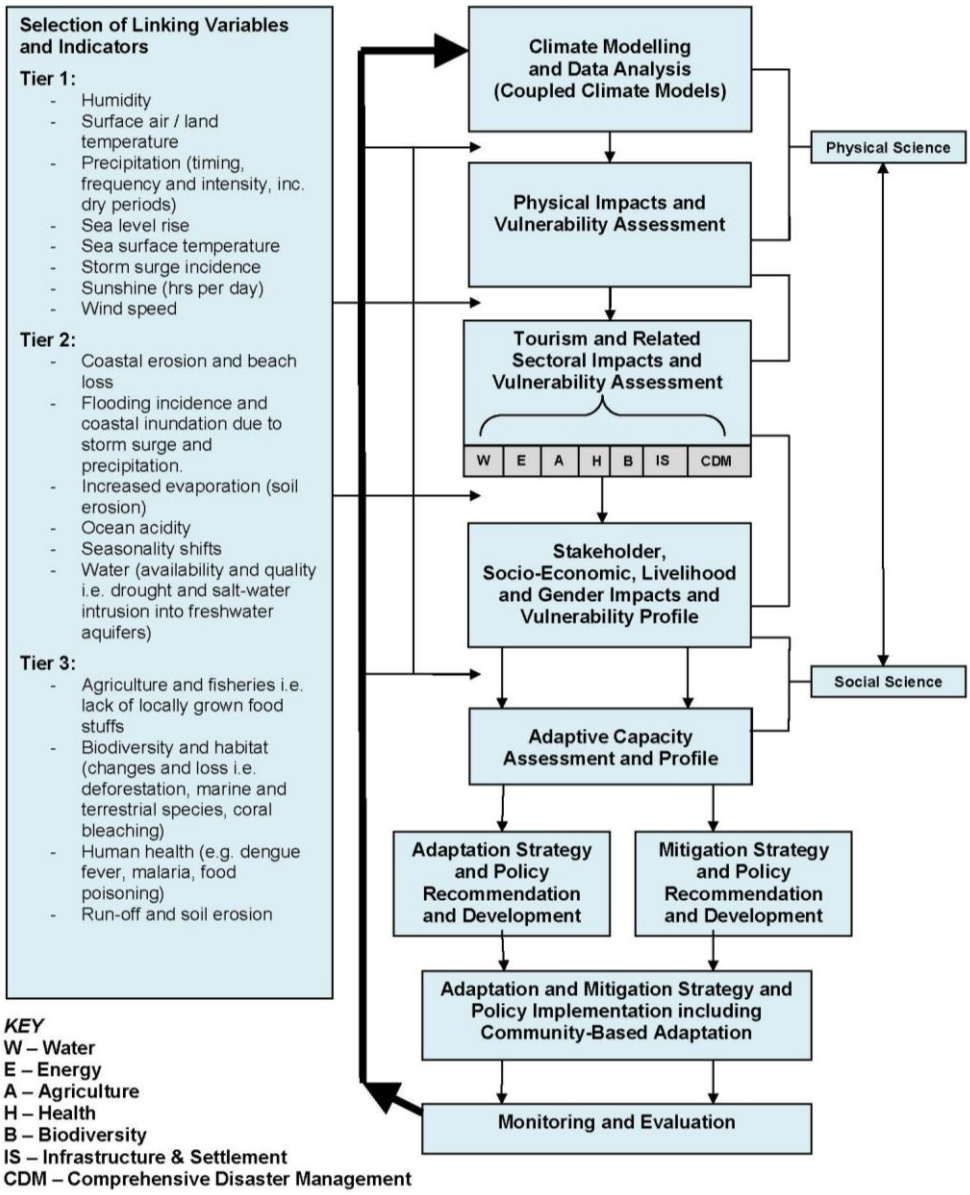
The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change,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

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

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

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

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

AHC ---------- Acute Haemorrhagic Conjunctivitis
AIC---------- Aviation-induced clouds
AOSIS ---------- Alliance of Small Island States
APD---------- Air Passenger Duty
AR4---------- Fourth Assessment Report (IPCC)
ARI---------- Acute Respiratory Infections
ASTER---------- Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ---------- Business as Usual
BEAD ---------- Bedrock Exploration Development Technologies
CAD---------- Caribbean Application Document
CAREC ---------- Caribbean Epidemiology Centre
CARICOM ---------- Caribbean Community
CCCCC---------- Caribbean Community Climate Change Centre
CCCRA ---------- CARIBSAVE Climate Change Risk Atlas
CCRIF---------- Caribbean Catastrophe Risk Insurance Facility
CDB---------- Caribbean Development Bank
CDEMA ---------- Caribbean Disaster Emergency Management Agency
CDM---------- Clean Development Mechanism (in the context of Energy/Emissions)
CDM---------- Comprehensive Disaster Management
CEHI ---------- Caribbean Environmental Health Institute
CFP ---------- Ciguatera Fish Poisoning
CITES---------- Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP---------- Conference of Parties
CPA---------- Country Poverty Assessment
CRFM ---------- Caribbean Regional Fisheries Mechanism
CROSQ---------- CARICOM Regional Organisation for Standards Quality
CSIRO ---------- Commonwealth Scientific and Industrial Research Organisation
CTO---------- Caribbean Tourism Organization
CZM ---------- Coastal Zone Management
DANA ---------- Damage Assessment and Needs Analysis
DFID---------- Department for International Development
DJF---------- Seasonal period of December, January, February
DRM---------- Disaster Risk Management
DRR---------- Disaster Risk Reduction
EAF ---------- Eco-system Approach to Fisheries
ECCU ---------- Eastern Caribbean Currency Union
ECE ---------- Energy Conservation and Efficiency
ECLAC---------- United Nations Economic Commission for Latin America and the Caribbean
EIA---------- Environmental Impact Assessment
EM-DAT ---------- The International Disaster Database
ENSO---------- El Niño Southern Oscillation
ETS ---------- Emission Trading Scheme
EU ETS ---------- European Union Emissions Trading System
EU---------- European Union
FAO---------- Food and Agriculture Organization
GCM---------- Global Circulation Model
GCP---------- Ground Control Point
GDEM---------- Global Digital Elevation Model
GDP ---------- Gross Domestic Product
GGCA ---------- Global Gender and Climate Alliance
GHG ---------- Greenhouse Gas

GIS ---------- Geographic Information Systems
HAB ---------- Harmful Algal Blooms
HFA ---------- Hyogo Framework for Action
IATA ---------- International Air Transport Association
ICT ---------- National Information and Communications Technology
ICZM ---------- Integrated Coastal Zone Management
IDB ---------- Inter-American Development Bank
IEA ---------- International Energy Agency
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
IVM ---------- Integrated Vector Management Programme
JJA ---------- Seasonal period of June, July, August
MAM ---------- Seasonal period of March, April, May
MEA ---------- Multilateral Environmental Agreements
MFDP ---------- Ministry of Finance, Development and Planning
MHE ---------- Ministry of Health and the Environment
MPA ---------- Marine Protected Area
MPWUTP ---------- Ministry of Public Works, Utilities, Transport and Post
MSD ---------- Ministry of Sustainable Development
MSMEs ---------- Micro, Small and Medium-sized Enterprises
NASA ---------- National Aeronautics and Space Administration
NBSAP ---------- National Biodiversity Strategy and Action Plan
NDC ---------- National Disaster Committee
NDE ---------- National Disaster Executive
NEMA ---------- National Emergency Management Agency
NEMS ---------- National Environmental Management Strategy and Action Plan
NEP ---------- National Energy Plan
NIA ---------- Nevis Island Administration
NSLC ---------- National Survey of Living Conditions
OECS ---------- Organisation of Eastern Caribbean States
PAHO ---------- Pan-American Health Organization
PPA ---------- Participatory Poverty Assessment
RCM ---------- Regional Circulation Model
RH ---------- Relative Humidity
RNAT ---------- Rapid Needs Assessment Team
SEP ---------- South East Peninsula
SIDS ---------- Small Island Developing States
SKED ---------- St. Kitts Electricity Department
SLR ---------- Sea Level Rise
SON ---------- Seasonal period of September, October, November
SSMC ---------- St. Kitts and Nevis Sugar Manufacturing Corporation
SST ---------- Sea Surface Temperature
TNC ---------- The Nature Conservancy
UK ---------- United Kingdom
UKERC ---------- United Kingdom Energy Research Centre
UKOT ---------- United Kingdom Overseas Territory (-ies)
UN-OHRLLS --------- United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States
UNDP ---------- United Nations Development Programme
UNEP ---------- United Nations Environment Programme
UNESCO ---------- United Nations Educational, scientific and Cultural Organization
UNFCCC ---------- United Nations Framework Convention on Climate Change

UNFPA ---------- United Nations Population Fund
UNWTO ---------- United Nations World Tourism Organisation
USAID ---------- United States Agency for International Development
UWI ---------- University of the West Indies
WHO ---------- World Health Organization
WSD ---------- St. Kitts Water Services Department
WWTS ---------- Wastewater Wetland Treatment Systems

EXECUTIVE SUMMARY

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

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

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

SELECTED POLICY POINTS

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

Overview of Climate Change Issues in St. Kitts

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

Detailed climate modelling projections for St. Kitts predict:

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

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

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

1. assess the vulnerability of the livelihoods of community residents in the **Old Road** area to climate change; and
2. project sea level rise and storm surge impacts on **Irish Bay, Basseterre Bay, Frigate Bay and Sugary Bay.**

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

- The Old Road Town community is in the parish of St. Thomas which has just over 25% of its population living in poverty.
- Some of the existing vulnerabilities have been self-imposed through environmental degradation and unsustainable practices.
- Employment is an important factor in the community's adaptive capacity at the household level.
- Consideration of the underlying power relations and gender equalities which create vulnerability both to poverty and climate hazards is essential.

Vulnerable coastlines

- 1 m SLR places 64% of the major tourism properties at risk and under a 2 m SLR scenario, 77% are at risk in Frigate Bay and Basseterre.
- With only 50 m of erosion, 79% of turtle nesting sites, a popular tourist attraction, would be at risk.
- SLR considerations are not currently incorporated into local land use development plans or tourism master plans.
- Rebuild costs for tourist resorts damaged and inundated by SLR amount to over US $936 million in 2050.

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. Kitts

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

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

Box 1: Climate Modelling Projections for St. Kitts

Temperature: Regional Climate Model (RCMs) projections indicate increases ranging from 2.4 - 3.2˚C by the 2080s in the higher emissions scenario.

Precipitation: General Circulation Models (GCM) projections indicate overall decreases in annual rainfall of between -41 to +13 mm per month by 2080 for the higher emissions scenario. RCM projections indicate a decrease of 7-22% in *total annual* rainfall.

Sea Surface Temperatures (SST): GCM projections indicate increases from +0.7˚C and +2.8˚C by the 2080s.

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

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

Figure 1: Erosion at the Marriott Resort (St. Kitts)

The majority of infrastructure and settlements in small islands, like St. Kitts, are located on or near the coast, including government, health, commercial and transportation facilities. This high density of development (particularly related to tourism) increases the risk of degradation of coastal and marine biodiversity thereby reducing its resilience to climate change impacts including SLR and storm surge.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Department of Development Control and Planning Authority to complete detailed coastal profile surveying at Irish Bay, Basseterre Bay, Frigate Bay and Sugary Bay.

Results for field study sites in Frigate Bay and Basseterre indicate that 1 m SLR places 64% of the major tourism properties at risk and under a 2 m SLR scenario, 77% are at risk. Critical beach assets would be affected much earlier than the SLR-induced erosion damages to tourism infrastructure; indeed, once

erosion is damaging tourism infrastructure, it means the beach, a vital tourism asset, has essentially disappeared. With a projected 100 m of erosion, 82% of all the resorts in St. Kitts and Nevis would be at risk. In contrast, with only 50 m of erosion, 79% of turtle nesting sites, a popular tourist attraction, would be at risk. Table 1 shows the different survey sites and their specific impact results under the various scenarios. The amount of beach lost demonstrates the great need for SLR considerations to be incorporated into local land use development plans in St. Kitts, but also into tourism master plans.

Table 1: Beach Area Losses at Four Resorts in St. Kitts

	Irish Bay/Basseterre Bay		Frigate Bay		Sugar Bay - 1		Marriott Resort	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)
0.5m	3,768	43%	5,677	36%	11,340	54%	8,394	25%
1.0m	1,628	61%	10,053	100%	3,383	70%	4,198	37%
2.0m	3,117	96%	-	-	5,382	95%	20,806	98%
3.0m	331	100%	-	-	1,055	100%	597	100%

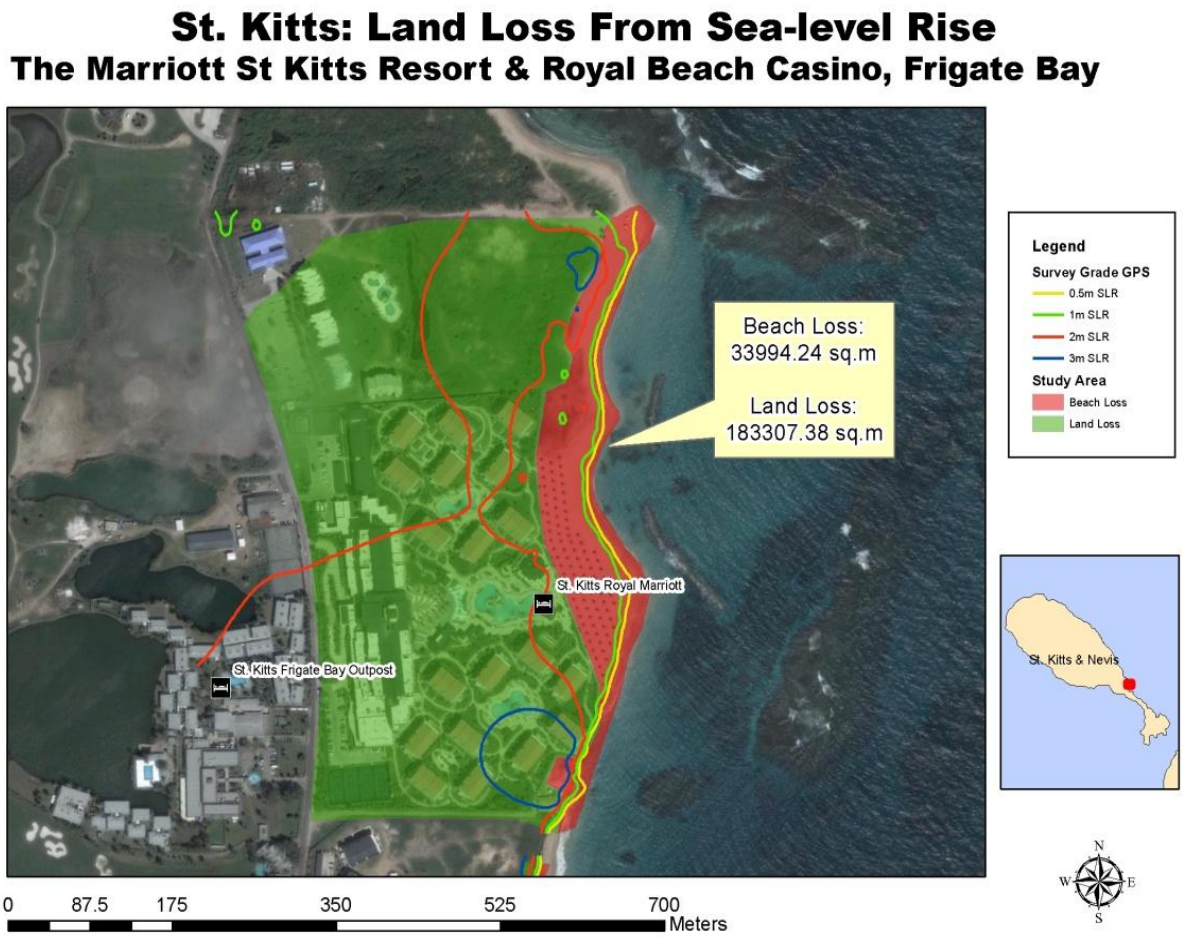


Figure 2: Sea Level Rise Vulnerability at The Marriott St. Kitts Resort and Royal Beach Casino, Frigate Bay, St. Kitts

St. Kitts is highly dependent on international tourism and the country will be particularly affected with annual costs as a direct result of SLR. Figure 2 (above) clearly illustrates that the longer term erosion

response of the shoreline to a 1m SLR would have significant implications for the shoreline and the loss of a total of high value commercial tourism properties.

Hard engineering structures such as dikes, levees, revetments and sea walls can be used to protect the land and related infrastructure from the sea to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. Unfortunately, the effectiveness of this approach may not withstand the test of time nor withstand against extreme events. Protection could also 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 a natural buffering capacity that can help reduce the adverse impacts of climate change[i]. Although less expensive and less environmentally damaging, soft engineering protection is only temporary and a variety of implications need to be considered.

Adaptation through managed retreat can have the benefit of saving on infrastructure defence costs (hard and soft engineering measures) while retaining the aesthetic value of the coast. However, for many tourist destinations in St. Kitts, retreat is both difficult in terms of planning, as well as expensive to implement. But without action St. Kitts is estimated to face annual losses between US $30 million in 2050 to over US $101 million in 2080 (based on a mid-range scenario). Rebuild costs for tourist resorts damaged and inundated by SLR amount to over US $936 million in 2050 up to US $2.2 billion in 2080 and estimated capital costs to rebuild the airport are between US $44 million by 2050 to US $132 million by 2080 and between US $15 million in 2050, to US $44 million by 2080 for rebuilding ports[ii]. Given these costs, it is recommended that a cost-benefit analysis of coastal protection be conducted at the local level, along with an inventory of existing coastal protection defences, their design range and maintenance status. This information will inform decision-making and planning for the tourism industry and other coastal development.

Community Livelihoods, Gender, Poverty and Development

More than 50 residents and workers from The Old Road Town, St. Thomas participated in CARIBSAVE's vulnerability assessment which included a vulnerability mapping exercise, focus-groups and household surveys which were developed according to a sustainable livelihoods framework. This research an understanding of: how the main tourism-related activities, including fishing, vending and other micro- and medium-sized commercial activities located along the coast and have been affected by climate-related events; the community's adaptive capacity and the complex factors that influence their livelihood choices; and the differences in the vulnerability of men and women.

Community Characteristics and Experiences

The Old Road Town is located on the western side of the island in the parish of St. Thomas. St. Thomas itself has a population of approximately 2,395 persons, which represents roughly 6% of the total population. Tourism and fishing are the main industries in St. Thomas. Several tourism attractions and points of interests located in this parish, and a fisheries complex was recently established in the area, providing a

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[i] IPCC. (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, & H. C.E., *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK: Cambridge University Press.

[ii] Simpson, M. C., Scott, D., Harrison, M., O'Keeffe, E., Sim, R., 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 (Summary Document).* United Nations Development Programme (UNDP), Barbados, West Indies.

base for local fishermen and housing Government officials working with the fisheries sector. St. Thomas has a moderate level of poverty by parish when compared to other parishes, as just over one-quarter of the persons living in St. Thomas are poor.

Community residents are most concerned with flooding, hurricanes/tropical storms and storm surge because of the current impacts these events have on their livelihoods. As a result, a review of drainage and engineering infrastructure with the goal of reducing flooding would be of great value to this community.

However, there is a clear understanding that some of the existing vulnerabilities have been self-imposed through environmental degradation and unsustainable practices which have compromised the community's ability to effectively manage some types of disasters. For example, it has been reported that some community residents who had been relocated by government have returned to areas that were designated as 'at-risk', or have even rented out these properties to other locals. Such decisions are likely as a result of perceived (and possibly actual short-term) benefit of that location combined with a low level of awareness about climate change risks.

The climate-related changes which have been noted by residents of Old Road Town, include:

- hotter days;
- reduction in rainfall;
- declines in biodiversity; and
- coastal erosion.

Figure 3: Community workshop in Old Road Town

Some results for The Old Road Town include:

- Employment is an important factor in the community's ability to adapt to climate change and reduce their own vulnerability at the household level.
- All community members reported that they know what to do in the event of a hurricane; 70% for flooding; and 25% for landslides.
- In the event of a catastrophic event or job loss, across the community household financial reserves would last between one and six months.

In Old Road there are small, non-governmental organisations or community-based groups that promote community cohesion and development. Community-focused or bottom-up adaptation planning to include capacity building and education programmes for such groups will therefore lend itself to greater consideration of local circumstances and inputs.

Challenges of poverty reduction and climate change need to be addressed in a coherent and synergistic way. 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.

Agriculture and Food Security

The close of the sugarcane industry in St. Kitts and Nevis in 2005 signalled a significant change in the agricultural landscape of The Federation, which depended on this crop for its prosperity for a period of 350 years. The Government's Adaptation Strategy in Response to The New EU Sugar Regime 2006 – 2013 is an intensive diversification programme that has resulted in increased production of non-traditional crops, livestock, fruits and vegetables. Some of the projected impacts from climate change are however already being felt.

In particular, changes in precipitation (increases and decreases) are having devastating impacts on crop production seasonally. The single most important contributing factor to land degradation in St. Kitts and Nevis is accelerating erosion caused by:

- overuse of lands for mono-crop, sugar cane agriculture;
- clearing of lands for residential and tourism development;
- farming above the 1,000 ft contour; and
- squatting or unregulated settlements.

In order to specifically deal with agriculture and climate change, a project involving farmers' cooperatives and the Government owned Capisterre Farm, can be used to model the impact of climate change on production and help to develop new, varieties of selected crops that respond to a changing climate.

Climate change concerns for agriculture are presently dealt with at the farm-level, but there is the need for more public discussion, supporting policies and an institutional framework to strengthen adaptive capacity of local farmers to mitigate the negative impacts.

The high level of public debt, the high cost of imported food to meet local needs, the global financial crisis and weak inter-sectoral linkages have caused persistent challenges for local farmers in St. Kitts, who bear costly production inputs for their crops. Furthermore, the low wages paid for farm work contributes to the vulnerability of this sector through declining interest. The island is facing agricultural land shortages because of the small physical size but also due to competition for land with tourism, housing, services and other facilities. Land use policies need to better consider agriculture so as to provide farmers with adequate land to provide a local food supply, but also to ensure agricultural practices do not have negative impacts on other land uses.

Energy and Tourism

Tourism is an increasingly significant energy consumer and emitter of greenhouse gases (GHG) both globally and in the Caribbean. St. Kitts and Nevis belong to the region's low emitters having per capita emissions just over half of the global average of 4.3 t CO_2. In the case of tourism in St. Kitts and Nevis, cruise ships (40%), aviation (24%) and accommodation (15%) were identified as the major direct consumers of energy and sources of emissions. When compared to national emissions of 196,000 t CO_2, the tourism sector accounts for about 88%.

Figure 4: Wind turbines as alternative energy source in Nevis

A detailed energy assessment of the tourism sector is needed, however, to confirm these figures, which in part are based on estimates with considerable uncertainties in assumptions. There is also uncertainty how emissions are divided between St. Kitts and Nevis, although approximately 80% of fuel imports are for St. Kitts and a comparison based on arrival numbers would suggest that about 80% of tourism-related energy use and associated emissions fall on the island.

St. Kitts' energy production is currently entirely based on diesel powered plants with a contribution of wind power likely to be included sometime in 2012. In St. Kitts, electricity prices have historically been kept artificially low through a government subsidy scheme, with the removal of the fuel surcharge in 2005 for residential electricity clients[iii]. This policy should be reviewed so as not to counteract efforts at energy efficiency (demand side), since lower costs encourage greater use.

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 to the passengers. Tourism's share in energy use and emissions is likely to grow in the future, leading to growing vulnerabilities in a business as usual (BAU) climate scenario. At the same time, the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise island economies.

The National Energy Action Plan for St. Kitts and Nevis has a section that speaks to the tourism sector, focussing on energy efficiency through technology and renewable alternatives, recycling, capacity building and a potential levy for high energy uses. Although the current Policy and Plan do not specifically refer to the sustainability of the sector under climate change, it does make it clear that the aim is to develop sustainable energy solutions. To improve the achievement of those goals the Government of St. Kitts and Nevis is encouraged to conduct energy audits to better understand where energy is used and where emissions occur.

Opportunities for collaboration with the agriculture sector exist with integration of renewable energy into farms in St. Kitts being a possibility. A greenhouse project for improving growing performance by directly

[iii] MOPWUEH (2011a). Draft Energy Sector Digest St. Kitts and Nevis. Ministry of Public Works, Utilities, Energy and Housing, Federal Government of St. Kitts and Nevis.

using the carbon dioxide present in geothermal steam is a possible option worth exploring. Similar work is already being attempted because wind and geothermal energy have been identified to have the greatest short to medium term development potential[iii]. In the period 2010-2012, 5.4 MW of wind power on St. Kitts and 2.2 MW on Nevis, as well as a 10 MW geothermal plant on Nevis are planned. Exploration of these joint sector projects is needed for economic efficacy with the limited resources available. To this end, St. Kitts and Nevis is planning considerable action that could make them a leader in renewable energy development in the region.

Water Quality and Availability

In St. Kitts, the majority of water comes from groundwater wells and currently, all residents of St. Kitts have access to water 24 hours per day, all of which is supplied by the St. Kitts Water Department. Over 50% of water supplies are consumed by the domestic sector, while the tourism, agriculture and commercial sectors each use between 10 and 15% of the island's water resources (Figure 5). No central sewerage system exists in either St. Kitts or Nevis; however, there is one treatment plant at Frigate Bay (St. Kitts). Soak-aways and septic tanks are the primary waste disposal method used by households. For the Basseterre aquifer, threats to water quality include contamination from oils spills, fertilisers and agrochemicals and bacteria.

To combat water pollution, it is recommended that the Water Department collaborate with the agricultural sector and planning department to develop land use policies that centre on water conservation and also protect against SLR and salt water intrusion.

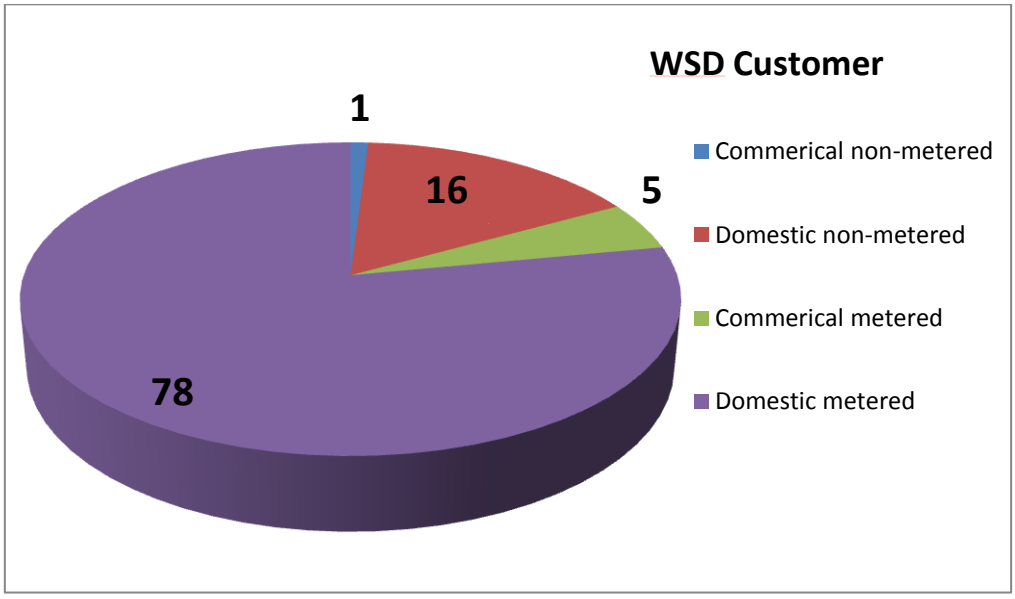

Figure 5: Distribution of Metered and Non-Metered Customers of the St. Kitts Water Services Department (%)

(Source: Dr Sahely, personal communication, April, 12, 2011)

Demand for water is expected to increase as the economy of St. Kitts and Nevis expands, particularly in the tourism and agriculture sectors where water requirements could double in the next 10 years. To exploit groundwater resources that are not currently exploited will require substantial capital investments to gain access to these aquifers. St. Kitts Water Services Department (WSD) executes government policy objectives, implements water conservation programmes (particularly during drought conditions), and carries out public education and awareness initiatives related to water resources. However, conflicting and growing demands for water from various sectors place pressure on the limited financial resources available

to the WSD. This shortage is an acute problem during the dry season when natural springs are subjected to periodic water shortages as a result of high tourism water demand. In these episodes, water is sourced from areas that have wells.

Drought frequency is not well documented so monitoring of collection and water storage is recommended to enhance management regulations. Water infrastructure should also be developed to reduce vulnerability during drought events and after major storms and hurricanes. In particular:

- water storage should be encouraged through incentives and every new building should have its own stored water infrastructure;
- the viability of additional storage should be assessed, allowing improved access to potable water in different communities; and
- losses in water distribution should be reduced through pipe replacement.

To help with these types of initiatives, public-private partnerships have been considered to manage various infrastructure projects such as maintenance and deep water drilling projects.

Comprehensive Natural Disaster Management

Flooding and tropical storms are the most frequently occurring natural hazards in St. Kitts, but the threat of volcanic eruption from Mt. Liamuiga (previously Mt. Misery) also exists, especially in the northern part of the island.

Studying impacts and damages from recent events can provide helpful tools and lessons in vulnerability reduction.

- Hurricane Georges in 1998 brought high winds, damaging 80-85% of homes and caused the evacuation of 3,000 persons[iv]. Infrastructure damages were also extensive: many schools reported damages; the main hospital, Joseph N. France General Hospital, lost 90% of its function[v]; and the power plant and many power lines and poles across the island were damaged. The vulnerability of built structures is thus quite high.

- The private sector is not immune to this vulnerability with tourism infrastructure suffering extensive damages and lost revenues when some facilities had to be closed for at least 2 months[vi].

- During dry periods, the risk of wildfires and drought also threaten agriculture and food security.

- After a recent flooding event, the National Emergency Management Agency (NEMA) made the statement that "significant funding is needed to mitigate flooding in several communities and in the central business district of Basseterre the capital city"[vi].

[iv] PAHO. (n.d.). *Impact of Hurricanes on the Health Sector.* Pan-American Health Organization

[v] UNISDR. (2009). *Hospitals Safe from Disasters 2008-2009 World Disaster Reduction Campaign.* United Nations International Strategy for Disaster Reduction.

[vi] NEMA. (2010). *Saint Kitts and Nevis: National progress report on the implementation of the Hyogo Framework for Action (2009-2011) interim.* National Emergency Management Agency, Prevention Web.

Figure 6: Hurricane Georges damage in St. Kitts

(Source: Elmes, 2001[vii])

Efforts to better understand the vulnerability and adaptive capacity in St. Kitts have been evident in recent years. Post-disaster mitigation projects following Hurricane Lenny and Hurricane Georges have been aimed at advancing disaster response and preparedness, as well as improving building and construction techniques and the management of shelters. These storms were a reminder that all sectors and areas of St. Kitts are at risk to extreme weather events.

The tourism industry, because of its economic importance, must have a disaster management plan and a sustainability plan for future developments. It is recommended that such a plan be implemented in conjunction with the National Emergency Management Agency (NEMA) with parallel efforts in Nevis so that combined efforts achieve widespread results and prevent future losses and damages from storms, hurricanes and other hazards.

There should be greater integration of community groups in disaster management and mitigation where possible since there are communities, such as Old Road Town, which have not only the need for such initiatives but also interested residents and groups.

Human Health

The potential effects of climate change on public health can be direct or indirect and can be conferred onto residents as well as visitors to a given destination[viii,ix,x,xi]. The acquisition of an infection can have

[vii] Elmes, L. (2001). Construction Principles and Practice as related to small buildings in St. Kitts and Nevis. Antigua: USAID/OAS PGDM building inspector training.

[viii] Ebi, K. L., Lewis, N. D. and Corvalan, C. (2006). Climate Variability and Change and their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector. *Environmental Health Perspectives, 114*(12), 1957-1963.

[ix] Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. Sari, *et al.* (2007). Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), (pp. 391 - 431). Cambridge, UK: Cambridge University Press.

consequences for persons visiting a destination and can have significant impacts on the economies of SIDS. The Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) highlighted the following communicable diseases and their relationship to health as follows, "*weather and climate influenced health care problems continue to constitute major sources of morbidity including gastrointestinal diseases, dengue and influenza*"[xii]. A recent study highlighted that heat stress was considered the most important issue related to climate change and climate variability to residents of St. Kitts and Nevis.

In addition, mortality and morbidity rates due to injuries sustained during natural disasters are important considerations when assessing the vulnerability of a country to climate change. Further concern exists for vector-borne diseases including dengue fever and malaria:

- St. Kitts' tropical climate and its central forested peaks are suitable conditions for mosquito proliferation and the conditions could become more favourable as a result of climate change[xii]. On average there has been one reported case of imported malaria every year between 2003 and 2010[xiii]. While this number is small, the possible re-emergence of malaria is considered to be a real threat to the region[xiv].

- Dengue fever is endemic to St. Kitts and Nevis and the total number of confirmed cases in both islands between 1995 and 2010 was 305; most cases occur in St. Kitts[x].

Further health concerns arise from poor hygiene and sanitation practices:

- The use of pit latrines in localised areas can contribute to the spread of water-related diseases such as gastroenteritis, acute haemorrhagic conjunctivitis and leptospirosis.

- Approximately 8.2% of the population use pit latrines (5.7%), ventilated pit latrines (1.2%) or have no access to toilet facilities (1.3%), thus many households are at great risk to such diseases.

The Ministry of Health should embark on a continuous health education and health promotion campaign aimed at locals and tourists. With good information on health and sanitation Kittitians can protect themselves and advocate for better national sanitation and health infrastructure. Similarly, policies and related funding strategies geared towards poverty reduction (such as the proposed Poverty Reduction Strategy) are key factors in climate change because of the link between disease transmission, environment and living conditions, which by extension affects the ability of communities and St. Kitts on the whole to adapt.

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[x] Gubler, D. J. (2002). Epidemic dengue dengue hemorrhagic fever as a public health problem. *Trends in Microbiology 10*(2), 100-103.

[xi] Patz, J. A., McGeehin, M. A., Bernard, S. M., Ebi, K. L., Epstein, P. R., Grambsch, A. *et al.* (2000). The potential health impacts of climate variability and change for the United States. Executive summary of the report of the health sector of the U.S. National Assessment. *Environmental Health Perspectives, 108*(4), 367-376.

[xii] MOE (2001). St. Kitts-Nevis Initial National Communication. Basseterre, St. Kitts-Nevis: Ministry of Environment, Government of St. Kitts Nevis

[xiii] P. Martin, Ministry of Health, personal communication, September 2011

[xiv] Rawlins, S. C., Hinds, A. and Rawlins, J. M. (2008). Malaria and vectors in the Caribbean: The continuing challenge of the disease forty-five years after eradication from the islands. *West Indian Medical Journal, 57*(5), 462-469.

Marine and Terrestrial Biodiversity and Fisheries

Very small islands, like St. Kitts, are at greater risk of losing their remaining natural resources and thus are particularly vulnerable to the projected impacts of climate change. For example:

- Increases in SSTs of about 1 to 3°C are projected to result in more frequent coral bleaching events, weakened coral structure and widespread mortality.
- Negative impacts on coral reefs, seagrasses and mangroves have serious implications for the country's fisheries sector as these ecosystems are critically important to the various life stages of many commercial species, including conch and lobster that are in high demand within the local and export markets.

To alleviate these stresses it is recommended that St. Kitts explore the feasibility of establishing fish sanctuaries, and create a strategy that should:

- establish an effective fish sanctuary management and enforcement system for coastal communities;
- enhance the capacity of resource managers and users to make the sanctuaries more resilient to climate change; and
- establish a sustainable finance mechanism for supporting fish sanctuary management.

The strategy should also 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. The Federation has various laws and plans such as the National Environmental Management Strategy and Action Plan 2005-2009 (NEMS) and the National Conservation and Environment Protection Act No. 5 of 1987 to inform and guide the implementation of best practice approaches to environmental management. However lack of enforcement of legislation and the failure to incorporate environmental costs into action plans and national budgets has limited the country's ability to live up to its obligations of ecosystem conservation. However, such a strategy provides an opportunity to assist in strengthening environmental management and building resilience in coastal ecosystems by empowering coastal communities to take part in monitoring the natural resources on which they depend.

Figure 7: Sargassum seaweed accumulation on beaches in 2011

Even though the main challenges facing biodiversity protection in St. Kitts are related to management and policy, technology may assist in building the resilience of biodiversity to climate change by reducing non-climatic stresses and improving conservation and management activities. The St. Kitts Department of Marine Resources is currently promoting the use of alternative fishing methods to reduce fishing pressure on near shore areas. The technology and telecommunications sectors have been identified as having a key role in the sustainability and development of the Federation, and are therefore upgrading infrastructure, hardware and software, as well as human capacity with the intention of applying cutting edge technology to various sectors.

Education and awareness projects using films on inbound flights can be effective tools in influencing human behaviour. The short videos would 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 necessary precautions during marine-based recreation (e.g. diving, snorkelling, boating).

Although not confirmed as a climate change related event, large quantities of Sargassum seaweed have been washing ashore on the islands of the Eastern Caribbean in July and August 2011. These floating mats of vegetation arrive in the Caribbean region annually but this year (2011) they appear to be doing so in unusually large quantities. Fishers are complaining that their nets and lines become entangled in the Sargassum and there is 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 poses a serious problem for the tourism industry as well as a major expense and logistical challenge for agencies that 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.

Conclusion

St. Kitts has a growing dependence on the tourism industry, supported by a diversity of natural assets which enable it to be successful and many local livelihoods are also very dependent on these resources. Coastal ecosystems and water resources in particular, are already facing serious pressures from increasing (and sometimes poorly planned) development and poor land management practices thereby decreasing the resilience of plant and animal species. The natural resource base is also affected by climate-related events. St. Kitts has a history of damages and losses from natural disasters that not only interrupt development progress at the national level, but also result in the investment of much time and resources into rebuilding homes and livelihoods after an impact. Since there is high confidence that climate change will result in more intense hurricanes and extreme events, posing even greater threats to ecosystems and the population, preparedness for disasters and climate change adaptation become common goals.

The CCCRA explored recent and future changes in climate in St. Kitts 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 now to increase the resilience of economies, businesses and communities to climate-related hazards.

It is clear that the Government of St. Kitts and Nevis is committed to adapting to climate change, as evidenced by some policy responses, current practices and planned actions; particularly the planned renewable energy initiatives. However, financial resource shortages along with limited technical capacities hinder successful adaptation efforts across most government ministries and other stakeholder groups. Additionally, resource users with little or incomplete awareness of their risks and alternative courses of action continue to degrade or over-extract from marine and terrestrial ecosystems in an effort to sustain themselves. Enforcement of laws to protect biodiversity remains a challenge, as does land use planning and regulation of settlements. Continued work in data collection, monitoring and evaluation of climate change adaptation policies, plans and activities will be key to successful development of a sustainable tourism industry in St. Kitts but also for development in the country as a whole.

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 (GHG) emissions and changes in the global climate system (NEMA, 2010). Notably, climate change is on-going, with "observational evidence from all continents and oceans … that many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC, 2007b, 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 sea-level rise (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 *et al.*, 2008). This should be seen in the light of (Dulal *et al*., 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 IPCC AR4 (IPCC, 2007b), been high on the global political agenda. The most recent United Nations (UN) Conference of Parties (COP) in Mexico in December 2010 agreed that increases in temperature should be stabilised at a maximum of 2°C by 2100. Notably, the 39 member states of the Alliance of Small Island States (AOSIS) have called in a recent Declaration to the UN

for a new climate change agreement that would ensure global warming to be kept at a maximum of 1.5°C (AOSIS, 2009).

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

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

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

1.1. *Climate Change Impacts on Tourism*

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

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

Impacts of mitigation policies on tourist mobility: Scientifically, there is general consensus that 'serious' climate policy will be paramount in the transformation of tourism towards becoming climatically sustainable, as significant technological innovation and behavioural change demand strong regulatory environments (e.g. Barr *et al.*, 2010; Bows *et al.*, 2009; Hickman and Banister, 2007; 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. The Caribbean is likely to be a casualty of international mitigation policies that discourage long-haul travel.

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

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

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

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and Climate*

The island of St. Kitts forms one half of the twin island Federation of St. Kitts and Nevis and is located in the northern part of the Lesser Antilles at 17° 15' north and 62° 45' west with Nevis 3 km to the south-east (MOE, 2001). St. Kitts is 176 km^2 in area and approximately 36.8 km long, with a narrow neck of land extending like a handle from the south-eastern end (MOSD, 2007). This stretch of land is referred to as the South East Peninsula (SEP) and the capital, Basseterre, is located to the southwest of the main island, adjacent to the SEP.

The islands are the summits of a submerged mountain range that forms the eastern boundary of the Caribbean Tectonic Plate (MOE, 2001). St. Kitts has 3 volcanic mountain ranges: central northwest (dominated by Mt. Liamuiga, an active volcano (GFDRR, 2010) with a pronounced crater and the Federations highest peak at 1,156 m); middle (dominated by Vrechild's mountain at 975 m, but otherwise consisting of a number of irregular peaks); southeast (a number of irregular peaks with the highest at 900 m). The slopes of the latter two ranges are steeper and shorter on the leeward coast and the land near the coast is typically flat or moderately sloped; and hence the site of most development (MOSD, 2007).

The slopes are cut by deep gullies or ghauts that act as the primary drainage channels (MOE, 2001), but they are almost entirely dry for most of the year. Only the relatively large Wingfield and Cayon rivers flow almost to the sea for much of the wettest part of the year (DOE, 2001).

The coastline is dominated by cliffs up to 30 m high with narrow black sand beaches, pebbles and boulders at the foot. Exceptions include the northwest where there are wider, yellow sand beaches and from Conaree to the southeast of the island there are long stretches of fine yellow sand beaches (MOSD, 2007). The coastal and marine ecosystems include coral reefs, seagrass beds, mangroves and salt ponds. The most extensive mangrove habitat occurs in the SEP along with the seagrass beds. Coral reefs are generally found along the southwest coast between Nag's Head and the southern end of Basseterre Bay, on the northwest coast between Sandy Point and Dieppe Bay, on the east coast between Conaree and Friar's Bay and on the southeast coast adjacent to the Narrows (MOSD, 2007).

The landscape of St. Kitts has been cleared of virgin forest at one time or another and although the peaks are still covered they do not show virgin forest characteristics; however unlike other islands the forested area is increasing (Poverty Research Unit, 2006). Lower slopes, particularly to the north, have secondary growth (tropical woodland and fruits) on abandoned farmland that was once used for sugar cane and higher slopes provide short grass used for livestock grazing. The lowlands are intensely used for development or farming and in the past the increasing demand for agricultural land resulted in many small farmers clearing forested land in the upper slopes resulting in soil erosion, and pollution of streams, rivers and coastal waters (MOE, 2001). Hawksbill and green sea turtles are found around the entire coast and a large number of resident and migratory birds depend on the mangrove and pond communities for feeding and nesting (MOSD, 2007).

As with most Caribbean islands, the climate of St. Kitts is heavily influenced by the marine environment. The average temperature at Basseterre is 27.8°C and seasonal and diurnal variations in temperature are small (typically 3-5°C). Only at higher elevations do temperatures drop below 17°C (MOSD, 2007).

St. Kitts has a wet season between August and September, when relative humidity is typically 78%. The drier months occur between January and April, when relative humidity drops to approximately 70% (MOSD, 2007). Rainfall is strongly related to altitude, with the central mountain range receiving an annual average of 2,500 mm to 4,000 mm (Climate Lab, n.d.) and coastal areas receiving a more modest annual average of 1,016 mm (MOSD, 2007). The situation is quite different along the SEP, where mean annual precipitation varies from 990 mm on the peaks to 864 mm at Cockleshell Bay (MOSD, 2007).

Given the location of St. Kitts in the north east Trade Winds, the prevailing wind direction swings seasonally between northeast and southeast, with mean speeds ranging from 8.7 km/h in November to 14.6 km/h in July. Higher speeds are experienced during the dry months of January and March and during the hurricane season (June to November), when low pressure systems and tropical disturbances pass through the area (MOSD, 2007). Some of the major hurricanes that have affected St. Kitts include Hurricane Hugo (1989), Hurricanes Luis and Marilyn (1995), Hurricane Georges (1998), and Hurricane Omar (2008) (MOE, 2001 and GFDRR, 2010).

2.2. *Socio-Economic Profile*

The recent country poverty assessment (CPA) of St. Kitts and Nevis, funded by the Caribbean Development Bank (CBD), outlined the economic and social situation of the Federation as follows:

> *The country has continued on a path of transformation from being a classic plantation economy in the post-emancipation period to a services oriented economy, engaged in participation in the international economy, through tourism and financial services, and to a lesser extent, with export-oriented light manufacturing and information processing. Most of this transformation took place in the last quarter of the 20th Century. The country has achieved middle income status and on the basis of the MDGs [Millennium Development Goals], has arrived at levels that place it among the better performing countries in the world, in terms of quality of life for the mass of its citizenry (Kairi Consultants Ltd, 2009).*

The Federation has a central government that covers both islands, but there is substantial devolution of power regarding economic and social development to the Nevis local government—Nevis Island Administration (NIA). There has been discussion through the years on the best way to operate the two islands and although the relationship between the Federal Government and NIA is not free of tension, there is an established structure that allows Nevisians to conduct their own affairs within the Federation (Kairi Consultants Ltd, 2009).

According to 2001 census data, the population of the Federation stood at just over 46,000 (34,930 on St. Kitts, 11,181 on Nevis) (Poverty Research Unit, 2006) and this increased to a mid-year population estimate for 2009 of 51,967 (ECCB, 2009). Although St. Kitts is not a low-lying island, over 60% of the population is located in coastal areas (Jeffers and Hughes, n.d.), with small villages strung along the main coastal road. This is partly due to the rugged, forest covered nature of the interior. The major urban areas are Basseterre (40% of the population), Sandy Point and Cayon (MOE, 2001). The gender distribution is almost equal, with slightly more females than males on both islands (Poverty Research Unit, 2006).

In 2005, St. Kitts and Nevis had the 3rd highest per capita GDP in the Organisation of Eastern Caribbean States (OECS), and above the average for CDB Borrowing Member Countries (CDB, 2006). Table 2.2.1 shows that the GDP for St. Kitts and Nevis grew between 1995 and 2001, before dropping in 2002 and 2003, and then recovering between 2004 and 2008. GDP increased by 59% from EC $888.9 million in 2000 to EC

$1,413.3 million in 2007 in gross terms (Kairi Consultants Ltd, 2009). In 2009 the economy has suffered again as a result of the global economic crisis.

Table 2.2.1: Gross Domestic Product for St. Kitts and Nevis 1995-2009

YEAR	Gross Domestic Product In Constant Prices (1990), EC $ (millions)
1995	436.7
1996	462.5
1997	496.3
1998	501.4
1999	521.1
2000	555.0
2001	564.1
2002	562.5
2003	555.5
2004	596.2
2005	627.5
2006	643.5
2007	670.8
2008	701.8
2009	642.1

(Source: ECCB, 2009; CDB, 2006)

The structure of the economy in St. Kitts and Nevis has undergone a substantial transformation in the last decade. In 2005, it was decided that the sugar industry that had underpinned the economy for centuries could no longer be supported after the loss of preferential trade agreements and decades of inefficient operations in the state run sugar company and ballooning public debt (Kairi Consultants Ltd, 2009; Poverty Research Unit, 2006). It is estimated that the closure of the sugar industry directly reduced GDP by approximately 1.9% (including the contribution of sugar cane and sugar manufacturing sub-sectors) and the limited diversification of agriculture has been inadequate to withstand the economic and social impacts. The indirect impact was therefore much greater because there were significant multiplier effects on other sectors of the economy. Developments in other sectors (construction, distributive trade, and financial services) have somewhat successfully counteracted this negative impact and created some buoyancy in the economy (Kairi Consultants Ltd, 2009).

Table 2.2.2: Percentage contribution of GDP by economic activity in constant prices.

YEAR	Agriculture	Construction	Hotels and restaurants	Manufacturing	Wholesale & retail trade	Banks & insurance
2001	4.92	19.05	4.37	13.56	11.86	12.37
2002	5.59	18.03	4.23	13.05	11.93	12.63
2003	4.96	15.95	5.62	13.18	12.66	13.07
2004	5.16	15.05	6.80	12.75	11.64	14.29
2005	4.78	14.46	7.72	12.48	11.29	14.82
2006	3.73	15.27	7.46	11.39	12.03	15.65
2007	3.90	15.31	6.34	11.14	12.05	16.18
2008	4.27	15.02	6.15	10.94	12.40	15.29
2009	4.34	11.49	5.58	10.52	12.47	17.10

(Source: ECCB, 2009)

It can be seen from the data shown in Table 2.2.2, and the graphical representation in Figure 2.2.1, that agriculture and tourism are relatively small contributors to GDP. Manufacturing, wholesale and retail trade (which is also a tourism influenced sector), construction, and banks and insurance are much larger contributors to the economy. In an effort to boost the economy, the Government of St. Kitts and Nevis has developed a programme to diversify the agricultural sector and stimulate sectors, such as tourism, export-oriented manufacturing, and banking (RLB, 2010). The only sector showing sustained growth is the banks and insurance sector, with the wholesale and retail sector remaining steady with slight growth.

In spite of tourism's relatively small contribution to GDP, it remains the principal foreign exchange earner (Jeffers and Hughes, n.d.) and in a small open economy, it is the foreign exchange earning sectors that support employment, revenue flows to the government and public sector employment (Kairi Consultants Ltd, 2009). The importance of tourism is discussed further in Section 2.3. The country has attracted investment in offshore activities and there is a fast-growing internet gambling industry established on St. Kitts. There are 6 accredited medical institutions that operate in the Federation, including 4 medical schools, a veterinary university and 1 nursing university (Poverty Research Unit, 2006).

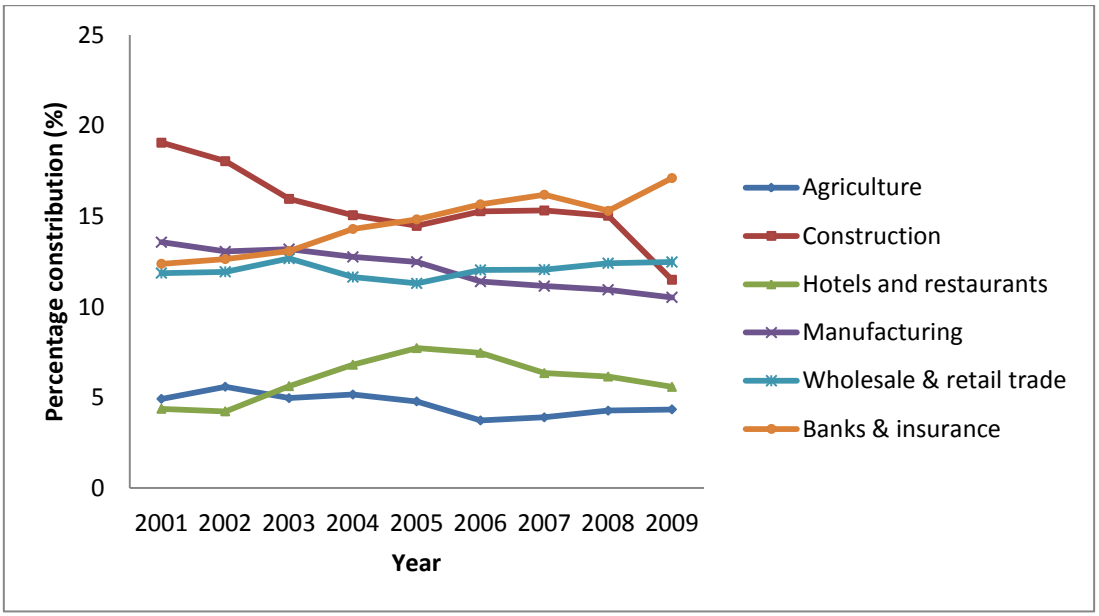


Figure 2.2.1: Percentage contribution to GDP by sector

Manufacturing is showing a steady decline over the last decade. After diversifying away from sugar to include electronics assembly, data processing and clothing production, manufactured exports accounted for 73% of total merchandise exports in 2000 (Poverty Research Unit, 2006). However, a number of factors have contributed to the steady decline of the sector. Within the Eastern Caribbean Currency Union (ECCU), value added contributions in the manufacturing sector declined by 9.3% in 2009 owing to slack external demand. More specifically, output of electronics components was down in St. Kitts and Nevis (ECLAC, 2010b). According to Kairi Consultants Ltd (2009) and the Poverty Research Unit (2006), factors that contributed to the decline include:

- Termination of the Multi-fibre Agreement, opening up garment production across the world;
- Formation of the North American Free Trade Area which enabled goods to move more freely from cheaper Mexican manufacturers into North America;
- Technological change that made export processing operations irrelevant;
- Arrangements under the Caribbean Basin Initiative no longer created any attractiveness in production operations in the Federation;
- High labour costs across other OECS islands;
- Higher electricity rates than Grenada and Saint Lucia;
- Adequate, but poor quality water supply;
- Exceptionally high port and freight charges.

Figure 2.2.1 shows that the construction sector in St. Kitts and Nevis declined between 2001 and 2004 before remaining stable to 2008. It has shown a sudden decline in the last set of data available for 2009. According to the UN Economic Commission for Latin America and the Caribbean (ECLAC) survey for 2009-2010, value added in the construction sector of the ECCU diminished by approximately 29% in 2009, in comparison with 1.7% growth in 2008 (20-25% in St. Kitts and Nevis). This was mainly due to difficulty in accessing financing for public and private sector projects (ECLAC, 2010b). The Government's recent stimulation efforts included an announcement in early 2010 that there would be a concession package for retooling the construction industry with the aim of strengthening local construction capabilities, improving the services offered by contractors, increasing efficiency in the delivery of products, and reducing labour through competition and increased efficiency (RLB, 2010).

Unemployment rates in St. Kitts and Nevis are low (5.1% for St. Kitts and Nevis, 6.3% for St. Kitts) compared to many other Caribbean nations, and the main sectors of employment are construction and the services sector, see Table 2.2.3.

Table 2.2.3: Percentage of labour force in St. Kitts by industry based on NSLC 2007

Industry	% labour force	Industry	% labour force
Agriculture & fisheries	2.7	**Transportation**	2.6
Manufacturing	9.6	**Services**	37.3
Construction	11.6	**Admin./ Social Security**	1.3
Wholesale & retail	7.3	**Education/ Social work**	9.6
Hotel & restaurant	4.2	**Other**	13.9

(Source: Kairi Consultants Ltd, 2009)

The National Survey of Living Conditions (NSLC) completed by Kairi Consultants Ltd in 2007 as part of the CPA found that there were marginally more males employed than females (94% male : 93.4% female in St. Kitts) (Kairi Consultants Ltd, 2009). The CPA also determined the national poverty rate and level of indigence and found that 21.8% of individuals fall below the poverty line (St. Kitts 23.7% poverty rate and

indigence at 1.4%), which is an improvement on 2000 levels. Given the low unemployment and high poverty rates, St. Kitts has a clear problem of the 'working poor', where salaries are too low to keep above the poverty line. The data collected shows that 81.6% of the poorest quintile of society in St. Kitts is working. It is therefore common to find people who work two jobs.

The improvement in the level of poverty between 2000 and 2007 has been attributed to government efforts under the Adaptation Strategy following the closure of the sugar industry. There has been closer attention paid to the poor through the distribution systems for school books, meals and uniforms; an expansion in employment through expenditure on infrastructure, a boom in construction and increased room stock in the tourism sector; and increased remittances from Kittitians overseas to their families in the lower income groups in St. Kitts (Kairi Consultants Ltd, 2009).

2.3. *Importance of Tourism to the National Economy*

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

As indicated above, although there is an increased focus on tourism in St. Kitts and Nevis, it is not one of the primary drivers of the economy as seen elsewhere in the Caribbean. Over the past decade, the hotel and restaurant sector has contributed between 4% and 8% of GDP in St. Kitts and Nevis combined, peaking in 2005 before declining to 2009. This sector is also responsible for 4.2% of the employment in St. Kitts (Table 2.2.2 and Table 2.2.3). Within the ECCU, tourism declined by 13% in 2009 due to a 12% fall in the higher-end stay-over visitors, despite an 18% rise in cruise ship passengers. The decline in stay-over visitors was even higher in St. Kitts and Nevis at 27% (ECLAC, 2010b). Table 2.3.1 and Figure 2.3.1 shows that in recent years, the tourism sector has become more dependent on cruise ship passengers (i.e. 83% in 2009 compared to 59% in early 2006). This is a concern since stay-over tourists spend more money on the island than cruise ship passengers. For example, in 2008 and 2009 the total number of visitors increased, but expenditure still declined compared to the peak in 2006. This is because the number of stay-over visitors had declined compared to the peak years 2005 and 2006.

Table 2.3.1: Visitor Arrivals to St. Kitts and Nevis 2001-2010

Year	Stopovers	Excursionists	Cruise ship passengers	Yacht passengers	Cruise ship calls	Expenditure (EC $ millions)
2001	69,241	3,622	252,172	6,962	358	167.00
2002	68,998	3,853	167,230	6,283	245	154.26
2003	90,562	4,054	146,317	5,855	270	203.45
2004	117,638	3,045	254,535	7,072	373	277.14
2005	140,504	4,309	215,351	4,355	244	327.12
2006	139,268	4,514	203,075	2,876	261	355.45
2007	123,062	5,177	249,323	1,911	242	336.92
2008	127,705	3,920	400,916	812	232	297.17
2009	93,081	3,708	450,553	209	235	225.41

(Source: OECS, 2010)

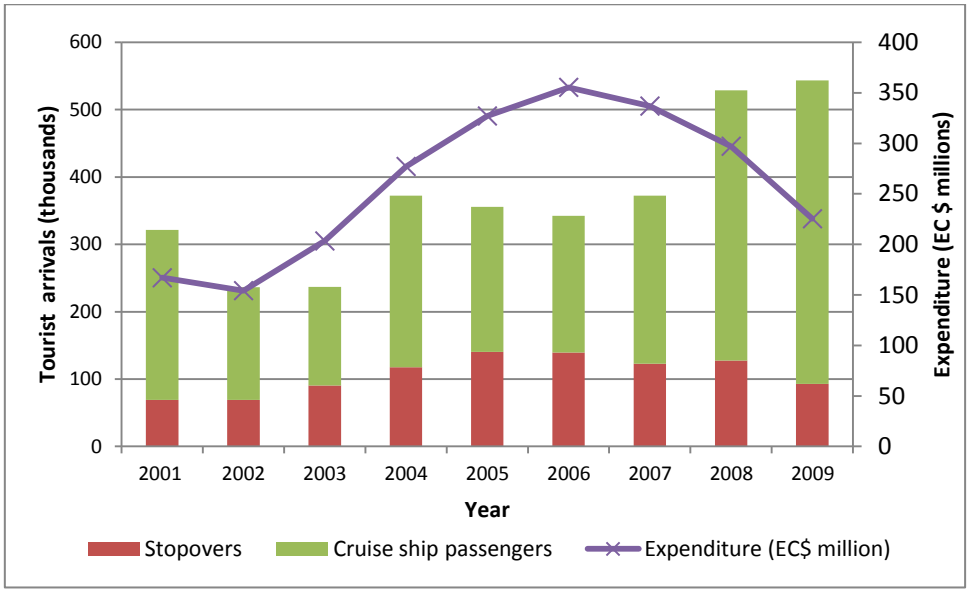


Figure 2.3.1: Distribution of tourist arrivals and expenditure.

The key markets in 2008 were the US (60%), Caribbean (23%), UK (8%) and Canada (6%). The distribution of market share changed to US (58%), Caribbean (24%), UK (7%) and Canada (7%) in 2009 (OECS, 2010), reflecting the downturn in the global economy, felt most strongly in the US and Europe. It is anticipated that tourism will increase again in 2010 with the addition of St. Kitts and Nevis to the itinerary of a number of large cruise ships. The ground breaking ceremony in 2010 at the prestigious Christophe Harbour development (due for completion in 2012) has also boosted the image of St. Kitts and Nevis as a 'high end' destination (RLB, 2010). There is limited data available on tourist arrivals for St. Kitts only, but in 2010 it is reported that St. Kitts alone received 91,561 stay-over visitors, 3,419 excursionists, and 512,445 cruise and yacht passengers. This shows that the increased number of large cruise ships has been successful in attracting more cruise passengers, with more passengers visiting St. Kitts in 2010 than visited St. Kitts and Nevis combined in 2009. As described above, the boost in cruise numbers does not appear to have boosted expenditure since total expenditure in St. Kitts in 2010 was EC $179 million (B. Harris, St. Kitts Statistics Department, personal communication, May 23, 2011).

According to the Caribbean Tourism Organisation (CTO), the average length of stay is 9.6 nights, with 50% staying in hotels and 41% in private residences (CTO, n.d.). Most of the tourist accommodation establishments are located in the Frigate Bay area and the number of hotel rooms has varied considerably over the period 1998-2007 (Table 2.3.2). It has been reported that the small number of hotel rooms does not provide enough incentive for large commercial airlines to provide regular service to the island (Poverty Research Unit, 2006).

Table 2.3.2: Number of hotel rooms in St. Kitts and Nevis

Year	Number of rooms	Year	Number of rooms
1998	1,543	**2003**	1,611
1999	1,508	**2004**	1,550
2000	1,602	**2005**	1,859
2001	1,489	**2006**	1,859
2002	1,438	**2007**	1,859

(Source: Kairi Consultants Ltd, 2009)

Some of the variability in the number of hotel rooms can be attributed to impacts from natural disasters, which have forced the temporary closure of some establishments. In 1998 and 1999, Hurricanes Georges and Lenny caused destruction to several hotel plants, resulting in a drop in arrivals. In 2000, stay over arrivals dropped due to the one year closure of the Four Seasons Hotel on Nevis and a period of transition at the largest hotel, Jack Tar Village on St. Kitts. The impact from these two storms also negatively affected the number of airline charters from the major markets (Jeffers and Hughes, n.d.). This scenario was repeated in 2008 when Hurricane Omar caused the closure of the Four Seasons for a second time, re-opening in December 2010. The closure of the resort also affected airlift, with American Airlines withdrawing service to Nevis in 2009 (Rianne Wiltshire – NIA Statistics, personal communication, May 11, 2011).

As stated earlier, the hotel and restaurant sector in St. Kitts employed 4.2% of the labour force in 2007 and the NSLC found that these jobs tend to be dominated by women. The hotels and restaurants sector also employs a larger percentage of the poorest quintile than in any other quintile, attracting people from the lower end of the skills hierarchy (Kairi Consultants Ltd, 2009). This dependency on a volatile and vulnerable sector such as tourism places the poorer segments of society at even greater risk following events such as hurricanes or the decline in tourism following external global crises.

3. CLIMATE MODELLING

3.1. *Introduction to Climate Modelling Results*

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

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

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

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

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

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

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

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

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

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

3.2. *Temperature*

Observations from the gridded temperature datasets indicate that mean annual temperatures over St. Kitts and Nevis have increased at an average rate of 0.12˚C per decade over the period 1960-2006. The observed increases have been more rapid in seasons June, July, August (JJA) and September, October, November (SON) at the rate of 0.16˚C per decade.

General Circulation Model (GCM) projections from a 15-model ensemble indicate that St. Kitts and Nevis can be expected to warm by 0.5˚C to 1.7˚C by the 2050s and 0.8˚C to 3.0˚C by the 2080s, relative to the 1970-1999 mean. The range of projections across the 15 models for any one emissions scenario spans around 1-1.5˚C. Projected mean temperature increase is similar throughout the year.

Regional Climate Model (RCM) projections indicate much more rapid increases in temperatures over St. Kitts and Nevis compared to the GCM ensemble median projections for the A2 scenario. RCM projections indicate increases of 3.2˚C and 2.4˚C in mean annual temperatures by the 2080s, when driven by the ECHAM4 and HadCM3 respectively. The GCM ensemble projections for the same period range from 1.7 to 3.0˚C.

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 surfaces due to their lower capacity to absorb heat energy, and we therefore see more rapid warming over St. Kitts and Nevis in RCM projections than in GCMs.

Table 3.2.1: Observed and GCM Projected Changes in Temperature for St. Kitts and Nevis

St. Kitts and Nevis: 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	0.2	**0.7**	0.8	0.9	**1.3**	1.7	1.7	**2.3**	3
Annual	25.9	0.12*	A1B	0.2	**0.7**	1	1	**1.4**	1.7	1.2	**2**	2.9
			B1	0.3	**0.7**	0.8	0.5	**1.1**	1.2	0.8	**1.4**	2
			A2	0.3	**0.7**	0.9	1	**1.4**	1.7	1.7	**2.5**	3
DJF	24.7	0.08*	A1B	0.2	**0.7**	1.1	0.9	**1.4**	1.7	1.2	**2.1**	3
			B1	0.3	**0.7**	0.8	0.5	**1.1**	1.3	0.8	**1.4**	2.1
			A2	0.2	**0.6**	0.8	0.8	**1.3**	1.7	1.5	**2.2**	2.9
MAM	25.3	0.10*	A1B	0.1	**0.6**	1	0.9	**1.4**	1.7	1	**2**	2.5
			B1	0.2	**0.6**	0.9	0.4	**1**	1.3	0.7	**1.3**	1.9
			A2	0.1	**0.7**	0.8	0.8	**1.3**	1.7	1.6	**2.2**	2.9
JJA	26.9	0.16*	A1B	0.2	**0.6**	0.9	0.9	**1.3**	1.7	1	**2**	2.8
			B1	0.2	**0.7**	0.8	0.5	**1**	1.3	0.8	**1.3**	2
			A2	0.3	**0.8**	1	0.9	**1.4**	1.9	1.7	**2.4**	3.1
SON	26.6	0.16*	A1B	0.3	**0.7**	1.1	1.1	**1.4**	1.9	1.4	**2**	3.1
			B1	0.4	**0.7**	1	0.7	**1.1**	1.4	0.9	**1.4**	2.1

Table 3.2.2: GCM and RCM Projected Changes in St. Kitts and Nevis under the A2 Scenario

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in ˚C	
	GCM Ensemble Range	1.7	2.3	3
Annual	*RCM (ECHAM4)*		3.2	
	RCM (HadCM3)		2.4	
	GCM Ensemble Range	1.7	2.5	3
DJF	*RCM (ECHAM4)*		3.2	
	RCM (HadCM3)		2.7	
	GCM Ensemble Range	1.5	2.2	2.9
MAM	*RCM (ECHAM4)*		3.1	
	RCM (HadCM3)		2.6	
	GCM Ensemble Range	1.6	2.2	2.9
JJA	*RCM (ECHAM4)*		3	
	RCM (HadCM3)		2.1	
	GCM Ensemble Range	1.7	2.4	3.1
SON	*RCM (ECHAM4)*		3.3	
	RCM (HadCM3)		2.1	

3.3. *Precipitation*

Gridded observations of rainfall over St. Kitts and Nevis do not indicate any statistically significant trend over the period 1960-2006. Long-term trends are difficult to identify due to the large inter-annual variability in rainfall in St. Kitts and Nevis.

GCM projections of future rainfall for St. Kitts and Nevis span both overall increases and decreases with wide variations, but tend towards decreases in more models. Projected changes in annual rainfall range

from -41 to +13 mm per month (-66% to +26%) by the 2080s across the 3 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 St. Kitts and Nevis are strongly influenced by the driving GCM providing boundary conditions. Driven by ECHAM4, RCM projections indicate large proportional decreases in JJA (-17%) and SON (-28%), a small decrease in December, January, February (DJF) (-2%), and an increase in March, April, May (MAM) (+19%) resulting in a moderate decrease (-7%) in total annual rainfall. When driven by HadCM3, RCM projects a large decrease in total annual rainfall (-22%) resulting mostly from large decreases in JJA (-46%) and SON (-35%).

Table 3.3.1: Observed and GCM Projected Changes in Precipitation for St. Kitts and Nevis.

St. Kitts and Nevis: 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	-8	**-3**	5	-22	**-2**	10	-41	**-13**	10
Annual	158.7	-2.1	A1B	-8	**-2**	5	-14	**-5**	8	-31	**-6**	13
			B1	-9	**-2**	13	-11	**-1**	7	-20	**-6**	9
			A2	-10	**-1**	11	-13	**-1**	6	-13	**-3**	4
DJF	124.6	3.1	A1B	-9	**0**	3	-13	**0**	7	-22	**0**	2
			B1	-13	**0**	9	-18	**-1**	6	-15	**0**	9
			A2	-10	**0**	12	-22	**-1**	17	-32	**-1**	6
MAM	123.4	-4.3	A1B	-4	**0**	8	-18	**0**	9	-25	**0**	10
			B1	-3	**0**	7	-11	**0**	2	-12	**0**	6
			A2	-20	**-5**	12	-38	**-13**	17	-65	**-20**	6
JJA	164.1	-3.4	A1B	-20	**-5**	8	-28	**-11**	18	-52	**-14**	10
			B1	-19	**-6**	40	-36	**-10**	0	-35	**-9**	13
			A2	-19	**-2**	12	-22	**-6**	22	-57	**-13**	29
SON	218.3	-3.7	A1B	-12	**0**	10	-25	**-3**	26	-42	**-2**	42
			B1	-25	**-4**	15	-30	**4**	27	-31	**-4**	23

Table 3.3.2: GCM and RCM Projected Changes in St. Kitts and Nevis under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in mm	
	GCM Ensemble Range	-41	**-13**	10
Annual	*RCM (ECHAM4)*		**-6**	
	RCM (HadCM3)		**-38**	
	GCM Ensemble Range	-13	**-3**	4
DJF	*RCM (ECHAM4)*		**-2**	
	RCM (HadCM3)		**-8**	
	GCM Ensemble Range	-32	**-1**	6
MAM	*RCM (ECHAM4)*		**9**	
	RCM (HadCM3)		**-4**	
	GCM Ensemble Range	-65	**-20**	6
JJA	*RCM (ECHAM4)*		**-11**	
	RCM (HadCM3)		**-73**	
	GCM Ensemble Range	-57	**-13**	29
SON	*RCM (ECHAM4)*		**-21**	
	RCM (HadCM3)		**-66**	

Table 3.3.3: Observed and GCM projected changes in precipitation (%) for St. Kitts and Nevis.

St. Kitts and Nevis: 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	-21	**-5**	4	-35	**-10**	20	-66	**-20**	19
Annual	158.7	-1.3	A1B	-18	**-3**	9	-27	**-7**	15	-49	**-13**	26
			B1	-20	**-3**	19	-26	**-9**	6	-32	**-7**	18
			A2	-15	**-2**	29	-34	**-3**	7	-33	**-8**	13
DJF	124.6	2.5	A1B	-16	**-2**	13	-27	**-1**	19	-23	**-1**	10
			B1	-16	**0**	25	-20	**-3**	18	-19	**-2**	20
			A2	-27	**-3**	21	-42	**-3**	56	-60	**-10**	9
MAM	123.4	-3.5	A1B	-11	**2**	25	-48	**1**	11	-47	**-4**	14
			B1	-13	**2**	18	-37	**0**	7	-23	**-2**	20
			A2	-31	**-7**	9	-46	**-10**	32	-80	**-36**	12
JJA	164.1	-2.1	A1B	-23	**-8**	6	-46	**-14**	35	-64	**-23**	19
			B1	-31	**-8**	30	-33	**-14**	3	-43	**-9**	24
			A2	-32	**-3**	8	-41	**-7**	21	-72	**-13**	28
SON	218.3	-1.7	A1B	-29	**0**	11	-33	**-5**	15	-59	**-2**	41
			B1	-35	**-4**	15	-39	**4**	16	-48	**-4**	22

Table 3.3.4: GCM and RCM projected changes in St. Kitts and Nevis under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			% Change	
	GCM Ensemble Range	-66	**-20**	19
Annual	*RCM (ECHAM4)*		**-7**	
	RCM (HadCM3)		**-22**	
	GCM Ensemble Range	-33	**-8**	13
DJF	*RCM (ECHAM4)*		**-2**	
	RCM (HadCM3)		**-6**	
	GCM Ensemble Range	-60	**-10**	9
MAM	*RCM (ECHAM4)*		**19**	
	RCM (HadCM3)		**0**	
	GCM Ensemble Range	-80	**-36**	12
JJA	*RCM (ECHAM4)*		**-17**	
	RCM (HadCM3)		**-46**	
	GCM Ensemble Range	-72	**-13**	28
SON	*RCM (ECHAM4)*		**-28**	
	RCM (HadCM3)		**-35**	

3.4. *Wind Speed*

Observed mean wind speeds from the ICOADS mean monthly marine surface wind dataset demonstrate increasing trends around St. Kitts and Nevis in all seasons over the period 1960-2006. The increasing trend in mean wind speed is 0.65 ms^{-1} per decade in MAM and JJA and 0.57 ms^{-1} per decade in SON.

Mean wind speeds over St. Kitts and Nevis 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 across the 15-model ensemble in all seasons.

RCM projections based on two driving GCMs give mixed results about changes in wind speeds. Driven by ECHAM4, the RCM indicates a very small change in wind speeds in all seasons except for DJF when the change is -0.6 ms^{-1} by the 2080s under the A2 scenario. Driven by HadCM3, the RCM projects relatively large increases in wind speeds in JJA (+0.8 ms^{-1}) and SON (+0.9 ms^{-1}) by the 2080s.

Table 3.4.1: Observed and GCM Projected Changes in Wind Speed for St. Kitts and Nevis.

St. Kitts and Nevis: Country Scale Changes in Wind Speed												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(ms^{-1})	*(change in ms^{-1} per decade)*		*Change in ms^{-1}*			*Change in ms^{-1}*			*Change in ms^{-1}*		
			A2	-0.2	0	0.2	-0.2	0	0.2	0	0.1	0.5
Annual	7.3		A1B	-0.3	0	0.1	-0.3	0	0.3	-0.2	0.1	0.3
			B1	-0.3	0	0.1	0	0.1	0.2	-0.2	0.1	0.3
			A2	-0.3	0	0.4	-0.6	0	0.2	-0.5	0.1	0.4
DJF	7.3	0.41*	A1B	-0.2	0	0.3	-0.2	0.2	0.4	-0.3	0.1	0.5
			B1	-0.3	0	0.3	-0.1	0	0.2	-0.3	0.1	0.4
			A2	-0.2	0	0.2	-0.7	0.2	0.5	-0.3	0.2	0.7
MAM	7	0.65*	A1B	-0.4	0.1	0.3	-0.4	0	0.4	-0.6	0.1	0.5
			B1	-0.5	0.1	0.2	-0.2	0.1	0.3	-0.2	0.1	0.4
			A2	-0.3	0	0.3	-0.2	0	0.2	-0.2	0.2	0.6
JJA	7.9	0.65*	A1B	-0.6	0	0.1	-0.1	0	0.2	-0.3	0.1	0.7
			B1	-0.2	0	0.2	-0.2	0.1	0.4	-0.2	0.1	0.3
			A2	-0.4	0	0.4	-0.1	0	0.3	-0.4	0.1	0.9
SON	6.8	0.57*	A1B	-0.7	0	0.3	-0.6	0.1	0.5	-0.3	0	0.7
			B1	-0.4	0.1	0.3	-0.3	0.1	0.3	-0.4	0.1	0.7

Table 3.4.2: GCM and RCM projected changes in St. Kitts and Nevis under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in ms^{-1}	
	GCM Ensemble Range	0	**0.1**	0.5
Annual	*RCM (ECHAM4)*		**-0.1**	
	RCM (HadCM3)		**0.3**	
	GCM Ensemble Range	-0.5	**0.1**	0.4
DJF	*RCM (ECHAM4)*		**-0.6**	
	RCM (HadCM3)		**-0.3**	
	GCM Ensemble Range	-0.3	**0.2**	0.7
MAM	*RCM (ECHAM4)*		**0.1**	
	RCM (HadCM3)		**-0.1**	
	GCM Ensemble Range	-0.2	**0.2**	0.6
JJA	*RCM (ECHAM4)*		**0.2**	
	RCM (HadCM3)		**0.8**	
	GCM Ensemble Range	-0.4	**0.1**	0.9
SON	*RCM (ECHAM4)*		**-0.1**	
	RCM (HadCM3)		**0.9**	

3.5. *Relative Humidity*

Observations from the HadCRUH do not show any statistically significant trend in relative humidity over the period 1973-2003 in St. Kitts and Nevis.

Relative humidity data has not been made available for all models in the 15-model ensemble. From the available data, the GCM projections indicate a small increase in RH in all seasons. The increase is generally higher for the higher-end emissions scenario A2. The ensemble sub-sample range does span both increases and decreases in RH in all seasons.

RCM projections indicate small increases in RH over St. Kitts and Nevis in all seasons. The increase is roughly 1% by the 2080s under the A2 scenario.

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. Kitts and Nevis.

St. Kitts and Nevis: 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		**0.2**			**0.7**			**1**	
Annual	78.5	-0.15	A1B	-0.4	**0.1**	0.5	-0.7	**0.4**	1.1	-1	**0.6**	1.2
			B1	-0.4	**0.1**	0.5	-0.5	**0.3**	0.8	-0.6	**0.4**	1
			A2		**0.1**			**0.6**			**1.4**	
DJF	77.4	0.16	A1B	-0.6	**-0.2**	0.8	-0.3	**0.3**	1.2	-0.8	**0.9**	2.2
			B1	-0.7	**0.1**	1.5	-0.1	**0.3**	1.3	-0.3	**0.9**	1.2
			A2		**0.4**			**0.7**			**1.1**	
MAM	77.9	-0.22	A1B	-0.3	**0**	0.6	-0.5	**0.3**	1.1	-1	**0.4**	1.5
			B1	-0.5	**0**	0.7	-1	**0.3**	0.7	-0.6	**0.5**	1.1
			A2		**0.1**			**0.4**			**1**	
JJA	79.1	-0.25	A1B	-0.5	**0.2**	0.7	-1	**0.4**	1.2	-1.1	**0.3**	1.3
			B1	-0.5	**0.1**	0.5	-0.8	**0.3**	0.9	-0.9	**0.5**	0.8
			A2		**0**			**0.4**			**0.6**	
SON	79.4	-0.28	A1B	-0.7	**0**	0.6	-0.8	**0.4**	1	-1.3	**0.4**	1.7
			B1	-1	**0.1**	0.5	-1	**0.1**	1	-0.8	**0.4**	1

Table 3.5.2: GCM and RCM projected changes in St. Kitts and Nevis under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in %	
	GCM Ensemble Range		**1**	
Annual	*RCM (ECHAM4)*		**1**	
	RCM (HadCM3)		**0.7**	
	GCM Ensemble Range		**1.4**	
DJF	*RCM (ECHAM4)*		**1.2**	
	RCM (HadCM3)		**0.1**	
	GCM Ensemble Range		**1.1**	
MAM	*RCM (ECHAM4)*		**1.3**	
	RCM (HadCM3)		**0.4**	
	GCM Ensemble Range		**1**	
JJA	*RCM (ECHAM4)*		**0.7**	
	RCM (HadCM3)		**0.8**	
	GCM Ensemble Range		**0.6**	
SON	*RCM (ECHAM4)*		**1**	
	RCM (HadCM3)		**1.6**	

3.6. *Sunshine Hours*

The number of 'sunshine hours' per day are calculated by applying the average clear-sky fraction from cloud observations to the number of daylight hours for the latitude of the location and the time of the year. The observed number of sunshine hours, based on ISCCP satellite observations of cloud coverage, indicates statistically significant increases in annual sunshine hours in St. Kitts and Nevis by 0.79 hours per decade over the period 1983-2001. The strongest increase is seen In JJA at the rate of 1.44 hours per decade.

The number of sunshine hours is projected by most models to increase slightly into the 21st Century in St. Kitts and Nevis, reflecting reduction in average cloud fractions, although the model ensemble spans both increases and decreases in all seasons and across emissions scenarios. The changes in annual average sunshine hours span -0.9 to +0.8 hours per day by the 2080s under scenario A2. The increases are large in JJA, with changes of -1.4 to +1.4 hours per day.

Comparison between GCM and RCM projections of sunshine hours for St. Kitts and Nevis shows that the RCM projections are generally higher than the highest GCM projections for the A2 scenario. 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 (1.2-1.9 hours per day), which is in agreement with the GCM projections.

Table 3.6.1: Observed and GCM Projected Changes in Sunshine Hours for St. Kitts and Nevis.

St. Kitts and Nevis: Country Scale Changes in Sunshine Hours												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(hrs)	*(change in hrs per decade)*		*Change in hrs*			*Change in hrs*			*Change in hrs*		
			A2	-0.2	**0**	0.3	-0.6	**0**	0.5	-0.9	**0.2**	0.8
Annual	6.5	0.79*	A1B	-0.3	**0**	0.3	-0.7	**0**	0.6	-0.7	**0.1**	0.8
			B1	-0.3	**0.1**	0.4	-0.4	**0**	0.3	-0.6	**-0.1**	0.5
			A2	-0.3	**0.1**	0.5	-0.5	**0.2**	0.4	-1	**0.1**	0.5
DJF	7.3	0.43	A1B	-0.4	**0**	0.3	-0.3	**0**	0.5	-0.5	**0.1**	0.4
			B1	-0.4	**0.1**	0.2	-0.3	**0**	0.3	-0.5	**0**	0.3
			A2	-0.5	**0**	0.4	-0.8	**0**	0.6	-1.2	**-0.1**	0.6
MAM	6.8	0.91	A1B	-0.7	**-0.2**	0.2	-0.8	**-0.1**	0.4	-1.2	**-0.1**	0.6
			B1	-0.5	**0**	0.6	-0.4	**0**	0.2	-1	**-0.2**	0.5
			A2	-0.5	**0**	0.5	-0.9	**0.1**	1.2	-1.4	**0.5**	1.4
JJA	6	1.44*	A1B	-0.7	**0**	0.5	-1.2	**0.1**	1.5	-1	**0.3**	1.4
			B1	-0.5	**0.1**	0.7	-0.5	**0.1**	0.8	-0.9	**0.2**	1.2
			A2	-0.4	**0.1**	0.3	-0.5	**0.1**	0.7	-0.3	**0.2**	1.2
SON	5.8	0.23	A1B	-0.4	**0**	0.6	-0.5	**0**	0.8	-0.5	**0.1**	1.2
			B1	-0.5	**0.1**	0.5	-0.3	**-0.1**	0.5	-0.4	**-0.1**	0.7

Table 3.6.2: GCM and RCM Projected Changes in St. Kitts and Nevis under the A2 Scenario.

		Projected changes by the 2080s SRES A2		
		Min	***Median***	***Max***
			Change in hrs	
	GCM Ensemble Range	-0.9	0.2	0.8
Annual	*RCM (ECHAM4)*		0.9	
	RCM (HadCM3)		1.3	
	GCM Ensemble Range	-1	0.1	0.5
DJF	*RCM (ECHAM4)*		0.8	
	RCM (HadCM3)		0.8	
	GCM Ensemble Range	-1.2	-0.1	0.6
MAM	*RCM (ECHAM4)*		0.3	
	RCM (HadCM3)		0.9	
	GCM Ensemble Range	-1.4	0.5	1.4
JJA	*RCM (ECHAM4)*		1.3	
	RCM (HadCM3)		1.6	
	GCM Ensemble Range	-0.3	0.2	1.2
SON	*RCM (ECHAM4)*		1.2	
	RCM (HadCM3)		1.9	

3.7. *Sea Surface Temperatures*

Sea-surface temperatures from the HadSST2 gridded dataset indicate statistically significant increasing trends in JJA and SON (0.12˚C per decade) in the waters surrounding St. Kitts and Nevis.

GCM projections indicate increases in sea-surface temperatures throughout the year. Projected increases range between +0.7˚C and +2.8˚C by the 2080s across all three emissions scenarios. The range of projections under any single emissions scenario spans roughly around 1.0 to 2.0˚C.

Table 3.7.1: Observed and GCM Projected Changes in Sea Surface Temperature for St. Kitts and Nevis.

St. Kitts and Nevis: 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	**0.6**	0.8	0.9	**1.2**	1.6	1.6	**2.1**	2.8
Annual	27.4	0.09*	A1B	0.1	**0.6**	1	0.9	**1.4**	1.6	1	**2.3**	2.6
			B1	0.3	**0.7**	0.7	0.5	**1**	1.2	0.7	**1.3**	1.8
			A2	0.5	**0.6**	0.8	1	**1.2**	1.7	1.5	**2**	2.9
DJF	26.5	0.06	A1B	0.1	**0.6**	1	0.8	**1.3**	1.6	1.1	**2.2**	2.7
			B1	0.3	**0.6**	0.8	0.4	**1**	1.3	0.7	**1.3**	1.9
			A2	0.5	**0.6**	0.8	1	**1.1**	1.6	1.4	**2**	2.7
MAM	26.6	0.07	A1B	0.1	**0.6**	1	0.9	**1.3**	1.6	0.9	**2**	2.4
			B1	0.3	**0.7**	0.9	0.4	**0.9**	1.2	0.6	**1.4**	1.8
			A2	0.5	**0.6**	0.8	0.9	**1.2**	1.5	1.4	**2.2**	2.7
JJA	28	0.12*	A1B	0.2	**0.6**	0.9	0.8	**1.4**	1.6	0.8	**2.2**	2.6
			B1	0.2	**0.6**	0.7	0.5	**1**	1.1	0.7	**1.3**	1.9
			A2	0.4	**0.7**	0.9	1	**1.3**	1.8	1.4	**2.3**	3
SON	28.3	0.12*	A1B	0.2	**0.7**	1.1	0.9	**1.5**	1.8	1.2	**2.4**	2.8
			B1	0.3	**0.6**	0.8	0.6	**1.1**	1.3	0.9	**1.2**	1.8

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 St. Kitts and Nevis.

GCM projections indicate increases in the frequency of 'hot' days and 'hot' nights by 35-96% of days/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 diminish in frequency, and 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. Kitts and Nevis.

St. Kitts and Nevis: Country scale changes in Temperature Extremes											
	Observed Mean 1970-99	Observed Trend 1960-2006	*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
			Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
	% Frequency	*Change in frequency per decade*	*Future % frequency*			*Future % frequency*			*Future % frequency*		
Frequency of Hot Days (TX90p)											
		A2				38	**53**	64	53	**79**	96
Annual		*A1B*				39	**53**	63	44	**69**	86
		B1				28	**42**	48	35	**49**	60
		A2				58	**74**	93	94	**98**	100
DJF		*A1B*				50	**78**	90	76	**95**	99
		B1				29	**48**	65	44	**71**	86
		A2				57	**77**	97	91	**98**	100
MAM		*A1B*				53	**79**	94	70	**98**	100
		B1				26	**47**	78	46	**74**	87
		A2				51	**84**	93	85	**99**	100
JJA		*A1B*				56	**85**	91	65	**97**	99
		B1				31	**68**	81	47	**79**	94
		A2				76	**90**	99	97	**99**	100
SON		*A1B*				78	**91**	99	90	**99**	100
		B1				54	**78**	92	74	**89**	99
Frequency of Hot Nights (TN90p)											
		A2				38	**52**	63	53	**75**	96
Annual		*A1B*				39	**53**	62	44	**68**	83
		B1				27	**43**	47	35	**47**	63
		A2				56	**68**	92	93	**98**	100
DJF		*A1B*				49	**72**	90	74	**94**	99
		B1				28	**44**	64	44	**63**	86
		A2				56	**75**	96	91	**97**	100
MAM		*A1B*				52	**76**	93	69	**95**	99
		B1				26	**47**	78	46	**72**	85
		A2				49	**84**	92	84	**98**	99
JJA		*A1B*				56	**85**	91	67	**95**	99
		B1				30	**71**	75	48	**78**	94
		A2				77	**87**	99	98	**99**	100
SON		*A1B*				78	**91**	99	91	**99**	100
		B1				54	**77**	93	74	**93**	98
Frequency of Cold Days (TX10p)											
		A2				0	**0**	0	0	**0**	0
Annual		*A1B*				0	**0**	0	0	**0**	0
		B1				0	**0**	2	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**	6	0	**0**	0

St. Kitts and Nevis: Country scale changes in Temperature Extremes												
	Observed Mean 1970-99	Observed Trend 1960-2006	*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*			
			Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*	
	% Frequency	*Change in frequency per decade*	*Future % frequency*			*Future % frequency*			*Future % frequency*			
			A2			0	**0**	0	0	**0**	0	
SON			*A1B*			0	**0**	0	0	**0**	0	
			B1			0	**0**	1	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**	2	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**	7	0	**0**	0	
			A2			0	**0**	0	0	**0**	0	
SON			*A1B*			0	**0**	0	0	**0**	0	
			B1			0	**0**	1	0	**0**	0	

3.9. *Rainfall Extremes*

Changes in rainfall extremes, based on 1- and 5-day rainfall totals, as well as excess 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 St. Kitts and Nevis.

GCM projections of rainfall extremes are mixed across the ensemble of models, ranging from both decreases and increases of all measures of extreme rainfall. The proportion of total rainfall that falls in heavy events decreases in most model projections, changing by -24% to +6% by the 2080s. The variability in the magnitude of the annual maximum daily rainfall shows very little or no change by the 2080s across all emissions. Maximum 5-day rainfalls tend to decrease in model projections ranging from -22 to +18 mm annually by the 2080s.

Table 3.9.1: Observed and GCM Projected Changes in Rainfall Extremes for St. Kitts and Nevis.

St. Kitts and Nevis: 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			-18	**-1**	8	-23	**-5**	4
Annual			*A1B*			-21	**-2**	8	-24	**-3**	6
			B1			-19	**0**	5	-20	**0**	4
			A2			-13	**0**	6	-13	**-1**	6
DJF			*A1B*			-10	**-1**	4	-12	**-1**	7
			B1			-11	**0**	5	-10	**-1**	7
			A2			-17	**0**	2	-18	**-5**	5
MAM			*A1B*			-11	**-4**	4	-14	**-6**	6
			B1			-9	**-1**	5	-10	**-1**	13
			A2			-20	**-2**	12	-23	**-3**	6
JJA			*A1B*			-21	**-5**	11	-22	**0**	6
			B1			-21	**-1**	4	-18	**0**	5
			A2			-21	**0**	5	-23	**-5**	9
SON			*A1B*			-29	**0**	11	-25	**0**	7
			B1			-18	**0**	9	-21	**1**	7
	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			-5	**0**	2	-7	**-1**	2
Annual			*A1B*			-5	**-1**	12	-8	**0**	6
			B1			-5	**0**	12	-4	**0**	9
			A2			-4	**0**	0	-2	**0**	3
DJF			*A1B*			-2	**0**	0	-3	**0**	1
			B1			-3	**0**	2	-4	**0**	4
			A2			-2	**0**	4	-6	**0**	1
MAM			*A1B*			-2	**0**	3	-3	**0**	2
			B1			-3	**0**	2	-2	**0**	2
			A2			-6	**0**	2	-7	**-2**	2
JJA			*A1B*			-5	**-1**	2	-8	**-2**	4
			B1			-6	**0**	4	-5	**0**	4
			A2			-4	**0**	4	-6	**-1**	4
SON			*A1B*			-5	**0**	18	-7	**0**	4
			B1			-4	**0**	13	-5	**0**	11

Maximum 5-day Rainfall (RX5day)								
	mm	*Change in mm per decade*	*Change in mm*			*Change in mm*		
		A2	-15	**0**	10	-20	**-7**	10
Annual		*A1B*	-13	**-4**	26	-22	**-3**	9
		B1	-16	**0**	21	-15	**2**	18
		A2	-9	**-1**	3	-8	**-1**	11
DJF		*A1B*	-9	**-1**	7	-10	**-1**	2
		B1	-11	**0**	7	-8	**-1**	7
		A2	-4	**0**	8	-14	**-1**	4
MAM		*A1B*	-5	**-1**	9	-13	**-2**	5
		B1	-8	**0**	1	-6	**0**	8
		A2	-12	**-3**	10	-31	**-7**	4
JJA		*A1B*	-18	**-6**	10	-33	**-2**	5
		B1	-12	**-1**	7	-15	**-1**	6
		A2	-13	**-1**	9	-19	**-5**	11
SON		*A1B*	-12	**-3**	35	-21	**-2**	14
		B1	-13	**0**	21	-16	**1**	28

3.10. *Hurricanes and Tropical Storms*

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

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

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

Climate models are still relatively primitive with respect to representing tropical storms, and this restricts our ability to determine future changes in frequency or intensity. We can analyse the changes in background conditions that are conducive to storm formation (boundary conditions) (e.g. Tapiador, 2008),

or apply them to embedded high-resolution models which can credibly simulate tropical storms (e.g. Knutson and Tuleya, 2004; Emanuel *et al.*, 2008). RCMs are able to simulate weak 'cyclone-like' storm systems that are broadly representative of a storm or hurricane system but are still considered coarse in scale with respect to modelling hurricanes.

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

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

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

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

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

3.11. *Sea Level Rise*

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

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

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

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

(Source: NOAA, 2009)

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

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

thermal expansion, with only a conservative estimate of the contribution from ice sheet melt (Rahmstorf, 2007).

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

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

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

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

3.12. *Storm surge*

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

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

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

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

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

Further impacts on storm surge flood return period may include:

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

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

4. VULNERABILITY AND IMPACTS PROFILE FOR ST. KITTS

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 the Old Road Town to provide additional community-level data. Field surveys in the Basseterre Bay and Frigate Bay areas 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 St. Kitts.

St. Kitts 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 St. Kitts, the major issues of climate change in St. Kitts are SLR, the likelihood of more intense weather systems and periods of drought. SLR is seen as the greatest potential impact, especially during intense storm swell conditions.

4.1. *Water Quality and Availability*

4.1.1. Background

In St. Kitts, the majority of water is sourced from approximately 28 groundwater wells, which provides for 70% of water needs, and 7 surface springs, which provides for 30% of water needs (MPWUTP, 2010). These wells are recharged primarily from rainfall, where average precipitation values of 1625 mm per year, but can be as high as 2000 mm/yr at higher elevations. For surface water, there are a number of intake areas, namely Wingfield, Frankland, Stonefort, Lodge, Phillip's and Greenhill. Wingfield is the greatest of the springs, supplying most of the water needs of Basseterre (See Table 4.1.1). It is estimated that approximately 4,500 m^3 per day (1 million gallons per day) are treated by sedimentation, rapid sand filtration and chlorination at the La Guerite Treatment Plant for supply into Basseterre. The 7 springs have a total combined flow of approximately 9,000 m^3 per day (2 million imperial gallons per day) (Dr Sahely, personal communication, April, 12, 2011).

Table 4.1.1: Surface Water Sources in St. Kitts

Spring	Average Flow (gpm)	Elevation (ft. amsl)
Wingfield	830,000	420'
Cayon/Greenhill	500,000	1590'
Franklands	240,000	1420'
Phillips	230,000	920'
Stonefort	50,000	1040'
Lodge	30,000	1590'
Milliken	30,000	1350'

(Source: MSD, 2007)

As the assistant Water Engineer of the St. Kitts Water Services Department (WSD) describes "The rest of our freshwater supply is provided by a network of 28 wells with a combined capacity of approximately 23,000 m^3 per day (5 million imperial gallons per day). The total capacity of storage reservoirs is about 32,000 m^3 (7 million gallons)" (Dr Sahely, personal communication, April 12, 2011). Groundwater augmentation began in the early 1970s (Christmas, 1977 cited in MHE, 2001), as prior to this period only surface water was utilised with accompanied increasing water deficits. Currently, it is estimated that approximately 50% of the available groundwater resources of the island have been exploited (Dr Sahely, personal communication, April, 12, 2011).

All residents of St. Kitts have access to water 24 hours per day, which is 100% supplied by the St. Kitts WSD of the Ministry of Public Works, Utilities, Transport and Post of the Government of St. Kitts and Nevis. Most of this water is piped directly to residences; while some households access water from nearby standpipes (i.e. 9.7% of the population access water from a stand pipe in their yard, 3.6% access water from a stand pipe outside their yard). In St. Kitts in 2007, 4.2% of households and 2.9% of individuals were defined as having poor access to water, that is, they do not have access to piped water. In both St. Kitts and Nevis 96.8% of the population has access to potable water and 86% stated they had water for 7 days of the week. There is no breakdown for type of toilet facilities by island, but for the entire federation 7% and 1% of the population utilises pit latrines and ventilated pit latrines. Only 5.8% of toilets are linked to a sewer system and 1.1% of the population indicated they do not have access to any type of toilet facility (Kairi Consultants Limited, 2009a). Springs and streams account for 35% of the water supply, but there is variable capacity across the island with arid areas unable to get sufficient supply and other areas with excess capacity (Kairi Consultants Limited, 2009b). Urbanisation has increased the demand for water.

Over 50% of water supplies are consumed by the domestic sector, while the tourism, agriculture and commercial sectors each utilise between 10 and 15% of the island's water resources. The current water supply is sufficient to meet all parishes due to investments in water infrastructure by the St. Kitts WSD over the last 10 years and as such water distribution is considered as equitable. However, Dr Sahely notes "demand for water is increasing, especially from agriculture and tourism, including educational tourism which brings a lot of students to the island (Dr Sahely, personal communication, April, 12, 2011). The most populated areas are Basseterre, Sandy Point and Cayon, which have received influx of residents from rural areas in recent years (MSD, 2007).

A desalination plant is run by one major hotel (Marriott Hotel), but desalination is not part of the public supply system (Kairi Consultants Limited, 2009b). The privately owned desalination plant run at the Marriott Hotel became fully operational in 2004. This reverse osmosis plant has an output of 1.25 million gallons per day of water, which is used to satisfy the needs of the 648 room resort and to provide irrigation water to its 18 hole golf club (The Solutions Group, n.d.).

No central sewerage system exists in either St. Kitts or Nevis; however there is a treatment plant at Frigate Bay. Soak-aways and septic tanks are used for domestic disposal. A study conducted in Basseterre coastal area indicated that there were cases of high total dissolved solids in the water samples taken in ponds and wells there (Sahely *et al.,* 2010), as well as high levels of faecal coliform bacteria as a result of squatter settlements, with insufficient infrastructure for waste disposal and sanitation (ECLAC, 2003).

There were 93,081 visitors and 127,705 stop over visitors in 2009 and 2008, respectively. Cruise ship passengers were as high as 450,553 in 2009 and 400,916 in 2008 and excursionists stood at 3,708 and 3,920 people in the same years (OECS, 2010). There are limited data available on tourist arrivals for St. Kitts only, but in 2010 it is reported that St. Kitts alone received 91,561 stay-over visitors, 3,419 excursionists, and

512,445 cruise and yacht passengers (B. Harris, St. Kitts Statistics Department, personal communication, May 23, 2011).

Table 4.1.2: Water Tariff for Domestic and Non-Domestic users in St. Kitts

	Water Usage (Imperial Gallons per Month)	Rate EC $ (US $)
Domestic (metered)	0 – 5,000	$ 7.20 ($2.70) per 1,000 gallons
Domestic (metered)	5,001–7,000	$9.60 ($3.60) per 1,000 gallons
Domestic (metered)	> 7,001	$12.00 ($4.50) per 1,000 gallons
Domestic (non-metered)	-	*$7.50 ($2.80) on every $5.00 ($1.85) of the annual assessed rental value of the premises
Non-domestic/Commercial (metered)	-	$15.00 ($0.56) per 1000 gallons
Non-domestic (non-metered)	-	**$12.50 ($4.60) on every $5.00 ($1.85) of the annual assessed rental value of the premises
Agriculture	-	$8.00 ($2.97) per 1,000 gallons

*Provided that in no case shall the sum payable in respect of any month be less than EC $18.00/mth
**Provided that in no case shall the sum payable be less than EC $37.50/mth
Conversion rate utilised: EC $1=US $0.37

(Source: Dr Sahely, personal communication, April, 12, 2011; MPWUTP, 2001)

The cost of water in St. Kitts was last revised in January, 2001. There are 3 pricing groups; domestic, non-domestic and a concessionary rate for farmers. These pricing groups are further sub-divided according to metered or non-metered costumers (See Table 4.1.2). The St. Kitts WSD is the sole water provider on this island, meaning that all water is provided by the Government. An exception is the Mariott Hotel which installed a desalination plant in 2004. There are 15,440 water customers in St. Kitts, which includes both commercial and domestic users. The majority of users, approximately 83% (78% domestic users and 5% commercial users) are metered (See Figure 4.1.1). However, the billing system used to estimate these figures are not very reliable and the ratio of metered to non-metered customers is regarded to range between 10 to 20% (Dr Sahely, personal communication, April, 12, 2011). In the National Action Programme for Combating Desertification and Land Degradation, there were approximately 100 public stand pipes and government facilities and water loss through the distribution system was estimated at about 10% (MSD, 2007).

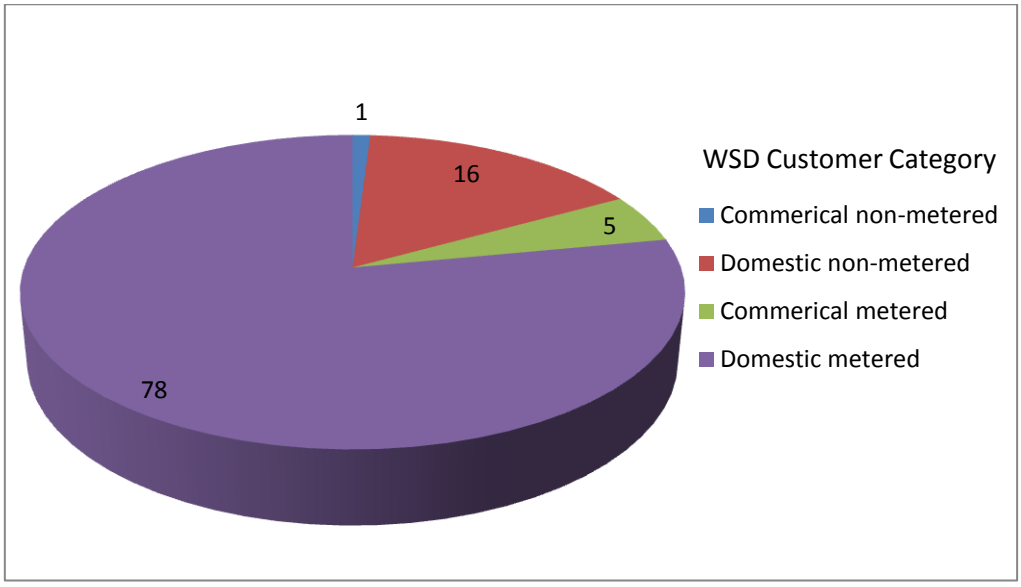


Figure 4.1.1: Distribution of Metered and Non-Metered Customers of the St. Kitts Water Services Department (%)
(Source: Dr Sahely, personal communication, April, 12, 2011)

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

A number of threats of water resources in St. Kitts have been identified. For example, the Basseterre aquifer is threatened by contamination from "oils spills from the mechanic shop at the sugar factory, fertiliser and agrochemicals, bacteria (from sewage effluents, farm and factory effluents, pig farms, solid waste disposal)" (Ocean Earth Technologies Consortium, 2009). Surface water sources are susceptible to siltation which also affects water intake structures, but these are periodic events and mainly are linked to heavy rainfall events (Dr Sahely, personal communication, April, 12, 2011). Some siltation problems have been associated with land conversion by farmers, particularly in the upper slopes. Other means by which land degradation has occurred include clearing of forested land for residential and tourism developments, land cleared at high elevations for farming and degradation as a result of squatting or unregulated settlements. Uncontrolled bushfires, particularly in the SEP, only worsen siltation and erosion problems (MSD, 2007). As a result of current developmental patterns in St. Kitts, freshwater and coastal ecosystems, which include mangroves and coral reefs, are also being degraded. St. Kitts is not a low-lying island, and as such flooding is not a common occurrence. Nonetheless, in 1998 flash flooding did occur, dumping 5 ft of mud on Basseterre. It is also noteworthy that at least 60% of the population lives in low-lying areas (MHE, 2001). Basseterre and its surrounding areas are the most vulnerable to flash flooding on the island (USACE, 2004). On the other hand, SLR may impact on coastal aquifers which the island depends on for the majority of its water supplies.

Drought in St. Kitts

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*., 2011). 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.

During the dry season, spring areas are subjected to periodic episodes of water shortages due to tourism water demand and the general rise in the standard of living of persons. In these episodes, water is sourced from areas that have wells (ECLAC, 2003). Aside from an increased water demand, lower than average rainfall or meteorological drought conditions periodically affects St. Kitts. Most recently in 2010, average rainfall was lower than recorded by the meteorological office at the St. Kitts International Airport. There was almost no rain for the first two weeks of February, 2010, where 0.5 cm was recorded. This can be compared to February 2009 where 4.95 cm of rain was recorded for the 4 week period. The water produced from surface intakes by the St. Kitts WSD in 2010 decreased by 15% of 2009 volumes. Further, the above-ground store tanks had reductions of stored water to 53% at Morne Peak and 33% at La Guerite of their full capacity. Storage tanks such as these usually maintain a greater than 80% operating level. Thus, the St. Kitts WSD described the situation as an extremely dry spell and issued advisories to the public through press releases and public appearances on television and radio. WSD also implemented conservation measures, including the repairing of leaks and limiting the use of hoses and sprinklers (MPWUTP, 2010).

Drought frequency is not well documented in St. Kitts. Aside from the 2010 drought event, another severe drought occurred between 1999 and 2000. Such droughts last between 1-2 months (Dr Sahely, personal communication, April, 12, 2011). Other recorded instances of dry spells include 2003, when water yield from wells was 40% of its normal output. This highlighted the necessity for more water storage across the island (ECLAC, 2003).

Before the closure of the sugar industry, which was a major income earner for the country, this crop was rain fed. As a result of dry spells, the productivity of the crop was affected. The St. Kitts WSD began supplying increased water for irrigation to mitigate this problem in 2005. However, this only represents 10% of the total water demand on the island. However, this does not represent the demand for water for irrigation as during conditions of dry spells and droughts, the agriculture sector's productivity is significantly affected as a result of decreased precipitation. Farmers that rely heavily on rainfall are worst affected (Dr Sahely, personal communication, April, 12, 2011).

During the dry season, the WSD issues public notices for consumers to conserve and restrict water usage to only essential purposes. In recent times, water restriction measures have not been utilised as precipitation levels have been fairly sufficient. However, during the 1999 to 2000 drought period, water restriction measures were implemented to management water resources. In the past, water restriction measures were also utilised in areas where infrastructure was inadequate (Dr Sahely, personal communication, April, 12, 2011). Rainwater harvesting is not widely practiced and is therefore not usually an option during dry spells and drought conditions in St. Kitts (MSD, 2007).

Greater use of groundwater resources assists in meeting water demands during conditions of drought, as occurred in 2010, where excess capacity from a network of 30 groundwater wells was tapped into. During the February 2010 drought, the official WSD press release stated that "the impacts were still evident on the amount of water stored in above-ground storage tanks. Under normal conditions, the storage tanks are operating at or above 80% of full capacity. In the midst of the drought (week of February 7th, 2010), two of

our largest storage tanks were down to 53% (Morne Peak) and 33% (La Guerite) of full capacity" (MPWUTP, 2010).

For the time being, the seasonal water resources are adequate to meet supply, however Dr Sahely has stated that "more frequent droughts would put significant pressure on our existing system especially if we do not invest in more effective and efficient infrastructure as well as water conservation" (Dr Sahely, personal communication, April, 12, 2011). In the case of St. Kitts, there is a need to take account of drought and arid conditions that afflict some areas of the island. In the Half Moon Area, there is need for back-up storage of water, and cisterns are necessary to deal with water shortages. There is need for mitigation measures to be introduced in light of conditions (Kairi Consultants Limited, 2009b).

Coastal Aquifers and the Potential for Saline Intrusion

Coastal aquifers are threatened by seawater intrusion with rising sea levels, exacerbated by a decrease in groundwater recharge through over abstraction and decreasing precipitation (Bates *et al*., 2008; Lewsey *et al*., 2004; Werner and Simmons, 2009). A rise in sea level as low as 0.1 m may cause a decrease in aquifer thickness of more than 10 m (Bobba *et al*., 2002). This will lead 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. Neighbouring aquifers will then 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. 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).

Groundwater resources were initially developed in St. Kitts due to its greater reliability compared to surface sources. Surface sources supplied more than 50% of water resources to St. Kitts up until 1992 (MHE, 2001). The Caribbean Environmental Health Institute (CEHI, 2006) describes costal aquifers in St. Kitts as being "divided into seven major ground water basins with an estimated total safe yield of 50,000 m^3 per day of which 27,300 m^3 per day has been developed to meet current demands". All of the groundwater resources from St. Kitts are sourced from coastal aquifers. Inevitability, with between 65 - 70% of water demand being derived from groundwater, the St. Kitts WSD are beginning to see early signs of saltwater intrusion (Dr Sahely, personal communication, April, 12, 2011). The Basseterre Valley Area has 10 supply wells, additional monitoring wells and a number of ponds (Sahely *et al*., 2010). Due to salt water intrusion at a number of points, 2 actions have been taken. The first action was to abandon one of the wells. Additionally metering was introduced into the district and tank level controlling, both in an attempt to conserve water in the area. To mitigate the problem, new water resources need to be explored; this should be combined with utilising a suitable well design to minimise saline intrusion (ECLAC, 2003). The monitoring of aquifers is deemed as crucial to their protection from the threat of over abstraction in future (USACE, 2004).

The water resources on the island are believed to be sufficient to meet current demand, but future increases in demand cannot be met with current infrastructure and from current supply sources. Fortunately, there are still groundwater resources that have not been exploited on the island; it is estimated that 50% of groundwater resources have not been tapped into (Dr Sahely, personal communication, April, 12, 2011). The Basseterre aquifer, which is a coastal unconfined aquifer, supplies 40% of the water used in St. Kitts and Nevis, making the area substantially important in economic, social and environmental concerns (Sahely *et al*., 2010). Problems of this catchment area include urban encroachment, inappropriate land use and pollution.

The latest study on groundwater sources in St. Kitts was conducted in 2009. Results indicated that the largest coastal aquifer on the island was safe from contaminants such as pesticides, herbicides, nitrates and so forth. However, there is evidence that total dissolved solids are increasing, which is an indication of early signs of saltwater intrusion and has prompted the WSD to decrease water abstraction rates (Dr Sahely, personal communication, April, 12, 2011).

4.2. *Energy Supply and Distribution*

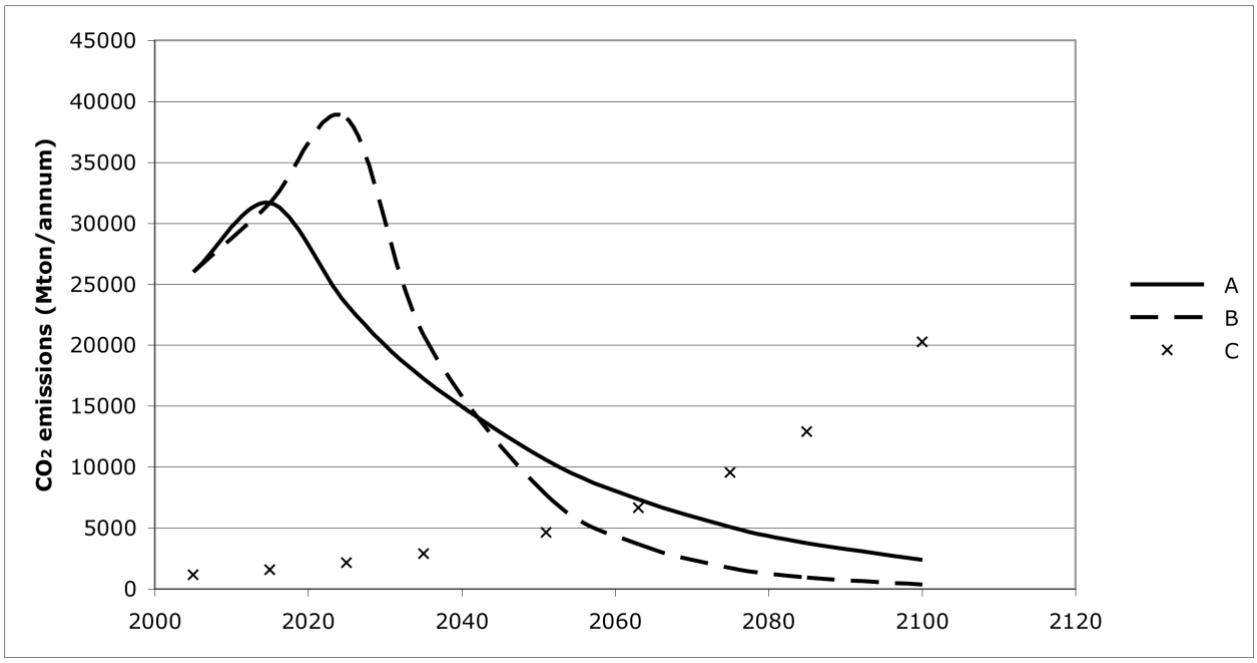
4.2.1. Background

A Global Perspective

Tourism is a significant user of energy and a concomitant contributor to emissions of GHGs. 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 being GHGs. When considering the radiative forcing of all GHGs, 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%), accommodation (21%), activities (4%), and other transport (3%) including cruise ships (1.5%).

Into 2050, emissions from tourism are expected to grow considerably. Based on a BAU scenario for 2035, which considers changes in travel frequency, length of stay, travel distance, and technological efficiency gains, it is estimated that emissions will increase by about 135% compared to 2005 (UNWTO-UNEP-WMO, 2008). 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 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 that are in line with global climate policy will consequently demand considerable changes in the tourism system, with a reduction in overall energy use, and a switch to renewable energy sources. Such efforts will have to be supported through technology change, carbon management, climate policy, behavioural change, education and research (Gössling, 2010). Carbon taxes and emissions trading are generally seen as key mechanisms to achieve emissions reductions. Destinations and tourism stakeholders consequently need to engage in planning for a low-carbon future.

The Caribbean Perspective

It is widely acknowledged that the Caribbean accounts for only 0.2% of global emissions of CO_2, with a population of 40 million (i.e. 0.6% of the world's population (Dulal *et al*., 2009)). However, within the region, emissions are highly unequally distributed between countries (Figure 4.2.2). For instance, Trinidad and Tobago, as an oil-producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. St. Kitts and Nevis belong to the region's low emitters at 2.6 t CO_2 on a per capita basis (i.e. a value comparably lower than the world annual average of 4.3 t CO_2). Note, however, that a more recent estimate of emissions in the islands (196,000 t CO_2; US EIA, 2010, see also calculations below) points at considerably higher per capita emissions of about 3.8 t CO_2 in 2008, given a population of 51,300 (ECCB, 2009).

In the future, global emissions have to decline considerably below 4.3 t CO_2 per year – the 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, there may be little room for St. Kitts and Nevis to become

more energy-intense, and there may consequently be a need to reduce national emissions in the medium-term future.

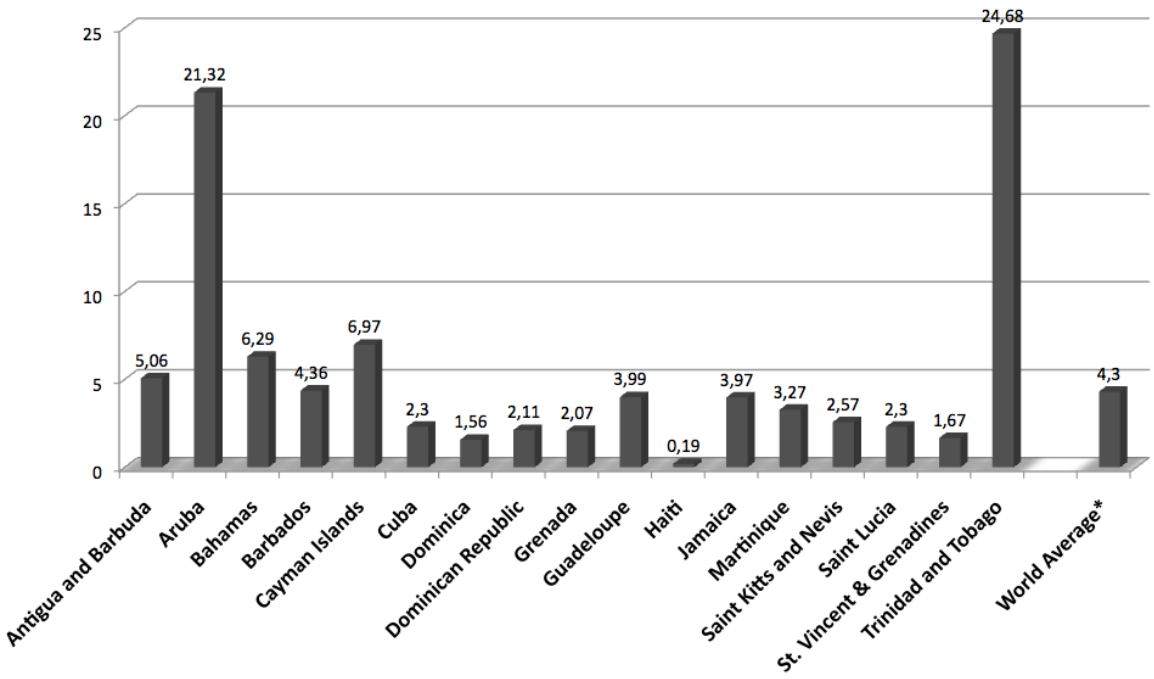


Figure 4.2.2: Per Capita Emissions of CO_2 in Selected Countries in the Caribbean, 2005

(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 with a focus on tourism.

St. Kitts and Nevis

Tourism is a mainstay of the St. Kitts and Nevis economy, with tourism expenditure totalling US $122 million in 2008 (UNWTO, 2010), as compared with the estimated GDP for 2010 of US $531 million at current prices (CIA World Factbook, 2011). St. Kitts and Nevis have to import considerable amounts of oil, totalling 1,225 barrels per day or 56,163 t in 2007 (CIA World Factbook, 2011; 1,300 barrels per day in 2008, according to US EIA (2010), which corresponds to emissions of about 196,000 t CO_2 in 2007 (US EIA, 2010). According to the Draft Energy Sector Digest, 68,161 tonnes of fuel oils were shipped in 2008 to St. Kitts Sea Port and 15,780 tonnes to Nevis Air and Sea Ports (MOPWUEH, 2011a). Based on these values, approximately 80% of total imports are for St. Kitts.

Electricity production in the Federation is based on two diesel fuelled power stations (one in each island), with additional input when needed from the St. Kitts Marriott Resort, which has been granted a license to produce its own electricity. The St. Kitts Electricity Department (SKED) is a government owned entity that operates a plant at Needsmust, which provides power for the entire island of St. Kitts. The Department is currently undergoing a corporatisation process which is due for completion on July 31, 2011, after which time the electricity operations will be managed by the St. Kitts Electricity Company (McCall, 2011). Overall electricity generation in St. Kitts from the SKED plant was 152.4 GWh in 2007, based on fuel use of 8.62 million gallons, or 30,940 t (Table 4.2.1).

Table 4.2.1: Electricity Generating Statistics, St. Kitts 1994-2007

YEAR	UNITS GENERATED (MWH)	NUMBER OF CONSUMERS	FUEL CONSUMPTION Imp. Gallons	LUBE OIL Imp. Gallons	PEAK DEMAND (MW)	INSTALLED CAPACITY (MW)
1994	66,354	15,673	3,952,103	21,924	11.40	18.45
1995	72,919	11,210	4,273,927	24,279	11.90	22.85
1996	74,299	11,212	4,528,205	20,199	12.40	22.85
1997	82,212	11,754	4,492,613	21,725	13.70	22.85
1998	88,347	12,058	4,908,166	23,346	14.94	22.85
1999	96,739	12,399	5,374,388	25,564	16.28	35.25
2000	108,002	12,938	n.a.	n.a.	17.30	n.a.
2001	112,619	13,647	6,195,302	14,821	18.10	n.a.
2002	119,351	13,861	n.a.	n.a.	18.90	n.a.
2003	120,583	14,437	7,094,255	20,102	18.90	n.a.
2004	123,022	14,789	7,210,083	24,465	20.20	n.a.
2005	134,926	n.a.	7,604,078	25,952	23.10	33.50
2006	136,751	15,224	7,838,034	29,186	21.30	33.50
2007	152,391	15,441	8,615,616	37,166	23.00	34.90
2008	143,086		8,097,222			

N.B. Total consumers declined in 1995 due to all inactive accounts being deleted from the system.

(Source: K. Bennett, St. Kitts Energy Department, personal communication May 18, 2011)

Another 26.2 million kWh were produced by the Marriott Resort in 2008, based on diesel consumption of about 110,000-115,000 imperial gallons per month (Table 4.2.2). Electricity has been bought and sold between SKED and Marriott since 2008, because the Marriott plant is connected to the National grid. Table 4.2.2 shows that in 2008 there was a problem meeting the demand for electricity following a number of engine failures and this was also the case in 2009 and 2010. This information is supported by the Draft Energy Sector Digest which reports that in 2009 SKED experienced problems with two newly purchased diesel generator sets, where 8.8 MW (2x4.4MW) was lost due to a fire. This was being compensated for by renting diesel generator sets.

Table 4.2.2: Production Statistics for the St. Kitts Marriott Resort

Year	Generation (thousand kWh)	Net exports (kWh)	Reason for transfer
2004	27,880		
2006	26,430		
2008	26,229	260,000	Between May and August SKED suffered multiple engine failures and had rolling blackouts.
2009		62,000	Between June and November same as above.
2010	25,798	-110,000	Net import to Marriott, but still had to assist SKED in Feb-May, July and August

(Source: G. Moise, General Manager, Royal Utilities, personal communication May 23, 2011)

The Marriot also uses economisers (heat recovery system) for heating water, but it is reported in the draft Energy Digest that due to the world crude price increases, they prefer to purchase power from the grid with increased introduction of renewable energy technologies leading to reduced electricity costs (MOPWUEH, 2011a).

It is difficult to identify the share of tourism in national energy use based on this data, other than to acknowledge that Marriott's production exists to primarily serve the needs of tourists using their property. While jet kerosene (domestic) is identified at 10.3% of national import of fuels of both islands, the volume of bunker fuels is not mentioned, and the year of the assessment would appear to be 1994 and therefore somewhat out-dated (MOE, 2001). 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 by sub-sector, which is for both islands in the absence of individual data (Table 4.2.3). The assessment is based on arrivals of 121,380 tourists, coming from the US (61%), other Caribbean countries (22%), the UK (8%), Canada (6%) and other countries of the world (3%) in 2008 (UNWTO, 2010; note that an alternative figure for tourist arrivals is 127,705 in 2008; OECS, 2010). There were also 402,000 cruise passenger arrivals in 2008 (UNWTO, 2010; 400,916 according to OECS, 2010).

Table 4.2.3: Assessment of CO_2 Emissions from Tourism in St. Kitts and Nevis, 2007-2008

Tourism sub-sector	Energy use	Emissions	%	Assumptions
Aviation[1)]	25,889 t fuel	40,776 t CO_2	24	Bottom-up calculation Based on actual arrivals
Jet kerosene[2)]	2,950 t fuel	9,292 t CO_2	5	Fuel use based on national bunker statistics (in the year 1994)
Road transport[3)]	754 t fuel	2,414 t CO_2	1	Including tourists, excursionists not considered
Cruise ships[4)]	21,230 t fuel	67,938 t CO_2	40	Bunkers for cruise ships
Accommodation[5)]	25.6 GWh	25,555 t CO_2	15	Based on energy statistics from Barbados
Activities[6)]	-	3,267 t CO_2	2	Global average
Sub-total	-	149,242 t CO_2	87	
Indirect energy use (factor 1.15)	-	22,386 t CO_2	13	To account for life-cycle emissions
Total	-	171,628 t CO_2	100	

1) Aviation fuels: here assumed to include 73,518 arrivals from the US (assumed distance from New York: 2,877), 26,907 from other Caribbean countries (distance: 500), 9,782 from the UK (distance London: 6,664), 7,274 from Canada (distance Montreal: 3,379) and 3,899 from other countries of the world (distance: 5,000). The total distance (return) flown is thus 668,451,760 pkm, which, at a pkm value of emissions of 0.122 kg CO_2 (world average, UNWTO-UNEP-WMO 2008), results in emissions of 81,551 t CO_2, out of which half (40,776 t CO_2) would be associated with the tourism system in St. Kitts and Nevis (bunker fuel approach).
2) According to St. Kitts and Nevis' (MOE, 2001) initial communication to the UNFCCC, 2,950 t of jet fuel was used domestically.
3) Road Transport: 121,000 international tourist arrivals in 2008 (UNWTO, 2010), with each tourist travelling an assumed 150 pkm on the island during the stay. At an assumed average of 0.133 kg CO_2 per pkm (50% occupancy rate; UNWTO-UNEP-WMO, 2008), emissions are in the order of 20 kg CO_2 (corresponding to about 8 l of diesel) per tourist, totalling 2,414 t CO_2, or about 754 t of fuel. Cruise tourists are not included, as these are day visitors not likely to engage in longer trips.
4) The amount of fuel bunkered in St. Kitts and Nevis for cruise ships is unknown. Consequently, a value of 169 kg CO_2 per day (Eijgelaar *et al*., 2010) is included in calculations as the share associated with cruise tourism in St. Kitts and Nevis. The 402,000 cruise tourists in 2008 (UNWTO, 2010; according to OECS, 2010, there were 400,916 cruise ship passengers in 2008) would consequently account for 67,938 t CO_2, or about 21,230 t fuel. Note that cruise ship passenger numbers were considerably lower in 2007, according to OECS (2010) accounting for 249,323. The higher 2008 value is used for calculations, as it more accurately reflects today's situation.
5) 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. Kitts and Nevis. Average length of stay is 9.6 days (Caribbean Tourism Organisation, n.d.) resulting in 1,161,600 nights. Electricity use would consequently have been in the order of 25.6 GWh. Electricity production is assumed to be less efficient in St. Kitts and Nevis, and a value of 1 kg CO_2 per kWh is assumed here, resulting in emissions of 25,555 t CO_2.
6) 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 121,000 tourists would thus have caused emissions from activities corresponding to 3,267 t CO_2. As energy use for activities will be partially fossil fuel, and partly electricity based, it is difficult to translate these values into energy use. This excludes emissions associated with day visitors (cruise ships).

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

Results indicate that cruise tourism is the most important sub-sector, accounting for 40% of emissions. This is followed by aviation (24%) and accommodation (15%). If compared to national emissions of 196,000 t CO_2, the tourism sector would thus account for about 88%. This is only for comparison, however, as aviation fuels are only partially contained in national energy statistics (MOE, 2001); (there are no direct flights from long-haul markets, hence the limited consumption of bunker fuels). An alternative comparison can be made by looking at energy consumption in hotels. As outlined, production in St. Kitts was 178.6 million kWh in 2007/2008 and according to the calculations in Table 4.2.3, approximately 15% would be consumed by tourism accommodation, provided that assumptions concerning energy intensity are correct.

This would equate to energy use of 29.4 million kWh in the accommodation sector alone, which is marginally more than the energy produced by the Marriott plant.

The distribution of energy use between tourism in St. Kitts and Nevis is also unknown. De Cuba (2006) reports that in 2004, 41% of electricity in St. Kitts was used for domestic purposes and 58% in the commercial sector, however, the latter is not broken down further. In 2008, 22,007 stay-over visitors arrived at Nevis airport (R. Wiltshire, NIA statistics office, personal communication May 11, 2011), that is about one fifth of international stop-overs in both islands (cf. OECS, 2010). Whether this accurately reflects the distribution of overall energy consumption in the respective islands' tourism systems is unknown, but this value may serve as an indicator of energy use and is comparable to the distribution of fuel imports between islands mentioned above.[1]

Trends in Energy use in St. Kitts

Trends in energy use are clearly increasing (Table 4.2.1), though there has been considerable oscillation over the years. Oil consumption for both islands increased from 449 barrels per day in 1990 to 1300 barrels per day in 2008, and associated emissions from 66,000 t CO_2 to 196,000 t CO_2 over the same period (US EIA, 2010). As outlined, it is not possible to distinguish trends between the two islands based on available data, but further growth in energy consumption is anticipated in both. De Cuba (2006) presents the projected peak demand for St. Kitts, which indicates considerable growth in the period 2005-2015 (Figure 4.2.3).

Figure 4.2.3: Projections of the Annual Peak Demand for St. Kitts 2005-2015
(Source: From Generation Expansion Plan (2005-2015) cited in De Cuba, 2006)

There also exists a projection of electricity demand for tourism for St. Kitts in particular, showing that current consumption is likely to double over the coming decade, mostly because of an extension of existing accommodation capacity and activities (primarily golf) through the Christophe Harbour development:

[1] There is limited data available on tourist arrivals for St. Kitts, but in 2010 it is reported that the island received 91,561 stay-over visitors, 3,419 excursionists, and 512,445 cruise and yacht passengers. Nevis received 7,494 stay-over arrivals, as well as 163 excursionists, 3,542 cruise ship passengers and 530 yacht passengers in 2010. If this data is correct, a far greater share of energy use and emissions falls on St. Kitts. There is a large fluctuation in arrivals, as arrivals in Nevis dropped dramatically in 2009 following the closure of the Four Seasons hotel. The reported figure of stay-over arrivals at Nevis airport, was 22,007 in 2008 (R. Wiltshire NIA statistics office, personal communication May 11, 2011 and B. Harris, Statistics Department, personal communication May 21, 2011).

…in the next 7 years 2 hotels with each 250 rooms, a harbour, golf course, 3 restaurants, 1400-1500 villas/houses etc. shall be constructed, utilizing about 20-22MW within the next 5-7 years. On long-term if all villas are build they anticipate in about 15 years (by 2025) a need of 27MW of capacity; the occupancy will be of a seasonal nature, where in high season periods it is important that sufficient power is available. (MOPWUEH, 2011a: 15)

Figure 4.2.4 shows how different tourism scenarios (low price and many tourists, normal price and regular numbers of tourists, high price and few tourists) would affect the island's energy use. The details of this model are however unclear without sourcing the original document. All scenarios point at greatly elevated energy consumption.

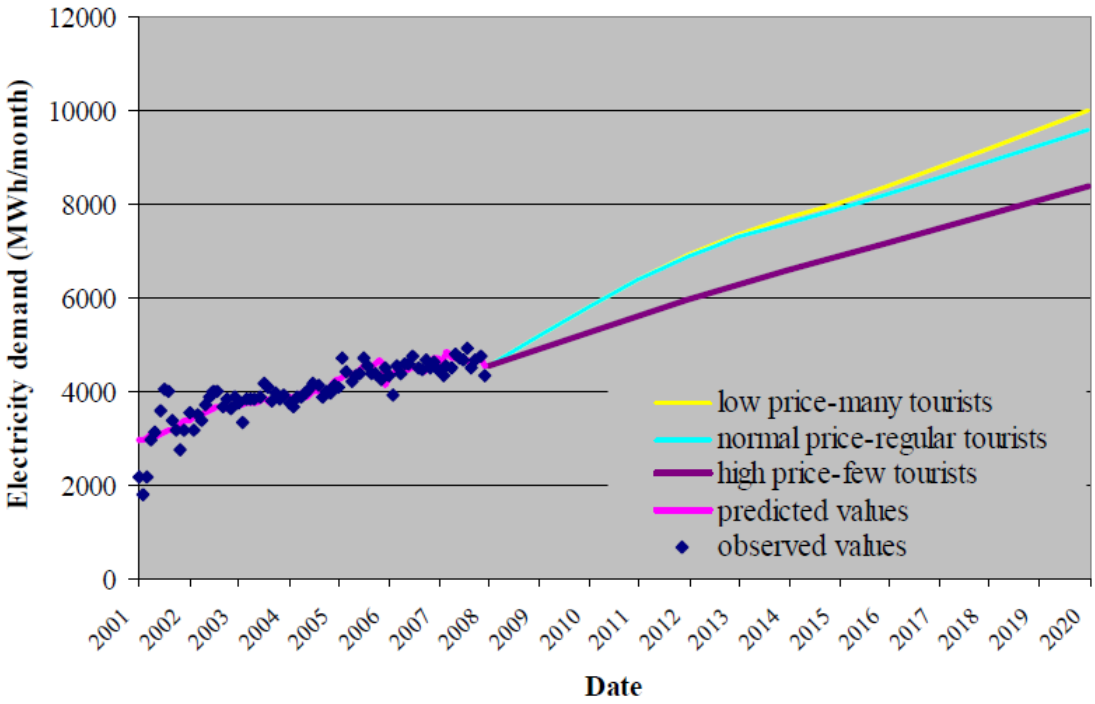


Figure 4.2.4: Electricity Demand Growth Based on Various Tourism Development Scenarios in St. Kitts
(Source: From Generation Expansion Plan (2005-2015) cited in MOPWUEH, 2011a)

Policy Response to Energy Challenges

The Government of St. Kitts and Nevis has developed draft versions of an Energy Sector Digest, National Energy Policy and National Energy Plan (MOPWUEH, 2011a, b, and c). In the Digest, the Government foresees strong economic growth and a concomitant rise in petroleum (MOPWUEH, 2011a). As economic growth is seen to be associated with low energy costs, the Government believes that a low-cost source of energy must be made available. At the same time, the Government is aware of the consequences of an increasingly energy intense economic system for global warming, outlining the need to develop renewable energy:

St. Kitts and Nevis contributed a minute 0.0006% of the total CO_2 output globally in 2008. It is therefore important to note that even if the federation were to make many changes even to the point of reducing its CO_2 emissions output altogether, it would not make much of a difference in the global warming issues facing the federation, as its contribution is so minute. Global warming is by its very nature a global problem, and as such, is a problem that must be addressed globally. Despite the fact that the

federation's contribution to global warming is miniscule, it will still be affected disproportionately by the effects of global warming. (MOPWUEH 2011a: 7)

National contributions to global warming are not usually measured in percentage terms in international climate negotiations, rather per capita emissions are used. As outlined, in 2008, the population of 51,300 (ECCB, 2009) may have caused emissions in the order of 196,000 (i.e. about 3.8 t CO_2 per capita). This does not include a considerable share of energy consumption associated with tourism in the islands, especially from cruise ships and aviation. If this were to be included, per capita emissions would likely exceed 4.3 t CO_2 (i.e. the global per capita average). Since energy consumption in St. Kitts and Nevis is anticipated to increase it is clear that the country needs to reduce its emissions.

Nevertheless, the Federation is keen to "champion the global use of a low carbon intense energy supply" (MOPWUEH, 2011a: 20). To this end, the islands will focus on regional integration, diversification and increased energy supply and security, with a view to participating in the Clean Development Mechanism (MOPWUEH, 2011a, b, c). With regard to policy in the transport sector, the National Action Plan reports that the Government strategy for transport will:

be focused on maintaining a level of adequate taxation on motor vehicles and automotive fuels, which will encourage the use of public transportation and paying greater attention to fuel consumption and assessing alternative forms of mobility and vehicles. Improved vehicle maintenance is also of great importance in ensuring optimum transportation efficiencies. In parallel public transport patterns and efficiency need to be increased as well as the traffic routing system improved. Pedestrians and bicyclists shall be supported by infrastructural and safety improvements (MOPWUEH, 2011c).

There is no mention of the cruise and aviation sub-sectors.

Renewable and Sustainable Energy

In 2006, a stakeholder meeting was held to discuss a sustainable energy plan for the islands (Lambrides *et al*., 2006), with another more recent consultation to present the first draft of the National Energy Policy document in Nevis on April 12 and 14, 2011 (Williams, 2011). Under the guiding principle of "Energy for Sustainable Development", the National Energy Policy is intended to set out the Government of the Federation of St. Kitts and Nevis' legal, institutional and economic framework with regard to energy (MOPWUEH, 2011b). The content of this document is presented in relevant sections. As early as 2006, important insights on energy use and options to restructure the energy system were presented by De Cuba (2006), who describes the optimal expansion capacity for St. Kitts:

…where the system architecture for the period 2008-2015 is: 4 x 800kW Nordex wind turbines, 2.9 MW Bio energy plant, an inverter/rectifier capacity of 3.5 MW and an increasing diesel capacity over the years from 50.6 to 63.4 MW in period 2005-2015. In a later stage a 5.4 MW Solar PV capacity is added to the energy production mix. This means less diesel is required compared to the BAU scenario, and thus less fuel usage, a lower cost of electricity production and lower CO_2 emissions. Note that the total installed capacity (diesel + RET capacity) is the minimal required installed capacity in order to have a 0% capacity shortage. (De Cuba, 2006: 16)

This is presented graphically in Figure 4.2.5 and shows that based on this study the renewable fraction is still under 10% by 2015. This determination considered both economic and socio-environmental factors in reaching the optimal scenario.

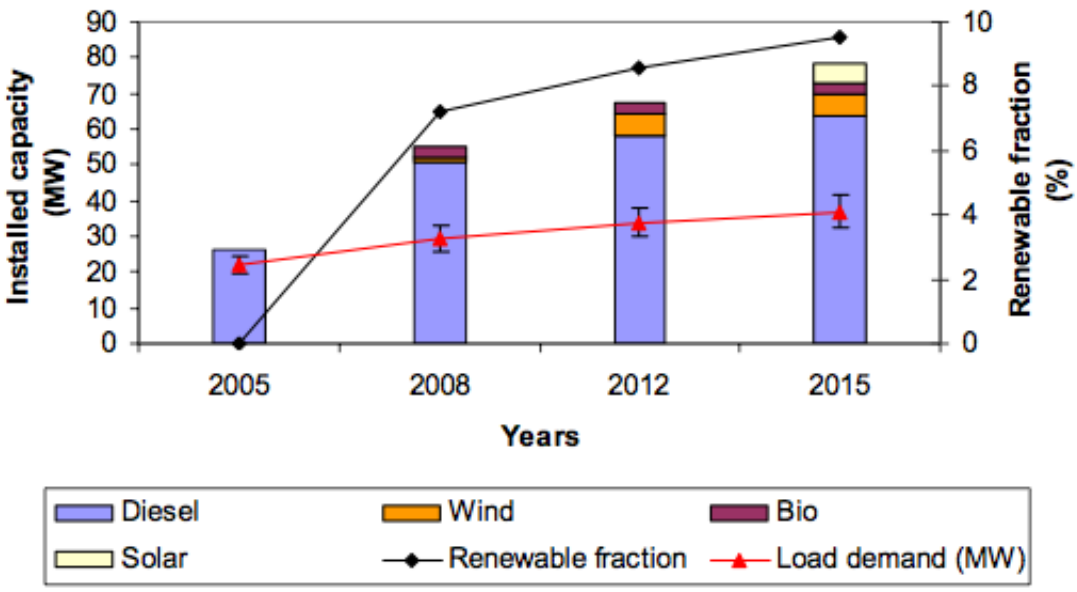


Figure 4.2.5: Optimal Capacity Expansion for St. Kitts

(Source: De Cuba, 2006)

Both St. Kitts and Nevis are currently pursuing projects in renewable energy development harnessing geothermal and wind energy to produce electricity. Wind and geothermal energy have been identified to have the greatest short to medium term development potential (MOPWUEH, 2011a). In the period 2010-2012, 5.4 MW of wind power on St. Kitts and 2.2 MW on Nevis, as well as a 10 MW geothermal plant on Nevis are planned. To facilitate this process,

> *A power purchase agreement is being negotiated for a 5.4 MW wind farm (Phase I) including access to 150 acres near the White Gate Development area on the northern part of St. Kitts. The project might be commissioned in Dec 2011. With regards to this project the SKED has expressed its need for technical due diligence and assistance in the planning in order to see how this could fit into the network and what the effects might be on the electricity grid and management. Also for the signature of the power purchase agreement more technical support as well as legal support is desired. (MOPWUEH, 2011a)*

According to a press release dated March 31, 2011, the first phase of the North Star wind energy project at Belle Vue consists of 3 turbines totalling 5.4 MW of power and subject to the timely delivery of the turbines, ground-breaking at the site should take place in July or August 2011 (SKNIS, 2011). Table 4.2.4 presents the options that are being considered for future renewable energy development over the short, medium and long term.

Table 4.2.4: Possible Future Wind, Solar and Geothermal Power

		St. Kitts		Nevis		Regional	
		Wind	Solar	Wind	Geothermal	Renewable	Fossil fuel
Short term (1-3 years)	Installed Capacity (MW)	5.4		2.2	10		
	Average capacity (MW)	2.7		0.9	9		
	Sum additional average capacity (MW)				12.6		
	Timing	2012		2010	2011		
Medium term (3-10 years)	Installed Capacity (MW)		5		35		
	Average capacity (MW)		2		33		
	Sum additional average capacity (MW)				35		
	Timing		2013		2015		
Long term (10-20 years)	Installed Capacity (MW)				20	30	
	Average capacity (MW)				18	28	
	Sum additional average capacity (MW)				46		
	Timing				2020	2020	

(Source: MOPWUEH, 2011a)

While considerable effort is made to develop renewable power sources, government energy policy (MOPWUEH, 2011b) does not seem to address fossil fuel consumption regarding aviation and cruise ships. There are a number of recommendations for improving public and private transportation from both a fuel efficiency and alternative fuel perspective, including the use of incentives for hybrid type vehicles and looking at alternative means of travel between islands of the Federation such as hovercraft (MOPWUEH, 2011b and c). However, there is currently no separate transport policy containing RET or energy efficiency targets and a Master Plan is still required for transportation (MOPWUEH, 2011a). It is suggested that the gradual decline in fuel consumption for transportation is primarily attributable to the attempts by households and businesses to reduce their transportation costs in light of rising oil prices, and the general increase in the cost of living (MOPWUEH, 2011a). According to the Government (MOPWUEH, 2011a), road transportation is responsible for 37% of CO_2 emissions.

Policy for Tourism

Specifically for tourism, the National Energy Action Plan (MOPWUEH, 2011:17) mandates that the Ministry of Tourism incorporates the National Energy Plan (NEP) into its strategy for the development of a more sustainable tourism sector in St. Kitts and Nevis. Specific emphasis is to be laid on issues such as:

a. Increased energy efficiency and utilisation of solar water heaters and other thermal sources to be used in either heating or cooling purposes;

b. Energy efficiency increases by new technology as for example heat exchanges and adsorption chilling for air conditioning;

c. Utilisation of combined heat-and-power plants in the sector for self-generation purposes of heat and electricity;

d. Recycling at the source in order to support and ease the utilisation of generated waste streams;

e. Utilise cleaner fuels as for example LPG or LNG;

f. Evaluation of a natural resource utilisation levy for high-class energy intensive tourism;

g. Organising capacity building events to especially small hotels that lack own concierge services;

h. Organising the collection of grease, fats and oils from hotels and restaurants in order to convert them into bio-diesel;

i. The Ministry of Tourism shall propose a strategic action plan for 10 years addressing the above issues. This plan shall be elaborated in collaboration with the Energy Commission and in accordance to the objectives defined by the NEP. The Plan will be elaborated with the support of the Energy Commission, Energy Unit and the National Statistics Department. The plan will be reviewed every 3 years in order to evaluate the proceedings and progress made. If necessary the plan will be changed or instruments shall be developed to support the achievement of the plans' objectives.

Again, no mention is made of the most relevant energy consuming sectors, i.e. cruise ships and aviation.

4.2.2. Vulnerability of the Energy Sector to Climate Change

Two key impacts related to energy and emissions are of relevance for the tourism sector and the wider economy. First 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 stabilising temperatures at 2°C by 2100 is taken seriously, both regulation and market-based instruments will have to be implemented to cut emissions of GHG. Such measures would affect the cost of mobility, in particular, air transport, being a highly energy- and emission-intense sector. The following sections will discuss past and future energy costs, the challenges of global climate policy and how these interact to create vulnerabilities in the St. Kitts and Nevis 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, 2010) projects for instance, that oil prices will almost double between 2009 and 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 USS120/barrel.

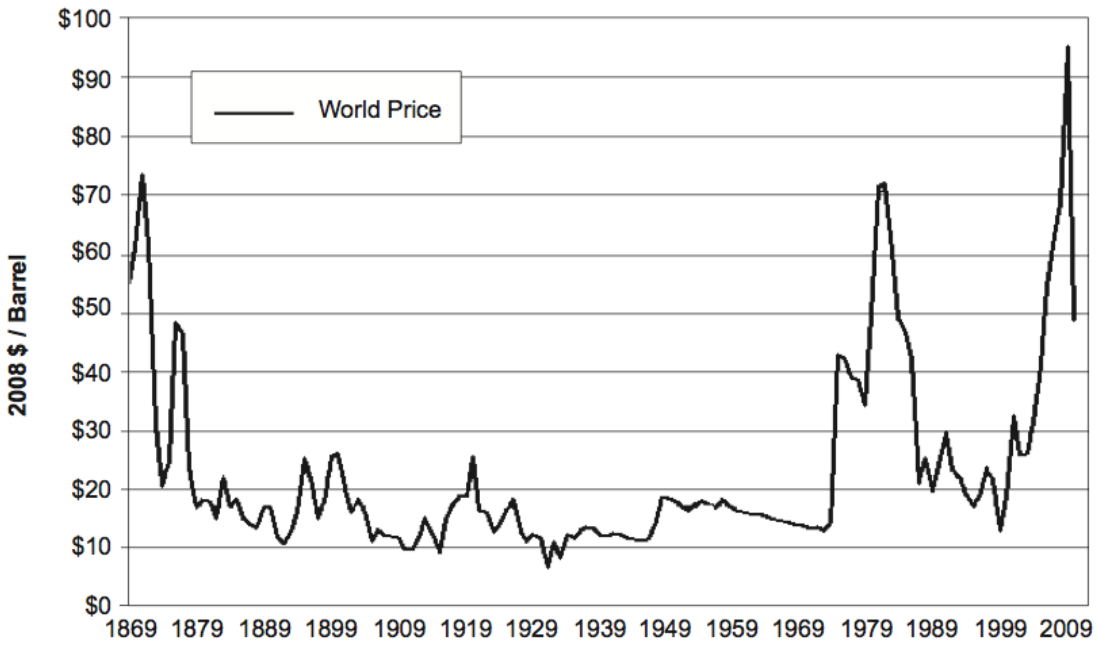


Figure 4.2.6: Crude Oil Prices 1869-2009

(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). Rising costs for conventional fuels will therefore become increasingly relevant, particularly for transport, the sector that is most dependent on fossil fuels with the least amount of options to substitute energy sources. Within the transport sector, aviation will be most affected due to limited options to use alternative fuels, which have to meet specific demands regarding safety and energy-density (cf. Nygren *et al*., 2009; Upham *et al*., 2009). Likewise, while there are huge unconventional oil resources, including natural gas, heavy oil and tar sands, oil shales and coal, there are long lead times in development, necessitating significant investments. The development of these oil sources is also likely to lead to considerably greater environmental impacts than the development of conventional oil resources (IEA, 2009).

These findings are relevant for the tourism system as a whole because mobility is a precondition for tourism. Rising oil prices will usually be passed on to the customer, a situation evident in 2008, when many airlines added a fuel surcharge to plane tickets 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 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, International Air Transport Association (IATA) projected the average 2008-price of a barrel of oil at US $87, up 6% from the average price level in 2007 (IATA, 2007). In early 2008, IATA corrected its projection of fuel prices to an average of US $106 per barrel for 2008, an increase of 22% over its previous estimate. However, in July 2008, oil prices reached US $147 per barrel, and IATA corrected its forecast for average oil prices in 2008 to almost US $142 per barrel, a price 75% higher than a year ago (IATA, 2008). In autumn 2008, again seemingly unexpected by the overwhelming majority of actors in tourism, the global financial system collapsed due to speculation of financial institutions with various forms of investment. As a result, the global economy went into recession, and by the end of 2008, oil prices had reached a low of US $40 per barrel.

Fuel price volatility in late 2008 exceeded 30% of operational costs (IATA 2009, see Figure 4.2.7) and 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. This reversed 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.

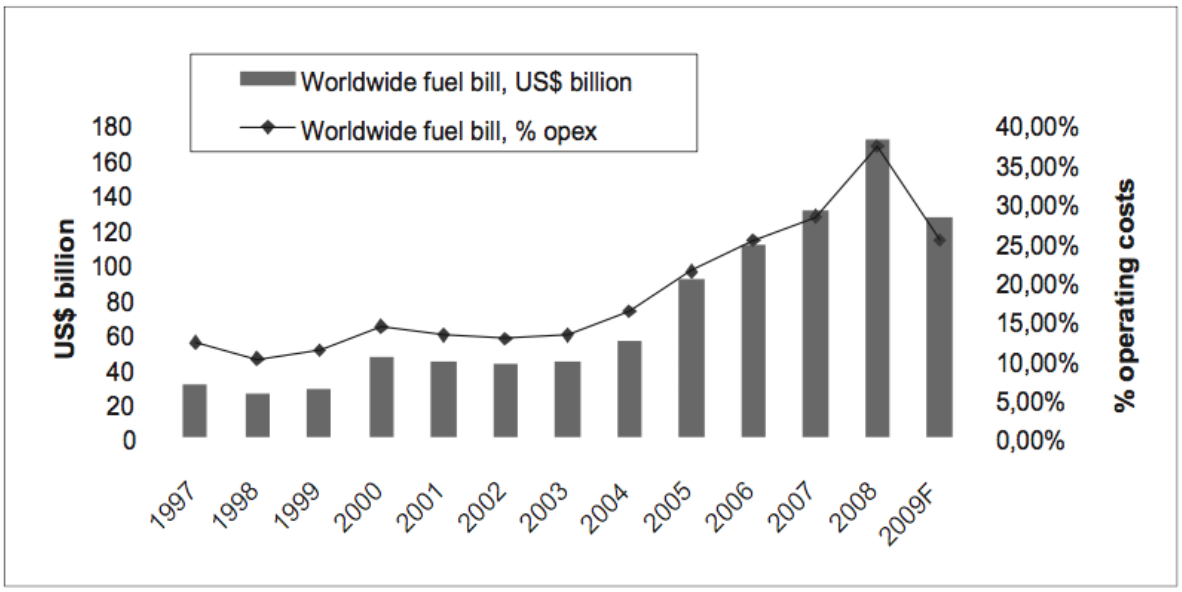


Figure 4.2.7: Fuel Costs as Part of a Worldwide Operating Cost

(Source: IATA, 2009)

Climate Policy

As described in the introduction, climate change is high on the global political agenda, but so far, the EU is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. While it is likely that the EU Emission Trading Scheme (ETS) will not seriously affect aviation, the only tourism sub-sector to be directly integrated in the scheme by 2012 (e.g. Mayor and Tol, 2009, see also Gössling *et al*., 2008), discussions are on-going of how to control emissions from consumption not covered by the EU ETS. This is likely to lead to the introduction of significant carbon taxes in the EU in the near future (EurActiv, 2009). Moreover, the EU ETS will set a tighter cap on emissions year-on-year, and in the medium-term future (i.e. around 2015-2025), it can be assumed that the consumption of energy-intense

products and services will become perceivably more expensive. There is also evidence of greater consumer pressure to implement pro-climate policies. While climate policy is only emerging in other regions, it can be assumed that in the near future, further legislation to reduce emissions will be introduced – the new air passenger duty in the UK is a recent example, and has already been followed by Germany's departure tax (as of January 1, 2011).

As of November 1, 2009, the UK introduced a new air passenger duty (APD) for aviation, which replaced its earlier, two-tiered APD. The new APD distinguishes 4 geographical bands, representing one-way distances from London to the capital city of the destination country/territory, and based on 2 rates, 1 for standard class of travel, and 1 for other classes of travel (Table 4.2.5).

Table 4.2.5: UK Air Passenger Duty as of November 1, 2009

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

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

(Source: HM Revenue and Customs, 2008)

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

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

There is consequently growing consensus among business leaders and policy makers that emissions of GHG represent a market failure. The absence of a price on pollution encourages pollution, prevents innovation, and creates a market situation where there is little incentive to innovate (OECD, 2010). While governments

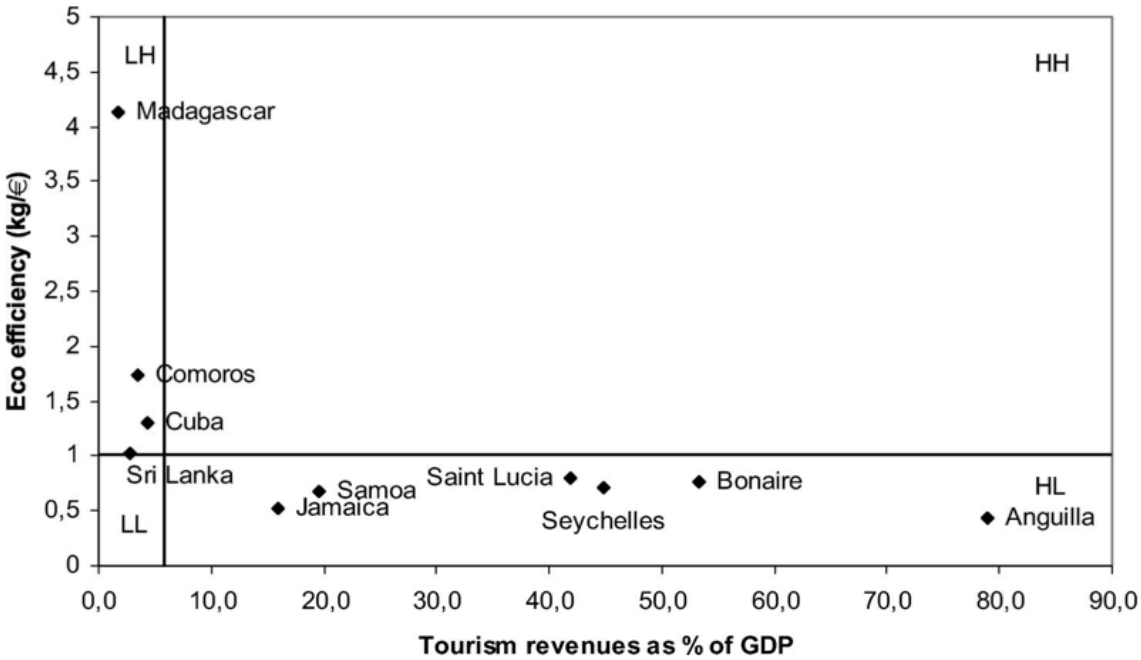
have a wide range of environmental policy tools at their disposal to address this problem, including regulatory instruments, market-based instruments, agreements, subsidies, or information campaigns, the fairest and most efficient way of reducing emissions is increasingly seen in higher fuel prices (i.e. the introduction of a tax on fuel or emissions) (e.g. Sterner, 2007; Mayor and Tol, 2007, 2008, 2009, 2010a,b; see also OECD, 2009 and 2010; WEF, 2009; PricewaterhouseCoopers, 2010).

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

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

Vulnerabilities

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, a situation not likely to change in the near future due to the existence of a large number of bilateral agreements. Furthermore, emissions trading as currently envisaged by the EU would, upon implementation in 2012, increase the cost of flying by just about €3 per 1,000 passenger-kilometres (pkm) at permit prices of €25 per tonne of CO_2 (Scott *et al*., 2010). Similar findings are presented by Mayor and Tol (2010b), who model that a price of €23/t CO_2 per permit will have a negligible effect on emissions developments. Other considerable increases in transport costs due to taxation are not currently apparent in any of the 45 countries studied by OECD and UNEP (2011), though such taxes may be implemented in the future. The example of the UK has been outlined above and Germany introduced a departure tax of €8, €25 and €45 for flights <2000 km, 2000-4000 km and >4,000 km as of January 1, 2011.

The implications of the EU ETS for tourism in island states were modelled by Gössling *et al*. (2008). The study examined the implications of the EU ETS for European outbound travel costs and tourism demand for 10 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 3 GHG mitigation policy scenarios for aviation (represented by varied carbon prices), 2 oil price projections, and 3 price elasticity estimates was conducted to examine the impact on air travel arrivals from 8 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 emphasize that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020 (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 SIDS in particular. To anticipate these changes and to prepare the vulnerable tourism economies in the Caribbean to these changes should thus be a key management goal for tourism stakeholders.

Climate Change Impacts on Energy Generation, Distribution and Infrastructure

A report on the potential impacts of climate change on the energy sector published by the U.S. Department of Energy distinguishes between direct 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.

St. Kitts' energy production is entirely based on diesel powered plants with a contribution of wind power likely to be included sometime in 2012. The wind power project is expected to contribute between 10 and 15% of the demand (SKNIS, 2011). According to the work of De Cuba (2006), the optimal combination of power supplies for St. Kitts in 2015 would still only consist of less than 10% of total capacity. Potential physical climate change impacts specific to traditional energy production systems, as well as the renewable technologies being considered by the Government for St. Kitts (wind and solar), 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 St. Kitts 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. 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. In 1998, Hurricane Georges inflicted damage estimated at EC $10,000,000 to the power plant building, with water damage to generators and a number of lines/poles brought down (PAHO, n.d.). In the aftermath of extreme weather, the process of restoring transmission and proper operation of generating facilities depends on road access and the amount of supplies available to replace infrastructure components that have been damaged or destroyed (see section 4.7, Comprehensive Natural Disaster Management). The vulnerability of the sector to extreme weather events therefore has even greater implications for increasing the recovery period and extending the loss of productivity in all other sectors within the country following an event (U.S. Department of Energy/National Energy Technology Laboratory, 2007; IPCC, 2007b; Contreras-Lisperguer and de Cuba, 2008).

Model projections for St. Kitts suggest an increase in mean annual temperatures, as well as the number of 'hot' days and nights to as much as 96% 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 heating and cooling purposes may increase in response to extremes in diurnal temperatures. Higher temperatures have also been shown to reduce the efficiency of energy generation at thermal power plants, similar to the Needsmust Power Station in St. Kitts. 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 and de Cuba, 2008). (See section 4.1, Water Quality and Availability).

St. Kitts is already implementing renewable energy projects utilising wind power and has determined that solar energy is the other viable option for the island. Alternative energy sources, while they are environmentally more sustainable, also face challenges from climate variability. 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 indicate the potential for increased wind speeds in the second half of the year, but decreases in December through to February (see 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 climate model projections for sunshine hours span both increases and decreases in all seasons and across emissions scenarios. There is however broad agreement across models that there will be an increase in sunshine hours in the rainy season, which potentially increases the viability of using photovoltaic technology – even if only on the basis of increasing incidence of sunshine (IPCC, 2007b; Contreras-Lisperguer and de Cuba, 2008).

Ocean-based impacts due to climate change 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 some key impact scenarios for St. Kitts and Nevis, which include landslides, beach erosion and flooding caused by storms and SLR. Power generating stations and other major infrastructure located on the coastline are therefore highly vulnerable to impacts resulting from SLR and storm induced surges.

The likelihood of climate change impacting on energy systems will vary. However, an assessment of the vulnerability of St. Kitts' systems should be prioritised, especially in the case of renewable energy sources which depend on climate and 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 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) Global Report (2009) stresses the need to adopt a more practical approach to agricultural research that requires participation from farmers who hold the traditional knowledge in food production.

This research examines the relationship between agriculture and tourism within the framework of climate change, and seeks to develop adaptation options to support national food security based on 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

St. Kitts and Nevis depended on the sugarcane industry for its prosperity for a period of 350 years. However, competition from large sugar producing countries such as Brazil, along with rising production costs and low world market prices, impelled the Government to shut down the state-owned St. Kitts and Nevis Sugar Manufacturing Corporation (SSMC) in 2005. Sugar cane production, which stood at 400,000 tonnes in 1955, had declined to just under 150,000 tonnes in 2005. The sugar industry was a major contributor to the Government's fiscal deficit, with annual losses equivalent to 4% of GDP (European Commission, 2007).

According to a study on agriculture and food security in the Eastern Caribbean Currency Union (Labadie, 2008), the agricultural sector in St. Kitts and Nevis is still recovering from the closure of the sugar industry. The contribution of the agricultural sector to GDP registered progressive decline from 15.6% in 1980 to 5.2% in 1999 and 4.85% in 2003. Today agriculture's contribution to national GDP is about 3.5%. The Nevis Island Administration (2010), reports that in 2009 agriculture contributed about EC $27.53 million to GDP for the twin island Federation. This figure represents a contraction of 8.05% over the previous year.

The national strategy promotes diversification into non-sugar crops and in that regard government policy seeks to provide opportunities for former sugar workers to be retrained and equipped for new agricultural opportunities. In the 2011 budget address for St. Kitts and Nevis, Prime Minister Dr Denzil Douglas alluded to investment in the re-orientation and expansion of the agricultural sector as a means of ensuring food security. Local farmers are being empowered through the provision of land and other essential inputs. The Prime Minister also explained that there was a push towards the development of commercialised farming. To this end, a Government owned vegetable and tree-crop farm at Capisterre has been established. This initiative was undertaken with the objective of boosting domestic production, reducing the price of vegetables, and supplying overseas markets where feasible. The Government envisions that the 115 acre farm, which is located in St. Paul's, would serve as a pilot for creating a strong synergistic relationship between the agricultural sector and the tourism industry.

4.3.3. An Analysis of the Agricultural Sector in St. Kitts

Historically, sugar cane occupied the prime agricultural land on St. Kitts. As a result, non-sugar agriculture was restricted to the growing of crops in the resting period of cane fields and small scale production where cane could not grow. On the other hand, Nevis island was not over-involved in sugar cultivation and therefore subsistence farming developed there at a greater level than on St. Kitts. The Government identified vegetable production as a part of its diversification thrust, with the aim of helping to reduce the spiralling food import bill.

According to the Nevis Island Administration (2010), more than 1,500 acres of land was provided for farming in St. Kitts and Nevis over the last 2 decades. Subsequently, the ability of farmers to meet a substantial portion of the demand for local produce has been enhanced. The provision of vegetables such as tomatoes, green peppers and pumpkin in 2009 was enough to meet 37.20% of the total demand. In addition, the re-introduction of the production of Sea Island Cotton on the island of Nevis in 2008 has improved agro-industry. In the 2008-2009 period, the Cotton Producers Association exported 9,500 pounds of cotton to Japan where it has secured a market earning import foreign exchange. The agricultural sector has also experienced a boost from the further development of agro processing, with investment in a new agro processing plant in 2009 at Prospect Industrial Site in Nevis. The establishment of the plant is expected to increase the economic value added to agriculture and provide new initiatives for export.

The Eastern Caribbean Central Bank (2011) reports that except for the agricultural sector, all other areas of the economy of St. Kitts and Nevis are estimated to have contracted in the period January to September 2010 compared with the performance in the corresponding period of 2009. Output in the agricultural sector is estimated to have increased in the period, mainly driven by a higher level of production in the crop and fisheries sub sectors which rose by 13.3% and 10.0%, respectively. This accomplishment is expected to reverse the downward trend of agriculture's contribution to GDP illustrated in Figure 4.3.1.

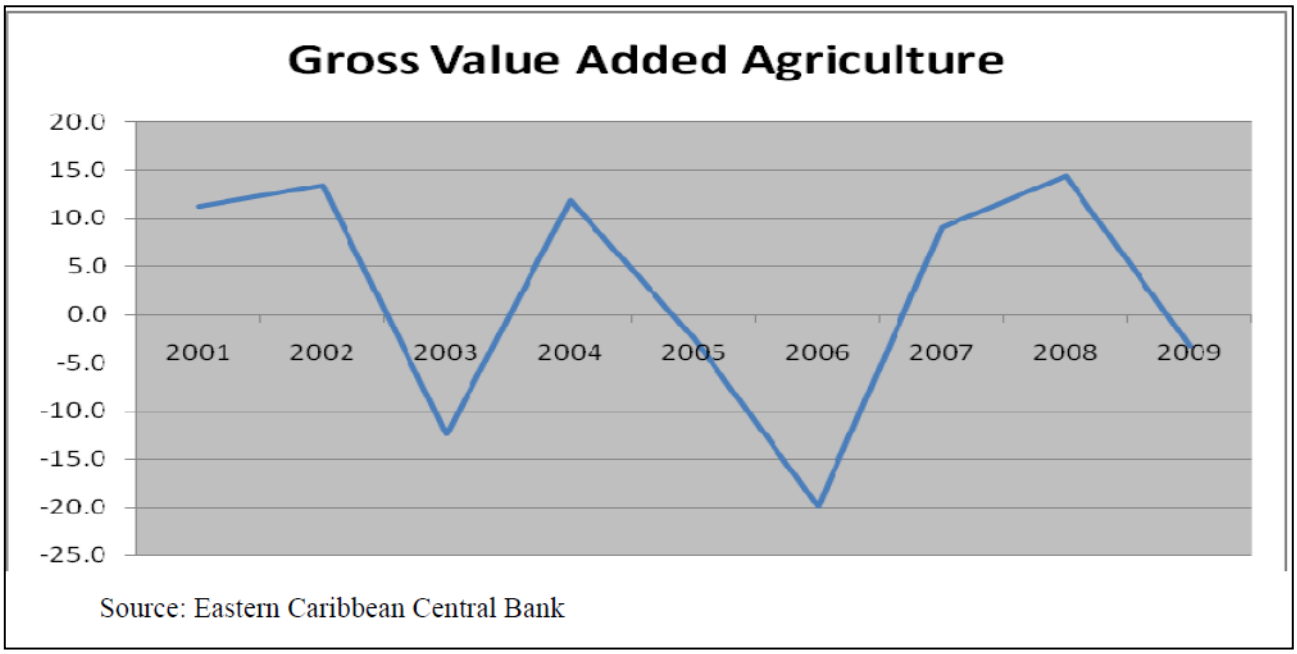


Figure 4.3.1: St. Kitts and Nevis Rate of Growth of GDP in Agriculture Constant Prices

In terms of food crop production, the annual agricultural review (2010) indicates that during 2009 an increase in vegetable production was recorded for pumpkin (26%), onion (60%), watermelon (97%), sweet

potato (17%), and pineapple (43%). Table 4.3.1 shows crop performance of major crops for the period under review.

Table 4.3.1: Annual Production of Major Food Crops for St. Kitts ('000 kg)

CROP	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carrot	54	44	49	82	87	60	54	81	61	44
Cabbage	55	64	101	104	82	67	71	80	172	133
Onion	50	5	17	28	17	9	19	22	51	82
S. Pepper	32	18	40	33	40	22	30	32	27	26
Tomato	50	73	94	119	114	85	132	141	117	85
Potato	160	130	111	100	120	88	110	126	239	200
Peanut	59	25	38	30	32	25	56	86	43	35
Pineapple	17	20	5	10	15	14	53	60	69	100
Watermelon	59	70	70	101	90	83	127	100	64	126

(Source: Department of Agriculture)

Despite a marked improvement in food crop production after the close of the sugar industry, the Food and Agriculture Organization (FAO) estimates that agricultural imports in St. Kitts and Nevis (US $58 million) are approximately 5 times higher than exports (US $11 million) (FAO, 2011). However, the Government's strategy for the development of the agricultural sector is designed to counteract this phenomenon with 6 broad policy objectives that pertain to the promotion of sustainable development in rural communities, increasing the competitiveness of the agricultural sector, diversifying agricultural production and exports, increasing food production, enhancing food security and strengthening inter-sectoral linkages.

4.3.4. Women and Youth in St. Kitts Agriculture

An ECLAC report on poverty in St. Kitts and Nevis (2007) estimates that with the closure of the sugar industry in 2005, 1,500 workers were made redundant, 300 of whom were women. With technical support from the Government, Inter-American Institute for Cooperation on Agriculture (IICA), and the Canada Gender Equality Programme, a group of women ex-sugar workers formed an agri-producing and processing cooperative, using local produce to make drinks, preserves, and condiments. The Fahies Women Agricultural Producers' Association was trained in entrepreneurship and agri-business management and the group has been using their newly acquired knowledge to develop projects for funding in areas such as water harvesting (IICA 2009).

Through the United States Agency for International Development (USAID) Farmer-to-Farmer program, the Community Achievers Project (CAP) in St. Kitts and Nevis trains the nation's youth in agriculture. Young people are currently receiving vocational training on various farming practices including how to set up a garden, composting, how to graft trees, reproduce banana trees, identify pests and make organic pesticides. The demonstration farm grows peppers, squash and watermelons broccoli, bananas, papayas, and greens.

The USAID funded Youth Workforce Development Assessment (2010) for Barbados and the Eastern Caribbean suggests that young people in St. Kitts and Nevis are not aware of the kinds of jobs and careers available in the market because the economy has shifted so dramatically from the sugar monoculture to services in the past 10 years. One young agriculture entrepreneur interviewed for this report opined that young people might be better motivated to work in high value-added organic farming for the tourism market if they were made to see such work as a career option of becoming an "agribusiness entrepreneur" instead of a "farmer."

4.3.5. Climate Change Related Issues and Agricultural Vulnerability in St. Kitts and Nevis

St. Kitts and Nevis initial national communication to the UNFCC (2001) reveals that under the Commonwealth Scientific Industrial Research Organisation (CSIRO) model projections, utilising the FAO WOFOST 4.1 biophysical model, a decrease in sugarcane yields is expected through to 2100. There is potential for an increase in yield with irrigation under this scenario, however inter-annual variations in rainfall are likely to adversely impact profitability. Predictions using the HadCM2 model are more severe in the climate change scenarios and suggest that climatic conditions by the second quarter of the Century would be too dry for rain-fed agriculture, with yields being below economically viable levels. In this model, sugarcane cultivation would only be possible in irrigated management conditions for which, the same model suggests, there would be inadequate water.

With regard to non-traditional crops, such as livestock, fruits and vegetables, projections under both the CSIRO and HadCM2 models indicate potentially devastating impacts on the prospects for cultivation of these agricultural products. In Nevis, rising sea levels are likely to lead to salinisation of agricultural soils in lowland areas, and in both islands salinisation of coastal aquifers will negatively affect availability of water for agriculture.

The national annual agricultural review (2010) bears out the validity of the predictions from the climate models. The report conveys that the harsh and long dry spells experienced by farmers in the Federation is making production more difficult. Vegetable production during 2009 was adversely affected by heavy and consistent rainfall in the last quarter of the year. This occurrence considerably reduced the amount of land preparation services that could have been carried out during that time and consequently reduced crop planting days for farmers.

During the 2011 budget speech, Dr Denzil L. Douglas, Minister of Finance, Sustainable Development and Human Resource Development announced plans for the Department of Agriculture to step up activities to combat various threats to increasing output in the sector including, climate change, the vulnerability of soil conditions and knowledge gaps by food producers. Crop and animal production is supposed to be boosted through the construction of dams to tap water, leading to an increase in the availability of local foods during the dry season.

4.3.6. Vulnerability Enhancing Factors: Agriculture, Land Use and Soil Degradation in St. Kitts

St. Kitts and Nevis' adaptation strategy document (2006), reports that when the sugar industry closed in 2005 there were 9,300 acres under sugar cane out of about 12,472 acres of land in agricultural production. This figure represents about 28% of the total area of the islands. Vegetables, roots and tubers are grown on holdings that are up to 8 hectares in size. Crop farming is dominated by small farmers with average holdings of less than 1.0 hectare and a few larger farms of holdings that are greater than 5.0 hectares. The strategy document identifies accelerating erosion as the single most important vulnerability factor for land degradation in St. Kitts and Nevis. The causes for this phenomenon pertain to overuse of lands for mono crop sugar cane agriculture; clearing of lands for residential and tourism development; farming on high elevations above the 1,000 ft contour; and squatting or unregulated settlements. The islands land resources are subject to competing demands in terms of agriculture, tourism, housing, services and facilities.

The Ministry of Sustainable Development (2007) informs on a second vulnerability factor for land use and soil degradation in St. Kitts and Nevis. The land tenure system is affected by lack of a proper land registration system; there is no specific land registry and no system of computerisation of records. A land use map for the Federation is provided below.

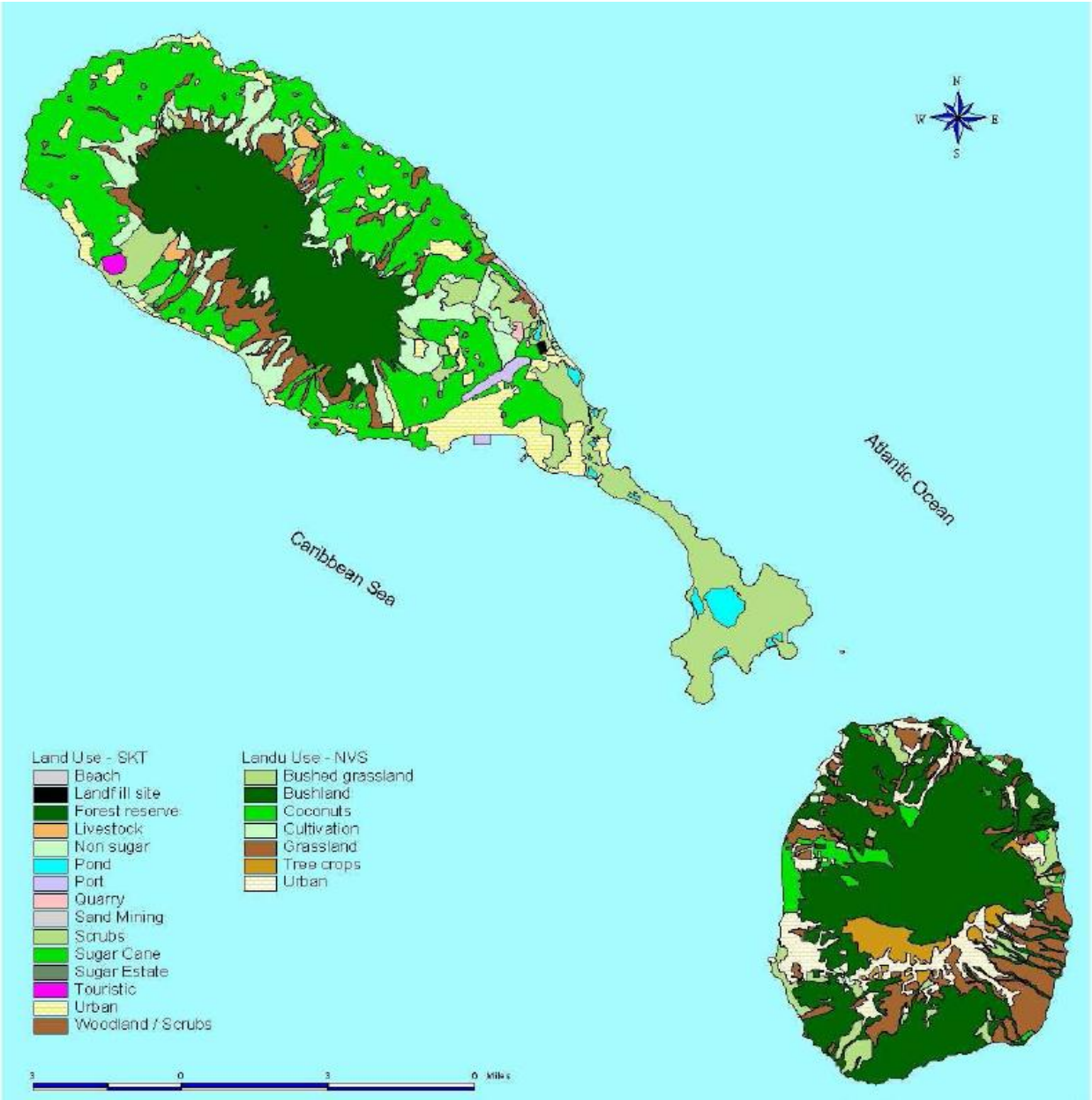


Figure 4.3.2: Land Use Map of St. Kitts and Nevis

The National Action Programme for Combating Desertification and Land Degradation in St. Kitts and Nevis (2007) demonstrates an understanding of the specific nature of the causes of land degradation in vulnerable communities. For instance, the text reveals that in Basseterre, along Bay Road, the discharge of dirty water and other wastes into the sea from residential areas, restaurants and hospital visibly contaminate the area. Deforestation on some hillsides in St. Kitts, mainly for charcoal, poles, fish traps, shacks and small farms on steep slopes, is evident in several areas. Cutting of mature vegetation in Nevis is attributed to the demand for fish pot sticks, charcoal, boat building materials, and construction materials for houses and joinery. The clearing of vegetation for houses on both steep and gently sloping lands additionally contributes to soil erosion, especially during the rainy season. Areas with excessive erosion include the beach at Frigate Bay, Pinney's Beach, Halfway and New Guinea Coasts, College Ghaut, lower Monkey Hill, Wades Garden, Old Road Bay, Brimstone Hill area, and the SEP. An abundance of feral

donkeys in Nevis and free ranging livestock have denuded the vegetative cover in several areas and scarred the land surface. Overgrazing by untethered animals accelerates erosion and is more pronounced in the dryer parts of the country, especially at Baths, Indian Castle and in the SEP.

Despite these vulnerability enhancing factors, a land resource analysis project funded by the Department for International Development (DFID), which was conducted to evaluate the scale and location of areas suitable for alternative agriculture, ecological preservation, and commercial or industrial activity, showed that the climatic conditions in St. Kitts are suitable for a wide variety of crops. The methodology used for the land-suitability assessment was based on the guidelines proposed by the FAO of the UN and are highly relevant to assessing the vulnerability factors for climate change (Daniel *et al*., 2009).

Six agricultural land use types were investigated; pineapples, field crops (dasheen, cassava, sweet potato and yam), fruit tree crops (sugar apples, custard apples, carambola, guava, Indian jujube and wax apple), vegetable crops (onions, peanuts, cucumber, tomato, sweet/hot peppers and sugar cane) and livestock production (beef, pork and mutton). The land resource analysis results show that a wide variety of agriculture is compatible with the environmental conditions present in St. Kitts. Most land areas are capable of successfully producing each of the crops under consideration. The land resource analysis study also revealed that land in St. Kitts appeared to be slightly less suitable for the production of livestock.

4.3.7. Social Vulnerability of Agricultural Communities in St. Kitts

According to the St. Kitts and Nevis CPA Report (2009), the closure of the sugar industry has had a serious negative impact on the lives of residents in several agricultural communities and affected the ability to sustain their livelihoods. It has also contributed to the general demise of agriculture in several rural areas. Contributing factors are the age and sex of former workers and extensive period working in the “mono culture” of the sugar industry. Many of the displaced workers were older females with low levels of education and few marketable skills who had worked as labourers. The FAO (2010), through its initiative on soaring food prices targeted support towards the poorest rural families and the worst affected marginal producers from among the small farmer crop and livestock sub-sector. FAO particularly recognised that female headed households were among the most vulnerable in terms of their inability to purchase adequate quantities of foods for their families.

The CPA report also suggests that although some ex-sugar-workers were given land to produce other crops, many have found it difficult to become involved in crop production. Major challenges are the acquisition of new skills, adjusting to different working conditions and work schedules, accepting change and getting accustomed to a new work culture. Two former agricultural communities were highlighted as particularly vulnerable to the social impact of the defunct sugar industry. St. Paul’s community, in which most of the population once worked in the sugar cane estates, consists of many women who were once labourers for periods ranging from a few to as many as 30 years. In St. Peter’s, except for a few older residents who have held on to their small plots, several small farmers have been displaced by large scale commercial farming of food crops for domestic use.

Another social vulnerability factor for agriculture in St. Kitts and Nevis is the scarcity of farm labour. The Agriculture Department in Nevis (The Nevis Island Administration online portal, 2011) reports that this problem could be as a result of the low wages paid for farm work. This was one of the challenges facing the agriculture industry in 2010. Land preparation was a major issue, particularly in Nevis during 2010 due to the continuous adverse weather conditions and a shortage of farm hands to cultivate the in time for crop production.

4.3.8. Economic Vulnerability: Climate Change and Agricultural Outputs in St. Kitts

The St. Kitts and Nevis Social Safety Net Assessment (UNICEF, 2010) indicates that the Federation is extremely vulnerable to external shocks such as hurricanes, commodity price fluctuations, and global economic turndowns. The islands are ranked as highly vulnerable when measured with respect to volatility of real per capita GDP and output due to its fragile ecosystems, natural disasters, the impact of economic development on the environment, and the potential impacts of climate change.

A major economic vulnerability factor related to climate change effects is that of the high cost of agricultural production in St. Kitts and Nevis. The small physical size of St. Kitts and Nevis rules out the possibilities of economies of scale for local farmers who are challenged to provide the necessary farm inputs at peak planting periods due to the lack of available funds. Input supplies are imported with money procured from the Small Farmers Agricultural Supplies account which is a revolving fund. The annual agriculture review (2010) reports that lack of funding affects the choice and quantity of crops planted, and the harsh and long dry spells makes production more difficult in the drier periods. A second vulnerability factor is that St. Kitts and Nevis is a net importer of food and a significant portion of the food that is imported can be grown locally. FAO (2006) suggests that opportunities exist for local produce to become competitive with imported products and to displace them on the supermarket shelves.

A competitiveness study of 4 crops as alternatives to sugar-cane; pumpkin, peanut, sweet potato and onion, (Edwards and Jacque, 2008) show that all 4 commodities are profitable, competitive and have comparative advantage. These characters are highest for the export commodities of pumpkin and sweet potato and lowest for the import-competing products of onion and peanuts. The main recommendation from this study was for an expansion of the production of the commodities of pumpkins, sweet potato and onions, together with efforts to reduce the impediments to market penetration.

Correspondingly, the annual agriculture review (2010) points to significant gaps in overall production for several crops and livestock commodities. The report presents income earning potential for farmers based on the national demand, actual quantities produced in 2009 and the opportunity gaps for increased for selected commodities. Based on this research, and the results of the competitiveness study, a profile for key crops that pertain to climate change and agricultural growth in St. Kitts and Nevis are presented in the following diagram.

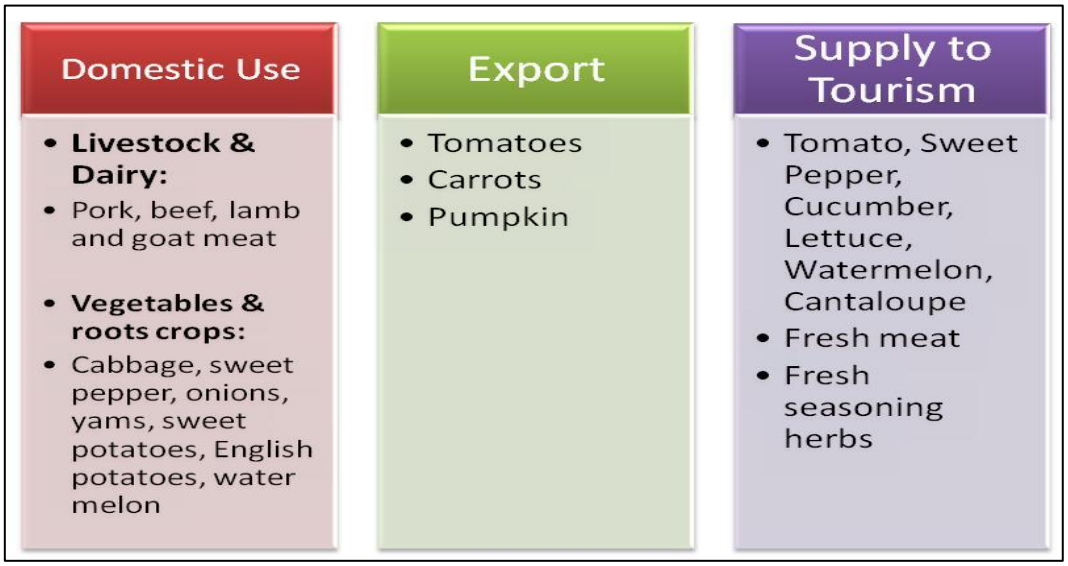


Table 4.3.2: Key Crop Profile in St. Kitts and Nevis

The Minister of Agriculture in the Nevis Island Administration (NIA), Robelto Hector, asserts that Nevis has enough fertile land with which to feed the twin island Federation, improve food security, strengthen the tourism sector with high quality local produce, and at the same time curtail the flow of foreign exchange that drains out of the country each month for the importation of agricultural goods that can be readily grown locally (Nevis Island Portal, 2011). Economic opportunities also exist in agro-processing with the making of candies, jams, drinks, wines and other uses from fruits such as star apples, mangoes, guavas, and tamarind.

4.4. *Human Health*

4.4.1. Background

The AR4 defines health as including '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 implications of the above as well as on the livelihoods on a local scale and to the economy on a national level. In endemic countries, the environmental and social conditions make particular populations vulnerable to further disease outbreaks. Climate change has the potential to further impact the quality of the environment and the resilience of the ecosystems thereby increasing the risk of disease epidemics.

Health is an important issue in the tourism industry because tourists are susceptible to acquiring 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 approximately 75% of travellers become ill while abroad, most often from infectious diseases; morbidity is most often due to diarrhoea or respiratory infections (Sanford, 2004). It is also important because it can have consequences for tourism destination demand which is a significant contributor to the GDP of 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 and can affect food security and the agriculture sector, and increase the susceptibility of populations to respiratory diseases and food- and water-borne related diseases (Confalonieri *et al*., 2007; Githeko and Woodward, 2003; Patz *et al.,* 2000; Taylor *et al*., 2009).

The Initial National Communication to the UNFCCC highlighted the following communicable diseases and their relationship to health as follows, "weather and climate influenced health care problems continue to constitute major sources of morbidity including gastrointestinal diseases, dengue and influenza" (MoE, 2001). In a study entitled, Knowledge, Attitude and Practices Study of the Issues of Climate Change/Variability Impacts and Public Health in Trinidad and Tobago and St. Kitts and Nevis, Rawlins *et al*., (2007) found that health was considered to be the first major issue with respect to climate change followed by water resources, agriculture, biodiversity and finally coastal degradation.

Table 4.4.1: Selected Statistics Relevant to the Health Sector of St. Kitts

Population	35,797 (2008)[1]
Unemployment rate	6.3% (2008)[2]
Poverty rate	23.7% (2008)[2]
Expenditure on Public Health	5.37% of GDP (2000-2005)[1]
Life Expectancy at Birth	69.8(male)/74.2(female) yrs (2008)[1]
Crude birth rate (per 1,000)	16.79 (2008)[1]
Crude death rate (per 1,000)	8.8 (2008)[1]

Sources: [1] (PAHO, 2008); [2](Limited, 2009b)

4.4.1. Direct Impacts

Weather Related Mortality and Morbidity

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes, tropical storms and floods are important considerations when assessing the vulnerability of a country to climate change. St. Kitts and Nevis lie on the southern edge of the Atlantic hurricane belt where cyclones and hurricanes occur throughout August, September and October (McSweeny *et al*., n.d.). It has therefore had a history of being vulnerable to extreme weather events, for example from 1989 to 2001, St. Kitts and Nevis was hit by 8 storms; Hugo, Felix, Gilbert, Iris, Luis, Marilyn, Bertha and Georges (MOE, 2001).

Past hurricane and tropical storm activity over St. Kitts and Nevis has also proven that the country is vulnerable to flooding (MOE, 2001). While these events have caused economic damage to the islands in general (Daniel, 2006), of particular concern in relation to the health sector has been the structural damage to J.N. France and Alexandra hospitals, which were repeatedly devastated by hurricanes in the past (PAHO, 1998).

The Initial National Communication to the UNFCCC noted that expected SLR could result in increased coastal erosion as well as inundation. The human settlements on the islands have been described as consisting "of a series of small villages along the island main road, which passes very close to the coastline", as well as supporting infrastructure along the coasts of each island makes both islands vulnerable to extreme weather conditions (MOE, 2001). Displacement of persons and loss of shelter are important because of the associated mental and physical health implications which will be further discussed below.

Increased Temperature and the Effect of Heat

Increasing temperatures can result in heat stress in a population and heat wave events have been found to be associated with short-term increases in mortality globally (Confalonieri *et al*., 2007), as well as morbidity related to heat exhaustion and dehydration (Hajat *et al.,* 2010; Sanford, 2004). This is relevant to St. Kitts and Nevis as the outcome of a Knowledge, Attitude and Practices Study of the Issues of Climate Change/Variability Impacts study in St. Kitts and Nevis showed that heat stress was considered the most important issue related to climate change and climate variability to residents (Rawlins *et al*., 2007). The elderly and young are more susceptible than other groups, as well as persons with chronic illnesses, people doing manual labour and persons who gain their livelihood outdoors (e.g. construction workers and fishermen). Increased temperatures can have a negative impact on persons prone to, or suffering from, cardiovascular diseases (Cheng and Su, 2010; Worfolk, 2000) which could be exacerbated by prolonged exposure.

Heat waves may increase humidity (Moreno, 2006) and is therefore of relevance to St. Kitts. In terms of tourism this will be an important consideration because most travellers seek countries with warm weather to escape the cold winters, but due caution should be taken by elderly travel when choosing destinations. Exposure to higher temperatures can also contribute to increase in skin diseases (Confalonieri *et al*., 2007).

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

4.4.2. Indirect Impacts

Increase in Vector-Borne Diseases

St. Kitts' tropical climate and its central forested peaks are suitable conditions for mosquito proliferation, especially the vectors of dengue fever and malaria and conditions may become more favourable as a result of climate change (MOE, 2001). Hales *et al*. (2002) summarises, "mosquitoes require standing water to breed, and a warm ambient temperature is critical to adult feeding behaviour and mortality, the rate of larval development, and speed of virus replication". Of course climate is not the only important factor in the successful transmission of disease, other factors include the disease source, the vector and a human population (Hales *et al.,* 2002). Climate change projections indicate the potential for more intense rainfall events; this would increase the rate at which mosquitoes proliferate by providing more numerous breeding sites.

Another important consideration for public health is that incurred from the tourism industry. The estimated annual arrival of excursionists and tourists to St. Kitts and Nevis is 353,801 people (CTO, 2009). This influx of people from non-endemic areas represents a susceptible population to vector borne disease infections once conditions on the island are favourable for disease transmission.

Malaria – St. Kitts and Nevis does not have many reported cases of Malaria. According to the Morbidity Review of Communicable Diseases in Caribbean Epidemiology Centre (CAREC) Member Countries, between 1980 and 2002 there were only 3 cases of Malaria reported in the St. Kitts and Nevis. That is, one in each of the years 1992, 1993 and 1996 (CAREC, 2008c). However, more recently, on average there has been one reported case of imported malaria every year between 2003 and 2010; 2008 had no cases and 2007 had 2 cases (Ministry of Health, 2011). While these numbers are small, the possible re-emergence of Malaria is considered to be a real threat to the region (Rawlins *et al*., 2008) and by extension to specific countries such as St. Kitts and Nevis. The risk of importing cases is a point that is often presented due to the high number of visitors to the Caribbean region and the increase in vector population due to a changing climate.

In St. Kitts, there are no recorded species of *Anopheles* mosquito that can transmit Malaria plasmodium. This can be explained by the smaller size and ecological niche of St. Kitts as well as its distance from the South American mainland (Rawlins *et al*., 2008). The cases which are reported are imported cases. This presents a very sensitive situation for St. Kitts as there is a risk of transmission of the disease from any of 17 of the 21 CAREC Member Countries that have *Anopheles* species (Rawlins *et al*., 2008). Also relevant is the fact that there has been an increase in migrants from countries where Malaria is endemic (PAHO, 2007b).

Malaria is therefore not a major concern in St. Kitts and its impact on the tourist industry is minimal. This approach is quite different from that adopted by other Caribbean islands where the prevalence of the

vector population is higher, but caution should be adopted in the future. At least one study has found that Malaria is the most common cause of fever among tourists upon returning from travel in infected areas (Wichmann *et al*., 2003). Additionally, it should be highlighted here that malaria is the most reported cause of hospitalisations in tourists from malaria prone destinations (Wilder-Smith and Schwartz, 2005).

Dengue Fever - Dengue fever is caused by 1 of 4 serotypes of a virus of the genus *Flavivirus* and family *Flaviviridae* (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, and exists in tropical and subtropical countries worldwide (Gubler, 2002; Patz *et al*., 2000; Rigau-Pérez *et al.,* 1998). The arthropod vector for dengue is *Aedes aegypti*. Population growth, urbanisation and modern transportation are believed to have contributed to its resurgence in recent times (Gubler, 2002).

It has been shown that dengue fever transmission is altered by increases in temperature and rainfall (Hales *et al*., 1996) and research on the association between the two is needed. 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 *et al*., 2002; Hsieh and Chen, 2009; Martens, Jetten, and 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).

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 *et al*., 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). This vector-borne disease has affected the region since as early as the 1800's (Pinheiro and Corber, 1997).

Dengue fever is endemic in St. Kitts and Nevis (MOE, 2001; PAHO, 2008). The total number of confirmed dengue cases in both islands between 1995 and 2010 is 305 but consists of a mixture of mostly confirmed and few suspected cases. There were 19.06 cases per year between 1995 and 2010; this was higher for the last 10 years with an average of 26 cases per year. Most cases occurred in St. Kitts, between 2005 and 2010 there were 113 cases in St. Kitts and 7 in Nevis (Ministry of Health, 2011).

Chen *et al*., (2006) demonstrated seasonal incidence of dengue in the Caribbean region. Indeed, of the 16 reported cases of dengue in 2010 in St. Kitts and Nevis, there was 1 case in February, but the rest of the cases occurred during the months of the rainy season – June with 1 case, July with 5 cases, September with 4 cases, October with 3 cases and November with 2 cases (Ministry of Health, 2011).

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

In Jamaica, Chadee *et al*. (2009) found that large storage drums used during dry spells and drought conditions were the main breeding sites of the vector, *Aedes aegypti*, accounting for a third of their breeding sites. Traditional targets of source reduction in Jamaica (i.e. small miscellaneous containers), were found to contain negligible numbers of pupae. However, if drought conditions become commonplace in the future due to climate change, the use of large water storage drums may be used and thus may provide suitable breeding sites for the vector *Aedes aegypti.*

Drought, air quality and respiratory illnesses

St. Kitts is one of the drier islands of the Caribbean region, experiencing annual rainfall of approximately 890 – 1,000mm per year. Though the island was unaffected during the 2009-2010 regional drought, rainfall patterns are also inconsistent, varying in intensity between years and given months. The island is therefore prone to periods of drought (MOE, 2001). These periods of dry spells and drought conditions can also contribute to the spread of disease, making the island vulnerable to diseases linked to inadequate water supply and sanitation.

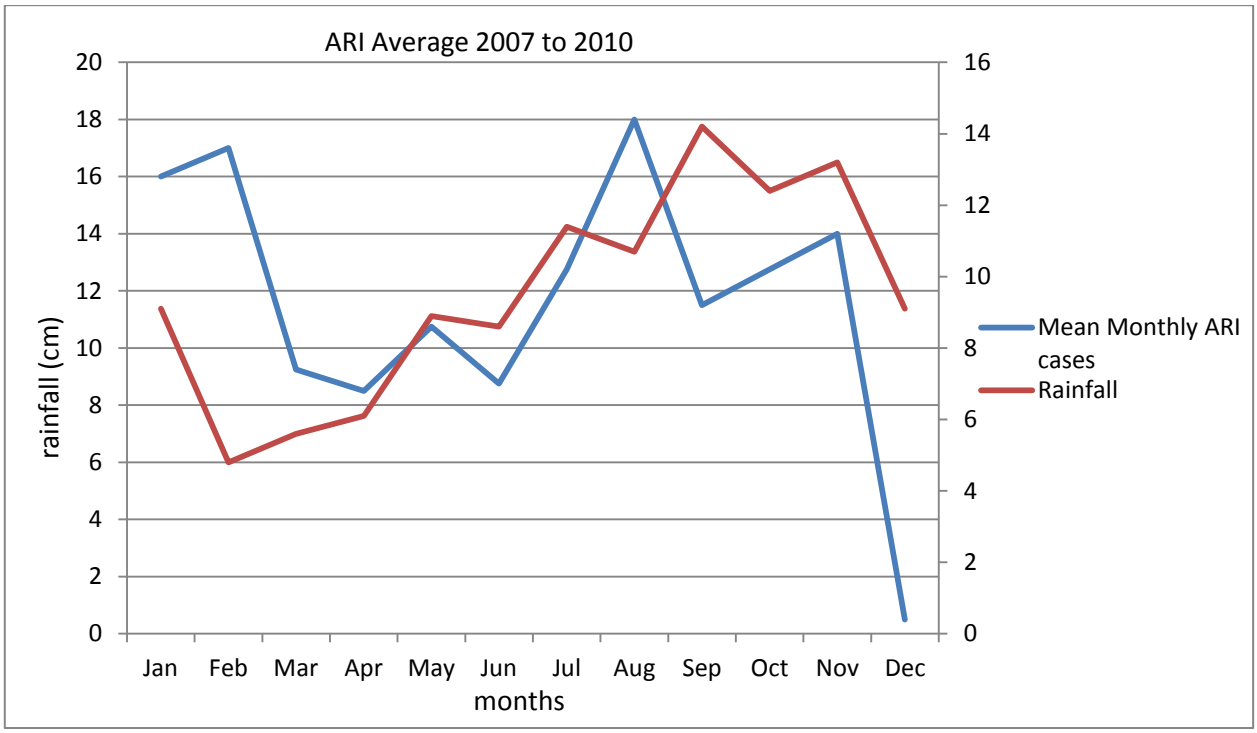


Figure 4.4.1: Mean Monthly Acute Respiratory Infections (ARI) Cases Against Rainfall in St. Kitts and Nevis
(Source: by author, data provided by Ministry of Health, 2011)

Drought related impacts relevant to St. Kitts include an increase in the incidence of gastroenteritis and the intensification of scabies. Other health problems that could arise include increased incidence of asthma, influenza, respiratory diseases and acute respiratory infections (ARI) due to increases in particulate air pollutants and changing air composition (Confalonieri *et al.*, 2007). Analysis of disease data for asthma, bronchitis and respiratory infections show that there is seasonal variability in St. Kitts (Amarakoon *et al.,* 2004). Indeed, Figure 4.4.1 demonstrates that in St. Kitts and Nevis ARI morbidity cases are more prevalent during the rainy season. Conversely, Figure 4.4.2 Gastroenteritis morbidity cases are more prevalent during the dry season. Monthly data from the Health Information Unit, Ministry of Health was only available for the last 4 years.

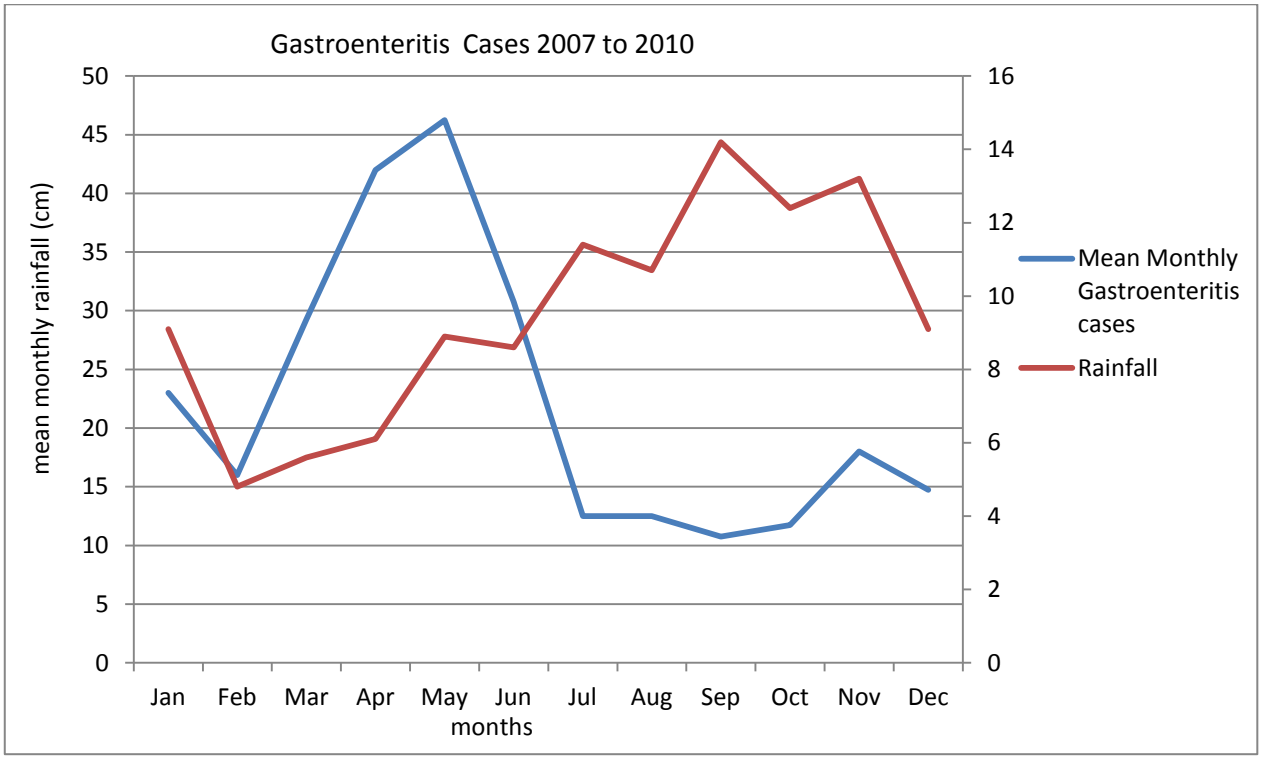


Figure 4.4.2: Mean Monthly Gastroenteritis Morbidity Cases Against Mean Monthly Rainfall in St. Kitts and Nevis
(Source: by author, data provided by Ministry of Health, 2011)

Table 4.4.2 shows ARI and influenza cases for St. Kitts between 2005 and 2010. It should be noted that incidence of ARI is higher in Nevis. Nevis did not have any cases of influenza during the same period, except for 2 cases of H1N1 Swine Flu in 2009, while St. Kitts had 9 cases (Ministry of Health, 2011). Additionally, increased storage of water during dry spells and drought conditions increases the number of breeding sites of the mosquito vectors for malaria and dengue.

Table 4.4.2: Acute Respiratory Infections and Influenza in St. Kitts

Year	2005	2006	2007	2008	2009	2010	Total
Sum of Acute Respiratory Infections < 5 yrs	6	2	23	6	25	30	92
Sum of Acute Respiratory Infections > 5 yrs	28	0	5	4	102	19	158
Influenza	60	51	112	64	70	7	364

(Source: Ministry of Health, 2011)

Air quality can also be affected by Sahara dust which travels across the Atlantic to the Caribbean annually. Sahara dust flows may increase during warmer summer months due to atmospheric circulation patterns, increasing in strength, thereby bringing greater volumes of particulate matter towards Caribbean islands as has been observed for the neighbouring island of Saint Lucia (Amarakoon *et al.,* 2004). It takes approximately one week for dust clouds to travel across the Atlantic to the Caribbean (Prospero and Lamb, 2003).

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, pulmonary and cardiac diseases. Further, these dynamics also occur against a background of normal and expected urbanisation and industrialisation that is occurring on a global scale and no also affects Caribbean islands such as St. Kitts.

Water Supply, Sanitation and Associated Diseases

St. Kitts experiences dry spells and periods of drought. It is therefore vulnerable to diseases linked to inadequate water supply and sanitation, as well as drought related impacts, which include an increase in the incidence of gastroenteritis and greater asthma and respiratory disease cases. As stated in the CPA 2007/2008 for St. Kitts and Nevis "In some communities where roads in the new housing developments have not been surfaced, dust is also a problem and contributes to asthma, allergies and other respiratory diseases"(Kairi Consultants Limited, 2009b).

In St. Kitts and Nevis, 96.8% of the country has access to safe water from a public source. In Kitts, 85.1% of the population has access to water in their dwelling. Other sources of water were public supply piped into the yard (8.6%) and water from public standpipes (4%) (Kairi Consultants Limited, 2009a). Water disinfection rates in St. Kitts are estimated at 70% after the St. Kitts WSD expanded its water chlorination programme in 2007 (Dr Sahely, personal communication, April, 12, 2011). A number of food-borne illnesses are associated with water and poor sanitation and include gastroenteritis, ARI, shigellosis, salmonella, legionella and cholera. Flooding can affect water supplies and contribute to the spread of diseases such as those mentioned above.

Gastroenteritis - Gastroenteritis is one of the major causes of morbidity in children in St. Kitts and Nevis. The total number of cases of gastroenteritis in children less than 5 years old dropped from 1,759 in the period 1995 and 2000 to 873 cases between 2000 and 2005 (PAHO, 2008). Additionally, between 1992 and 1995, gastroenteritis was also the most common infectious disease and 1 of 2 main causes of morbidity in children (PAHO, 1998). There have also been 3 deaths due to gastroenteritis in St. Kitts in the last 8 years; 1 death in 2003, 2004 and 2005 (Ministry of Health, 2011). As stated in the Initial National Communication to the UNFCCC, as a result of possible climate change related phenomena "rising water tables can be expected to lead to deterioration of hygienic conditions and to the development and diffusion of water borne diseases" (MOE, 2001). Table 4.4.3 shows the reported Gastroenteritis cases in St. Kitts in the last 6 years. The incidence of the disease is lower in St. Kitts when compared to Nevis. Gastroenteritis as well as other gastrointestinal diseases is important diseases which can negatively impact the tourism industry in St. Kitts and outbreaks have been reported in the region from hotels, restaurants, cruise ships and mass gatherings (CAREC, 2008b).

Table 4.4.3: Reported cases of Gastroenteritis in St. Kitts between 2005 and 2010

Year	2005	2006	2007	2008	2009	2010
Sum of Gastroenteritis < 5 yrs	13	6	53	24	9	98
Sum of Gastroenteritis > 5 yrs	18	13	34	42	4	96

(Source: Ministry of Health, 2011)

Legionnaires disease - Another disease associated with water is legionnaires disease and is linked to climate change due to the greater incidence of the disease in hot humid rainier conditions (Fisman *et al.,* 2005). Legionnaires disease is essentially a severe form of pneumonia which arises when the host is exposed to "aerosolised water containing the bacteria or aspirates water containing the bacteria" (Fields *et al.,* 2002). The negative bacteria legionella is one of the main causative agents of Legionnaires disease and is found in freshwater environments growing best between 32-45°C. As a result, it thrives in stored hot water environments such as in spas, hot tubs and humidifiers which forms a suitable reservoir for harbouring the bacteria. In addition it also thrives in natural waters, pipes, distribution systems, air conditioners, showers and cooling towers (Fisman *et al.,* 2005; Rose *et al.,* 2001). It is therefore a disease of relevance in the tourism industry, having been the cause of illness on a number of cruise ships (Fisman *et al.,* 2005) and

tourist hotels in various parts of the world. However, in the Caribbean region, research on the prevalence of the disease is limited to work at a hotel in Antigua conducted by Hospedales *et al*. (1997) and the quality of potable water in hospitals in Trinidad and Tobago by Nagalingam *et al*. (2005). Nonetheless, its relevance to health and climate change in St. Kitts, is evident, given the tourism thrust of the Government of St. Kitts and Nevis. Further, the climate and the need for water-storage in the Caribbean region translate to a continued risk for legionnaires outbreaks.

Food Security and Malnutrition

St. Kitts does not have a significant agricultural sector owing to its size, geography and rainfall patterns, so it therefore has to import substantial amounts of food. If food availability is altered in neighbouring islands due to a reduction or change in rainfall patterns, this can have a ripple effect on the economy of Nevis. Conversely, increased precipitation may also result in increased incidence of pests as well as flooding and contamination from sewage especially from pit latrines. This can impact the health of the population, especially in poor and marginalised communities. Aside from the diseases mentioned in the previous subsections, malnutrition becomes a serious concern. The IPCC AR4 has stated that under-nutrition, protein energy malnutrition and/or micronutrient deficiencies are major impacts of climate changes and its possible impacts (Confalonieri *et al.,* 2007). Indeed in St. Kitts and Nevis from 2002-2004, the rate of undernourishment was 10% of the population (Trotman *et al.,* 2009).

Food production and fisheries stock are considered an integral part of the agricultural Sector. The *Reefs at Risk in the Caribbean* Report states that 'widespread unemployment, densely populated coastal zones, easy access to the reefs, and narrow shelf areas mean the reef resources have been heavily used to provide livelihoods and sustenance' which all are applicable in the case of St. Kitts. The report also links reduction in fisheries stocks with malnutrition due to a decrease in the protein content in the diet (Burke and Maidens, 2010).

Ciguatera Fish Poisoning – The Caribbean region is also well known for the food poisoning illness called Ciguatera Fish Poisoning (CFP) (Tester *et al.,* 2010). Although CFP is not mentioned in the Initial National Communication to the UNFCCC, surveys conducted in the Caribbean in the 1960s, 1970s and 1980s found that CFP was more prevalent in islands north of Martinique (Olsen *et al.,* 1984). St. Kitts is several islands north of Martinique in the Caribbean archipelago and the leeward region of the island was mapped with a 'high frequency' of CFP. A more recent CFP assessment by Tester *et al.,* (2010) estimated the annual CFP incidence in St. Kitts and Nevis to be 5.5 per 10,000 in 1981, 0.04 per 10,000 from 1998 – 2006. No cases have been reported between 2004 and 2010.

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

Increased Precipitation and Water-Related Diseases

Increased precipitation may also result in contamination of water by sewage, especially from pit latrines which may be transported to flooded areas. In St. Kitts approximately 8.2% of the population use pit latrines (5.7%), ventilated pit latrines (1.2%) or had no access to toilet facilities (1.3%) (Kairi Consultants

Limited, 2009b). This is of less relevance to St. Kitts which is a low-lying island (i.e. 9% is <2°), with flooding being an uncommon occurrence (MHE, 2001). Nonetheless, poor hygiene and sanitation practices and the use of pit latrines in localised areas can contribute to the spread of water-related diseases such as gastroenteritis, acute haemorrhagic conjunctivitis (AHC) and leptospirosis. An increase in the transmission of vector borne diseases such as schistosomiasis, malaria and dengue could become more prevalent during the rainy and hurricane seasons.

An example of a disease is that's spread is related to water supply and sanitation is AHC. Known in the region as 'pink eye' or 'red eye', AHC 'is a viral infection of the eye that causes symptoms of pain, redness, swelling, and watery or pus-like discharge. Fever and symptoms of an upper respiratory tract infection may occur' (CAREC, 2008a). St. Kitts and Nevis experienced its biggest outbreaks of AHC in 1981 when there were 545 cases. Following this there was an increase over subsequent years in the year 1998 with 132 cases. Additionally, although not highlighted as an outbreak in the CAREC morbidity report, the year 2003 had another 193 reported cases which is consistent with an increase in reported cases in most Caribbean territories for that year (CAREC, 2008a). In St. Kitts there have just been 2 reported cases in the last six years – 1 case in April, 2007 and 1 in January 2009 (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). The disease appears to be more common in St. Kitts, as all reported cases by the Ministry of Health for St. Kitts and Nevis in the last years were from St. Kitts (See Table 4.4.4).

Table 4.4.4: Reported Cases of Leptospirosis in St. Kitts between 2005 and 2010

Year	2005	2006	2007	2008	2009	2010
Leptospirosis	2	0	4	0	2	8

(Source: Ministry of Health, 2011)

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 AR4, 'there is good evidence to suggest that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human–pathogen–rodent contact' (Confalonieri *et al.,* 2007) and the seasonal patterns of leptospirosis has recently been demonstrated in Trinidad by Mohan *et al.* (2009). Preliminary examinations of the Ministry of Health data (Table 4.4.5) indicates that between 2007 and 2011 the disease was more associated with the latter rainier half of the year in St. Kitts and Nevis. It is noteworthy that leptospirosis has been found to be one of the diseases of importance contracted by travellers (Jansen *et al.,* 2005) and could therefore have implications for tourists.

Table 4.4.5: Morbidity Statistics for Leptospirosis between 2007 and 2010 in St. Kitts and Nevis

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007	-	-	-	-	-	-	-	-	2	1	-	-	4*
2008	2	-	-	-	2	1	0	1	1	1	-	-	8
2009	-	-	-	-	-	-	-	-	1	-	1**	1	3
2010	1	-	-	-	-	1	-	1	-	1	1	3	8

**Month of one case not given*
***Patient died*

(Source: Ministry of Health, 2011)

While low in frequency, the 1990s reported leptospirosis morbidity cases during most years (CAREC, 2008d; PAHO, 1998, 2008). Between 1992 and 1995, of 10 cases of leptospirosis, the majority were from agricultural sugar cane workers where rodent populations were significant (PAHO, 1998). In 1996, there were 6 cases, with another 10 cases in the year 1998. There was a subsequent decline, with only 7 cases in the following 8 years up until 2005, with 4 years of those years leptospirosis-morbidity free (CAREC, 2008d). The incidence of leptospirosis may be higher than that described above due to the under-reporting of cases as a result of a low index of suspicion as has been the reported and described in Trinidad and Tobago (Mohan *et al.,* 2009). As has been observed in Trinidad, the exposure to leptospirosis and contracting the disease may not necessarily be limited to occupational groups (e.g. householders) (Mohan *et al.,* 2009). This is perhaps true for St. Kitts, as cases have been higher in the last 5 years after the close of the sugar cane industry.

As is the case for dengue fever, conditions are expected to become even more favourable for the proliferation of rodents in the future, in St. Kitts and Nevis, according to CSIRO modelling research done for the Initial National Communication to the UNFCCC (MOE, 2001). For instance, in the CPA of St. Kitts the following statements are made; "there is also the challenge of the spread of rodents. Rats are nesting in the erstwhile cane fields now that there is no weeding and cleaning in the abandoned sugar estates" and "vacant overgrown lots and old abandoned vehicles are not only unsightly, but also attract and serve as breeding ground for rodents" (Kairi Consultants Limited, 2009b).

Schistosomiasis - Schistosomiasis is water borne disease worth mentioning as it has been identified by the IPCC AR4 (Confalonieri *et al.,* 2007). This disease is spread by aquatic snails, and is a water related parasitic disease. It exists in the Caribbean region and is endemic in a few countries, having been studied by numerous scientists in the Caribbean region including Ferguson *et al.,* (1960), Prentice (1980), Bundy (1984) and Karup and Hunjan (2010). PAHO (2007a) estimated that between '20-30% of [people] living in Latin America and the Caribbean are infected with one of several intestinal helminths and/or schistosomiasis.' As for St. Kitts the human infection rate was 25% but could have been up to 50% of the population in the 1930's. Natural abatement occurred in the 1940s as a consequence of the introduction of a domestic water scheme which, while diverting the course of natural streams, resulted in the destruction of the natural habitat of the snail in low-lying areas (Ferguson *et al.,* 1960).

Factors associated with transmission of the disease include walking bare footed, washing hands before meals, trimming of nails, outdoor recreational activities with high contact with the surrounding such as playing cricket, swimming in fresh water, fishing in fresh water. Poor hygiene also increases the chance of infection (Kurup and Hunjan, 2010). A decline in the use of irrigation channels to support sugarcane production as a result of the closing of the sugar industry in the last decade may have further reduced suitable habitats of the snail vector. Conversely, changes in drainage patterns could increase suitable habitats in land that has not been cultivated since the industry's closure.

4.5. *Marine and Terrestrial Biodiversity and Fisheries*

4.5.1. Background

St. Kitts and Nevis possess a variety of ecosystems and biological species. A biodiversity profile of the Federation recorded up to 936 species of vascular plants, including those introduced for horticultural, fruit crop and agricultural purposes, only one of which is endemic to St. Kitts. Terrestrial fauna includes up to 200 species of birds, 126 of which are native, 2 species of amphibians, 9 reptiles and 6 species of bats, the only native mammal of St. Kitts and Nevis (Lepage, 2011; Horwith and Lindsay, 1999). Records of invertebrates as well as marine species are incomplete, but a variety of insects, corals, sponges, cetaceans, crustaceans, marine turtles, and fish can be found among the islands various ecosystems.

The economy, culture, livelihoods and human wellbeing of the people of SIDS, like St. Kitts, are intimately linked to the state of the environment and biological diversity. Although tourism is not one of the primary drivers of the economy of St. Kitts and Nevis, the sector employs 4.2% of the Kittitian labour force in the hotel and restaurant sector, (National Survey of Living Conditions, 2007) and is the principal foreign exchange earner. There is an increased focus on tourism in St. Kitts and Nevis and in recent years the tourism sector has become more dependent on cruise ship passengers. By its very nature, tourism is a resource dependent industry. Cruise tourism is of particular concern to biodiversity conservation because a large volume of people engaging in leisurely activities are spatially and temporally confined and can therefore exceed the carrying capacity of an ecosystem. In addition to the local pressures that threaten the sustainability of St. Kitts ecosystems is the impact of global warming. Human activities are perpetuating a vicious cycle: biodiversity loss is accelerating the rate of global climate change, and in turn global climate change is accelerating the rate of biodiversity loss. Healthy ecosystems are vital to global and local climate regulation; for example, forests and coral reefs are carbon reserves that sequester GHG and could help to curtail climate change. Changes in a country's land cover affect local temperature and precipitation patterns. SIDS have been determined to be most vulnerable to global climate change and the Caribbean Region is one of the world's biodiversity hotspots. It is a region with high endemic species diversity, with at least 1,500 endemic species of vascular plants, and has lost at least 70% of its original habitat (Myers *et al.*, 2000). This means that Caribbean islands are at great risk to losing their remaining natural resources, thus increasing their vulnerability to a phenomenon over which they have little control. If this were to happen the impacts could be devastating.

Adaptation to climate change will involve an adjustment in processes, practices and structures at the community, national and regional levels. The Government of St. Kitts and Nevis has acknowledged the importance of its biological resources to the tourism product and to sustainable development. As such, it has already begun to take steps towards biodiversity conservation through the development of plans and policies. In order to be effective over the long term, adaptation strategies for biodiversity should take an ecosystem based approach. This means that strategies must aim to enhance the quality of terrestrial and marine ecosystems, strengthen the linkages between habitats, increase the size and number of protected areas and improve their management with greater stakeholder involvement. Strategies should also aim to strengthen the linkages between resource users and resource managers by building capacity through education/awareness and empowering resource users to be environmental stewards. If the tourism sector, a significant consumer of natural resources, is to be sustainable, it must engage more actively in the conservation and management of protected areas. Planning and managing for resilient ecosystems, and adapting to a dramatically changing climate must become a key priority for the Government of St. Kitts and

Nevis. The following sections will discuss the biodiversity of St. Kitts that is particularly important to the country's tourism and supporting sectors.

Importance and status of forest ecosystems

Although most virgin forests in St. Kitts have been cleared, the cessation of the sugarcane industry has allowed for secondary growth so that presently the forested area is increasing (Figure 4.5.1)(Poverty Research Unit, 2006). Five vegetative types have been described for St. Kitts: rainforest, dry evergreen forest, palm brake, elfin woodland and dry scrub woodland (Figure 4.5.2). Reaching 1,156 m at the highest peak, the Central Forest Reserve is covered with 12,500 acres of cloud forest that provide important habitat for a number of resident and migratory birds. In 2009, the Central Forest Reserve was designated as a globally important bird area.

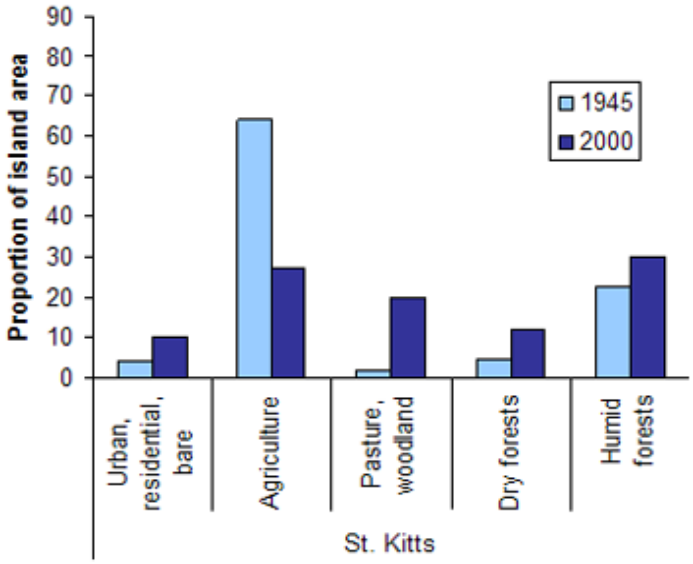


Figure 4.5.1: Land Cover Change on St. Kitts between 1945 and 2000.

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

Forest ecosystems provide a number of goods and services to the people of St. Kitts. The island's forests are associated with watersheds that are important for providing a continuous supply of clean water. Ground cover of plants, litter and soils absorb and filter rain-water before it is released into aquifers, streams and rivers. This biome also buffers the flow of watercourses after heavy rains, providing important protection to low-lying areas and coastal ecosystems, such as coral reefs, from floodwaters and associated sedimentation. Forest products are used to support various livelihoods in tourism and supporting sectors. For example, wooden sticks are used in making fish pots, roots and herbs are harvested to make beverages or medicines, and other materials are used in for the production of crafts and jewellery. The forest also provides eco-tourism employment opportunities for trail guides and tour operators.

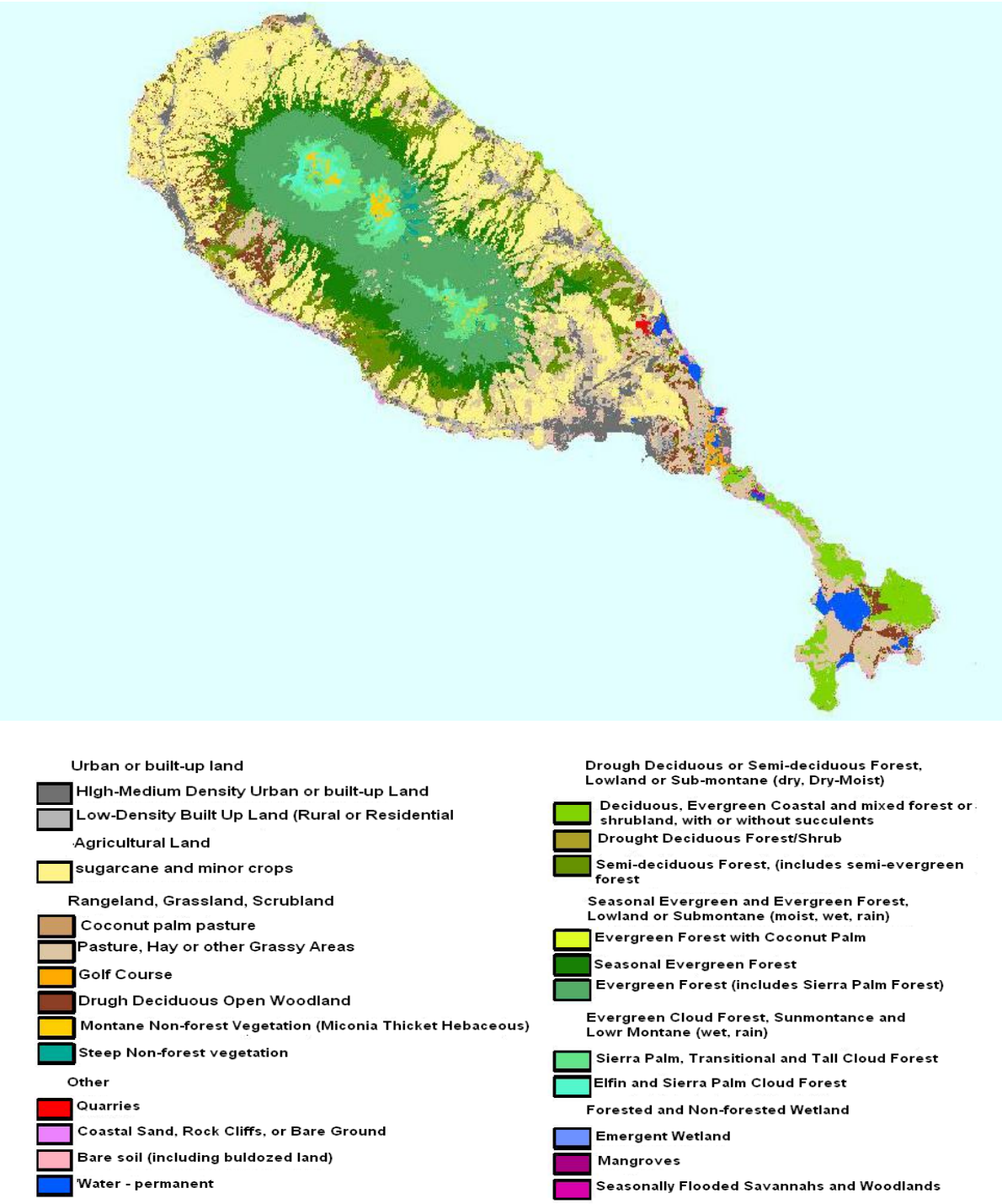


Figure 4.5.2: St. Kitts Land Cover and Forest Formations

(Source: http://landsat.gsfc.nasa.gov/graphics/news/sci0021lg.jpg)

Most of St. Kitts' forests have been affected by human activities - such as the indiscriminate clearing of land for plantation agriculture and development purposes - so that very little natural vegetation remains. Unfortunately, loss of habitat and the introduction exotic species, such as the mongoose and the Green and Vervet monkeys, have depleted much of the island's animal wildlife so that the few species of terrestrial fauna remain. Today only 2 species of amphibian (a third species is believed to be extinct having succumbed to predation by the mongoose) and 11 reptiles (2 of which are now extinct) are found on St. Kitts (Edwards, 2008). Feral populations of Green or Vervet Monkey are a common threat to agriculture but simultaneously have become somewhat of a tourist attraction. Since the closure of the sugar industry and the growth of the tourism sector, the Government has reviewed its policies on land use planning and management, but additional revisions are necessary to avoid further stress on plant communities.

Importance and Status of Beaches

St. Kitts has 13.1 km of black volcanic sand beaches and 13.2 km of golden sand beaches(DOE, 2000). While these beaches are important attractions for tourists and recreational areas for residents, they also provide many more essential ecosystem services. They provide critically important habitat for many animals such as shore birds and globally threatened marine turtles that are known to nest along St. Kitts shores - particularly on the Cayon, Keys and North Friars Beaches (Caribbean News Now, 2011). The vegetation that grows on beaches and sand dunes promotes shoreline stability by reducing the mobility of sand grains, thereby increasing the resilience of beaches to erosive wave action. Economic benefit is also realised from the physical protection of coastal infrastructure provided by beaches that act as a line of defence against high waves. Furthermore, beaches are an important feature in the fisheries sector as landing sites that are used by artisanal fishers to launch their vessels and haul in their catches (Figure 4.5.3).

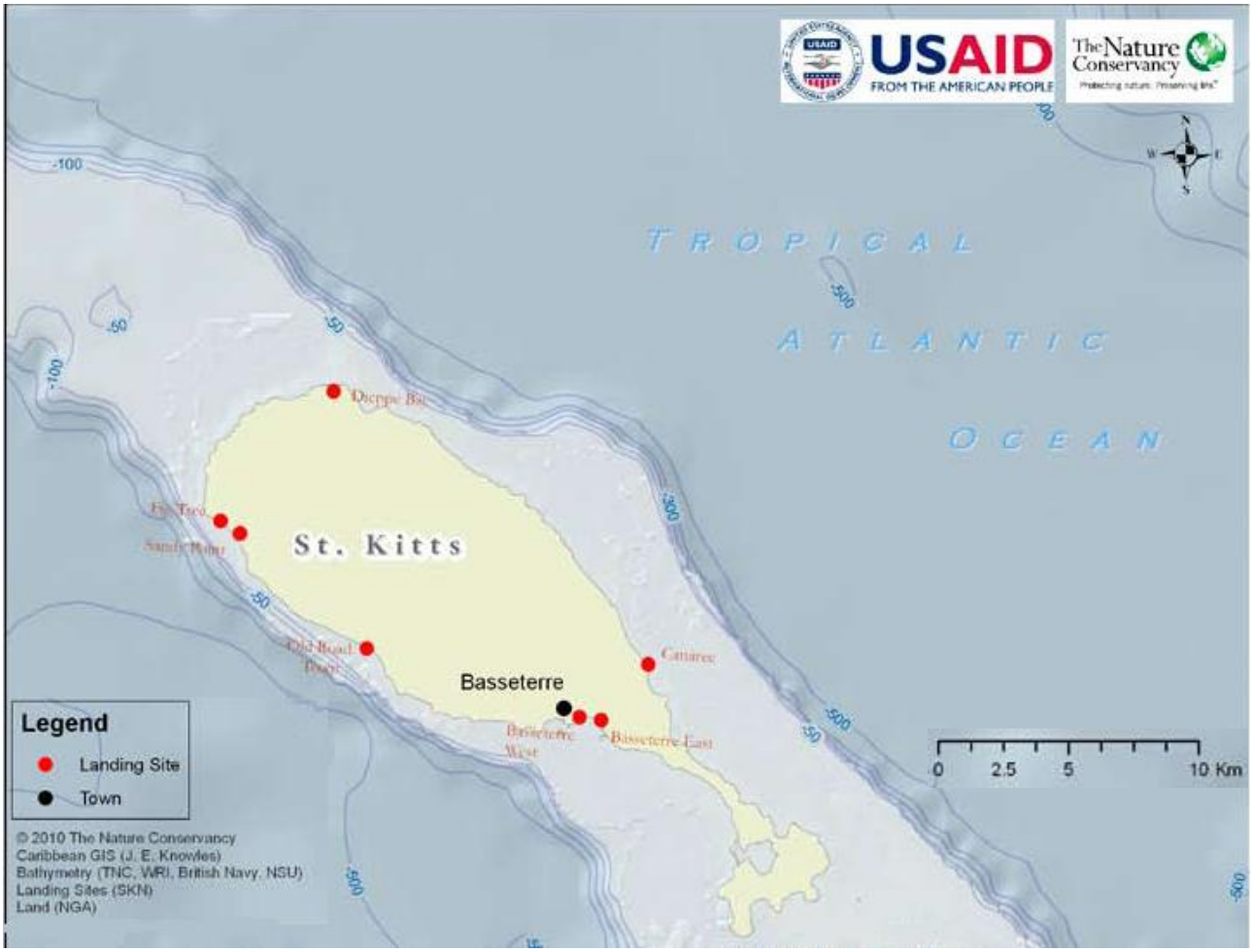


Figure 4.5.3: Location of Fish Landing Sites in St. Kitts

Inadequate building setbacks, construction activities in near shore areas and sand mining are all negatively impacting on this important coastal resource. Although the removal of large quantities of beach sand is forbidden by law, illegal sand mining still occurs and has led to beach erosion along the west coast from South Frigate Bay to Pump Bay in Sandy Point (see section 4.6). The aesthetics of several of the island's beaches that are popular tourist attractions are being degraded (DOE, 2000). Illegal sand mining is a serious concern that disrupts the natural movement of sand on beaches, leading to potential rapid beach erosion. Sand that is naturally washed away from a beach during a storm is usually eventually recovered from the near shore deposits. However, if beach sand is depleted by mining activities, there will be insufficient

resource in the deposits for post-event recovery. Another concern is the use of heavy equipment for sand-mining that can compact turtles nests and crush the eggs.

Importance and Status of Wetlands

Owing to the lack of rivers and the susceptibility of its aquifers to saltwater intrusion, available water in St. Kitts has been calculated as 576 m^3 per inhabitant per year, placing it among the most water scarce islands in the Eastern Caribbean (FAO, 2003). The Wingfield and Cayon rivers are the most notable rivers in the island; these flow almost to the sea for much of the wettest part of the year, but their flow is diminished during the dry season (DOE, 2001).

Wetlands in St. Kitts are not abundant and are limited to a few mangrove stands and salt ponds. These ecosystems provide habitat to a variety of organisms such as the migratory birds that depend on mangrove and pond communities for feeding and nesting (MOSD, 2007). Freshwater fish and other aquatic are found in lagoons and streams but these have not been well documented.

The most extensive mangrove habitat in St. Kitts occurs in the SEP. This mangrove forms part of a nutrient exchange system with associated coral reefs and seagrass beds. These 3 ecosystems are essential nurseries for juvenile fish and habitat for marine species, several of which are commercially important. Mangrove vegetation protects coastlines and infrastructure by reducing the impact of cyclonic winds and buffering high energy waves. Their roots filter pollutants and thereby regulate coastal water quality; an essential provision for fisheries and marine based tourism activities. There are 8 relatively small mangrove sites along the coastal area of St. Kitts mainly associated with Greatheeds Ponds, Half Moon Pond, Frigate Bay Pond and Friar's Bay Pond. The most common species are *Avicennia germinans, Laguncularia racemosa, Rhizophora mangle* and *Avicennia schaueriana*. Mangrove stands have been lost primarily due to conversion to salt pond production and to a lesser extent tourism development (FAO, 2005). It is worthwhile to note that the island's largest hotel is located on the SEP and the area is slated for further development.

Table 4.5.1: Changes in wetlands area in St. Kitts and Nevis 1980-2005

Most reliable estimate		1980	1990	Annual change 1980-1990		2000	Annual change 1990-2000		2005	Annual change 2000-2005	
Ha	Reference year	Ha.	Ha.	Ha.	%	Ha.	Ha.	%	Ha.	Ha.	%
79	1991	85	80	-1	-0.6	75	-1	-0.6	70	-1	-1.4

(Source: FAO, 2007)

Salt ponds in St. Kitts are saline lagoons that provide habitat to mangroves, shore birds, fish and other species. Generally they do not exceed 1 m in depth and may evaporate entirely during dry the dry season being replenished when rainfall runs off from surrounding hillsides. Human activities continue to impact on salt ponds either through development of surrounding lands or direct use of the ponds. Salt was once mined from Little and Great Salt Ponds, but this practice has virtually ceased. The Half Moon Pond was converted to a marine shrimp farm that ran into numerous technical problems and had to be abandoned (Walters and Anrooy, 2003) and the Greatheeds Pond is under threat from leachates from a nearby garbage dump and industrial plants, putting at risk a great number of resident and migratory birds.

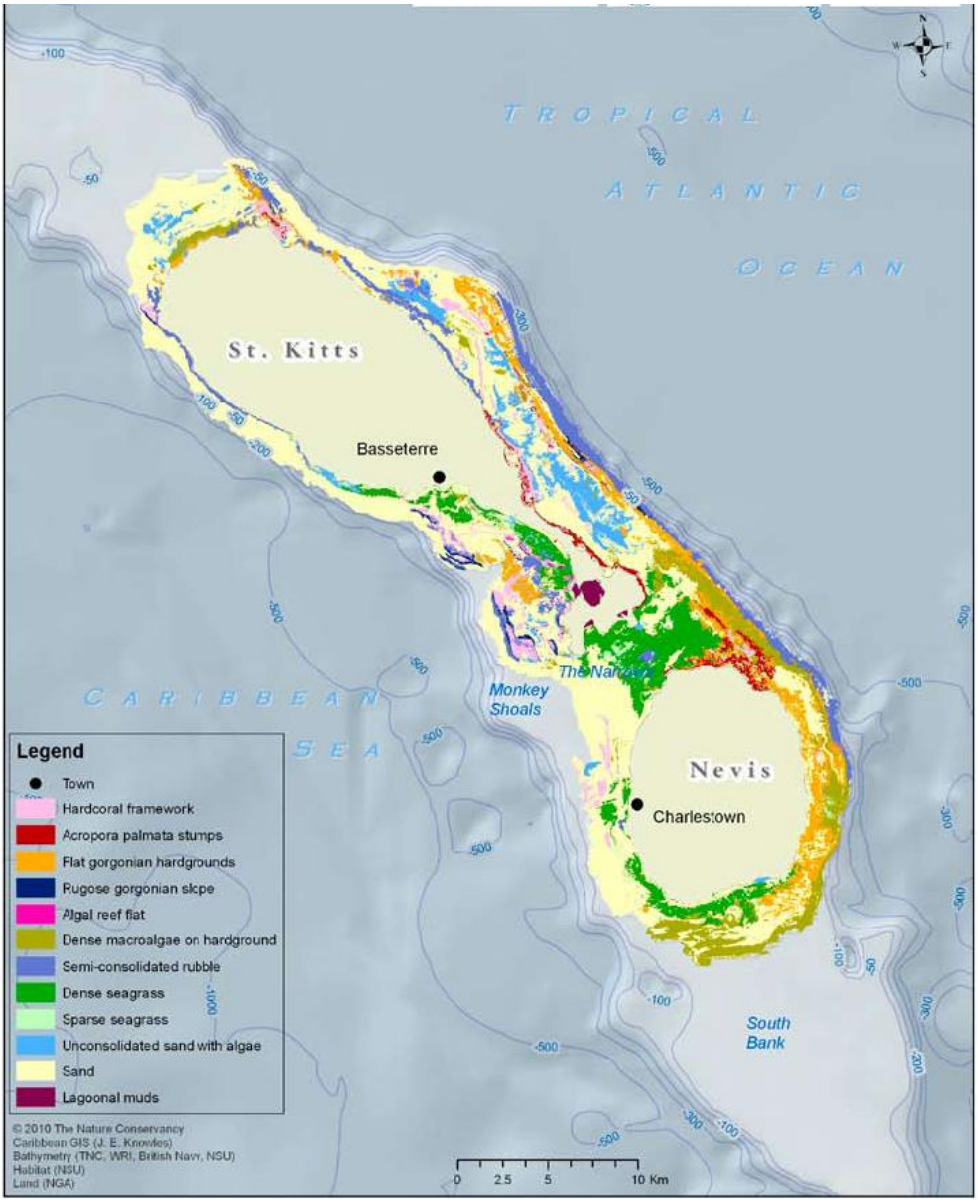
Importance and Status of Coral Reefs

Coral reefs, "the rainforests of the sea", serve to protect an island's shoreline, maintain its marine biodiversity, contributes to tourist recreational activities, and support artisanal fisheries. In St. Kitts, coral reefs are generally found along the southwest coast between Nag's Head and the southern end of

Basseterre Bay, on the northwest coast between Sandy Point and Dieppe Bay, on the east coast between Conaree and Friar's Bay and on the southeast coast adjacent to the Narrows (MOSD, 2007). The diversity of corals ranges from species categorised as critically endangered by the International Union for Conservation of Nature, such as staghorn (Acropora cervicornis) and elkhorn (Acropora palmata), to the more common finger coral (Porites divaricata) (Agostini et al., 2010).

Coral reefs around the island of St. Kitts provide an attraction to scuba divers and snorkelers, help to absorb the energy of waves thereby protecting the coastline from damage, and support the island's fisheries. Many of the marine species that are harvested for commercial use and targeted in sport-fishing spend part or all of their lives among reefs which provide spawning and foraging grounds as well as habitat. Corals are also significant contributors to beach sand (CZMU, n.d.).

Up to 75% of the Caribbean regions coral reefs have been lost as a result of local stressors. Scientists predict that rising CO_2 levels could drive reefs to extinction within this Century if immediate action is not taken. If the Caribbean was to lose its reefs, this would mean not only a loss in revenue from dive tourism and loss of beach attractions, but also a serious threat to food security, human safety, possible dramatic changes in coastlines, costly damage to coastal infrastructure. A number of factors are contributing to the degradation of reefs around St. Kitts. High macro-algae and lower coral cover, low species diversity and imbalanced proportions of herbivorous fish and top predators are indicative of an unhealthy marine environment. The Reefs at Risk analysis determined that overfishing threatened all reefs around the island. Coastal development was also ranked as a significant threat to 95% of the reefs around St. Kitts and Nevis. Sedimentation from steep topography has been worsened by the clearing of sugar cane fields for conversion to other land uses. Dredge-and-fill operations for the construction of ports and marinas as well as agro-chemicals and inadequately treated sewage from hotels and other industries are also negatively impacting marine ecosystem health (Government of St. Kitts and Nevis, 2004). According to the National Action Programme for Combating Desertification, all urban areas on St. Kitts lack adequate treatment facilities for domestic sewage and waste water (MOSD, 2007). Frigate Bay, Sandy Point and the SEP have been notably affected by pollution, soil run-off and sewage effluent. The result is the seepage of inadequately treated waste into near shore areas with negative impacts on the health of corals, seagrasses and other marine life. Mucus, brown spotting, and discoloration of sea fans, coral blushing and bleaching are also affecting reefs around St. Kitts (St. Kitts Foundation, 2007).



Modelled bathymetry (ocean depths) of the near-shore areas (less than 30-metre depth) based on 2.5 x 2.5-meter satellite imagery. These depths were modelled using field-referenced depth sounding and correlated with multispectral imagery to provide an estimation of depth and assist with the classification of benthic habitats. (Source: The Nature Conservancy, 2010)

Figure 4.5.4: Bathymetry Map of St. Kitts and Nevis

Importance and Status of Seagrass Beds

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

- as primary producers in the food chain of the reef community;
- in fixing nitrogen;
- in providing habitats, feeding, breeding, recruitment sites and nursery grounds for juveniles and adults of reef organisms including commercially important species such as queen conch and spiny lobster, as well as the endangered green sea turtle;
- in reducing sediment movement in near shore waters thus in stabilising the coastline;
- and removing sediments from the water column; decreasing turbidity of the water.

Seagrass beds in St. Kitts, dominated by turtle grass and manatee grass species, are mostly common in the SEP, particularly in the Narrows (Figure 4.5.4). Anchor damage, dredge-and-fill operations, siltation, sedimentation and chemical pollution of marine environment continue to adversely impact on seagrass health and increase the vulnerability of this fragile yet essential marine habitat to potential climate change impacts.

Importance and Status of Fisheries

There are 4 major fisheries in St. Kitts: demersal or bank, coastal pelagic, ocean pelagic, and conch fisheries. The fisheries sector of St. Kitts is important to national food security, provides income for about 350 fishers (48% fulltime), supports other livelihoods such as fish processing and vending and is an important source of foreign exchange earnings (CRFM, 2010). The majority of fishers are artisanal and engage in the multi-gear, multi-species demersal fishery harvesting doctor fish, trigger fish, grunts, squirrel fish, snappers, goat fish, parrot fish, groupers (Serranidae) and lobsters. About 5 nautical miles off-shore, approximately 10% of registered fishers harvest coastal pelagic species such as gars, ballyhoo and jacks. Ocean pelagic fisheries are highly seasonal targeting dolphin, tunas and mackerel (FAO, 2006) and is the only subsector of the fishing industry that has consistently shown significantly increased landings in recent years (WECAFC, 2001).

Most near shore reefs have been overfished of large predators so that primarily small herbivorous fish are now the remaining species and these too are facing fishing pressure (St. Kitts Foundation, 2007). Conch is the primary export species with as much as half of the conch harvested being sold to exporters (Steinback *et al.*, 2010). Conch exports have been increasing annually (Table 4.5.2) with over 110, 000 kg of conch meat exported from St. Kitts and Nevis in 2010 (CITES, 2011). There is evidence of population declines of conch and lobster in certain areas and is thought to be mainly due to habitat degradation, dredging and hurricanes (CITES, 2003). These two species are of importance to the food and beverage sector of the hotel industry and the demand will likely increase as tourism expands.

Table 4.5.2: Fisheries Production as Landing for St. Kitts 2003-2005

Product	2003	2004	2005
Fish	197,547	280,268	157,635
Conch	43,947	61,213	67,843
Lobster	2,488	3,832	26,314
miscellaneous	56,735	69,136	30,776

(Source: Edwards, 2008)

In November 2010, sightings of the invasive lionfish were reported in waters surrounding St. Kitts. The voracious *Pterois volitans*, the Indo-Pacific lionfish, is an invasive species that has no apparent natural predators in the Caribbean and this has allowed the species to spread very rapidly throughout the region from both northern and southern ends of the Caribbean Basin. The fish feeds not only on reef fish such as parrotfish, which are important to maintaining reef health, but also on the juveniles of commercially important species. The Department of Marine Resources is greatly concerned about the threat this could pose for the country's fishing industry. As interest in dive tourism in St. Kitts increases and climate change impacts accelerate, it will become increasingly important to rehabilitate the near shore marine environment, protect the health of coral reefs and rebuild fisheries so as to protect economic interest and livelihoods.

4.5.2. Vulnerability of Biodiversity and Fisheries to Climate Change

Vulnerability of Forests to Climate Change

While small changes in temperature and precipitation are known to have significant effects on forest ecosystems, there has been little research focused on the projected impacts of climate change on terrestrial biodiversity in the Caribbean Region. Climate change related variations in average daily temperature, seasonal precipitation and extreme weather events will exacerbate the effects of existing human stressors on forest ecosystems. Alterations in the average annual temperature and precipitation patterns may affect the growth of trees and other plant species within the forest. In St. Kitts, rainfall is strongly related to altitude with the central mountain range receiving an annual average of 2,500 mm to 4,000 mm (Climate Lab, n.d.) and coastal areas receiving a more modest annual average of 1,016 mm (MOSD, 2007). The situation is quite different along the SEP where mean annual precipitation varies from 990 mm on the peaks to 864 mm at Cockleshell Bay (MOSD, 2007). Decreases in precipitation and increased average daily temperatures could result in a loss of rainforest zones and an associated increase in the tropical dry forest zones. The implications are a loss of habitat for endemic species, and a loss of revenue for the eco-tourism sector.

Mount Liamuiga is the tallest peak in St. Kitts, rising to 1,156 m and grows a type of vegetation classified as cloud montane forest. These species require almost continual cloud coverage and are most vulnerable to climate change(Foster, 2001). Assuming a cooling rate of 1°C per 150 m of altitude, a projected increase of 1.7^{o}C would require vegetative zones to migrate vertically by 260m, 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. The tropical rainforest of the Central Forest Range may be impacted by projected changes in humidity. Reduced moisture could result in forests becoming much drier, potentially causing the wilting and death of epiphytes, which provide important habitat for birds, insects and reptiles (Foster, 2001). Loss of forest cover will also increase the risk of soil erosion.

Caribbean forests have always suffered physical damage from storms, but there is evidence that the increasing intensity of hurricanes is causing more severe damage, with potentially longer term consequences for the integrity of the forest structure and canopy. Severe damage to trees and animal habitats may take years to return to normal. The recent exit from the sugar industry has left lands unprotected and increases the likelihood of land slippage and soil erosion that usually accompany heavy rainfall and intense winds during extreme weather events. The cost of repairing infrastructure and maintaining roads and trails across St. Kitts 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.

Vulnerability of beaches to climate change

Climate change, in particular SLR and extreme events, is likely to increase rates of beach erosion. 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 fish landing sites. Climate change impacts on beaches will also threaten the survival of species such as marine turtles and shore birds. A 1-2 m SLR is predicted to damage 35-43% of turtle nesting sites on the island (Simpson *et al.,* 2010; also see section 4.6). Turtles exhibit strong nesting site fidelity and will undertake long distance migrations in order to return to their natal beach to nest.

Given the small fraction of hatchlings that survive to adulthood the loss of beach nesting sites has grave implications for marine turtle populations. Furthermore, warmer average daily temperatures may skew sex ratios in developing turtle eggs and thereby reduced the reproductive capacity of sea turtles. Such impacts will mean a loss of potential for the country's expanding ecotourism industry, disruption of marine ecosystem balance, and loss of a tourism product. As a signatory to Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), St. Kitts has an obligation to protect these marine reptiles.

Intense tropical cyclones and accompanying storm surges will also alter beach profiles and impact on nesting areas (Simpson *et al.*, 2010). Dramatic changes can occur to the beach profile during a single extreme weather event and although recovery occurs, it may not be to pre-hurricane conditions. During the 1990s several hurricanes passed through the region impacting on St. Kitts beaches. Hurricane Luis in 1995 struck the island eroding much of the sand at South Friar's Bay; subsequently Hurricane Georges and Lenny in 1998 and 1999 respectively were equally damaging (Figure 4.5.5). Frequent events do not allow sufficient time for beaches to recover in between events.

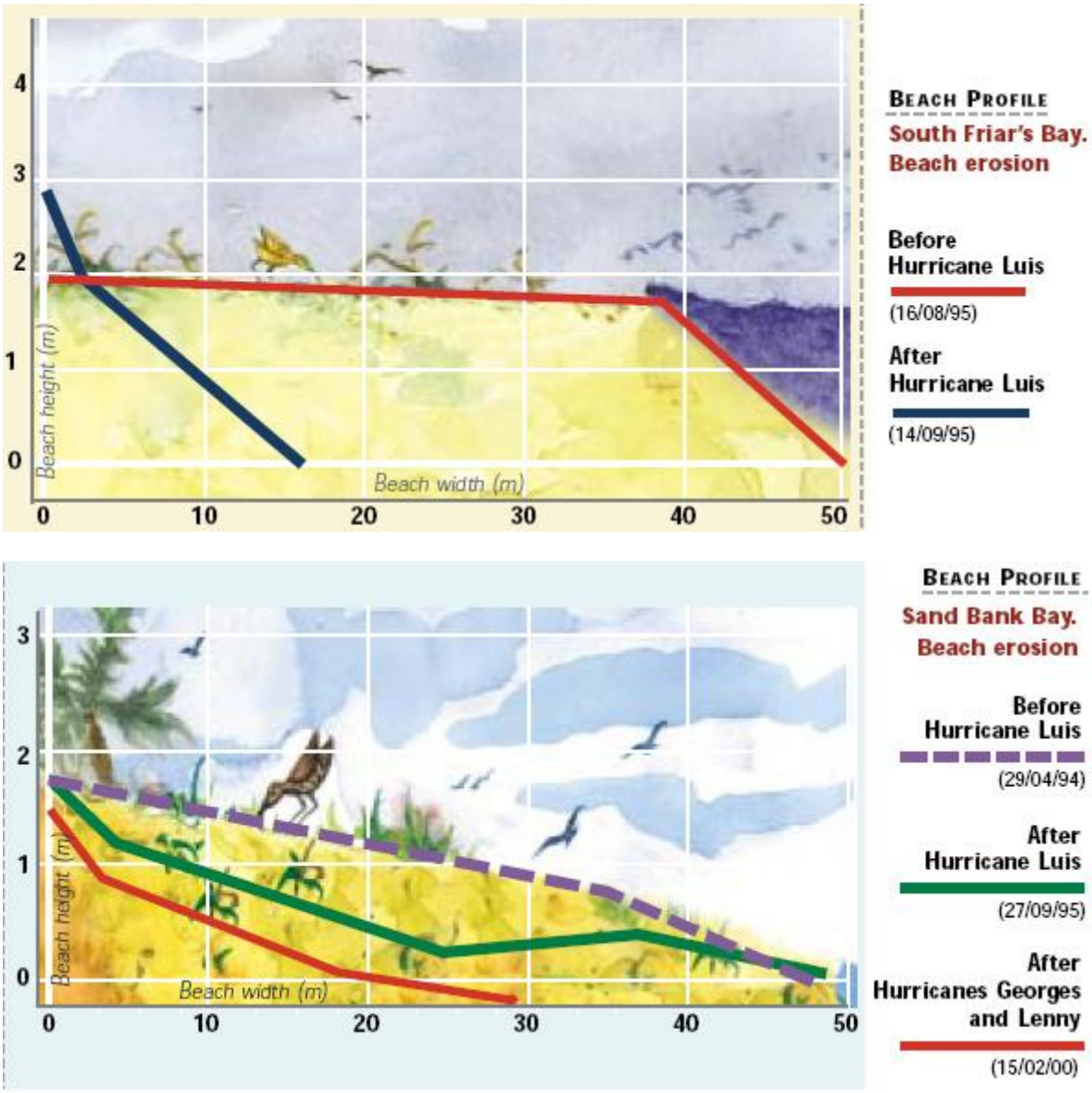


Figure 4.5.5: Hurricane Impacts on Beach Profiles in St. Kitts

(Source: UNESCO, n.d.)

Vulnerability of Coral Reefs to Climate Change

Although fragile, coral reefs have shown the ability to acclimatise and adapt to temporal and spatial changes in their environment throughout their geological history. However, the current rate of SLR may exceed their ability to migrate vertically (through growth and accretion) and decrease the amount of sunlight available to them. Increased atmospheric CO_2 is also causing changes in atmospheric and oceanic characteristics with which corals must contend. Ocean acidification, SLR and increased SST present additional stresses on the coral reefs around St. Kitts; coral reefs that are already degraded by poor water quality and over-fishing.

Observed SST from the HadSST2 gridded dataset have followed a statistically significant increasing trend of 0.09˚C per decade in the waters surrounding St. Kitts and Nevis for the period 1960-2006 with the highest change during JJA (+0.12˚C). GCM projections indicate increases in sea-surface temperatures throughout the year. Projected increases range between +0.7˚C and +2.8˚C by the 2080s across all three emissions scenarios. The range of projections under any single emissions scenario spans roughly around 1.0 to 2.0˚C (see section 3). Increases in SST of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals (Nicholls R. P., 2007). Increased frequency of bleaching episodes means reduced recovery time for coral polyps and greater likelihood of mortality. Furthermore, warmer oceanic waters will facilitate the uptake of anthropogenic CO_2 which creates additional stress on coral reefs. Increased CO_2 fertilisation will change seawater pH, having a negative impact on coral and other calcifying organisms since more acidic waters will dissolve and thus weaken the skeletal structure of such organisms.

It is difficult to predict whether Caribbean corals will keep pace with SLR, increased SST and other climate change impacts. What is more certain is that corals' ability to adapt to climate change is dependent on the degree of localised environmental stressors that they are exposed to. 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, Global assessment of coral bleaching and required rates of adaptation under climate change, 2005). Coral reefs have been shown to keep pace with rapid postglacial SLR when not subjected to environmental or anthropogenic stresses (Hallock, 2005).

Vulnerability of Seagrass Beds to Climate Change

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 localised decreased in salinity and resulting decreased productivity of sea grass habitats. On the other hand, CO_2 enrichment of the ocean may have a positive effect on photosynthesis and growth (Campbell *et al.*, 2006). Associated ocean acidification may not hamper primary productivity of sea grasses since photosynthetic activity of dense sea grass stands have been shown to increase local pH. The impact of increased SST on seagrass beds in the Caribbean is uncertain since studies have suggested that the photosynthetic mechanism of tropical sea grasses becomes damaged at temperatures of 40-45°C (Campbell *et al.*, 2006).

Intense hurricanes can uproot these delicate aquatic plants; often 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 sea grass beds, smothering plants and blocking essential light. This is of particular concern in the coastal waters around the SEP, where local dive shops have observed widespread siltation caused by large-scale tourism development projects.

Vulnerability of Fisheries to Climate Change

Although little is known about the long-term effects of climate change on the Caribbean Sea and on its fisheries, these resources are likely to be impacted by climate change. As discussed in previous sections, climate change is already impacting on coral reefs and will generally have negative and possibly debilitating impacts on other ecosystems that are important to various life stages of commercial fish, namely coral reefs, seagrass beds and mangroves. The potential negative impacts that will occur as a result of increasing sea temperatures, shifts in tidal patterns, intensified hurricane activity and SLR will place additional stresses on fisheries resources that are already threatened from over-fishing and habitat loss.

Fishers in some of the Eastern Caribbean islands have reported reduced catches and have attributed this loss of revenue to observed changes in ocean currents that they believe are affecting fish distribution. Increased periods of precipitation will increase the quantity of sediment eroded from abandoned sugar cane fields and washed into near shore habitats. Pelagic fisheries may be affected by increased SST, which could drive these species away in search of cooler temperatures and potentially alter breeding and migration patterns. Pelagic species currently hold the greatest potential for fisheries expansion in St. Kitts and are also important to a number of sport-fishing operators.

Of further concern to the fisheries sector is the effect that global warming will have on the incidence of vector borne diseases. Ciguatoxin infection tends to occur more frequently in northern Caribbean islands however, there is the concern that SST increases can expand the range of the infectious algae and increase the frequency of algal blooms that can contaminate some seafood species (SDEU, 2001). Any possible correlation between human health risks, such as ciguatera poisoning, and climate change should give impetus to researching climate change impacts on regional fisheries (see Section 4.4.2).

Although not confirmed as a climate change related event, large quantities of Sargassum seaweed have been washing ashore on the islands of the Eastern Caribbean in July and August 2011. 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 are complaining that their nets and lines become entangled in the Sargassum and there is 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 poses a serious 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.

Figure 4.5.6: Unusual Amount of Sargassum Seaweed Washed up on a Caribbean Beach August 2011
(Source: Richard Roach)

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. St. Kitts 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. St. Kitts relies on its tourist industry for much of its national income, and therefore the economic effects of SLR and storm induced erosion are significant (Daniel, 2001). 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. Frigate Bay and Basseterre) (Daniel, 2001). 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 (St. Kitts) and local scale (Irish Bay, Basseterre Bay, Frigate Bay, Sugar Bay), with adaptation and protection infrastructure options discussed. Please refer to Section 4.7 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).

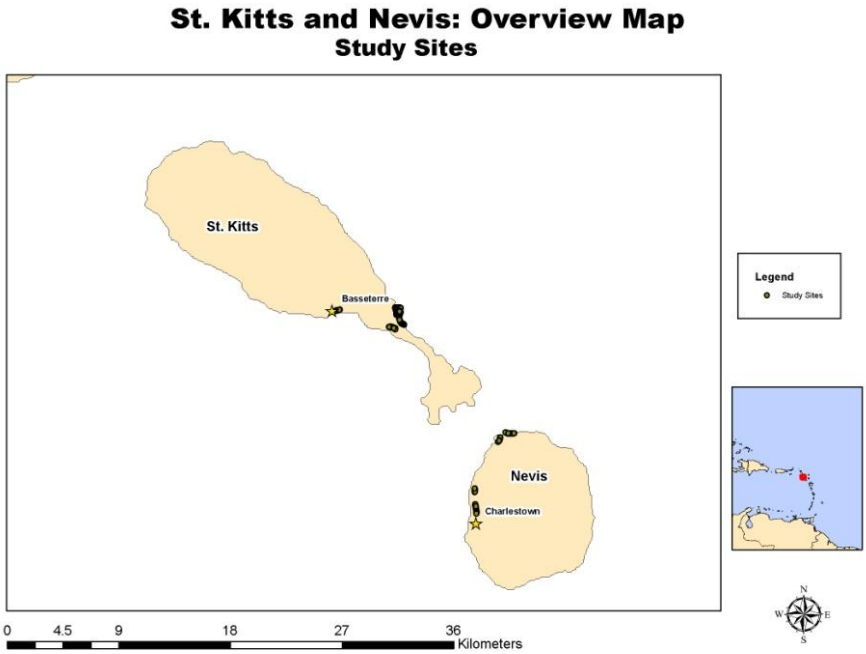


Figure 4.6.1: St. Kitts and Nevis- Overview Map

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 St. Kitts are Irish Bay, Basseterre Bay, Frigate Bay, and Sugar Bay, 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 (Simpson *et al.*,

2010; IPCC, 2007b), 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 St. Kitts, 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, 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 St. Kitts and Nevis. The sea level has risen in the Caribbean at about 3.1 mm/year from 1950 to 2000 (Church *et* al*.,* 2004). Global SLR is anticipated to increase as much as 1.5 m to 2 m above present levels in the 21st Century (Rahmstorf, 2007; Vermeer and Rahmstorf, 2009; Grinsted *et al.*, 2009; Jevrejeva *et al.*, 2008; Horton *et al.*, 2008). It is also important to note that recent studies of the relative magnitude of regional SLR also suggest that because of the Caribbean's proximity to the equator, SLR will be more pronounced than in some other regions (Bamber *et al.,* 2009; Hu *et al.,* 2009).

Based on the SLR scenarios for the Caribbean (section 3) and consistent with other assessments of the its potential impacts (e.g. Dasgupta *et al.,* 2007 for the World Bank), 1.0 m and 2.0 m SLR scenarios and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential vulnerability of major tourism resources across St. Kitts. The beaches of St. Kitts have been monitored since the early 1990s and indicate there is change from season to season and from year to year, but the underlying trend in many locations has been a loss of beaches due to accelerated erosion. Figure 4.6.2 illustrates that the impacts of beach erosion are already being seen in St. Kitts.

Figure 4.6.2: Erosion at the Marriott Resort (St. Kitts)

To examine the exposure of St. Kitts to SLR at the national level, research grade Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) data sets that were recently publically released by the National Aeronautics and Space Administration (NASA) and the Japanese Ministry of Economy, Trade and Industry, were integrated into a Geographic Information System (GIS). The ASTER GDEM was downloaded from Japan's Earth Remote Sensing Data Analysis Centre using a rough outline of the Caribbean to select the needed tiles, which were then loaded into an ArcMap document. The next step was to mosaic the tiles into a larger analysis area, followed by the creation of the

SLR scenarios as binary raster layers to analyse whether an area is affected by SLR through the reclassification of the GDEM mosaics (see Simpson *et al.*, 2010 for a more detailed discussion of the methodology). These assessments were used to calculate the impacts of sea level rise on both 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 *et al.*, 2004).

Table 4.6.2 identifies what tourism infrastructure would be at risk of inundation from a 1 m and 2 m SLR scenario and to erosion of 50 and 100 m. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 64% of the major tourism properties at risk, with 77% at risk with a 2 m SLR. It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure.

Table 4.6.1: Impacts associated with 1m and 2m SLR and 50m and 100m beach erosion in St. Kitts and Nevis

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Land	Major Road Networks	Seaport Lands
SLR	1.0m	64%	35%	50%	0%	50%
	2.0m	77%	43%	50%	0%	50%
Erosion	50m	68%	79%	-	-	-
	100m	82%	79%	-	-	-

Indeed if erosion is damaging tourism infrastructure, it means the beach will have essentially disappeared. Table 4.6.1 highlights that with projected 100m erosion, 82% all the resorts in St. Kitts and Nevis would be at risk. Such impacts would transform coastal tourism in St. Kitts and Nevis, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees. Sea turtle nesting sites, a tourist attraction, are also at risk to SLR and erosion, with 79% affected by a 50 m erosion scenario. Transportation infrastructure, also of key importance to tourism, is at risk. Ports are threatened, with 50% of port lands in the country projected to be inundated with a 1 m SLR, followed by half of airport lands.

St. Kitts is highly dependent on international tourism, and the country will be particularly affected with annual costs as a direct result of SLR. St. Kitts will incur annual losses between US $30 million in 2050 to over US $101 million in 2080 (based on a mid-range scenario). Capital costs are also high, with rebuild costs for tourist resorts damaged and inundated by SLR amounting to over US $936 million in 2050 up to US $2.2 billion in 2080. Infrastructure critical to the tourism sector will also be impacted by SLR resulting in capital costs to rebuild airport estimated to be between US $44 million by 2050 to US $132 million by 2080. Capital costs to rebuild ports are estimated to be between US $15 million in 2050, to US $44 million by 2080 (Simpson *et al.,* 2010).

In addition to the national assessment, the CARIBSAVE partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the St. Kitts Department of Development Control and Planning 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 4 locations in St. Kitts 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, antenna, survey stick and data logger was used for data collection in St. Kitts.

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 Lecia Disto laser distancing meter.

Figure 4.6.3: Training the St. Kitts Development Control and Planning Authority staff in 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 0.015-0.3 m while the horizontal accuracy had a mean average of 0.015-0.2 m accuracy. Each transect point measurement was averaged over 30 readings taken at 1 second intervals. At each point, the nature of the ground cover (e.g. sand, vegetation, concrete) was logged to aid in the post-processing analysis. Ground control points (GCP) were taken to anchor the GPS positions to locations that are identifiable from aerial photographs to improve horizontal accuracy. These were taken where suitable landmarks existed at each transect location and throughout the island. GCP points were measured over 60 readings at 1 second intervals.

Following the field collection, all of the GPS points were downloaded on to a Windows PC, and converted into several GIS formats. Most notably, the GPS points were converted into ESRI Shapefile format to be used with ESRI ArcGIS suite. Aerial Imagery was obtained from Google Earth, and was geo-referenced using the GCPs collected. The data was then inspected for errors and incorporated with other GIS data collected

while in the field. Absolute mean sea level was determined by comparing the first GPS point (water's edge) to tide tables to determine the high tide mark. Three dimensional topographic models of each of the study sites were then produced from a raster topographic surface using the GPS elevation points as base height information. A Triangular Irregular Network (TIN) model was created to represent the beach profiles in three dimensions. Contour lines were delineated from both the TIN and raster topographic surface model. For the purpose of this study, contour lines were represented for every metre of elevation change above sea level. Using the topographic elevation data, flood lines were delineated in one metre intervals. In an effort to share the data with a wider audience, all GIS data will be compatible with several software applications, including Google Earth.

Figure 4.6.4: Total Land Loss, Basseterre Bay, Basseterre, St. Kitts

The high resolution imagery provided by this technique is essential to assess the vulnerability of infrastructure and settlements to future SLR, but its ability to identify individual properties also makes it a very powerful risk communication tool. Having this information available for community level dialogue on potential adaptation strategies is highly valuable. Results for the popular Marriott Resort and Royal Beach Casino in Frigate Bay, St. Kitts, showed a 3 m flood scenario resulted in a total loss of almost 40,000 m^2 of beach area 183,000 m^2 of land area (see Figure 4.6.4 and Figure 4.6.5).

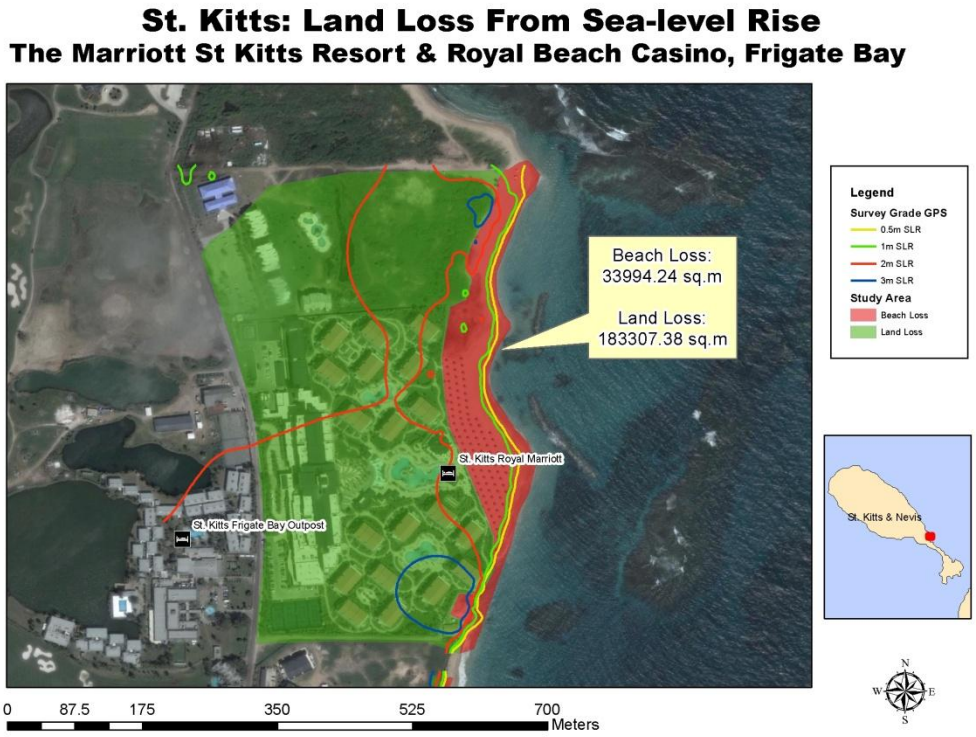


Figure 4.6.5: Sea Level Rise Vulnerability at The Marriott St. Kitts Resort and Royal Beach Casino, Frigate Bay, St. Kitts

Even under a 0.5 m SLR, over 40% of the highly valued beach resource at Irish Bay/Basseterre Bay and Sugar Bay-would be inundated. With a 1m sea level rise, all study sites, except the Marriott Resort would be more than 50% inundated (Table 4.6.2). The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive that these beach areas along with the prevailing climate are the island's main tourism attractions.

Table 4.6.2: Beach Area Losses at Four Resorts in St. Kitts

	Irish Bay/Basseterre Bay		Frigate Bay		Sugar Bay - 1		Marriott Resort	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)
0.5m	3768	43%	5677	36%	11340	54%	8394	25%
1.0m	1628	61%	10053	100%	3383	70%	4198	37%
2.0m	3117	96%	-	-	5382	95%	20806	98%
3.0m	331	100%	-	-	1055	100%	597	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 in order to identify inappropriate development zones, appropriate buffer zones, land uses or building codes and the use of technology to model, forecast and project risks (UNEP, 2007, p. 15). The development of technology for mapping, data analysis, modelling and measurement of hazard information offers decision makers a much better understanding of the interaction hazards have with their economy and society.

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

the tourism sector as well, since tourists may not be familiar with the hazards in their destination and will thus require direction from their hosts.

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

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

4.7.2. Natural Hazards in the Caribbean and St. Kitts

There are 3 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

Hydro-meteorological: The greatest risk of flooding comes during times of heavy rainfall when mountain streams can quickly become raging torrents as they flow down slope into settlements.

Although much of the upper watersheds in St. Kitts are still forested, deforestation in the flat areas near the coast makes settlements vulnerable to flooding (Cooper, 2001). Mass movement of soils and rocks can also create problems during floods. Specifically in College Street Ghaut (near Monkey Town) and in Canyon Ghaut, bank collapse from erosion has caused problems for properties near the riverbank (Cooper, 2001). Fortunately, St. Kitts has twenty-three years of daily rainfall data from seven stations distributed over the entire island (Cooper, 2001). This data can inform decision making and allow for statistical analysis about the types of storms that trigger mass movements and cause flood problems.

Figure 4.7.1 shows some of the highly vulnerable (dark blue and brown) areas within Basseterre, as well as some of the other areas nearby that also are regularly impacted by flooding (pink and yellow). Vulnerable areas in the rest of the island were mostly in the northern coastal areas and are generally of lower risk levels. After a recent event, National Emergency Management Agency (NEMA) made the statement that "significant funding is needed to mitigate flooding in several communities and in the central business district of Basseterre the capital city" (NEMA, 2010). The tightly related issue of adaptive capacity and disaster management policy can be found in section 5.7.

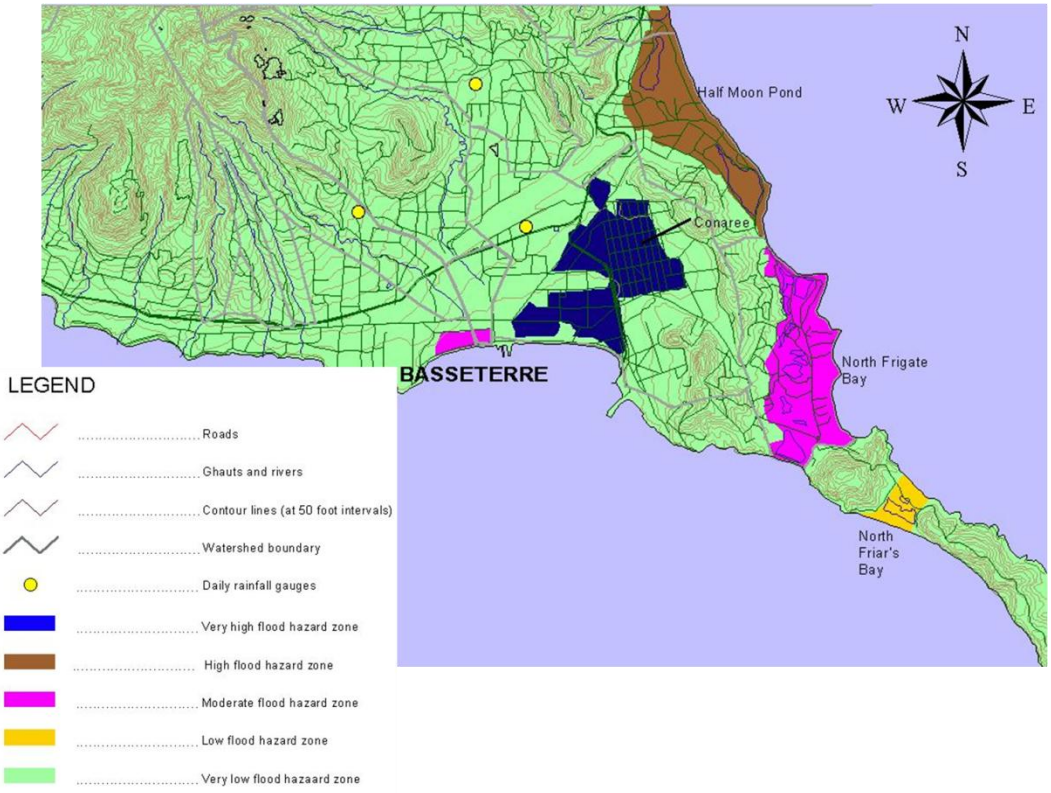


Figure 4.7.1: Flood mapping in Basseterre area

Source: (Cooper, 2001)

Other hydro-meteorological hazards have impacted St Kitts in recent years.

Table 4.7.2 summarises the impacts to the citizens, the economy and various physical structures. Considering how and why different areas and sectors of St Kitts were impacted or damaged is part of understanding the dynamic pressures that interact to generate vulnerability.

Table 4.7.2: Historical Record of Natural Disasters in St. Kitts

Date of Event Type (name of storm)	# of People Affected	Deaths	Economic Impacts (US $millions)	Physical Damages
Flooding 1987			0.5	
September 1989 Hurricane Hugo	1,300	1	46	
September 1995 Hurricane Luis	1,800	0	197	Severe damage to JN France Hospital
September 1998 Hurricane Georges	10,000	5	400	Loss of 90% of the function of JN France Hospital
November 1999 Hurricane Lenny	1,180	0	41.4	
October 2008 Hurricane Omar		0	Unknown[1]	Visible coastal erosion and infrastructure damage in some areas Loss of Four Seasons Resort (Nevis)

[1] IMF funding for balance of payment impacts was US $19 million, however this is not a direct damage estimate.

(Source: EM-DAT, 2011; UNISDR, 2009; Marcello, 2011; IMF, 2009)

Biological: In times of low rainfall and high heat there are other hazards of concern. Burning of trees to clear land for livelihood activities, such as agriculture, creates risk of wildfire during times of drought (ECLAC, 2003). Drought also has implications for food security, agricultural land quality, as well as water supply (see sections 4.1 and 4.3). These types of hazards are less frequent than heavy rainfall hazards, but the risks are still real at times and must be considered by disaster managers.

Geological: St. Kitts is an island of volcanic origin, located in the Leeward Island chain. It is larger than its neighbour Nevis and has a land area of 168 km^2 (GFDRR, 2010). The highest peak in St. Kitts is Mt. Liamuiga, an active volcano, with a height of 1,155 m (GFDRR, 2010). The volcanic record for St. Kitts indicates a 2,000 year cycle of volcanic eruptions and continuing hot spring and fumaroles activity indicates that Mt. Liamuiga is still active at present (GFDRR, 2010).

> *Mt Liamuiga has been monitored continuously by a single short-period seismograph station at Bayfords Farm 8 km southeast of the crater since 1957. From the records of this station it has been established that the normal or background rate of occurrence of small earthquakes is about one per month. Since 1957 there have been two major earthquake swarms associated with Mt. Liamuiga and a number of minor ones* (Simpson and Shepherd, 2001).

Despite few recent eruptions and no reliable historic report of eruptions, Mt. Lamuiga is still active and thus an eruption is possible. Figure 4.7.2 shows that the north of the island, near Mt. Liamuiga is the most vulnerable to a possible explosive magmatic eruption. The delineation of vulnerability levels is a rough estimation of which parts of the island are most likely to experience impact from magma flows following an eruption (Simpson and Shepherd, 2001).

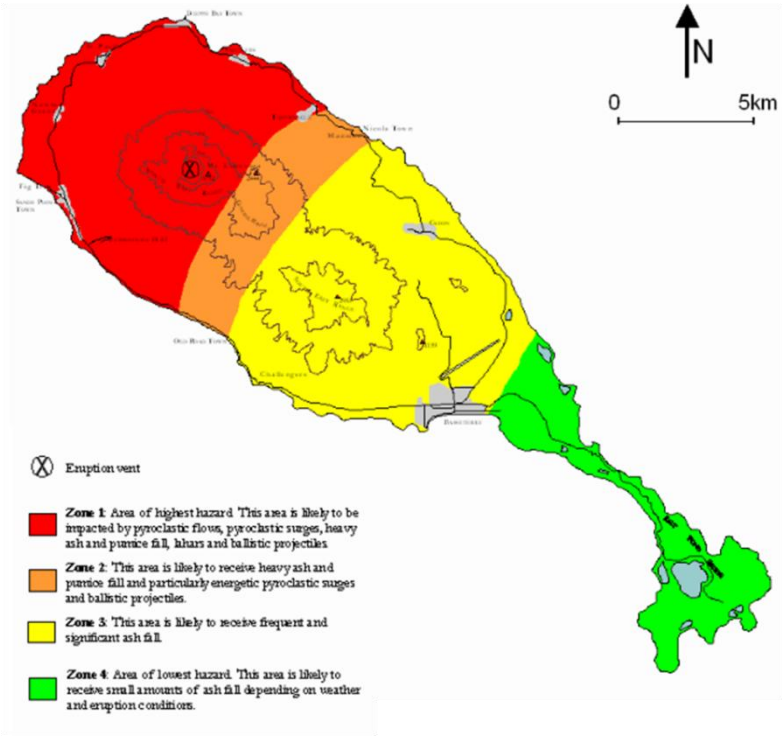


Figure 4.7.2: Preliminary Volcanic Hazard - Map for an Explosive Magmatic Eruption at Mt. Liamuiga

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

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

Madhavi Ariyabandu (UNECLAC, UNIFEM and UNDP, 2005)

4.8.1. Background

Overview of Livelihoods, Poverty, Gender and Development Issues in St. Kitts

The St. Kitts labour market exhibits some differences in trends of employment for males and females. Males generally dominate the construction sector, and during construction booms job opportunities are more readily available for men. Women are generally ill-favoured for work in this sector. On the other hand, the tourism sector, and especially the hotel sub-sector, employs significantly more females than males. The tourism sector is highly susceptible to negative economic and climate impacts which immediately suggest more severe implications for the women working in this sector. Additionally, the hotels and restaurants sector also employs a larger percentage of the poorest quintile than in any other quintile, attracting people from the lower end of the skills hierarchy. Overall, the poorest quintile relies heavily on services, construction, manufacturing and tourism (in that order) for employment (Kairi Consultants Ltd., 2009a). This dependency on volatile and vulnerable sectors such as tourism places the poorer segments of society at even greater risk following events such as hurricanes or the decline in tourism following external global crises.

CPA for St. Kitts published in 2009 (Kairi Consultants Ltd., 2009a) provides a comprehensive assessment of the level and distribution of poverty as it stood between 2007 and 2008. The CPA comprised of an Assessment of the Macro Social and Economic Environment; a combined NSLC and Household Budgetary Survey (HBS); a Participatory Poverty Assessment (PPA); and an Institutional Assessment (IA). According to the NSLC, the national poverty rate (St. Kitts and Nevis) stood at 21.8% at the time of the survey (2007/8). For St. Kitts specifically, 23.7% of the population was living below the poverty line, and 1.4% were considered extremely poor (indigence rate). The rate of vulnerability however was fairly high at the time of the survey, with nearly 40% of the population considered vulnerable to becoming poor in the event of an adverse natural or economic shock to the country (see Table 4.8.1).

Table 4.8.1: Poverty Indicators and Statistics for St. Kitts (Data for 2000 and 2007)

POVERTY INDICATORS	% Individuals (2000)	% Individuals (2007)	Difference	Annual Indicator Line (2007)
Indigence Rate (percentage of individuals below the indigence line)	11.0	1.4	- 9.6	EC $2,595 (~ USD $961)
Poverty Rate (percentage of individuals below poverty line)	30.5	23.7	- 6.8	EC $7,329 (~ USD $2,714)
Vulnerability (percentage of individuals below the vulnerability line but not below the poverty line)		37.8		EC $9,161 (~ USD $3,392)

(Source: Kairi Consultants Ltd., 2009a)

Specific trends in the conditions and characteristics of the nation's poor are highlighted by (Kairi Consultants Ltd., 2009a). In St. Kitts, the most poverty-stricken parishes include St. John – one of the more remote parishes, St. Mary and St. George – the latter in which the capital is located (see Figure 4.8.1). The poor population is comprised of more females than males (4,737 women compared to 4,338 men). Roughly one-third of the entire population is without educational certification. More acutely, almost half of the poorest population quintile (slightly more males than females) does not have any educational certification. Lack of certification has implications for viability in the job market, especially given current international job market standards, and will remain a barrier to the poorest citizens for escaping poverty. A greater percentage of women within the lowest socio-economic group are employed when compared to men. However, men have higher employment rates in higher socio-economic groupings. Other social and demographic characteristics of poverty in St. Kitts are outlined in Table 4.8.2 (Kairi Consultants Ltd., 2009a).

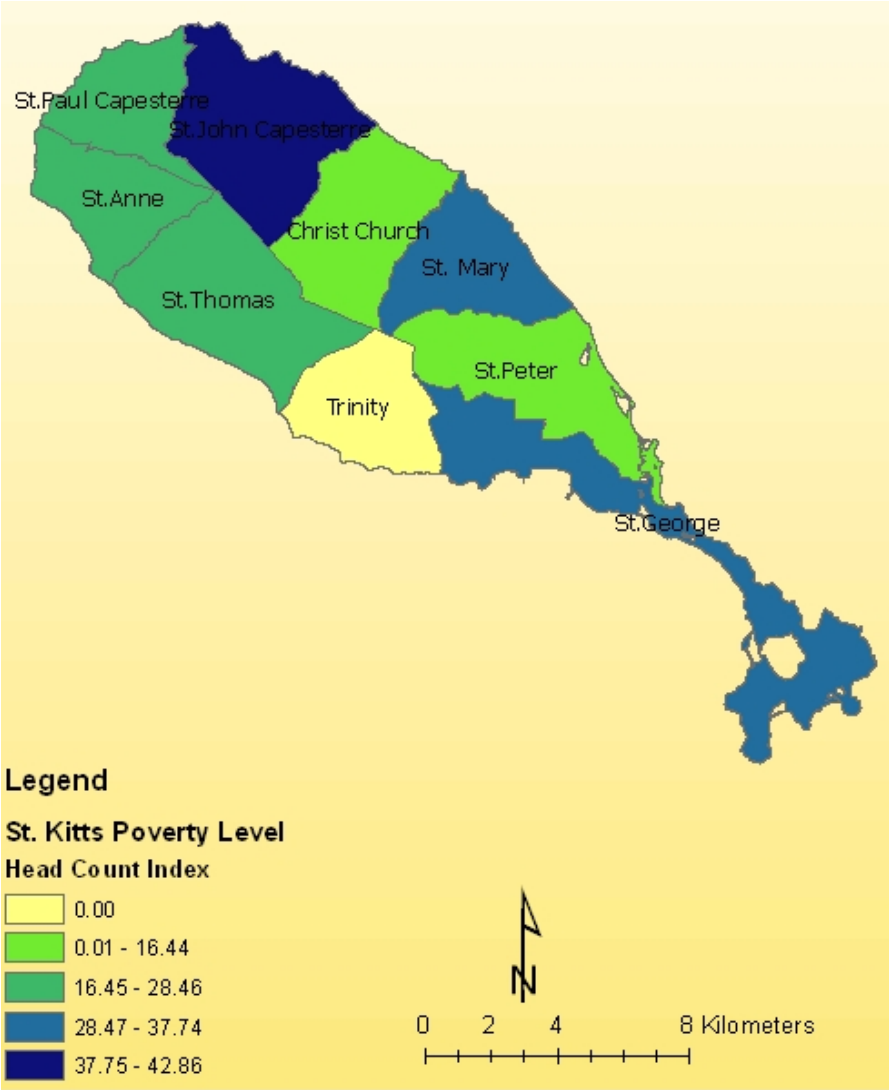


Figure 4.8.1: Distribution of Poverty in St. Kitts by Parish

(Source: Kairi Consultants Ltd., 2009a)

Table 4.8.2: Some of the Characteristics of the Poor within St. Kitts

VARIABLE	DESCRIPTION
Age Group	Nearly half (41%) of the poor population are under the age of 14 and approximately 67% of the poor are 24 years old or younger, highlight the severe disparity of poverty across age groups and the increased likelihood of being poor as a young person.
Employment	Approximately 81% of the poor population is engaged in some income making activity, although the earnings from these activities are insufficient to bring them above the poverty line. This is critical, as employment is the main strategy for escaping poverty. Those who are poor and not working also comprise majority of the unemployed population in St. Kitts. The unemployment rate of the poor population is also higher than that of the non-poor population, which is consistent with other Caribbean countries.
Gender	The percentage of women who live in poverty in St. Kitts is a little higher than that of poor men, corresponding to the gender ratio of the population. Women are also more likely to be indigent. However, although men have a slightly higher likelihood of being employed generally, women within the poorest socio-economic quintile have a higher employment rate than men, which is unlike the pattern observed in Nevis and other OECS territories.
Dwelling	Although persons living in poverty tend to have lower quality structures, concrete structures are the predominant dwelling type for both poor and non poor households. Slightly more than half of the poor population reside in concretes structures. Majority of the remaining poor live in houses made of wood or timber. Many poor residents do own the house in which they live (almost 60%) or pay rent (31.4%).

(Source: Kairi Consultants Ltd., 2009a)

According to the 2007 statistics, persons living in poverty and those vulnerable to falling below the poverty line collectively make up 60% of the population. This is a concerning reality when considering the economic vulnerability of the population. As highlighted previously, despite the existing levels of poverty, there has been an improvement in the living conditions of the poor in St. Kitts between the assessments conducted in 2000 and 2007 (see Table 4.8.1), owing to Government's focus on poverty alleviation and the provision of social services to help improve the lives of persons living in poverty (Kairi Consultants Ltd., 2009a). However, those who remain in poverty, in the wake of climate change, are at greater risk to falling deeper into economic depression. Likewise, other vulnerable groups, such as female single parents in large households, the expanding elderly population and the vast number of workers and families dependent on the agriculture, fisheries and tourism sectors – given previous experiences and existing disadvantages – should be primary concerns in consideration of any future natural or economic shocks to the nation. These vulnerable groups together comprise more than 60% of the island's population, and any future shocks will further disable these groups, and undermine the stability of the nation overall.

4.8.1. Vulnerability of Livelihoods, Gender, Poverty and Development to Climate Change

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. Already vulnerable groups include women, children and the nation's 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.

Poverty is an important factor in vulnerability, and climate change and poverty are inextricably linked, particularly as the poor are and will continue to be the most affected. The impacts of climate change undeniably aggravate the issue of poverty in all societies, and especially where poverty is extreme and widespread (Figure 4.8.2 highlights some of these impacts). The areas where impoverished persons reside are more often at greater risk when compared to areas inhabited by stronger economic groups, particularly remote rural and coastal areas which are disconnected from essential services and resources. The impacts and aftermath of extreme weather events (e.g. flooding, drought, loss of lands and crops) and SLR (e.g. coastal erosion, salt water intrusion) deteriorate an already dire situation and leave persons in poverty with even less resources to survive (Kettle *et al.*, n.d.). Conversely, climate change itself and the impacts it presents are also augmented by these same conditions of poverty, where the lack of access to resources and services almost dictates unsustainable environmental practices for survival (e.g. intense use of fossil fuels which promotes deforestation and contributes to GHG emissions, mismanagement of agricultural land and resources which encourages soil erosion, and decline in quality and output) (UNFPA, 2007; Kettle *et al.*, n.d.).

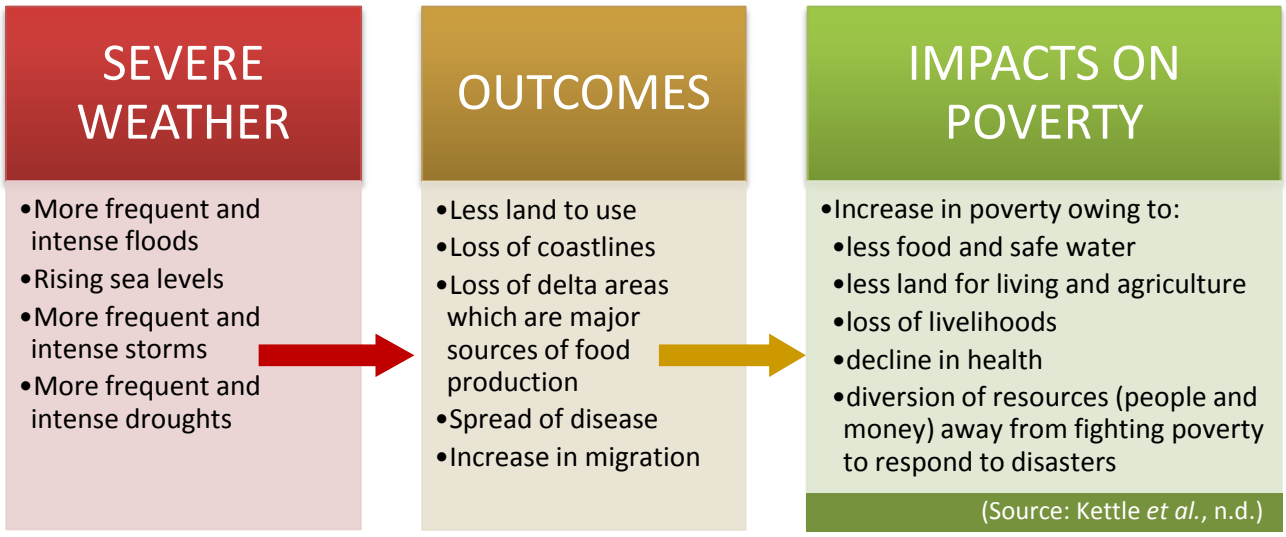


Figure 4.8.2: The Impacts of Climate Change on Poverty

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 (Global Gender and Climate Alliance, 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 predispose individuals to increased vulnerability. Women therefore, who tend to have less access to assets and resources will bear disproportionate impacts from climate change on their livelihoods and general well-being, exacerbating existing risks and revealing other hidden issues (GGCA, 2009). The potential effects of climate change impacts (both direct and indirect) on women are highlighted in Table 4.8.3.

Table 4.8.3: Direct and Indirect Risks of Climate Change and their Potential Effect on Women

CLIMATE CHANGE EFFECTS	POTENTIAL RISKS	EXAMPLES OF RISKS	POTENTIAL EFFECT ON WOMEN
DIRECT			
	Increased ocean temperatures	Rising incidence of coral bleaching due to thermal stress.	Loss of coral reefs can damage the tourism industry, a sector in which women comprise 46% of the workforce.
	Increased drought and water shortage	Morocco had 10 years of drought from 1984 to 2000; northern Kenya experienced four severe droughts between 1983 and 2001.	Women and girls in developing countries are often the primary collectors, users and managers of water. Decreases in water availability will jeopardise their families' livelihoods and increase their workloads, and may have secondary effects such as lower school enrolment figures for girls or less opportunity for women to engage in income-generating activities.
	Increased extreme weather events	Greater intensity and quantity of cyclones, hurricanes, floods and heat waves.	In a sample of 141 countries over the period 1981–2002, it was found that, natural disasters (and their subsequent impact), on average, kill more women than men or kill women at an earlier age than men.
INDIRECT			
	Increased epidemics	Climate variability played a critical role in malaria epidemics in the East African highlands and accounted for an estimated 70% of variation in recent cholera series in Bangladesh.	Women have less access to medical services than men, and their workloads increase when they have to spend more time caring for the sick. Poorer households affected by HIV/AIDS have fewer resources to adapt to climate change impacts. Adopting new strategies for crop production or mobilizing livestock is harder for female-headed and infected households.
	Loss of species	By 2050, climate change could result in species extinctions ranging from 18–35%.	Women often rely on crop diversity to accommodate climatic variability, but permanent temperature change will reduce agro-biodiversity and traditional medicine options, creating potential impacts on food security and health.
	Decreased crop production	In Africa, crop production is expected to decline 20–50% in response to extreme El Niño-like conditions.	Rural women in particular are responsible for half of the world's food production and produce between 60-80% of the food in most developing countries. In Africa, the share of women affected by climate-related crop changes could range from 48% in Burkina Faso to 73% in the Congo.

(Source: Global Gender and Climate Alliance, 2009)

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). Multiple variables contribute to the overall

vulnerability of women in the country. Amongst the poor in particular, many women are caregivers and carry the economic burden of households, which is often meagrely supported by jobs with a low income and based in the informal sector. These factors place them, and those that they are responsible for, at greater risk to natural events than men (Buvinic *et al.*, 1999; Kairi Consultants Ltd., 2009a).

Outlined in section 3 are the likely changes to occur for given climate and ocean variables for St. Kitts and Nevis over the next few decades. Based on the assessment of outputs produced by both Regional and Global Climate Models, it is projected (to varying degrees) that the mean annual temperature and the number of 'hot' days and nights will increase, as well as the likelihood of more intense cyclones as a result of warmer sea surface temperatures – although the latter is less conclusive. Future rainfall trends are also less conclusive because, depending on the model; projections include both increases and decreases in total annual rainfall. However, most models indicate in a decline in rainfall, and the number of 'cold' days and nights will be nominal by the 2080s. Gradual SLR has been observed over previous years and therefore is expected to continue, but uncertainty remains with the actual rates of increase.

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. Likely outcomes in climate based on these projections include hotter, drier conditions and variable rainfall with implications for drought-like conditions and variations in agricultural outputs. Simpson *et al*. (2010) indicated that some of St. Kitts and Nevis' key climate change vulnerabilities as a volcanic island with mountainous topography and a narrow coastal zone include localised flooding and landslides from storms, and coastal erosion from SLR and storms. SLR poses a major threat to coastal tourism infrastructure. A 2m SLR scenario will affect at least 18 (86%) major tourism resorts (based on the report) in the twin island federation. The fisheries sector, which is a critical component of the local economy, is also at risk from SLR and storm surge impacts on physical infrastructure.

In light of these changes in climate, the risks to vulnerable social and livelihood groups increase. Hurricanes in particular are of great concern. Hurricanes are the most destructive climate events to affect the region, and with the likelihood of stronger events, their impact will be more widespread and severe. Hurricane Omar is one of the more recent systems to affect St. Kitts and Nevis. In October 2008, the passage of Hurricane Omar (Category 3 at the time) resulted in damage to power transmission lines and minor damage to houses. Inter-island transport infrastructure was severely impacted, with 2 passenger vessels suffering serious damage. The western coastline and Frigate Bay, where major tourism infrastructure is located, experienced severe beach erosion (CDERA, 2008).

Other inferences can be made based on the projections outputted by both the RCM and GCM. What is certain is that current climate trends will change in one way or another, and will therefore affect those industries and activities that are climate-sensitive and strongly dependent on natural resources. Undoubtedly, a number of vulnerable sectors and subsectors are important to the subsistence of especially poorer households. However, gradual weather changes, SLR and the potential for increasing intensity (and possibly frequency which, although inconclusive, should remain a priority concern and be treated as such) of extreme weather events will have substantial effects on livelihood assets and activities in St. Kitts – with implications for sector contributions to GDP, employment, existing poverty levels and other facets of economic and social development (Alcamo *et al.,* 2007; Willbanks *et al.*, 2007).

4.8.2. Case Study: The Old Road Town

The Old Road Town 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. Kitts and Nevis.

The Old Road Town is located on the western side of the island in the parish of St. Thomas. St. Thomas itself has a population of approximately 2,395 persons, which represents roughly 6% of the total population (Kairi Consultants Ltd., 2009b; SugarCity, 2011). Tourism and fishing are the main industries in St. Thomas. Several tourism attractions and points of interests located in this parish, and a fisheries complex was recently established in the area, providing a base for local fishermen and housing Government officials working with the fisheries sector (SugarCity, 2011). St. Thomas has a moderate level of poverty by parish when compared to other parishes, as just over one-quarter of the persons living in St. Thomas are poor.

The CARIBSAVE *Community Vulnerability and Adaptive Capacity Assessment* methodology employed participatory tools to determine the context of this community's exposure to hazards, and a sustainable livelihoods framework to assess its 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.

Natural Resources and Community Livelihoods

Community residents are involved in a number of livelihood activities. The main sources of income include tourism, cottage industries, light manufacturing, agriculture (both farming and fishing), vending and craft making. These persons are either self-employed or employed by another person or entity. Some of the local tourism enterprises include Spratnet (a family-owned and operated restaurant), where employees engage in fishing and fish processing; Sky Safari (a zip line activity); rainforest tours; ATV tours and cultural/heritage tours (e.g. Caribelle Batik on Romney Manor Estate – one of the main employers in St. Thomas, and almost all of the customers are tourists). Some residents are also employed by the public sector and work in the community at satellite government offices including the post office, community centre and police station. Based on these income sources, it is evident that residents depend on various natural resources, which include the marine life (for fisheries), forest and mountain environments (for zip line, ATV and rainforest tours).

Community Knowledge of Climate Change and Observed Changes to the Natural Environment

Community knowledge of climate change varies among residents. Most residents consider their level of knowledge to be average and below average, and women in particular are not very confident about their level of knowledge when compared to men. Perceptions of risk also vary, as some community residents differ in opinion on the level of threat or impact that climate change will have on their lives. Despite this, residents have observed noticeable changes in weather patterns, and to the state of the natural environment, within recent times and have expressed their perspectives on the causes as they relate to climate change, the current and potential future impacts, and the likely consequences. Many of the observations outlined below were found to be consistent with the projected changes in climate published by the IPCC and other leading authors on climate change.

A rise in temperature is one of the most apparent changes observed by the community. Days are reported to be much hotter than before. Residents are also aware of the relationship between temperatures and extreme weather events, and anticipate that hurricane activity will increase. Hurricanes are very destructive systems and as such, community residents remain very concerned about the possibility of their increasing intensity. Some residents have also suggested that there is a possible linkage between the increasing temperatures, and the occurrence of earthquakes. Conversely, a reduction in rainfall has also been observed, with the expectation by residents that the year 2011 would see insufficient rainfall for those whose livelihoods depend on it (e.g. farmers). A rise in sea level has also been observed, and is associated in part to the erosion that has taken place on the coastal border of Old Road. The community is aware that one of the main causes of SLR is the continuous and rapid rate at which polar ice caps are melting.

Negative human actions were expressed to be the main cause of climate change, primarily the "deterioration of the Ozone Layer with Ozone Depleting Substances", and pollution of the natural environment by various means. Misconceptions about the linkages between ozone layer depletion and climate change suggest that climate change awareness needs to be enhanced. In any event, these activities also lead to the deterioration of the natural environment on a whole – with severe consequences such as reducing an ecosystem's or community's resilience. There has been a decline in biodiversity (most obvious in the marine environment) and the health of coral reef systems, resulting from higher sea temperatures, marine pollution and resource over-extraction. As a result, the fisheries industry has felt the repercussions through reductions in catches and fishermen having to travel further out to sea in order to fish. Farmers have also suffered from the higher temperatures and lack of rainfall. Other issues of concern include the destruction of terrestrial habitat for physical development and the creation of some tourism facilities, improper use and maintenance of natural and man-made drainage systems owing to littering and sedimentation, and in some cases improper development. In relation to the destruction of terrestrial biodiversity, monkeys have been raised as a significant issue in St. Kitts. They have become more invasive because of the loss of their regular habitat, which has driven them to encroach on human settlement and activities. As a result, farmers' crops and produce are under threat, and residents are reportedly harassed by monkeys.

The community believes that specific vulnerabilities of the population in general have mostly been self-imposed by way of environmental degradation and unsustainable practices, and have compromised the population's ability to adapt to climate change and effectively manage disasters. Despite this, the community concedes that all citizens have some degree of responsibility for building their resilience and taking measures to reduce their vulnerability to climate change by being environmentally conscious and well-prepared to deal with extreme weather events.

Impacts of Weather and Climate on Community Livelihoods and Development

Some of the main weather conditions experienced by the community, and hazards which affect the community include:

1. hurricanes and storms;
2. heavy rains which subsequently cause or contribute to inland flooding, land erosion and land/mudslides; and
3. storm surge events associated with tropical storms which may result in severe beach erosion and coastal flooding.

The projected increase in hurricane intensity will undoubtedly have serious implications for life, livelihoods and property should St. Kitts be impacted in the future by stronger systems. Hurricane tracks are sporadic, and it cannot be determined exactly when or how often future impacts will occur.

Flooding has had major impacts on property, livelihoods and access on previous occasions, particularly as there is a single major roadway around the island which is parallel to the coastline (and very close at some points). Heavy rains and subsequent flooding of this roadway has severely affected vehicle and pedestrian access. As a result, persons were unable to travel to work and back. Residents working in government or employed by the private sector may have suffered minimal (if any) economic impacts. However, taxi and tour operators, farmers and vendors from the community who need to travel to other parts of the island to ply their trade lose customers and business each day that that the road is inaccessible. This loss of revenue affects them and the households that depend on this income, and longer periods of flooding translate to more severe losses.

In response to flooding, some drainage work has been done to divert water flows away from properties. But land erosion has reportedly worsened after the cessation of sugar cultivation, because many sugar cane fields have been cleared for physical development.

Various weather-related events present different opportunities or challenges for livelihoods within the community.

- In the case of tourism, rain generally halts most outdoor activities, but may also encourage more indoor tourism activities. Rainfall will likely offset activities that depend on sunshine and thereby affect the level of success of tour organisers, guides and other tour-related personnel.
- Fishermen are significantly affected by high winds and high sea swells (even without rain), and are usually unable to fish as a result. Given the projected increase in temperatures and sunshine hours, outdoor tourism activities may not suffer significantly in this respect, but if the climate becomes too uncomfortable as a result, tourists may also be discouraged from visiting.
- The agriculture sector will be seriously impacted by increasing temperatures over time, reduced rainfall and the increasing incidence of soil erosion and landslides with sudden and intense rainfall events. This is not only a concern for farmers and their families, but for the entire population as well, because food production and food security is threatened in light of these impacts. St. Kitts does not produce 100% of their food requirements, and therefore depend on imports. This dependence will deepen if crop production declines and the livelihoods of farmers and vendors of produce will be at risk.

Some community residents however, have knowingly placed themselves at risk. There are reported situations where persons who were relocated by government from a hazardous area, eventually moved back there, or even rented out the at-risk properties to other locals. Community members have resolved that it remains, in part, their responsibility to do as much as they can to reduce the impacts of climate changes on their lives.

Gender Roles in Community Development

At the community level of government, a Member of Parliament is the locally-based resident who is elected to represent the St. Christopher #4 constituency (which includes the Old Road community). The MP is elected based on his/her perceived ability to represent the views and interests of majority (if not all) of the electorate within his/her respective constituency, and is trusted with ensuring and advancing the overall development of communities within the constituency (Unison Global Corporation, 2009). Currently, the parliamentary representative is male, but there are no legal restrictions on women in assuming these roles.

Government units with responsibility for various social and physical development and improvement works also play their own respective roles in community development, under the direction of the overseeing Minister. In Old Road, there are small-scale non-government or community-based groups, comprised of both men and women, which promote community interaction and development. The community asserts that community-focused or bottom-up planning will lend itself to greater involvement and consideration of community ideas. Top-down planning tends to result in less community involvement and consideration. In light of this, community residents are normally invited to be involved and participate in decision making activities (through meetings, community walk-through exercises, etc.), but the community is not confident that their ideas are being taken on board or implemented.

There are no prevalent or outstanding issues of gender inequality within the community. However, some specific social and economic roles are dominated by either men or women. Women in the community have more family and caretaking roles and responsibilities. Women tend to be more observant of issues, participate more in meetings and forums, and speak out on specific issues more than men. Conversely, men are more visible in politics, and dominate some areas of employment, including fishing and construction. Some men also play active roles in community leadership. However, it is perceived that more men need to participate in community forums and activities, and to speak out on issues that directly affect them.

Gender Roles in Disaster Management

With regards to disaster management, the community, and St. Kitts in general; is considered to be a very reactive society, and major issues are only made a priority *after* experiencing severe negative impacts. The NEMA is the government body responsible for national disaster management efforts. However, community perceptions are that NEMA can be slow or inefficient in response to some events. Additionally, there is a National Disaster Management Plan but it is not widely known within the community. NEMA intends to make residents aware of the Plan's existence, the strategies incorporated, and to put the plan into action.

In the wake of a disaster, existing hardships for community residents are accentuated, which forces the community to unite in an effort to overcome. For instance, there is one community member who owns heavy-duty equipment and often lends assistance with recovery efforts after severe flooding events. As with other communities, roles in disaster management (specifically preparation, response and recovery) are assumed by men, women or both, insofar as community experiences with hurricanes are concerned. However, men are usually looked upon more to take charge of more physically demanding preparation, response and recovery activities (e.g. securing physical assets, post-event repairs, search and rescue activities). Women mainly take the lead on more domestic activities, such as ensuring food and water supplies are adequate. In households headed by women, all preparation activities may fall upon them if they are unable to get assistance from men outside of the household. There are implications of greater vulnerability and exposure to hazards for women who are unable to manage all of these tasks unassisted. The same situation exists for men as well, but there are is a greater proportion of single female-headed households in this community compared to men in similar circumstances.

Important components of disaster management - communication, information sharing and early warning systems are considered ineffective by some community members. These members feel that there is a lack of communication within the community, and between the community and higher levels, which prevent progress in exploring and implementing solutions – not only in relation to disaster management, but overall community development. Other residents suggest that although there is a lot of public awareness activity, especially in relation to disaster preparation, sometimes the media used are not the most practical for the audience being targeted. It was recommended that residents need to be given information and "shocking, thought-provoking" messages consistently, and in a language that they can understand in order for them to

assimilate these messages to take requisite action. A multi-faceted approach for public awareness is needed to reach all target groups. Reportedly, there is no formal multi-hazard warning or advisory service within the community. Persons from the community may call local radio station personnel to make them aware of the situations and to broadcast important information. Radio programmes, panel discussions and call-in programmes have been effective communication media in the past on weather and climate event information. Mobile telecommunication technology has also started to play a very important role in information relay in the community.

5. ADAPTIVE CAPACITY PROFILE FOR ST. KITTS

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 Watercourses and Waterworks Act 1949 is the main legislation that governs control, management of water resources and watershed conservation. However it is out-dated, for instance the Watercourses and Waterworks Ordinance Cap 1956 does not make reference to or provisions for groundwater resources (Ocean Earth Technologies Consortium, 2009). Another piece of legislation with some focus on water resources is the National Conservation and Environmental Act 1987. It also subsumed the responsibility for forestry as it allowed for the repeal of the Forestry Act. As a consequence, measures to ensure healthy forests and their conservation are included in this act which also serves a secondary function of water protection. While groundwater is addressed in the legislation it is only indirectly in the document where it makes reference to protecting and maintaining areas - with special mention of ghauts - important in water recharge rather than through direct references to groundwater systems (MSD, 2007). However, it does allow for the designation of lands important water recharge as protected areas. The act is in the process of revision (Ocean Earth Technologies Consortium, 2009). A new Water Resources Management Act is being drafted and is expected to be completed at this end of this year (2011).

The Solid Waste Management Act 1996 and the newer Solid Waste Management Bill address sewage disposal which was not covered in the Water courses and Waterworks Act (MSD, 2007) and prohibits solid waste disposal in any water catchment area without a solid waste management license except for household that dispose of solid waste on their private property (Ocean Earth Technologies Consortium, 2009). The Development Control and Planning Act 2000 which contains planning and infrastructure guidelines and standards and land use code regulations. It also dictates that measures for the prevention of erosion, landslides and flooding are to be undertaken in Environmental Protection Areas (Ocean Earth Technologies Consortium, 2009).

The National Environment Action Plan, similar to the National Conservation and Environmental Act 1987, has a responsibility of Forestry. Objective # 3 of the St. Kitts Agricultural Strategic Plan 2005 – 2009 is “to develop surface water sources for agricultural development” while on the other hand groundwater resources have been designation for domestic use. Such a move was rationalised based on the fact that land at higher elevations is more productive for agricultural production than that in low-lying areas and access to water in hill sides is more feasible for farmers (Government of St. Kitts and Nevis, 2004). Finally as mentioned, there is no Forestry Act but forestry management is covered in National Environment Action Plan and the National Physical Development Plan. Finally other legislation of relevance include the Public Health Act of 1969 which ensures environmental health standards are maintained, the Pesticides Act of 1973 and the Litter Act of 1989 which prohibit practices that can encourage pollution of water courses.

5.1.2. Management

St. Kitts WSD is the main body responsible for managing water resources in St. Kitts. With the motto ‘Water Is Life – Every Drop Counts’, the responsibilities of these departments includes identification, management, treatment and protection of surface and groundwater resources and maintenance and construction of water infrastructure in St. Kitts (Gardner, 2006). It also executes all policy objects of the government, implements water conservation programmes particularly during drought conditions and public education and awareness of water resources.

The WSD has over 100 staff members. The responsibilities of the department range from "managing water systems, constructing and maintaining service reservoirs, pumping stations and distribution pipelines as well promotion of water conservation. Our primary goal is to provide a safe and reliable water supply to the people of St. Kitts" (Dr Sahely, personal communication, April, 12, 2011). While the staff turnover rate is low, due to financial constraints, the WSD has not been able to replace staff members that have retired. Well-trained human resource capital will be necessary to effectively address the various issues that the WSD faces which include "conflicting demands for water from various sectors and climate change, specialised, well-trained human resource capital will be necessary" (Dr Sahely, personal communication, July, 06, 2011).

A number of other agencies also have a role in the management of water resources in St. Kitts and Nevis. The Environmental Health Department/Public Health Department is also responsible for monitoring water quality for domestic and related uses (e.g. bacteriological analysis). The Department of Agriculture, through the protection of forests and therefore catchment areas, also protects water resources in the islands. The Department of Physical Planning and the Public Works Department regulate land use practices. Finally the St. Kitts and Nevis Solid Waste Management Corporation is responsible for waste water management (MHE, 2001). The Department of Physical Planning and the Environment which is based in St. Kitts is the lead agency for environment and protected areas management and because of the overlap with water resource protection, it is also the main agency responsible for watershed management in the country (Gardner, 2006).

As Dr Sahely of the St. Kitts Water Department summaries, "there is no centralized wastewater collection and treatment in St. Kitts with the exception of a few package treatment plants and one larger conventional activated sludge plant at the St. Kitts Marriott Resort. Onsite wastewater treatment and disposal is widely practiced with septic tanks and soak away systems being the most prevalent" (Dr Sahely, personal communication, April, 12, 2011). As with expected increases in water demand by consumers, wastewater management will also introduce new challenges for the WSD. In February 2011, the Global Environment Facility - Integrated Water and Coastal Area Management Project hosted a 5 day workshop with a wastewater theme. The workshop informed stakeholders on best practices related to the design, construction, inspection, maintenance and operation of onsite wastewater treatment technologies (Dr Sahely, personal communication, April, 12, 2011).

Demand for water is expected to increase as the economy of St. Kitts and Nevis expands, particularly in the tourism and agriculture sectors where water requirements could double in the next 10 years. To exploit groundwater resources that have not been utilised, will require substantial capital investments, as there are accessibility constraints to these aquifers. A Public-Private Partnership between the Government of St. Kitts Nevis and the Bedrock Exploration Development Technologies (BEAD) was established with the aim of developing groundwater resources through deep well drilling. As Dr Sahely explained "BEAD will cover all upfront costs for the exploration, drilling and outfitting of wells. BEAD will provide water to the nearest water distribution system. The Government of St. Kitts will pay for each unit of water delivered for a period of 10 years after which the well will become the property of the Government of St. Kitts-Nevis. Drilling is expected to begin in the third quarter of 2011" (Dr Sahely, personal communication, April, 12, 2011). Desalination has not been considered because of the greater cost involved, it is estimated that it is 10 times more expensive to produce desalinated water than it would be to abstract groundwater (MSD, 2007).

There have been efforts to improve the water quality that the WSD distributes through pollution mitigation measures. In 2007, residents and other water users such as tourists to the island of St. Kitts, benefited from a water chlorination project that sought to expand the chlorination programme, which reached 70% island coverage and representing a fourfold increase in the disinfection coverage at the time. This project was

funded by the Spanish Agency for International Cooperation (Dr Sahely, personal communication, April, 12, 2011).

St. Kitts and Nevis is part of the Global Environment Facility funded Integrating Watershed and Coastal Areas Management in Caribbean SIDS project. Through this project work in critical aquifer and well-field management and protection have been undertaken in a demonstration project. This involves the mitigation of threats from contaminants, on-the-ground protection and improvements in the management of water consumption by all stakeholders (Dr Sahely, personal communication, April, 12, 2011).

The establishment of the 530 acre Basseterre Valley Aquifer National Park was undertaken as a water resource management initiative (Gardner, 2006). This was in keeping with policy goal of aquifer protection outline in the Medium Term Economic Strategy 2005 – 2007. However the Water Resources Management Plan 2009 the follow summary is made: "In general, well-field protection remains a serious challenge due to constraints on resources needed for comprehensive monitoring and effective planning. Moreover, insufficient legislative mechanisms greatly limit implementation of these policies in relation to the two major issues affecting the Basseterre Valley aquifer: wastewater management and urban encroachment into the aquifer lands that were historically under sugar cane" (Ocean Earth Technologies Consortium, 2009).

The Government of St. Kitts and Nevis has made a number of commitments at the regional level to reduce poverty of which access to water is a determinant. One of these commitments makes direct reference to water resources and as stated in the CPA for St. Kitts and Nevis it involves "the mobilisation, among CARICOM Member States, of professional skills and the development of institutional capacity for more efficient management of water resources with a view to ensuring safe water to poor communities, efficient utilisation of water in the agricultural sector, and minimisation of pollution of water resources, reduction of water based sources of pollution to coastal areas, and enhancing public awareness of watershed management, waste water management and waste management" (Kairi Consultants Limited, 2009a).

5.1.3. Technology

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

The WSD is severely limited by inadequate data collection and storage. The demand for water resources is expected to increase and to meet these water demands increased infrastructure will be required. The current capacity has to be expanded by investments in pipelines and reservoirs. Future water expectations are also being balanced by ensuring water conservation management approaches are adopted, as the WSD also has on its agenda water loss prevention (Dr Sahely, personal communication, April, 12, 2011).

The WSD has not considered utilising desalination plants; one of the main reasons behind this is the cost of energy which is required to operate such plants. In the future, a rise in energy costs may continue to make the desalination choice less favoured to alternative water resource options (Dr Sahely, personal communication, April, 12, 2011).

Current water resources are not considered sufficient to cope with increases in demand. As such, the WSD began a process of public and private partnership to explore the best way to develop groundwater

infrastructure on the island through the means of deep well drilling technology (Dr Sahely, personal communication, April, 12, 2011).

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). In St. Kitts and Nevis, the National Energy Plan does have a section that speaks to the tourism sector, focussing on energy efficiency through technology and renewable alternatives, recycling, capacity building and a potential levy for high energy uses (MOPWUEH, 2011c). This document has shown that tourism's share of energy use and emissions in St. Kitts and Nevis is considerable, and likely to grow in the future, leading to growing vulnerabilities in a BAU scenario. At the same time, the sector holds great potential for energy reductions and should thus be one of the focus points of policy considerations to de-carbonise island economies.

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 in section 4.2.2, emissions of GHG essentially represent a market failure where there is little incentive to innovate (OECD, 2010). 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 and as suggested for high energy tourism, uses in the National Energy Plan (MOPWUEH, 2011c). In St. Kitts electricity prices have historically been kept artificially low through a government subsidy scheme. Since 2005, the fuel surcharge was removed for residential electricity clients (MOPWUEH, 2011a). Taxation is generally more acceptable if taxes are earmarked for a specific use, which in this case could include incentives for the greening of tourism businesses. Tax burdens would then be cost-neutral for tourism, but 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 bed night spent in hotels, resorts, guesthouses and yachts, which accounts for 60% of government revenue (McAller *et al*., 2005).

Money collected in various ways could be re-invested in sustainable energy development. Haraksingh (2001) 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, which is captured in the National Energy Policy (MOPWUEH, 2011b). However, government ambitions to reduce electricity prices in St. Kitts and Nevis could counteract efforts at energy efficiency, since lower costs encourages greater use.

The vision of the Federation of St. Kitts and Nevis is "to become an island nation with a sustainable energy sector where reliable, renewable, clean and affordable energy services are provided to all its citizens" (MOPWUEH, 2011b). Although the current Policy and Plan do not specifically refer to the sustainability of the sector under climate change, it does make it clear that the aim is to develop sustainable energy solutions.

5.2.2. Management

Any action on reducing energy use and emissions of GHG has to begin with a review of emission intensities, to ensure that action taken will lead to significant reductions. From a systems perspective, hundreds of minor actions will not yield anywhere near as much as one change in the major energy consuming sub-sectors. Aviation is thus, as outlined earlier, a key sector to focus on, followed by - in smaller to medium-sized islands - hotels, as these are comparably energy-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 island or not.

Tourism management is primarily concerned with revenue management, as the ultimate goal of any economic sector is to generate profits and jobs. A general critique of tourism management in this regard must be that it is too occupied with revenue, rather than profits as well as multiplier effects in the economy. This is an important distinction because profits have been declining in many tourism sub-sectors, such as aviation, where revenues have been increasing through continuously growing tourist volumes, while profits have stagnated. This is equally relevant for average length of stay, which is falling worldwide: to maintain bed-night numbers, destinations have consequently had to permanently increase tourist numbers. Both trends need to be reversed.

In an attempt to look at both profits and emissions of GHG, a number of concepts have been developed. One of the most important overall objectives can be defined as 'reduce the average energy use/emissions per tourist'. In the case of St. Kitts and Nevis, average emissions per tourist are already comparably low (i.e. corresponding to emissions of 675 kg CO_2 per tourist for air travel) (Table 4.2.3). Table 5.2.1 illustrates the situation for a number of other islands in terms of weighted average emissions per tourist (air travel only), as well as emissions per tourist for the main market. The table can serve as a benchmark for inter-island comparison.

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

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

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

Table 5.2.2: Arrivals to Emissions Ratios

	Anguilla	Bonaire	Jamaica	Saint Lucia
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 islands due to the lack of data on tourist expenditure by country and tourist type (e.g. families, singles, wealthy-healthy-older-people,

visiting friends and relatives, etc.), but Figure 5.2.1 illustrates this for the case of Amsterdam/Netherlands (Gössling *et al*., 2005). By assigning eco-efficiencies, it is possible to identify the markets that generate a high yield for the destination, while only causing marginal emissions. For instance, in the case of Amsterdam, a German tourist causes emissions of 0.16 kg CO_2 per € of revenue, while a visitor from Australia would emit 3.18 kg CO_2 to create the same revenue.

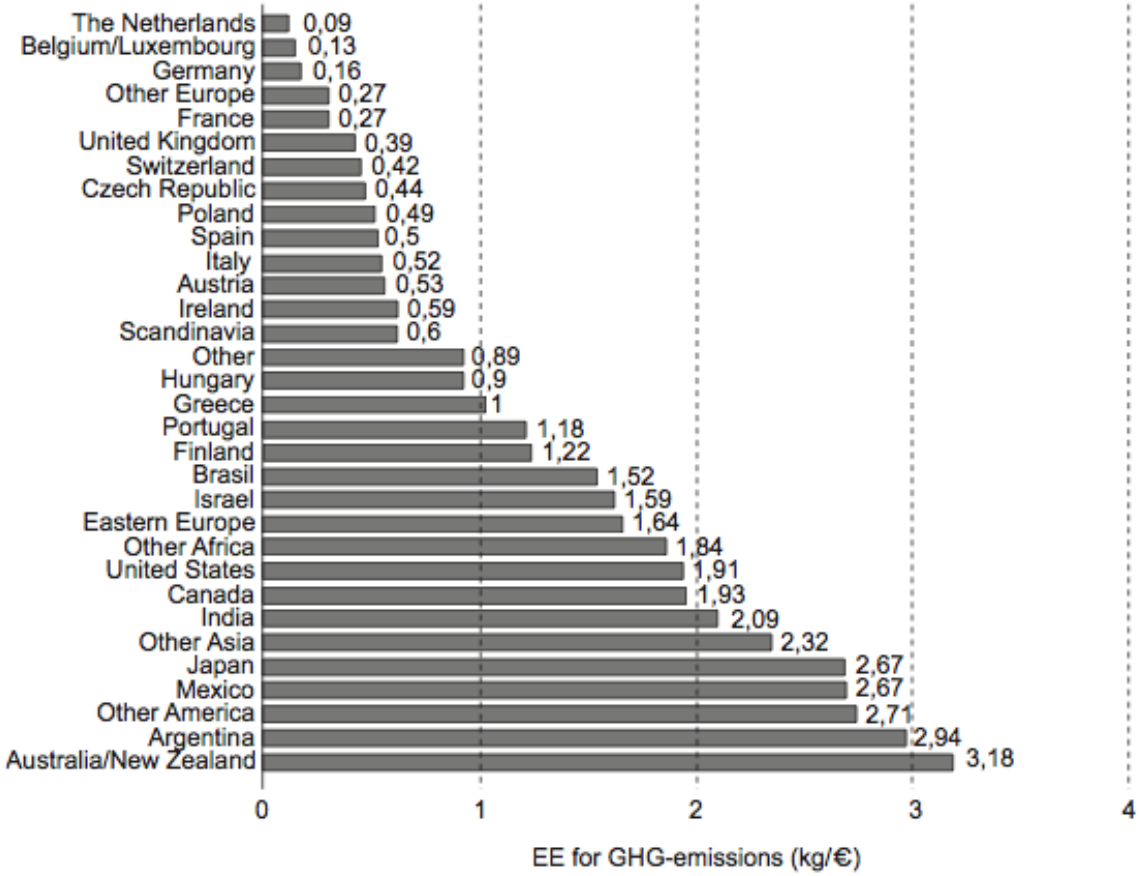


Figure 5.2.1: Eco-efficiencies of Different Source Markets, Amsterdam

(Source: Gössling *et al*., 2005)

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

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

in hotels, tourists also support resource savings: 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).

Options for reducing the vulnerability of the existing energy sector include running cables underground and de-centralising power generation and/or storage. While running power cables underground is more expensive, the greater transmission capacity and reduced losses associated with advanced conductor materials renders them more attractive for underground burial, which would reduce their vulnerability to human and weather-related disturbances(U.S. Department of Energy/National Energy Technology Laboratory, 2007). Distributed generators offer the benefit of being able to operate independently of the greater transmission and distribution infrastructure. Provided a constant supply of fuel, they are able to provide continuous power to critical end uses or, in some cases, into smaller regional grid networks in the event of a power outage. Power storage devices offer the same benefit with no emissions, but on a more limited time frame(U.S. Department of Energy/National Energy Technology Laboratory, 2007).

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 and Six Senses Spa, Thailand, reports payback times of between 6 months and 10 years for measures saving hundreds of thousands of Euros per year. Examples of the economics of resource-savings from the Caribbean include 5 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 Barbados Dollars (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 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 on going in the Caribbean on how to use the CDM in restructuring the energy system (e.g. MEM, 2009). 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. While the CDM is thus an instrument to achieve technological innovation, it is not an instrument to achieve carbon neutral status. There is also uncertainty regarding the future of the CDM, as a post-Kyoto climate agreement has not been signed. According to the Draft Energy Digest no National Designated Authority is in place as the capacities to participate in CDM with a NDA do not exist and it is difficult to come up with the necessary resources to capacitate such an entity to function properly. Staff salary and resources will be needed to make CDM participation possible. It is also noted that participation in the CDM would be beneficial given the wind and geothermal projects coming online that would benefit from such a support mechanism (MOPWUEH, 2011a).

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

- Policy, including regulation, taxation and incentives, is important to increase pressure on stakeholders to engage with energy management – this is an area that is generally seen as less relevant and efforts to engage significant stakeholder numbers will demand strong policy environments. The existing draft National Energy Policy should therefore be finalised and implemented as a priority.
- Vast options exist to reduce energy demand through carbon management. In particular, this includes a rethinking of markets based on their eco-efficiency, which can potentially lead to increasing turnover and declining energy costs, while also bringing greater attention to the diversification of markets. Carbon management also means to address average length of stay, and measures to stimulate spending: evidence indicates that there is considerable scope to increase both. Maintaining bed night numbers without addressing losses in average length of stay does

otherwise, meaning to be stuck in 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.

5.3. *Agriculture and Food Security*

5.3.1. Policy

The Agriculture and Fisheries Policy developed by the Minister of Agriculture, Co-operatives, Fisheries, Lands and Housing in February 2001, places emphasis on agricultural production and marketing, promotion of farmers development, agricultural diversification and transition, land allocation and distribution, and fisheries management and development.

A number of policy related issues are currently challenging adaptive capacity for agriculture and food security in St. Kitts and Nevis. One issue relates to the lack of freehold title for most farms. Since the Government is the main landowner, most farmers do not own their own properties and farmers cannot use land rental/lease certificates as collateral for credit. FAO (2006) suggests that this is one of the reasons why local farmers do not appear inclined to undertake long-term investment in land improvement which is critically needed for climate change adaptation.

Another policy issue involves land distribution to the various economic sectors. There are currently several competing economic interests for limited land especially in St. Kitts. Farmers are not sure about the priority being given to land for agricultural activity. This has limited agricultural development especially for farmers who want to expand their operations.

Policy research in agriculture for St. Kitts and Nevis (Naraine, 2005) showed that agricultural diversification at the national level is driven by diversification at the individual farm level. The implication here is that in terms of climate change adaptation the same principles may apply. Farmers will respond to the impacts of varying climate even if policy initiatives do not exactly address their needs. The Government of St. Kitts and Nevis' Adaptation Strategy in Response to The New EU Sugar Regime 2006 – 2013 outlines a clear action plan to address agricultural diversification, food safety, security and nutrition. This framework is intended to strengthen policy and planning activities in the agriculture sector, expand public and private sector linkages, and improve coordination and implementation. However, there needs to be an actual policy on climate change mitigation and adaptation for agriculture which would focus on prioritizing and addressing the problems caused by climate change impacts as identified by local farmers.

5.3.2. Technology

Research on information needs of stakeholders in the agricultural and rural sector of St. Kitts and Nevis (AGRICO, 2005) showed that there were specific knowledge gaps in agricultural technology. For instance, agro-processors lacked technical capacity to make value-added products from local fruits and medicinal plants. Farmers also asked for support in the areas of integrated pest management, post-harvest technology, grading systems, greenhouse technologies, hydroponics, and water resource management.

The Government of St. Kitts and Nevis has had the benefit of collaboration between the Department of Agriculture and the Republic of China (Taiwanese) Agricultural Mission to aid in building national capacity. The Taiwanese Mission conducts research on various food crops and exposes local farmers to the current technologies and the emerging tools in agriculture. The Agro-Processing Unit and the two demonstration farms in St. Kitts, as well as the demonstration farm in Cades Bay, Nevis, are designed to conduct research and training to meet the needs of the local agricultural industry. Support is provided in the areas of cultivation, propagation, farm management, organic composting and post-harvest handling.

5.3.3. Farmers' Adaptation - Initiatives and Actions

Preliminary consultation with representatives from farmers' organisations represented at the CARIBSAVE National Stakeholder Workshop held in St. Kitts on 16th June 2011 indicates a level of awareness about the importance of the use of agricultural innovation to mitigate against climate change impacts. Small farmers have already begun to explore options in hydro-organoponics, greenhouse technologies and water harvesting.

5.3.4. Summary

Agricultural diversification is the main development policy being used to improve rural livelihoods and food security in St. Kitts and Nevis. The high level of public debt, the high cost of imported food to meet local needs, the global financial crisis, and weak inter-sectoral linkages have caused persistent challenges for local farmers who bear costly production inputs for their crops. Climate change concerns for agriculture are presently dealt with at the farm-level, and there is the need for more public discussion, supporting policies and an institutional framework to strengthen adaptive capacity of local farmers to mitigate against the negative impacts.

5.4. *Human Health*

5.4.1. Policy

The Public Health Act 1969 and related Public Health Regulations have the authority to maintain environmental health, control pollution and waste management. The Public Health Act 1969 and the Litter Abatement Act of 1989 are two main pieces of legislation that have a role in the environment and maintaining health in the country. However, the Public Health Act does not address surveillance of water pollution. The Social Development Assistance Act 1999 is one of the main pieces of legislation geared toward poverty eradication. The Tourism Strategic Plan, through its inclusion of the community in the industry, contributes to job-creation and improvements in the social conditions in such communities (MFDP, 2004). Health has also been included in the National Information and Communications Technology Strategic Plan 2006, which seeks to expand public information and advice resources in the country (Government of St. Kitts and Nevis, 2006).

Public expenditure on health as a percentage of GDP was 3.63% between 1990 and 1994 (PAHO, 2008), which has risen to 6% as of 2009 (WHO, 2011). Table 5.4.1 shows health expenditure between 1995 and 2009 (WHO, 2011). In the 2011 budget, money allocated to the health sector remained the same as that allocated in 2010. The sum allocated to the Ministry of Health was $34,916,553 comprising $33,919,253 for Recurrent Expenditure and $997,300 for Capital Expenditure. This was done despite current economic challenges in the Federation in an effort to ensure health care can be accessed by all citizens (Government of St. Kitts and Nevis, 2010a).

Table 5.4.1: St. Kitts and Nevis: Health Expenditures, 1995 – 2009

Year	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09
% of GDP	5.4	5.4	5.1	5.1	5.3	5.5	5.3	5.8	5.7	5.6	5.4	5.8	6.1	5.8	6.0

(Source: WHO, 2011)

As mentioned previously, the poverty rate is 23.7% of the population, with another 37.8% of the population at risk to economic shocks (Kairi Consultants Limited, 2009b). In the CPA St. Kitts and Nevis 2007/2008, the following comment is made: "A major challenge that is faced is a debt crisis that limits the scope of the Government in respect of its initiatives in poverty reduction. The most recent estimate suggests that the Debt to GDP ratio, though declining, stood at 174% of GDP. The Government is constrained by the debt crisis and can hardly afford any new programmes of poverty reduction" (Kairi Consultants Limited, 2009a). Such a situation has prompted the Government to re-examine its social and economic policies and programmes with the aim of poverty reduction. In 2010-2011, the country's financial situation has improved due to the government's successes in arresting public debt accumulation, successful implementation of fiscal measures and a GDP surplus in the last years (Government of St. Kitts and Nevis, 2010a). Policies and related funding strategies geared towards poverty reduction (such as the soon to be developed Poverty Reduction Strategy) are key factors in climate change because of the link of disease transmission, environment and living conditions, which by extension affects the ability of communities and a country in general to adapt.

5.4.2. Management

There are two separate Ministries of Health and the Environment, one in St. Kitts and one in Nevis, which are responsible for policy formulation (PAHO, 2008), the current full portfolio title being Ministry of Health, Social Services, Community Development, Culture and Gender Affairs. The Ministry of Health is the executive arm of the nation's health care system. Its mission is "utilizing its resources to ensure a healthy population by guaranteeing access to health services which are available, acceptable and affordable to all users in the Federation" (Government of St. Kitts and Nevis, 2010a). Within the ministry, 2 departments oversee these responsibilities. The Public Health Department is responsible for maintenance of environmental health, vector control and surveillance, pollution control and waste management. The Department of Environment is responsible for the implementation of the National Conservation Environmental Protection Act (MOE, 2001). The Health Promotion Unit was inaugurated in 2000 (PAHO, 2008).

As with most other countries, there are a number of other departments and agencies that have a secondary role in protection of the government's health. The Nevis Solid Waste Corporation is separate from the Solid Waste Management Authority in St. Kitts. The Social Assistance Department assists the indigent poor particularly through the provision of medication and other services.

There is one main referral centre in St. Kitts, the 150-bed Joseph N. France Hospital (PAHO, 2008). In addition, there are 11 Community Health Centres on the island, including those at Cayon, Irish Town, Molineaux, New Town, Old Road, Sadlers, St. Paul's, St. Peter's and Tabernacle (Kairi Consultants Limited, 2009a). The location of these health centres on both islands - there is a total of 16 in St. Kitts and Nevis - results in each household being within roughly 3 miles of a facility (PAHO, 2008). This is supported by the fact that when asked the "reason for not visiting a health practitioner", none of the 7,929 respondents indicated that the practitioner was too far, and a mere 1.4% of respondents indicated that it was too expensive (Kairi Consultants Limited, 2009a). This is crucial in times of natural disasters and emergency situations.

Primary and secondary health care is free of charge to children of school age and to persons 62 years of age and above, regardless of socio-economic status (Kairi Consutlants Limited, 2009a). Additionally there are the Mary Charles in Molineux and Pogson in Sandy Point district hospitals in St. Kitts. The island does not have a private hospital (PAHO, 2008). Approximately 45% of the population uses Public Hospitals or Health Centres. Tertiary care has to be sought outside of the country in nearby Puerto Rico, the United States of America, Trinidad and Tobago or Barbados (Kairi Consultants Limited, 2009a).

The estimated supply of doctors in 2004 was 11.8 per 10,000 persons and in 2005 there were 68 physicians on the island. While the number of doctors has been increasing, the number of nurses has been found to be decreasing with 63.4/10,000 in 1991, 43.9/10,000 in 1997 and 37.5/10,000 in 2005. The causes of this decline include migration to developed countries and aging as well as retirement rates in the field (PAHO, 2008). (Limited, 2009a)

In the 2011 Budget Speech, there is some mention of climate change but for the most part it does not directly relate to the health sector. One example of an indirect role in climate change is the thrust by the Department of Agriculture to increase water storage so that during the dry season crop and animal production can be sustained or that output increase can in comparison to previous years. The primary foci in the health sector evolve around seven key areas which include Non-Communicable Diseases and Physical Activity; Health and the Environment; Family Health; Health System Development; Mental Health and Substance Abuse; HIV/AIDS and STD's; and Human Resource Development (Government of St. Kitts and

Nevis, 2010a). In addressing the areas of Health and the Environment, Family Health and Health System Development, climate change and health issues may be indirectly addressed.

In terms of the over quality of health care in St. Kitts and Nevis, the CPA St. Kitts and Nevis 2007/2008 found that "most people were of the view that there has been a general improvement in the health status of residents. The state-of-the-art health centre in Newtown offers a wide range of services and programmes to residents including home visits, family health services, dental services, health maintenance and disease…" and "…while some residents felt convinced that there was need for improvement in the health services, most were agreed that primary health care and secondary health care were reasonable and had surely improved in recent years" (Kairi Consultants Limited, 2009a). Overall, 53% and 44.6% of the population of St. Kitts and Nevis were very satisfied and satisfied, respectively, with the health care treatment received from the health sector (Kairi Consultants Limited, 2009a).

As is the trend in the Caribbean region, non-communicable chronic diseases present the greatest trend in St. Kitts and Nevis. However, in the Caribbean region the priorities regarding climate change and health is more closely centred on communicable diseases such as vector borne diseases and gastrointestinal diseases. Therefore climate change policies should focus on these areas to arrest any increases in the incidence of these diseases due to climatological occurrences. In a survey asking if climate change and climate variability information should be made a national health priority in mitigation measures in the health sector, 91% of respondents favoured such an approach (Rawlins *et al.,* 2007).

5.5. *Marine and Terrestrial Biodiversity and Fisheries*

Adaptation requires "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007). The adaptive capacity of ecosystems then is the property of a system to adjust its characteristics or behaviour, to expand its coping range under existing climate variability, or future climate conditions (Brooks and Adger, 2004). Despite global action to reduce GHG, climate change impacts on biodiversity are unavoidable due to climate inertia. Natural ecosystems have long demonstrated the ability to adapt to changes in their physical environment. The rate at which climatic change occurs may exceed the rate at which ecosystems can adapt. Furthermore, natural environments 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 (Hopkins *et al.*, 2007). 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):

- 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.

In 2001, St. Kitts and Nevis submitted the National Biodiversity Strategy and Action Plan for the Confederation. The document identified a number of factors that are contributing to environmental degradation. These are:

- Poverty;
- Tourism ventures;
- Lack of public awareness and education;
- Traditional medicine;
- Pollution;
- Cultural attitudes;
- Unsustainable development practices;
- Overgrazing;
- Monoculture sugarcane cultivation;
- Infrequent research;
- Agro-processing;

- Severe hurricanes;
- Recreational activities;
- Introduction of invasive alien species.

Continued degradation of ecosystems will intensify climate change impacts and subvert any progress that has been made in mitigating GHG emissions. Development of Caribbean nations depends on the sustained services offered by healthy ecosystems and a greater diversity of biological species enhances the resilience of a nation's ecosystems to climate change. Healthy reefs, forests and freshwater resources are better able to rebound from extreme events and to acclimatise to increasing temperatures. It is therefore imperative to adapt to the changes that are already in progress and that will continue to progress due to climate inertia, to preserve and restore natural resources - the very foundation of the island's economy and livelihoods. The following sections will thus assess the country's adaptive capacity to minimise biodiversity loss in the face of global climate change.

5.5.1. Policy

Climate change adaptation strategies for biodiversity can either support or violate principles of equity, cultural norms and sustainable development depending on the policies that guide these actions. The capacity of countries to implement climate change adaptation strategies will therefore be enhanced by polices which take advantage of linkages between socio-economic and environmental sectors. Increasing recognition of the importance of preserving environmental health, increased interface with global environmental institutions and the demands of financial and donor institutions have resulted in improved participation of Caribbean countries in MEA. The Government of St. Kitts and Nevis has signed the following MEAs that have bearing on the country's biodiversity:

- Cartagena Convention on Law of the Sea – June 1999;
- International Convention on the Prevention of Marine Pollution – 1998;
- United Nations Convention to Combat Desertification – June 30, 1998;
- CITES – May 15, 1994;
- UNFCCC – March 1994;
- Convention on Biodiversity – January 1993;
- Montreal Protocol on Substances that Deplete the Ozone Layer – August 10, 1992.

Successful implementation of MEAs and fulfilment of their goals depend in part on the existence of supportive national legislation. St. Kitts National Environmental Management Strategy and Action Plan 2005-2009, was adopted in 2005 and is one of the main strategy documents informing the implementation of best practice approaches to guide environmental management over the long term (European Commission, 2007). The Strategy focuses on:

- living conditions of the population;
- protection from coastal erosion;
- upgrading of standards to deal with hurricanes and violent storms;
- agriculture and pesticide use

The main law governing biodiversity and ecosystems is the National Conservation and Environment Protection Act No. 5 of 1987, which covers management and development of natural and historic resources, establishment of protected areas, and the establishment of an advisory Conservation Commission. The National Physical Development Plan of 2006 earmarks special areas for environmental

protection. St. Kitts and Nevis also has a number of other laws that impact on its biodiversity including the Forestry Act, The Fisheries Act No. 4 of 1981, Plant Protection (Cap. 97).

A range of tools exist that may be utilised to assess the implications of climate change adaptation strategies from socio-economic and environmental perspectives. Environmental Impact Assessment (EIA) is one such tool for which the Development Control and Planning Act No. 14 of 2000, section 26(2) of 2006 makes provision. However, a lack of training and equipment for properly conducting EIAs are constraints to the effective use of this tool in St. Kitts (Gardner L. , 2006). The assessment identifies a lack of appropriately implemented policies, lack of enforcement of legislation and the failure to incorporate environmental costs into action plans and national budget as shortcomings that have limited in the country's ability to live up to its obligations of ecosystem conservation(Government of St. Kitts and Nevis, 2004).

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). Within the Federation of St. Kitts and Nevis, a number of institutions are charged with the responsibility of ensuring the sustainable use of biological resources (Table 5.5.1). The Departments of Physical Planning and Environment within the Ministry of Sustainable Development are responsible for national environmental management, protection, and conservation including watershed protection, land-use planning and development control and beach profile monitoring. The various departments do not fall under the same umbrella and this has resulted in ad hoc approaches to natural resource management and hinders a more desirable holistic approach (Government of St. Kitts and Nevis, 2004).

The Government of St. Kitts and Nevis recognises the need for the fisheries sector to secure a higher place in the country's development agenda and has thus recently restructured a Department of Marine Resources to deal with fisheries and other matters (Deane and McConney, 2010). In November 2010, The Nature Conservancy (TNC) conducted a marine spatial planning process and developed a draft marine zoning design for St. Kitts and Nevis outlining areas for marine management. These areas will be proposed to policy makers in 2011 and, if successful, will become marine managed areas by January 2012. The Department of Marine Resources received a small grant in order to prepare for an ecosystem approach to fisheries (EAF) governance (i.e. one which focuses not only the natural resource but also takes into account the human component of ecosystems). Outputs from marine zone design proposed by TNC will be used to guide the creation of a managed marine protected area (MPA) to help boost fish stocks; one of the initiatives under the EAF. Both the marine zoning project and preliminary work on EAF have been consultative and incorporated multi-sector, multi-stakeholder trade-offs and negotiations. Commendably, a series of meetings with fisher-folk were held in order to get their perspective on what the fisheries industry should look like. Their responses were used for a scoping report. Prior to finalizing the EAF plan will be shared with fisher-folk and the general public for their approval. Fishers have also expressed an interest in receiving marketing assistance (Williams, 2011).

Existing institutional infrastructure and resources to successfully implement the EAF Plan are currently inadequate and will only be further burdened with the growing threat of climate change on biodiversity. Constraints to effective management include inadequate monitoring, surveillance and law enforcement; lack of the ability to assess fish stocks and biodiversity; and overall, limited financial resources. Although data is collected regularly from fisheries landing sites (species, weight, area fished and gear used) the

Department of Fisheries depends on regional and international organisations for scientific research support, such as for stock assessments.

An additional concern with regards to fisheries management is that whereas the majority of Caribbean nations have banned the hunting of sea turtles because of their endangered status, St. Kitts and Nevis still allow regulated fishing of the species. A closed season from October 1 to February 28 and species specific size limits under the 1995 Fisheries Regulations guide the harvest of these marine reptiles. However the closed season does not coincide with the nesting season of all species and weight limits do not necessarily protect adults before they have had a chance to reproduce(Curran-Ragan, 2010)(AVMA, 2011). St. Kitts is in a position to reduce fishing pressure on these endangered creatures that are already facing multiple, unprecedented threats including climate change.

Table 5.5.1: Key Actors with a Role in Managing Biological Resources in St. Kitts

Division	Responsibility
Forestry	Protection and management of forest and wildlife and watershed management
Fisheries Unit	Management and development of fisheries, protection and management of marine reserves
Pesticide Board	Enforcement of Pesticides Act and Regulation
SSMC	Management of Sugar Cane Lands
National Housing Corporation (NHC)	Housing supply
Physical Planning Unit	Implementation of planning legislation
Public Health Department	Maintenance of environmental health, pollution control, waste management
Solid waste management	Management of solid waste
Department of Environment	Implementation of national conservation environmental protection act (NCEPA)
Water Department	Watershed management
Urban Development Corporation	Management of Port Zante
Frigate Bay Development Corporation	Regulating development in the Frigate Bay area

Protected Areas

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). There are few areas in St. Kitts that are designated for environmental protection however several have been proposed. Under the Protected Areas and Associated Livelihoods project, the St. Kitts Central Forest Reserve, inclusive of the Park Olivees Mountain, Mount Liamigua and the Verchilds Mountain, was selected for protection because of the ecologically significant habitat found above 1,000 ft and the last remaining area of tropical forest the island. The livelihoods subproject is conducting research on forest-dependent livelihoods, and providing grants and training to assist in maintaining sustainable livelihoods.

There are no legally declared MPA as of yet but preliminary work done by TNC and MarGov will help to guide the Government's commitment under the Caribbean Challenge to protect 20% of its coastline by 2020. The Narrows, the area between St. Kitts and Nevis and encompassing the Booby Island Shoal, has

been proposed as a MPA. The site has also been selected for socio-economic monitoring under the SocMon because of its importance to fisheries and tourism. While there are existing laws that permits the government to declare MPAs, it is currently inadequate to support the development and implementation of comprehensive, integrated framework (Bovino, 2010). Plans are underway to develop a master plan and associated legislation for St. Kitts marine and coastal zone protection.

5.5.3. Technology

A high degree of access to technology at various levels (i.e. from local to national) and in all sectors may potentially play a significant role in biodiversity adaptation to climate change (Burton, 1996). Technology may be used to build the resilience of biodiversity to climate change by reducing non-climatic stresses and improving conservation and management activities. For example, the St. Kitts Department of Marine Resources is currently promoting the use of alternative fishing methods, such as horizontal and long-line fishing to reduce fishing pressure on near shore areas and to ensure the health of inshore nurseries and the coral reefs around the island.

In addition, the technology and telecommunications sectors have been identified as having a key role is the sustainability and development of the Federation therefore infrastructure, hardware and software as well as human capacity are being upgraded towards this end (Government of St. Kitts and Nevis, 2010b). The Ministry for Technology and Communications recognises the potential benefits of the application of cutting edge technology to various sectors such as health, banking, and education. Strengthening of the technology and telecommunications sectors in St. Kitts is good news for the environmental managers as this offers much potential in the conservation of biodiversity. For example database development and management for a comprehensive assessment of natural resources as suggested by the Technology Needs Assessment for St. Kitts and Nevis (RM Consulting Inc.). GIS and remote sensing are key tools in mapping habitats and resource use for effective spatial planning. These technologies were utilised by TNC in the marine zonation project and will prove useful in long term monitoring of the island's ecosystems as they continue to adapt to changing climatic conditions.

Technological interventions will work best when there is a sense of ownership by the community and if on-going management of the intervention is within their capacity. As such traditional or indigenous technology should not be overlooked as it is often more readily accessible to SIDS and in some cases can be better suited to the local context than more modern technologies.

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. Kitts and Nevis. 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. Kitts and its people. Adaptations to minimise vulnerabilities in St. Kitts 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 (Daniel, 2001). There are 3 main types of adaptation policies that can be implemented to reduce the vulnerability of the tourism sector in St. Kitts to SLR and improve the adaptive capacity of the country: (1) Hard engineering defences and (2) soft engineering defences, which both aim to protect existing infrastructure and the land on which the infrastructure is built, as well as (3) retreat policies, which aim to establish setbacks and thereby move people and/or infrastructure away from risk. A summary of examples for each of the three types of adaptation polices are provided in Table 5.6.1, along with a summary of select advantages and disadvantages of each. Adaption options discussed in this report should be implemented in the framework of Integrated Coastal Zone Management (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 and Nicholls, 2010).

Table 5.6.1: Summary of Adaptation Policies to reduce St. Kitts' vulnerability to SLR and SLR-induced beach erosion

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

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

5.6.1. Technology – Hard Engineering

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

5.6.2. Technology – Soft Engineering

Protection can be implemented through the use of soft engineering methods, which require naturally formed materials to control and redirect erosion processes. For example, beaches, wetlands and dunes have natural buffering capacity which can help reduce the adverse impacts of climate change (IPCC, 2007b). Through beach nourishment and wetland renewal programmes, the natural resilience of these areas against SLR impacts can be enhanced. Moreover, these adaptation approaches can simultaneously allow for natural coastal features to migrate inland, thereby minimizing the environmental impacts that can occur with hard engineering protection. Replenishing, restoring, replanting and reshaping sand dunes can also improve the protection of a coastal area, as well as maintain, and in some cases improve, the aesthetic value of the site. Although less expensive and less environmentally damaging, soft engineering protection is only temporary. For example, the 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. This is particularly true for highly developed areas where roads and infrastructures can impede setbacks, as well as 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 CZM in St. Kitts. The Department of Development and Planning is responsible for managing development and fostering stakeholder participation in environmental management. The St. Kitts Department of Environment is responsible for the institutionalisation of environmental policies, watershed management, management of protected areas, as well as public education. The Fisheries Department, with help from a variety of NGOs, is responsible for beach clean-up and public awareness. Since 1991, St. Kitts beaches have been monitored, measuring the beach slope and width every 3 months around the island, by the Department of the Environment, who were, at times, assisted by the Fisheries Department and the Department of Development and Planning (Chambers, 2000).

In 2000, the National Conservation and Environment Protection Act for St. Kitts designated all beaches of the SEP and selected beaches on the mainland as Protected Areas. At present, St. Kitts beaches are largely unmanaged, creating a wealth of issues including unplanned development, user conflict, overcrowding, sand dune destruction and removal of vegetation (Farrell, 2002). Fortunately government, non-governmental organisations, community based organisations and the private sector have all begun to recognise the importance of maintaining beaches in St. Kitts to ensure the island's economic success, including the success of tourism. Playing a leading role in coastal stewardship on the island is the St. Christopher Heritage Society. This NGO provides an important linkage between government, private sector and the community by monitoring and ensuring the preservation of St. Kitts' beaches, bringing attention to issues of coastal degradation and destruction (Farrell 2002).

Introduction of guidelines for development setbacks for specific beaches, cliffs and the mouth of ghauts were established for Nevis, but still need to be completed for St. Kitts (DOE, 2001). As a result, setbacks guidelines do not exist and cannot therefore be enforceable for developments that not only exist, but that are being proposed. A great deal of existing infrastructure on the island needs to be protected. Figure 5.6.1 highlights the coastal zones in St. Kitts that at the greatest risk for coastal erosion.

As signatories to the UNFCCC, and members of the Caribbean Planning for Adaptation to Climate Change, St. Kitts is committed to proposing and formulating coastal zone related policies (DOE, 2001). Despite these initiatives, there is no comprehensive plan to deal with the impacts of climate change. Progress has been made in terms of improving building techniques for building constructions and inspection to make these buildings less vulnerable to SLR, but more needs to be done to protect people and the tourism sector from the imminent impacts of climate change (DOE, 2001).

In 2011, Basseterre, St. Kitts, hosted delegates across the region to explore issues related to climate change. As a host, the conference provided a unique opportunity to discuss the implications of climate

change for St. Kitts, with a particular focus on response mechanisms, particularly mitigation and adaption strategies that can be employed to reduce the risk of climate change on the lives and livelihoods of the people in St. Kitts (Government of St. Kitts and Nevis, 2011). The outcome of the conference has been formulated into a document which is now being considered by the Government of St. Kitts and Nevis to inform future policy directions (Government of St. Kitts and Nevis, 2011).

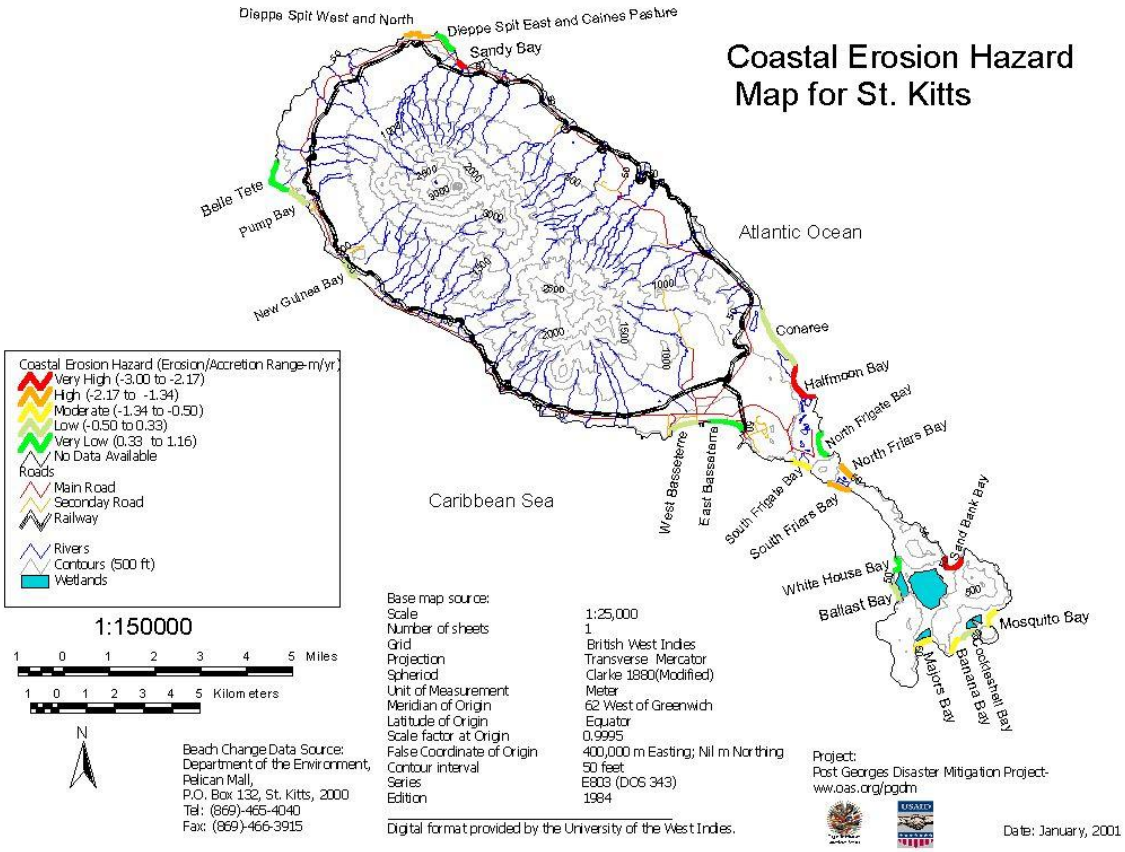


Figure 5.6.1: Coastal Zone Hazard Map for St. Kitts

(Source: Daniel, 2001)

5.7. *Comprehensive Natural Disaster Management*

Adaptive capacity can be measured through examination of policies and plans implemented for the management of disasters, as well as the actions taken following a disaster. Being able to reduce the impacts of natural disasters on a small island nation is often difficult, especially when facing major hazard threats on a regular basis. The post-disaster time period is a time when extra resources are needed to finance imports of food, energy, and inputs for the agricultural and manufacturing sectors. As a result, efforts to build resilience, or adaptive capacity, gets put aside while immediate survival, shelter and health needs are prioritised along with the remedy of hazardous living conditions.

5.7.1. Management of Natural Hazards and Disasters

The disaster management system can be thought of as a cycle where preparedness, mitigation[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).

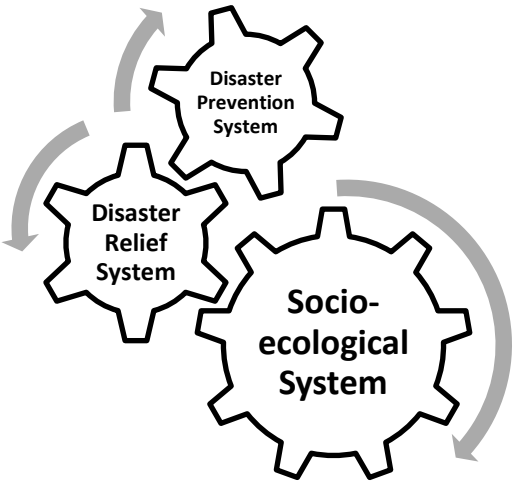


Figure 5.7.1: Relationship of the Disaster Management System and Society

Caribbean Disaster Management and Climate Change

As a region, the Caribbean has made coordinated efforts to prepare for and respond to disasters. The Caribbean Disaster Emergency Management Agency, CDEMA, (previously the Caribbean Disaster Emergency Response Agency, CDERA) was created in 1991. CDEMA plays a leadership role in disaster response, mitigation and information transfer within the region, operating the Regional Coordination Centre during major disaster impacts in any of their 18 Participating States, while also generating useful data and reports on hazards and climate change. The primary mechanism through which CDEMA has influenced national and regional risk reduction activities is the Enhanced Comprehensive Disaster Management (CDM) Strategy (CDEMA, 2010b). The primary purpose of CDM is *to strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change* (CDEMA, 2010) (emphasis added).

[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 4 priority outcomes of the CDM framework are:

1. Institutional capacity building at national and regional levels;
2. Enhanced knowledge management;
3. Mainstreaming of disaster risk management into national and sector plans; and
4. Building community resilience.

These outcomes have been further broken down into outputs that assist in the measurement of progress towards the full implementation of CDM at the national and community level and within sectors (see Table 5.7.1). The CDM Governance Mechanism is comprised of the CDM Coordination and Harmonization Council and six (6) Sector Sub-Committees. These sectors include – *Education, Health, Civil Society, Agriculture, Tourism and Finance.* These 6 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, 2010b).

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 CTO, CARICOM Regional Organization for Standards and Quality (CROSQ), and the University of the West Indies will be implementing a Regional Disaster Risk Management (DRM) Project for Sustainable Tourism (The Regional Public Good) over the period of January 2007 to June 2010. The project aims to reduce the Caribbean tourism sector's vulnerability to natural hazards through the development of a '*Regional DRM Framework for Tourism*'. Under the Framework, a '*Regional DRM Strategy and Plan of Action'* will be developed, with a fundamental component being the development of standardised methodologies for hazard mapping, vulnerability assessment and economic valuation for risk assessment for the tourism sector (CDERA, 2007; CDERA, 2008).

Finally, the link between CDM and climate change cannot be ignored. Projections for the region suggest that more extreme temperatures and more intense rainfall in certain seasons could lead to a greater number of hydro-meteorological disasters. Many of the hazards facing Caribbean countries already pose threats to lives and livelihoods and climate-related events are regular occurrences. This has been recognised with the mention of climate change in the CDM strategy. The CCCRA report will not only offer improvements to the existing disaster management framework in the region, but will also offer pragmatic strategies for action which will build resilience in the Caribbean to the predicted impacts from climate change (see herein, sector reports on Climate Modelling, Water Quality and Availability, Marine and Terrestrial Biodiversity, Identification of Vulnerable Groups, Human Health, Energy, Settlements and Infrastructure).

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 Organizations are strengthened for supporting CDM implementation and a CDM program is developed for implementation at the national level* *1.2 CDERA CU is strengthened and restructured for effectively supporting the adoption of CDM in member countries* *1.3 Governments of participating states/ territories support CDM and have integrated CDM into national policies and strategies* *1.4 Donor programming integrates CDM into related environmental, climate change and disaster management programming in the region.* *1.5 Improved coordination at national and regional levels for disaster management* *1.6 System for CDM monitoring, evaluation and reporting being built*	***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 recognized as the roadmap for building resilience and Decision-makers in the public and private sectors understand and take action on Disaster Risk Management* *3.2 Disaster Risk Management capacity enhanced for lead sector agencies, National and regional insurance entities, and financial institutions* *3.3 Hazard information and Disaster Risk Management is integrated into sectoral policies, laws, development planning and operations, and decision-making in tourism, health, agriculture and nutrition, planning and infrastructure* *3.4 Prevention, Mitigation, Preparedness, Response, recovery and Rehabilitation Procedures developed and Implemented in tourism, health, agriculture and nutrition, planning and infrastructure*	***OUTPUTS*** *4.1 Preparedness, response and mitigation capacity (technical and managerial) is enhanced among public, private and civil sector entities for local level management and response* *4.2 Improved coordination and collaboration between community disaster organizations and other research/data partners including climate change entities for undertaking comprehensive disaster management* *4.3 Communities more aware and knowledgeable on disaster management and related procedures including safer building techniques* *4.4 Standardized holistic and gender-sensitive community methodologies for natural and anthropogenic hazard identification and mapping, vulnerability and risk assessments, and recovery and rehabilitation procedures developed and applied in selected communities.* *4.5 Early Warning Systems for disaster risk reduction enhanced at the community and national levels*

(Source: CDEMA, 2010)

5.7.2. Management of Disasters in St. Kitts

Disaster management in St. Kitts and Nevis is led by NEMA, an organisation created under the Ministry of National Security, Immigration and Labour (NEMA, 2010). "On St. Kitts, The National Disaster Committee (NDC) composed of relevant national ministers and ranking government officials, private sector, and non-governmental organisations, serves as the coordinating body between the office of the Prime Minister and

Cabinet"(GFDRR, 2010, p. 222). The NDC is chaired by the Prime Minister and it is the National Disaster Executive (NDE) that then reports to the NDC and the NDE also oversees the operational aspects of the NEMA program (GFDRR, 2010). Nevis has its own agency, the Nevis Disaster Management Department. The separation of disaster management responsibility between the 2 islands has its benefits in terms of improving local actions and communication, but poses a challenge to national funding allocation and the standardisation of actions in Disaster Risk Reduction (DRR) within the Federation of St. Kitts and Nevis.

The government agencies are supported by the community and an advisory council. St. Kitts is sub-divided into 8 districts, which each have several hundred volunteers that support NEMA; district committees are managed by a small team of elected volunteers (NEMA, 2007). The National Disaster Mitigation Council was established in 1999 and is led by the Deputy Prime Minister. The Council is comprised of other Permanent Secretaries, Heads of key response agencies, tourism and private sector agencies, as well as non-governmental organisations (NGOs) (NEMA, 2007). This Council provides policy guidance and general oversight to NEMA.

Generally, St. Kitts and Nevis have been criticised for a lack of institutional cooperation and collaboration within institutions and between the two islands (ECLAC, 2003). "Given the frequency of the passage of hurricanes over St. Kitts and Nevis in recent years, there is the need for effective emergency response planning, consistent coordination and liaison among government agencies, response agencies and organisations and community support groups. St. Kitts' and Nevis' National Disaster Mitigation Council, which is responsible for formalizing the institutional arrangements for disaster mitigation and management, needs significant institutional strengthening. Also, a catastrophe insurance programme needs to be in place to cater for emergencies. The land use and management programme is necessary to preserve the quality of the environment". These weaknesses negatively affect the capacity of the nation to adapt to climate change, as well as affecting the preparedness and response capacity during disasters. In acknowledging these weaknesses, action can be prioritised so that the limited funds are used to build capacity at the institutional and community level.

Efforts to better understand the vulnerability and capacity in St. Kitts has been evident in recent years. Since the major hurricane impacts in the late 1990s, "[r]ushed/inadequately planned development is being discouraged to ensure human safety" (DOE, 2001, p. 28). Post-disaster mitigation projects following Hurricane Lenny and Hurricane Georges specifically, aimed at advancing disaster response and preparedness as well as improving building and construction techniques and the management shelters (DOE, 2001). Progress has so far been slow since "development[s] which were introduced a decade ago did not respond to coastal setbacks and so still pose threats to human safety and the economic viability of their area"(DOE, 2001, p. 28). Nonetheless, the NEMA is actively working to create a disaster management system that reduces vulnerability and loss of life in emergency situations.

The Federation of St. Kitts and Nevis is also a Participating State of CDEMA and has thus taken the Regional CDM Strategy and Plan into consideration in their activities. In his address to the ISDR in Geneva in 2009, Mr Herbert, the National Disaster Coordinator, commented: "We view [the CDM] approach as very important and necessary, especially as a small twin island nation with limited natural resources and situated in a region that is highly vulnerable to natural hazards". As a Participating State, St. Kitts and Nevis can continue to benefit from the programming and capacity building efforts CDEMA executes throughout the region.

Funding Post-disaster Activities

Following major disasters, there is a Rapid Needs Assessment Team (RNAT), led by CDEMA, who is deployed to the impacted state to conduct a Damage Assessment and Needs Analysis (DANA) (UNDP, 2011). The skilled assessment team has carried out a standard assessment procedure across many of the CDEMA Participating States. However, the DANA process is only executed upon the request of the impacted state. Therefore, the assessment information is not available following *every* disaster and as such, all disaster offices should also have the capacity to execute a post-disaster assessment on their own. Making use of CDEMA's coordination activities across multiple countries builds response capacity by taking advantage of the resources and personnel from neighbouring countries and thus can also enhance the response and reconstruction efforts. Nevertheless, the need to incorporate the principles of 'building back better' into response by having accurate and reliable post disaster assessment information must also be a priority. In that way, the post-disaster context becomes an opportunity for building resilience and institutionalising DRR goals.

In addition, the post-disaster context is an opportunity for lessons learned. Following Hurricane Earl, some economic impact assessment training has started for personnel in Nevis (no such training was found in the documentation for St. Kitts). NEMA has recognised lessons relating to gender. Although funds are not allocated specifically for recovery and reconstruction in the national budget, there are measures to give the necessary special attention to female-headed households in recovery activities (NEMA, 2010). This measure of gender consideration, albeit difficult without proper funding, is a good example of how St. Kitts is updating their disaster management activities in response to good practices and lessons learned from global disasters.

5.7.3. Policy

The National Disaster Management Act

The St. Kitts and Nevis National Disaster Management Act was passed in 1998 and supplies the legal framework for NEMA operations. The Natural Disaster Mitigation Policy and Plan outlines the legal and institutional framework under which NEMA is mandated and regulated (NEMA, n.d.). These documents provide the necessary guidance to disaster management activities in all parts of the disaster cycle. NEMA works with local and district committees to develop response capacity and contingency plans for execution during disaster situations (GFDRR, 2010). During a disaster, NEMA reports on St. Kitts to the Office of the Prime Minister.

Reviews of hazard and vulnerability were undertaken in 2001 following Hurricane Georges and public health facilities were again assessed in 2009 (NEMA, 2010). With the report on the country's progress towards the HFA goals it was expressed that "an up to date hazard vulnerability and risk assessment on St. Kitts and Nevis [is needed]. This will require significant financial resources and supporting expertise. At present, there are significant aspects of planning and development activities with regard to DRR that are not informed by current data" (NEMA, 2010). The inclusion of a timeline on which vulnerability and hazard assessments are required to be conducted must therefore be better enforced.

Environmental Impacts and Development Planning:

Land use development and natural hazards are intricately related. Without proper consideration of the natural environmental processes during development planning, risks can be created and people's lives are put at risk. For that reason, it is common practice to include some kind of EIA or natural hazard impact

assessment in the land use planning process. Planning legislation was first enacted for St. Kitts and Nevis in 2000 with assistance from the Organisation of Eastern Caribbean States, Environmental and Sustainable Development Unit (OECS-ESDU); this was the first attempt in addressing the need for uniform planning standards across both islands (ECLAC, 2003). In 2006, the National Physical Development Plan was approved and includes a comprehensive land use guide (NEMA, 2010). This is a positive first step toward risk reduction. However, progress continues to be limited by financial constraints and technical resources.

The EIA process in St. Kitts is regulated by the Development Control and Planning Act (2000) (Trotz *et al.*, 2004). EIAs are mandatory for various development types based on size or environmental sensitivity and public participation is encouraged. Formal guidelines, criteria and methods for assessment do not exist but the Physical Planning Division provides guidance on a case-by-case basis (Trotz *et al.,* 2004). "In support of this Act, the St. Kitts-Nevis Building Code was upgraded and the Building Inspectorate was increased" (NEMA, 2007). Risk mapping has been done as part of the building code, but enforcement is still considered a weakness and the building code legislation is the only formal legislation with DRR considerations (GFDRR, 2010).

Further to the EIA process, the use of a building code for all structures is a valuable tool through which to control some vulnerability. 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 codes as the primary base documents with additional input from the Caribbean Uniform Building Code 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 Subcommittee who will provide comments before it is submitted to CARICOM (Jonathan Platt, Barbados National Standards Institute, personal communication, May 4, 2011).

The earthquake risk in St. Kitts is significant because of its proximity plate boundaries and the shallow centres of volcanic activity in the region (GFDRR, 2010). Because of this risk, the need for a building code that considers earthquake shaking has been acknowledged in St. Kitts and Nevis. Mr Herbert, in his address to the ISDR, shared that "among other initiatives, [Saint Kitts and Nevis has] revised [its] building code, increased the number of building inspectors, constructed multi-purpose community centres-shelters, undertook sea defence works and trained many residents in various aspects of disaster management" (Herbert, 2009). This initiative is building capacity within St. Kitts and not only reduces vulnerabilities to natural hazards, but also generates resilience to some likely impacts from climate change.

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 choose to seek insurance. The Caribbean is home to the first risk pooling facility designed to limit financial impacts of catastrophic hurricanes and earthquakes in Caribbean member countries, by providing short-term liquidity when the policy is triggered (CCRIF, 2011). Originally, the insurance index was based on degree of shaking during earthquakes or wind speed for hurricane events and the member country would qualify for a pay-out based on their policy and the level of damages deemed to be associated with either wind or shaking. Recently, the need to also consider water damages has been noted. As a result, the Caribbean Catastrophe Risk Insurance Facility (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 use of insurance can also help individuals and small businesses. Private household level insurance, micro-insurance and DRR-aligned welfare program are not readily available for Kittitians, nor is crop insurance available for farmers (NEMA, 2010). The building requirements for new constructions are likely only followed as a means to obtain mortgages and insurance. In the absence of this insurance, damages from natural disasters are borne by the individuals or they become dependent on government pay-outs, which are sometimes slow to be dispersed and cannot always be made available to everyone who is affected. As noted, the Caribbean is a high-risk region and this risk is increasing as a result of climate change. This highlights the importance of adaptation and mitigation at the community and national level because preventing the extent (social, environmental and financial) of damages is the best chance St. Kitts has for resilience in the future.

5.7.4. Technology

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 can also sometimes cause negative effects in other locations along the coast. Disaster management practices have also found that structural protection is very expensive and research has shown that sometimes these structures worsen the impacts of a disaster when the size of the structure is incongruent with the protection needed in a particular 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 section 5.6.

Technology and Public Education

Public education begins in schools as children are good vessels for dissemination of basic emergency information. The national curriculum includes DRR information for primary school children and some information also gets transferred to students in secondary and tertiary level classes (NEMA, 2010). A more consistent dissemination of information to students beyond primary school could be a means of improving capacity in the general public, though other methods do exist in St. Kitts.

Other public information sources exist in St. Kitts. A Disaster Management Documentation Centre was created recently to provide resources for residents and visitors who are undertaking research on disaster management in the island. A full time Community Outreach Officer is in charge of island-wide programming on both islands (NEMA, 2010). The NEMA website is currently under construction so information transfer relies heavily on other media sources. Newspaper, radio, public service announcements, brochures and flyers are distributed throughout St. Kitts on an on-going basis (NEMA, 2010). Much progress has been made on reaching risk-prone communities, but materials are also needed for the growing community of non-English speakers. This type of programming is limited by financial constraints and lack of appropriate equipment and multimedia programmes (NEMA, 2010).

Early Warning Systems

St. Kitts and Nevis is committed to disaster and vulnerability reduction. In 2009, the twin island federation demonstrated its commitment to this through its engagement in and support of regional initiatives for

tsunami early warning systems and other coastal hazards in the Caribbean (Herbert, 2009). Media is actively involved in dissemination of warnings and the high-risk communities receive timely and understandable warnings for predictable events (e.g. hurricanes) (NEMA, 2010). NEMA has acknowledged that warning systems for other hazards are also needed, for example tsunami warning systems are not in place (NEMA, 2010). Early warning systems are an integral part of DRR as they provide information to individuals and communities, not just of impending danger, but evacuation notices serve also as a constant reminder of the ever-present risks in their surroundings.

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 Old Road 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 21 respondents were surveyed, 7 of whom were male and 14 were female. One male respondent did not indicate the gender of the head of household, and therefore only 20 surveys were analysed on the basis of the gender of the head of household. When analysis is performed on the gender of the respondent, all 21 surveys are included.

5.8.1. Demographic Profile of Respondents

Residency in the Community

Overwhelmingly, respondents were long-time residents of St. Kitts, with 71.4% (N= 15) of the sample indicating that they had lived in their community for a minimum of 20 years. Female and male respondents, however, displayed a dissimilar distribution in terms of length of time in their community. There were twice as many female respondents than male respondents, with females indicating slightly shorter periods of time spent in the community. The majority (57.1%) of females indicated living in the community for more than 20 years; 21.4% for less than 5 years; and 21.3% between 6 and 20 years. All of the 7 male respondents indicated living in the community for more than 20 years.

Table 5.8.1: Length of Residency in Community

Residency	Male		Female		Total	
1 - 5 years	0	0.0%	3	21.4%	3	14.3%
6 - 10 years	0	0.0%	1	7.1%	1	4.8%
11 - 15 years	0	0.0%	1	7.1%	1	4.8%
16 - 20 years	0	0.0%	1	7.1%	1	4.8%
Over 20 years	7	100.0%	8	57.1%	15	71.4%

Age Distribution

The sample was a predominantly younger sample, with 65% of respondents being under the age of 45.

Table 5.8.2: Age Distribution of Sample

Age	Male		Female		TOTAL	
25 - 34	5	71.4%	7	50.0%	12	57.1%
35 - 44	1	14.3%	4	28.6%	5	23.8%
45 - 54	1	14.3%	1	7.1%	2	9.5%
55 - 59	0	.0%	2	14.3%	2	9.5%

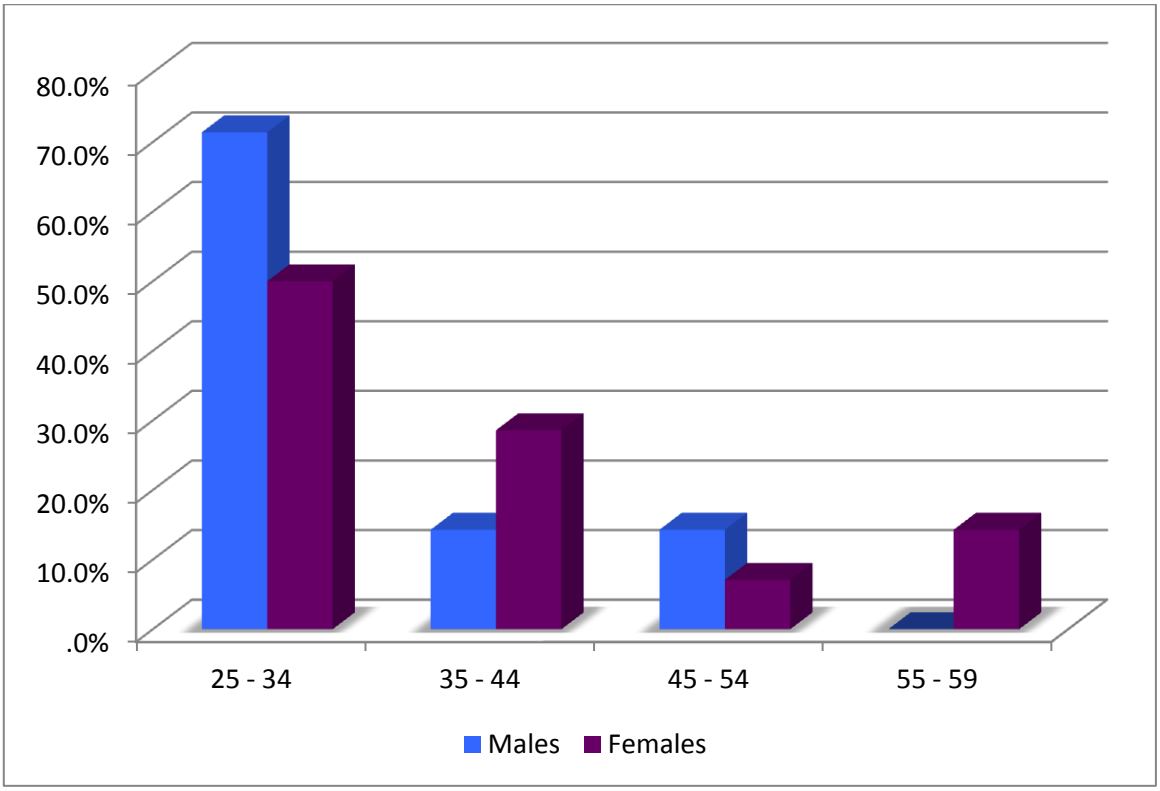


Figure 5.8.1: Age of Respondents

Household Form and Structure

Given the younger demographic of the sample, 38% of respondents indicated being single. None of the respondents indicated being widowed while 38% were either married or common law, and approximately 24% were in a visiting relationship.

Table 5.8.3: Relationship Status of Respondents

Status	Male		Female		Total	
Single	2	28.6%	6	42.9%	8	38.1%
Single (Visiting Relationship)	2	28.6%	3	21.4%	5	23.8%
Married	1	14.3%	3	21.4%	4	19.0%
Other/Common Law	2	28.6%	2	14.3%	4	19.0%

When disaggregated on the basis of sex, there was no difference in the marital status of male and female respondents.

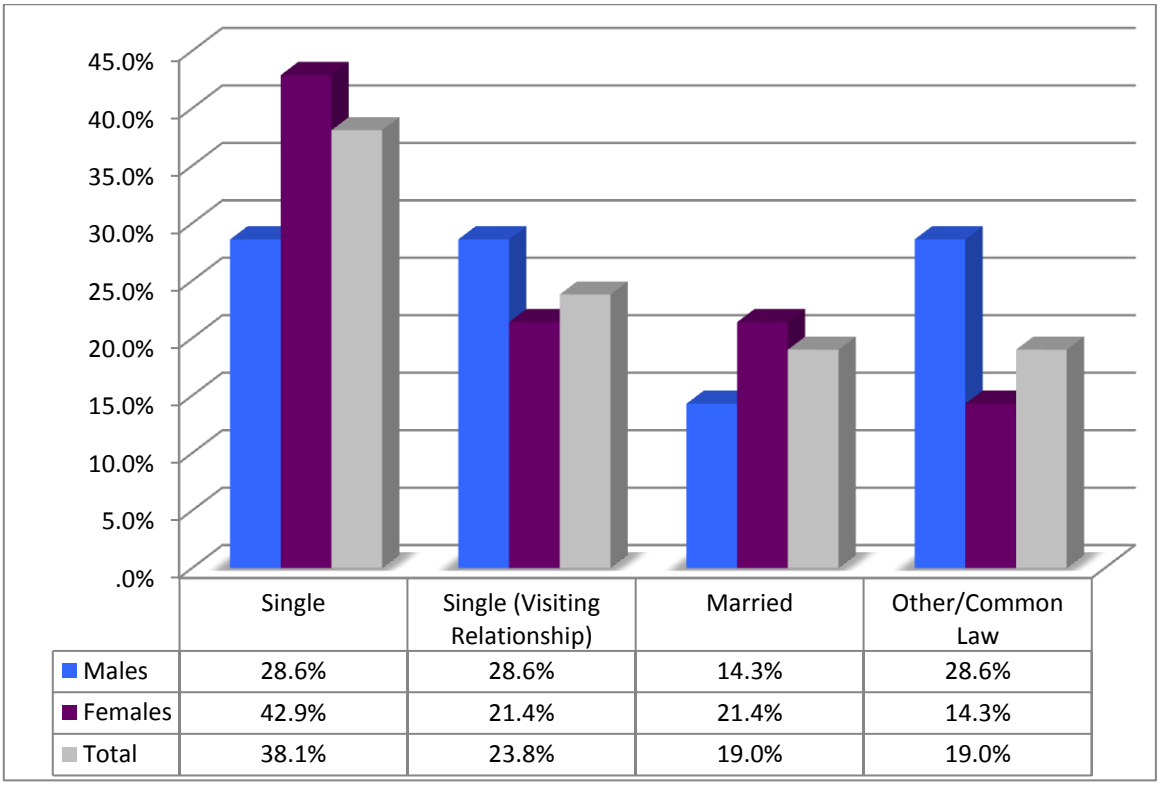


Figure 5.8.2: Relationship Status of Respondents

5.8.2. Household Headship

A third of the respondents sampled listed themselves as the heads of their respective households (N = 14). A larger proportion of male respondents, compared to female respondents, indicated themselves as the heads of their households; 100% of male respondents indicated this compared to 50% of female respondents.

Table 5.8.4: Perception of Headship of Household

Perceived as Head of Household	Sex of Respondent			
	Male		Female	
Yes	7	100.0%	7	50.0%
No	0	.0%	7	50.0%

With regards to household size, 20% of households consisted of between 1 and 3 persons. Almost half of the households consisted of between 4 and 5 people, while the remaining 30% of households had 6 or more members. Female respondents belonged to larger households, with 78.6% belonging to households of 4 or more people compared to males with only 57.1% belonging to households of 4 or more people.

Table 5.8.5: Family Size by Sex of Respondent

Size of Household	Sex of Respondent					
	Male		Female		Total	
1	1	8%	0	0%	1	5%
2 - 3	2	17%	1	13%	3	15%
4 - 5	4	33%	5	63%	9	45%
6 - 7	4	33%	1	13%	5	25%
8 - 9	0	0%	1	13%	1	5%

5.8.3. Education and Livelihoods

The largest proportion of the sample (57%) indicated that they had completed a secondary level of education. Of note, when compared between males and females there is a slightly higher proportion of males who had undertaken community college or a tertiary sector education (university, professional designation etc.).

Table 5.8.6: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		Total	
Primary	1	14.3%	3	21.4%	4	19.0%
Secondary (Ordinary Level)	5	71.4%	7	50.0%	12	57.1%
Community College	1	14.3%	2	14.3%	3	14.3%
Tertiary	0	0.00%	2	14.3%	2	9.5%

Table 5.8.7 shows that just over half of the respondents sampled bear responsibility for being the household breadwinner. This is, however, much more the case for men than it is for women, as only 43% of female respondents bore this responsibility compared to 86% of the male respondents. The male to female distribution in income earning responsibility is very similar to the distribution of respondents who were the heads of their households (see Table 5.8.4).

Table 5.8.7: Sample Distribution by Main Income Earning Responsibility

Are you the main income earner?	Sex of Respondent					
	Male		Female		Total	
Yes	6	86%	6	43%	12	57%
No	1	14%	8	57%	9	43%

Although the number of breadwinners in the sample was moderate, Table 5.8.8 shows that all respondents were gainfully employed.

Table 5.8.8: Sample Distribution by Involvement in Income Generating Activity

Are you involved in income generating activity?	Sex of Respondent					
	Male		Female		Total	
Yes	7	100%	14	100%	21	100%
No	0	0%	0	0%	0	0%

Figure 5.8.3 shows that a large portion of the households sampled indicated an income of US $1,000 or less. Most of the sample fell within the US $750 – $1,000 range. There were some distinct differences in the incomes recorded by male and female headed households. The latter dominated the highest category (greater than US $1,000), but there were more male headed households in the two lowest ranges. With the variance in incomes, purchasing power may or may not be strong based on household size, lifestyle and quantity of expenses. Large households with a low household income will be at a greater disadvantage than relatively small households which have a higher income. This in turn detracts from, or contributes to the ability of the household to respond to negative external shocks.

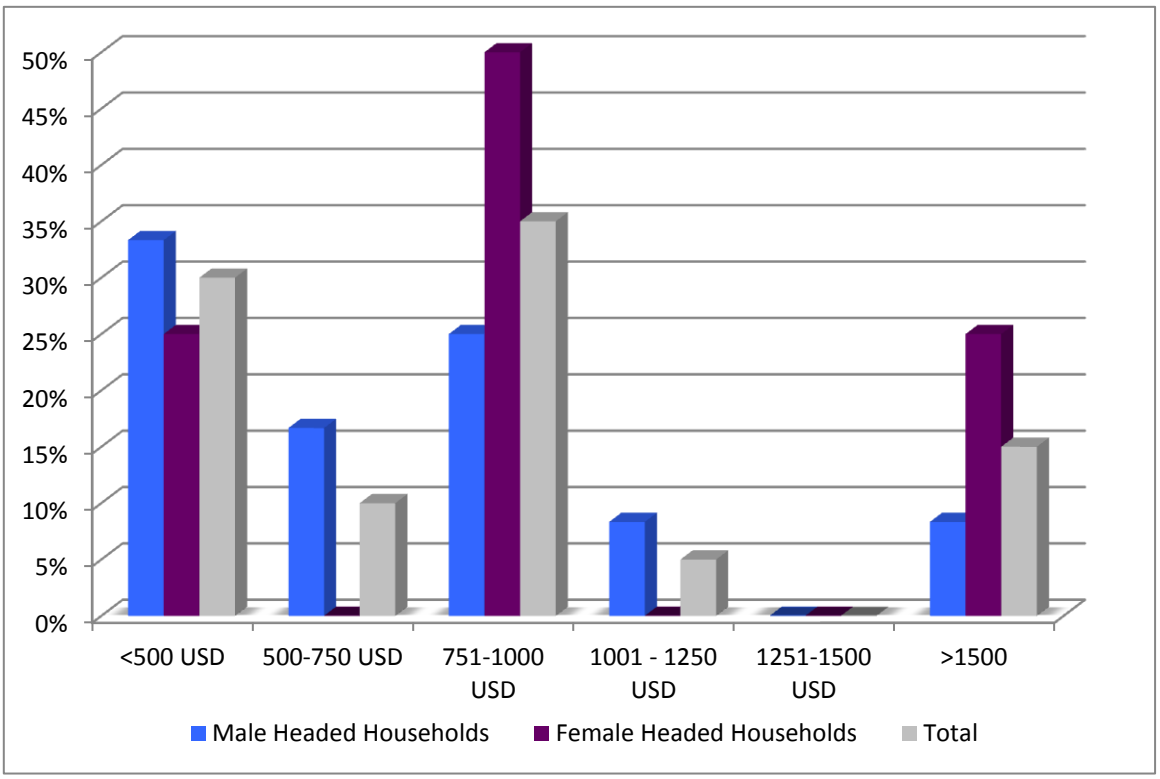


Figure 5.8.3: Household Sample Distribution by Average Monthly Earnings

In terms of employment in the tourism sector, Table 5.8.9 shows that there was a similar proportion of the sample working in the tourism and other sectors. The majority of respondents indicated working in non-tourism sectors (57%), whereas 43% of respondents indicated working in the tourism sector.

Table 5.8.9: Labour Market Participation: Involvement in Tourism Sector

Involvement in Tourism Sector	Male		Female		Total	
Yes	2	29%	7	50%	9	43%
No	5	71%	7	50%	12	57%

When asked more specifically which sub-sector they work in, 28.6% responded 'other' and 2 respondents (1 male, 1 female) indicated they were tour operators (See Table 5.8.10).

Table 5.8.10: Labour Market Participation: Involvement in Tourism Sectors

Employment Sector	Male		Female		Total	
Taxi Driver	0	0.0%	0	0.0%	0	0.0%
Tour Operator	1	14.3%	1	7.1%	2	9.5%
Hotel Workers	0	0.0%	0	0.0%	0	0.0%
Restaurant Workers	0	0.0%	0	0.0%	0	0.0%
Craft sellers or vendors	0	0.0%	0	0.0%	0	0.0%
Informal tour guides	0	0.0%	0	0.0%	0	0.0%
Privately owned business	0	0.0%	1	7.1%	1	4.8%
Other	1	14.3%	5	35.7%	6	28.6%
Did not answer	5	71.4%	7	50.0%	12	57.1%

The greatest number of respondents who are not working in tourism were employed in agriculture (14.3%) and government (14.3%). There were 9.5% of respondents indicating that they were domestic workers, as well as 9.5% indicating they were self-employed. One respondent (4.8%) worked in health services (See Table 5.8.11).

Table 5.8.11: Labour Market Participation: Involvement in Non-Tourism Sectors

Employment Sector	Male		Female		Total	
Agriculture	3	42.9%	0	0.0%	3	14.3%
Domestic worker	0	0.0%	2	14.3%	2	9.5%
Health Services	0	0.0%	1	7.1%	1	4.8%
Government Worker	1	14.3%	2	14.3%	3	14.3%
Self Employed	0	0.0%	2	14.3%	2	9.5%
Other	1	14.3%	0	0.0%	1	4.8%

5.8.4. Food Security

All of the respondents indicated that their food supply was procured from grocery stores or super markets. Additional sources of food included growing their own food (25.0%), traditional markets (30.0%), and community shops (25.0%).

Table 5.8.12: Source of Food Supply

Source of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Grown by Family	3	50%	1	16.67%	0	0%	1	12.5%	5	25%
Grocery store/Supermarket	6	100%	6	100%	0	0%	8	100%	20	100%
Open air/Traditional market	5	83.33%	1	16.67%	0	0%	0	0%	6	30%
Community	4	66.67%	0	0%	0	0%	1	12.5%	5	25%
Barter	0	0%	0	0%	0	0%	0	0%	0	0%
Other	0	0%	1	16.67%	0	0%	0	0%	1	5%

When asked about the adequacy of the household food supply, all but two respondents (both males) 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, but more research in this area could provide further insights.

Table 5.8.13: Adequacy of Food Supply

Adequacy of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Yes	4	66.7%	6	100%	0	0%	8	100%	18	90%
No	2	33.3%	0	0%	0	0%	0	0%	2	10%

5.8.5. Financial Security and Social Protection

One quarter of the respondents (25%) from female headed households and 33.3% of respondents from male headed households indicated that they receive support from relatives. In terms of giving financial support, 60% of respondents indicated giving financial support to friends, and 25% indicated giving support to a relative. Female respondents gave to religious organisations, whereas males did not.

Table 5.8.14: Distribution by Financial Responsibility for House (Receive Support)

Sources of Financial Support for Household	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Relative	0	0.0%	2	33.3%	0	0.0%	2	25.0%	4	20.0%
Family Friend	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Religious Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Charitable Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
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%

Table 5.8.15: Distribution by Financial Responsibility for House (Give Support)

Recipients of Financial Support from Household	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Relative	1	16.7%	1	16.7%	0	0.0%	3	37.5%	5	25.0%
Family Friend	5	83.3%	4	66.7%	0	0.0%	3	37.5%	12	60.0%
Religious Organisation	0	0.0%	2	33.3%	0	0.0%	2	25.0%	4	20.0%
Charitable Organisation	1	16.7%	1	16.7%	0	0.0%	0	0.0%	2	10.0%
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%

Respondents seemed equally preferential to accessing credit from less and more formal sources; 45% accessed credit from a commercial bank or credit union, while 35% sought loans from a “sou-sou” or partner scheme. Furthermore, 25% of respondents indicated seeking loans from other sources.

Table 5.8.16: Distribution by Access to Credit

Source of Credit	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Commercial Bank Loan	3	50.0%	1	16.7%	0	0.0%	2	25.0%	6	30.0%
Credit Union Loan	1	16.7%	1	16.7%	0	0.0%	1	12.5%	3	15.0%
Sou Sou / Partner	1	16.7%	1	16.7%	0	0.0%	5	62.5%	7	35.0%
Other	2	33.3%	1	16.7%	0	0.0%	2	25.0%	5	25.0%

When asked about their financial security, respondents generally believed that in the instance of job loss or the occurrence of some natural disaster, their financial reserves would last between 1 and 6 months.

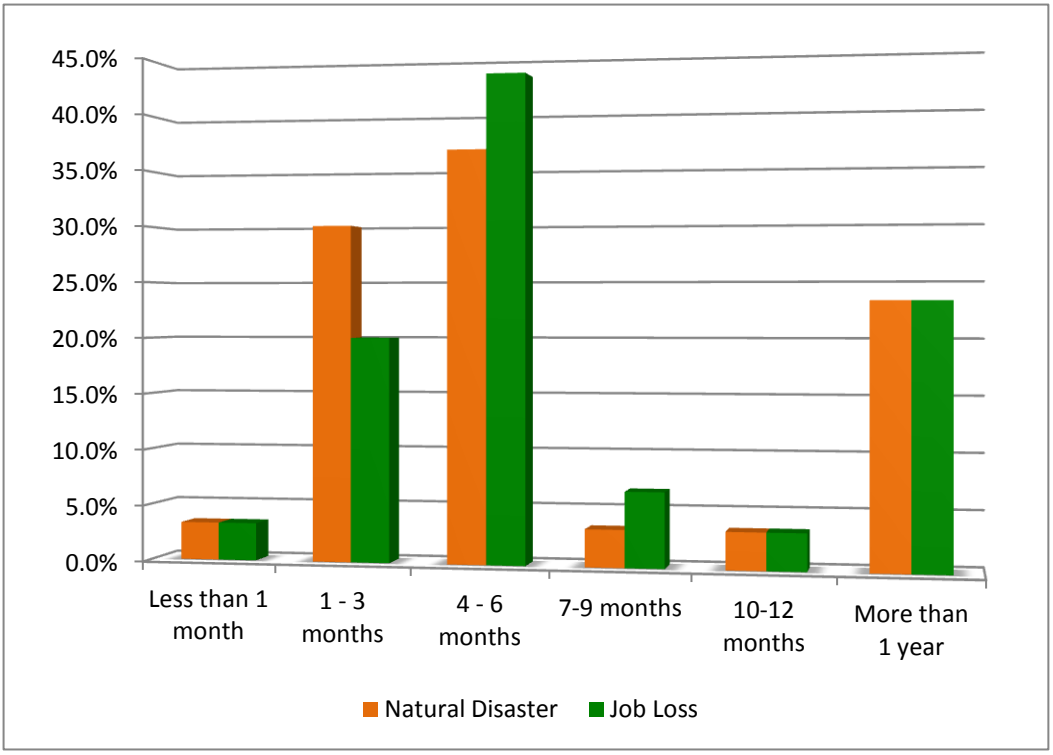


Figure 5.8.4: Financial Security: Job Loss or Natural Disaster

In relation to job loss, half (50%) of the male respondents (N = 3) indicated that they would have financial coverage for less than one month. Six of the 8 respondents from female headed households indicated they have financial reserves for 1 to 3 months. One additional female respondent from a female headed household indicated having reserves for 4-6 months, and one respondent indicated they had reserves for 10 to 12 months. All of the female respondents from male headed households indicated that they had reserves for 6 months or less.

Table 5.8.17: Sample Distribution by Financial Security: Job Loss

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	3	50.0%	2	33.3%	0	0.0%	0	0.0%	5	25.0%
1 - 3 months	0	0.0%	2	33.3%	0	0.0%	6	75.0%	8	40.0%
4 - 6 months	1	16.7%	2	33.3%	0	0.0%	1	12.5%	4	20.0%
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%	1	12.5%	1	5.0%
More than 1 year	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	5.0%
Do not know	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	5.0%

Similarly, respondents from female headed households indicated similar periods of financial coverage for a natural disaster as they had for job loss. Generally, male respondents also indicated the similar periods of financial coverage as above. In the event of a natural disaster, 4 male respondents indicated they had financial resources for less than 3 months.

The perception of the 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 5.8.18: Sample Distribution by Financial Security: Natural Disaster

Financial Reserve	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	1	16.7%	1	16.7%	0	0.0%	1	12.5%	3	15.0%
1 - 3 months	3	50.0%	2	33.3%	0	0.0%	6	75.0%	11	55.0%
4 - 6 months	0	0.0%	3	50.0%	0	0.0%	0	0.0%	3	15.0%
7 – 9 months	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	5.0%
10 – 12 months	0	0.0%	0	0.0%	0	0.0%	1	12.5%	1	5.0%
More than 1 year	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Do not know	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	5.0%

In terms of social protections provisions, respondents generally had little private social protection, with only 7 respondents having health insurance (35% of sample). Less than 20% of the sample had flooding or storm surge insurance. More specifically:

- From female headed households, no respondent had flooding, storm surge, or fire insurance, though some respondents had private pension (25%) and national insurance (25%).
- Male headed households had a higher rate of insurance coverage for home insurance against hurricane damage (42% covered), storm surge (33% covered), flooding (33% covered), and fire insurance (42% covered).

Table 5.8.19: Sample Distribution by Social Protection Provisions

Social Protection Provision	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Health Insurance	1	16.7%	3	50.0%	0	0.0%	3	37.5%	7	35.0%
Private Pension Savings Plan	0	0.0%	2	33.3%	0	0.0%	2	25.0%	4	20.0%
National Insurance / Government Pension	2	33.3%	4	66.7%	0	0.0%	2	25.0%	8	40.0%
Home Insurance - Hurricane Damage (water/wind)	3	50.0%	2	33.3%	0	0.0%	1	12.5%	6	30.0%
Home Insurance - Flooding	3	50.0%	1	16.7%	0	0.0%	0	0.0%	4	20.0%
Home Insurance - Storm Surge	3	50.0%	1	16.7%	0	0.0%	0	0.0%	4	20.0%
Home Insurance - Fire	3	50.0%	2	33.3%	0	0.0%	0	0.0%	5	25.0%

5.8.6. Asset Base

Ownership of assets, similar to provisions of social protection, were generally high for respondents. The highest proportion of respondents indicated ownership of houses (70%), followed by Land (55%) and Business (20%). There were few differences between male and female respondents when it came to ownership of assets (see Table 5.8.20).

Table 5.8.20: Sample Distribution by Ownership of Assets: Capital Assets

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
House	4	66.7%	4	66.7%	0	0.0%	6	75.0%	14	70.0%
Land	4	66.7%	2	33.3%	0	0.0%	5	62.5%	11	55.0%
Livestock	0	0.0%	1	16.7%	0	0.0%	0	0.0%	1	5.0%
Industrial/Agricultural	0	0.0%	1	16.7%	0	0.0%	0	0.0%	1	5.0%
Commercial Vehicles	1	16.7%	1	16.7%	0	0.0%	1	12.5%	3	15.0%
Private Business	2	33.3%	2	33.3%	0	0.0%	0	0.0%	4	20.0%
Other (boat)	0	0.0%	0	0.0%	0	0.0%	1	12.5%	1	5.0%

A further examination of assets revealed that respondents most often indicated having television sets (100%), mobile phones (95%), radios (90%), Internet (70%) and DVD players (70%) in their homes. Furthermore, 55% of residents indicated having landline phones while 50% of respondents indicated having a desk top computer and 45% indicated having laptops.

Table 5.8.21: Sample Distribution by Ownership of Assets: Appliances / Electronics

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Computer (Desktop)	3	50.0%	3	50.0%	NA	NA	4	50.0%	10	50.0%
Computer (Laptop)	1	16.7%	4	66.7%	NA	NA	4	50.0%	9	45.0%
Internet	3	50.0%	6	100.0%	NA	NA	5	62.5%	14	70.0%
Television	6	100.0%	6	100.0%	NA	NA	8	100.0%	20	100.0%
Video Player / Recorder	4	66.7%	2	33.3%	NA	NA	0	0.0%	6	30.0%
DVD Player	6	100.0%	4	66.7%	NA	NA	4	50.0%	14	70.0%
Radio	4	66.7%	6	100.0%	NA	NA	8	100.0%	18	90.0%
Telephone (Land line)	3	50.0%	3	50.0%	NA	NA	5	62.5%	11	55.0%
Telephone (Mobile)	6	100.0%	6	100.0%	NA	NA	7	87.5%	19	95.0%

The issue of communication in the instance of a climate related event seems more critical when measured against access to transportation. The sample most predominantly had access to public transportation, though members of male headed households had more access to private motorised vehicles. Only one respondent from a female headed household had access to a private motorised vehicle, whereas six respondents from male headed households had this access.

Table 5.8.22: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male Headed		Female Headed		Sample	
Private motorised vehicle	6	50.00%	1	12.50%	7	90.00%
Private non-motorised vehicle	0	0.00%	1	12.50%	1	94.74%
Public transit	6	50.00%	6	75.00%	12	94.74%
Other	0	0.00%	1	12.50%	1	94.74%

The largest proportion of respondents (90.0%) indicated that their home was made of wood and 10% indicated their house was made of blocks and cement. There is little difference between male and female headed households.

Table 5.8.23: Sample Distribution by Ownership of Assets: House Material

House Material	Male Headed		Female Headed		Sample	
Blocks and cement	10	83.3%	8	100.0%	18	90.0%
Wood	2	16.7%	0	0.0%	2	10.0%

Respondents indicated that they had good access to sanitation conveniences, with 90% of all respondents indicating that they always had access to liquid waste disposal. All respondents indicated that they always have access to indoor water-flush toilets and 95% indicated they always have access to garbage collection.

Table 5.8.24: Sample Distribution by Ownership of Assets: Access to Sanitation Conveniences

Amenity	Access	Male Headed	Female Headed	Sample
Liquid Waste Disposal	Always	91.7%	87.5%	90.0%
	Sometimes	0.0%	0.0%	0.0%
	Never	8.3%	0.0%	5.0%
Indoor water-flush toilets	Always	100.0%	100.0%	100.0%
	Sometimes	0.0%	0.0%	0.0%
	Never	0.0%	0.0%	0.0%
Garbage collection	Always	91.7%	100.0%	95.0%
	Sometimes	8.3%	0.0%	5.0%
	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, with 100% of males indicating they made decisions for their household, and 71.4% of females indicating they made decisions for their households. In terms of decision making in the informal community, one male indicated having a decision making role. In the formal community, 2 female respondents, and no male respondents, indicated they were responsible for decision making.

Table 5.8.25: Power and Decision Making

Site of Decision Making	Males		Females	
Household	7	100.0%	10	71.4%
Informal Community	1	14.3%	0	0.0%
Formal Community	0	0.0%	2	14.3%

Table 5.8.26: Power and Decision Making: Intra Household

Site of Decision Making	Male Headed						Female Headed					
	Male		Female		Total		Male		Female		Total	
Household	6	100.0%	5	83.3%	11	91.7%	0	0.00%	5	62.5%	5	62.5%
Informal Community	1	16.7%	0	0.0%	1	8.3%	0	0.00%	0	0.0%	0	0.0%
Formal Community	0	0.0%	1	16.7%	1	8.3%	0	0.00%	1	12.5%	1	12.5%

5.8.8. Social Networks and Social Capital

Both male and female respondents were moderately active in their community; 28.6% of female and 42.9% of male respondents reported belonging to a social group within the community.

Table 5.8.27: Social Networks: Community Involvement

Membership	Male		Female	
Yes	3	42.9%	4	28.6%
No	2	28.6%	8	57.1%

With regards to support systems, male respondents tended to rely on relatives both inside and outside of their households for physical help and financial assistance. Furthermore, male respondents also indicated relying on family friends and religious organisations for personal advice. Interestingly, 71.4% of male respondents indicated relying on religious organisations for personal advice, yet none give financial support to these organisations. Female respondents indicated relying mostly on relatives outside the household for physical, personal, and financial help. Female respondents also relied on relatives within the house for physical help while looking to family friends for personal advice.

Table 5.8.28: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	Female	Male	Female	Male	Female
Relative (within the household)	28.6%	35.7%	14.3%	21.4%	28.6%	7.1%
Relative (outside the household)	42.9%	50.0%	14.3%	42.9%	57.1%	50.0%
Family friend	42.9%	28.6%	42.9%	42.9%	14.3%	14.3%
Religious Organisation	0.0%	0.0%	71.4%	28.6%	0.0%	0.0%
Non-religious Charity	0.0%	0.0%	0.0%	7.1%	14.3%	7.1%
Government Agency	14.3%	0.0%	14.3%	7.1%	0.0%	7.1%

5.8.9. Use of Natural Resources

Subsistence

The forest/bush was deemed to be the most important resource for subsistence, with 28.6% of respondents indicating it as very important for subsistence activities. The second most important resource was agricultural land, with 19.0% of respondents indicating that it as very important.

Livelihood

Agricultural land and forests were identified as very important for livelihoods by 19.0% of the sample. Additionally, 14.3% of the sample indicated that rivers, mountains, caves and wild animals were very important for their livelihoods.

Recreation

Other than in the instance of the sea and mountains, respondents generally indicated a low level of use for natural resources for recreation purposes, with more than 75% of respondents indicating that other resources were not of particular importance to them.

When further disaggregated on the basis of sex, there was little disparity in the use of natural assets. As aforementioned, male respondents were more likely to list a resource as important, the vast majority of respondents indicated 'None/Do Not Use' most often, skewing these results. However, one point to note is that male respondents were more dependent on coastal natural resources for livelihood and subsistence while female respondents were slightly more dependent on agricultural lands.

Table 5.8.29: Use and Importance of Natural Resources

Resource	Importance	Subsistence		Livelihood		Recreation	
River / Stream	Very Important	3	14.3%	3	14.3%	3	14.3%
	Somewhat important	0	0.0%	0	0.0%	2	9.5%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	18	85.7%	18	85.7%	16	76.2%
Sea	Very Important	2	9.5%	1	4.8%	10	50.0%
	Somewhat important	1	4.8%	1	4.8%	6	30.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	18	85.7%	19	90.5%	4	20.0%
Coral Reefs	Very Important	1	4.8%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	1	6.3%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	20	95.2%	21	100.0%	15	93.8%
Mangrove	Very Important	1	4.8%	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	20	95.2%	21	100.0%	21	100.0%
Agricultural Land	Very Important	4	19.0%	4	19.0%	0	0.0%
	Somewhat important	1	4.8%	0	0.0%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	16	76.2%	17	81.0%	21	100.0%
Bush and Forest	Very Important	6	28.6%	4	19.0%	4	19.0%
	Somewhat important	1	4.8%	0	0.0%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	14	66.7%	17	81.0%	17	81.0%
Mountain	Very Important	3	14.3%	3	14.3%	7	33.3%
	Somewhat important	0	0.0%	0	0.0%	2	9.5%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	18	85.7%	18	85.7%	12	57.1%
Caves	Very Important	0	0.0%	3	14.3%	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	21	100.0%	18	85.7%	21	100.0%
Wild Animals	Very Important	0	0.0%	3	14.3%	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	21	100.0%	18	85.7%	21	100.0%

Table 5.8.30: 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	42.9%	0.0%	42.9%	0.0%	42.9%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	57.1%	100.0%	57.1%	100.0%	57.1%	85.7%
Sea	Very Important	0.0%	14.3%	0.0%	7.1%	57.1%	46.2%
	Somewhat important	14.3%	0.0%	14.3%	0.0%	28.6%	30.8%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	85.7%	85.7%	85.7%	92.9%	14.3%	23.1%
Coral Reefs	Very Important	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	92.9%	100.0%	100.0%	50.0%	100.0%
Mangrove	Very Important	0.0%	7.1%	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%	92.9%	100.0%	100.0%	100.0%	100.0%
Agricultural Land	Very Important	0.0%	28.6%	42.9%	7.1%	0.0%	0.0%
	Somewhat important	14.3%	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	85.7%	71.4%	57.1%	92.9%	100.0%	100.0%
Bush and Forest	Very Important	57.1%	14.3%	42.9%	7.1%	57.1%	0.0%
	Somewhat important	0.0%	7.1%	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	42.9%	78.6%	57.1%	92.9%	42.9%	100.0%
Mountain	Very Important	42.9%	0.0%	42.9%	0.0%	71.4%	14.3%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	14.3%	7.1%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	57.1%	100.0%	57.1%	100.0%	14.3%	78.6%
Caves	Very Important	0.0%	0.0%	42.9%	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%	57.1%	100.0%	100.0%	100.0%
Wild Animals	Very Important	0.0%	0.0%	42.9%	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%	57.1%	100.0%	100.0%	100.0%

Agriculture

Only 7 respondents indicated they were involved in the agriculture sector. Three respondents indicated they always had access to water, and 3 indicated that they sometimes had access to water. One respondent did not answer the question. Given the small sample, no conclusions can be made on the basis of gender.

Table 5.8.31: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	1	25.0%	2	66.7%	3	42.9%
Sometimes	3	75.0%	0	0.0%	3	42.9%
Never	0	0.0%	0	0.0%	0	0.0%

5.8.10. Knowledge, Exposure and Experience of Climate Related Events

Respondents indicated very good levels of knowledge in relation to hurricanes (35%), and average (65%) or very good knowledge (15%) of flooding. Respondents indicated average (50%) and very good (15%) knowledge of storm surges; average (40%) and very good (20%) knowledge of drought; average (60%) and very good (10%) knowledge of landslides.

When examined on the basis of household structure and headship, females consistently showed lower levels of knowledge of climate related events. In the instance of drought, 50% of female respondents from male and female headed households indicated that their knowledge was poor, compared to 16.7% of male respondents. Similar results are seen in terms of storm surges, with 75% of respondents from female headed households indicating that their knowledge was poor, compared to 25% from male headed households.

Table 5.8.32: Knowledge of Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	5.0%	0.0%	16.7%	8.3%	0.0%	0.0%	0.0%
	Average	60.0%	83.3%	50.0%	66.7%	0.0%	50.0%	50.0%
	Very Good	35.0%	16.7%	33.3%	25.0%	0.0%	50.0%	50.0%
Flooding	Poor	20.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%
	Average	65.0%	66.7%	33.3%	50.0%	0.0%	87.5%	87.5%
	Very Good	15.0%	0.0%	33.3%	16.7%	0.0%	12.5%	12.5%
Storm Surge	Poor	45.0%	16.7%	33.3%	25.0%	0.0%	75.0%	75.0%
	Average	50.0%	66.7%	66.7%	66.7%	0.0%	25.0%	25.0%
	Very Good	15.0%	16.7%	33.3%	25.0%	0.0%	0.0%	0.0%
Drought	Poor	40.0%	16.7%	50.0%	33.3%	0.0%	50.0%	50.0%
	Average	40.0%	83.3%	16.7%	50.0%	0.0%	25.0%	25.0%
	Very Good	20.0%	0.0%	33.3%	16.7%	0.0%	25.0%	25.0%
Landslides	Poor	30.0%	16.7%	33.3%	25.0%	0.0%	37.5%	37.5%
	Average	60.0%	83.3%	50.0%	66.7%	0.0%	50.0%	50.0%
	Very Good	10.0%	0.0%	16.7%	8.3%	0.0%	12.5%	12.5%

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 that such an event occurs:

- In the event of a Hurricane, all respondents were aware of what to do, without having to ask for assistance.
- In the instance of Flooding, a slightly smaller proportion of respondents sampled (70%) were aware of appropriate action to take, without asking for assistance
- In the event of a Landslide, only 25.0% respondents were aware of what should be done.

Table 5.8.33 highlights the few notable differences between respondents from male and female headed households.

Table 5.8.33: Knowledge of Appropriate Response to Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	100.0%	100.0%	100.0%	100.0%	0.0%	100.0%	100.0%
	No	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Don't Know	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flooding	Yes	70.0%	66.7%	66.7%	66.7%	0.0%	75.0%	75.0%
	No	25.0%	16.7%	33.3%	25.0%	0.0%	25.0%	25.0%
	Don't Know	5.0%	16.7%	0.0%	8.3%	0.0%	0.0%	0.0%
Storm Surge	Yes	45.0%	83.3%	33.3%	58.3%	0.0%	25.0%	25.0%
	No	25.0%	16.7%	50.0%	33.3%	0.0%	12.5%	12.5%
	Don't Know	30.0%	0.0%	16.7%	8.3%	0.0%	62.5%	62.5%
Drought	Yes	50.0%	66.7%	33.3%	50.0%	0.0%	50.0%	50.0%
	No	30.0%	0.0%	50.0%	25.0%	0.0%	37.5%	37.5%
	Don't Know	25.0%	33.3%	16.7%	25.0%	0.0%	25.0%	25.0%
Landslides	Yes	25.0%	16.7%	33.3%	25.0%	0.0%	25.0%	25.0%
	No	35.0%	0.0%	66.7%	33.3%	0.0%	37.5%	37.5%
	Don't Know	40.0%	83.3%	0.0%	41.7%	0.0%	37.5%	37.5%

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

When questioned about the perceived risk of climate related events to their households, respondents most often indicated a high risk of hurricanes (30%) and flooding (30%), though this was slightly more so in the case of respondents from male headed households (flooding = 33.3%, hurricane = 33.3%) than those from female headed households (storm surge = 25%, hurricane = 25%). It was, however, female respondents from male headed households indicating higher levels of perceived risk compared to male respondents.

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

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	5.0%	0.0%	0.0%	0.0%	0.0%	12.5%	12.5%
	Low Risk	65.0%	83.3%	50.0%	66.7%	0.0%	62.5%	62.5%
	High Risk	30.0%	16.7%	50.0%	33.3%	0.0%	25.0%	25.0%
Flooding	No Risk	40.0%	83.3%	16.7%	50.0%	0.0%	25.0%	25.0%
	Low Risk	30.0%	0.0%	33.3%	16.7%	0.0%	50.0%	50.0%
	High Risk	30.0%	16.7%	50.0%	33.3%	0.0%	25.0%	25.0%
Storm Surge	No Risk	65.0%	83.3%	50.0%	66.7%	0.0%	62.5%	62.5%
	Low Risk	10.0%	16.7%	0.0%	8.3%	0.0%	12.5%	12.5%
	High Risk	20.0%	0.0%	33.3%	16.7%	0.0%	25.0%	25.0%
Drought	No Risk	40.0%	16.7%	50.0%	33.3%	0.0%	50.0%	50.0%
	Low Risk	35.0%	33.3%	16.7%	25.0%	0.0%	50.0%	50.0%
	High Risk	10.0%	16.7%	16.7%	16.7%	0.0%	0.0%	0.0%
Landslides	No Risk	55.0%	50.0%	50.0%	50.0%	0.0%	62.5%	62.5%
	Low Risk	25.0%	16.7%	16.7%	16.7%	0.0%	37.5%	37.5%
	High Risk	15.0%	33.3%	16.7%	25.0%	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 events for the community than they did for their own households with regards to hurricanes and storm surges. For all other risks, respondents reported lower levels of risk to climate related events for the community than they did for their own households

Similar to the patterns observed in relation to perceived risk to respondents' households, female respondents from both males and female headed houses indicated higher levels of risk for their community in the instance of hurricane, flooding and storm surge than male respondents.

Table 5.8.35: 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	25.0%	33.3%	33.3%	33.3%	0.0%	12.5%	12.5%
	High Risk	70.0%	50.0%	66.7%	58.3%	0.0%	87.5%	87.5%
Flooding	No Risk	5.0%	0.0%	16.7%	8.3%	0.0%	0.0%	0.0%
	Low Risk	60.0%	83.3%	33.3%	58.3%	0.0%	62.5%	62.5%
	High Risk	30.0%	0.0%	50.0%	25.0%	0.0%	37.5%	37.5%
Storm Surge	No Risk	25.0%	0.0%	33.3%	16.7%	0.0%	37.5%	37.5%
	Low Risk	20.0%	16.7%	0.0%	8.3%	0.0%	37.5%	37.5%
	High Risk	25.0%	0.0%	50.0%	25.0%	0.0%	25.0%	25.0%
Drought	No Risk	30.0%	0.0%	50.0%	25.0%	0.0%	37.5%	37.5%
	Low Risk	55.0%	83.3%	33.3%	58.3%	0.0%	50.0%	50.0%
	High Risk	5.0%	0.0%	0.0%	0.0%	0.0%	12.5%	12.5%
Landslides	No Risk	35.0%	16.7%	33.3%	25.0%	0.0%	50.0%	50.0%
	Low Risk	25.0%	0.0%	33.3%	16.7%	0.0%	37.5%	37.5%
	High Risk	20.0%	33.3%	16.7%	25.0%	0.0%	12.5%	12.5%

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

The disparity between perceived risk at the household and community level was greatest in the instance of hurricane events. For example, 30% of respondents indicated a high risk for their households, compared to 70% whom indicated a high risk for their respective community.

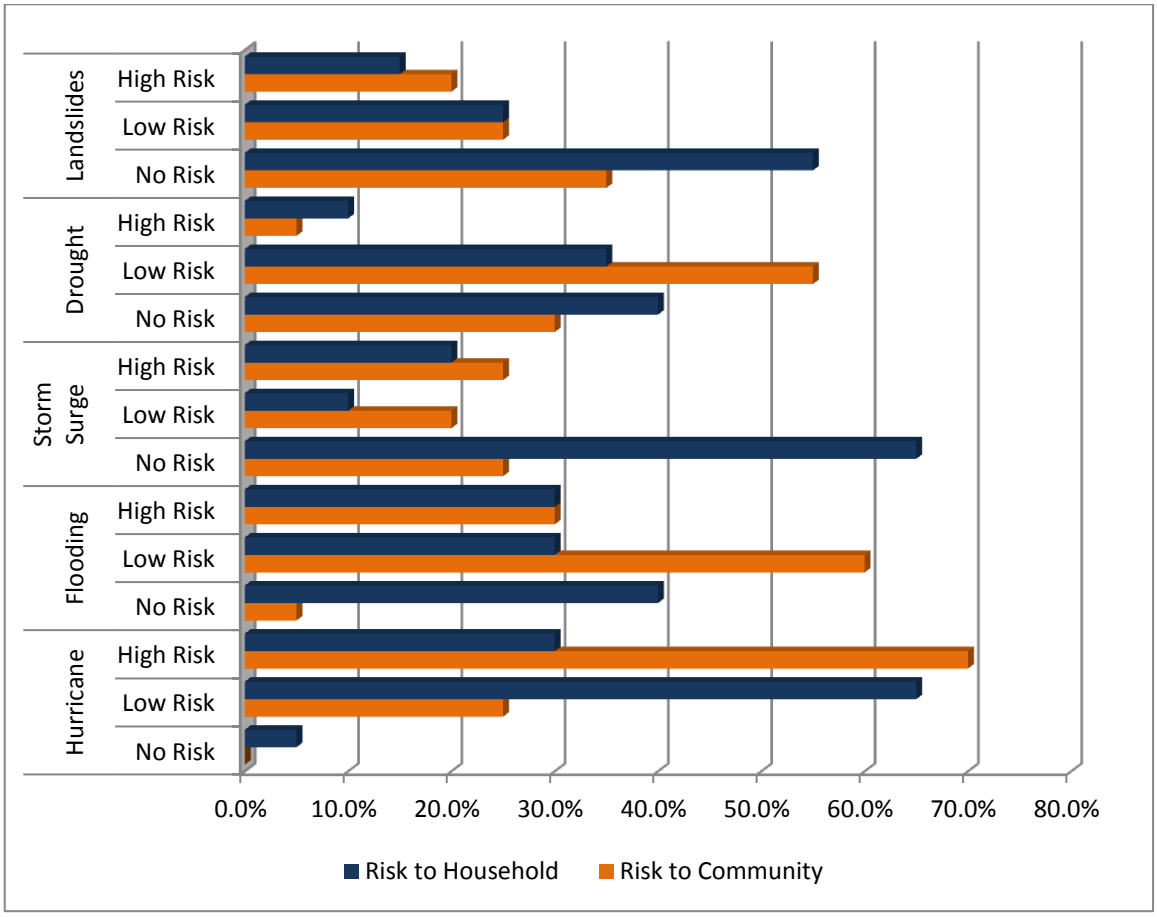


Figure 5.8.5: Perception of Risk for Climate Related Events

Similar to the perceptions of risk of climate related events, respondents consistently reported higher levels of support received within the community than in their respective households during such an event. The greatest disparity was observed in residence in shelter, infrastructure improvements, and relief supplies. The disparity in the availability of education materials and evacuation assistance is also worth noting.

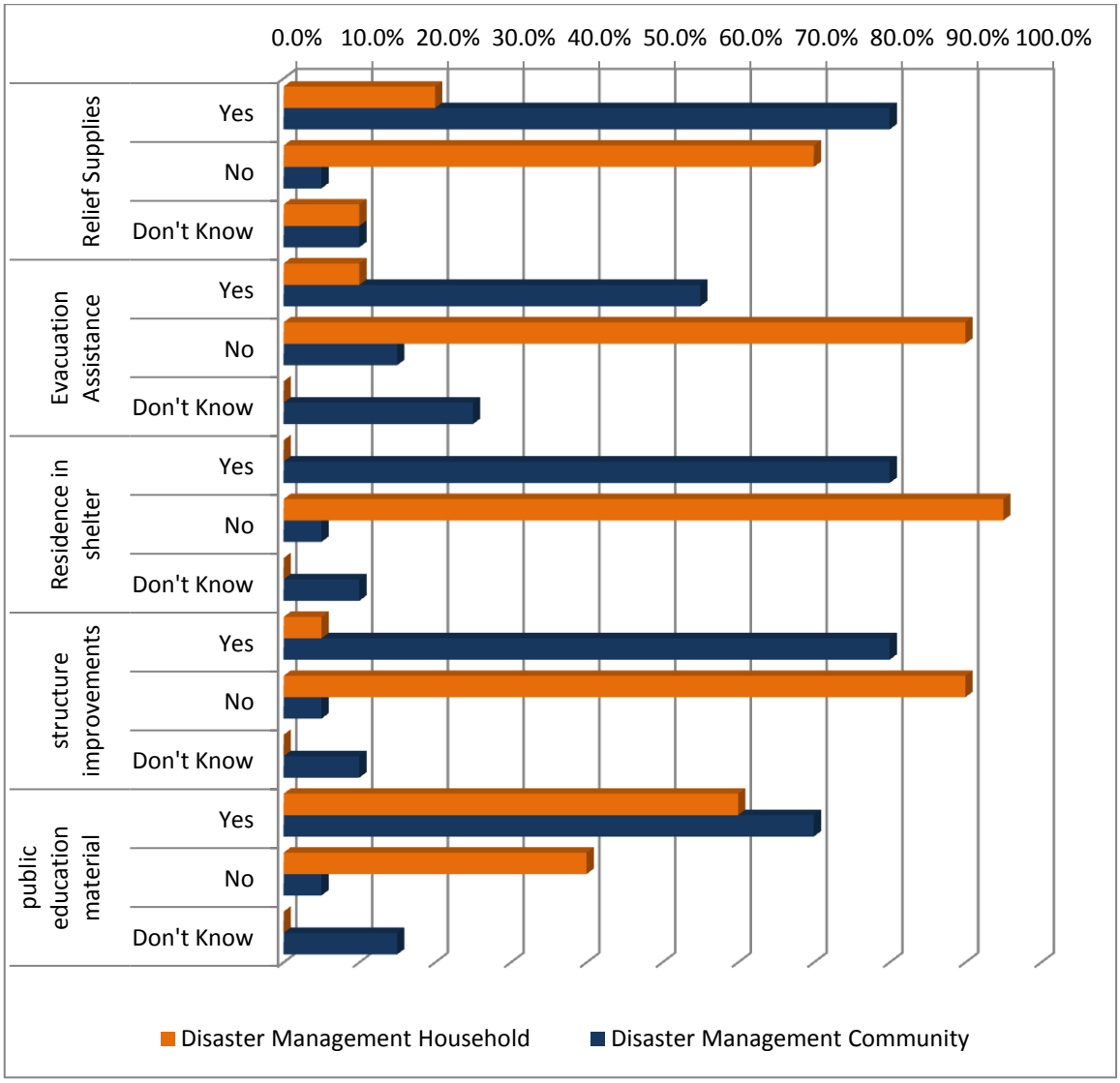


Figure 5.8.6: Support during Climate Related Events

6. RECOMMENDED STRATEGIES AND INITIAL ACTION PLAN

The following recommendations have been developed in consultation with national and community stakeholders through the use of various participatory tools. They support the main objective of the CCCRA which is to provide a scientific (physical and social) basis to support decision making, policy and planning by governments, communities and the private sector that increase resilience of economies and livelihoods to climate change. The recommendations are also consistent with the strategies and programmes identified in the *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change* endorsed by the CARICOM Heads of State.

Recommendations are presented as an initial plan of action with a brief description of the intervention, the national and/or local stakeholders involved and the expected benefits, and are categorised according to short-, medium- and long-term interventions. All recommendations are considered 'No-regret' or 'Low-regret' strategies. 'No-regret' strategies seek to maximise positive and minimise negative outcomes for communities and societies in climate-sensitive areas such as agriculture, food security, water resources and health. This means taking climate-related decisions or actions that make sense in development terms, whether or not a specific climate threat actually materialises in the future. 'Low-regret' adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components, for example installing larger diameter drains or hurricane shutters at the time of initial construction or refurbishment (World Bank, 2012).

Each one or a group of recommendations can be further developed into a concept note or project proposal with a full action plan, with much of the supporting information found in this document. Earlier sections of this report have provided the rationale for recommended interventions based on the vulnerabilities and adaptive capacity identified for key sectors.

6.1. *Cross Cutting Actions*

The following activities must be undertaken in the short-term, across a number of sectors, to ensure the success of the more specific and practical recommendations presented in later sections. These cross-cutting actions provide the necessary foundation, in terms of information and data, development policy, awareness raising and cross-sectoral linkages from which wider actions to combat the threat of climate change on future development can be 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:

- **Conduct 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. However, capacity assessments and appropriate training may be needed initially to ensure that St. Kitts and Nevis has the necessary personnel, capable of undertaking both energy and carbon audits.
- **Epidemiology data with climate signals:** Further research is needed to link the epidemiology of diseases in St. Kitts with climate data. More detailed information, especially presenting temporal, environmental and climatological data, is needed. This has been specifically prescribed for St. Kitts and Nevis by Rawlins et al., (2007) in their Knowledge, Attitude and Practices Study of the Issues of Climate Change/Variability Impacts and Public Health in the country. They state that "there is a need for climate-based impacts on health issues to be carefully examined and evaluated, then presented to the community for their action in preventing disease".
- **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.
- **Improve data collection, especially for bathymetric and meteorological data, and ameliorate monitoring of beach erosion, installing more tidal gauges to monitor SLR.** Although data is currently collected for many of these variables, more data and standardisation of methods for data collection will allow for improved decision making. There is no meteorological service available in St. Kitts or Nevis, and so weather forecasts are provided by Antigua and Barbuda. In coordination with the relevant ministries, it is recommended that more tidal gauges be installed and a standard methodology for data collection be devised.
- **Develop an in-depth water monitoring programme.** The WSD is severely limited by inadequate data collection and storage, hampering its ability to make water resource development decisions. A programme should be established to address this, including the monitoring of ground and surface water quantity and quality.

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 has been revised in recent years, Section 5.7.3, but should nonetheless 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.

- **National Energy Policy and Plan:** There is a need to ensure that climate change is considered in the existing plan and policy, not just from a mitigation standpoint, but also in relation to ensuring that the energy infrastructure and systems will be sustainable under climate change. For example, assessing the vulnerability of coastal infrastructure and power plants. 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.
- **Integrate SLR into the design of all coastal structures:** Environmental Assessments and construction permits for coastal structures should be required to take into account the most recent estimates of SLR from the scientific community. The Department of Development and Planning 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 St. Kitts and Nevis 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 St. Kitts.
- **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 guide reviews and updates of the official land use plans. The development of official SLR risk maps should also be considered to further guide future coastal development. In particular, there needs to be work in the following areas:
    - Develop and enforce 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; and (ii) unplanned and unsustainable agriculture should not be practiced.
    - Ensure the protection of existing mangrove forests.
- **Incorporate SLR and climate change impacts into tourism master plans.** Work with relevant tourism stakeholders to develop sustainable tourism plans with a focus on diversification of the tourism product toward the interior of the island. 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 island. 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. NEMA, and the Ministries of Tourism and Physical Development should collaborate on this project to create a sustainable tourism plan that is in line with other sustainable development goals in St. Kitts.

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. Kitts in the past, 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.

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 and is supported by an acknowledgement in the studied community that awareness building is needed with regard to climate change and associated hazards:

- Climate change issues in general;
- Novel efforts by NEMA, building on their existing good work, would stimulate fresh interest in the public in areas of disaster risk reduction and emergency preparedness.
- Water conservation at the household and hotel level to alleviate pressure on groundwater systems. In hotels, conservation measures should include the installation of low flush toilets, automated faucet controls in public facilities, aerated faucets in guest rooms, and low flow showerheads in bathrooms (MHE, 2001).
- The proper use of rainwater harvesting systems including water treatment;

- 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.
    - In a study entitled "A Knowledge, Attitude and Practices Study of the Issues of Climate Change/Variability Impacts and Public Health in Trinidad and Tobago and St. Kitts and Nevis", while the majority of respondents believed that health was the most important issue that that would affect them, 56% of respondents could not specify what specific impacts had the potential to affect them (e.g. food borne diseases, vector borne diseases etc.) (Rawlins, et al., 2007).
- The level of awareness of SLR impacts and costs needs to be raised for all levels of the St. Kitts Government and administration to better inform decision makers within the tourism sector including operators, investors, planners, developers, policy makers, architects and communities.
- Promotion of sustainable seafood.

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. NEMA can work with the Red Cross to develop a culturally appropriate communication plan that will not only communicate the vital information Kittitians need to reduce their vulnerability, 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 in St. Kitts and Nevis. 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 St. Kitts 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*

In addition to mainstreaming water considerations into land-use plans and building codes, raising awareness of the need for water conservation at both the household and hotel level, and collecting additional data to monitor water quality and quantity, Sections 6.1.1, 6.1.2 and 6.1.4, a number of other

specific activities are recommended for the water sector. However, all of the activities and recommendations would form smaller components of a holistic and integrated water resources management plan (IWRM). These points should be considered in the drafting of the new Water Resources Management Act.

Medium term

Review and enhance the Water Resources Management Plan, 2009: The St. Kitts WSD is responsible for managing water resources in St. Kitts, however the basis of IWRM is that different users of water are interdependent and 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. The main components of IWRM are: managing water resources at the lowest possible level (at the river basin or watershed scale); optimising supply and managing demand; providing equitable access to water resources through participatory and transparent governance and management; establishing improved and integrated policy, regulatory and institutional frameworks; utilising an inter-sectoral approach to decision making; integrating management means that we receive multiple benefits from a single intervention. IWRM requires that platforms be developed to allow different stakeholders to work together. As such, cooperation with the Department of Physical Planning and the Environment, the Environmental Health Department, Department of Agriculture, Solid Waste Management Corporation and the Public Works Department will be required since all of these agencies have roles in water management. In addition, various private sector stakeholders and the general public will need to be consulted. Institutional and legislative frameworks at all stages of water planning and management should be revisited, assessed and, if necessary, amended to allow the implementation of IWRM.

Specific components of an IWRM plan that have been highlighted in this research for St. Kitts are:

- **Develop measures to protect aquifers from surface contamination and protect water quality.** This should include re-vegetation of hill slopes and the implementation of a comprehensive reforestation programme to reduce erosion and protect water quality from sediments. The proposed plans to designate the Basseterre Valley Aquifer Area into a Natural Park – *St. Kitts National Capitol Park* and the *St. Kitts National Botanical Plaza*, which includes the restoration of native forest (Dr Sahely, personal communication, April, 12, 2011) should be implemented. Upper watershed areas, which are suitable for sustained production of water, should be declared as protected areas, including the Wingfield, Frankland's, Stonefort, Greenhill, Phillips and Lodge catchments (MSD, 2007). These protection zones should be built into the land-use plans described in Section 6.1.2.
- **Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes.** In particular, (i) water storage should be encouraged through incentives and regulation (Section 6.1.2 on the building code); (ii) the viability of additional storage should be assessed, allowing improved access to potable water in different communities; and (iii) water distribution losses should be reduced through pipe replacement.
- **Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation.** The country has a number of activities that demand considerable quantities of water, for instance golf courses and the tourism industry particularly through cruise ships. Waste water from the domestic and tourism use can be recycled to produce irrigation water, either for agriculture or the irrigation of golf courses. This would alleviate the pressure on groundwater supplies. A specific method for waste water treatment is outlined in Section 6.6.

- **Undertake broad consultation over the licensing of abstraction for private water supply.** Licensed abstraction would allow much closer control over groundwater levels and enable mitigation of potential impacts of drought and sea-level rise. However, for this to be effective, detailed information on the impacts of licensed abstraction on groundwater levels would be required.
- **Develop computer models of groundwater flow to account for the impact of SLR on groundwater levels.** Numerical models of ground-water have been used elsewhere to establish how SLR impacts on aquifer thickness and saline intrusion (e.g. Bobba, 2002). Due to the particular vulnerability of aquifers in St. Kitts, these models should be developed urgently to effectively mitigate the effects of climate change on freshwater resources.

Investing in IWRM is a no-regret option given the evidence presented that there are already a number of water resource issues and water quality issues that should be addressed to improve sustainability of the resource. In addition, issues such as water quality and water supply have further impacts on ecosystems and human health.

6.3. *Energy Supply and Distribution*

St. Kitts and Nevis have already undertaken substantial investigations and developed a draft National Energy Plan and Policy that advocates a number of initiatives to move towards becoming "an island nation with a sustainable energy sector where reliable, renewable, clean and affordable energy services are provided to all its citizens" (MOPWUEH, 2011b). With the steadily increasing global fuel prices, all of these options are no-regret since establishing greater energy security and increasing energy efficiency will alleviate some of the financial pressures already being experienced.

Short term

Create incentives for low-carbon technology use: The introduction of low-carbon technology needs to be supported through incentive structures. An ecological tax reform, for instance, could shift tax burdens from labour to energy and natural resources, and thus "reward" users of low-carbon technology. Other incentives could include financial support, reward mechanisms or awards. There is also a range of examples of bonus-malus systems in tourism and transport, rewarding those choosing to pollute less. The majority of incentives would have to be developed through the Ministry of government with responsibility for Finance and taxation. However, in order to ensure that the incentive scheme will be successful there should be substantial co-ordination with other relevant ministries, such as Tourism, Public Utilities and the St. Kitts Electricity Company.

Medium term

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 Plan and 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.

Stabilise energy pricing to influence energy use and emissions: Taxes, emission trading, and other economic instruments are needed to steer energy use and emissions, conveying clear, long-term market

signals. It is important for these economic instruments to significantly increase the costs of fossil fuels and emissions. Price levels also need to be stable (not declining below a given level), progressive (increasing at a significant rate per year) and foreseeable (be implemented over longer time periods), to allow companies to integrate energy costs in long-term planning and decision-making. Electricity prices in St. Kitts have historically been kept low through subsidies and Government ambitions to reduce electricity prices in St. Kitts and Nevis could counteract efforts at energy efficiency. As with the recommendation on incentives, this would require collaboration between the Ministries of Finance, Energy and the St. Kitts Electricity Company.

Use regulation to stimulate changes and adaptation: In addition to the adjustment of energy pricing and the implementation of policy there are other opportunities to stimulate behavioural change through regulation. Energy-intense forms of tourism and transport could be banned or regulations imposed that require, for example, a percentage of hire cars to be of a certain size or electric to facilitate rapid adoption of the technology.

6.4. *Agriculture and Food Security*

While biophysical model projections are useful for gaining an appreciation of the likely climate change impacts on rain-fed agriculture, future research should draw upon experiences of how local farmers already adapt to weather variability and extreme events as a reference point for adaptation to the uncertain and changing conditions of the future.

Short term

Continue collaboration between the Taiwanese Mission in St. Kitts and Nevis and decision makers and technicians in agriculture. Continuing the existing collaboration between researchers attached to the Taiwanese Mission and decision makers and technicians in agriculture can be the key to developing projects that deal with agriculture and climate change, ensuring that the knowledge produced is both useful and *used* by local farmers. The four crops identified in the competitiveness study as alternatives to sugar-cane; pumpkin, peanut, sweet potato and onion, (Edwards and Jacque, 2008) can be used to model the impact of climate change on production of these four crops with adaptation strategies (such as stress tolerant varieties and improved crop management) and *without* adaptation strategies. At the CARIBSAVE National Stakeholder workshop, representatives from the Sandy Point Agricultural Co-op Society Limited expressed an interest in becoming involved in trials to improve understanding of climate sensitivity and tolerance in crops. A multi-location project with the farmers from this cooperative, coupled with the novel, government owned Capisterre Farm, can help to develop new, adapted varieties of the four selected crops that respond to a changing climate. This low-regret option is needed to boost the sustainability and profitability of agriculture in a country that has moved away from sugar cane. It is a flexible intervention, because once the methodology and technical capacity have been established it can be repeated for other crops or for different climate scenarios. The findings should also be transferable to other countries in the region.

6.5. *Human Health*

Medium term

Conduct assessments focussing on the links between health, tourism and climate change: The need for additional information on the epidemiology of diseases is highlighted in Section 6.1.1, but there is also a

need to investigate the links to tourism. 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 fail to diagnose the disease in every case (Wilder-Smith and Schwartz, 2005). It is recommended that a study of visitors leaving the island be conducted to determine the validity of this statement.

Important questions to be answered in the tourism sector are 'would substitution of destinations occur if tourism related health problems increased as a result of climate change?' and 'what is the perception of tourists to health and climate change in the island?' The consequences of air travel and the cost of health care incurred by 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 St. Kitts has found numerous ways to adapt to the range of health issues described. This type of research would be best carried out by tertiary research institutions in the region, utilising data collected in the health and tourism sectors. Additional data would be available from national tropical disease centres in source market countries. The collection of such data would be labour intensive, but would be a valuable contribution to health research and understanding the wider, indirect impacts of climate change. Potential collaboration with CEHI, CCCCC, CAREC and PAHO should also be explored.

Build a supply of public health resources for the surveillance, prevention and control of vector borne diseases: The Public Health Department of the Ministry of Health is responsible for maintaining environmental health and vector control and surveillance. 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". For St. Kitts this will require the implementation of measures that ensure appropriate inclusion in the National Disease Surveillance Systems, which is particularly important for schistosomiasis as this disease is not reported in the country. It is therefore recommended that the Integrated Vector Management (IVM) Programme approach of the WHO be adopted. Diseases that have a climate change signal in St. Kitts include dengue fever and to a lesser extent malaria. Limited human capacity and attention to evaluation are two major challenges to the utilisation of IVM and need to be addressed under this recommendation.

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 as a practical way to execute effective disease control (Ebi *et al*., 2006). Such a system would consider temperature signatures for vector borne diseases for example, however these must first be validated (Amarakoon *et al*., 2006) and should be site-specific (Ebi *et al*., 2006). Other signatures could be further researched such as the use of the pre-seasonal treatment (Chadee, 2009). With respect to respiratory infections, a special Early Warning System could also be developed.

6.6. *Marine and Terrestrial Biodiversity and Fisheries*

Short term

Improve the management and resilience of fish sanctuaries. Management of MPAs in the Caribbean often suffer from a severe lack of funds, which subsequently limits the effectiveness of the MPA in boosting fish stocks. Therefore, creating a strategy for the following areas would benefit the sanctuaries, but also the fishers and the wider community:

- establishing a more effective fish sanctuary management and enforcement system for coastal communities;
- enhancing the capacity of resource managers and users to make the sanctuaries 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. This no-regret intervention will have benefits regardless of the outcomes of climate change and is flexible enough to be adapted to suit the needs of the specific community. Key government stakeholders are the Ministry of Tourism, the Departments of Physical Planning and Environment within the Ministry of Sustainable Development and the Department of Marine Resources. However, it is important that this initiative is not driven by the public sector alone, but works with private sector entities and communities as well. In fact, ownership and management of the MPA initiative may be best placed within the community if it is to be sustainable in the long-term.

Mangrove restoration and protection: Reforestation of the mangrove stands will improve the health of fish nurseries, fish sanctuaries and coral reefs, thus benefitting the livelihoods of those engaged in marine-based activities. Healthy mangrove forests also provide better protection of the coastline and coastal communities from natural disasters such as storm surge and hurricanes. However, reforestation projects will not be effective as long as development projects that remove and damage mangrove stands are still approved. St. Kitts therefore needs clear legislation to protect mangroves from being cleared for development, see Section 6.1.2 and the development of a land-use plan. Setback guidelines, as available for the sister island of Nevis, are one way of ensuring mangrove protection.

One method of mangrove reforestation which 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 would like to explore the option of using water-proofed paper tubing that will biodegrade over time. This adaptation from the REM methodology will simplify the process since the piping will not have to be removed once the saplings have grown to reproductively mature trees. A natural alternative is the use of bamboo wave attenuators to protect developing saplings. The Department of Environment and the Department of Marine Resources might be best placed to lead this initiative with substantial support from communities and NGOs.

Medium term

Construct/restore Wastewater Wetland Treatment Systems (WWTS): This option for wastewater treatment would be a viable solution for addressing issues of water quality and limited resources for

irrigation mentioned in Section 6.2. A study on hotel sewage package treatment plants in Saint Lucia found that the highest quality effluent was at a wetland treatment system for a medium-sized hotel (UNEP, 1998). Wetlands naturally act as bio-filters to remove contaminants from wastewater. Sewage is first pre-treated with screening and settling, the wastewater then flows into a three-tiered, free-water-surface wetland system dug into a hill. The wetland effluent passes through a filter and then is disinfected with an ultraviolet lamp. WWTS are a low maintenance, low energy and cost effective alternative to conventional treatment options. They also add aesthetic and habitat values. Priority sites for constructed/restored wetlands should include hotels and tourist related operations, especially those near fish sanctuaries and other important ecosystems. This strategy provides an opportunity to strengthen collaboration between the tourism, planning, water and environment departments. Hotels that utilise the WWTS may also benefit from gaining preferred status as eco-friendly establishments. This type of system would essentially be a private sector initiative, but will need support from the various regulatory ministries such as Public Health Department, Physical Planning and Environment.

Promote sustainable seafood: The movement towards sustainable seafood will lend support to the Department of Marine Resources' objective to reduce fishing pressure in near shore areas. By creating awareness and promoting the catch and sale of more sustainable fish and seafood species a shift can be made in *consumer* demand towards more sustainable seafood. Guidelines such as Seafood WATCH by the Monterey Bay Aquarium and the Blue Ocean Institute seafood guide provide examples of a programme that can be tailored to the St. Kitts' catch profile. A sustainable seafood programme presents an opportunity for the private sector, in particular the tourism industry, to participate in managing the resources that they depend on. Information for consumers and fishers in the form of pocket-sized guides and mobile phone applications will allow for wide spread distribution and easy access to information. The Department of Marine Resources could initiate this recommendation and look for sponsorship from the private sector. The guide could also be developed in collaboration with regional research institutions like CERMES at UWI Cave Hill.

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. Kitts and Nevis, 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. This no-regret option will assist decision-makers with existing problems regardless of the future outcomes of climate change.

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.

Commence coastal protection adaptation planning early: At present there is no comprehensive plan to deal with climate change and the beaches are largely unmanaged. The government of St. Kitts needs to work with local stakeholders, including the St. Christopher Heritage Society, on the development of coastal protection systems. The detailed local level planning for coastal protection needs to begin in the short term 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. Planning for coastal adaptation is a low-regret option since substantial effort is required to undertake the necessary groundwork. However, once the investigations have been completed, the planning process that is based on sound information should be flexible enough to adapt to any new understanding of SLR impacts.

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. Determining the secondary and tertiary economic impacts of damages to the tourism sector and possible adaptation strategies for St. Kitts should be a priority for future research. This will enable the identification of the degree to which St. Kitts 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. This type of investigation should be instigated by the Ministry of Sustainable Development, but may be best undertaken by a private consultant with expertise in this area. Although the focus of the analysis is on SLR, understanding the possible impacts of a damaged tourism sector on other areas of society and planning for diversification remains useful even if SLR does not happen. The tourism sector could equally be damaged from an incident that causes long-lasting bad publicity, the cessation of airlift due to untenable fuel costs or a continued and worsening global recession.

Assess the adaptive capacity of the tourism sector 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. The primary responsibility for this recommendation lies with the Ministry of Tourism and Ministry of Sustainable Development. Substantial consultation should be undertaken with the private tourism sector to ensure that there is buy-in to any future plans for retreat.

Review and develop policies and legal framework to support coordinated retreat from high-risk coastal areas. The land use plans highlighted in 6.1.2 must support coordinated retreat from high-risk coastal areas. The Government of St. Kitts must review existing policy and legal frameworks to assess the responsibilities of the state and landowners for the decommissioning of coastal properties damaged by the impacts of SLR. The Government should also examine the 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 reassessed in light of new SLR projections to ensure that new developments are not built in vulnerable coastal areas.

6.8. *Comprehensive Natural Disaster Management*

Short term

Review the early warning systems: The review of existing systems for warning communities and individuals should be reviewed, especially for flooding and landslides. The recommendation is strongly linked to the need for improved and timely data collection highlighted in Section 6.1.1. NEMA should work closely with the meteorological services in Antigua and Barbuda as well as develop national capacity perhaps through the assistance of CIMH. The specific community research also led to a similar recommendation, Section 6.9.

Medium term

Conduct capacity building and technical training programs for NEMA employees so that the current technical deficiencies can be remedied and skills gained. The need for training on Economic Impact Assessment and post-disaster Damage and Needs Assessment was revealed during this research. To achieve CDEMA's capacity building goals under the Comprehensive Disaster Management Strategy and Plan, technical training within the Participating States' disaster offices should be a priority. The RNAT team and the CARICOM Disaster Response Unit have excellent technical expertise within the military but those teams are only required with major disasters and often leave before all affected communities are assessed. Therefore, this recommendation is to build capacity at the local and national level. In this way, NEMA and their volunteer community groups can manage risks better and also have a better understanding of the vulnerability in the communities across St. Kitts. The need for community level activities was also raised by members of the studied community in Section 6.9. This is a no-regret option since the island already suffers from natural disasters regardless of the outcomes of climate change.

Seek out alternative funding options for disaster risk reduction, vulnerability reduction, sustainable development or hazard mitigation from regional and international organisations to ensure continuity of programming and staff within NEMA. Substantial funding is available in loans, grants and support for sustainable development or post-disaster reconstruction and outside the CCRIF there is no donor engagement in St. Kitts (GFDRR, 2010, p. 225). St. Kitts has reported that limited financial resources are available from the national government; however disaster management activities have direct links to sustainable development. Funds which address risk reduction will also have benefits to the livelihoods of those in St. Kitts. The Inter-American Development Bank has a Disaster Prevention Fund that can be used for institutional strengthening and equipment. This type of funding can help keep programmes running by directly funding positions in NEMA. The benefit would then be a set of capable staff that can continue to work on DRR and preparedness in St. Kitts.

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

During the consultations, community residents highlighted various strengths and gaps in their ability to adapt to climate change, and also put forward recommendations to increase their resilience. Many of these recommendations are inter-related, so that concerted effort on one area should have a positive feedback effect in other areas. In some cases similar recommendations are identified in the relevant sectoral assessments, thereby providing additional support for that particular recommendation.

Short term

Promote education and awareness of climate change and associated hazards within the community. Despite the knowledge of climate change that exists within the community, residents themselves see a

need for more awareness building activities. In particular the community suggested creating appropriate information and awareness tools for schools and youth, empowering them to communicate climate change. Similar strategies could be used for other community residents to empower them to increase their own resilience to climate change. In communities, an attitude seems to exist of "Each One Teach One" which would contribute to the sustainability of messages and capacities to respond to climate change. As outlined in Section 6.1.4, education activities should be coordinated across sectors to maximise impact and avoid duplication of efforts.

Review drainage and engineering infrastructure to reduce flooding. A comprehensive review of drainage issues and the implementation of some specific actions that could eliminate or reduce flooding would reduce the vulnerability of communities and their livelihoods. Identification of flood prone areas should also feed into the land use plan mentioned in Section 6.1.2. The Department of Physical Planning should initiate this investigation that may require a private consultant with the necessary expertise.

Medium term

Identify opportunities for community level disaster mitigation activities that can be implemented through collaboration between the District Disaster body and the community. The community reported that there is no formal multi-hazard warning or advisory service within the community and therefore suggested that a community-based and community-run disaster management group or council should be established. There is also a need for a multi-hazard warning system within the community. Mobile telecommunication technology has started to play a very important role in information relay and can be integrated into a community-based warning system. Both of these components of community capacity building are supported by the findings in Section 6.8.

Build capacity to strengthen the resilience of livelihoods in coastal communities to climate change: This should be done using the proven approach of Action Research, whereby selected individuals gain practical knowledge through first-hand experience and personal exchanges. This type of initiative is best implemented regionally. Specific activities include:

- *Establishment of Action Learning groups* from selected communities;
- *Sharing lessons and providing opportunities* to learn how linkages between micro-, small and medium-sized enterprises (MSMEs) provide effective adaptation to climate change, can expand markets and promote business sustainability, through:
    - workshops
    - knowledge networks
- *Analysing and addressing constraints to adaptation;*
- *Training for alternative livelihoods and value-added products.*

The fish sanctuaries suggestion in Section 6.6 is one example of an initiative that can strengthen the resilience of livelihoods in coastal communities.

Long term

Mainstream gender and poverty into climate change and related policies: Challenges of poverty reduction and climate change need to be addressed in a coherent and synergistic way. It needs to draw on the lessons and progress in development policy and particularly the recognition of the importance of gender differences if policies are to be sustainable, effective, and benefit all sectors of the population. Achieving sustainable and effective responses to climate change requires attention to the underlying power relations and gender equalities which create vulnerability both to poverty and climate hazards, and a more gender-

sensitive approach which takes into account and evaluates the differing and potentially inequitable access which men and women have to economic, ecological, social and human resources, institutions, governance and infrastructure. These factors could be addressed through a project to:

- *Provide gender disaggregated data and evidence on the impacts of climate change* to show how men and women are being affected differently by climate-related changes. This could be done for direct impacts, such as extreme weather conditions or disasters, water shortages, food insecurity or changes in land use. This could also be done for indirect secondary impacts, such as access to energy, changes in employment opportunities, sectoral impacts (e.g. agriculture, tourism and fisheries), and increased migration or conflict.

- *Conduct a gender- analysis on the social impacts of current policies on adaptation and mitigation* and how they may benefit or adversely affect men and women in different ways. Even when policies have clear gender-related statements or objectives, rarely do they have the mechanisms in place to integrate gender at a programme level or to measure the impact of the policies from a gendered perspective. Economic cost-benefit analyses often overlook the social implications and there is a lack of methodology for measuring the gendered impacts of current policies.

- *Improve institutional capacity in key agencies to implement gender sensitive policy or gather gendered data.* This is needed due to the lack of gender experts involved in policy design and implementation around climate change; the lack of awareness or gender training of key staff in ministries and statistics offices responsible for climate change data and policies; and a general disconnect between the reality of poor people's (and particularly under-represented women's) lives and policy makers.

7. CONCLUSION

7.1. *Climate Modelling*

Recent and future changes in climate in St. Kitts 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 RCMs.

We use a combination of GCM and RCM projections in the investigations of climate change for a country and at a destination to make use of the information about uncertainty that we can gain from a multi-model ensemble together with the higher-resolution simulations that are only currently available from two sets of model simulations. Further information about model uncertainty at the local level might be drawn if additional regional model simulations based on a range of differing GCMs and RCMs were generated for the Caribbean region in the future.

7.2. *Water Quality and Availability*

In St. Kitts, the majority of water is sourced from approximately 28 groundwater wells which provides for 70% of water needs and 7 surface springs which provides for 30% of water needs (MPWUTP, 2010). Currently, it is estimated that approximately 50% of the available groundwater resources of the island have been exploited (Dr Sahely, personal communication, April, 12, 2011). The current water supply is sufficient to meet all parishes due to investments in water infrastructure by the St. Kitts Water Services. No central sewerage system exists in either St. Kitts or Nevis; however there is one treatment plant at Frigate Bay. The cost of water in St. Kitts was last revised in January, 2001. There are 3 pricing groups; domestic, non-domestic and a concessionary rate for farmers. These pricing groups are further sub-divided according to metered or non-metered costumers. The St. Kitts WSD is the sole water provider on this island, meaning that all water is provided by the Government. Approximately 83% of users are metered.

Groundwater resources were initially developed in St. Kitts due to its greater reliability compared to surface sources. All of the groundwater resources from St. Kitts are sourced from coastal aquifers. Inevitability, with 70% of water demand being derived from groundwater, the St. Kitts WSD are beginning to see early signs of saltwater intrusion (Dr Sahely, personal communication, April, 12, 2011).

During the dry season, spring areas are subjected to periodic episodes of water shortages due to tourism water demand and the general rise in the standard of living of persons. In these episodes, water is sourced from areas that have wells (ECLAC, 2003). Greater use of groundwater resources assists in meeting water demands during conditions of drought.

The water resources on the island are believed to be sufficient to meet current demand, but future increases in demand cannot be met with current infrastructure and from current supply sources. Fortunately, there are still groundwater resources that have not been exploited on the island; it is estimated that 50% of groundwater resources have not been tapped into (Dr Sahely, personal communication, April, 12, 2011). A number of threats of water resources in St. Kitts have been identified, including contamination of aquifers and siltation of surface water sources.

While the staff turnover rate in WSD is low, due to financial constraints the WSD has not been able to replace staff members that have retired. The WSD is severely limited by inadequate data collection and storage.

Demand for water is expected to increase as the economy of St. Kitts and Nevis expands, particularly in the tourism and agriculture sectors where water requirements could double in the next 10 years. To exploit groundwater resources that have not been utilised will require substantial capital investments as there are accessibility constraints to these aquifers. Desalination has not been considered because of the greater cost involved (i.e. it is estimated that it is 10 times more expensive to produce desalinated water than it would be to abstract groundwater) (MSD, 2007).

It is recommended that actions be taken to advance mainstreaming water considerations into land-use plans and building codes, raising awareness of the need for water conservation at both the household and hotel level, and collecting additional data to monitor water quality and quantity. Additionally other specific activities are recommended for the water sector, which would form smaller components of a holistic and integrated water resources management plan (IWRM). These points should be considered in the drafting of the new Water Resources Management Act.

1. Review and enhance the Water Resources Management Plan, 2009. Specific components of an IWRM plan that have been highlighted in this research for St. Kitts include:

a. Develop measures to protect aquifers from surface contamination and protect water quality.
b. Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes.
c. Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation.
d. Undertake broad consultation over the licensing of abstraction for private water supply.
e. Develop computer models of groundwater flow to account for the impact of SLR on groundwater levels.

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. In the case of St. Kitts and Nevis, information on energy use in tourism is scarce, and further effort should be directed at developing energy databases.

Any Caribbean nation's ambition should be to reduce its energy use and to increasingly use renewable energy produced in the region. In practice, this appears to be hampered by the lack of detailed databases on energy use by sub-sectors, which is a precondition for restructuring energy systems. To this end, Francis *et al*. (2007: 1231) suggest that:

> *… given the absence of a more detailed database on energy consumption and GDP in Haiti, Barbados, and Trinidad and Tobago, further research can be directed at two important issues. First, with wider data on energy consumption and GDP (total and sectoral), a decomposition analysis could be undertaken, which can add value by identifying the main drivers, a useful approach to the formulation of effective policies.*

These insights also apply for other islands. While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of GHG, it also appears clear that energy demand in all islands could be substantially reduced at no cost, simply because the tourism sector in particular is wasteful of energy, and because carbon management allows for the restructuring of markets. Furthermore, technological options to develop renewable energy sources exist, and can be backed up financially by involving carbon markets, as well as voluntary payments by tourists. To move the tourism sector forward in making use of these potentials, it appears essential that policy frameworks focusing on regulation, market-based instruments and incentives be implemented.

St. Kitts and Nevis have, in the form of the draft National Energy Policy Draft and the draft National Energy Action Plan (MOPWUEH, 2011b,c), 2 of the most advanced documents in the region to address energy use and to strategically re-structure the energy sector towards renewable energy sources (windpower and geothermal). At 3.8 t CO_2 per capita, St. Kitts and Nevis is approaching global average emissions of CO_2 (4.3 t CO_2 per year). However, this is likely to be an underestimate of national emissions, because the islands do not operate direct long-haul flights, and national energy consumption thus only considers energy used to reach the next hub. The energy demand of the islands' tourism system (both inbound and outbound) is thus considerably larger. Even if just a share of emissions associated with tourism to the islands was included in national emissions, this would push St. Kitts and Nevis considerably over the global average of 4.3 t CO_2 per capita per year threshold, which already needs to be seen as an unsustainable value. In the future, there is thus a need to reduce absolute emissions of CO_2 in the islands, which appears not possible even when ambitious plans to exploit geothermal energy and to build up wind power capacity are realised.

National documents to address this situation (MOPWUEH, 2011 a,b,c) do not mention energy use and emissions associated with cruise tourism and aviation, which are the main contributors and both could be considerably reduced through the strategic restructuring of markets.

Increased domestic energy demand and new tourism developments place severe pressure on future St. Kitts and Nevis generation expansion planning and production capacity. In order for the tourism industry and other economic sectors to be competitive, it is required that the countries rely on cleaner energy supplies and increased energy efficiency. Energy prices should be kept high, however, as this is a precondition for efficient use and innovation. Rather, specific initiatives, such as electric cars, should be favoured for governmental subsidies.

7.4. *Agriculture and Food Security*

The state of agriculture and food security in St. Kitts and Nevis as they relate to climate change revolves around several key priorities which include:

- Raising rural incomes and providing employment in the face of the closure of the sugar industry;
- Diversifying agriculture through the introduction of new crops, and increasing the availability of locally grown fruits and vegetables ;
- Developing inter-sectoral linkages with tourism.

The national agricultural policy is designed to stimulate private sector investment in agri-business and farming as a means of raising rural incomes and meeting the needs of the displaced sugar workers. Diversification is the main strategy that is being used to increase food production and address issues surrounding food security. Nevis Department of Agriculture has a convincing history of forging and facilitating links between agriculture and tourism. The challenge is to integrate renewable energy and adaptation to climate change technologies into agricultural businesses; and to provide a supporting policy framework for helping small-holder farmers in St. Kitts and Nevis to adapt to climate change using innovative technological solutions.

7.5. *Human Health*

The vulnerabilities of the health sector to climate include weather related morbidity and mortality and the diseases that are affected by changes in temperature, as well as a number of emerging and re-emerging communicable diseases such as dengue, gastroenteritis, leptospirosis, schistosomiasis, 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 St. Kitts. 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, sanitation and potable and accessible water supply related issues, especially during the rainy season and the spread of acute respiratory infections and food- and water- borne illnesses. It is further evident that these factors can influence other sectors, most notably the tourism. The current debt crisis will affect the ability to address issues of poverty, which represents one of the most vulnerable groups in St. Kitts to climate change and climate variability. Therefore the impact of climate change on health in St. Kitts should be fully evaluated and addressed, with further investigation to the links with other sectors such as tourism and water. This will benefit the economy and society of St. Kitts through increasing the country's resilience to the impacts of climate change and offering better adaption options. Increased research and validation of data, for

example with diseases of low prevalence such as Malaria, and those that exist at a regional scale, such as schistosomiasis, should be given greater attention in their infancy with respect to their threat to national health. 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*

St. Kitts is to be commended for the efforts made in policy and strategy development with regards to managing its environment. The Government has developed policies and in collaboration with other agencies, has begun to implement strategies towards monitoring and building the resilience of its biodiversity to climate change impacts. Still, financial constraints, along with limited human resources and difficult access to technology, are challenges faced by many SIDS in the Caribbean region, reducing the island's capacity to adapt to the expected impacts of climate change.

While the Government of St. Kitts and Nevis recognises the importance of ecosystems to sustainable development, it needs to increase its capacity for the management and protection of the nation's natural resources. The local population and growing tourism industry are reliant on a limited natural resource base that is already suffering from the effects of coastal erosion, saltwater intrusion and habitat fragmentation. The small size of the island of St. Kitts makes it very vulnerable to the impacts of climate change and, further losses of biodiversity and ecosystem function will place additional strain on the already fragile economy and on the livelihoods of inhabitants.

The island's coral reefs face pressure from over-fishing, eutrophication and siltation, particularly since the closure of the sugar industry and improperly planned conversion of cane fields to inappropriate uses that have led to soil erosion. Mangroves, beaches and forests are also negatively impacted by coastal development and other human activities. A holistic approach to climate change adaption with respect to biodiversity will involve examining and taking advantage of the linkages between marine and terrestrial ecosystems. Reducing, or ideally eliminating, behaviours that lead to environmental degradation will build the resilience of its ecosystems, allowing them to better cope with an increasingly variable and challenging climate.

Adaptation strategies will be most effective if an ecosystem-based approach is used as opposed to the protection of individual species of flora and fauna. Strengthening the adaptive capacity of St. Kitts' ecosystems in the face of climate change can only be achieved within the context of collaboration between stakeholders. It is essential that polices are put into action quickly, as climate inertia means those factors that bring about SLR, higher SSTs and increased storm intensity are already in place and accelerating. The strategies recommended in this document are cross sectoral and seek to engage the private sector - a sector that is often overlooked in the framework of natural resource management. The recommendations support current activities geared towards biodiversity management in St. Kitts by enhancing ecosystem resilience, restoration and protection, as well as building capacity through education and empowerment of natural resource users to serve as environmental stewards.

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. Kitts is highly vulnerable to climate change and SLR. Tourism, a very large and important sector of the economy, is

also the key activity taking place in the island's coastal areas. Given the importance of tourism, St. Kitts 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 St. Kitts 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 St. Kitts if it is to help curb development in vulnerable areas and protect vulnerable tourism assets.

The Government of the St. Kitts 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 St. Kitts do not suffer from the consequences of potential 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 St. Kitts and Nevis.

7.8. *Comprehensive Natural Disaster Management*

St. Kitts has advanced many initiatives that address the threats they face from natural hazards. Despite the small size of NEMA, progress is being made on public awareness and early warning systems. Beyond NEMA, there is a need to better incorporate hazards into regular activities. Land use planning and building codes were recently updated, yet implementation continues to be limited by a lack of financial resources and technical capacity. As a result, vulnerabilities are not being prevented as best they could.

The natural hazards facing St. Kitts are numerous and unpredictable, therefore investments in preparedness and capacity building will improve the overall resistance and resilience to impacts when they do occur. The recommendations herein are a few, tangible activities that can assist in continuing the efforts of NEMA and also encourage DRR in other important sectors in St. Kitts. Disaster management is led by NEMA, but can only be successful when it is part of everyday decision making across the spectrum of sectors and communities.

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

It is well documented that women and men are differently affected by the effects of climate variability and change. Reasons include the different responsibilities men and women assume in relation to care work, income generating work, as well as their different levels of dependency on natural resources, knowledge and capacities to cope with the effects because of differences in the access to education and information systems.

Research findings indicate that community residents agree that men and women are affected differently by weather-induced hazards and disasters. Residents involved in agriculture are facing the effects of climate

change now, and are trying to adapt as they can. Tourism is prominent in the landscape, as there are several nearby tourism-related businesses. Persons from within the community are employed by these enterprises and are therefore vulnerable to loss of income should tours and other activities be interrupted by weather events. Other residents have to travel to different communities for work, and can be affected by access/transport restrictions owing to flooding events. Generally, all residents are affected by hurricanes and tropical storms, but the residents and businesses situated closest to the coastline are faced with the additional threat of storm surge and SLR impacts. Local fishermen face the risk of damaged boats during hurricanes and high sea swell events. Women, especially women who are single parent heads of households with children and elderly members, are generally considered more vulnerable to harsher weather impacts, because of the heavier burdens of family care and security and dependence on neighbours for emergency assistance (in cases where the number of dependent household members are high). Specific actions are required to improve the resilience of these vulnerable groups, and of the community as a whole, to weather and climate impacts.

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