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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 Nevis

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

March 2012

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ACKNOWLEDGEMENTS

The CARIBSAVE Partnership wishes to thank all the people across Nevis and in the Caribbean who have contributed to this National Risk Profile and to the Risk Atlas as a whole. There have been a multitude of people who have provided their time, assistance, information and resources to making the Risk Atlas effective and successful, so many people that it makes it impossible to mention all of them here on this page. We would, therefore, like to thank some of the key people and organisations here that have made the Risk Atlas and this National Profile possible. The CARIBSAVE Partnership wishes to thank the Ministry of Tourism Nevis for its support and assistance, in particular Mr Tyrone O'Flaherty, Permanent Secretary and Mr Troy Liburd; and Ms Rene Walters from Department of Physical Planning.

We wish to express great thanks to the Caribbean Community Climate Change Centre, the Caribbean Tourism Organisation and the Association of Caribbean States for their collaboration and support.

Additionally, we wish to thank the following institutions:

- The Climate Studies Group, Department of Physics, University of the West Indies, Mona Campus
- The Meteorological Institute of the Republic of Cuba (INSMET)
- Anton de Kom University of Suriname
- The University of Waterloo
- The Institute for Gender and Development Studies, University of the West Indies, Mona Campus
- The Health Research Resource Unit, Faculty of Medical Science, University of the West Indies, Mona Campus
- Ministry of Public Works, Housing, Energy and Utilities, St. Kitts Energy Department
- Nevis Island Administration, Ministry of Finance, The Statistics Office
- Ministry of Sustainable Development, Statistics Department
- Nevis Island Administration, Nevis Electricity Company Limited
- Ministry of Health
- Health Information Unit, Ministry of Health
- Ministry of Youth, Social and Community Development
- Nevis Tourism Authority

The CARIBSAVE Partnership would also like to extend its thanks to the Oxford University Centre for the Environment. Finally, last and by no means least, many thanks to the vision and commitment of the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID) for funding the CARIBSAVE Climate Change Risk Atlas.

This publication is to be cited as follows:

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. (2012). CARIBSAVE Climate Change Risk Atlas (CCCRA) - Nevis. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

PROJECT BACKGROUND AND APPROACH

Contribution to climate change knowledge and understanding

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

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

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

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

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

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

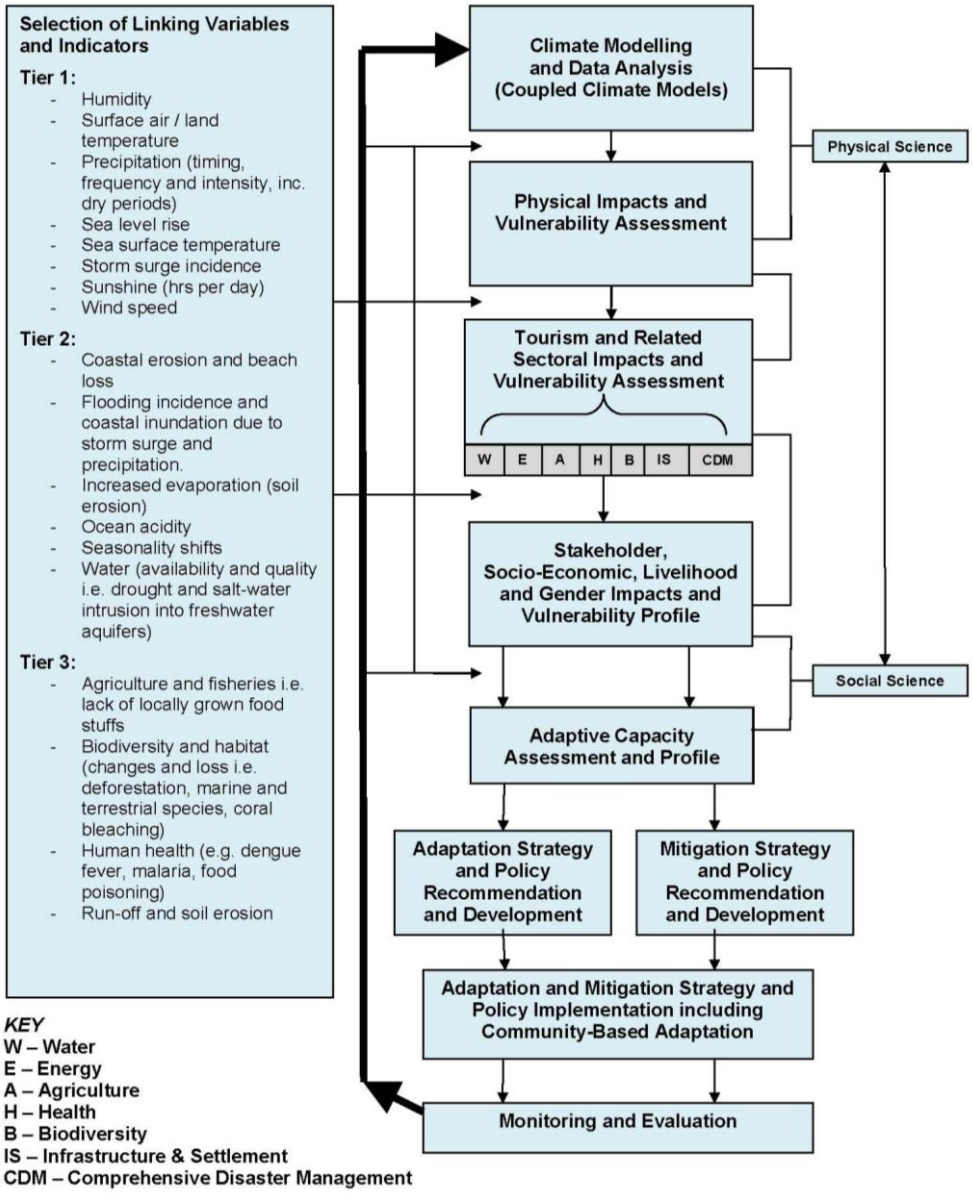
The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change,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

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

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

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

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



CCCRA Profiling Flow Chart

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

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

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

LIST OF ABBREVIATIONS AND ACRONYMS

AIC---------- Aviation-induced clouds
AOSIS ---------- Alliance of Small Island States
APD---------- Air Passenger Duty
AR4---------- Fourth Assessment Report (IPCC)
ASTER---------- Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ---------- Business as Usual
BEAD---------- Bedrock Exploration Development Technologies
CARDI---------- Caribbean Agricultural Research and Development Institute
CAREC ---------- Caribbean Epidemiology Centre
CARICOM ---------- Caribbean Community
CBA---------- Community Based Adaptation
CCCCC---------- Caribbean Community Climate Change Centre
CCCRA ---------- CARIBSAVE Climate Change Risk Atlas
CCRIF---------- Caribbean Catastrophe Risk Insurance Facility
CDB---------- Caribbean Development Bank
CDC---------- Centre for Disease Control and Prevention
CDEMA ---------- Caribbean Disaster Emergency Management Agency
CDM---------- Clean Development Mechanism (in the context of Energy/Emissions)
CDM---------- Comprehensive Disaster Management
CEHI ---------- Caribbean Environmental Health Institute
CEP ---------- Caribbean Event Programme
CITES---------- Convention on International Trade in Endangered Species
COP---------- Conference of Parties
CPA---------- Country Poverty Assessment
CPACC ---------- Caribbean Planning for Adaptation to Climate Change
CRFM ---------- Caribbean Regional Fisheries Mechanism
CRI---------- Climate Risk Index
CRID---------- Regional Disaster Center – Latin America and the Caribbean
CROSQ---------- CARICOM Regional Organisation for Standards Quality
CSGM ---------- Climate Studies Group Mona
CTO---------- Caribbean Tourism Organization
CZM ---------- Coastal Zone Management
DANA ---------- Damage Assessment and Needs Analysis
DF---------- Dengue Fever
DFID---------- Department for International Development
DHF---------- Dengue Hemorrhagic Fever
DJF---------- Seasonal period of December, January, February
DRM---------- Disaster Risk Management
DRR---------- Disaster Risk Reduction
ECE ---------- Energy Conservation and Efficiency
ECCU ---------- Eastern Caribbean Currency Union
ECLAC---------- United Nations Economic Commission for Latin America and the Caribbean
EIA---------- Environmental Impacts Assessment
EM-DAT ---------- The International Disaster Database
ENSO---------- El Niño Southern Oscillation
EOC---------- Emergency Operations Centre
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 System
HFA---------- Hyogo Framework for Action
IAASTD---------- International Assessment of Agriculture Knowledge, Science and Technology for Development
IEA---------- International Energy Agency
INSMET---------- Meteorological Institute of the Republic of Cuba
IPCC ---------- Intergovernmental Panel on Climate Change
ISDR ---------- International Strategy Disaster Reduction
ITCZ---------- Inter-tropical Convergence Zone
IVM---------- Integrated Vector Management
IWRM ---------- Integrated Water Resources Management
MEA ---------- Multilateral Environmental Agreements
MPA---------- Marine Protected Areas
NASA---------- National Aeronautics and Space Administration
NDA ---------- National Designated Authority
NDC ---------- National Disaster Committee
NDE---------- National Disaster Executive
NEP---------- National Energy Plan
NEMA---------- National Emergency Management Agency
NEMS ---------- National Environmental Management Strategy
NEVLEC---------- Nevis Electricity Company Limited
NDMD ---------- Nevis Disaster Management Department
NGO---------- Non-Governmental Organisation
NIA ---------- Nevis Island Administration
NSLC ---------- National Survey of Living Conditions
NSWMA---------- Nevis Solid Waste Management Authority
NWD ---------- Nevis Water Department
OECS ---------- Organisation of Eastern Caribbean States
RCM---------- Regional Circulation Model
RET ---------- Renewable Energy Technology
RH ---------- Relative Humidity
SIDS ---------- Small Island Developing States
SLR---------- Sea Level Rise
SST---------- Sea Surface Temperature
TIN---------- Triangular Irregular Network
UNDP ---------- United Nations Development Programme
UNEP---------- United Nations Environment Programme
UNESCO---------- United Nations Educational, Scientific and Cultural Organization
UNFCCC ---------- United Nations Framework Convention on Climate Change
UNIFEM ---------- United Nations Development Fund for Women
UNFPA---------- United Nations Population Fund
UNWTO ---------- United Nations World Tourism Organisation
UWI ---------- University of West Indies
WIP---------- West Indies Power
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 Nevis

Nevis 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 Nevis 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 **Jessups and Cotton Ground** areas to climate change; and
2. project sea level rise and storm surge impacts on **Lover's Bay, Jessups, Oualie and Pinney's Beach**.

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

Vulnerable community livelihoods

- Tourism, farming and fishing are the main livelihood activities in the Jessups and Cotton Ground.
- Improper waste disposal, overfishing and development activities have been attributed to an increase in the severity of flooding (in some instances), depletion of fish stocks and the decline in coral reef health.
- Observations in the community include: sea level rise, increasing sea surface temperatures, an increase in ambient temperature, depletion of marine and terrestrial biodiversity and more frequent heavy rain events.

Vulnerable coastlines

- Even under a 0.5 m SLR, over 40% of the highly valued beach resource at Jessups, Oualie and Pinney's Beach would be inundated.
- Sea turtle nesting sites are also at risk to SLR and erosion, with 79% affected by a 50 m erosion scenario.
- Local tourism operators perceive that beaches along with the prevailing climate are the island's main tourism attractions.
- Projected 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 Nevis

The projections of *temperature, precipitation, sea surface temperatures;* and *tropical storms and hurricanes* for Nevis 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 Nevis

Temperature: Regional Climate Model (RCM) projections indicate an increase ranging from 2.4˚C to 3.2˚C in mean annual temperatures by the 2080s, in the higher emissions scenario.

Precipitation: General Circulation Model (GCM) projections of rainfall span both overall increases and decreases, ranging from -41 to +10 mm per month by 2080 under the higher emissions scenario. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate large decrease in annual rainfall (-22%) when compared to simulations based on ECHAM4 (-7%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.7˚C and +2.8˚C by the 2080s across all three emissions scenarios.

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

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

The majority of infrastructure and settlements in small islands, like Nevis, 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.

Figure 1: Erosion at Lover's Beach (Nevis)

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 of Lover's Bay, Jessups, Oualie and Pinney's Beach.

Even under a 0.5 m SLR, over 40% of the highly valued beach resource at Jessups, Oualie and Pinney's Beach would be inundated. With a 1 m SLR, all study sites would be more than 50% inundated (Table 1). 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 1: Beach Area losses at Four Resorts Nevis

	Lover's Bay		Jessups		Oualie		Pinney's Beach	
SLR Scenario	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m^2)	Beach Area Lost To SLR (%)	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	5471	37%	3823	54%	4482	66%	8914	41%
1.0m	2718	55%	1339	72%	1570	89%	2744	53%
2.0m	3485	78%	1978	100%	731	100%	9416	96%
3.0m	3249	100%	-	-	-	-	899	100%

Indeed if erosion is damaging tourism infrastructure, it means the beach will have essentially disappeared. With projected 100 m erosion, 82% of the resorts in Nevis would be at risk. Such impacts would transform coastal tourism in 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 across the two islands (St. Kitts and Nevis) projected to be inundated with a 1 m SLR.

St. Kitts and Nevis is highly dependent on international tourism and will be particularly affected with annual costs as a direct result of SLR. St. Kitts and Nevis 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 $15 million in 2050, to $44 million by 2080[i].

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

Community Livelihoods, Gender, Poverty and Development

More than 50 residents and workers from the Jessups and Cotton Ground communities[ii] (in the parish of St. Thomas) participated in CARIBSAVE's vulnerability assessment which included a vulnerability mapping exercise (See Figure 3), focus groups and household surveys which were developed according to a sustainable livelihoods framework. This provided 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.

Figure 2: Beach area with small jetty used by pleasure craft and fishers

Some of Nevis' main tourism attractions are based in St. Thomas, including the Four Seasons Resort Nevis, golf courses, eco-trails, hiking, numerous beaches and some historical sites. The St. Kitts and Nevis Taiwan Agriculture Project is also based in St. Thomas and some fishers land their catches along the shoreline. The importance of tourism, agriculture and fisheries is quite high and these sectors and those who depend on them for their livelihoods, are very vulnerable to climate change impacts.

Community Characteristics and Experiences

Tourism in Nevis depends heavily on healthy coastal and marine resources, which include beaches, a clear and shallow nearshore and vibrant coral reefs for a variety of recreational activities. Farmers (including back-yard subsistence farmers) depend on fertile soil conditions and predictable wet and dry seasons in order to have higher outputs. Fisheries-based livelihoods, similar to tourism, thrive where there is an abundance of marine life and healthy coral habitats.

However, the integrity of these resources in Nevis is threatened by a changing climate and changes have already been observed. Some of the more evident changes include more frequent hydro-meteorological events (storms, heavy rains), SLR, sea surface temperature rise, an increase in ambient temperature and depletion of marine and terrestrial biodiversity. Changes in seasons have also been observed, although no specific patterns were identified. Aside from the impacts of climate change, some notable changes in the environment have been attributed to human actions. These actions may even exacerbate climate change impacts, but in the very least, they affect the livelihoods and wellbeing of residents. Improper waste disposal, overfishing and development activities have been cited as issues of concern and are attributed to an increase in the severity of flooding (in some instances), depletion of fish stocks and the decline in coral reef health, respectively.

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

Hurricanes are the greatest concern for community residents as they cause the most physical damage. The main tourism employer on the island, the Four Seasons Hotel, had been closed on two occasions since its establishment in 1991 as a result of storm events. The location of the resort makes it very prone to impacts from flooding and inundation from sea swells and storm surge. These closures, which lasted months at a time, resulted in temporary unemployment and loss of income for many locals who work at the resort and a significant loss of revenue at the national level.

Hurricane Omar in 2008 had the greatest impact, resulting in the closure of the property for two years between October 2008 and December 2010 to allow for extensive repairs and refurbishment. Not only those directly employed by the resort were affected, but also all of those persons employed in related industries (e.g. scuba diving, craft making, tour guides etc.). Fortunately, some staff members worked at other hotels in St. Kitts during the period of closure and subsequently returned to the Four Seasons Hotel after its reopening. Others went into self-employment in catering, roadside barbeque stalls and vending in the capital, Charlestown, which was relatively uncommon before. With the loss of income during the closure of the Four Seasons resort, workers were unable to pay loans and mortgages during this period and this led to the reclamation of vehicles, land and houses which were acquired on hired purchase through local banks. What is unclear is if projected climate change was given due consideration in the rebuild.

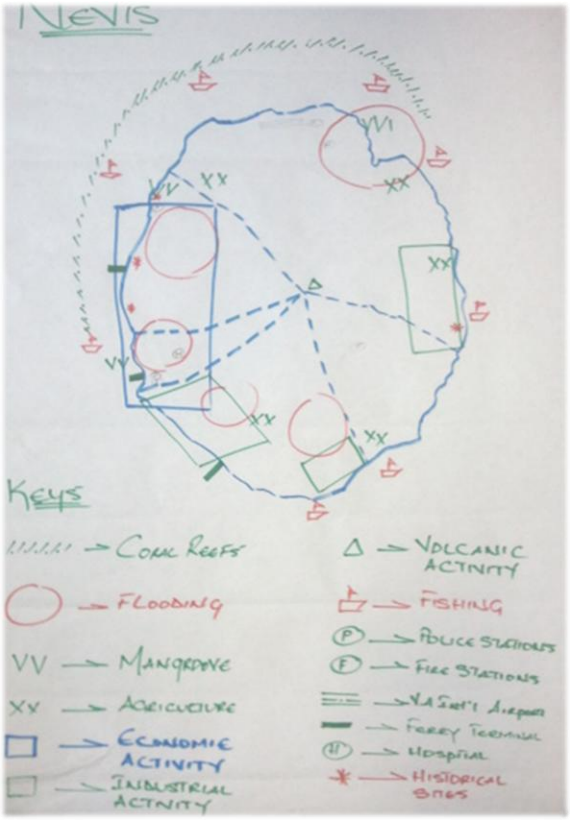


Figure 3: Hand-drawn Community Map showing areas of vulnerability to hazards around Nevis

The Nelson Spring area in St. Thomas is prone to flooding when storms or heavy rains occur. Apart from this, there is little concern for the physical impacts of flooding, landslides and other climate related events on the community. Weather events have more serious consequences for *livelihood activities,* especially tourism and residents working in tourism are highly vulnerable to weather impacts. During hurricanes, churches are used as shelters, but need significant improvements if they are to meet the standard required for effective hurricane shelters, as the structures may pose hazards in themselves.

The health of the coral eco-systems around the area is declining and this is blamed primarily on mining and quarry activities on the eastern side of the island. This in turn is associated in part to the decline of fisheries on the island. Overfishing is also seen to be a major problem in fisheries (both marine and freshwater fish), but while some community residents acknowledge the decline in fisheries, most attempts to get fishers to conserve and practice more sustainable fishing methods have been futile.

Climate change poses a specifically dire threat for social and economic groups which are inherently vulnerable; including women, children, the poor, the elderly, the disabled and persons working in volatile, climate sensitive sectors. Efforts by the Government of St. Kitts and Nevis have seen a reduction in poverty within the last decade, however close to half of the local population (in Nevis) was collectively rated as poor, or considered vulnerable to falling into poverty. Such persons, many of whom are involved in volatile

sectors include large numbers of unskilled or low-skilled women. This is an important consideration in developing a suitable adaptation intervention for this community, bearing in mind that many households are headed by women and are therefore responsible for an entire family.

In further consideration of the community's capacity to respond to climate change events, their access to and dependence on a suite of 'livelihood assets' was examined. Ownership of houses, land and communication and entertainment assets is fairly high amongst both men and women and would tend to suggest that most community residents can afford a comfortable lifestyle. Housing structures are strong and sanitation conveniences are present in most cases. Provisions for personal and household protection are in place by some residents, but a high number of households are without home insurance because of a distrust of insurance companies based on previous experiences when trying to claim for losses after storm events. There is little indication of any adaptation or mitigation strategies by residents to protect themselves, their households and their livelihoods against impacts of extreme weather. This is of great concern as it has implications for household and overall community vulnerability to present day and future climate change impacts. Slight gender differences arose out of the household survey, but few highlight any significant disadvantages for men or women in relation to each other.

In the face of climate change and the threat that it poses to Caribbean societies and economies, the comprehensive integration of poverty, gender and livelihood issues into climate change impact and vulnerability assessment and planning processes is essential to developing appropriate adaptation strategies. Recommendations put forward to address vulnerability and adaptive capacity concerns range from infrastructural assessments and development, networking and collaboration, training and education activities and policy reform to incorporate gender and poverty lenses. These are only some of the activities that can be implemented in the short and long term and will require efforts at all levels and across sectors to build the resilience of communities like Cotton Ground and Jessups to the impacts of climate change.

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 country, which depended on this crop for its prosperity for a period of 350 years. However, the Government's intensive diversification programme has resulted in increased production of non-traditional crops, livestock, fruits and vegetables. Climate projections under both the CSIRO and HadCM2 models indicate potentially devastating impacts on the prospects for cultivation of these agricultural products and in both islands salinisation of coastal aquifers will negatively affect availability of water for agriculture. Some of these impacts are already being realised according to the National Annual Agricultural Review (2010), which reports that the harsh and long dry spells experienced by farmers in St. Kitts and Nevis 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.

A significant contributory factor to vulnerability in the agriculture sector is land degradation as a result of the over use of lands for mono crop sugar cane agriculture; clearing of lands for residential and tourism development; farming on high elevations above the 1000 ft contour; and squatting or unregulated settlements. Competing demands on the island's land resources for agriculture, tourism, housing, services and facilities in conjunction with unenforced legislation and fragmented policies has exacerbated the situation.

In addition to the physical aspects of vulnerability, agriculture in Nevis is affected by scarcity of farm labour. This is generally attributed to the low wages paid for farm work and the consequent lack of interest.

Climate changes 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. 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 prioritising and addressing the problems caused by climate change impacts as identified by local farmers.

Research on information needs of stakeholders in the agricultural and rural sector of St. Kitts and Nevis[iii] 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. So this is clearly where several interventions can be made to address capacity gaps and knowledge about climate change.

Given the existing initiatives in Nevis, there are opportunities for developing projects that specifically deal with agriculture and climate change. A multi-location 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, adapted varieties of selected crops that respond to a changing climate. Similarly, the Taiwanese Agricultural Mission in St. Kitts and Nevis conducts research on various food crops and exposes local farmers to the current technologies and the emerging tools in agriculture. Capacity should therefore be built to include aspects on climate change.

Energy and Tourism

St. Kitts and Nevis belong to the region's low emitters at 2.6 t CO_2 per capita as compared with the global annual average of 4.3 t CO_2 per capita. However, more recent estimates suggest considerably higher emissions of 3.8 t CO_2 per capita. In the case of tourism in St. Kitts and Nevis, 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 account for about 88%. 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 and assumptions. There is also uncertainty how emissions are divided between St. Kitts and Nevis, although approximately 20% of fuel imports are for Nevis and a comparison based on arrival numbers would suggest that about 20% of tourism related energy use and associated emissions fall on the island.

The Nevis Electricity Company (NEVLEC) is the wholly owned subsidiary of the Nevis Island Administration that generates, transmits, distributes and sells electrical energy in Nevis. The power plant is located at

[iii] AGRICO Ltd. (2005). *Assessment of Agricultural Information Needs in African, Caribbean & Pacific (ACP) States.* Country Study: St. Kitts & Nevis Final Report. Netherlands: Technical Centre for Agricultural and Rural Cooperation (CTA).

Prospect Industrial Site with a total installed capacity of 13.4 MW. Table 2 presents the production and consumption data for NEVLEC over the past decade.

Table 2: Electricity generating statistics, Nevis 2001-2009

Years	Electricity Production (kWh)	Unit Consumption (kWh)	Wind Production (kWh)
2001	36,529,470	29,369,300*	
2002	44,441,970	36,306,750	
2003	46,472,420	37,376,190	
2004	47,668,050	38,021,830	
2005	52,020,160	42,169,360*	
2006	54,346,510	44,030,680	
2007	55,303,180	44,607,790	
2008	55,779,790	44,520,950	
2009	50,995,700	39,756,300	
2010	50,851,480	41,251,750	1,237,250

*These values were forecast/estimated because not all data was collected for those particular years.

(Source: Cartwright Farrell, NEVLEC, personal communication, May 11, 2011)

Oil consumption in St. Kitts and Nevis has increased from 449 bbl per day in 1990 to 1300 bbl per day in 2008 and further growth is projected to 2015. De Cuba (2006) presents the projected peak demand for Nevis, which indicates considerable growth in the period 2005 - 2015, Figure 4.

In addition to the diesel plant, the WindWatt Wind Farm on Maddens Estate in south-eastern Nevis (2.2 MW capacity) was opened in summer 2010 and was the first wind power project in the OECS. The eight turbines have been providing 1.1 MW, with an allowance to go to a maximum of 1.6 MW of power. Work is ongoing for the development of a 10 MW geothermal power plant, with additional discussions regarding expansion by another 30 MW to supply St. Kitts by underwater cable.

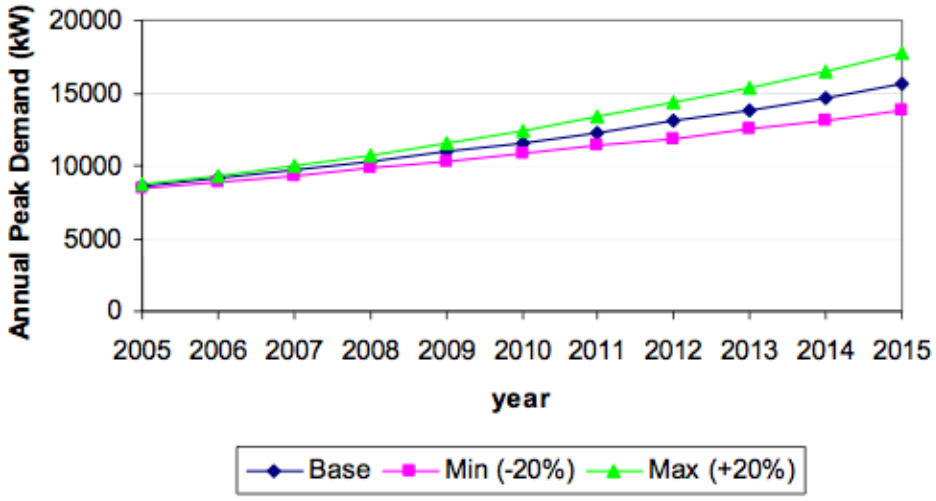


Figure 4: Projections of the annual peak demand for Nevis 2005-2015

(Source: De Cuba, 2006)

St. Kitts and Nevis have, in the form of the draft National Energy Policy and the draft National Energy Action Plan, two of the most advanced documents in the region to address energy use and to strategically re-structure the energy sector towards renewable energy sources (wind power and geothermal). The documents propose that the islands focus on regional integration, diversification and increased energy

supply and security, with a view to participating in the Clean Development Mechanism, thereby reducing emissions and cost of energy. The optimal combination of power supplies for Nevis will achieve a contribution of 30 - 35% of capacity from renewable sources[iv]. Table 3 presents the options that are being considered for future renewable energy development over the short, medium and long term.

Table 3: 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)

Rising prices for fossil fuels and emerging climate policy will make the tourism sector in Nevis increasingly vulnerable. 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. Rising oil prices will affect tourism in particular since aviation has limited options for using alternative fuels and increases in fuel costs will inevitably be passed on to the passengers. The International Energy Agency (IEA, 2010) 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. 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.

Overall, current frameworks to mitigate GHG emissions from aviation do not seem to represent a substantial threat to tourism development[v,vi,vii], but new regulatory regimes and market based instruments to reduce emissions in line with global policy objectives would cause changes in the global tourism system that could affect in particular SIDS. To anticipate these changes and to prepare the vulnerable tourism

[iv] De Cuba, K.H. (2006). *Towards a Sustainable Energy Plan for St. Kitts and Nevis: Long term electricity cost assessment of electricity supply scenarios for promoting the introduction of Renewable Energy Technologies on Small Island Developing States in the Caribbean. The St. Kitts and Nevis experience.* Masters Thesis, Utrecht University, Netherlands.

[v] Mayor, K. & Tol, R.S.J. (2007).The impact of the UK aviation tax on carbon dioxide emissions and visitor numbers. *Transport Policy,* 14, 507-513.

[vi] Gössling, S., Peeters, P., & Scott, D. (2008).Consequences of climate policy for international tourist arrivals in developing countries. *Third World Quarterly*, 29(5): 873-901.

[vii] Rothengatter, W. (2009). Climate Change and the Contribution of Transport: Basic Facts and the Role of Aviation. *Transportation Research Part D Transport and Environment*, 15(1): 5–13.

economies in the Caribbean to these changes should thus be a key management goal for tourism stakeholders.

St. Kitts and Nevis is planning considerable action that could make the twin island federation a leader in renewable energy development in the region but the direct impacts of climate change on energy generation, distribution and transmission infrastructure must be considered. This has implications for existing traditional (fossil fuel based) energy systems as well as proposed renewable energy initiatives that are being implemented. It is therefore recommended that the sustainability of the chosen technologies given the projected climate changes is carefully assessed. 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 Nevis 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. The turbines installed in Nevis are designed to be winched down in the event of an approaching hurricane. Power generating stations and other major infrastructure located on the coastline are also highly vulnerable to damage from flooding and inundation resulting from SLR and storm induced surges. Temperature increases have been shown to reduce the efficiency of energy generation at thermal power plants and reduced precipitation may affect water availability for non-contact cooling of power generators. Alternative energy sources, while they are environmentally more sustainable, also face challenges from physical climate change impacts and these must be considered in energy sector planning.

Tourism's share in energy use and emissions is considerable and likely to grow in the future, leading to growing vulnerabilities in a business-as-usual 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. In St. Kitts and Nevis the National Energy Plan addresses the tourism sector, focusing on energy efficiency through technology and renewable alternatives, recycling, capacity building and a potential levy for high energy uses.

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"[viii]. 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. Installation of wind turbines that can be winched down in the event of an approaching storm indicates that the type of assessments that have been considered and are further required in other areas to assess the sustainability of the sector.

It is advisable for all destinations in the Caribbean to initiate discussions on new tourism management models to reduce energy use and emissions, with a focus on market structure and average length of stay. The rationale is that some markets are economically more beneficial, while consuming considerable less energy and causing lower emissions. The analysis of markets based on a combined assessment of their economics and energy intensity should thus be a key priority. Furthermore, average length of stay is

[viii] MOPWUEH (2011b) Draft National Energy Policy St. Kitts and Nevis.Ministry of Public Works, Utilities, Energy and Housing, Federal Government of St. Kitts and Nevis.

declining throughout the region and to maintain a stable number of bednights tourist volumes would have to continuously grow in the future. This would make islands more vulnerable to energy prices and climate policy. Marketing efforts to increase average length of stay should thus be considered and evidence from a case study in Barbados suggests that this is indeed feasible and at the same time there is scope to increase spending.

Policy frameworks need the active engagement of stakeholders in tourism planning with regard to energy use and emissions. Policy goals must be communicated and monitored to ensure that stakeholders engage in the required changes in their operations. Consequently, measures ranging from regulation to market based instruments to incentives will have to be implemented.

As a strategy to achieve low-energy, low-emission societies in the Caribbean islands, eight specific measures are recommended, some of which are already captured in the draft National Energy Policy and Plan. These include i) measures to improve knowledge and awareness of energy consumption, emissions of greenhouse gases and climate change among stakeholders; ii) energy audits to better understand where energy is used and where emissions occur; iii) the definition of action plans to avoid energy use, increase efficiencies and develop renewable energies; iv) the translation of carbon management, technological innovation and policy in co-ordinated management strategies; v) the pricing of energy through taxes and emissions trading to convey clear, long-term market signals; vi) regulation of carbon intense activities in combination with vii) incentives for low-carbon technology and consumption; and viii) the documentation of progress and its communication to stakeholders and society.

Water Quality and Availability

Groundwater is the main source of water in Nevis where there are 14 active wells[ix]. However, compared to larger St. Kitts, water is less available on Nevis due to rainfall patterns as a result of the lower elevations of its central mountains, absence of significant springs and prominence of a layer of silica pan covered with a layer of clayey soils that inhibits the prolific water infiltration. Approximately 91% of piped-borne water is obtained from ground water sources and 9% from surface springs. According to the Water Services Department, water resources are considered sufficient to meet current water demands on the island, despite the fact that the average annual rainfall is 1170 mm which is lower than St. Kitts and lower than other islands in the Caribbean.

[ix] USACE. (2004). *Water Resources Assessment of Dominica, Antigua, Barbuda, St Kitts and Nevis*. Mobile, Alabama: Mobile District and Topographic Engineering Center, US Army Corps of Engineers. pp. 95.

Figure 5: A rainwater storage tank as is used by many householders in Nevis

Adequate supply may be due to the fact that, unlike many other Caribbean countries, the island has become greatly adapted to rainwater harvesting. According to a study on rainwater harvesting in selected Caribbean countries, 80 – 90% of the residents and businesses in Nevis can capture water, whereas for St. Kitts only 5% of the island can accomplish the same[x]. The water storage capacity of Nevis is approximately 3 million gallons of water/day.

In both St. Kitts and Nevis, 96.8% of the population has access to potable water and 86% of households have water for seven days of the week. The data did not provide a breakdown of the type of toilet facilities by island, but for the entire federation 7% and 1% of the population utilises pit latrines and ventilated pit latrines respectively. 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[xi]. The Nevis Water Department has approximately 7,500 customers all of which are metered, however water rates are either flat or metered. The cost of water is higher in Nevis than St. Kitts and this may encourage independent water storage.

This sector is vulnerable to climate change in a number of ways. Hurricane activity can impact on water infrastructure and SLR can contaminate coastal aquifers with saline water. There have also been reports of heavy metal contaminants in ground water resources[ix]. The majority of population utilises septic tanks and this therefore causes the concern that heavy rainfall leading to flooding can introduce bacteriological contaminants into the aquifers. However, flooding in Nevis is less of a concern than other Caribbean islands because only 4% of Nevis has <2 ° slope. Nonetheless, turbidity issues are exacerbated by unregulated building and road construction on steep slopes which increases erosion. Conversely during dry spells and drought conditions, ground water recharge rates decrease affecting the available water resources. This is particularly important to Nevis as it depends on groundwater resources even more than St. Kitts.

When droughts occur in Nevis, they generally last for between 2 to 3 months. The Nevis Water Department usually issues public notices for consumers to conserve water and depending on the severity, water rationing may be carried out. It is estimated that if there is a 10 to 20% decline in annual precipitation ground water recharge rates would be affected, as Mr Morris of the Nevis Water Services Department summarises “If we would have more frequent droughts, our surplus would be at risk and our storage would suffer”. The agriculture sector is most affected during drought conditions.

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[x] CEHI. (2006). *Programme to Promote Rainwater Harvesting in the Caribbean Region*. Castries Caribbean Environmental Health Institute, pp. 38.

[xi] Kairi Consultants Limited. (2009a). Country Poverty Assessment St. Kitts and Nevis 2007/2008, Living Conditions in a Small Island Developing State, Final Report, Volume 1: Living Conditions in St. Kitts and Nevis. Tunapuna: Kairi Consultants Limited.

As in St. Kitts, the Watercourses and Waterworks Ordinance 1956 is the main legislation that governs management of water resources in Nevis, however it is outdated and does not make reference to, or have any provisions for groundwater resources. There is no legislation that directly addresses water conservation but there are a number of other pieces of legislation that have some role in water resources management in the island. One of these is the National Conservation and Environmental Act 1987 which includes the responsibility for forestry. 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. A new Water Resources Management Act is being drafted.

The Nevis Water Department (NWD) is responsible for production, distribution and water quality in Nevis and is currently working with the Caribbean Development Bank on a project entitled the Nevis Water Supply Enhancement Project as well as the Nevis Water Distribution Master Plan for the execution of the activities under the project. One component of the project will make provisions for NWD to become a Statutory Body.

In response to climate change, efforts should be made to protect water infrastructure to reduce vulnerability during major storms and hurricanes. In particular, (i) where lacking, water storage should be encouraged through incentives and every new building should have its own stored water infrastructure; (ii) the viability of additional storage should be assessed, allowing improved access to potable water in different communities; and (iii) losses in water distribution should be reduced through pipe replacement.

Comprehensive Natural Disaster Management

Nevis faces an array of natural hazards that have a great potential to cause significant loss of life and seriously affect livelihoods, including flooding, volcanic eruption and tropical storms. The vulnerability of communities in Nevis is, however, manageable if actions are taken at the household, community and national level to prepare and mitigate the impacts.

Nevis' location on the Atlantic Hurricane Belt means that heavy rainfall and high winds associated with low pressure systems, including hurricanes, impact the island with some regularity. While Hurricane Omar (2008) did not pass directly over the island, it caused serious damage to a major establishment on the island, the Four Seasons Resort as described in an earlier section of this document. Renovations to this facility were estimated at EC $120 million[xii].

Storm surges associated with hurricanes and tropical storms exacerbate the erosion process on the coast. As a result, cumulative erosion impacts pose a significant threat to coastal eco-systems and structures (e.g. tourism developments) and extreme events will worsen those impacts. The high dependence and proven vulnerability of tourism in Nevis calls for local disaster management authorities to work with relevant tourism stakeholders to develop and implement tourism sector disaster plans, with a focus on vulnerability reduction and hazard mitigation in the tourism industry.

Flooding is also a major concern and 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. Soil stability is threatened by clearing of vegetation, which increases the risk of landslides and reduces

[xii] Marcello, G. (2011). After Hurricane Omar, Four Seasons is Back. *The St. Kitts Nevis Observer No.855*. Retrieved 1/11/2011, from: http://www.thestkittsnevisobserver.com/2011/03/18/four-seasons.html.

infiltration capacity, thus exacerbating flooding. Earthquakes and volcanoes can also occur in Nevis, which can further compound vulnerability and undermine efforts to build resilience to climate events.

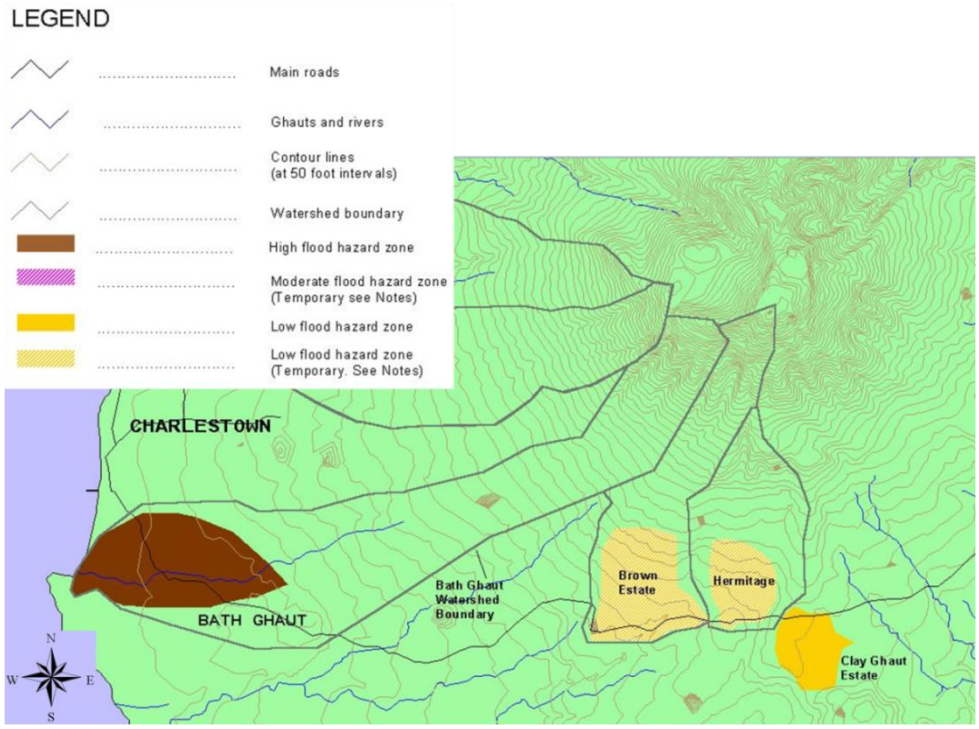


Figure 6: Nevis flood risk map

(Source: Cooper, 2001)

There is much strength in the Nevis disaster management system as both St. Kitts and Nevis have made progress in the achievement of their Hyogo Framework for Action (HFA) goals for disaster risk reduction (DRR). Disaster management in St. Kitts and Nevis is led by the National Emergency Management Agency (NEMA), within the Ministry of National Security, although Nevis has its own agency, the Nevis Disaster Management Department (NDMD). The separation of disaster management responsibility between the two islands has its benefits in terms of improving local actions and communication, but poses a challenge to funding allocation and for standardised action in disaster risk reduction within the Federation.

Nevis' disaster management policy and legislation come from the National Disaster Management Act for St. Kitts and Nevis (1998). Reviews of hazard and vulnerability were undertaken in 2001 following Hurricane Georges and public health facilities were again assessed in 2009. However, there is need for an up to date national vulnerability and risk assessment to inform development activities with respect to DRR.

Related policies also have implications for vulnerability reduction:

- Land use development, building practices and natural hazards are intricately related.
- 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.
- In 2006, the National Physical Development Plan was approved and includes a comprehensive land use guide. This is a positive first step toward risk reduction; however, progress continues to be limited by financial constraints and technical resources.

Reduction of vulnerability at the smallest level is imperative in efforts to minimise overall hazard implications. Participatory and innovative community education and capacity building designed to reach all levels of Nevisian society are essential for enabling individuals to manage their own risk levels and also build resilience to natural hazard events. In particular, technological tools and equipment have valuable benefits to disaster and emergency management and the NDMD is capitalising on this area. The NDMD website offers valuable information to the public and national curriculum also includes hazard information in secondary and tertiary level classes. The mass media are also actively involved in dissemination of warnings and the high-risk communities receive timely and understandable warnings for predictable events (e.g. hurricanes).

Human Health

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

St. Kitts and Nevis' 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*"[xiii]. 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. Displacement of persons and loss of shelter bear health implications related to water and food as well as psychological effects.

Even though Nevis is one of the drier islands of the Caribbean region, experiencing annual rainfall that of approximately 890 – 1000mm per year, concern exists for vector-borne diseases including dengue fever and malaria due to its tropical climate. Periods of dry spells and drought conditions can also contribute to the spread of air and food borne conditions linked to inadequate water supply and poor sanitation, including gastroenteritis, the intensification of scabies shigellosis, salmonella, legionella and cholera; and the increase in incidence of asthma, influenza, respiratory diseases and Acute Respiratory Infections (ARI) due to increases in particulate air pollutants and a changing air composition. Figure 7 demonstrates that in St. Kitts and Nevis ARI cases are more prevalent during the rainy season. Conversely, in **Figure**Figure 8 gastroenteritis morbidity cases are more prevalent during the dry season. This suggests that interventions could be made with regard to household and individual practices.

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

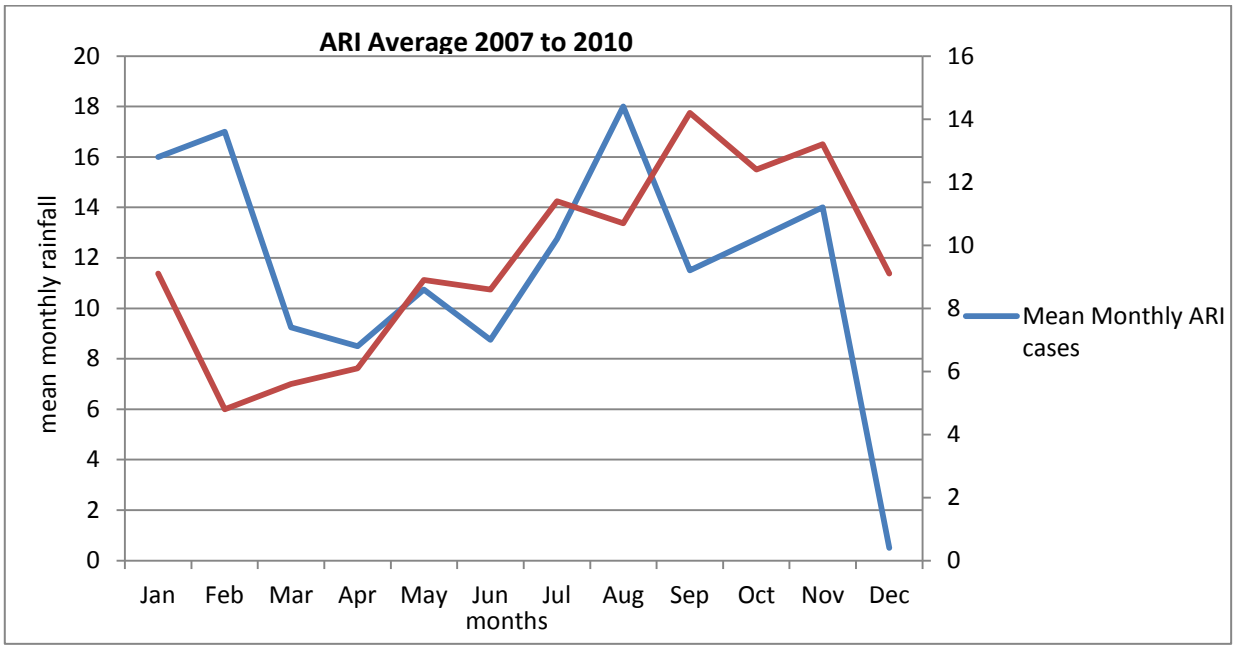


Figure 7: Mean Monthly Acute Respiratory Infections (ARI) morbidity cases against Rainfall in St. Kitts and Nevis

(Source: by author, data provided by Ministry of Health, 2011)

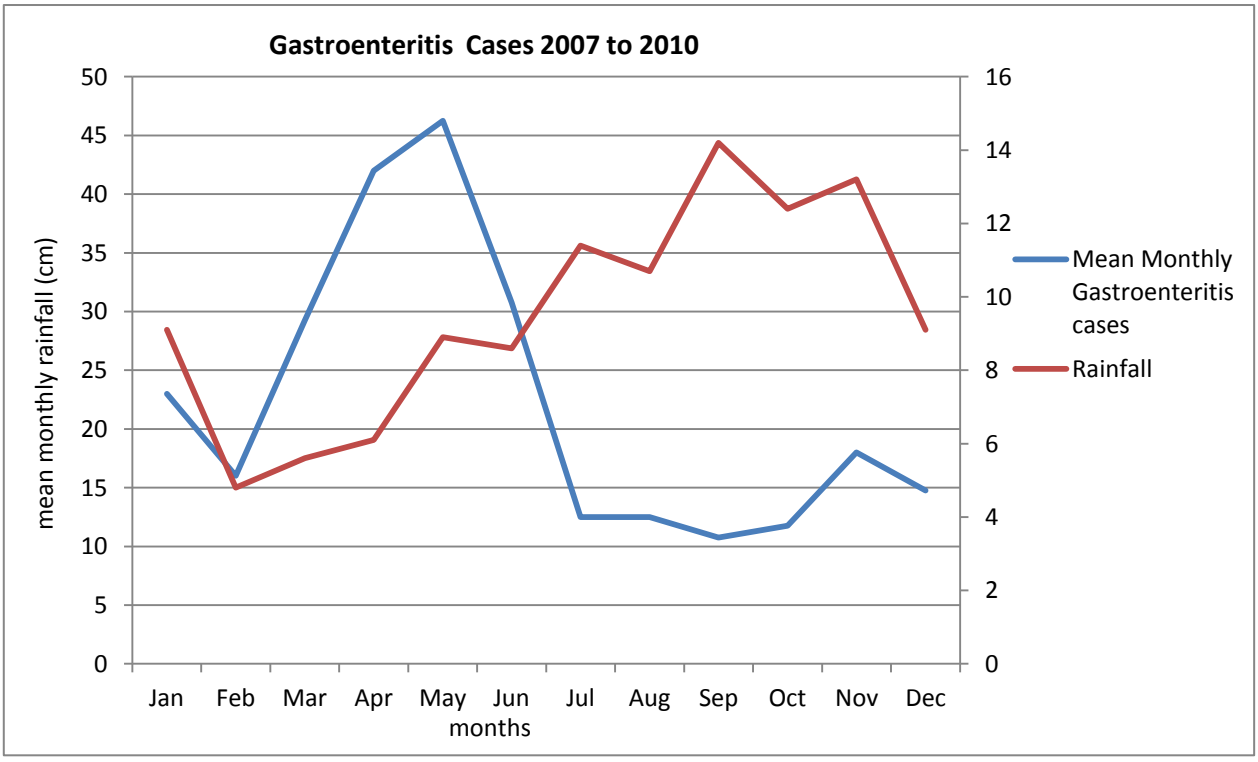


Figure 8: Mean Monthly Gastroenteritis morbidity cases against Mean Monthly Rainfall in St. Kitts and Nevis

(Source: by author, data provided by Ministry of Health, 2011)

However, further research should be conducted to link the epidemiology of diseases in Nevis with climate data, including studies to determine correlations link climate change, tourism and health to fully understand the extent of health risks.

Nevis does not have a significant agricultural sector owing to its size, geography and rainfall patterns and therefore has to import substantial amounts of food. Extreme climate conditions can compromise both local and external sources of food. 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 previously, malnutrition may become a serious concern. Food production and fisheries stock are considered an integral part of the Agricultural Sector so a reduction in fish stocks can also contribute to malnutrition due to a decrease in the protein content in the diet.

The Government of St. Kitts and Nevis places significant emphasis on health, exemplified by their increasing public expenditure on health despite current economic challenges - in an effort to ensure health care can be accessed by all citizens. 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 linkages between disease transmission, environment and living conditions, which by extension affects the ability of communities and Nevis on the whole to adapt.

Nevis has its own Ministry of Health, under the Ministry of Health, Social Services, Community Development, Culture and Gender Affairs. Within the ministry two departments oversee these responsibilities; these are the Public Health Department and the Department of Environment. Other important institutions include the Health Promotion Unit which was inaugurated in 2000, the Solid Waste Management Authority in St. Kitts and the Social Assistance Department which indirectly form the base for institutions to respond to the impacts of climate change.

In the Caribbean region, the priorities regarding climate change and health are 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.

Marine and Terrestrial Biodiversity and Fisheries

The Caribbean Region is one of the world's biodiversity hotspots and is at great risk of losing its remaining natural resources thus increasing its vulnerability to climate change. Maintaining and preserving the biodiversity and ecological products and services of Caribbean SIDS is of paramount importance for the sustainability of livelihoods that depend on them. In particular, in recent years the tourism sector has become a major part of the local economy, with a high dependence on natural resources.

Forests have always played an important role in well being and livelihoods of Nevisians and to the country's economy, providing several ecological services and supporting small eco-tourism initiatives (e.g. guided hikes which are conducted along the Nevis Peak and several rainforest trails, such as Jessups and Butler's Source). Such services are significant to the support of the country's fledgling tourism industry by contributing to visitor comfort, physical safety and enjoyment. However, forests continue to face threats from human activity as lowlands are intensely used for development or farming.

Climate change related variations in average daily temperature, seasonal precipitation and extreme weather events will exacerbate the effects of existing human stressors on forest eco-systems. 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.

The major beaches in Nevis are on the west and north coasts and are important recreational spots for tourists and residents. Despite the importance of beaches and coral reefs to tourism and fisheries, poor land use management, sand mining and other human activities have degraded these key natural assets. Beach sediment along with the vegetation found growing on beaches act as buffers protecting coastlines and coastal infrastructure from wind and wave erosion. Beaches are also important to biodiversity conservation through the provision of habitat and nesting grounds for a diversity of species such as shorebirds, marine turtles and molluscs.

Corals are habitat, feeding and nursery grounds for juvenile fish, molluscs, crustaceans and marine reptiles that support commercial and recreational fisheries, as well as marine based tourism activities such as snorkelling and diving. There is currently only one dive operator in Nevis at the Oualie Beach Resort; however the popularity of this activity is increasing thus maintaining healthy reefs will become ever more important to the tourism industry. Coral reefs also provide shoreline protection and are also a significant source of beach sand. This supply of sand is critically important for the continued existence of beaches, which themselves also contribute to shoreline protection by helping to reduce the destructive force of high energy waves.

Beach profile monitoring has revealed that although beaches in Nevis have shown signs of recovery after extreme weather events, they have not yet returned to pre-hurricane conditions. Climate change is very likely to exacerbate current trends of beach and reef loss, because of coral bleaching events, more intense storms and SLR.

On previous occasions, the resulting storm surge from the passage of hurricanes (Hugo, 1989; Luis 1995 and Omar, 2010) caused severe erosion of the island's beaches. As much as 20 m of sand from Pinney's Beach in front of the Four Seasons Hotel was removed by wave action so that the water's edge was close to the restaurant. The resort also lost part of its pier and the pavilion and swimming pool were undermined (compare Figure 9 and Figure 10). Similarly the Sandpipers Restaurant of Pinney's Beach when completed in August 1995 was 37 m from the water's edge. After the passage of Hurricane Luis the beach was so severely eroded that the sea encroached on the property's restaurant. Hurricane Luis eroded the beach and the land behind the beach undermining the foundations of the restaurant and the swimming pool. The implementation of adequate setback provisions would have prevented much of this damage.

Figure 9: Pinney's Beach, August 1995, before Hurricane Luis.

Figure 10: Pinney's Beach, October, 1995.

(Source: Cambers, 1996)

The fisheries sub-sector is also an important component of the local economy and numerous Nevisians go out to sea daily. Coastal fisheries have declined sharply in recent years and fishers have attributed this

decline to a degraded marine environment, unsustainable fishing practices and extreme weather events[xiv]. It is perceived that Kittitian fishermen are also fishing heavily for parrotfish (roughly estimated at 90% of catch) and this will have serious implications for coral reef health in Nevis as well as St. Kitts. Climate change is projected to affect fisheries by altering the distribution and movements of pelagic species, as well as by reducing key nursery and breeding habitats (e.g. coral reefs, seagrass beds, mangroves). Landing sites for boats may also be lost with SLR and accelerated coastal erosion. The recent arrival of the invasive lionfish (first reported in November 2010) is potentially a major threat to the fisheries of St. Kitts and Nevis, as this rapidly expanding species is a voracious predator on small reef fish.

The Government of St. Kitts and Nevis has acknowledged the importance of its biological resources to the tourism product and to sustainable development and as such 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 eco-system based approach. This means that strategies must aim to:

1. enhance the quality of terrestrial and marine eco-systems;
2. strengthen the linkages between habitats;
3. increase the size and number of protected areas; and
4. 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 these stakeholder groups to be environmental stewards. If the tourism sector, is to be sustainable, it must engage more actively in the conservation and management of protected areas. Planning and managing for resilient eco-systems and adapting to a dramatically changing climate must become a key priority for the Government of St. Kitts and Nevis.

The Government of St. Kitts and Nevis is a signatory to many Multilateral Environmental Agreements (MEAs) that have bearing on the country's biodiversity. The St. Kitts and Nevis National Environmental Management Strategy and Action Plan 2005 - 2009 (NEMS), 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. The National Physical Development Plan of 2006 earmarks special areas for environmental protection and the Integrated Strategic Development Plan for Nevis recognises several biodiversity related strengths and weaknesses in the island including a high potential for growth of resource-oriented economic activities but poor environmental management and development planning. The Nevis Resource Assessment and Zoning Plan 1990 is the land development policy for the island which restricts development in areas of special environmental and ecological interests.

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 Nevis. The National Biodiversity Strategy and Action Plan (NBSAP) for St. Kitts and Nevis includes a gap assessment of policy and legal structure that identifies a number of other areas

[xiv] Agostini, V. N., Margles, S. W., Schill, S., & Blyther, R. J. (2010). *Marine Zoning in Saint Kitts and Nevis: A Path Towards Sustainable Management of Marine Resources.* Florida, USA: The Nature Conservancy.

that are weak, absent or conflicting. 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 eco-system conservation.

The Nevis Island Administration is responsible for environmental management in Nevis as well as development control and forward planning. This agency is assisted by The Department of Physical Planning, Natural Resources and Environment, the Ministry of Communication and Works, and Public Utilities and Posts in implementing the conventions on Climate Change, Biological Diversity and Desertification. The Nevis Historical and Conservation Society is also active in projects related to biodiversity conservation. There are, however, constraints to effective management including inadequate monitoring, surveillance and law enforcement; lack of the ability to assess fish stocks and biodiversity; and overall, limited financial resources.

An additional concern with regards to fisheries management is that there are no legally declared Marine Protected Areas (MPA). But preliminary work done by The Nature Conservancy and the Marine Resource Governance in the Eastern Caribbean (MarGov) project 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 marine protected area (MPA). Stakeholders should therefore be encouraged to collaborate in the creation of a strategy for:

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

The strategy should increase the involvement of the tourism sector in supporting community-based MPAs, as well as provide opportunities for alternative livelihoods and technologies for public education. It is

Additionally, short films encouraging visitors to be more conscious of their impacts on the fragile eco-systems of the islands can be shown during in-bound international flights and on local TV networks. The films should focus on positive actions that visitors can take to minimise negative impacts on the environment, and engage local expertise as possible including actors, cameramen, technicians etc. Other stakeholders will include the various tourism organisations. By reducing anthropogenic stresses on the environment, eco-system health will improve and become better able to cope with climate change.

Conclusion

Nevis 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 eco-systems 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.

Nevis 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 eco-systems and the population, preparedness for disasters and climate change adaptation become common goals.

The CCCRA explored recent and future changes in climate in Nevis 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 eco-systems 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 Nevis 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 emissions and changes in the global climate system (Simpson M. , et al., 2010). Notably, climate change is ongoing, with "observational evidence from all continents and oceans … that many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC, 2007b, p. 8). Observed and projected climate change will in turn affect socio-economic development (Stern, 2006; Global Humanitarian Forum, 2009), 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 and extreme events. Deterioration in coastal conditions is expected to affect fisheries and tourism, with sea level rise being "expected to exacerbate inundation, storm surge, erosion and other coastal hazards, threatening vital infrastructure, settlements and facilities that support the livelihood of island communities" (IPCC, 2007b, p. 15). Climate change is projected to reduce water resources in the Caribbean to a point where these become insufficient to meet demand, at least in periods with low rainfalls (IPCC, 2007b). Together, these changes are projected to severely affect socio-economic development and well-being in the world (Stern, 2006), with the number of climate change related deaths expected to rise to 500,000 per year globally by 2020 (Global Humanitarian Forum, 2009). However, not all regions are equally vulnerable to climate change. The Caribbean needs to be seen as one of the most vulnerable regions, due to their relative affectedness by climate change, but also in terms of their capacity to adapt (Bueno, Herzfeld, Stanton, & Ackerman, 2008). This should be seen in the light of (Dulal, Shah, & Ahmad, 2009, p. 371) conclusion that:

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

Climate change has, since the publication of the Intergovernmental Panel on Climate Change's 4th Assessment Report (IPCC, 2007b), been high on the global political agenda. The most recent UN Conference of Parties (COP) in Mexico in December 2010 agreed that increases in temperature should be stabilised at a

maximum of 2°C by 2100. Notably, the 39 member states of the Alliance of Small Island States have called in a recent Declaration to the United Nations for a new climate change agreement that would ensure global warming to be kept at a maximum of 1.5°C; (AOSIS, 2009).

So far, the European Union is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. Some individual countries are taking action, such as the Australian Government's comprehensive long-term plan for tackling climate change and securing a clean energy future. The plan outlines the existing policies already underway to address climate change and cut carbon pollution and introduces several critical new initiatives and has four pillars: a carbon price; renewable energy; energy efficiency; and action on land. As a group, AOSIS member states account for less than 1% of global greenhouse gas emissions (UN-OHRLLS, 2009). However, according to a recent report of the IPCC the projected impacts of global climate change on the Caribbean region are expected to be devastating (IPCC, 2007c).

An analysis of the vulnerability of CARICOM nations to sea level rise (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 M. C., et al., 2010).

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

1.1. *Climate Change Impacts on Tourism*

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

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

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

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

> *It is important to 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 & Scott, 2010).

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

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and climate*

Nevis is the smaller island (approximately 93 km^2) of the twin island Federation of St. Kitts and Nevis in the northern part of the Lesser Antilles. It is located two miles (3 km) to the south-east of St. Kitts at 17° 10' north and 62°35' west. The island is almost circular with a length of 12.3 km and a width of 9.6 km at its widest point (MOSD, 2007).The main town is Charlestown on the west coast.

The islands are the summits of a submerged mountain range that forms the eastern boundary of the Caribbean Tectonic Plate (MOE, 2001). The highest point on Nevis is the central Nevis Peak (985 m) with Windy Hill (309 m), Saddle Hill (381 m) and Butlers Mountain (478 m) helping to define a north-northwest to south-southeast spine across the island (MOSD, 2007). Nevis is volcanically active with fumaroles and hot springs (GFDRR, 2010).

Water drains in a radial pattern from Nevis Peak to the ocean through ten (10) major drainage basins (DOE, 2001). Almost all of these drainage channels are dry for large periods of the year, flowing mostly after heavy rainfall. The Bath Stream is the only exception, flowing year-round to the sea from springs less than 1.6 km inland (DOE, 2001).

The land is typically flat near the coast featuring sandy beaches, fresh water lagoons, rocky shores and cliffs. The beaches and lagoons (sourced from either mountain run-off or springs) are mostly found on the leeward coast with a 4 km stretch of beach between Charlestown and Cades Bay. The rocky shores and cliffs are found on the south and east coasts. Other important coastal ecosystems (in addition to the freshwater lagoons) include coral reefs and seagrass beds (MOSD, 2007).

The landscape of Nevis has been cleared of virgin forest at one time or another and although the peaks are still covered (11% of the total land area of St. Kitts and Nevis, (Poverty Research Unit, 2006) they do not show virgin forest characteristics. Lower slopes have secondary growth on abandoned farmland and the lowlands are intensely used for development or farming (MOSD, 2007). Much of the land on Nevis is cultivated by rural farmers growing vegetables and coconuts and there is a large coconut forest on the west side (Poverty Research Unit, 2006). The Nevis Tourism Authority promotes the islands as a nature lover's paradise.

As with most Caribbean islands the climate of Nevis is heavily influenced by the marine environment. The average temperature is typically 27°C and seasonal and diurnal variations in temperature are small. Only at higher elevations do temperatures drop below 17°C (MOSD, 2007).

Nevis 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%. Annual average rainfall on Nevis is about 1170 mm (DOE, 2001).

Given the location of Nevis in the northeast Trade Winds, the prevailing wind direction swings seasonally between northeast and southeast, with mean speeds ranging from 8.7km/h in November to 14.6km/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 Nevis include Hurricane Hugo (1989),

Hurricanes Luis and Marilyn (1995), Hurricane Georges (1998), Hurricane Omar (2008) (MOE, 2001; GFDRR, 2010).

2.2. *Socio-economic profile*

The recent country poverty assessment of St. Kitts and Nevis, funded by the Caribbean Development Bank, 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 [Millennium Development Goals] MDGs, 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). Like St. Kitts, the population is concentrated in the capital, Charlestown with most villages following a ribbon-style development along the island main road (MOE, 2001), which runs along the coast in the northern half of the island and further inland in the south. 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 Caribbean Development Bank (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, 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[1] for St Kitts and Nevis 1995-2009

YEAR	Gross Domestic Product In Constant Prices (1990), EC$[2] (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: CDB, 2006; ECCB, 2009)

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 (Poverty Research Unit, 2006; Kairi Consultants Ltd, 2009). 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).

[1]Data from these two sources do not agree exactly in overlapping years. 1995-2000 is from CDB, (2006) and 2001-2009 is from ECCB, (2009).

[2]The Eastern Caribbean dollar is tied to the US dollar (US $1.00 = EC $2.70).

Table 2.2.2: Percentage contribution of GVA 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 & 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 particularly on Nevis and there is a fast-growing internet gambling industry established on St. Kitts. Six accredited medical institutions operate in the Federation, including 4 medical schools, a veterinary university and a nursing university (Poverty Research Unit, 2006).

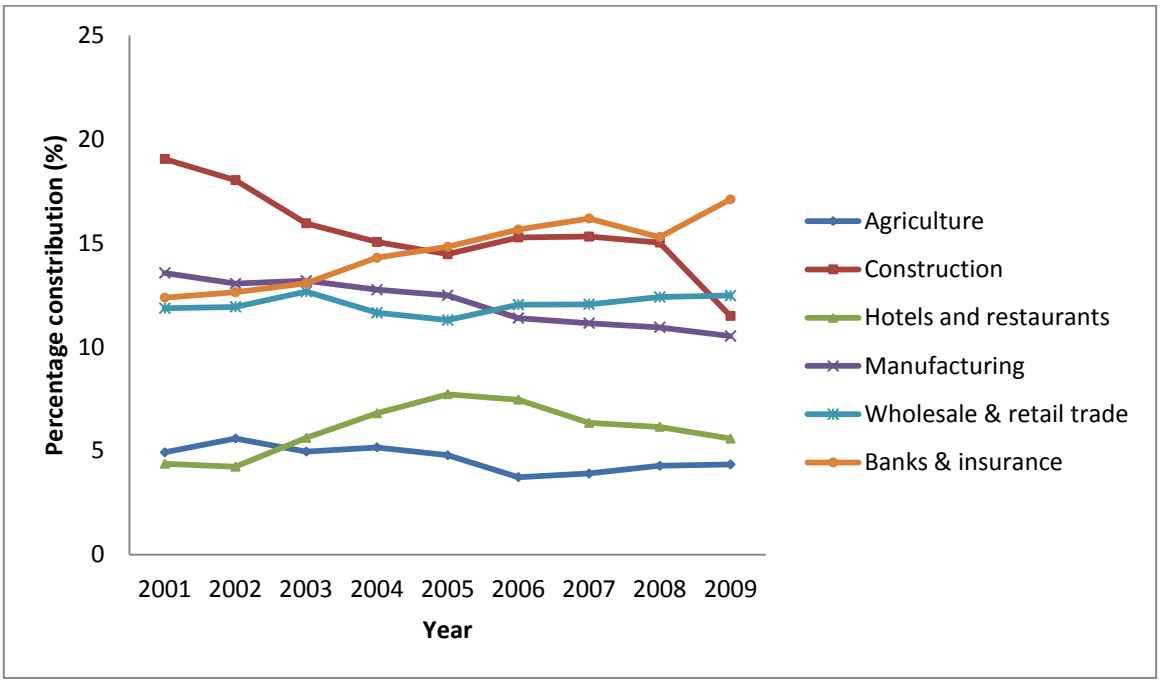


Figure 2.2.1: Percentage contribution to GDP by sector

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). Factors contributing 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 cf. other OECS islands,
- Higher electricity rates than Grenada and Saint Lucia,
- Adequate, but poor quality water supply,
- Exceptionally high port and freight charges (Poverty Research Unit, 2006; Kairi Consultants Ltd, 2009).

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 ECLAC economic 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 due mainly to difficulty in accessing financing for public and private sector projects (ECLAC, 2010b). 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, 1.5% for Nevis) (Kairi Consultants Ltd, 2009) 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 Nevis by industry based on NSLC 2007

Industry	% labour force	Industry	% labour force
Agriculture & fisheries	4.4	**Transportation**	4.0
Manufacturing	1.6	**Services**	27.6
Construction	14.5	**Admin./ Social Security**	1.9
Wholesale & retail	4.9	**Education/ Social work**	5.7
Hotel & restaurant	17.3	**Other**	18.0

(Source: Kairi Consultants Ltd, 2009)

The National Survey of Living Conditions (NSLC) completed by Kairi Consultants Ltd in 2007 as part of the Country Poverty Assessment (CPA) found that there were marginally more males employed than females (98.6% male: 98.4% female in Nevis) (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 (Nevis 15.9% poverty rate and zero indigence) which is an improvement on 2000 levels. Given the low unemployment and high poverty rates, Nevis has a clear problem of the 'working poor', where salaries are

too low to keep above the poverty line. The data collected shows that 96.8% of the poorest quintile of society in Nevis is working, but the highest unemployment rate (8%) is found amongst the poorest women. It is therefore common to find people who work two jobs in order to make ends meet.

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, especially in Nevis, 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 sea level rise, 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. The hotel and restaurant sector has contributed between 4% and 8% of GDP in St. Kitts and Nevis over the past decade, peaking in 2005 before declining to 2009 and is responsible for 17.3% of the employment, 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-endstay-over visitors and despite an 18% rise in cruise ship passengers. The decline in stay-over visitors was even in higher in St. Kitts and Nevis at 27% (ECLAC, 2010b). Table 2.3.1 and Figure 2.3.1 show that in recent years the tourism sector has become more dependent on cruise ship passengers (83% in 2009 cf. 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 (Nevis only)	Excursionists (Nevis only)	Cruise ship passengers (Nevis only)	Yacht passengers (Nevis only)	Cruise ship calls (Nevis only)	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 (6,361)	1,911	242 (43)	336.92
2008	127,705 (22,007)	3,920	400,916 (3,764)	812 (424)	232 (22)	297.17
2009	93,081 (7,878)	3,708	450,553 (3,765)	209 (112)	235 (19)	225.41
2010	(7,657)	(163)	(3,542)	(530)	(26)	

(Source: OECS, 2010; R. Wiltshire, personal communication, May 11, 2011)

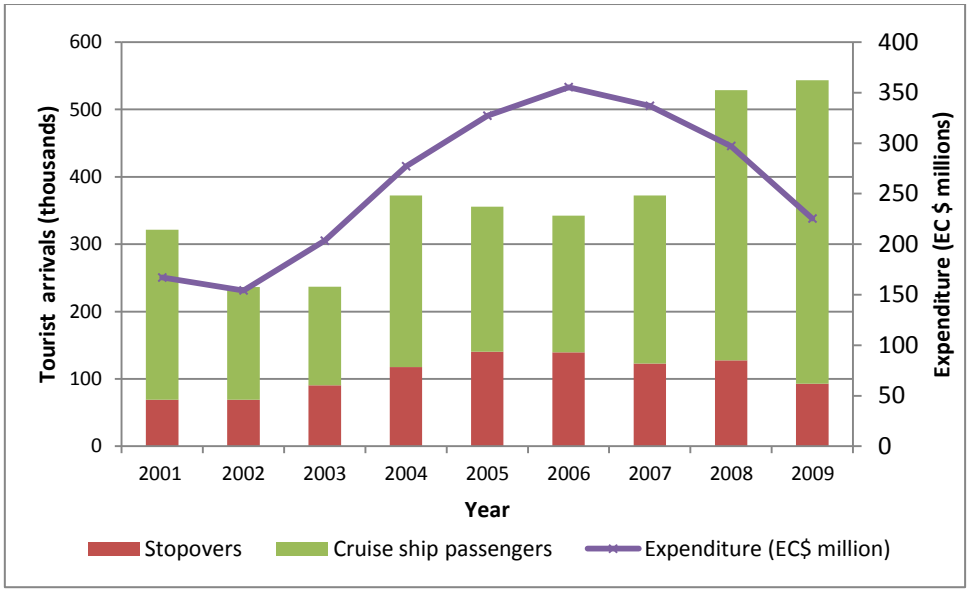


Figure 2.3.1: Distribution of tourist arrivals and expenditure.

The numbers in brackets in Table 2.3.1 are the statistics for Nevis specifically and were provided by the NIA Statistics department. They show that Nevis has a relatively small share of the cruise and stopover market, but accounts for almost half of the yacht passengers visiting the twin-island state (Rianne Wiltshire – NIA Statistics, personal communication, May 11, 2011).

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 at the prestigious Christophe Harbour development (due to for completion in 2012) at the start of 2010 has also boosted the image of St. Kitts and Nevis as a 'high end' destination (RLB, 2010).

According to the Caribbean Tourism Organisation the average length of stay is 9.6 nights with 50% staying in hotels and 41% in private residences (Caribbean Tourism Organisation, n.d.). Tourist accommodation

establishments are located both along the north and west coasts and further inland. According to the Nevis Tourism Authority there were 9 hotels, 13 guest houses and 14 villas in 2010 (Nevis Tourism Authority, 2011). The number of hotel rooms available in the Federation has varied considerably over the period 1998-2007 as shown in 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 islands (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 with the resultant 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 & Hughes, n.d.). This scenario was repeated in 2008 when Hurricane Omar caused the closure of the Four Seasons Resort for a second time. This explains the large drop in stop-overs in Nevis between 2008 and 2009, Table 2.3.1. The resort re-opened in December 2010. The closure of the resort also affected airlift, with American Airlines withdrawing service to Nevis in 2009 (4,574 flights in 2008, 2,880 in 2009 and 3,346 in 2010) (Rianne Wiltshire – NIA Statistics, personal communication, May 11, 2011).

As stated earlier, the hotel and restaurant sector employed 17.3% 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 (20%), 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 Nevis 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), which have been used in the CCCRA, 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 JJA and 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 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 three emissions scenarios. The overall decreases in annual rainfall projected by GCMs occur largely through decreased JJA and SON rainfall, but these changes are less consistent between models.

RCM projections of rainfall for 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 DJF (-2%), and an increase in 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*		
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
		A2				0	**0**	0	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*		
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 exceedance of a relative threshold for 'heavy' rain, were examined. 'Heavy' rain is determined by the daily rainfall totals that are exceeded on 5% of wet days in the 'current' climate or reference period, relative to the particular climate of a specific region or season.

There is insufficient daily observational data to identify trends in rainfall extremes in 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 as % total rainfall falling in Heavy Events (R95pct).

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***
%	*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

Table 3.9.2: Observed and GCM projected changes in rainfall extremes for St. Kitts and Nevis for Maximum 1-day rainfall (RX1day)

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	*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

Table 3.9.3: Observed and GCM projected changes in rainfall extremes for St. Kitts and Nevis for Maximum 5-day Rainfall (RX5day)

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
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 Nevis 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 NEVIS

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 Jessups and Cotton Ground to provide additional community-level data. Field surveys at Jessups, Oualie, Lover's Bay and Pinney's Beach 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 Nevis.

Nevis 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 Nevis, the major issues of climate change are SLR and the likelihood of more intense weather systems, increasing temperatures and periods of drought. Sea water rise is seen as the greatest potential impact, especially during intense storm swell conditions. Various government agencies, including the Department of Marine Resources, the Ministry of Sustainable Development and Education and the Ministry of Public Works, play varying roles in the protection of Nevisians from such impacts.

4.1. *Water Quality and Availability*

4.1.1. Background

Groundwater is the main source of water in Nevis where there are 14 active wells (USACE, 2004), however, compared to larger St. Kitts, water is considered to be less available on Nevis due to rainfall patterns as a result of the lower elevations of its central mountains, absence of significant springs and prominence of a layer of silica pan covered with a layer of clayey soils that inhibits the prolific water infiltration (MHE, 2001).

Approximately 91% of piped-borne water is obtained from ground water sources and 9% from surface springs (Mr Morris, personal communication, June 28, 2011). All water comes from rainfall which is mainly orographic. Rainfall drains into 10 drainage basins that originate around centrally located Nevis Peak, the highest point on the island. In general water flows through ephemeral ghauts that come alive 3 to 4 times for the year to the sea. The rain falls heaviest between June to October (MHE, 2001).

Nevis is divided into two hydrological basins, the Charlestown Basin on the western side and the Fountain Basin on the eastern side of the island (USACE, 2004). As described in the National Report Integrating the Management of Coastal Wetlands in St. Kitts and Nevis "at least three quarters of the land area is covered by very shallow clay soils underlain by a silica pan that severely limits infiltration" (MHE, 2001). The island has no natural reservoirs (USACE, 2004).

According to the Nevis Water Department, water resources are considered sufficient to meet current water demands on the island (Mr Morris, personal communication, June 28, 2011). However, the average annual rainfall is 1,170 mm which is lower than St. Kitts and lower than other islands in the Caribbean. As a consequence, the use of storage in cisterns is quite common as a means of storing rainwater to supplement NWD supplies. The majority of these wells are considered to be operating near capacity. There were more

wells in the past; however a number of them were abandoned due to low yield. Water is also sourced from surface intakes, namely Nevis Peak, Prison Farm, Campus Spring and Jessups. It is estimated that Nevis needs 1 million gallons of water per day, due to the high demand from the tourism sector, such as with hotels and for a number of golf courses around the island. Water is also sourced from rainfall sources (ECLAC, 2003). The domestic sector uses the greatest amount of water. The water sector is public and water is distributed to 95% of Nevis (Mr Morris, personal communication, June 28, 2011).

The water storage capacity of Nevis is approximately 3 million gallons of water/day. The island has also become greatly adapted to rainwater harvesting, according to a study on rainwater harvesting in selected Caribbean countries, 80 – 90% of the residents and businesses in Nevis can capture water, whereas for St. Kitts only 5% of the island can accomplish the same (CEHI, 2006). Nevis does not currently utilise desalination technology to supply its water demands.

In Nevis, in 2007, 3% of households and 1.5% 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% of households have water for seven days of the week. There is also 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).

Table 4.1.1: Water Tariffs for users in Nevis

	Water Usage (Gallons per Month)	Rate $EC ($US)
Domestic	<3,000	$8.00 ($2.96) per 1000 gallons
Domestic	<3,000	$10.00 ($3.70) per 1000 gallons
Hotel	-	$25.00 ($9.25) per 1000 gallons
Domestic Farming	≤10,000	$5.00 ($1.85) per 1,000 gallons
Agriculture	>10,000	$10.00 ($3.70) per 1000 gallons
Small Businesses/Ships	-	$20.00 ($7.40) per 1000 gallons
Needy	-	$3.00 ($1.11) per 1000 gallons
Domestic Farming	≤10,000	$5.00 ($1.85) per 1,000 gallons
Agriculture	>10,000	$10.00 ($3.70) per 1000 gallons
Small Businesses/Ships	-	$20.00 ($7.40) per 1000 gallons
Needy	-	$3.00 ($1.11) per 1000 gallons

(Source: Mr George Morris, NWD, 2011)

The Nevis Water Department has approximately 7,500 customers all of which are metered whereas in St. Kitts there are both metered and unmetered costumers. The water rates are either flat rates or metered rates which are shown in Table 4.1.1. The cost of water is higher in Nevis that St. Kitts in all categories. There is no 'Needy' water rate in St. Kitts. Water loss is estimated to be between 17% and 35% (Mr Morris, personal communication, June 28, 2011).

In 2010, EC $8.1 million was spent on capital expenditure and another $3.1 million on recurring expenditure. In 2011, there was a significant decrease in spending on capital expenditure, at $5.2 million while recurring expenditure increased slightly to $3.6 million (Mr Morris, personal communication, June 28, 2011).

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

The water sector in Nevis is vulnerable to climate change in a number of ways. Hurricane activity can impact on water infrastructure. Sea level rise can contaminate coastal aquifers with saline water. There have also been reports of heavy metal contaminants in ground water resources (USACE, 2004). The majority of population utilises septic tanks and this therefore leaves the concern that of biological contamination of aquifers (Kairi Consultants Limited, 2009b).

When there is heavy precipitation, resultant flooding impacts on the water quality in springs increasing turbidity levels and can introduce bacteriological contaminants. However, flooding is less of a concern than other Caribbean islands because only 4% of Nevis has <2 ° slope (MHE, 2001). Nonetheless, turbidity issues are exacerbated by unregulated building and road construction on steep slopes which increases erosion. Deforestation of lands for agriculture and during quarrying exercises also decreases the quality of water entering ghauts (MHE, 2001). Conversely during dry spells and drought conditions, ground water recharge rates decrease affecting the available water resources (Mr Morris, personal communication, June 28, 2011). This is particularly important to Nevis as it depends on groundwater resources even more than St. Kitts.

Drought in Nevis

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.

When droughts occur in Nevis, they generally last for between 2 to 3 months. The Nevis Water Department usually issues public notices for consumers to conserve water. Depending on the severity water rationing is carried out. As noted previously the average rainfall per year is 1,170 mm but has dropped to between 885 and 942 mm during drought conditions in the past (USACE, 2004). Average annual rainfall can be as low as 750 mm on the windward side and as high as 1,310 mm on the at Hamilton estate on the slope of Nevis Peak (MHE, 2001). Some natural arid areas also exist on the island (Kairi Consultants Limited, 2009a). Additionally, the rainforest area on the island which is concentrated in the centre of the island around Nevis Peak is very small and therefore water is quickly exposed to evaporation. This limits the amount groundwater recharge that can occur, and is further affected by the steepness of ghauts (40% slopes) that channel precipitation that originates from the peak (MHE, 2001).

In the 1990's, three major droughts occurred and are described as follows; "During the 1990 to 1991 drought, average rainfall for the 2-year period was 942 mm (37 inches). In 1993, average rainfall was 942 mm (37 inches), and it was 885 mm (35 inches) in 1997" (USACE, 2004). The drought of 2009/2010 also affected Nevis and was described as "one of the worst droughts that we have experienced in the past 50 years" however the country was fairly well prepared for below average rainfall. Some steps that helped to

mitigate the effect of the drought as described by Minister of Public Utilities "We cleaned the old wells, we repaired leaking reservoirs and broken pipes, we met an eight-inch line between Fothergills and Golden Rock, which was reduced to a six inch bottleneck up to Stoney Hill. We replaced the six inch line with an eight inch and that alone allowed us to move more water" (Nevis Island Administration, 2011c).

The agriculture sector is most affected during drought conditions. It is estimated that if there is a 10 to 20% decline in annual precipitation ground water recharge rates would be affected, as Mr Morris of the Nevis Water Department summaries "we would have more frequent droughts, our surplus would be at risk and our storage would suffer" (Mr Morris, personal communication, June 28, 2011).

Groundwater Resources and 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), leading to substantial declines in freshwater availability. Reductions in groundwater recharge to inland aquifers can also lead to seawater intrusion if they are next to saline aquifers (Chen et al., 2004), indicating a potential knock-on effect where coastal aquifers become saline due to sea level rise, then neighbouring aquifers experience saltwater intrusion during dry periods with low groundwater recharge. With global average sea levels found to be rising at a rate of 1.8 ± 0.3 mm per year (White et al., 2005) and with rates increasing (Church and White, 2006), coastal aquifers may be severely impacted by saltwater intrusion and many countries may lose vital water resources.

Storm surges from hurricanes can cause extensive damage to aquifers (Anderson, 2002), the risk of which will increase as higher sea levels reduce the level of the storm-surge required for contamination to occur. In the Caribbean, sea levels have been observed to have risen between 1.5 and 3 mm per year (see Section 3). 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).

While there are approximately 14 active wells in Nevis, some have been abandoned in the past due to their low yields (ECLAC, 2003). In Nevis coastal aquifers are at an elevation of around 2 m and are up to 70 m in mountainous areas. The freshwater/saltwater interface is estimated to be at 20 m in coastal areas (USACE, 2004). The size of the island and therefore proximity to the coast on all fronts is close and as such there are concerns of saline contamination (Mr Morris, personal communication, June 28, 2011). However, some wells are considered to be naturally brackish and the water is also high in calcium, but has been used has irrigation water and for landscaping (ECLAC, 2003). While St. Kitts still depends on coastal aquifers for groundwater resources, Nevis has begun to utilise bedrock drilling at higher elevations over coastal aquifers to counter this threat and to exploit new sources of water resources (Mr Morris, personal communication, June 28, 2011). Aside from salinity concerns, the Country Poverty Assessment has noted that "The planning authorities are concerned about the impact of septic tanks on aquifers: proximity to aquifers is likely to lead to problems with sewerage, eventually. A sewage plant is being contemplated" (Kairi Consultants Limited, 2009b). This potentially further reduces the available water resources.

4.2. *Energy Supply and Distribution*

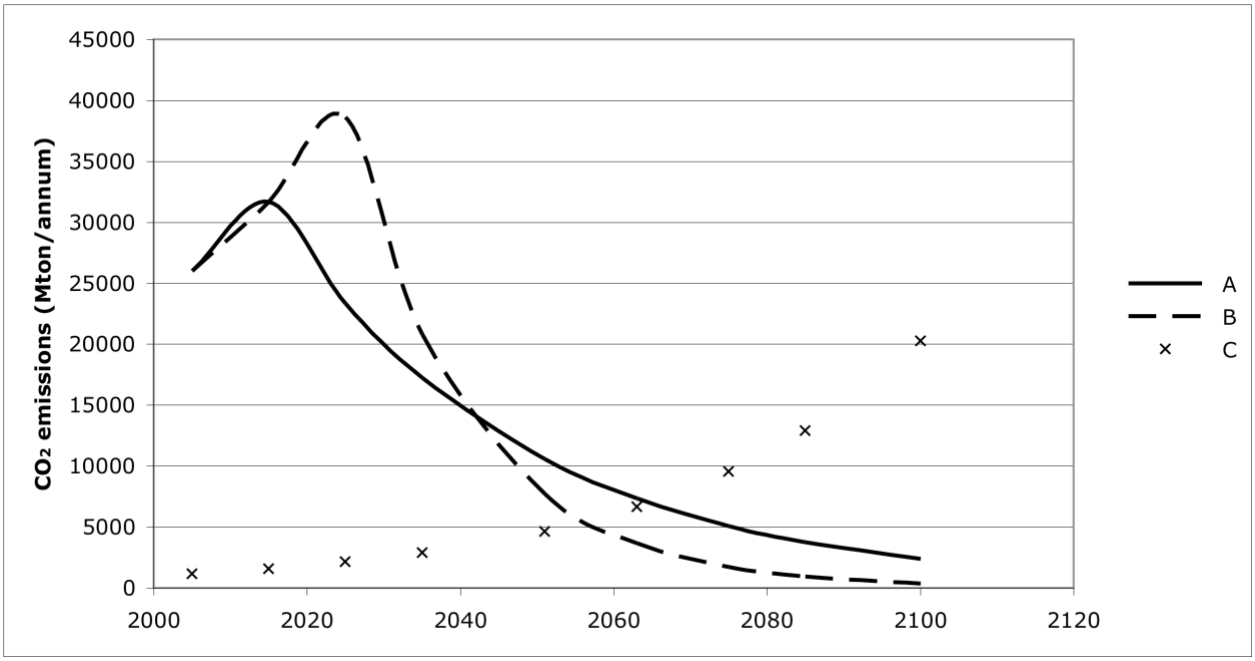
4.2.1. Background

A global perspective

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

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

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



Lines A and B 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). (Source: Scott et al. 2010)

Figure 4.2.1: Global CO_2 emission pathways versus unrestricted tourism emissions growth.

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

The Caribbean perspective

It is widely acknowledged that the Caribbean accounts for only 0.2% of global emissions of CO_2, with a population of 40 million, i.e. 0.6% of the world's population (Dulal *et al*., 2009). Within the region, emissions are however highly unequally distributed between countries, Figure 4.2.2. For instance, Trinidad & Tobago, as an oil-producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. 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 Intergovernmental Panel on Climate Change (IPCC) suggests a decline in emissions by 20% by 2020 (IPCC, 2007b), 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.

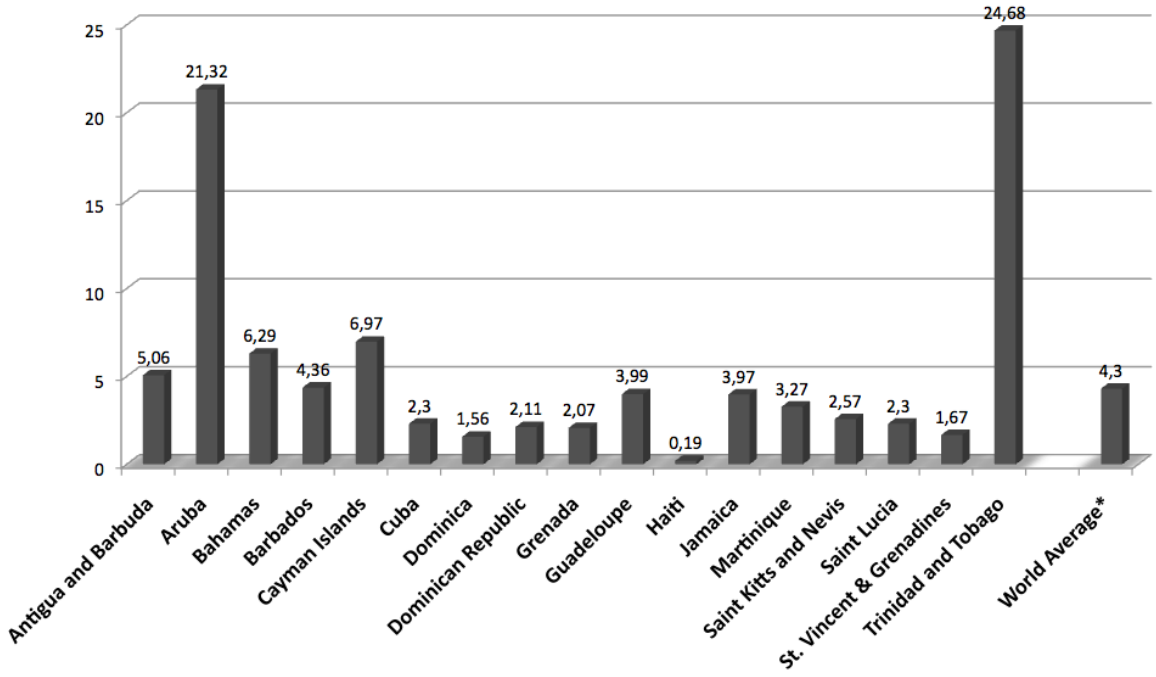


Figure 4.2.2: Per capita emissions of CO_2 in selected countries in the Caribbean, 2005

(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 & 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 tons of fuel oils were shipped in 2008 to St. Kitts Sea Port and 15,780 tons to Nevis Air and Sea Ports (MOPWUEH, 2011a). Based on these values, approximately 20% of total imports are for Nevis.

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 Nevis Electricity Company (NEVLEC) is the wholly owned subsidiary of the Nevis Island Administration that generates, transmits, distributes and sells electrical energy in Nevis. The power plant is located at Prospect Industrial Site with a total installed capacity of 13.4 MW (NEVLEC, n.d.). Table 4.2.1 presents the production and consumption data for NEVLEC over the past decade.

Table 4.2.1: Electricity generating statistics, Nevis 2001-2009

Years	Electricity Production (kWh)	Unit Consumption (kWh)	Wind Production (kWh)
2001	36,529,470	29,369,300*	
2002	44,441,970	36,306,750	
2003	46,472,420	37,376,190	
2004	47,668,050	38,021,830	
2005	52,020,160	42,169,360*	
2006	54,346,510	44,030,680	
2007	55,303,180	44,607,790	
2008	55,779,790	44,520,950	
2009	50,995,700	39,756,300	
2010	50,851,480	41,251,750	1,237,250

*These values were forecast/estimated because not all data was collected for those particular years.

(Source: Cartwright Farrell, NEVLEC, personal communication, May 11, 2011)

The drop in production between 2008 and 2009 was a result of the closure of the Four Seasons Hotel following damage by Hurricane Omar. Four Seasons represents about 1.1-1.2 MW of power demand or 20% of the base load of 5 MW (MOPWUEH, 2011a and C. Farrell, personal communication, July 22, 2011). Since the hotel re-opened in December 2010, production has been increased to meet the renewed demand.

In addition to the diesel plant, the WindWatt Wind Farm on Maddens Estate in south-eastern Nevis (2.2 MW capacity) was opened in summer 2010, and was the first wind power project in the OECS (Coward, 2010; Green Antilles, 2010; Green Island, 2010). The eight turbines have been providing power (1.1 MW, with an allowance to go to a maximum of 1.6 MW) to NEVLEC through a power purchase agreement since July 21, 2010 (MOPWUEH, 2011a; C. Farrell, NEVLEC, personal communication, July 26, 2011).

According to the work of De Cuba the balance of customers on Nevis is as shown in Table 4.2.2.

Table 4.2.2: Customer distribution in Nevis, 2004

Sector	Nevis
Domestic/residential use	32%
Commercial	65%
General suppliers	-
Street lighting	3%
Total	100%

(Source: De Cuba, 2006)

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 in St. Kitts exists to primarily to 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: UNWTO-UNEP-WMO, 2008; DEFRA, 2010; 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, consumption in Nevis was 41 GWh in 2010 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 6.2 GWh in the accommodation sector alone, which is considerably different to the value calculated in Table 4.2.3 of 25.6 GW, thus emphasising the need for improved energy audits in the sector.

The distribution of energy use between tourism in St. Kitts and Nevis is also unknown. De Cuba (2006) reports that in 2004, 32% of electricity in Nevis was used for domestic purposes and 65% 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), i.e. 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.[3]

Trends in energy use in St. Kitts and Nevis

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 bbls per day in 1990 to 1300 bbls 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 Nevis, which indicates considerable growth in the period 2005-2015, Figure 4.2.3.

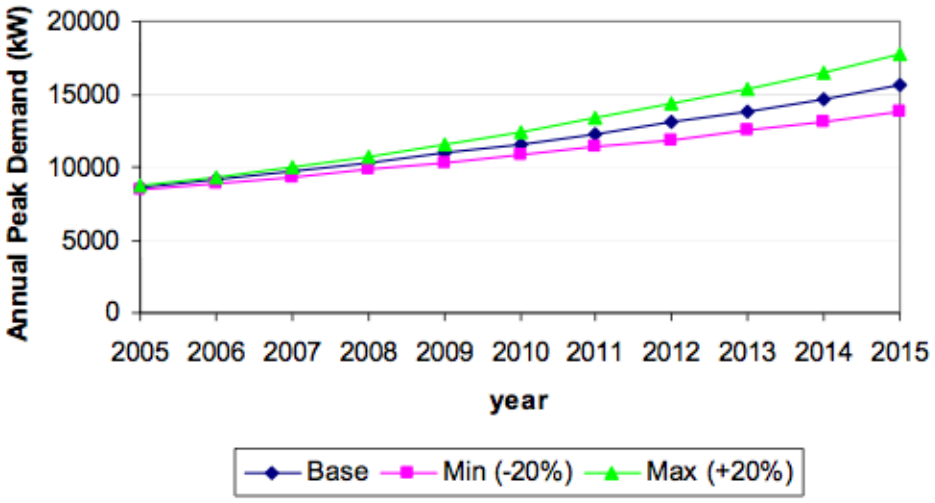


Figure 4.2.3: Projections of the annual peak demand for Nevis 2005-2015

(Source: De Cuba, 2006)

There also exists a projection of electricity demand for tourism in Nevis, with Figure 4.2.4 showing how different tourism scenarios (base case, minimum growth and maximum growth of the sector) 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.

[3] 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).

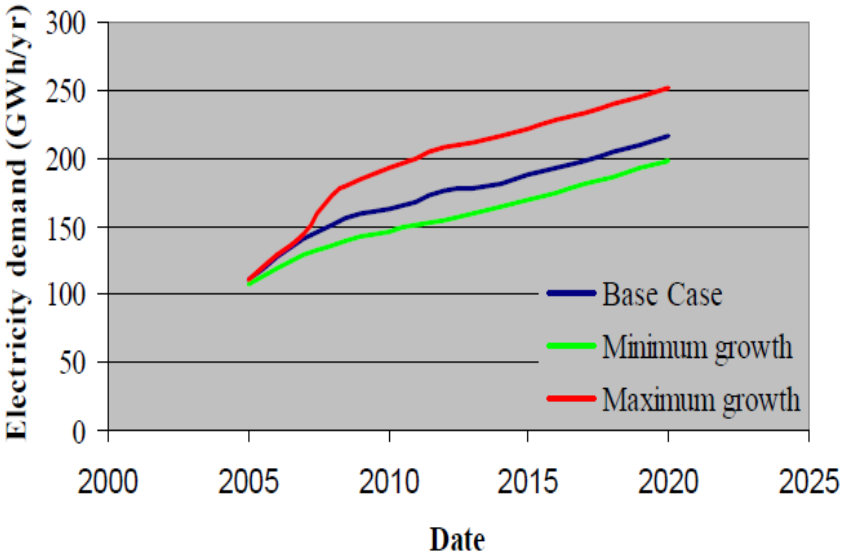


Figure 4.2.4: Electricity demand growth based on various tourism development scenarios

(Source: From E. Brederode, 2008 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 percent of the total CO2 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 CO2 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. (Source: 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. As energy consumption is anticipated to increase in the islands it is clear that even St. Kitts and Nevis need to reduce their 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 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. (Source: MOPWUEH, 2011c)

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

Policy on 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 in 2006, important insights on energy use and options to restructure the energy system were presented by De Cuba (2006), who describes the optimal expansion scenario for Nevis:

…the system configuration consists of diesel capacity, 10 MW geothermal capacity and 6 x 800 kW Nordex turbines as wind energy (see Figure 4.2.5). In the case of the N2 scenario a 10 MW geothermal technology development will be in operation in 2012, while in the wind option is introduced in a later stage (See Figure 4.2.6). As in scenario N1, here the geothermal technology has a great impact on the fuel usage and thus also the COE, next to this the CO_2 emissions are reduced considerably. (Source: De Cuba, 2006: 17)

The determination of the optimum considers both economic and socio-environmental factors, but notably in both scenarios fossil fuels remain an important part of the energy mix, with renewables representing 30-35% of the capacity.

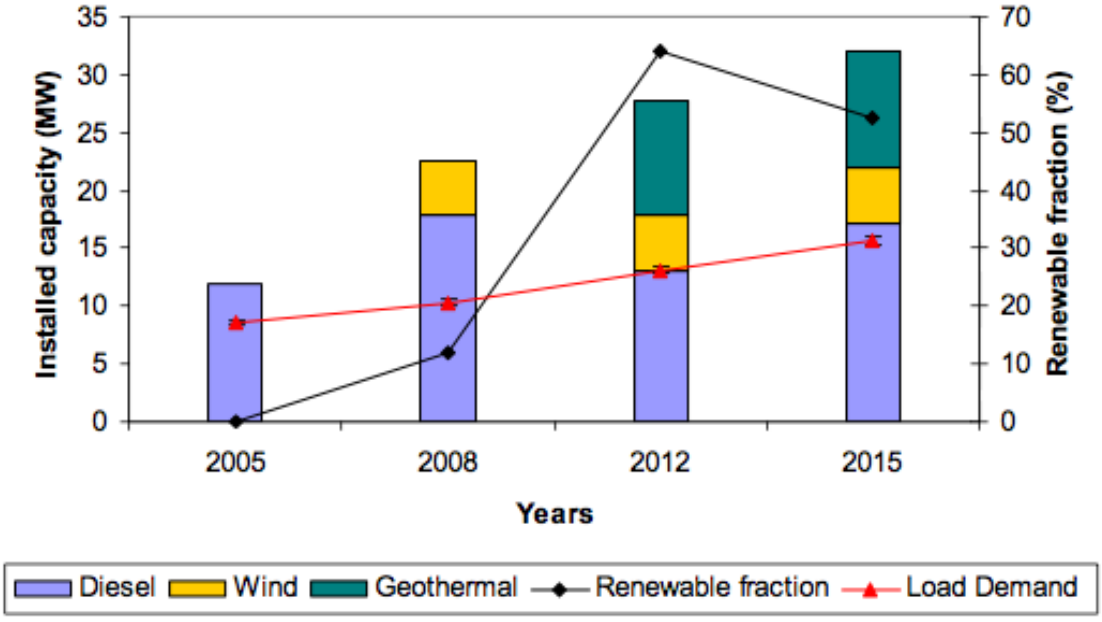


Figure 4.2.5: Overview of the results of the N1 scenario for Nevis

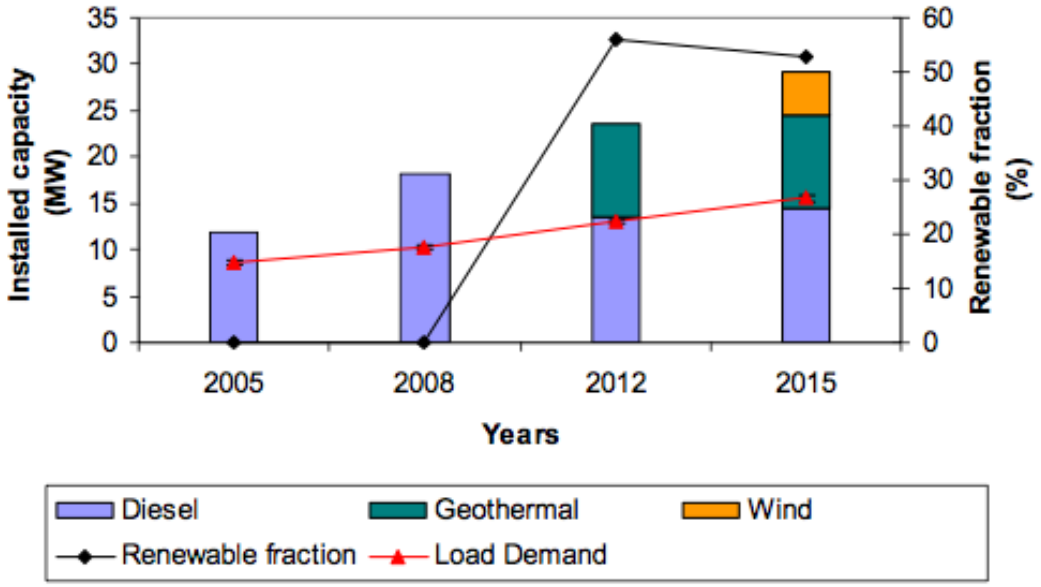


Figure 4.2.6: Overview of results of the N2 scenario for Nevis

(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 2010-12, wind power capacity of 2.2 MW has been installed on Nevis, and a 10 MW geothermal plant is planned.

With regard to geothermal power, development on Nevis is ongoing. A power purchasing agreement was signed between NEVLEC and West Indies Power (WIP) on the 20th of April, 2009 for a 10 MW geothermal power plant, and there are discussions for the funding of an additional 30 MW geothermal project to be developed by WIP in Nevis, in order to also supply the power demands of St. Kitts via submarine cable (see also Table 4.2.4). NEVLEC is the sole distributor of power on Nevis, so WIP cannot sell power directly to any party/entity in the Federation other than NEVLEC (MOPWUEH, 2011a). 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 for transportation is still required (MOPWUEH, 2011a). Nevis has expressed a general interest in using electric cars powered by geothermal generated electricity and it is suggested that tax incentives and duties are needed to stimulate introduction of such vehicles with authorities and agencies leading by example (MOPWUEH, 2011a). It is also that the gradual decline in fuel consumption for transportation is attributable primarily 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 emissions of CO_2.

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 plan 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 each 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 greenhouse gases. Such measures would affect the cost of mobility, in particular, air transport, being a highly energy- and emission-intense sector. The following sections will discuss past and future energy costs, the challenges of global climate policy and how these interact to create vulnerabilities in 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 4.2.7) – for the first time since 1981 (IEA, 2009) - world oil prices have already begun to climb again in 2009, and are projected to rise further. The International Energy Agency (IEA) (IEA, 2010) projects for instance, that oil prices will almost double between 2009 and 2035 (in 2009 prices). Notably, Figure 4.2.7 shows the decline in oil prices in 2009; in March 2011, Bloomberg reported Brent spot prices exceeding USS120/barrel.

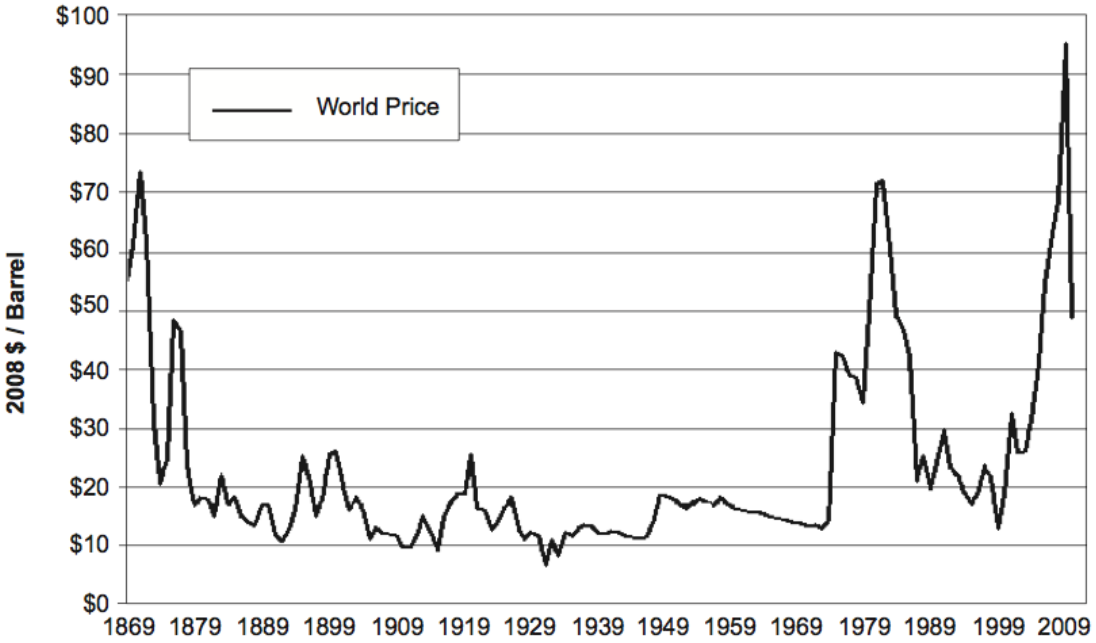


Figure 4.2.7: Crude oil prices 1869-2009

(Source: after Williams, 2010)

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

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

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

Fuel price volatility, in late 2008 exceeding 30% of operational costs (IATA 2009, see Figure 4.2.8), had a range of negative impacts for airlines. Before the financial crisis, it appeared as if low-fare carriers would be severely affected by high fuel prices, with even profitable airlines reporting falling profits, grounded aircraft and cancelled routes: high fuel prices had clearly affected the perception of travellers to fly at quasi-zero costs (cf. Gössling and Upham, 2009). However, when fuel costs declined because of the financial crisis, low cost carriers were apparently seen by many travellers as the only airlines still offering flights at reasonable prices, reversing passenger choices to the disadvantage of the flag carriers. These examples show that high and rising oil prices, as well as price volatility can significantly affect tourism and in particular airlines, increasing destination vulnerability.

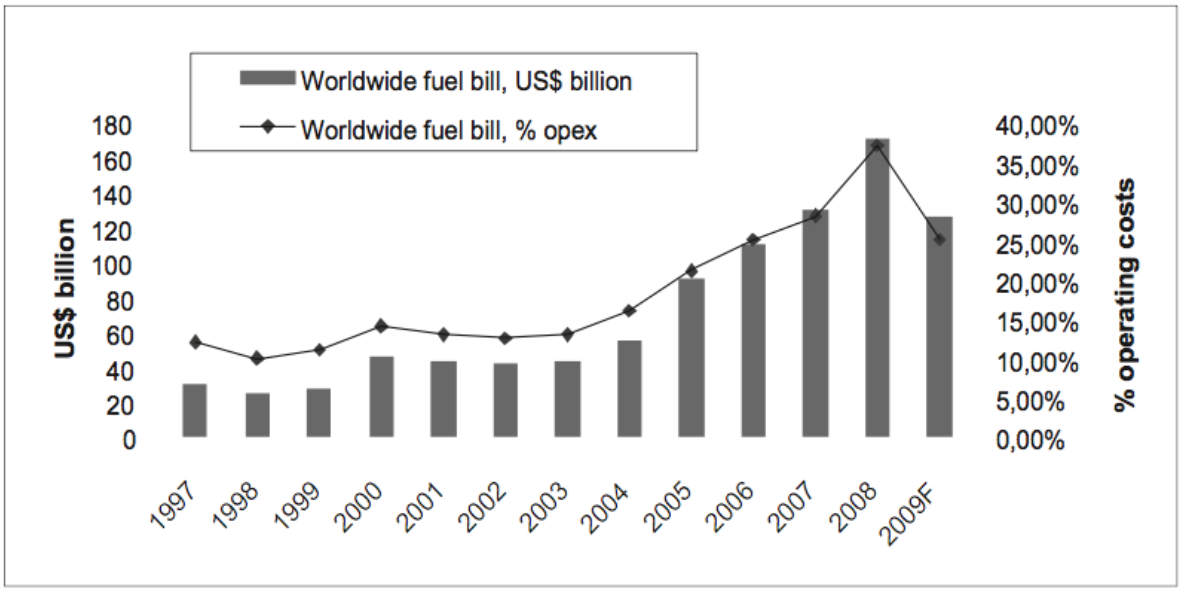


Figure 4.2.8: Fuel costs as part of a worldwide operating cost

(Source: IATA, 2009)

Climate policy

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

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

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

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 & Customs, 2008)

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

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

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

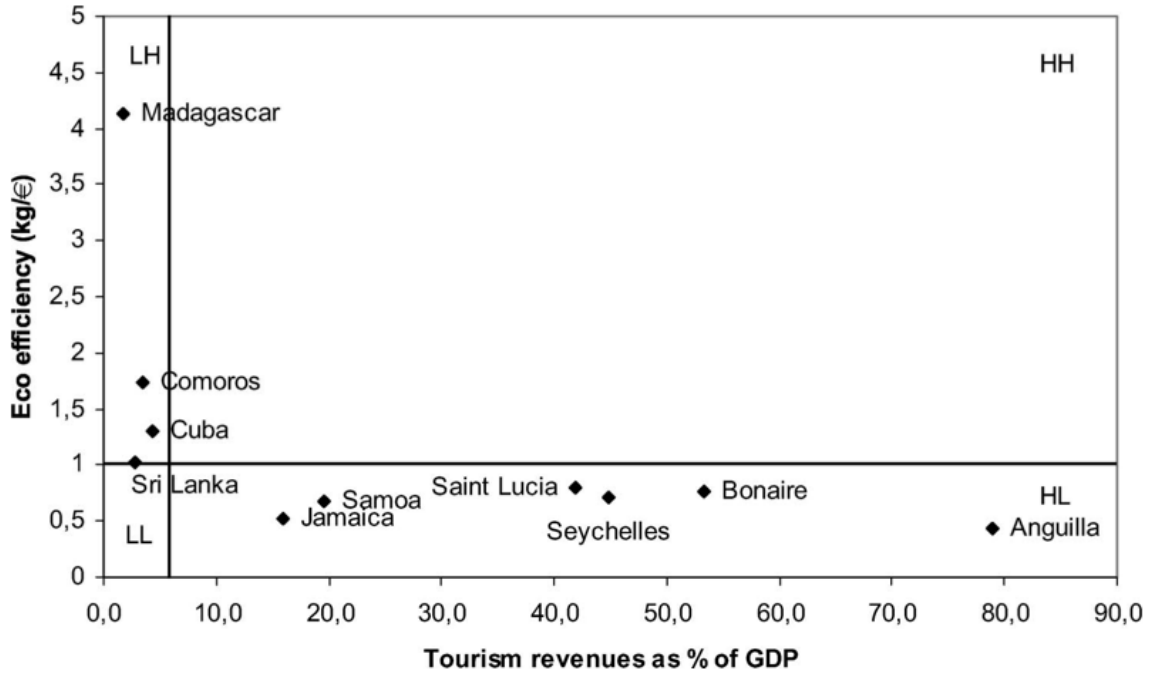
2010). While governments have a wide range of environmental policy tools at their disposal to address this problem, including regulatory instruments, market-based instruments, agreements, subsidies, or information campaigns, the fairest and most efficient way of reducing emissions is increasingly seen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

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

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

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 4.2.9 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. (Source: Gössling et al., 2008)

Figure 4.2.9: Vulnerability of selected islands, measured as eco-efficiency and revenue share

While global climate policy affecting transportation is currently only emerging, there are already a number of publications seeking to analyse the consequences of climate policy for tourism-dependent islands. There is general consensus that current climate policy is not likely to affect mobility because international aviation is exempted from value-added tax (VAT), a situation not likely to change in the near future due to the existence of a large number of bilateral agreements. Furthermore, emissions trading as currently envisaged by the EU would, upon implementation in 2012, increase the cost of flying by just about €3 per

1,000 passenger-kilometres (pkm) at permit prices of €25 per ton of CO_2 (Scott *et al*., 2010). Similar findings are presented by Mayor and Tol (2010b), who model that a price of €23/t CO_2 per permit will have a negligible effect on emissions developments. Other considerable increases in transport costs due to taxation are not currently apparent in any of the 45 countries studied by OECD & UNEP (2011), though such taxes may be implemented in the future. The example of the UK has been outlined above and Germany introduced a departure tax of €8, €25 and €45 for flights <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 ten tourism-dependent less developed island states with diverse geographic and tourism market characteristics. It confirmed that the EU-ETS would only marginally affect demand to these countries, i.e. causing a slight delay in growth in arrival numbers from Europe through to 2020, when growth in arrivals would be 0.2% to 5.8% lower than in the baseline scenario (Gössling *et al*. 2008).

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

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

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

Climate change impacts on energy generation, distribution and infrastructure

A report on the potential impacts of climate change on the energy sector published by the U.S. Department of Energy distinguishes between direct impacts: which affect energy resource availability, fuel and power production, transmission and distribution processes; and indirect impacts which are brought on by other

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

Nevis' energy production is almost entirely based on one diesel powered plant with a contribution from wind power and progress being made regarding geothermal energy. Potential physical climate change impacts specific to traditional energy production systems as well as the renewable technologies being considered by the Government for Nevis (wind and geothermal) 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 Nevis 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. The turbines installed in Nevis are designed to be winched down in the event of an approaching hurricane (C. Farrell, NEVLEC, personal communication, July 26, 2011). In the aftermath of extreme weather, the process of restoring transmission and proper operation of generating facilities depends on road access and the amount of supplies available to replace infrastructure components that have been damaged or destroyed (see Section 4.8.3). The vulnerability of the sector to extreme weather events therefore has even greater implications for increasing the recovery period and extending the loss of productivity in all other sectors within the country following an event (U.S. Department of Energy/National Energy Technology Laboratory, 2007; IPCC, 2007b; Contreras-Lisperguer & de Cuba, 2008).

Model projections for Nevis 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 Climate Modelling Section). 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 Prospect Power Station in Nevis. The climate modelling projections also indicate a decrease in mean annual rainfall, (although these predictions are more uncertain than temperature changes) which may affect water availability for non-contact cooling of power generators (Contreras-Lisperguer & de Cuba, 2008). (See Water Section on issues of Water Availability).

Nevis is already implementing renewable energy projects utilising wind power and progress is being made in developing the islands geothermal potential. 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 Climate Modelling Section).

Geothermal energy generation can be affected by climate change in much the same ways as fossil fuel generation systems. Power is generated using steam cycles and is driven by the difference in ambient and combustion temperatures. In light of this, changes in air temperature can impact the overall efficiency of the system (Contreras-Lisperguer & de Cuba, 2008).

Climate change, ocean-based impacts on the energy system include storm surge events and SLR. These processes are a threat primarily to infrastructure located within the coastal zone, and within the impact range of these events. Simpson et al. (2010) highlight that some key impact scenarios for St. Kitts and Nevis, considering its geophysical nature 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 Nevis' systems should be prioritised, especially in the case of renewable energy sources which depend on climate and priority coastal infrastructure such as power plants.

4.3. *Agriculture and Food Security*

4.3.1. Background

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

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

4.3.2. The Importance of Agriculture to National Development

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 tons in 1955 had declined to just under 150,000 tons in 2005. The sugar industry was a major contributor to Government's fiscal deficit, with annual losses equivalent to 4 percent 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 Nevis

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 two 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 important 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%t respectively. This accomplishment is expected to reverse the downward trend of agriculture's contribution to GDP illustrated in the table below.

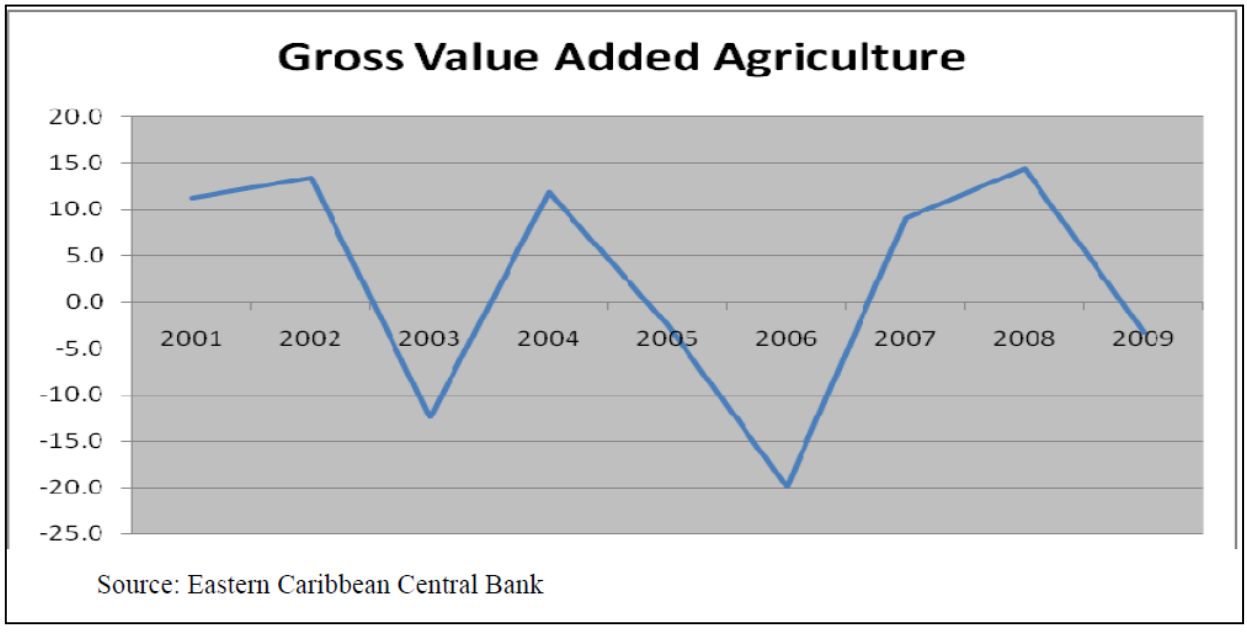


Figure 4.3.1: St. Kitts & Nevis Rate of Growth of GDP in Agriculture Constant Prices

In terms of food crop production, the annual agricultural review (2010) indicates that during 2009 increased vegetable production was recorded for pumpkin (26%), onion (60%), watermelon (97%), sweet potato (17%), and pineapple (43%). The table below 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
Sweet 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, 2010)

Despite a marked improvement in food crop production after the close of the sugar industry, FAO (2011) estimates that agricultural imports in St. Kitts & Nevis (US $58 million) are approximately five times higher than exports (US $11 million). However, the government's strategy for the development of the agricultural sector is designed to counteract this phenomenon with six 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 Nevis Agriculture

A UNECLAC report on poverty in St. Kitts and Nevis (2007) estimates that with the closure of the sugar industry in 2005 one thousand five hundred (1,500) workers were made redundant, three hundred (300) of whom were women. With technical support from the government, 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 USAID Farmer-to-Farmer program, the Community Achievers Project (CAP) in St. Kitts & 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 ten 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 Nevis

St. Kitts and Nevis initial national communication to the UNFCCC (2001) reveals that under the 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 budget speech 2011 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 Nevis

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 1000 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 on the next page.

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 Southeast Peninsula. 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 Southeast Peninsula.

Despite these vulnerability enhancing factors, a land resource analysis project funded by 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 Food and Agriculture Organization of the United Nations 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.

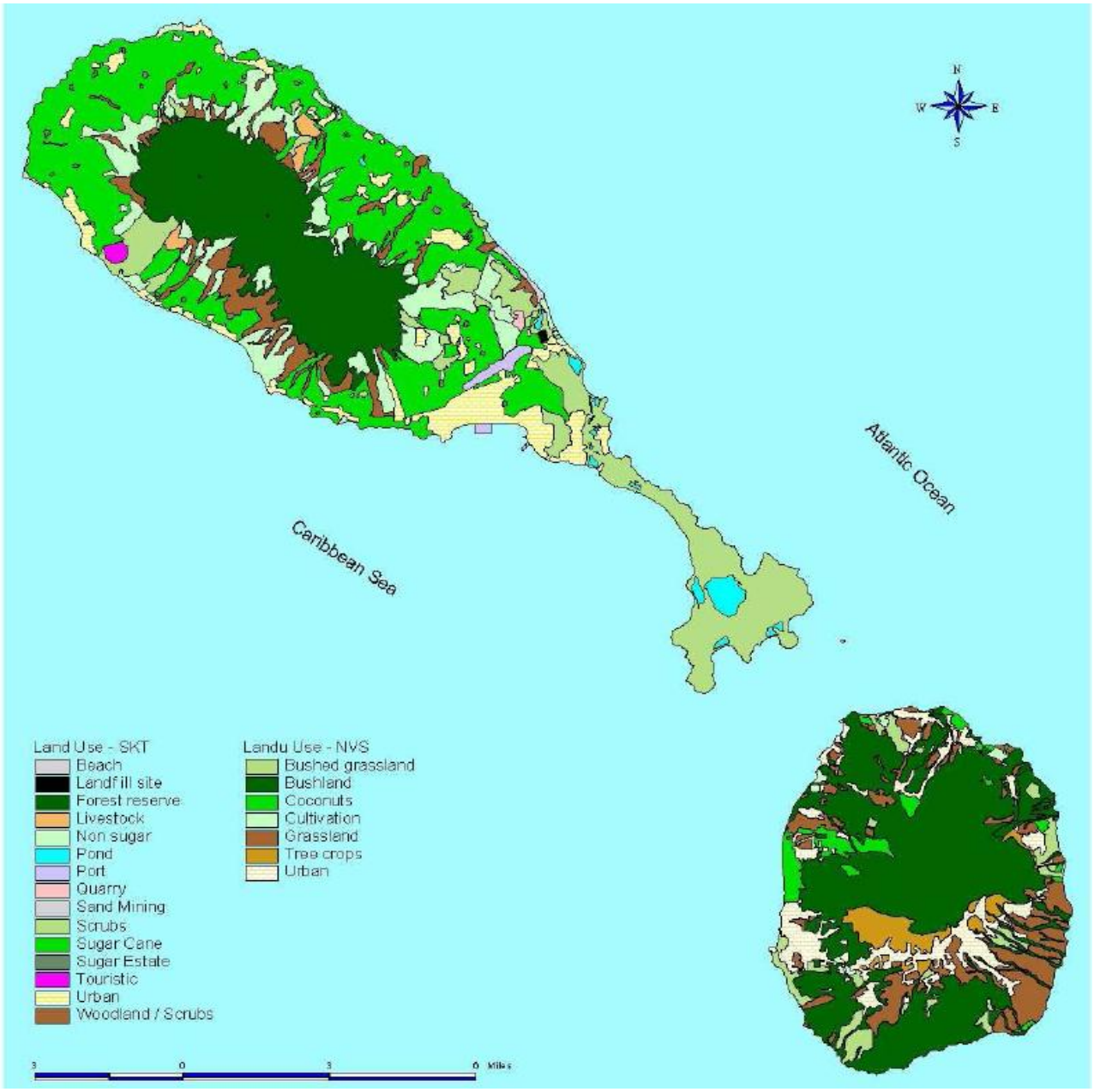


Figure 4.3.2: Land Use Map for St. Kitts and Nevis

4.3.7. Social Vulnerability of Agricultural Communities in Nevis

According to the St. Kitts and Nevis Country Poverty Assessment 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 Food and Agriculture Organization (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 country poverty assessment 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 thirty 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 & Agricultural Outputs in Nevis

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 four crops as alternatives to sugar-cane; pumpkin, peanut, sweet potato and onion, (Edwards & Jacque, 2008) show that all four 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.

Figure 4.3.3: Key Crop Profile: St. Kitts & 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 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (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 of travellers who become ill abroad approximately 75% contract 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 Gross Domestic Product (GDP) of Small Island Developing States (SIDS).

The potential effects of climate change on public health can be direct or indirect effects (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, sea level rise 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 United Nations Framework Convention on Climate Change 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 Nevis

Population	10,725 (2008)[1]
Unemployment rate	1.5% (2006)[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)	13.98 (2008)[1]
Crude death rate (per 1,000)	10.3 (2008)[1]

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

4.4.2. Direct Impacts

Weather Related Mortality and Morbidity

Mortality and morbidity rates due to injuries sustained during natural disasters such as hurricanes, tropical storms and floods are important considerations when assessing the vulnerability of a country to climate change. 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.). Therefore it has 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, that were repeatedly devastated by hurricanes in the past (PAHO, 1998).

The Initial National Communication to the UNFCCC noted that expected sea level rise 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 heatwave 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.

In general, increased temperatures may result in an increase in morbidity and mortality (Hajat et al., 2010) which is directly related to heat exhaustion and dehydration (Sanford, 2004). The elderly and young of the population are more susceptible than other groups as well as persons with chronic illnesses, people doing manual labourers and persons who gain their livelihood outdoors e.g. construction workers and fishermen. Heat waves may increase humidity and urban air pollution (Moreno, 2006) and is therefore of relevance to Nevis. 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 enthusiasts 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.

4.4.3. Indirect Impacts

Increase in Vector-Borne Diseases

Nevis' 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. Nevis has a relatively small share of the stay-over and cruise market when compared to St. Kitts, but accounts for almost half of yacht passengers visiting the Federation. 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 – There are not many cases of the Malaria reported in St. Kitts and Nevis, on average there has been one reported case every year between 2003 and 2010 all of which were imported cases. The last case, in 2010 was reported in Nevis (Ministry of Health, 2011). Despite the fact that this represents a small incidence of Malaria, the possible re-emergence of Malaria is considered to be a real threat to the region and by extension to specific countries such as St. Kitts and Nevis (Rawlins et al., 2008). The risk of importing cases is a point that is often presented due to the high number of visitors to the Caribbean region as noted above and the increase in vector population due to a changing climate.

Although St. Kitts has no recorded species of *Anopheles* mosquito vector that can transmit Malaria, Nevis has 2 of the 29 species that exist throughout the region (Rawlins, et al., 2008). However, cases that have been reported in the last 30 years have all been imported cases. The risk of transmission from other countries is high as *Anopheles* mosquitoes are present on 17 of the 21 Caribbean Epidemiology Centre

(CAREC) Member Countries (Rawlins, et al., 2008). According to the Morbidity Review of Communicable Diseases in CAREC Member Countries, between 1980 and 2005 there were just 6 cases of Malaria reported in the St. Kitts and Nevis (CAREC, 2008c).

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 hospitalizations in tourists from Malaria prone destinations (Wilder-Smith and Schwartz, 2005).

Dengue Fever - Dengue fever is caused by one of four 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 *Aedesaegypti*. Population growth, urbanization 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 island of St 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, & 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 - 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 2010is 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 average 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 but only 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 (1 case), July (5 cases), September (4 cases), October (3 cases) and November (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 predominantly an urban disease (Pinheiro and Corber, 1997) which makes highly populated areas are 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

Nevis is one of the drier islands of the Caribbean region, experiencing annual rainfall that of approximately 890 – 1000mm per year. Though the island was 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.

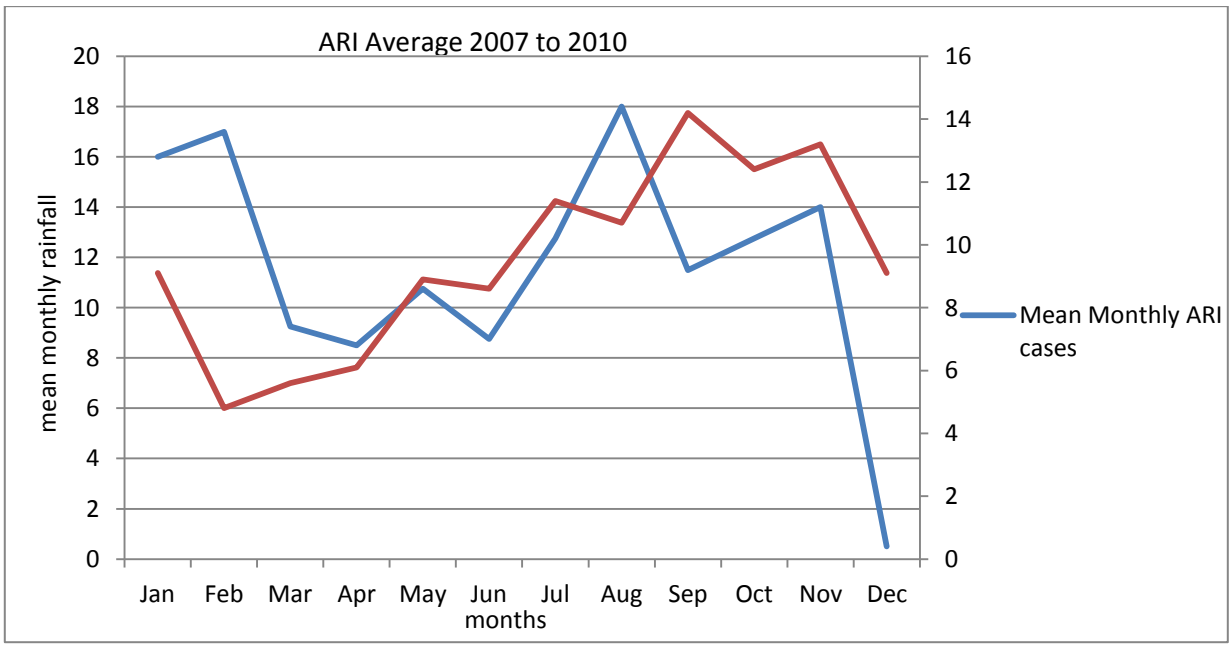


Figure 4.4.1: Mean Monthly Acute Respiratory Infections (ARI) morbidity cases against Rainfall in St. Kitts and Nevis

(Source: by author, data provided by Ministry of Health, 2011)

Drought related impacts relevant to Nevis 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. Lucia (Amarakoon et al., 2004). Figure 4.4.1 demonstrates that in St. Kitts and Nevis ARI cases are more prevalent during the rainy season. Conversely, in 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 four years.

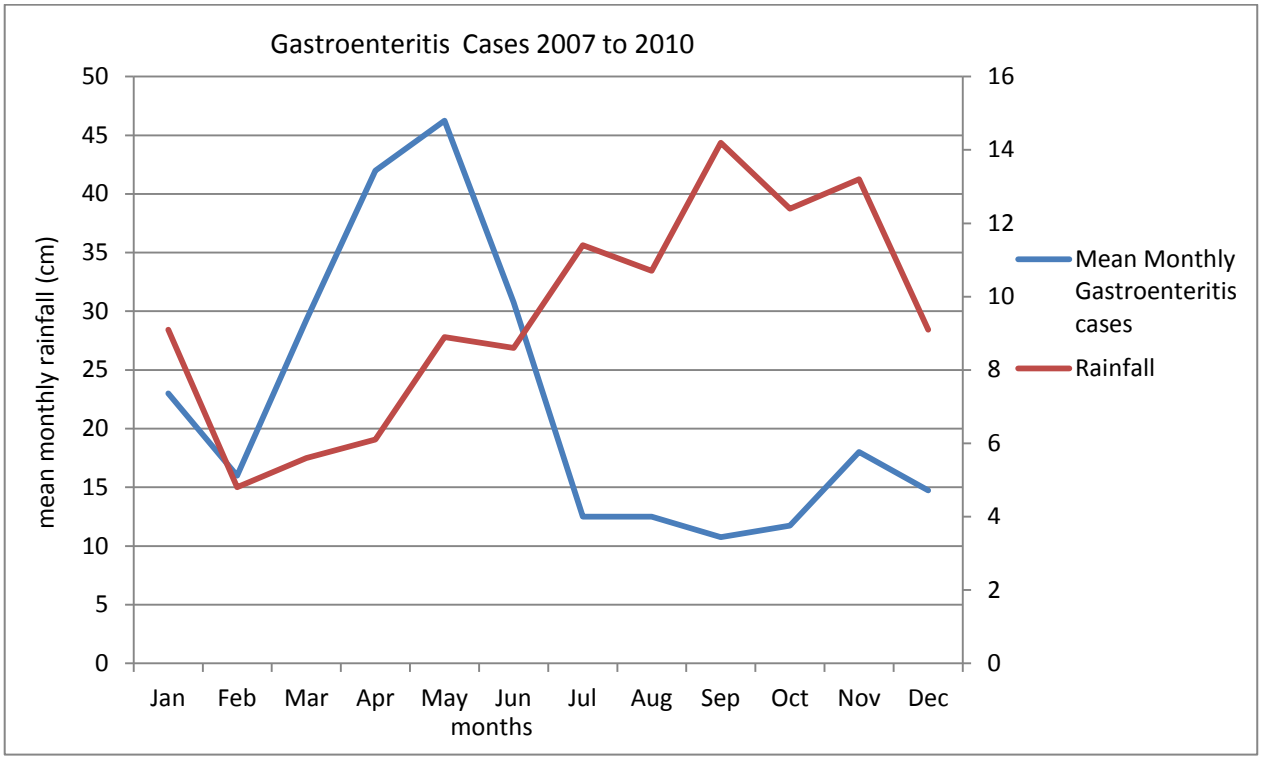


Figure 4.4.2: Mean Monthly Gastroenteritis morbidity cases against Mean Monthly Rainfall in St. Kitts and Nevis

(Source: by author, data provided by Ministry of Health, 2011)

Table 4.4.2 shows Acute Respiratory Infections for Nevis between 2005 and 2010. It should be noted that incidence of ARI is higher in Nevis than in St. Kitts. Nevis did not have any cases of Influenza during the same period except for 2 cases of H1N1 Swine Flu in 2009 (Ministry of Health, 2011). Additionally, as mentioned before 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: Morbidity cases for Acute Respiratory Infections (ARI) in Nevis between 2005 and 2010

Year	2005	2006	2007	2008	2009	2010	Total
Sum of Acute Respiratory Infections < 5 yrs	105	54	33	26	34	69	321
Sum of Acute Respiratory Infections > 5 yrs	37	3	1	13	56	100	210

(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 island of St. Lucia (Amarakoon et al., 2004). It takes approximately one week for dust clouds to travel across the Atlantic to the Caribbean (Prospero & 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 diseases and those with 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 also affects Caribbean islands such as Nevis.

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 Country Poverty Assessment 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, 2009a).

In St. Kitts and Nevis 96.8% of the country has access to safe water from a public source (Kairi Consutlants Limited, 2009a). In Nevis, 79% of the population has access to water in their dwelling, being 6% less than St. Kitts. Other sources of water were public supply piped into the yard (13%) and water from public standpipes (2.5%) (Kairi Consultants Limited, 2009b). A number of food-borne illnesses are associated with water and poor sanitation and include Gastroenteritis, Salmonella, Shigellosis as well as Cholera. Flooding can also 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 GE in children >5 years dropped from 1759 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 one of two main causes of morbidity in children (PAHO, 1998). There have also been 5 deaths due to Gastroenteritis in Nevis in the last few years – 1 death in 2005, 2006, 2009 and 2 deaths in 2010 (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). Gastroenteritis and other gastrointestinal diseases are important diseases which can negatively impact the tourism industry in Nevis. 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 Nevis between 2005 and 2010

Year	2005	2006	2007	2008	2009	2010	Total
Sum of Gastroenteritis < 5 yrs	108	40	75	51	40	47	361
Sum of Gastroenteritis > 5 yrs	37	3	1	13	56	100	210

(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 gram 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 in the past

(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 Hospedaleset *al*., (1997) and the quality of potable water at hospitals in Trinidad and Tobago by Nagalingam et al., (2005). Nonetheless its relevance to health and climate change in Nevis is evident given the tourism thrust of the government of St. Kitts and Nevis. Given the climate and the need for water storage in the Caribbean region it is clear that there is always a risk for Legionnaires outbreaks.

Food security and Malnutrition

Nevis 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 Fourth Assessment Report states that under-nutrition, protein energy malnutrition and/or micronutrient deficiencies are major impacts of climate changes (Confalonieri, et al., 2007). Indeed in St. Kitts and Nevis between the 2002-2004 periods, 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 is relevant to some rural communities in Nevis. 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 1980's, 1970's and 1960's found that Ciguatera was more prevalent in islands north of Martinique (Olsen et al., 1984). Nevis 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 Ciguatera assessment by Tester et al., (2010) estimated the Annual Ciguatera Fish Poisoning incidence of Ciguatera in St. Kitts and Nevis to be 5.5 per 10,000 in 1981, 0.04 per 10,000 between 1998 – 2006. No cases have been reported between 2004 and 2010.

An increase in the incidence of Ciguatera may arise as seas become warmer due to climate change, triggering harmful algal blooms increase (HAB's) which produce 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 transported to flooded areas. In Nevis approximately 11.7% 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,

2009c). 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 and Leptospirosis. An example of a disease is that its spread is related to water supply and sanitation is Acute Haemorrhagic Conjunctivitis (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 Nevis alone, there have just been 6 reported cases in the last six years – 1 case 2005 and 5 in October of 2008 (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). There was only one reported cases of the disease in 2009 Nevis, all cases reported in at least the last 6 years (2005 -2010) were from St. Kitts (Ministry of Health, 2011). However, due to the proximity of the island it is mentioned briefly here. In the IPPC Fourth Assessment Health report it states that "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). Seasonal patterns of Leptospirosis has recently been demonstrated in Trinidad by Mohan et al. (2009) and as Table 4.4.4 shows that during 2007 and 2011 the disease was more associated with the latter rainier half of the year in St. Kitts and Nevis (Ministry of Health, 2011). Additionally, 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 4.4.4: 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

(Source: Ministry of Health, 2011)
**Month of one case not given*
***Patient died*

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 126 species of bird, 3 species of amphibians, 4 reptile species and 6 species of bats, the only native mammal of St. Kitts and Nevis (Lepage, 2011; Horwith & 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 Nevis, are intimately linked to the state of the environment and biological diversity. Fishing, agriculture and tourism are the main economic drivers on Nevis, with the latter being the principal foreign exchange earner, employing 17.3% of the Nevisian labour force in hotels and restaurants alone. 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. Tourism is a resource dependent industry, and cruise tourism in particular is a concern to biodiversity conservation since very large numbers of people engaging in leisurely activities, that are confined spatially and temporally, can exceed the carrying capacity of an ecosystem. In addition to the local pressures, global warming impacts threaten the sustainability of Nevis' ecosystems. Small Island Developing States (SIDS), and those in the Caribbean in particular, have been determined to be some of the most vulnerable nations to global climate change. The Caribbean Region is also one of the world's biodiversity hotspots, i.e. a region with high endemic species diversity (at least 1,500 species of vascular plants as endemics), that has lost at least 70% of its original habitat (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 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. Maintaining and preserving the biodiversity and ecological products and services of Caribbean SIDS is of paramount importance for the sustainability of livelihoods and communities.

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 and as such 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 Nevis that is particularly important to the country's tourism and supporting sectors.

Status of forests

About 20% of the land area of Nevis is covered with forest/woodland (MOE, 2001). According to the Beard system of classification six vegetative classes have been described for Nevis: rain forest, dry evergreen forest, montane thicket, palm brake, elfin woodland and dry scrub woodland (Lindsay & Horwith, 1999). The rain forests are located primarily on the northwestern side of the mountain above Jessups and is dominated by Mountain cabbage palm (*Euterpe globosa*), Gumlin (*Dacryodes excelsa*), and Burrwood (*Sloanea truncata*). Palm brake is located on very steep slopes or in areas exposed to high winds above 550 m on the eastern and southern slopes and above 700 m on the northern and western slopes of Nevis. Mountain cabbage palm is also the dominant species found along the band of montane forest that has been classified as palm brake vegetation. At the mountain summit, palm brake is replaced by elfin woodland. The highest point on Nevis is the central Nevis Peak (985 m), with Windy Hill (309 m), Saddle Hill (381 m) and Butlers Mountain (478 m) all helping to define a north-northwest to south-southeast spine across the island (MOSD, 2007). Nevis Peak is primarily rainforest but is characterised by a cap of clouds that covers the summit most days only dissipating during periods of dry weather. The vegetation found within this cloud forest, also known as elfin woodland, is characterised by low growing gnarled, tangled shrubs along with mosses, epiphytes and lianas.

Forests have always played an important role in well-being and livelihoods of Nevisians and to the country's economy. Forest vegetation is important to biodiversity conservation by providing habitat to terrestrial animal species including 126 bird species, 5 species of bat and 3 amphibian species, 4 species of reptile and numerous species of insects. Trees, shrubs and other forest plants protect and regulate the quality of the island's freshwater resources, regulate the micro-climate, provide windbreakers during extreme cyclonic events and absorb flood waters during periods of heavy rainfall. Guided hikes are conducted along the Nevis Peak and several rainforest trails, such as Jessups and Butler's Source. Such services are significant to the support of the country's fledgling tourism industry by contributing to visitor comfort, physical safety and enjoyment.

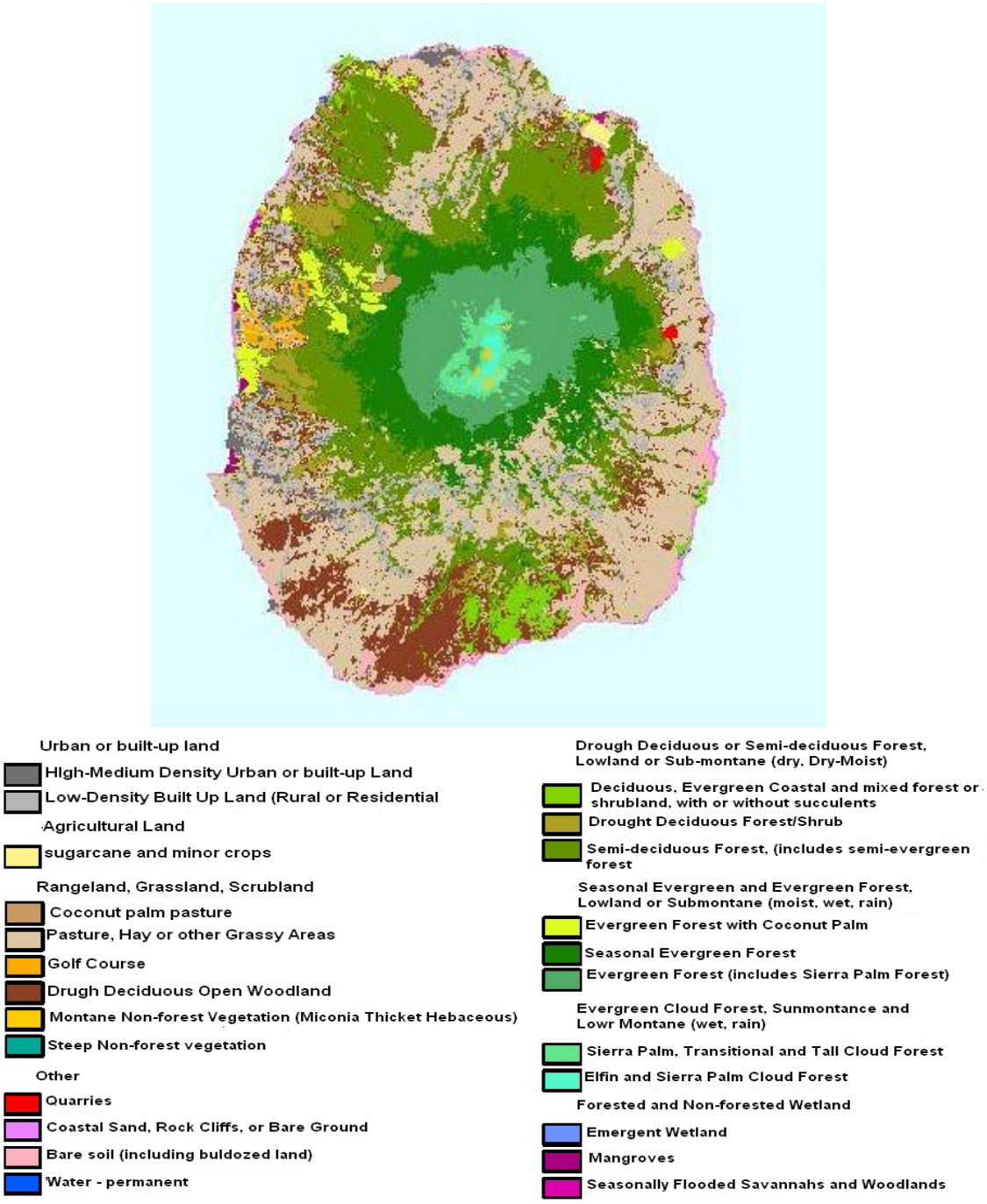


Figure 4.5.1: Nevis Land Cover and Forest Formations
(Source: http://landsat.gsfc.nasa.gov/graphics/news/sci0021lg.jpg)

The landscape of Nevis has been cleared of virgin forest at one time or another and although the peaks are still covered (11% of the total land area of St. Kitts and Nevis, (Poverty Research Unit, 2006)) they do not show virgin forest characteristics. Forest and other vegetative resources continue to face threats from human activity as lowlands are intensely used for development or farming (MOSD, 2007). The lands of Bath Village and Indian Castle are degraded from overgrazing by free roaming animals. As a result of the lack of vegetation, low levels of rainfall and high levels of sea blast, these exposed soils are prone to rain and wind driven erosion (Government of St. Kitts and Nevis, 2004a). Furthermore the terrain slopes steeply from 40^0 from peak to coastline, and is characterised by deeply incised channels called ghauts that allow water to run-off into the sea. The steep topography combined with overgrazing has made these ghauts a major source of sediment and a main cause of siltation of coral reefs.

Forest degradation and over-grazing are serious concerns for Nevis and if left unchecked could have many implications for the ecosystems, people and economic sectors of the island. The relatively small extent of Nevis' rainforest limits the amount groundwater recharge that can occur, and recharge is further affected by the steepness of ghauts that channel precipitation into the sea (MHE, 2001). As the tourism industry grows so will the demands on the islands' water resources. Current and projected impacts of climate change on forests and the products and services that they supply will be discussed in Section 4.5.2 of this document.

Importance and current status of beaches

The mixed variety of powdery white coral sand, foraminifera sand and volcanic sand beaches in Nevis are essential to the island's economic, environmental and social well-being. The major beaches are on the west and north coasts and are important recreational spots for tourists and residents. Beach sediment along with the vegetation found growing on beaches act as buffers protecting coastlines and coastal infrastructure from wind and wave erosion. Beaches are important to biodiversity conservation through the provision of habitat and nesting grounds for a diversity of species such as shorebirds, marine turtles and molluscs. Yet another value of this resource is the role that it plays in the island's fisheries sector. The main fisheries landing sites - Charlestown, Jessups, Cotton Ground, Jones Bay, New Castle, Long Haul and Indian Castle- are beaches (Figure 4.5.2).

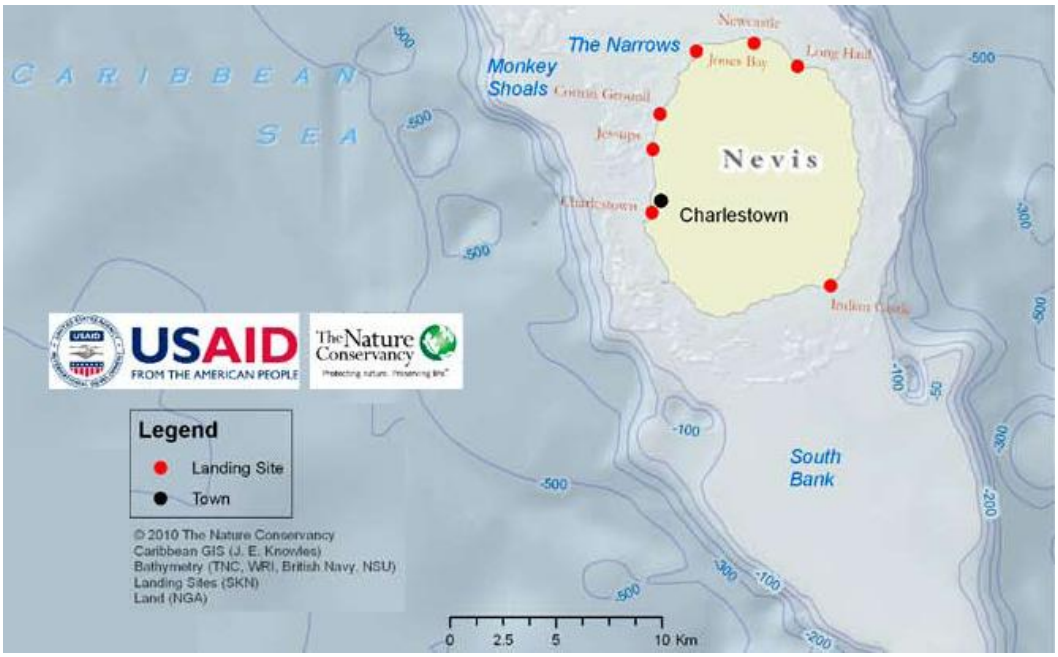


Figure 4.5.2: Landing Sites: Location of fish landing sites in Nevis

Despite the importance of beaches to tourism and related sectors, poor land use management and other human activities have degraded this key coastal asset. Improper shoreline development has negatively affected some beaches such Pinneys, Indian Castle and Nisbett beaches (see Figure 4.5.4 and Figure 4.5.5). Pinneys beach is the most prominent sandy beach in Nevis and is thus an important tourism area stretching for 4 km along the coastline from Charlestown to Cades Bay. Since the 1970's this stretch of sand has experienced dramatic rates of coastal erosion with considerable economic costs to property owners and the national economy (UNESCO, 2007). Another contributor to beach erosion is the removal of sand for construction aggregate. Illegal sand mining in many areas of Nevis threatens to deplete sand resources and

exacerbate coastal erosion since extraction of sand from coastal systems reduces the beach's natural ability to recover from storms and hurricanes.

Importance and status of wetlands and freshwater ecosystems

In Nevis, there are ten major drainage basins that are dry for most of the year with the exception of the Bath Stream which flows year round from springs (DOE, 2001). Only a few small ponds and swamps comprise the wetlands in Nevis, the most extensive of these is the Bogs. Other wetlands are found at Nelson Spring, behind Hurricane Hill beach, near Nisbet Hotel and behind the beach at White Bay. Seven stands of white mangrove are found on western and northern portions of the island occupy about 70 ha in total (2005 estimate) (FAO, 2005). White mangrove (*L. racemosa)* and buttonwood mangrove (*Conocarpus erectus)* are the most common species growing in these stands. The red mangrove was once extensive on Nevis island but in recent times has been reduced to a single tree near Double Deuce Beach Bar on Pinney Beach (Knorr, n.d.). Another feature associated with the leeward coastline of Nevis is its system of freshwater lagoons. These may be the result of either mountain ghaut run-off, as is the case for the Pinneys Estate lagoons, or underground springs as evidenced at Nelson Springs in Cotton Ground (Cambers G. , 1998). The lagoons support a variety of birds, butterflies, fish and aquatic plants. They have also been a source of water for residents and passing ships.

Coastal wetlands play an important role in protecting land from inundation by sea swells and by dissipating wave energy thus protecting shorelines and infrastructure from erosion. Wetlands also protect the sea by filtering sediment and other land-based derived pollutants that can reduce the quality of coastal waters and damage the marine ecosystems, namely coral reefs and seagrass beds. When properly managed, wetlands can be tourist attractions. Although only a few studies have been done on the biodiversity of freshwater ecosystems in Nevis it is known that a few species of crustaceans live within wetlands and waterways including the Caribbean crayfish, Caribbean mud fiddler crab, great land crab, ghost crab, hermit/soldier crab and lesser blue crab (Government of St. Kitts and Nevis, 2004a). Wetlands also provide brooding and nesting grounds for a large number of resident and migratory birds in Nevis, a significant service considering that Nevis has been named on Birdlife International as one of the Important Bird Areas (IBA) in the Caribbean. Mangroves are important nursery areas for many marine species including commercially important species of fish and lobster.

Coastal development and the use of mangroves as rubbish dumps have been the main culprits of wetland degradation in Nevis. Wetlands have been cleared in favour of residential and commercial infrastructure; mangrove at the Camp River mouth, to the west of Nisbett Plantation have also been impacted by the presence of groynes updrift of the stand that have led to erosion and reduced stability for the trees (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis, 1998). Additionally mangroves, particularly the red mangrove species, were at one time heavily harvested for charcoal production (FAO, 1998).

Importance and current status of coral reefs

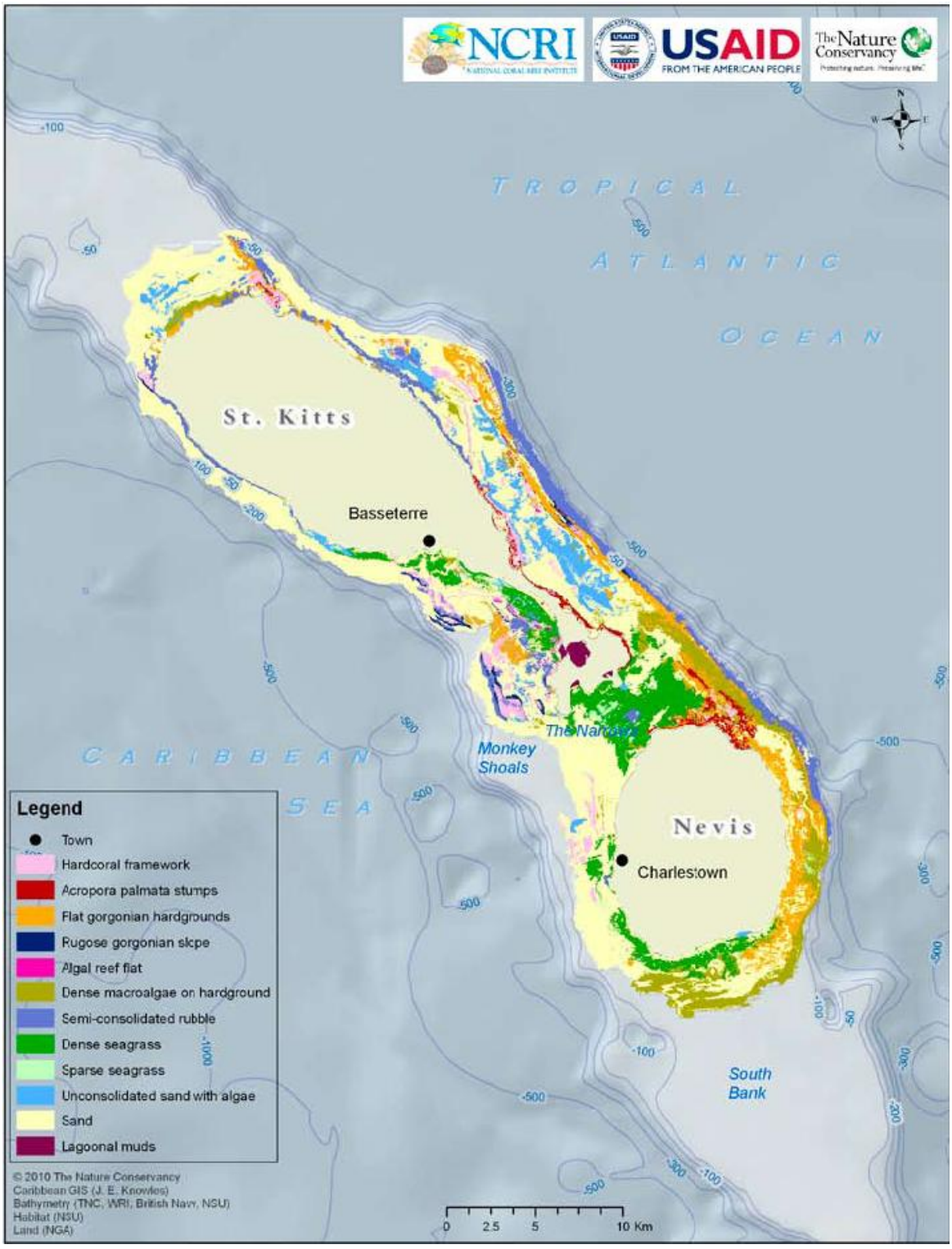


Figure 4.5.3: Modelled bathymetry (ocean depths) of the near-shore areas (less than 30-meter depth) based on 2.5 x 2.5-meter satellite imagery

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

A variety of coral species are found in the coastal waters of Nevis ranging from species categorised as critically endangered by the International Union for Conservation of Nature (IUCN), such as staghorn (*Acropora cervicornis*) and elkhorn (*Acropora palmata*), to the more common finger coral (*Porites divaricata*). Corals provide numerous goods and services for small islands. These "rainforests of the sea" are

habitat, feeding and nursery grounds for juvenile fish, molluscs, crustaceans and marine reptiles that support commercial and recreational fisheries, as well as marine-based tourism activities such as snorkelling and diving. There is currently only one dive operator in Nevis at the Oualie Beach Resort; however the popularity of this activity is increasing thus maintaining healthy reefs will become ever more important to the tourism industry. Coral reefs provide shoreline protection and are also a significant source of beach sand. This supply of sand is critically important for the continued existence of beaches, which also contributes to shoreline protection by helping to reduce the destructive force of high energy waves. Coral reefs also have value in terms of their historic, cultural, medicinal and ecological significance (Schuhmann, 2008).

The Reefs at Risk Revisited report ranked Nevis among the countries that are most dependent on reefs and also whose reefs are among the most threatened (Burke, Reytar, Spalding, & Perry, 2011). A preliminary assessment of reefs of St. Kitts and Nevis, conducted by the Coral Reef Alliance (CORAL), identified a lengthy list of perceived threats to coral reef health. Most of the threats are man-made as seen in the table below.

Table 4.5.1: Categorized threats to coral reefs in Nevis

Land use	Tourism related activity	Other
Coastal zone development	Tourism development	Poverty
Agricultural run off	Golf course chemicals	Lack of resources
Rock quarry	Divers	Overfishing
Sedimentation from unpaved roads	Anchoring/lack of moorings	Irresponsible fishing
Loss of wetlands/coastal resources	Cruise ship pollution	Lack of education
Deforestation	Groundings	Lack of enforcement
Ghaut pollution		Lack of cooperation among stakeholders
Overgrazing		Hurricanes
Inland development		
Sewage		

Nevis accounts for almost half of yacht passengers visiting the Federation; these vessels along with hotels and cruise ships produce large amounts of sewage and waste water that end up in coastal waters increasing the risk of coral disease. White pox is one such disease that has devastated coral reefs throughout the Caribbean and is believed to be responsible for much of the coral reef loss there since 1996. The pathogen is a human strain of the common intestinal bacterium *Serratia marcescens*; the most likely cause of the disease in coral reefs is inadequately treated sewage (UGA, 2010). Physical damage from boats, divers and storms continue to contribute to the deterioration of reefs. Overfishing disrupts the reef community and creates an imbalance that leaves corals susceptible to overgrowth by algae.

Importance and status of seagrass beds

There are several large seagrass beds around St. Kitts and Nevis particularly in the area between the two islands known as The Narrows (Figure 4.5.3). These seagrass communities are typically co-dominated by turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*). Seagrass beds play an important role:

- as primary producers in the food chain of the reef community producing more than 4000 g C/m2/yr
- in fixing nitrogen

- in providing habitats, feeding, breeding, recruitment sites and nursery grounds for juveniles and adults of reef organisms including the major commercial species queen conch (Strombus gigas), which is regulated by the Convention on International Trade in Endangered Species (CITES)
- in reducing sediment movement in nearshore waters and removing sediments from the water column
- in decreasing turbidity of the water

Since the 1990's it was generally conceded that seagrasses around Nevis, especially around Charlestown, were "slowly disappearing" (Robinson in Cambers 1998). Those factors that have contributed to the degradation of coral reefs also impact on seagrasses, namely anchor damage and sedimentation, shipping-related pollution and land-based run-off have caused physical damage to seagrasses and reduced the quality of coastal water (Eckert & Honebrink, 1992).

Small quantities of a marine algae *Gracilaria* sp. also referred to as 'seamoss' is harvested, partially processed and exported to neighbouring islands. Harvesting methods sometimes cause destruction of the substrate on which they grow (Government of St. Kitts and Nevis, 2004a).

Importance and current status of fisheries

Nevis has a relatively small ocean shelf, stable annual water temperature and minimal areas of upwelling. These factors restrict nutrient supply and subsequently the offshore fisheries; nevertheless fisheries are an important livelihood option in Nevis. About 300 fishers (70% full time) are involved in the harvest of demersal or reef/bank, coastal pelagic and ocean pelagic fish species as well as lobster and conch (CRFM, 2010). Nevis appears to be a regional settlement area for queen conch larvae (Anon, 1999) and 8% of conch harvested in the Federation is landed in Nevis (Nicholls R. P., 2007).

Coastal fisheries have declined sharply in recent years, and anecdotally, fishers have reported smaller catches of conch, lobster, and large pelagic and demersal fishes. The decline has been attributed to a degraded marine environment, unsustainable fishing practices and extreme weather events (Agostini, Margles, Schill, & Blyther, 2010). Construction of a new ferry dock and groynes on the west coast and in St. Thomas has had negative environmental impacts on fisheries causing siltation of nearby marine areas. Local currents transport the sediment along the coast of Nevis causing sedimentation of large areas of seagrass beds that are known nursery areas for young snappers and goatfish.

Overfishing and poor fishing practices are also responsible for the reduced catches. Illegal nets with under-sized mesh capture immature fish that are wastefully discarded. Although the use of these nets has reduced there are still a few fishers who continue with this unsustainable practice. An ongoing feud exists between Nevisian and Kittitian fishermen because the latter reportedly steal fish from fish pots set by Nevis fishermen. It is perceived that Kittitian fishermen are also fishing mainly for parrotfish (roughly estimated at 90% of catch), and this will have serious implications for coral reef health and stability (pers. comm.). Community perception is that reef species such as goatfish, butterfly fish and red hind have been severely depleted. Formerly, nearshore areas off the St. Thomas coast were once teeming with conch, but this is no longer that case; conch is now harvested in deeper waters off-shore using SCUBA gear.

The recent arrival of the invasive lionfish (1st reported in November 2010) is potentially a major threat to the fisheries of St. Kitts and Nevis, as this rapidly expanding species is a voracious predator on small reef fish. To date very few reports of larger native fish predating on lionfish have been reported, and local control measures are unlikely to have a substantial impact on its population. Regional research on lionfish

is increasing and should be monitored closely for management recommendations. (See http://www.gcfi.org/Lionfish/Lionfish.html for review of recent papers)

Table 4.5.2: Fisheries landings for Nevis 2003-2007

Product (lbs)	2003	2004	2005	2006	2007
Fish	471,995	497,050	466,680	501,750	402, 500
Conch	94,895	66,225	55,830	109,060	128, 800
Lobster	81,665	77,095	71,185	52,960	38, 675
Miscellaneous Species	54,840	24,180	4,630	-	
Total	561, 920	664, 550	598, 325	663, 770	569, 975

(Source: Fisheries Division St Kitts and Fisheries Division, Nevis)

4.5.2. Vulnerability of Biodiversity and Fisheries to Climate Change

Climate change impacts on forests

While small changes in temperature and precipitation are known to have significant effects on forest ecosystems, there has been little research focused on the projected impacts of climate change on terrestrial biodiversity in the region. Climate change related variations in average daily temperature, seasonal precipitation and extreme weather events will exacerbate the effects of existing human stressors on forest ecosystems. Alterations in the average annual temperature and precipitation patterns may affect the growth of trees and other plant species within the forest. Decreases in precipitation and increased average daily temperatures could result in a loss of rainforest zones and an associated increase in the tropical dry forest zones. The implications are a loss of habitat for endemic species, and a loss of revenue for the eco-tourism sector.

Nevis Peak (985 m) is primarily rainforest but is characterised by a cap of clouds at the summit. The vegetation found within this cloud forest is considered to be most vulnerable to climate change (Foster, 2001). Assuming a cooling rate of 1^{o}C per 150 m of altitude, a projected increase of 1.7 ^{o}C would require vegetative zones to migrate vertically by 260 m, and up to 530 m in a 3.5 ^{o}C scenario (Day, 2009). The result could be a displacement of cloud forests into progressively smaller regions at the tops of mountains – possibly causing the loss of entire cloud forests if vertical migration is not possible. 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.

Climate change impacts on beaches

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, iguanas and shore birds. A 1-2 m SLR is predicted to damage 7-10% of turtle nesting sites on the island (Simpson, *et. al.,* 2010).

Warmer average daily temperatures may skew sex ratios in developing eggs and thereby reduce the reproductive capacity of sea turtles. The combined impacts of SLR, storm surges and higher temperatures could have significant effects on sea turtle populations as well as the country's expanding ecotourism industry. St. Kitts and Nevis is signatory to CITES and thus is obligated to protect marine reptiles.

Intense tropical cyclones and accompanying storm surges will also alter beach profiles and impact on nesting areas (Simpson M. , et al., 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, 2010). In 1989 and 1995 major hurricanes, Hugo and Luis, passed through the region and although they did not directly hit Nevis the resulting storm surge caused severe erosion of the island's beaches. As much as 20 m of sand from Pinney's Beach in front of the Four Seasons Hotel was removed by wave action so that the water's edge was close to the restaurant. The resort also lost part of its pier, and the pavilion and swimming pool were undermined (compare Figure 4.5.4 and Figure 4.5.5). Similarly the Sandpipers Restaurant of Pinney's Beach when completed in August 1995 was 37 m from the water's edge. After the passage of Hurricane Luis the beach was so severely eroded that the sea encroached on the property's restaurant (UNESCO, 2007).

Figure 4.5.4: Pinney's Beach, August 1995, before Hurricane Luis. The restaurant and swimming pool are located just behind the tree line.

(Source: Cambers, 1996)

Figure 4.5.5: Pinney's Beach, October, 1995.
Hurricane Luis eroded the beach and the land behind the beach undermining the foundations of the restaurant and the swimming pool. The implementation of adequate setback provisions would have prevented much of this damage (Source: Cambers, 1996)

Beach profile monitoring by Sandwatch has revealed that although beaches in Nevis have shown signs of recovery after extreme weather events, they have not yet returned to pre-hurricane conditions. Up to one year after Hurricane Hugo in 1989, beaches had only recovered to 76% of their pre-hurricane levels on average measuring 6.4 m (21 ft) less in width than before the hurricane (Cambers G. , 1996). High waves caused by hurricanes move sand into deep water offshore, where it can never be resumed to the normal accretion and erosion system.

Climate change impacts on coral reefs

The ability of coral reef ecosystems to survive the impacts of climate change will depend on the extent of degradation caused by local stressors and the frequency of exposure to climatic impacts (Donner, 2005). Increased sea surface temperature, ocean acidification, SLR and extreme events will each increase incidents of coral damage. Corals are vulnerable to thermal stress and have low adaptive capacity to changes in temperature. In response to an anomalous sea surface temperature (SST) (about 1°C above average seasonal temperature) and increased solar radiation corals bleach, i.e. expel the symbiotic algae that are critical to the life of the coral (Mimura, et al., 2007).

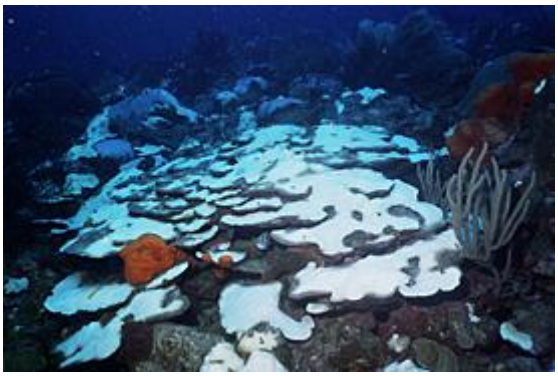


Figure 4.5.6: Caribbean coral bleached during 2005 bleaching event
(Source: Todd LaJeunesse, Penn State)

Observed sea surface temperature (SST) from the HadSST2 gridded dataset indicates 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 SST throughout the year. Projected increases range from +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 sea surface temperature 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.

Warmer oceanic waters will facilitate the uptake of anthropogenic CO_2 thus placing additional stress on coral reefs. Increased CO_2 fertilisation will reduce 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 and dramatically slow their growth. Furthermore rising sea levels may reduce the amount of available light necessary for the photosynthetic processes of the corals' symbiotic zooxanthellae.

Coral structure is also susceptible to heavy damage from hurricanes as they may be broken, uprooted and destroyed during high wave or storm surge events. Hurricanes are expected to increase in intensity over the coming years and each event will set back any recovery that damaged reefs have been able to make. The loss of corals would mean a reduction in the physiological functions that benefit the islands they surround as well as great economic losses to fisheries and tourism sectors (Anderson, 2000). The ability of coral reef ecosystems to withstand the impacts of climate change will depend on the extent of degradation from other anthropogenic pressures and the frequency of future bleaching events (Donner, 2005). Coral reefs have been shown to keep pace with rapid postglacial sea level rise when not subjected to environmental or anthropogenic stresses (Hallock, 2005) it is therefore imperative that Caribbean states reduce or ideally eliminate the negative impacts that arise from human activity.

Climate change impacts on seagrass beds

Climate change presents a relatively new threat to seagrass ecosystems and as such the impacts of climate change on seagrass beds remain largely uncertain. Potential threats may arise from SLR, changes in localised salinity, increased SST and intensity of extreme weather events.

As with corals, SLR may reduce the sunlight available to sea grass beds and hence reduce their productivity. While there is no consensus amongst the models as to whether the frequencies and intensities of rainfall on the heaviest rainfall days will increase or decrease in the region, increased rainfall could mean localised decreased in salinity and resulting decreased productivity of seagrass habitats. On the other hand, CO_2

enrichment of the ocean may have a positive effect on photosynthesis and growth (Campbell, McKenzie, & Kerville, 2006). Associated ocean acidification may not hamper primary productivity of seagrasses since photosynthetic activity of dense sea grass stands have been shown to increase local pH. The impact of increased SST on seagrass beds in the Caribbean is uncertain since studies have suggested that the photosynthetic mechanism of tropical seagrasses becomes damaged at temperatures of 40-45°C (Campbell, McKenzie, & Kerville, 2006).

Intense hurricanes can uproot these delicate aquatic plants as was the case with Hurricane Luis in 1995 which ripped seagrass out of its substrate and deposited masses of the vegetation along the coastline, so much so that on some beaches dead seagrass formed "carpets" up to 4' thick (UNESCO, 2007). Intense rainfall accompanying tropical cyclones are likely to cause massive sedimentation, given the steep slopes of the island, thus increasing the turbidity of waters surrounding seagrass beds, smothering plants and blocking essential light.

Climate change impacts on fisheries

Jessups and Cotton Ground communities have been identified as highly vulnerable to climate change impacts (see section 4.8). Building resilience in these communities is necessary since they are of significance to Nevis' fisheries sector: 90% of the conch landed in Nevis is landed in Jessups, and Cotton ground is used mainly by fish trappers. 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 Nevis have reported reduced catches and have attributed this loss of revenue in part to observed changes in ocean currents that they believe are affecting fish distribution. Increased periods of precipitation will increase the quantity of sediment washed into near shore habitats. Pelagic fisheries may be affected by increased SST which could drive these species away from the tropics 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 Nevis and are important to employment 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 and blooms of toxic algae. 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.

Although not confirmed as a climate change related event large quantities of Sargassum seaweed have been washing ashore islands of the Eastern Caribbean. These floating mats of vegetation arrive in the Caribbean region annually but this year appears to be doing so in unusually large quantities. Fishers have complained 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. 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 4.5.7: 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 sea level rise. Nevis 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. Nevis relies on the wider 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. Pinneys Beach) (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 (Nevis) and local scale (Jessups, Oualie, Lover's Bay and Pinney's Beach), with adaptation and protection infrastructure options discussed. Please refer to the following section for climate change vulnerabilities and adaptation measures associated with event driven or 'fast-onset' impacts such as disasters and hazards (e.g. hurricanes, storm surges, cyclones).

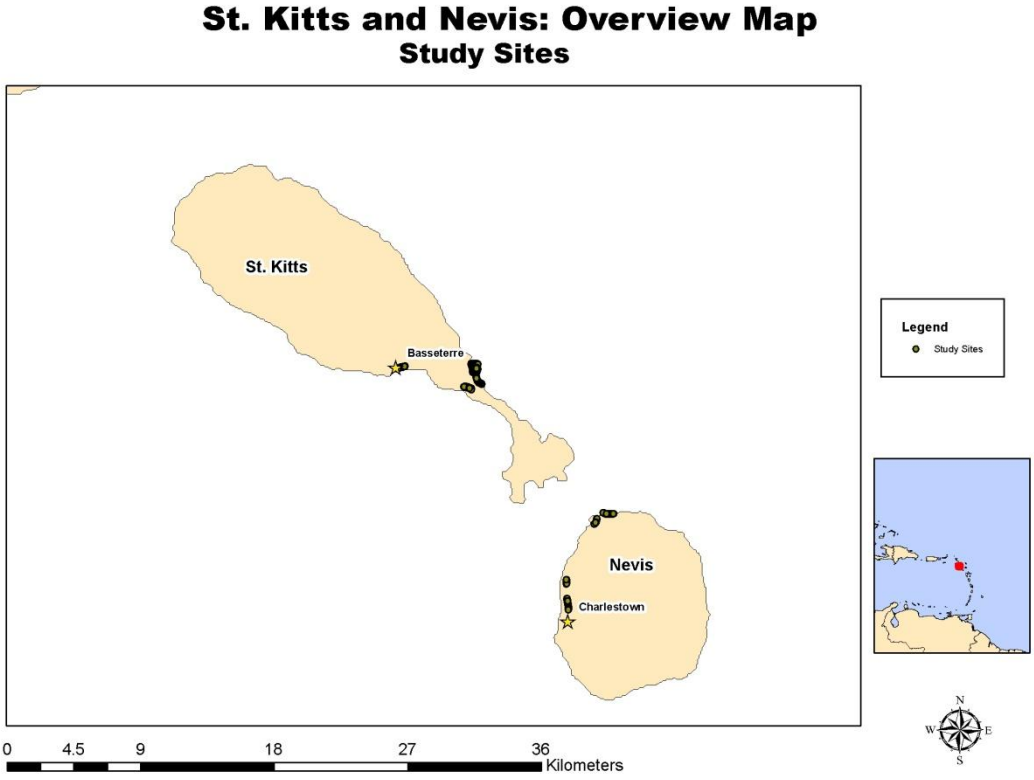


Figure 4.6.1: St. Kitts and Nevis - Overview Map

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 the Nevis are in Jessups, Oualie, Lover's Bay and Pinney's Beach, including notable resorts, ports and an airport that lies at less than 6 m above sea level and will therefore be affected. The estimated coastline retreat due to SLR will have serious consequences for land uses along the coast (Mimura, *et al*., 2007; Simpson, *et. al.,* 2010) including tourism development and infrastructure. A primary design goal of coastal tourism resorts is to maintain coastal aesthetics of uninterrupted sea views and access to beach areas. As a result, tourism resort infrastructure is highly vulnerable to SLR inundation and related beach erosion. Moreover, the beaches themselves are critical assets for tourism in Nevis, with a large proportion of beaches being lost to inundation and accelerated erosion even before resort infrastructure is damaged.

4.6.2. Vulnerability of Infrastructure and Settlements to Climate Change

There is overwhelming scientific evidence that SLR associated with climate change is projected to occur in the 21st century and beyond, representing a chronic threat to the coastal zones in Nevis. The sea level has risen in the Caribbean at about 3.1 mm/year from 1950 to 2000 (Church, White, Coleman, Lambeck, & Mitrovica, 2004). Global SLR is anticipated to increase as much as 1.5 m to 2 m above present levels in the 21st Century (Rahmstorf, 2007; Vermeer & Rahmstorf, 2009; Grinsted, Moore, & Jevrejeva, 2009; Jevrejeva, Moore, & Grinsted, 2008; Horton, Herweijer, Rosenzweig, Liu, Gornitz, & Ruane, 2008). It is also important to note that recent studies of the relative magnitude of regional SLR also suggest that because of the Caribbean's proximity to the equator, SLR will be more pronounced than in some other regions (Bamber, Riva, Vermeersen, & LeBrocq, 2009; Hu, Meehl, Han, & Yin, 2009).

Based on the sea level rise scenarios for the Caribbean 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 sea level rise scenarios and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential vulnerability of major tourism resources across Nevis. The beaches of Nevis 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, a photo of the beach at Lover's Beach illustrates that the impacts of beach erosion are already being seen in Nevis.

Figure 4.6.2: Erosion at Lover's Beach (Nevis)

To examine the exposure of Nevis to sea level rise, 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 as a whole.

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

Table 4.6.1 identifies what tourism infrastructure at the national level would be at risk of inundation from a 1 m and 2 m sea level rise scenario and to erosion of 50 and 100 metres. 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 1 m and 2 m SLR and 50 m and 100 m beach erosion in St. Kitts and Nevis

		Tourism Attractions		Transportation Infrastructure		
		Major Tourism Resorts	Sea Turtle Nesting Sites	Airport Lands	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. With projected 100 m erosion, 82% of the resorts in St. Kitts and Nevis would be at risk. Such impacts would transform coastal tourism in 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 across the two islands projected to be inundated with a 1 m SLR, followed by half of airport lands.

St. Kitts and Nevis is highly dependent on international tourism, and will be particularly affected with annual costs as a direct result of sea level rise. St. Kitts and Nevis 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 $15 million in 2050, to $44 million by 2080.

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 Department of Development Control and Planning Authority to complete detailed coastal profile surveying (Figure 4.6.3). Using survey grade GPS equipment the CARIBSAVE field teams conducted survey transects (perpendicular to the shoreline) at 4 locations in Nevis 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 Nevis.

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 staff from the Development Control and Planning Authority in using High Resolution Coastal Profile Surveying with an RTK GPS System – Pinney's Bay - Nevis

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 metres 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, Oualie Beach, Oualie Bay, Nevis

The high resolution imagery provided by this technique is essential to assess the vulnerability of infrastructure and settlements to future sea level rise, 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 Oualie Beach found that a 2 m flood scenario resulted in a total loss of more than 6782 m^2 of beach area and an additional loss of 20,112 m^2 of land area.

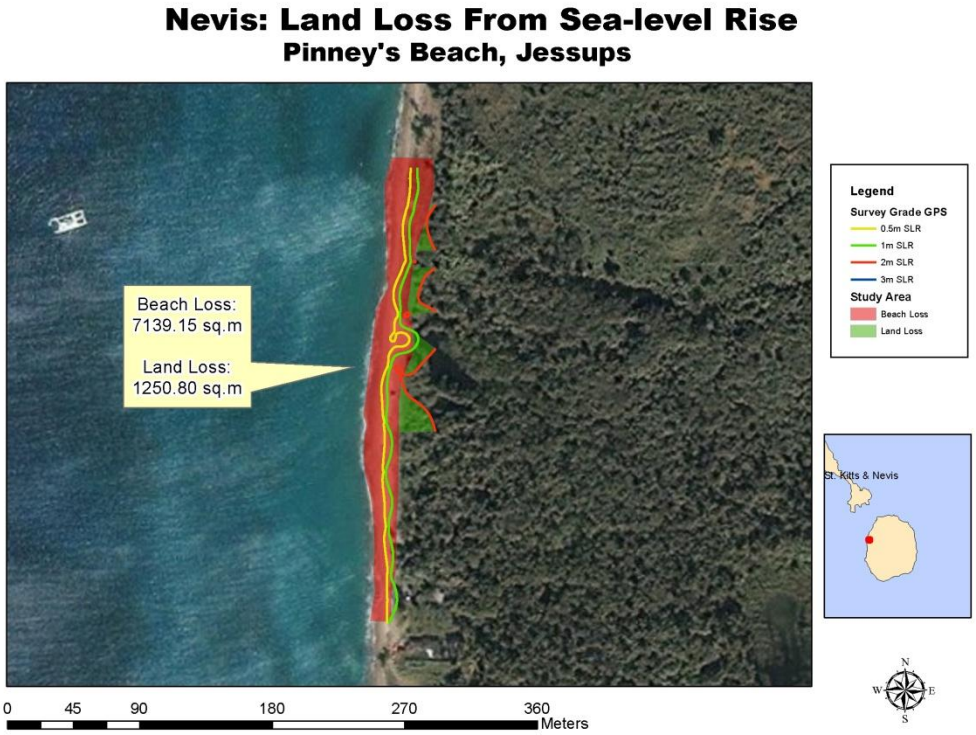


Figure 4.6.5: Sea Level Rise Vulnerability at Pinney's Beach, Jessups, Nevis St.

Even under a 0.5 m sea level rise, over 40% of the highly valued beach resource at Jessups, Oualie and Pinney's Beach would be inundated. With a 1 m sea level rise, all study sites 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 Nevis

	Lover's Bay		Jessups		Oualie		Pinney's Beach	
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	5471	37%	3823	54%	4482	66%	8914	41%
1.0m	2718	55%	1339	72%	1570	89%	2744	53%
2.0m	3485	78%	1978	100%	731	100%	9416	96%
3.0m	3249	100%	-	-	-	-	899	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 Nevis, 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 Nevis

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

Table 4.7.1: Types of Hazards in the Caribbean Basin

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

Geological hazards: Nevis is an island of volcanic origin, located in the Leeward Island chain. It is smaller than its neighbor 3 km to the north, St. Kitts, and has a land area of 93 km^2 (GFDRR, 2010). Mount Nevis is a centrally located, active volcanic peak which reaches 984 m (GFDRR, 2010). The volcanic record for Nevis is insufficient to indicate a cycle of eruptions, however, the fumarolic and hot spring activity are evidence of the active nature of Mount Nevis.

Hydro-meteorological hazards: 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. Cutting of forests for use in fish pots, fishing rods and to clear land for agriculture threaten slope stability (ECLAC, 2003). "Generally, soils on Nevis have drainage described as slow to very slow. They are mostly clays and clay loams and thus their slow infiltration rates would cause high amounts of runoff. Additionally, overgrazing that has compacted the surface of the ground reduces infiltration rates, increasing the amount of runoff and hence increasing the possibility of flooding" (Cooper, 2001). Associated landslides and mud-

flows can result where the steep volcanic slopes lack vegetative cover. This added sediment and material compounds the flood risk by adding dangerous material and increasing the rate of flow.

Although much of the upper watersheds in Nevis are still forested, deforestation in the flat areas near the coast are vulnerable to flooding (Cooper, 2001). Various areas are vulnerable, but specifically persons living along Lower Bath Ghaut area are exposed to the danger when the Bath Ghaut is fast flowing as a result of heavy rains (Cooper, 2001).

While the extent of flooding is difficult to predict, climate change models that predict more intense rainfall events and historic flooding events provide adequate and substantial evidence for the need to protect communities and housing from flood impacts. As Figure 4.7.1 demonstrates, many of the main roads in Nevis are intersected by surface streams and ghauts. The potential for flooding to create isolated communities is therefore of concern and individuals must be prepared to shelter and feed themselves in such extreme rainfall events.

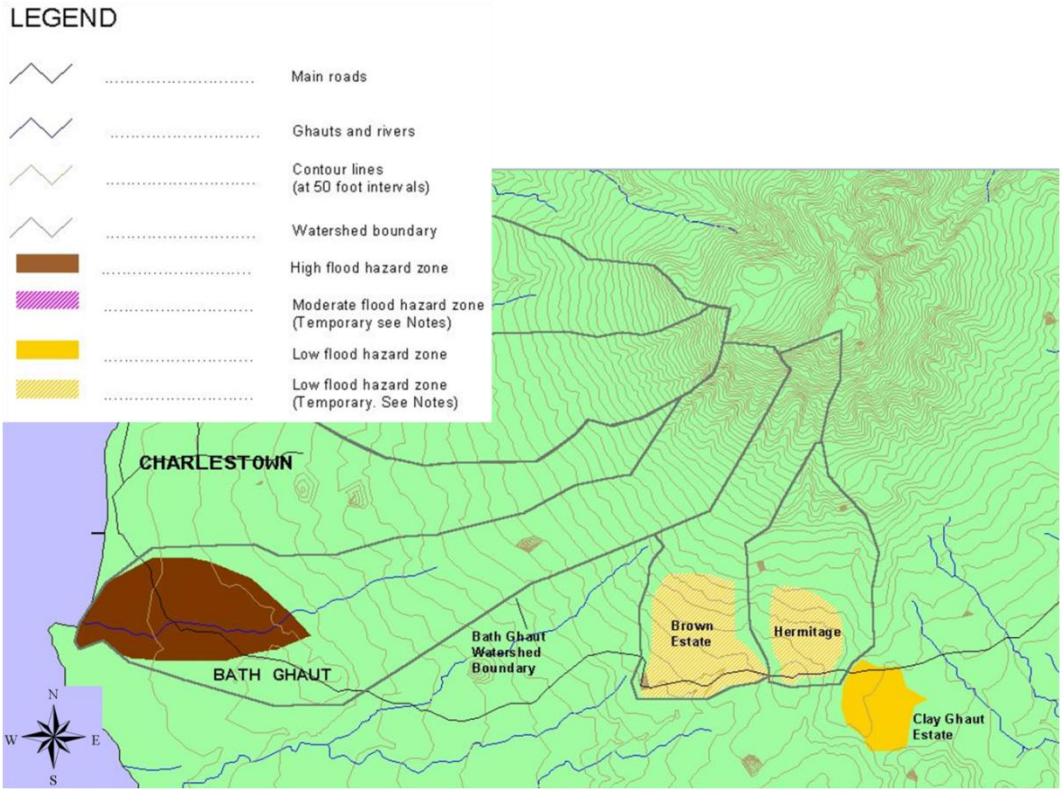


Figure 4.7.1: Nevis flood risk map

(Source: Cooper, 2001)

Hurricanes also threaten Nevis. High winds from storms demand that housing and infrastructure be able to withstand a certain wind speed. Much of the urban areas in Nevis are exposed to high winds because of their proximity to the coast, thus the population is vulnerable to this kind of impact, in addition to the associated flooding vulnerability. Figure 4.7.2 shows the coastal areas around Nevis that are at risk to coastal erosion. Storm surges associated with hurricanes and tropical storms exacerbate the erosion process on the coast. As a result, cumulative erosion impacts pose a significant threat to coastal ecosystems and settlements and extreme events will worsen those impacts.

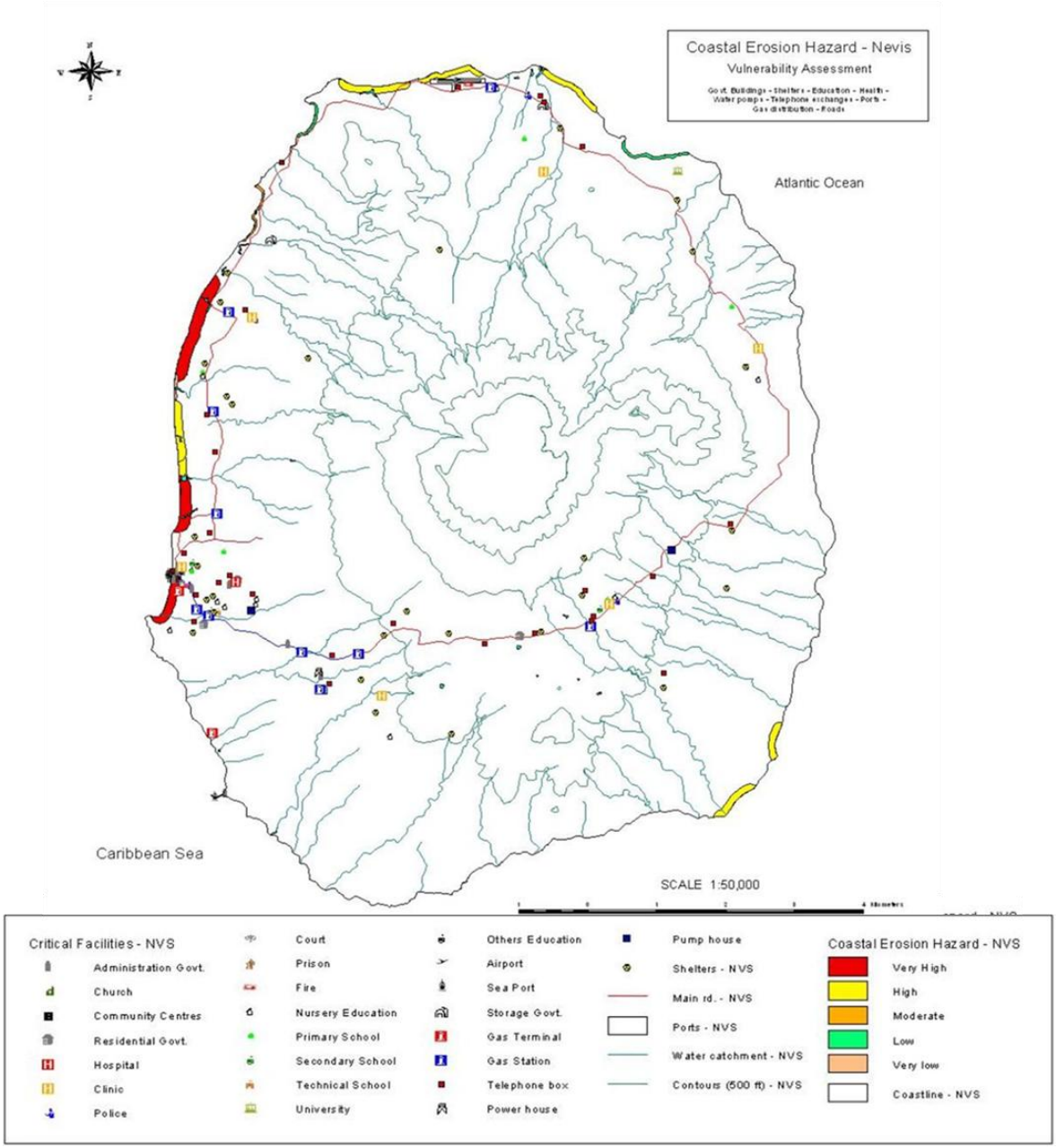


Figure 4.7.2: Coastal erosion hazard map – Nevis

(Source: Nevis Disaster Management Agency, n.d.)

4.7.3. Vulnerability of the Tourism Industry in Nevis

Nevis, like most Caribbean islands, has a great economic dependence on tourism. Coastal resources including beaches, coral reefs, seagrass beds, and mangroves offer important natural protection to coastal tourism infrastructure as well as offering the aesthetic resources that tourists expect from a Caribbean destination. Nevis has seen tropical storms, hurricanes and storm surge damage these natural resources in the past and efforts to use structural protection (e.g. groynes and seawalls) have been attempted. Yet many hotels and resorts remain vulnerable to disaster impacts (see detailed discussion in Section on Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements).

Nevis' economic dependence on tourism was epitomised when the Four Seasons closed after Hurricane Omar in 2008. While Omar did not make direct impact in Nevis, he created significant damage to Nevis'

largest tourism resort, The Four Seasons. The Four Seasons Resort in Nevis was closed for two years and only in 2011 was it reopened following an estimated EC $120 million in renovations (Marcello, 2011). The re-opening of the resort has allowed 700-800 Nevisians to return to employment finally (Marcello, 2011). Not only those directly employed by the resort were affected, but also all of those persons employed in related industries (e.g. scuba diving, craft making, tour guides etc.).

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

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

Madhavi Ariyabandu (ECLAC, UNIFEM and UNDP, 2005)

4.8.1. Background

With a relatively small population size and density, Nevis' economy was originally supported by primary peasant production, followed by small scale tourism operations. With the establishment of the Four Seasons Hotel in Nevis, the single largest employer (second to Government); tourism became the main employer by sector (in terms of both direct and indirect employment). Aside from tourism, major employers by sector include the Services and Construction sectors (Section 2.2, Table 2.2.3).

Some gender distinctions exist within the local labour market, especially by major employers. Construction is a male-dominated sector, whereas tourism employs more females than males. Women tend to face more restrictions in accessing some types of employment outside of the public sector than men. Work in the tourism industry is less gender-biased than in the construction sector, and the higher ratio of women to men is more a consequence of male perceptions of servitude in the tourism industry (and therefore reluctance to work in tourism). 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 citizens in 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., 2009). 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.

The Country Poverty Assessment (CPA) report for St. Kitts and Nevis published in 2009 (Kairi Consultants Ltd., 2009) provides a comprehensive account 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 National Survey of Living Conditions (SLC) 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 Nevis specifically, 15.9% of the population was living below the poverty line, and just over a quarter of the population were deemed vulnerable to becoming poor in the event of an adverse natural or economic shock to the country. However, indigence was non-existent (see Table 4.8.1).

Table 4.8.1: Poverty Indicators and Statistics Nevis (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)	17.0	-	- 17.0	EC $2,931 (~ USD 1,085)
Poverty Rate (percentage of individuals below poverty line)	32.0	15.9	- 16.1	EC $9,788 (~ USD 3,625)
Vulnerability (percentage of individuals below the vulnerability line but not below the poverty line)		28.8		EC $12,325 (~ USD 4,531)

(Source: Kairi Consultants Ltd., 2009)

Specific trends in the conditions and characteristics of the nation's poor are highlighted in the report. In Nevis specifically at the time of the study, the most poverty-stricken parishes included St. John (dark blue) and St. George (see Figure 4.8.1).

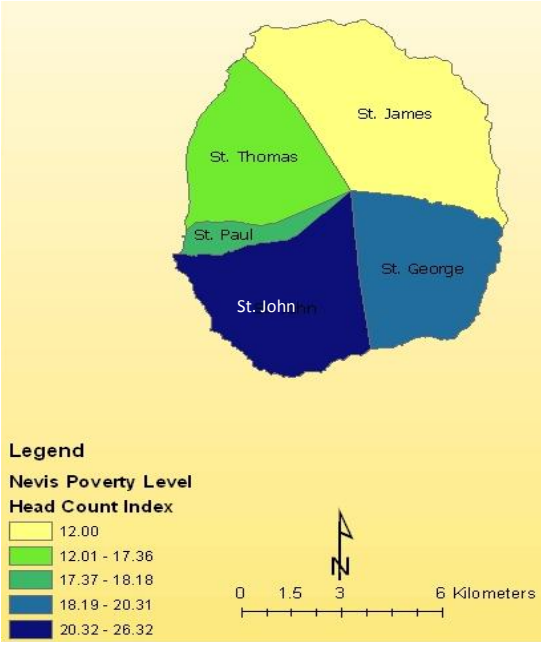


Figure 4.8.1: Map Showing Distribution of Poverty in Nevis by Parish

(Source: Kairi Consultants Ltd., 2009)

Gender differences are some of the most apparent amongst the poor. The poor population is comprised of more females than males (996 women compared to 964 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 Nevis are outlined in Table 4.8.2 (Kairi Consultants Ltd., 2009).

Table 4.8.2: Some of the Characteristics of the Poor within Nevis

VARIABLE	DESCRIPTION
Age Group	Similar to St. Kitts, and the findings of CPAs conducted in other OECS territories, a disproportionate percentage of the poor are children and young persons. More than half (58%) of the poor population are 24 years old or younger. Additionally, the ratio of dependency amongst the poor is higher than the national ratio.
Employment	According to the St. Kitts and Nevis CPA, a significant percentage of the poor in Nevis are employed, which highlights a severe case of the "working poor" – unable to move above the poverty line because of insufficient income.
Gender	The difference in percentage of poor men and poor women in Nevis is very nominal, suggesting little gender bias in the likelihood of being poor. However, the characteristics of poverty experienced by men and women are somewhat varied. Based on the CPA, males "were marginally more likely to be among the non-indigent poor and vulnerable groups [...] when compared to their respective representations in the population" (Kairi Consultants Ltd., 2009). With respect to unemployment, there were more poor women who were without employment at the time of the study. In fact, within the lowest per capita consumption quintile of the population, there were no men who were unemployed at the time of the survey.
Dwelling	Concrete structures are the most popular type of dwelling amongst the poor (and non-poor) – but only marginally so. Combined wood and concrete structures are also common (32.3%) followed by wooden structures. However, most dwellings inhabited by the poor population are owned by the occupants (with or without mortgage).

(Source: Kairi Consultants Ltd., 2009)

As highlighted in the Introduction, despite the existing levels of poverty, differences between poverty statistics recorded in 2000 and 2007/8 indicate an improvement in living conditions of the poor in Nevis over the seven year period. This decline in poverty has been attributed to Government's focus on poverty alleviation and the provision of social services to help improve the lives of the poor, especially following the cessation of the sugar industry in the twin island federation (Kairi Consultants Ltd., 2009).

4.8.2. 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. As indicated previously, groups predisposed to vulnerability include women, children and the poor, owing to their lack of access to resources and opportunities which translates into low resilience and exposes them more to climate change impacts than other groups. The impacts of climate change undeniably aggravate poverty in all societies, and especially where poverty is extreme and widespread (Figure 4.8.2 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 sea level rise (e.g. coastal erosion, salt water intrusion) deteriorate an already dire situation and leave persons in poverty with even less resources to survive (Kettle, Hogan, & Saul, n.d.; UNFPA, 2007).

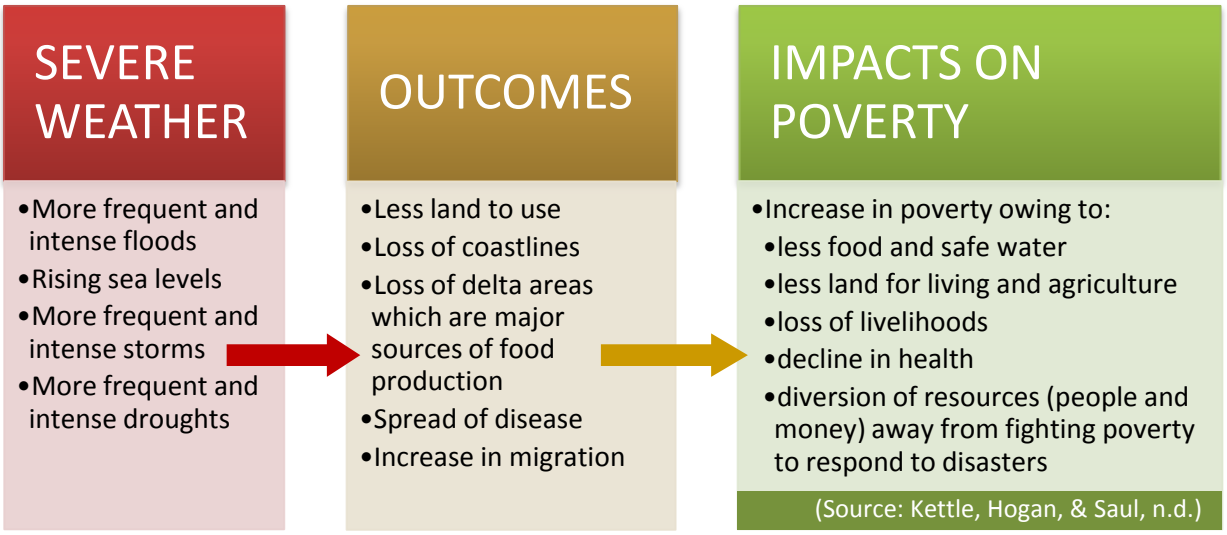


Figure 4.8.2: The Impacts of Climate Change on Poverty

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 (GGCA, 2009). The size and composition of an individual or social group's asset base (natural, physical, social, human and financial) will determine to what extent they will be affected by, and respond to climate change impacts. A larger quantity and/or diversity of assets imply greater resilience and adaptive capacity. Conversely, a lack of assets will predispose individuals to increased vulnerability.

While disasters create hardships for everyone, natural disasters kill, on average, more women than men or kill women at a younger age than men (WHO, 2010). 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, Vega, Bertrand, Urban, Grynspan, & Truitt, 1999; Kettle, Hogan, & Saul, n.d.).

In the Caribbean specifically, Kambon (2005) highlighted the varied responses of gender to all stages of a natural disaster (predominantly hurricanes) based on the observed social impacts of disasters following the 2004 Tropical Atlantic Hurricane season. Some of these differences are highlighted in Table 4.8.3.

Table 4.8.3: Examples of Gender Differences in Response to Natural Disasters in the Caribbean

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

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

Outlined in the Climate Modelling Section of this document are the 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 sea level rise 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 2 m SLR scenario will affect at least 18 (86%) major tourism resorts (based on the report) in the twin island federation. Fisheries infrastructure, which is a critical component of the local economy is also at risk from sea level rise and heightened storm surge impacts.

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 two passenger vessels suffering serious damage (CDERA, 2008a).

Other inferences can be made based on the projections outputted by both the Regional Climate Model and Global Climate Models. 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, tourism being a primary concern in the case of Nevis. Undoubtedly, a number of vulnerable sectors and subsectors are important to the subsistence of especially poorer households. However, gradual weather changes, sea level rise 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 Nevis – with implications for sector contributions to GDP, employment, existing poverty levels and other facets of economic and social development (Alcamo, et al., 2007; Wilbanks, et al., 2007).

4.8.3. Case Study: Jessups and Cotton Ground, Nevis

Overview

The Jessups and Cotton Ground communities were selected as the local communities 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 Nevis Island Administration of the Federation of St. Christopher and Nevis.

The parish of St. Thomas is one of five (5) parishes in Nevis, and is located on the western side of the island. As with all other parishes, it stretches from the central peak (Nevis Peak) outward to the coastline. The parish capital is Cotton Ground, and other communities include Jessups, Barnes Ghaut and Stuarts. Tourism, agriculture and fishing are all important economic activities which have operations in St. Thomas. Some of the main tourism attractions are based in St. Thomas, including Four Seasons Resort Nevis, golf courses, numerous beaches and some of Nevis' historical sites. The St. Kitts and Nevis Taiwan Agriculture

Project is based in St. Thomas and some fishers land their catches along the shoreline. Other privately owned entities and essential services are located within St. Thomas.

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

Natural Resources and Community Livelihoods

A number of persons within the community are employed at the nearby Four Seasons Resort. Tourism in Nevis depends heavily on healthy coastal and marine resources, which include beaches, a clear and shallow nearshore and vibrant coral reefs for a variety of recreational (and mainly dry weather) activities. There is only one dive operator based at a hotel (Oualie Beach Resort) in Nevis, and diving is becoming more popular. Other tourism activities are conducted inland and include golf, eco-trails and hiking.

Some residents also engage in farming and fishing. Persons working in agriculture depend on fertile soil conditions in conjunction with a suitable combination of sunshine and rainfall in order to have higher outputs (notwithstanding other pressures such as pests and diseases). Fishermen thrive where there is an abundance of marine life and healthy coral habitats. A lack or decline in any of these conditions will affect farmers and fishermen significantly. Important farming and fishing infrastructure are located within or in close proximity, including the two fish landing sites adjacent to the Jessups and Cotton Ground communities (See Figure 4.5.2).

Areas of mangrove can also be found close to Nelson Spring in Saint Thomas, but no specific livelihood uses have been cited by the community. Nevertheless, they provide important ecosystem services by way of coastal protection and nursery spaces for marine life. Otherwise, other community members are employed as civil servants, or may have their own micro-enterprises.

In light of the importance of natural resources, their stability is under threat by a changing climate, and consequently, the livelihood activities that depend on these resources are at stake. Community residents have begun to observe changes in weather and climate, especially those that work in more climate-sensitive sectors.

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

Members of the community are aware of climate change and its impacts, although they do not think that their own knowledge is sufficient. The perceptions of risk also vary, with some community members recognising an immediate impact, whereas other members see climate change as a future phenomenon. Community residents working in tourism are aware that climate change is a new area which the tourism sector is investigating. This notwithstanding, sustainability is a major focus of the sector, which incorporates disaster management, and thereby touches on some elements of climate change. Some of the

changes that have been observed and associated with climate change include more frequent hydro-meteorological events (storms, heavy rains), sea level rise, sea surface temperature rise, an increase in ambient temperature and depletion of marine and terrestrial biodiversity. Changes in seasons have also been observed, although no specific patterns were identified.

Aside from the impacts of climate change, some notable changes in the environment have been attributed to human actions and impacts. These actions may even exacerbate climate change impacts, but in the very least, they affect the livelihoods and well-being of residents. Some actions include the blockage of underpasses – which allow surface run-off from rainfall to flow underneath the roads – with solid waste. This contributes to flooding upward from the underpass locations during heavy rainfall. The blockage also resulted in drying up of the nearby pond, which is fed by some of the runoff. Flooding is also exacerbated by relatively poor drainage at roadsides, because roadside culverts are too small and shallow to carry the volume of run-off from even moderate rainfall events.

Reports on the stability and health of the coral ecosystem are not very positive. Community perceptions suggest that the mining and quarry activities on the eastern side of the island are to blame for the continuous decline and deaths in coral reefs on the east coast. Development on the west coast is also blamed for coral reef decline in those areas. This in turn is associated in part to the decline of fisheries on the island. Overfishing is also seen to be a major problem in fisheries (both marine and freshwater fish), but while some community residents acknowledge the decline in fisheries, most attempts to get fishers to conserve and practice more sustainable fishing methods have been futile.

Impacts of Weather and Climate on Community Livelihoods and Development

In terms of *physical* impacts, hurricanes cause the most physical damage, which is the case in other Caribbean territories. Additionally, the Nelson Spring area in St. Thomas is prone to some flooding when storms or heavy rains occur. Apart from this, there is little concern for the physical impacts of flooding, landslides and other climate related events on the community, suggesting that the frequency and/or severity of impact from these events are low. These events, however, have greater significance in other parishes. Heavy rainfall and resulting earth movements also contribute to the deterioration of roads, creating further expenses for Government in repairing damaged roads.

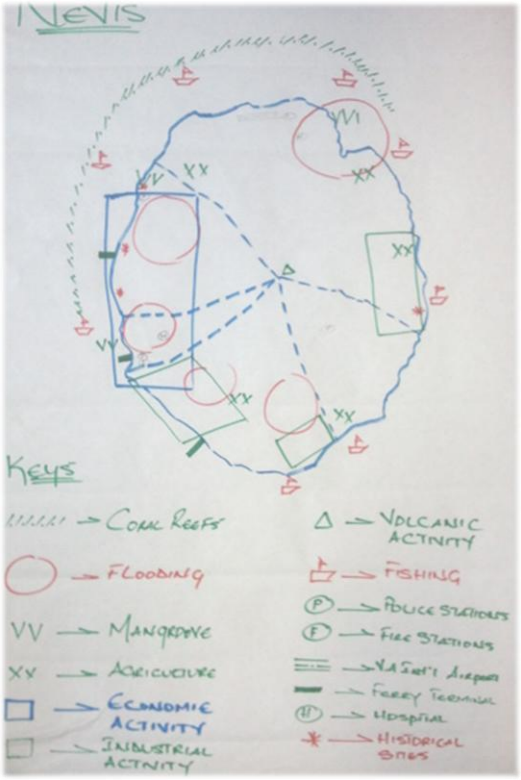


Figure 4.8.3: Community Hand-drawn Map Showing Areas of Importance and Vulnerability to Hazards around Nevis

Weather events have more serious consequences for livelihood activities – especially tourism – and residents working in tourism are highly vulnerable to weather impacts. The main tourism employer, the Four Seasons Hotel, had been closed on two occasions for an extensive period of time since its establishment in 1991 as a result of storm events. The location of the resort makes it very prone to impacts from rainfall, sea swells and storm surge. These closures, which lasted months at a time, resulted in temporary unemployment and loss of income for many locals who work at the resort, and a significant loss of revenue at the national level. Hurricane Omar in 2008 had the greatest impact, resulting in the closure of the property for two years between October 2008 and December 2010 to allow for repairs and refurbishment. As a result, some staff members worked at other hotels in St. Kitts during the period of closure (but subsequently returned to the Four Seasons Hotel after its reopening). Others went into self-employment in catering, roadside barbeque stalls and vending in the capital, Charlestown, which was relatively uncommon before. Residents seek to work with the resort because it is considered a good employer. With the loss of income during the closure of the Four Seasons resort, workers were unable to pay loans and mortgages during this period, and this led to the reclamation of vehicles, land and houses which were acquired on hired purchase through local banks.

Community Leadership and Development

At the level of Government, a Member of Parliament is the locally-based resident who is elected to represent the Nevis #11 constituency (which includes the parish of St. Thomas). 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. Outside of government, there are no formal community or village councils. 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. There are small-scale non-

government or community-based groups which promote community interaction and development. These organisations are also open to both men and women.

Gender Vulnerability

Within the community and Nevis in general, there are a number of female-headed households with women as single parents. Households who were headed by women working at the resort were significantly affected by the closure of the Four Seasons Resort. A number of them travelled to St. Kitts for alternative work during the day, and have to leave their children at home. This is believed to have contributed to the rise in deviant behaviour in youth. Some workers (both male and female) also have to work 2-3 shifts, or they have other part-time jobs; suggesting that they have high debts, or have to support a large household with limited financial resources. Female workers who have multiple jobs or work multiple shifts are forced to leave their children alone at night. As mentioned previously, when the tourism sector is affected by weather, workers are either temporarily placed out of work, or shifts (and therefore salary) are reduced, leaving them with less income to support themselves and the household. These occurrences increase the vulnerability of female single-parent heads working in tourism and the families that depend on them to impacts from weather, much more than men.

Disaster Management in the Community

It is acknowledged generally that the community has a more reactive approach to disaster management than one that focuses on early preparation. Within the community, responses to extreme weather events such as hurricanes are similar to other communities investigated. Both men and women are involved in response and recovery activities. Men are more involved in laborious repair and recovery efforts, whereas women are mainly responsible for the family and household supplies and needs. Women, however, tend to have greater access to social networks as they are more connected and involved in social and community groupings. The elderly and young children, as expected, are less involved in preparations and recovery, and normally depend on assistance from more able family or community members.

During hurricanes, churches are used as shelters, but need significant improvements if they are to meet the standard required for effective hurricane shelters, as the structures may pose hazards in themselves. The Royal St. Kitts and Nevis Police Force is seen as a key agency in community disaster recovery efforts. They are very visible in communities after storm events and residents in need of assistance turn to those police officers who are present and willing to help.

The Nevis Disaster Management Department is using the church as an avenue for public awareness and education of members of the church who belong to the larger community. Schools were also targeted previously to educate students in disaster management and sustainable development. However, these efforts were reported to be relatively unsuccessful in most cases. Teachers are now being targeted to expose them to the realities of environmental degradation and climate change, in hope that they will pass the message on to their students in the classroom.

5. ADAPTIVE CAPACITY PROFILE FOR NEVIS

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

As in St. Kitts, the Watercourses and Waterworks Ordinance 1956 is the main legislation that governs management of water resources in Nevis. 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). There is no legislation that directly addresses water conservation but there are a number of other pieces of legislation that have some role in water resources management in the island. One of these 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 (MOSD, 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 2011.

The National Environment Action Plan, similar to the National Conservation and Environmental Act 1987, has a responsibility of Forestry. Objective No. 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, 2004b). 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. There is also the Agriculture Department Act No. 18 of 1973 and Physical Planning Act 2000.

Nevis does not have a National Sanitation policy, septic tanks and soakaways are most widely used in the country. There is however a Nevis Solid Waste Management Authority. The Four Seasons Hotel has its own sludge plant and a few package treatment plants exist on the island. Land use policies have not been factored into water policies either (Mr Morris, personal communication, June 28, 2011).

5.1.2. Management

The Nevis Water Department (NWD) is responsible for production, distribution and water quality in Nevis. Its functions are to (Administration, 2011b):

- Production of potable water from various sources, springs and wells.
- Distributed potable to customers at reasonable pressure 70 to 100 pounds per square inch (psi).
- Maintain water quality standards of World Health Organization (WHO) or better.
- Collect revenue associated with the charges according to the water rates.
- Educate the customers as to conservation methods.

- Establish Integrated Water Resources Management strategies

The NWD is currently working with the Caribbean Development Bank on a project entitled the Nevis Water Supply Enhancement Project as well as the Nevis Water Distribution Master Plan for the execution of the activities under the project. One component of the project will make provisions for NWD to become a Statutory Body and legislation effecting this will be based (Mr Morris, personal communication, June 28, 2011).

The Environmental Health Department also does some monitoring of water resources in Nevis. There is no island wide studies that have been done on water quality. The Nevis Water Department recognises the importance of its customers in controlling water wastage and therefore publishes out water conservation tips on a periodic basis to inform the general public of ways they can reduce their water consumption. It also partakes in radio programmes and conducts school visits and distributes pamphlets (Mr Morris, personal communication, June 28, 2011).

Other agencies have an indirect role. For instance, the Department of Environment has a role in watershed and groundwater protection through its responsibilities in environmental conservation and preservation. Other relevant agencies include: the Department of Agriculture through forest preservation, land conservation and appropriate land use; the Department of Planning through regulating land use and habitation of watershed areas as well as appropriate zoning; the Public Works Department through building of roads and road maintenance; and the Public Health Department through water quality monitoring (MHE, 2001; USACE, 2004).

As noted previously, water resources are considered to be sufficient to meet current demands, however there is the need for water conservation (Kairi Consultants Limited, 2009b). The Nevis Water Department is in the process of adding one million gallons of storage as well as upgrading its pipeline network (Mr Morris, personal communication, June 28, 2011).

The Nevis Water Supply Enhancement Project is due to be completed in 2013 which is funded by the CDB. The Nevis Water Department has projected that the project, valued at EC $26.9 million, will cater for water demands, related to population growth, tourism agriculture and light industries up to 2021 (Mr Morris, personal communication, June 28, 2011). The project is being executed based on the Nevis Water Distribution Master Plan and its main components include “upgrading the water supply network, capacity building, public education and water resource management” (Nevis Island Administration, 2011a).

The Nevis Water Department along with the Ministry of Works also has a public-private partnership with the Bedrock Exploration Development Technologies (BEAD) Company and is in the process of developing more ground water resources for the Nevis. This project has an output of an additional 1 million galls of water per day. Desalination technology is not considered a viable option at present because there are sufficient groundwater resources to be exploited to meet the demands of Nevis (Mr Morris, personal communication, June 28, 2011).

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 Country Poverty Assessment 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).

5.2. *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, focusing 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 are 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 earlier and pointed out by OECD (2010), emissions of greenhouse gases essentially represent a market failure where there is little incentive to innovate. It has been shown that the fairest and most efficient way of reducing emissions is to consider increased fuel prices, i.e. to introduce a tax on fuel or emissions. Carbon taxes may be feasible for accommodation, car transport and other situations where tourism activities cause environmental problems and as suggested for high energy tourism uses in the National Energy Plan (MOPWUEH, 2011c). In Nevis a fuel surcharge is applied on top of the baseline electricity rates to account for the variability in fuel prices (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 greenhouse gases has to begin with a review of emission intensities, to ensure that action taken will lead to significant reductions. From a systems perspective, hundreds of minor actions will not yield anywhere near as much as one change in the major energy consuming sub-sectors. Aviation is thus, as outlined earlier, a key sector to focus on, followed by - 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 greenhouse gases, a number of concepts have been developed. One of the most important overall objectives can be defined as 'reduce the average energy use/emissions per tourist'. 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	1302	62 550	81	803 (USA; 41%)
Comoros	1754	17 603**	31	1929 (France; 54%)
Cuba	1344	2 319 334	3 117	556 (Canada; 26%)
Jamaica	635	1 478 663	939	635 (USA; 72%)
Madagascar	1829	277 422	507	2 159 (France; 52%)
Saint Lucia	1076	317 939	342	811 (USA; 35%)
Samoa	658	101 807	67	824 (New Zealand; 36%)
Seychelles	1873	128 654	241	1935 (France; 21%)
Sri Lanka	1327	549 309	729	606 (India; 21%)

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

(Source: Gössling *et al.,* 2008)

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

Table 5.2.2: Arrivals to emissions ratios

	Anguilla	Bonaire	Jamaica	Saint Lucia
Primary market Emissions ratio	USA 0.8	USA 0.5	USA 0.8	USA 0.9
Secondary market Emissions ratio	UK 2.5	Netherlands 1.6	-	UK 2.0
Third market Emissions ratio	-	-	-	Barbados 0.1
Fourth market Emissions ratio	-	-	-	Canada 1.0

(Source: Gössling *et al.* 2008)

To integrate emissions and revenue, energy intensities need to be linked to profits. An indicator in this regard can be eco-efficiencies, i.e. the amount of emissions caused by each visitor to generate one unit of revenue. This kind of analysis is generally not as yet possible for Caribbean islands due to the lack of data

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

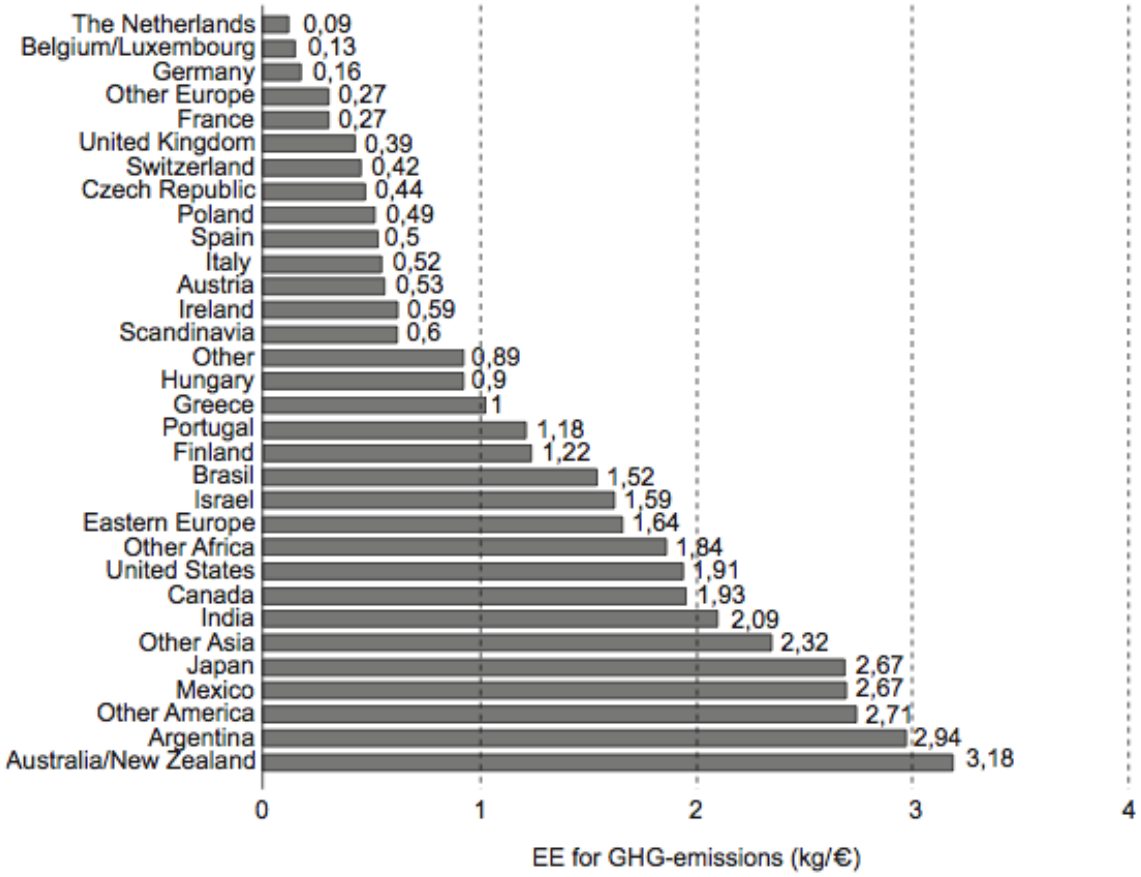


Figure 5.2.1: Eco-efficiencies of different source markets, Amsterdam

(Source: Gössling *et al*. 2005)

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

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

that 73% of respondents are willing to drive less by car, 70% stated willingness to use smaller cars, and 81% are positive about electric cars. With regard to A/C use, one of the major factors in energy use in hotels, tourists also support resource savings: 71% stated to be willing to use fans rather than air conditioning, 90% agree that switching off air conditioning when leaving the room is acceptable, and 65% agree on using air conditioning at a 1°C higher temperature than the set room temperature actually used during the stay.

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

5.2.3. Technology

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

Table 5.2.3: Jamaican case studies for resource savings

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

(Source: Meade and Pringle, 2001)

It is beyond the scope of this report to list all technical measures to reduce energy use, and readers are referred to Gössling (2010) for further guidance: case studies provided in this book indicate technology-based energy savings potentials of up to 90% for accommodation.

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

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

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

The CDM is the most important framework for the supply of carbon credits from emission reduction projects, which are approved, validated and exchanged by the UNFCCC secretariat. CDM projects can be implemented in all non-Annex I countries, and are certified by operational entities (OE) designated by UN COP (IPCC, 2007). The CDM thus generates credits, typically from electricity generation from biomass, renewable energy projects, or capture of CH_4, often a problem in the context of waste management, which can be sold in the regulatory or the voluntary carbon markets. As such, it is a novel instrument to restructure islands towards low-carbon economies.

Discussions are already ongoing in the Caribbean on how to use the CDM in restructuring the energy system (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 (NDA) 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 in order 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 two years, though attention has to be paid to increasing tourist arrival numbers, which can outweigh achievements in efficiency gains. Adaptation should focus on policy, management and technology.

- Policy, including regulation, taxation and incentives, is important to increase pressure on stakeholders to engage with energy management – this is an area that is generally seen as less relevant and efforts to engage significant stakeholder numbers will demand strong policy environments. 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 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 prioritising 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 changes 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 (ICT) Strategic Plan 2006, which seeks to expand public information and advice resources in the country (Government of St. Kitts and Nevis, 2006a).

Public expenditure on health as a % of GDP was 3.63% between 1990 and 1994, 4.71% between 1995 and 1999 (PAHO, 2008). Table 5.4.1 shows health expenditure between 1995 and 2009. The expenditure on health has increased overall in the last fifteen years (WHO, 2011). More recently, 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 EC $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, 2010).

Table 5.4.1: St. Kitts and Nevis: Health expenditures, 1995 – 2000

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, 2009c). In the Country Poverty Assessment 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 Consutlants 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 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, 2010). 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 government nation's health care system. Its mission is "Utilising 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" (Nevis, 2010). Within the ministry two 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 (NCEPA) (MOE, 2001). The Health Promotion Unit was inaugurated in 2000 (PAHO, 2008).

As with most other countries there are a number of other departments 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 Nevis, the 50-bed Alexandra Hospital and no private hospital (PAHO, 2008). There are 5 Health Centres in Nevis which deliver primary health care (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% 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). Approximately 20.2% and 24.5% of the population use Public Hospitals or Health Centres. Tertiary care has to be sought outside of the country in nearby Puerto Rico or the United States of America, or in 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). The services of doctors are limited in St. Kitts and Nevis and they have thus had to forge some partnerships for specialists from neighbouring countries such as Cuba and St. Vincent (Nevis Island Administration, 2009).

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, 2010). 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 2009, the Vance W. Amory International Airport in Nevis received continuous surveillance for H1N1 influenza virus in the first 90 days of the outbreak. Similarly, full coverage of cruise ships and some surveillance of cargo ships was successfully achieved (Nevis Island Administration, 2009).

In terms of the over quality of health care in St. Kitts and Nevis, the Country Poverty Assessment 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 Consutlants 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 around 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, 2007b). The adaptive capacity of ecosystems then is the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability, or future climate conditions (Brooks & Adger, 2004). Despite global action to reduce greenhouse gases, climate change impacts on biodiversity are unavoidable due to climate inertia. Natural ecosystems have long demonstrated the ability to adapt to changes in their physical environment. The rate at which climatic change occurs may exceed the rate at which ecosystems can adapt. Furthermore, natural environments which are already stressed by human activities have compromised ability to cope with and to adapt to climate change. This adaptive capacity assessment thus considers the country's ability to conserve its biodiversity through managing sustainable resource use and the capacity to implement strategies to protect its natural environment.

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

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

BIODIVERSITY: SIX PRINCIPLES FOR CLIMATE CHANGE ADAPTATION
Conserve existing biodiversity
Reduce sources of harm not linked to climate
Develop ecologically resilient and varied landscapes
Establish ecological networks through habitat protection, restoration and creation
Make sound decisions based on analysis
Integrate adaptation and mitigation measures into conservation management, planning and practice

(Source: Hopkins, Allison, Walmsley, Gaywood, & Thurgate, 2007)

In 2001 St. Kitts and Nevis submitted the National Biodiversity Strategy and Action Plan (NBSAP) 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 green house gas (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, therefore it is imperative to adapt to the changes that are already in progress and that will continue to progress due to climate inertia, in order 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, and that are supported by communities and stakeholders. 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 Multi-lateral Environmental Agreements (MEA). The Government of St. Kitts and Nevis has signed the following Multilateral Environmental Agreements (MEA) 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 (MARPOL) – 1998;
- United Nations Convention to Combat Desertification – June 30, 1998;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – May 15, 1994;
- United Nations Framework Convention on Climate Change – 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. The St. Kitts and Nevis National Environmental Management Strategy and Action Plan 2005-2009 (NEMS), 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. 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 and the Integrated Strategic Development Plan for Nevis recognises several biodiversity related strengths and weaknesses in the island including a high potential for growth of resource-oriented economic activities but poor environmental management and development planning. The Nevis Resource Assessment and Zoning Plan 1990 is the land development policy for the island which restricts development in areas of special environmental and ecological interests. 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 Nevis (Gardner, 2006). The NBSAP for St. Kitts and Nevis includes a gap assessment of policy and legal structure that identifies a number of other areas that are weak, absent or conflicting. 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, 2004a).

5.5.2. Management

Successful implementation of international and national policies depends on related institutional arrangements. A nation's adaptive capacity is greater if the roles and responsibilities for implementation of adaptation strategies are well delineated by central governments and are clearly understood at national, regional, and local levels (Burton, 1996). The Nevis Island Administration (DPPNRE) is responsible for environmental management in Nevis as well as development control and forward planning. This agency is assisted by The Department of Physical Planning, Natural Resources and Environment, the Ministry of Communication and Works and Public Utilities and Posts in implementing the conventions on Climate Change, Biological Diversity and Desertification. The Nevis Historical and Conservation Society are also active in projects related to biodiversity conservation, however, their programmes of work (and those of the government departments) are not guided by prescriptions of the three conventions (Homer, 2006).

One of the functions of environmental authorities in Nevis is to monitor ecosystems. Beaches are monitored on a regular basis by The Nevis Historical & Conservation Society assisted by the Fisheries Division and the Department of Planning and Development. The agencies involved collect data and analyse trends on erosion and accretion. In 2010 the National Trust began a 6 month coral reef monitoring programme to gather vital data about the reef ecosystems in the vicinity of the Federation to facilitate their monitoring, management, and protection. There are, however, shortcomings in management of Nevis' ecosystems and biodiversity resulting from misunderstandings of the roles and the functions of the

government agencies involved and a lack of communication between government agencies and NGOs, CBOs and the general public about resource management and use (CANARI, 2009). Other 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. Interviews conducted with residents of Nevis identified various issues with regards to fisheries management and enforcement of fisheries regulations. The police may be called upon when illegal activity is observed however when they arrive at the scene the fishermen have already left. Maintenance of accurate records within the fisheries division is also constrained by fishers who do not produce correct information on their catches. Seining is discouraged in Nevis because of the damage to the bottom and coral reefs (Nicholls R. P., 2007) and the local government of Nevis has attempted to stop the use of fish nets with undersized mesh by taking it off the market. However, the Nevisian fishers are able to purchase these nets from St. Kitts, at a lower price. A federal effort is required to put a stop to this issue.

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). Nevis is in a position to reduce fishing pressure on these endangered creatures that are already facing multiple, unprecedented threats including climate change.

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 no legally declared Marine Protected Areas (MPA) as of yet but preliminary work done by The Nature Conservancy 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 marine protected area (MPA). The site has also been selected for socio-economic monitoring under the SocMon because of its importance to fisheries and tourism. A marine component for Nevis' protected areas – Nevis Peak National Park and Camps River Watershed – has also been proposed (Potter at. al. in Arthurton & McDonald, 2010). Existing law permits the Government to declare Marine Protected Areas but it is currently inadequate to support the development and implementation of a comprehensive, integrated framework (Bovino, 2010). Plans are underway to develop a master plan and associated legislation for St. Kitts and Nevis 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 experiences of Hurricanes Luis and on Nevis beaches and the tourism sector motivated the Physical Planning Unit to enforce more stringent building setbacks from the high water mark and implement beach stabilisation measures (Robinson in Cambers 1998) using hard technology (see section on Sea Level Rise and Storm Surge Impacts on Coastal

Infrastructure and Settlements) such as groynes and jetties which have been built along the north coast of Nisbett beach to slow erosion and stabilise sand movement.

The Technology and Telecommunications sectors have been identified as having a key role in the sustainability and development of the Federation therefore infrastructure, hardware and software as well as human capacity are being upgraded towards this end (The Government of St. Christopher and Nevis, 2010). 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 and Nevis 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., n.d.).

Having recently received a refurbished laptop, multimedia projector and underwater camera, the Department of Fisheries on Nevis is now better equipped to safeguard its marine environment (NIA, 2010). Geographic information systems (GIS) and remote sensing are key tools in mapping habitats and resource use for effective spatial planning. These technologies were used 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 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 Nevis and its people. Adaptations to minimise vulnerabilities in Nevis 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 three main types of adaptation policies that can be implemented to reduce the vulnerability of the tourism sector in Nevis to SLR and improve the adaptive capacity of the country: (i) Hard engineering defences and (ii) soft engineering defences, which both aim to protect existing infrastructure and the land on which the infrastructure is built, as well as (iii) retreat policies, which aim to establish setbacks and thereby move people and/or infrastructure away from risk. A summary of examples for each of the three types of adaptation polices are provided in Table 5.6.1, along with a summary of select advantages and disadvantages of each. Adaption options discussed in this report should be implemented in the framework of ICZM and all decisions need to take into account the broad range of stakeholders involved in decision-making in the coastal zone. Adaptations should benefit coastlines in light of both climate and non-climate stresses and adaptations will be promoted as a process towards ICZM rather than an endpoint (Linham & Nicholls, 2010).

Table 5.6.1: Summary of Adaptation Policies to reduce the vulnerability 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 defences - Can be completed independently of centralised management plans	- May be technologically unfeasible and expensive for larger buildings and resorts - Only protects the individual structure (not surrounding infrastructures such as roads)
Soft Engineering Defences		
Beach nourishment and replanting of coastal vegetation[2, 3, 8]	- Enhances slope stability - Reduces erosion - Preserves natural beach aesthetics - Provides protection for structures behind beach - Improves biodiversity and ecological health	- Can ruin visitor experience while nourishment is occurring (e.g., restrict beach access) - Can lead to conflict between resorts - Differential grain size causing differing rates of erosion (e.g. new sand vs. natural sand) - Difficult to maintain (e.g., nourishment needs to be repeated/replenished, unsuccessful plantings) - Will not work on open coastlines (i.e., requires locations where vegetation already exists)
Replant, restructure and reshape sand dunes[3, 8]	- Enhances slope stability - Reduces erosion	- Conflict among resort managers (e.g, 'sand wars') - Temporary (waves will continually move sand)
Retreat Policies		
Relocate settlements and relevant infrastructure[2, 9, 10, 11, 12]	- Guaranteed to reduce SLR vulnerability - Less environmental damage to coastline if no development takes place - Retains aesthetic value	- Economic costs (e.g. relocation, compensation) - Social concerns (e.g. property rights, land use, loss of heritage, displacement) - Coordination of implementation is challenging (e.g., timing of relocation is problematic) - Concerns with abandoned buildings

[1] (Silvester & Hsu, 1993) [2] (Nicholls & Mimura, 1998) [3] (French, 2001) [4] (El Raey, Dewidar, & El Hattab, 1999) [5] (Krauss & McDougal, 1996) [6] (Boateng, 2008) [7] (Lasco, Cruz, Pulhin, & Pulhin, 2006) [8] (Hamm, Capobiancob, Dettec, Lechugad, Spanhoffe, & Stivef, 2002) [9] (Fankhauser, 1995)[10] (Orlove, 2005) [11] (Patel, 2006) [12] (Barnett J. , 2005)

5.6.1. Technology – Hard Engineering

Hard engineering structures are manmade, such as dikes, levees, revetments and sea walls, which are used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. The capital investment needed for engineered protection is expensive and not ideal in sparsely populated areas. 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 & 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 minimize the impact of flooding caused by SLR.

5.6.2. Technology – Soft Engineering

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

5.6.3. Policy

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

possible, especially in highly developed areas where roads and infrastructures can impede setbacks or on small islands where land resources are limited.

For many tourist destinations retreat is both difficult in terms of planning (and legally challenging) and expensive to implement. Resorts and supporting tourism infrastructure are large capital investments that cannot be easily uprooted to allow the sea to move inland. If the resorts cannot be moved, then the alternative is to leave them damaged and eventually abandoned, degrading the aesthetics of the destination coastline. It is important that the retreat policy be well organized, 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 responsible for CZM in Nevis with beach management falling under the umbrella of several government agencies. The Department of Development and Planning plays the leading role in coordinating beach management and is responsible for managing developments and fostering stakeholder participation in environmental management. The Nevis 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 the late 1980s, Nevis' beaches have been monitored by the Nevis Historical and Conservation Society, measuring the beach slope and width every three months at numerous sites around the island.

As signatories to the United Nation Framework Convention on Climate Change, and members of the Caribbean Planning for Adaptation to Climate Change, St. Kitts and Nevis 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 aid with buildings that are 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 March 2011, the Government of St. Kitts and Nevis, in collaboration with the Sector for Social and Human Sciences of UNESCO, brought together OECS and CARICOM representatives and identified tangible efforts that can be pursued across the region to enhance the mitigation and adaptation capacity of both the region, as well as locally in Nevis (UNESCO 2011).

Setbacks exist in Nevis for all developments, including housing, hotels, commercial buildings, airports, roads and swimming pools (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998). For cliffed coasts, the setback is 15 m from the edge of the cliff. On low rocky shores, the setback is 30 m from the natural vegetation line. Setbacks along beaches have been determined for individual beaches/beach sections based on historical changes over the last forty-five years, predicted impacts of a major hurricane, and predicted change due to sea level rise (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998). These beach setbacks are measured from the line of permanent vegetation (tree line or scrub line), with are further grouped into four categories (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998). Category 1 setback is 18 m; category 2 setback is 24 m; category 3 setback is 37 m; category 4 setback is 152 m (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998). Small individual buildings that are made of wood and have no concrete foundations that are used exclusively as restaurants and/or bars are an exception from the above beach setbacks, and are

allowed to host their structures 8 m landward of the vegetation line (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998).

Most of the beaches in Nevis fall into category 2 and 3. For example, Cades Bay to Mosquito Bay, as well as most of the north coast beaches except Nisbett to Camps, are category 2. Gallows Bay, Pinney's Beach, Nisbett to Camps, White Bay and Indian Castle on the southeast coast are all category 3. The mangrove coastline from the mouth of Camp River to Nisbett is a category 4, where it is recommended that special measures be put into place to conserve the mangrove wetland. Longhaul Bay is the only category 1 in Nevis (Cambers G. , Planning for Coastline Change: Coastal Development Setback Guidelines in Nevis., 1998). Although setbacks guidelines exist, they are not enforceable for developments that already exist. Consequently, there remains a great deal of existing infrastructure on the islands that need to be protected.

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, get 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[4] 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).

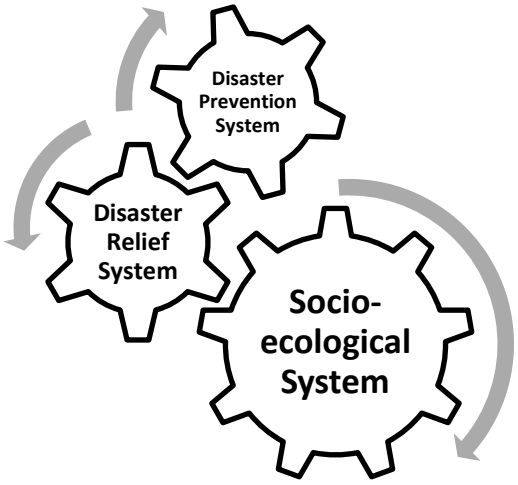


Figure 5.7.1: Relationship of the Disaster Management System and Society

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, 2010). The primary purpose of CDM is *to strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change* (CDEMA, 2010)(emphasis added).

[4] In the disaster management literature, 'Mitigation' refers to strategies that seek to minimise loss and facilitate recovery from disaster. This is contrary to the climate change definition of mitigation, which refers to the reduction of GHG emissions.

This regional disaster management framework is designed to inform national level disaster planning and activities but also takes into consideration potential climate change impacts in its resilience building protocols. The four **Priority Outcomes** of the CDM framework are:

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

These outcomes have been further broken down into outputs that assist in the measurement of progress towards the full implementation of CDM at the national and community level and within sectors (see Table 5.7.1). The CDM Governance Mechanism is comprised of the CDM Coordination and Harmonisation Council and six (6) Sector Sub-Committees. These sectors include – *Education, Health, Civil Society, Agriculture, Tourism and Finance.* These six sectors have been prioritised in the Enhanced CDM Strategy as the focus during the period from 2007 to 2012. CDEMA facilitates the coordination of these committees (CDEMA, 2010).

To address disaster management in the Caribbean tourism sector, CDEMA, with the support of the Inter-American Development Bank (IDB) and in collaboration with the Caribbean Tourism Organization (CTO), CARICOM Regional Organization for Standards and Quality (CROSQ), and the University of the West Indies (UWI) 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 2008b).

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.

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 recognised as the roadmap for building resilience and Decision-makers in the public and private sectors understand and take action on Disaster Risk Management* *3.2 Disaster Risk Management capacity enhanced for lead sector agencies, National and regional insurance entities, and financial institutions* *3.3 Hazard information and Disaster Risk Management is integrated into sectoral policies, laws, development planning and operations, and decision-making in tourism, health, agriculture and nutrition, planning and infrastructure* *3.4 Prevention, Mitigation, Preparedness, Response, recovery and Rehabilitation Procedures developed and Implemented in tourism, health, agriculture and nutrition, planning and infrastructure*	***OUTPUTS*** *4.1 Preparedness, response and mitigation capacity (technical and managerial) is enhanced among public, private and civil sector entities for local level management and response* *4.2 Improved coordination and collaboration between community disaster 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 Nevis

Disaster management in St. Kitts and Nevis is led by the National Emergency Management Agency (NEMA), an organisation created under the Ministry of National Security (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 a National Disaster Executive (NDE) reports to the NDC and oversees the operational aspects of the NEMA program (GFDRR, 2010). Nevis has its own agency, the Nevis Disaster Management Department (NDMD). The separation of disaster management responsibility between the two islands has its benefits in terms of improving local actions and communication, but poses a challenge to funding allocation and the need for standardised action in disaster risk reduction within the Federation of St. Kitts and Nevis.

Nevis is sub-divided into five (5) districts, which each has several hundred volunteers that support NEMA; these 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 and non-governmental organisations (NGOs) (NEMA, 2007). This Council provides policy guidance and general oversight to NEMA. District Emergency Committees are the direct link between the communities of Nevis and the Disaster Management Committee. These small teams represent the communities and have roles including:

- shelters
- feeding
- clothing
- first-aid
- collection damage statistics
- communications (Nevis Disaster Management Committee, 2005)

During emergencies, the Premier will activate an Emergency Operations Centre (EOC), based at the Bath Hotel or other suitable location selected by the Disaster Management Committee. The EOC is equipped with radios, generators, information storage and retrieval and this equipment is used before, during and after the disaster impact to communicate with government agencies and the general public (Nevis Disaster Management Committee, 2005). The EOC also helps in the assessment of needs and destruction following a disaster event. The EOC is therefore a vital part of disaster management in Nevis.

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 formalising 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” (UNDP, 2011b). While in design, the system for disaster management appears well organised, this assessment implies that greater work is needed so that the practice of disaster management in St. Kitts and Nevis is effectively reducing vulnerability and building resilience.

Since the major hurricane impacts in the late 1990s, "[rushed/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 of 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 NDMD 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 International Strategy for Disaster Reduction (ISDR) in Geneva in 2009, Mr. Herbert (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".

Post-disaster activities

The Eastern-Caribbean Donor Group (ECDG) is a mechanism for cooperation between development agencies in Barbados and the Eastern Caribbean. Operating under the UNDP, the Eastern Caribbean Donor Group for Disaster Management (ECDGDM) facilitates disaster and emergency response activities at the request of the affected Member State (UNDP, 2011a). In conjunction with CDEMA, the ECDGDM provides funds for initial damage assessments following an impact and assist the national government in coordinating the response. There is a Rapid Needs Assessment Team (RNAT), led by CDEMA, who is deployed to the impacted state to conduct a Damage Assessment and Needs Analysis (DANA) (UNDP, 2011a). The skilled assessment team provides a standard assessment procedure across many of the CDEMA Participating States. However, the DANA process is only executed upon the request of the impacted state. Therefore, the assessment information is not available following *every* disaster and as such, all disaster offices should also have the capacity to execute a post-disaster assessment on their own. Making use of CDEMA's coordination activities across multiple countries builds response capacity by taking advantage of the resources and personnel from neighbouring countries and thus can also enhance the response and reconstruction efforts. Nevertheless, the need to incorporate the principles of 'building back better' must also be a priority so that the post-disaster context becomes an opportunity for building resilience and institutionalising disaster risk reduction goals. The NDMD identified Damage Assessment and Needs Analysis as a part of recent training for volunteers, discipline forces and other personnel (NEMA, 2007).

In addition, the post-disaster context is an opportunity for lessons learned. Nevis has had limited studies on the economic costs and benefits of DRR. Recently an Economic Impact Assessment was completed for Nevis following Hurricane Earl (August 29, 2010) (NEMA, 2010). In relation to this, some economic impact assessment training has started for personnel. Although funds are not allocated 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 Nevis is updating their disaster management activities in response to good practices and lessons learned from global disasters. Related work in needs and vulnerability assessment is taking place throughout the region. CDEMA's coordinating activities across multiple countries builds response capacity by taking advantage of the resources and personnel from neighbouring countries. This enhances the response and reconstruction efforts in each country when taken advantage of the partnership. Nevertheless, the need to incorporate the principles of 'building back better' must also be a priority nationally so that the post-disaster context becomes an opportunity for building resilience and institutionalising disaster risk reduction goals.

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 also 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 and NDMD report to the Office of the Premier.

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 environmental impact assessment (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 an effort to comprehensively address [the] diverse challenges, the Government is in the process of preparing a Physical Development Plan for the island of St. Kitts...as a blueprint for land use over the next 15 years...The Plan was developed on the basis of wide public consultation"* (ECLAC, 2003, p. 216).

In 2006, this 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 Nevis is regulated by the Development Control and Planning Act (2000) (Trotz, Rogers, de Romilly, & Clarke, 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, Rogers, de Romilly, & Clarke, 2004).

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 (ICC) codes as the primary base documents with additional input from the Caribbean Uniform Building Code (CUBiC) and earlier assessments on wind load and seismic considerations. The Code has already been

prepared and the next step is for each of the 15 states involved to review the documents and prepare their own Caribbean Application Document (CAD). This document will most likely be prepared by specialists who will determine how the regional code should be applied given each country's own peculiarities, for example some countries will focus more heavily on flooding and less on seismic considerations. The CAD will then be reviewed by all of the relevant stakeholders on the National Stakeholder Subcommittee who will provide comments before it is submitted to CARICOM (Personal communication - Jonathan Platt, Barbados National Standards Institute, May 4, 2011). The earthquake risk in Nevis 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. Mr. Herbert, in his address to the ISDR, shared that "among other initiatives, [St. 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 is a positive indication of Nevis' capacity to adapt to seismic and other hazards.

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 sometimes also cause negative effects in other locations along the coast. Disaster management practices have also found that structural protection is very expensive and can sometimes worsen the impacts of a disaster when the size of the structure is incongruent with an event (e.g. sea wall structures, if broken or damaged, can add debris and exacerbate flooding and erosion). Further discussion of the structural responses to climate change and SLR, as well as related land management policies, such as coastal setback regulations, can be found in the Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements, or in Cambers, 1998.

Technology and Public Education

The NDMD website is a well developed resource with much information for the public about current hazards and previous events. The multitude of information is a bit visually distracting, but with some time, much information can be located. The national curriculum includes disaster risk reduction information for primary school children and some information also gets transferred to students in secondary and tertiary level classes (NEMA, 2010).

A Disaster Management Documentation Center 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). Also newspaper, radio, public service announcements, brochures and flyers are distributed throughout Nevis 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 (EWS)

Communication is a major part of an effective warning system. In Nevis the Emergency Telecommunications Centre is located in the Control Room of Charlestown Police Station and additional

radio operators will be brought in to assist during emergencies (Nevis Disaster Management Committee, 2005). The Disaster Management Committee has a good relationship with the Amateur Radio Citizens Band Operators, Cable and Wireless and the Police so that these groups can assist in providing persons and radios during a disaster.

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). Specific warning systems are in place for multiple hazards in Nevis. For geologic hazards, the University of the West Indies (UWI) Seismic Research Unit has at least 1 seismograph in all volcanic islands so that warnings can be sent if eruption is suspected (Nevis Disaster Management Committee, 2005).

Flood warnings require information on water levels and flow speed in rivers, but more importantly, record of the amount of precipitation falling on Nevis over time. Rain gauges are present in Nevis, but often data is only collected from one gauge thus data may not be representative of the entire island (Cooper, 2001). The Antigua and Barbuda Meteorological Services provide weather forecasts to Nevis as there is no local service. This will have an impact on the accuracy of forecasts and also the timing of dissemination to the public.

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 Jessups and Cotton Ground communities 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 28 respondents were surveyed, eight of whom were male and 20 female. Four respondents did not indicate the gender of the head of household, and therefore only 24 surveys are analysed on the basis of the gender of the head of household. When analysis is performed on the gender of the respondent, all 28 surveys are included.

5.8.1. Demographic Profile of Respondents

Residency in the Community

Respondents were generally long-time residents of Nevis, with 53.6% (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, with females indicating slightly shorter periods of time spent in the community. 55% of females indicated living in the community for more than 15 years while 87.5% of male respondents indicated living in their community for more than 15 years (see Table 5.8.1).

Table 5.8.1: Length of Residency in Parish / Community

Residency	Male		Female		Total	
Less than one year	0	.0%	2	10.0%	2	7.1%
1 - 5 years	1	12.5%	1	5.0%	2	7.1%
6 - 10 years	0	.0%	3	15.0%	3	10.7%
11 - 15 years	0	.0%	2	10.0%	2	7.1%
16 - 20 years	3	37.5%	0	.0%	3	10.7%
Over 20 years	4	50.0%	11	55.0%	15	53.6%

Age Distribution

Table 5.8.2 shows the age distribution of the sampled respondents. Whereas males were distributed near-evenly across most age ranges, most of the females (70%) were concentrated in the 35-44 and 45-54 age categories. Figure 5.8.1 presents a graphical representation of the age distribution, which clearly shows the large proportion of women in these two age groups.

Table 5.8.2: Age Distribution of Sample

Age	Male		Female		Total	
Under 25	1	12.5%	1	5.0%	2	7.1%
25 - 34	2	25.0%	2	10.0%	4	14.3%
35 - 44	1	12.5%	8	40.0%	9	32.1%
45 - 54	2	25.0%	6	30.0%	8	28.6%
55 - 59	0	0.0%	2	10.0%	2	7.1%
Over 60	2	25.0%	1	5.0%	3	10.7%

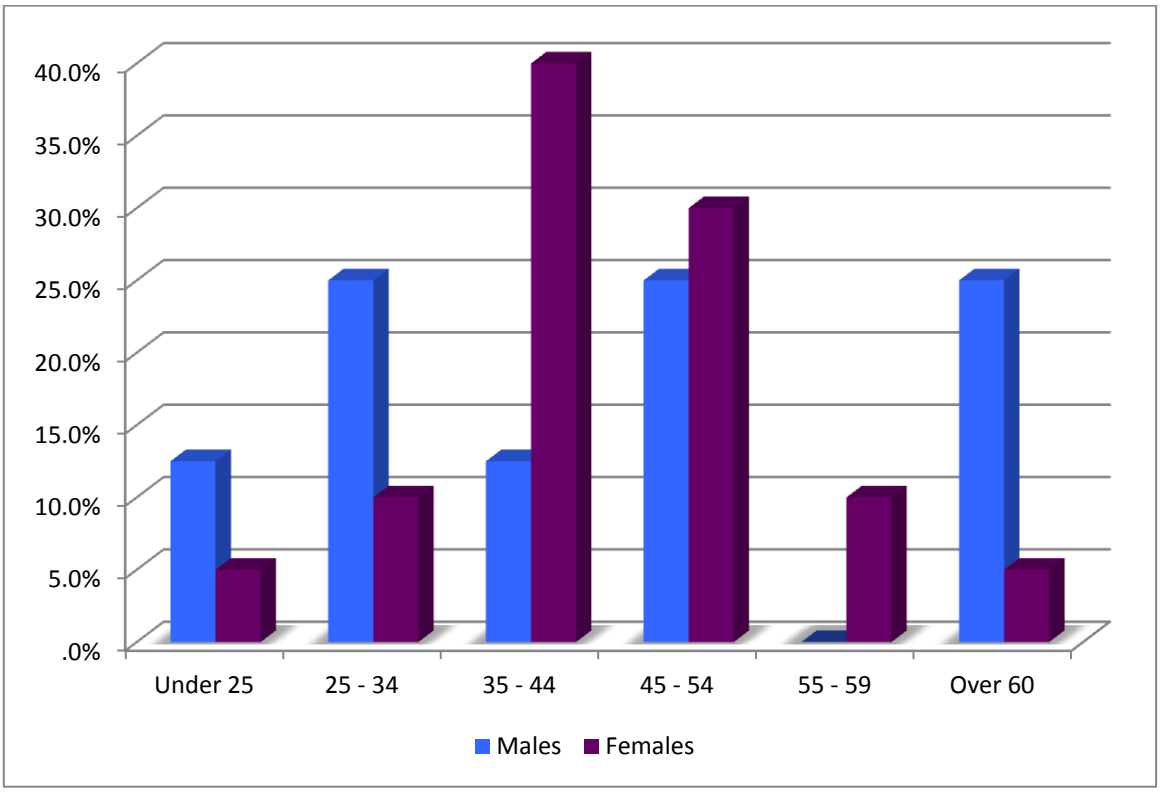


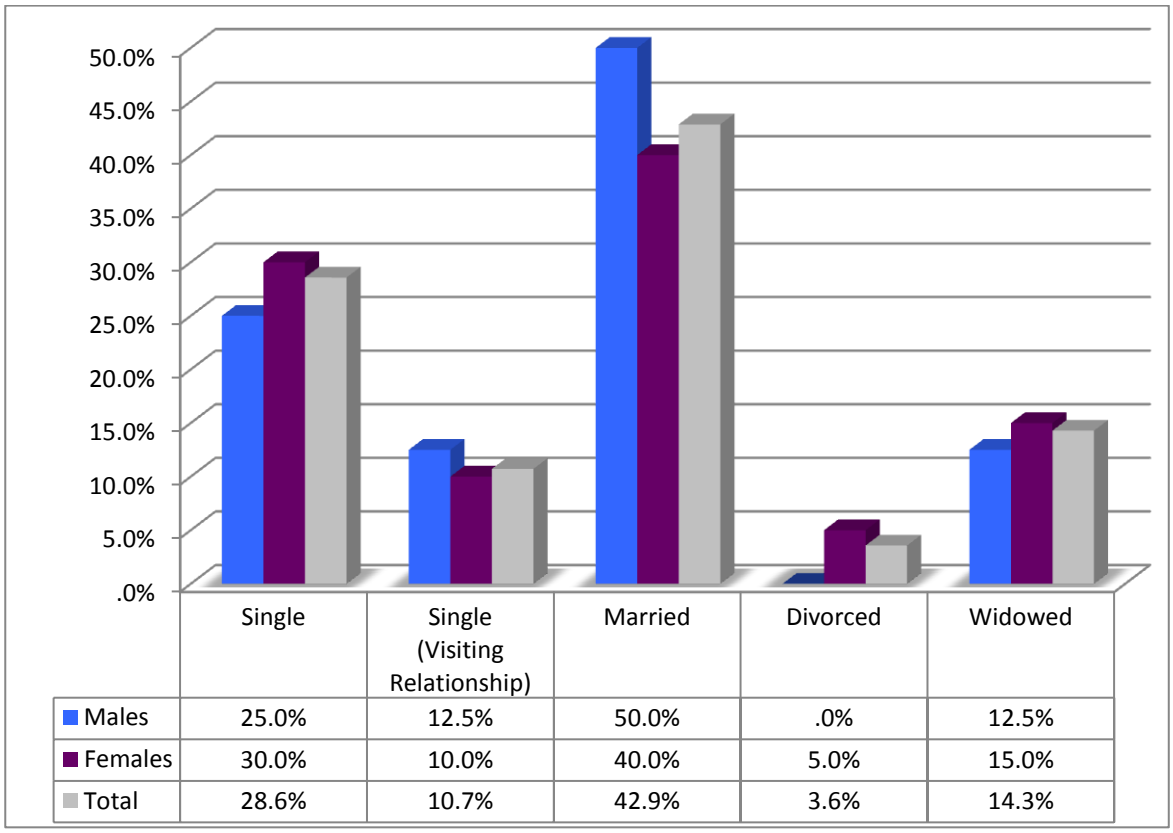
Figure 5.8.1: Age of Respondents

Household Form and Structure

With regards to the relationship status of respondents, a large percentage (42.9%) of the respondents was married. Another 28.6% of the sample were single, 20% of females were divorced or widowed, whereas only one male was widowed (12.5%). Generally however, there is very little difference between male and female respondents in terms of relationship status.

Table 5.8.3: Relationship Status of Respondents

Status	Male		Female		Total	
Single	2	25.0%	6	30.0%	8	28.6%
Single (Visiting Relationship)	1	12.5%	2	10.0%	3	10.7%
Married	4	50.0%	8	40.0%	12	42.9%
Divorced	0	0.0%	1	5.0%	1	3.6%
Separated	0	0.0%	0	0.0%	0	0.0%
Widowed	1	12.5%	3	15.0%	4	14.3%



	Single	Single (Visiting Relationship)	Married	Divorced	Widowed
Males	25.0%	12.5%	50.0%	.0%	12.5%
Females	30.0%	10.0%	40.0%	5.0%	15.0%
Total	28.6%	10.7%	42.9%	3.6%	14.3%

Figure 5.8.2: Relationship Status of Respondents

Generally, results indicate that community residents are more likely to be married, or otherwise, single. Some community residents (10.7%) are also involved in visiting relationships. Relationships, whether formal or informal, may imply a greater level of stability within a household (specifically where partners in informal relationships are living together), because there is the opportunity to share responsibilities and combine assets. There is a greater level of ease compared to households headed by single residents, where in this case, a marginally higher percentage of women were single compared to men.

5.8.2. Household Headship

Close to two-third of the respondents sampled listed themselves as the heads of their respective households (N=18/ 64.3%). This was more so the case for male respondents, of which 75% indicated that they were considered the head of their households. In comparison 60% of female respondents indicated that they were considered the head of their household (see Table 5.8.4). However, the sample comprised of a slightly greater percentage of female-headed households (54.5%) compared to male-headed households (see Table 5.8.5).

Table 5.8.4: Perception of Headship of Household

Perceived as Head of Household	Sex of Respondent			
	Male[1]		Female	
Yes	6	75.0%	12	60.0%
No	1	12.5%	8	40.0%
1: One male respondent (12.5%) did not indicate an option				

Table 5.8.5: Household Headship

Gender of Respondent	Male Headed Households		Female Headed Households		Sample (n=24)	
Male	6	54.5%	1	7.7	7	29.2%
Female	5	45.5%	12	92.3%	17	70.8%
Total (% of Sample)	11	45.8%	13	54.2%	24	100%

With regards to household size, 30% (N=7) of households consisted of between one and three people. Another 21% of households consisted of between four and five people, 29% of six or seven people, and 17% of households had more than eight or nine people (see Table 5.8.6).

Table 5.8.6: Family Size by Sex of Head of Household

Size of Household	Household Size By Sex of Head of Household					
	Male		Female		Total (n=24)[1]	
1	3	27%	0	0%	3	13%
2 - 3	1	9%	3	23%	4	17%
4 - 5	0	0%	5	38%	5	21%
6 - 7	4	36%	3	23%	7	29%
8 - 9	2	18%	2	15%	4	17%
1: One respondent (3% of sample) did not indicate household size						

There are slightly more households headed by females, however, males tended to be heads of the largest households, marginally more so than females. No definitive correlations can be drawn between household headship and size, but it is evident that both men and women bear responsibility for large households. Overall, close to half of the households in Table 5.8.6 have at least 6 persons. However, it is generally perceived that female household heads (especially single females) are in a more vulnerable position compared to their male counterparts, because of differential (limited) access to assets and job opportunities compared to men.

5.8.3. Education and Livelihoods

Table 5.8.7 shows that the largest proportion of the sample (N=14 /50.0%) indicated completing Secondary level of education, three of whom had completed advanced level Secondary education studies. There are a similar proportion of males and females who had undertaken Tertiary level education (university, professional designation etc.). One male respondent and one female respondent each completed Technical and Vocational Studies and Teachers' Training, respectively. This is somewhat commensurate with the tendency for males and females to enter these respective fields.

Table 5.8.7: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		Total	
Primary	2	25.0%	4	20.0%	6	21.4%
Secondary (Ordinary Level)	1	12.5%	10	50.0%	11	39.3%
Secondary (Advanced Level)	2	25.0%	1	5.0%	3	10.7%
Technical-Vocational Institute	1	12.5%	0	0.0%	1	3.6%
Teachers College	0	0.0%	1	5.0%	1	3.6%
Tertiary	2	25.0%	4	20.0%	6	21.4%

Based on responses, males are more likely to have progressed onto more advanced Secondary level studies, whereas females only reached ordinary level studies. Education is required for social mobility, and remains a critical component for poverty alleviation, as it provides persons with a means of securing work. Having completed Secondary level education or higher would imply a greater advantage in job seeking and security, depending on the level of work, and a large portion of the sample have completed this. However, a small percentage still only have Primary level education. Additionally, just over one-quarter of the sample has pursued further studies, and this is more evident in men than women. This is of some concern because job market constraints and competition require many persons to continually pursue some form of study or training so that they can proceed to higher employment ranks.

Table 5.8.8: Sample Distribution by Main Income Earning Responsibility

Are you the main income earner?	Sex of Respondent					
	Male[1]		Female		Total	
Yes	4	50%	9	45%	13	46%
No	3	37.5%	11	55%	14	50%
1: One male respondent (12.5%) did not indicate income earning responsibility						

Although there is a large percentage of male household heads amongst the respondents, and to a lesser extent – female heads, not all of them are the main income earners for the household. Table 5.8.8 shows that only 50% of the male respondents and 45% of female respondents are the household breadwinners, compared to 75% and 60% of male and female household heads respectively. A large proportion of the sample (75%) however, is employed, and the employment rate is the same for both males and females (see Table 5.8.9).

Table 5.8.9: Sample Distribution by Involvement in Income-Generating Activities

Are you involved in income generating activity?	Sex of Respondent					
	Male		Female		Total	
Yes	6	75%	15	75%	21	75%
No	2	25%	5	25%	7	25%

In terms of household income, the largest percentage of the sample recorded average monthly household incomes over US $1,000. Household incomes for approximately 28% of the sample fell below US $1,000, and just over 10% fell below US $500. There would be greater concern for those households and household

members in the lowest two financial brackets because it is likely that they are living in poverty or vulnerable to becoming poor (based on the established 2007 poverty and vulnerability lines; see Section 4.8). In terms of gender, responses from males in the sample, whom were mostly household heads, indicated higher household incomes compared to females. The largest percentage of female-headed households (30%) fell in the second lowest income bracket. In contrast however, a significantly larger percentage of male respondents indicated the lowest range for average monthly income (see Figure 5.8.3).

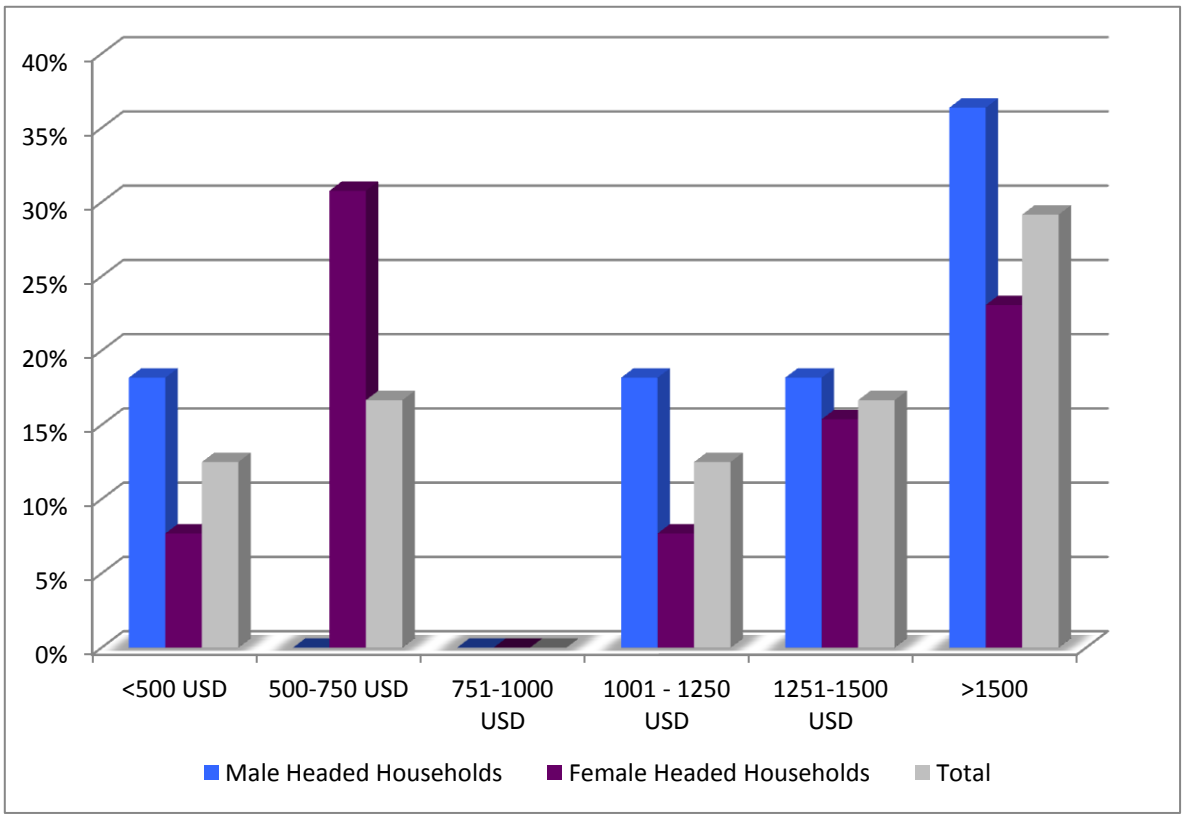


Figure 5.8.3: Sample Distribution by Average Monthly Earnings

With regards to employment in the tourism sector, respondents generally worked in non-tourism sectors; 75% of respondents were employed in a non-tourism industry and 11% worked in the tourism industry. For the remainder of the sample, this question was not applicable owing to unemployment. Of the respondents working in the tourism sector, one was a hotel worker and two were craft vendors (see Table 5.8.10).

Table 5.8.10: Labour Market Participation: Involvement in Tourism Sectors

Employment Sector	Male		Female		Total	
Taxi Driver	0	0.00%	0	0.00%	0	0.00%
Tour Operator	0	0.00%	0	0.00%	0	0.00%
Hotel Workers	0	0.00%	1	5.00%	1	3.57%
Restaurant Workers	0	0.00%	0	0.00%	0	0.00%
Craft sellers or vendors	1	12.50%	1	5.00%	2	7.14%
Informal tour guides	0	0.00%	0	0.00%	0	0.00%
Privately owned business	0	0.00%	0	0.00%	0	0.00%
Other	0	0.00%	0	0.00%	0	0.00%
Did not answer	7	87.50%	17	85.00%	24	85.71%

There were 21 respondents that indicated working in non-tourism sectors. The largest proportion of these respondents were employed in education (14.3%), followed by government (10.7%) and health services

(10.7%). Two respondents (7.1%) were employed in administrative sectors, and another 7.1% were employed in retail services. Of the remaining sample, 3.6% were employed in building/construction and 3.6% in the banking/financial sector.

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

Employment Sector	Male		Female		Total	
Administration	0	0.0%	2	10.0%	2	7.1%
Agriculture	0	0.0%	0	0.0%	0	0.0%
Banking/Financial	0	0.0%	1	5.0%	1	3.6%
Building/Construction	1	12.5%	0	0.0%	1	3.6%
Domestic worker	0	0.0%	0	0.0%	0	0.0%
Education	1	12.5%	3	15.0%	4	14.3%
Manufacturing	0	0.0%	0	0.0%	0	0.0%
Mechanical/Technical	0	0.0%	0	0.0%	0	0.0%
Retail Sales and Services	0	0.0%	0	0.0%	0	0.0%
Health Services	1	12.5%	2	10.0%	3	10.7%
Government Worker	1	12.5%	2	10.0%	3	10.7%
Information Technology	0	0.0%	0	0.0%	0	0.0%
Science/Technology	0	0.0%	0	0.0%	0	0.0%
Self Employed	0	0.0%	0	0.0%	0	0.0%
Student	0	0.0%	0	0.0%	0	0.0%
Transportation	1	12.5%	0	0.0%	1	3.6%
Ten respondents did not indicate a sub-sector.						

5.8.4. Food Security

Table 5.8.12 shows that all respondents procure some, or all, of their food supply from grocery stores or supermarkets. Additional sources of food included Traditional Markets (29.2%) and Community Shops (12.5%). Some respondents (20.8%) also grew their own food, which indicates some level of self-sufficiency amongst respondents in obtaining food, despite a high level of dependence on supermarkets.

Table 5.8.12: Source of Food Supply

Source of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Grown by Family	2	33.3%	2	40.0%	0	0.0%	1	8.3%	5	20.8%
Grocery store/Super market	6	100.0%	5	100.0%	1	100.0%	12	100.0%	24	100.0%
Open air/Traditional market	2	33.3%	2	40.0%	1	100.0%	2	16.7%	7	29.2%
Community	0	0.0%	0	0.0%	1	100.0%	2	16.7%	3	12.5%
Barter	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

When asked about the adequacy of the household food supply, all but three respondents (one male and two females) indicated having an adequate supply throughout the year (see

Table 5.8.13). The distribution by gender shows no disparities, but given the small sample size a definitive conclusion cannot be made in regards to gender and food adequacy. However, more research in this area could provide further insights. The adequacy of food supply may be related to household income, where households with low incomes may suffer from food shortages as a result of being unable to buy needed items.

Table 5.8.13: Adequacy of Food Supply

Adequacy of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Yes	5	83.3%	5	100.0%	1	100%	10	83.3%	21	87.5%
No	1	16.7%	0	0.0%	0	0%	2	16.7%	3	12.5%

5.8.5. Financial Security and Social Protection

Financial Support

Both Table 5.8.14 and Table 5.8.15 show that, while a few households either provide for or receive financial support from others, established support linkages with persons/entities outside of the household are minimal. Of the sample, 12.5% of respondents received financial support from relatives, while 4.2% received support from religious and charitable organisations. Only females from female headed households indicated that they received support.

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%	0	0.0%	0	0.0%	3	25.0%	3	12.5%
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%	1	8.3%	1	4.2%
Charitable Organisation	0	0.0%	0	0.0%	0	0.0%	1	8.3%	1	4.2%
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%

In terms of providing support, 37.5% of respondents indicated giving money to family and friends. This was more so the case for male respondents than female respondents. Respondents also gave financial support to charitable organisations and the government.

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	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Family Friend	5	83.3%	1	20.0%	0	0.0%	3	25.0%	9	37.5%
Religious Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Charitable Organisation	1	16.7%	1	20.0%	0	0.0%	1	8.3%	3	12.5%
Government	0	0.0%	0	0.0%	0	0.0%	1	8.3%	1	4.2%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Support systems exist more for the benefit of outside parties than for the households themselves, which may suggest that households are financially stable, and can therefore support other persons and entities periodically, especially when the findings on household income are taken into consideration. There are still

some households that need financial support, especially amongst female households, which raises some concern for the well-being of more disadvantaged female-headed households. The preference for support from relatives rather than more formal sources may owe to various possibilities in relation to the level of need, access (knowledge, eligibility) and comfort or trust.

Despite the lack of indication of formal support for households, options for larger scale credit are still explored by some residents. Respondents seemed more inclined to access credit from formal sources compared to informal sources; as 25% of the sample accessed credit from commercial banks (12.5%) and credit unions (12.5%), while 8.3% participate in a "Sou-Sou" or partner scheme.

Table 5.8.16: Distribution by Access/Use to Credit

Source of Credit	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Commercial Bank Loan	1	16.7%	0	0.0%	1	100.0%	1	8.3%	3	12.5%
Credit Union Loan	0	0.0%	1	20.0%	0	0.0%	2	16.7%	3	12.5%
Sou Sou / Partner	0	0.0%	2	40.0%	0	0.0%	0	0.0%	2	8.3%

Financial Security

Majority of the sample indicated having a low level of financial security (three months or less) in both instances of job loss or a natural disaster (roughly 33% of the sample in each instance), with smaller percentages indicate moderate (4 – 9 months) and high (over 10 months) levels of security (see Figure 5.8.4).

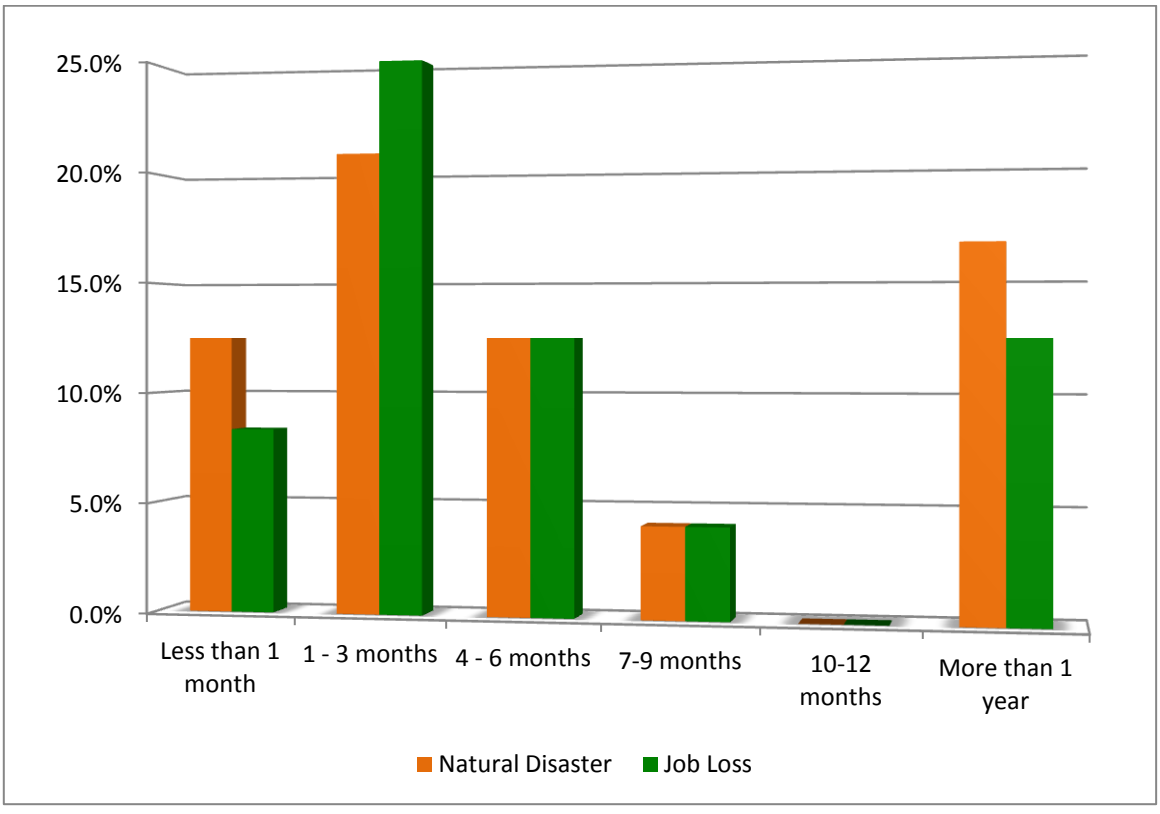


Figure 5.8.4: Financial Security: Job Loss or Natural Disaster

More specifically: in relation to Job Loss, 33.3% of respondents indicated that their reserves would last less than 3 months whereas 12.5% indicated their reserves would last for more than one year. However, 37.5% of the sample did not answer this question; only 3 of the 7 males answered this question, and it is not possible to make any conclusions based on gender (see Table 5.8.17). The

uncertainty of the state of household financial security may also suggest that it is not a household priority.

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	0	0.0%	0	0.0%	0	0.0%	2	16.7%	2	8.3%
1 - 3 months	1	16.7%	2	40.0%	0	0.0%	3	25.0%	6	25.0%
4 - 6 months	0	0.0%	0	0.0%	1	100.0%	2	16.7%	3	12.5%
7 - 9 months	0	0.0%	1	20.0%	0	0.0%	0	0.0%	1	4.2%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
More than 1 year	1	16.7%	1	20.0%	0	0.0%	1	8.3%	3	12.5%
Do not know	4	66.7%	1	20.0%	0	0.0%	4	33.3%	9	37.5%

Similar results are seen in terms of job loss from natural disasters. Of the sample, 33.2% of respondents indicated having reserves that would last for less than 3 months. Another 16.7% indicated their reserves would last for more than one year, and 33.3% did not know how long their reserves would last (see Table 5.8.18). Again, given the small sample size, it is not possible to make any conclusions on the basis of gender.

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%	0	0.0%	0	0.0%	2	16.7%	3	12.5%
1 - 3 months	0	0.0%	1	20.0%	0	0.0%	4	33.3%	5	20.8%
4 - 6 months	1	16.7%	1	20.0%	1	100.0%	0	0.0%	3	12.5%
7 - 9 months	0	0.0%	1	20.0%	0	0.0%	0	0.0%	1	4.2%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
More than 1 year	1	16.7%	1	20.0%	0	0.0%	2	16.7%	4	16.7%
Do not know	3	50.0%	1	20.0%	0	0.0%	4	33.3%	8	33.3%

Social Protection

In terms of social protection provisions, there is a moderate level of personal provisions (health insurance, pension) amongst sample respondents. Eleven respondents indicated having health insurance (45.8% of sample) and some residents also have pension plans in place. However, household provisions against weather impacts are slightly lower, and this is more evident in male headed households. Only 33.3% of the sample had home insurance against hurricane damage and storm surge while 37.5% of respondents had home insurance for flooding and fire. Uninsured households, should they suffer any extreme damage or loss of assets during a weather-related event, are limited in their ability to rebuild and restore property. There were similar rates of coverage for male and female headed households (see Table 5.8.19).

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%	4	80.0%	0	0.0%	6	50.0%	11	45.8%
Private Pension Savings Plan	3	50.0%	3	60.0%	0	0.0%	2	16.7%	8	33.3%
National Insurance / Government Pension	4	66.7%	4	80.0%	0	0.0%	5	41.7%	13	54.2%
Home Insurance - Hurricane Damage (water/wind)	1	16.7%	2	40.0%	0	0.0%	5	41.7%	8	33.3%
Home Insurance - Flooding	1	16.7%	3	60.0%	0	0.0%	5	41.7%	9	37.5%
Home Insurance - Storm Surge	1	16.7%	3	60.0%	0	0.0%	4	33.3%	8	33.3%
Home Insurance - Fire	1	16.7%	3	60.0%	0	0.0%	5	41.7%	9	37.5%

The high number of households without home insurance (and against hurricane damage in particular) may owe to several reasons, including a lack of awareness of insurance benefits, inability to afford insurance, or a lack of desire to acquire a plan. However, based on feedback from numerous residents, it would appear that the primary reasons for continuing without insurance is (a) a high sense of distrust of insurance companies based on previous experiences when trying to claim for losses after storm events, and (b) persons in the lower income bracket cannot afford to pay insurance, and prefer to manage loss as it happens.

5.8.6. Asset Base

Ownership of assets was found to be high in some cases and low in others. The highest proportion of respondents indicated ownership of houses (83.3%), land (54.2%) and private businesses (16.7%), respectively. Generally, males had slightly higher rates of asset ownership than females, although findings show that more female heads owned the houses that they resided in (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	5	83.3%	4	80.0%	1	100.0%	10	83.3%	20	83.3%
Land	3	50.0%	3	60.0%	1	100.0%	6	50.0%	13	54.2%
Livestock	0	0.0%	1	20.0%	0	0.0%	0	0.0%	1	4.2%
Industrial/Agricultural	1	16.7%	0	0.0%	0	0.0%	0	0.0%	1	4.2%
Commercial Vehicles	2	33.3%	0	0.0%	0	0.0%	1	8.3%	3	12.5%
Private Business	2	33.3%	0	0.0%	0	0.0%	2	16.7%	4	16.7%
Other (boat)	0	0.0%	0	0.0%	0	0.0%	1	8.3%	1	4.2%

A further examination of assets revealed that respondents most often indicated having television sets (100%), radios (95.8%), mobile phones (87.5%), landline phones (79.2%) and DVD Players (70.8%) in their homes. Additionally, 54.2% of respondents indicated having a desktop computer; while 45.8% indicated having laptops (see Table 5.8.21). There were similar rates of electronic asset ownership between males and females. The findings suggest that community residents have multiple ways of accessing information

and communicating with others, which becomes important in disaster management. The high rates of asset ownership also suggest that generally, most community residents enjoy a comfortable lifestyle.

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%	4	80.0%	0	0.0%	6	50.0%	13	54.2%
Computer (Laptop)	2	33.3%	4	80.0%	1	100.0%	4	33.3%	11	45.8%
Internet	3	50.0%	4	80.0%	1	100.0%	8	66.7%	16	66.7%
Television	6	100.0%	5	100.0%	1	100.0%	12	100.0%	24	100.0%
Video Player / Recorder	2	33.3%	3	60.0%	1	100.0%	5	41.7%	11	45.8%
DVD Player	4	66.7%	4	80.0%	1	100.0%	8	66.7%	17	70.8%
Radio	5	83.3%	5	100.0%	1	100.0%	12	100.0%	23	95.8%
Telephone (Land line)	3	50.0%	5	100.0%	1	100.0%	10	83.3%	19	79.2%
Telephone (Mobile)	5	83.3%	5	100.0%	0	0.0%	11	91.7%	21	87.5%

In terms of transportation, respondents predominantly have access to personal transportation (54.2%), followed by public transportation (41.7%), though members of male headed households had slightly more access to private motorised vehicles, whereas residents of female-headed households depended more on public transit than residents in male-headed households.

Table 5.8.22: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male Headed		Female Headed		Sample	
Private motorised vehicle	7	63.6%	6	46.2%	13	54.2%
Private non-motorised vehicle	1	9.1%	2	15.4%	3	12.5%
Public transit	4	36.4%	6	46.2%	10	41.7%
None	0	0.0%	3	23.1%	3	12.5%
Other	1	9.1%	2	15.4%	3	12.5%

The largest proportion of respondents (N=19/79.2%) indicated that their homes were made of blocks and cement and 20.8% (N=5) indicated their house was made of wood (see Table 5.8.23). Disparities between male and female headed households were slight, as male headed households were more likely to be made of blocks and cement.

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

House Material	Male Headed		Female Headed		Sample	
Bricks and mortar	0	0.0%	0	0.0%	0	0.0%
Blocks and cement	9	81.8%	10	76.9%	19	79.2%
Mud	0	0.0%	0	0.0%	0	0.0%
Wood	2	18.2%	3	23.1%	5	20.8%
Other	0	0.0%	0	0.0%	0	0.0%

Houses made predominantly of wood tend to be less resistant against extreme weather impacts. Given the predominance of houses made of blocks and cement, it would imply greater structural stability and greater chances of withstanding hurricanes. However, as there have been instances where wooden houses have withstood hurricane conditions which caused damage to concrete structures, the correlation between house material and damage risk is not absolute. The material is merely an indicator of the integrity of the structure.

Table 5.8.24 shows that most respondents have fairly high access to sanitation conveniences, with 75.0% of respondents sampled indicating that they always had access to liquid waste disposal and 91.7% always had access to indoor water-flush toilets. Additionally, 87.5% of respondents always had access to garbage collection. There was little difference between male and female headed households, though male headed households reported slightly more access to sanitation conveniences than female headed households.

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	81.8%	69.2%	75.0%
	Sometimes	9.1%	7.7%	8.3%
	Never	9.1%	23.1%	16.7%
Indoor water-flush toilets	Always	90.9%	92.3%	91.7%
	Sometimes	0.0%	0.0%	0.0%
	Never	9.1%	7.7%	8.3%
Garbage collection	Always	90.9%	84.6%	87.5%
	Sometimes	9.1%	7.7%	8.3%
	Never	0.0%	7.7%	4.2%

Access to sanitation conveniences serve as an indicator of the state of environmental health of households and the community in general, and any risks to the physical health of residents as a result of a lack of access. Given the level of access to sanitation services and conveniences in the community, concerns for health threats associated with poor sanitation are fairly low.

5.8.7. Power and Decision Making

Both female and male respondents indicated high levels of responsibility for decision making at the level of the household, and within the community to a lesser extent. All males and 95.0% of females indicated having a role in the decision making at the household level, much in line with the high percentages of household headship amongst the sample, and mature ages of respondents. At the informal community level, both males (12.5%) and females (10.0%) indicated having a role in decision making. At the formal community level, both males (12.5%) and females (30.0%) indicated having a role in decision making (see Table 5.8.25).

Table 5.8.25: Power and Decision Making

Site of Decision Making	Males		Females	
Household	8	100.0%	19	95.0%
Informal Community	1	12.5%	2	10.0%
Formal Community	1	12.5%	6	30.0%

5.8.8. Social Networks and Social Capital

Both male and female respondents were active in their community; 65% of females and 50% of male respondents reported belonging to a social group (see Table 5.8.26). Social capital can be an important source of support, especially in households where there are deficits in financial and physical capital. Social capital in this instance seems to be fairly strong, especially amongst women. Additionally, personal support networks of friends that live in and outside of the community may also exist that can assist households during difficult times.

Table 5.8.26: Social Networks: Community Involvement

Membership	Male		Female[1]	
Yes	4	50.0%	13	65.0%
No	4	50.0%	5	25.0%
1: Two female respondents (10%) did not indicate membership				

With regards to support systems, male respondents tended to rely more on relatives outside their households for physical help, personal advice and financial assistance. Males (37.5%) also relied on some government agency for financial support. Female respondents relied more heavily on relatives both in and outside of the household for physical help, personal advice, and financial help. A number of women also seek personal advice from friends (see Table 5.8.27).

Table 5.8.27: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	Female	Male	Female	Male	Female
Relative (within the household)	12.5%	50.0%	12.5%	45.0%	12.5%	25.0%
Relative (outside the household)	50.0%	50.0%	37.5%	40.0%	50.0%	35.0%
Family friend	25.0%	20.0%	0.0%	45.0%	0.0%	25.0%
Religious Organisation	12.5%	5.0%	12.5%	5.0%	0.0%	10.0%
Non-religious Charity	0.0%	0.0%	0.0%	0.0%	12.5%	5.0%
Government Agency	0.0%	0.0%	25.0%	0.0%	37.5%	15.0%

5.8.9. Use of Natural Resources

Subsistence

Generally, natural resource use for subsistence was fairly low. Although six of the nine listed resources were indicated by at least one respondent, this number never rose above five (see Table 5.8.28). Agricultural land (17.9%) was often indicated to be the most important resource for subsistence, likely as a supplementary source of food for some households as the finding corresponds with data in Table 5.8.12. The second and third most important resources were the sea and coral reefs, with 14.3% and 7.1% of respondents respectively ranking each with some degree of importance.

Livelihood

Natural resource use for livelihood purposes was also low. Similar to resource use for subsistence purposes, six of the nine listed resources were selected by at least one respondent, but no more than this in most cases (see Table 5.8.28). Bush and forests appear to be the most important amongst the sample, with

14.3% of respondents identifying this resource as being “very important” for livelihoods. Furthermore, 3.6% of the sample indicated that mangroves, agricultural land, mountains, and caves were very important for livelihoods.

Recreation

The most important resource for recreation is the sea, as close to two-thirds of the sample indicated that the sea was important to one degree or another for recreation. Mountains were also highlighted by some of the respondents. Five other resources were indicated by at least one participant, but generally, these resources were of little importance to the sample for recreation (see Table 5.8.28).

For the resources that were indicated by respondents, when further disaggregated on the basis of sex, there was little disparity in the use of natural assets, although in most cases a slightly larger proportion of male respondents have a higher dependence on natural resources than female respondents (see Table 5.8.29).

Table 5.8.28: Use and Importance of Natural Resources

Resource	Importance	Subsistence		Livelihood		Recreation	
River / Stream	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	1	3.6%	0	0.0%	1	3.6%
	Not at all important	0	0.0%	0	0.0%	1	3.6%
	None / Do Not Use	27	96.4%	28	100.0%	26	92.9%
Sea	Very Important	2	7.1%	0	0.0%	12	42.9%
	Somewhat important	2	7.1%	1	3.6%	6	21.4%
	Not at all important	0	0.0%	0	0.0%	1	3.6%
	None / Do Not Use	24	85.7%	27	96.4%	9	32.1%
Coral Reefs	Very Important	1	3.6%	0	0.0%	2	8.3%
	Somewhat important	1	3.6%	0	0.0%	1	4.2%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	26	92.9%	28	100.0%	21	87.5%
Mangrove	Very Important	0	0.0%	1	3.6%	1	3.6%
	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	28	100.0%	27	96.4%	27	96.4%
Agricultural Land	Very Important	5	17.9%	1	3.6%	3	10.7%
	Somewhat important	3	10.7%	3	10.7%	0	0.0%
	Not at all important	1	3.6%	0	0.0%	0	0.0%
	None / Do Not Use	19	67.9%	24	85.7%	25	89.3%
Bush and Forest	Very Important	0	0.0%	4	14.3%	1	3.6%
	Somewhat important	0	0.0%	0	0.0%	2	7.1%
	Not at all important	0	0.0%	0	0.0%	1	3.6%
	None / Do Not Use	28	100.0%	24	85.7%	24	85.7%
Mountain	Very Important	0	0.0%	1	3.6%	4	14.3%
	Somewhat important	1	3.6%	0	0.0%	2	7.1%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	27	96.4%	27	96.4%	22	78.6%
Caves	Very Important	0	0.0%	1	3.6%	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	28	100.0%	27	96.4%	28	100.0%
Wild Animals	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	2	7.1%	0	0.0%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	26	92.9%	28	100.0%	28	100.0%

Table 5.8.29: Use and Importance of Natural Resources, by Sex of Respondent

Resource	Importance	Subsistence		Livelihood		Recreation	
		Male	Female	Male	Female	Male	Female
River / Stream	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	5.0%	0.0%	0.0%	12.5%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	12.5%	0.0%
	None / Do Not Use	100.0%	95.0%	100.0%	100.0%	75.0%	100.0%
Sea	Very Important	12.5%	5.0%	0.0%	0.0%	37.5%	45.0%
	Somewhat important	12.5%	5.0%	0.0%	5.0%	25.0%	20.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	12.5%	0.0%
	None / Do Not Use	75.0%	90.0%	100.0%	95.0%	25.0%	35.0%
Coral Reefs	Very Important	0.0%	5.0%	0.0%	0.0%	25.0%	5.0%
	Somewhat important	0.0%	5.0%	0.0%	0.0%	25.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	90.0%	100.0%	100.0%	50.0%	95.0%
Mangrove	Very Important	0.0%	0.0%	0.0%	5.0%	0.0%	5.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	95.0%	100.0%	95.0%
Agricultural Land	Very Important	37.5%	10.0%	0.0%	5.0%	25.0%	5.0%
	Somewhat important	12.5%	10.0%	0.0%	15.0%	0.0%	0.0%
	Not at all important	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	50.0%	75.0%	100.0%	80.0%	75.0%	95.0%
Bush and Forest	Very Important	0.0%	0.0%	12.5%	15.0%	0.0%	5.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
	None / Do Not Use	100.0%	100.0%	87.5%	85.0%	75.0%	90.0%
Mountain	Very Important	0.0%	0.0%	0.0%	5.0%	12.5%	15.0%
	Somewhat important	0.0%	5.0%	0.0%	0.0%	25.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	95.0%	100.0%	95.0%	62.5%	85.0%
Caves	Very Important	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	95.0%	100.0%	100.0%
Wild Animals	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	10.0%	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%	90.0%	100.0%	100.0%	100.0%	100.0%

Agriculture

Seven respondents indicated involvement in agriculture on any scale. They also indicated having reliable access to water, which is essential for productivity (see Table 5.8.30).

Table 5.8.30: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	5	100.0	2	100.0	7	100.0
Sometimes	0	0.0%	0	0.0%	0	0.0%
Never	0	0.0%	0	0.0%	0	0.0%

5.8.10. Knowledge, Exposure and Experience of Climate Related Events

Table 5.8.31 shows that over half of the respondents indicated either average or above average knowledge of most climate-related events, including hurricanes, flooding and drought events. When examined on the basis of gender of the respondent, there was a small difference between male and female headed households. In most cases, males in male headed households considered themselves more knowledgeable of climate related events than females in the same category. Similarly females in female-headed households were more aware than their male counterparts.

Respondents showed various levels of awareness of the appropriate course of action to be taken in the instance of the different types of events:

- In the event of a hurricane, 87.5% of the sample was aware of what to do, without having to ask for assistance.
- In the instance of flooding, a slightly smaller proportion of respondents (50.0%) were aware of appropriate action to take, without asking for assistance.
- In the instance of a storm surge, 41.7% of respondents were aware of appropriate action to take, without asking for assistance.
- In the instance of a drought, 66.7% of respondents were aware of appropriate action to take, without asking for assistance.
- In the event of a landslide only 25%of respondents were aware of what should be done.

In terms of gender, men exhibited a greater awareness of appropriate actions to be taken in most cases (see Table 5.8.32).

Table 5.8.31: Knowledge of Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	25.0%	33.3%	0.0%	18.2%	0.0%	33.3%	30.8%
	Average	41.7%	16.7%	60.0%	36.4%	100.0%	41.7%	46.2%
	Very Good	33.3%	50.0%	40.0%	45.5%	0.0%	25.0%	23.1%
Flooding	Poor	41.7%	33.3%	80.0%	54.5%	0.0%	33.3%	30.8%
	Average	29.2%	16.7%	0.0%	9.1%	100.0%	41.7%	46.2%
	Very Good	25.0%	50.0%	20.0%	36.4%	0.0%	16.7%	15.4%
Storm Surge	Poor	54.2%	16.7%	60.0%	36.4%	100.0%	66.7%	69.2%
	Average	16.7%	33.3%	20.0%	27.3%	0.0%	8.3%	7.7%
	Very Good	29.2%	50.0%	20.0%	36.4%	0.0%	25.0%	23.1%
Drought	Poor	41.7%	0.0%	60.0%	27.3%	100.0%	50.0%	53.8%
	Average	33.3%	66.7%	20.0%	45.5%	0.0%	25.0%	23.1%
	Very Good	20.8%	33.3%	20.0%	27.3%	0.0%	16.7%	15.4%
Landslides	Poor	58.3%	66.7%	60.0%	63.6%	0.0%	58.3%	53.8%
	Average	16.7%	0.0%	20.0%	9.1%	100.0%	16.7%	23.1%
	Very Good	20.8%	33.3%	20.0%	27.3%	0.0%	16.7%	15.4%

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

Table 5.8.32: Knowledge of Appropriate Response to Climate Related Events

Event	Knowledge	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	87.5%	100.0%	100.0%	100.0%	100.0%	75.0%	76.9%
	No	12.5%	0.0%	0.0%	0.0%	0.0%	25.0%	23.1%
Flooding	Yes	50.0%	66.7%	40.0%	54.5%	100.0%	41.7%	46.2%
	No	45.9%	33.3%	60.0%	45.5%	0.0%	50.0%	46.2%
Storm Surge	Yes	41.7%	100.0%	20.0%	63.6%	0.0%	25.0%	23.1%
	No	50.0%	0.0%	60.0%	27.3%	100.0%	66.7%	69.2%
Drought	Yes	66.7%	83.3%	60.0%	72.7%	100.0%	58.3%	61.5%
	No	29.1%	16.7%	40.0%	27.3%	0.0%	33.3%	30.8%
Landslides	Yes	25.0%	33.3%	40.0%	36.4%	0.0%	16.7%	15.4%
	No	70.9%	66.7%	60.0%	63.6%	100.0%	75.0%	76.9%

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

When questioned around the perceived risk of their households to climate related events, respondents most often indicated a High Risk to Hurricanes (33.3%). Only 8.3% thought there was a high risk of their household to drought impacts, and 4.2% thought they were at high risk to landslides. A large percentage of respondents perceived a low level of risk to their households for flooding and drought events and to a lesser extent, hurricanes and storm surge events, indicating that there are some minor concerns in relation to household safety and protection (see Table 5.8.33). For storm surge events specifically, many of the community households are located away from the sea, thus prompting responses of lower risk. The perception of risk by men and women vary somewhat depending on the event, with no particular trends.

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

Event	Risk Perception	SAMPLE[1]	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	4.2%	16.7%	0.0%	9.1%	0.0%	0.0%	0.0%
	Low Risk	58.3%	83.3%	80.0%	81.8%	0.0%	41.7%	38.5%
	High Risk	33.3%	0.0%	20.0%	9.1%	100.0%	50.0%	53.8%
Flooding	No Risk	25.0%	33.3%	40.0%	36.4%	0.0%	16.7%	15.4%
	Low Risk	75.0%	66.7%	60.0%	63.6%	100.0%	83.3%	84.6%
	High Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Storm Surge	No Risk	50.0%	50.0%	40.0%	45.5%	100.0%	50.0%	53.8%
	Low Risk	45.8%	50.0%	40.0%	45.5%	0.0%	50.0%	46.2%
	High Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Drought	No Risk	20.8%	16.7%	0.0%	9.1%	100.0%	25.0%	30.8%
	Low Risk	70.8%	66.7%	80.0%	72.7%	0.0%	75.0%	69.2%
	High Risk	8.3%	16.7%	20.0%	18.2%	0.0%	0.0%	0.0%
Landslides	No Risk	54.2%	50.0%	60.0%	54.5%	0.0%	58.3%	53.8%
	Low Risk	37.5%	50.0%	40.0%	45.5%	0.0%	33.3%	30.8%
	High Risk	4.2%	0.0%	0.0%	0.0%	100.0%	0.0%	7.7%

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

Respondents reported higher levels of risk for the community than they did for their own households with regards to hurricanes, flooding and storm surge (see Table 5.8.34 and Figure 5.8.5). For all other events, they reported lower levels of risk for the community. Differences in perceptions by gender also vary.

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

Event	Risk Perception	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	50.0%	66.7%	80.0%	72.7%	0.0%	33.3%	30.8%
	High Risk	41.7%	33.3%	20.0%	27.3%	0.0%	58.3%	53.8%
Flooding	No Risk	12.5%	16.7%	20.0%	18.2%	0.0%	8.3%	7.7%
	Low Risk	75.0%	66.7%	80.0%	72.7%	0.0%	83.3%	76.9%
	High Risk	8.3%	0.0%	0.0%	0.0%	100.0%	8.3%	15.4%
Storm Surge	No Risk	37.5%	16.7%	20.0%	18.2%	0.0%	58.3%	53.8%
	Low Risk	45.8%	50.0%	60.0%	54.5%	0.0%	41.7%	38.5%
	High Risk	8.3%	16.7%	0.0%	9.1%	100.0%	0.0%	7.7%
Drought	No Risk	25.0%	16.7%	0.0%	9.1%	100.0%	33.3%	38.5%
	Low Risk	66.7%	50.0%	100.0%	72.7%	0.0%	66.7%	61.5%
	High Risk	4.2%	16.7%	0.0%	9.1%	0.0%	0.0%	0.0%
Landslides	No Risk	50.0%	50.0%	40.0%	45.5%	0.0%	58.3%	53.8%
	Low Risk	45.8%	33.3%	60.0%	45.5%	100.0%	41.7%	46.2%
	High Risk	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

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

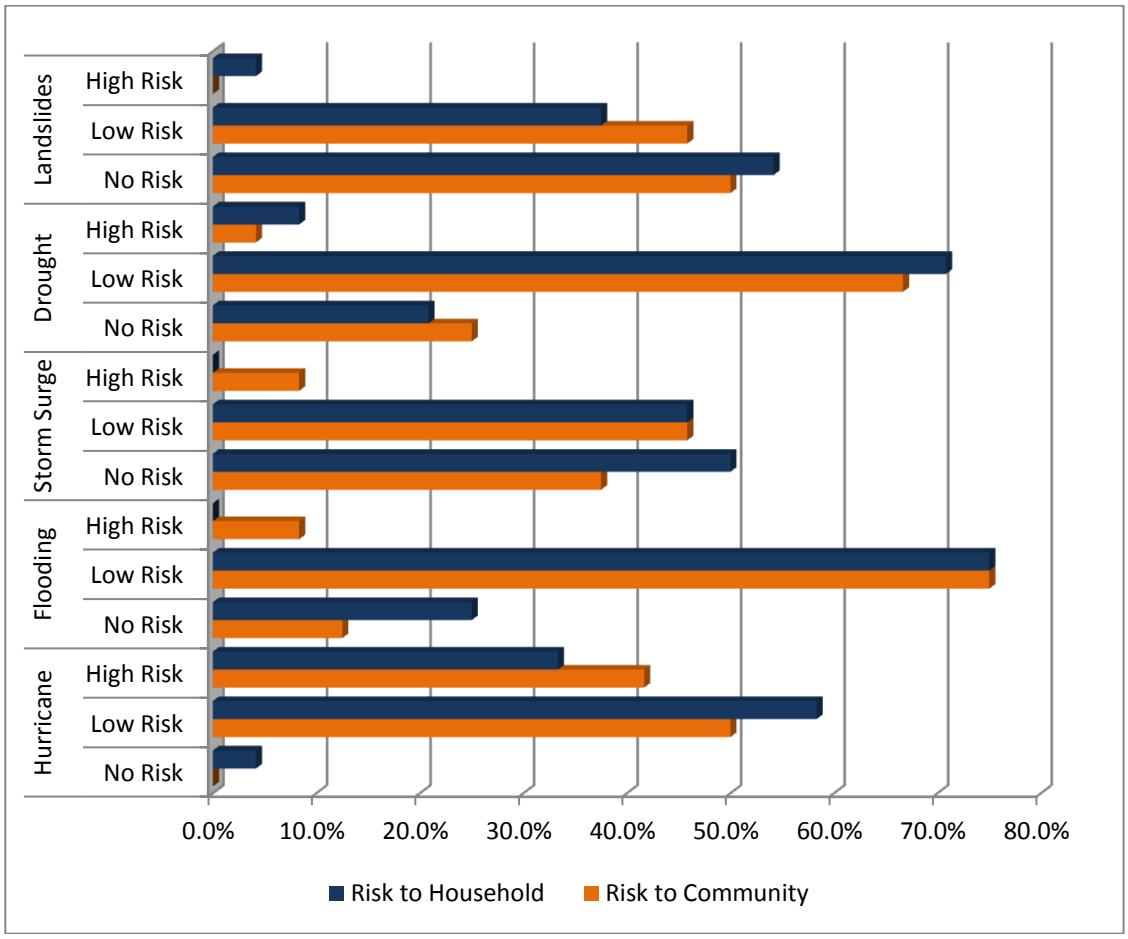


Figure 5.8.5: Perception of Risk for Climate Related Events: Household and Community

Similar to perceptions of risk to climate related events, respondents consistently reported higher levels of support received within the community than in their respective households (see Figure 5.8.6). The greatest disparity was observed in relief supplies, structure improvements received and evacuation assistance. The disparity in residence in shelter and public education materials also bears noting. However, some areas of support, such as evacuation assistance and shelter residence are sought only as needed, and therefore the high percentage of respondents who have responded “no” to these options in relation to disaster support for the household may suggest that there was little need for them by most residents on previous occasions.

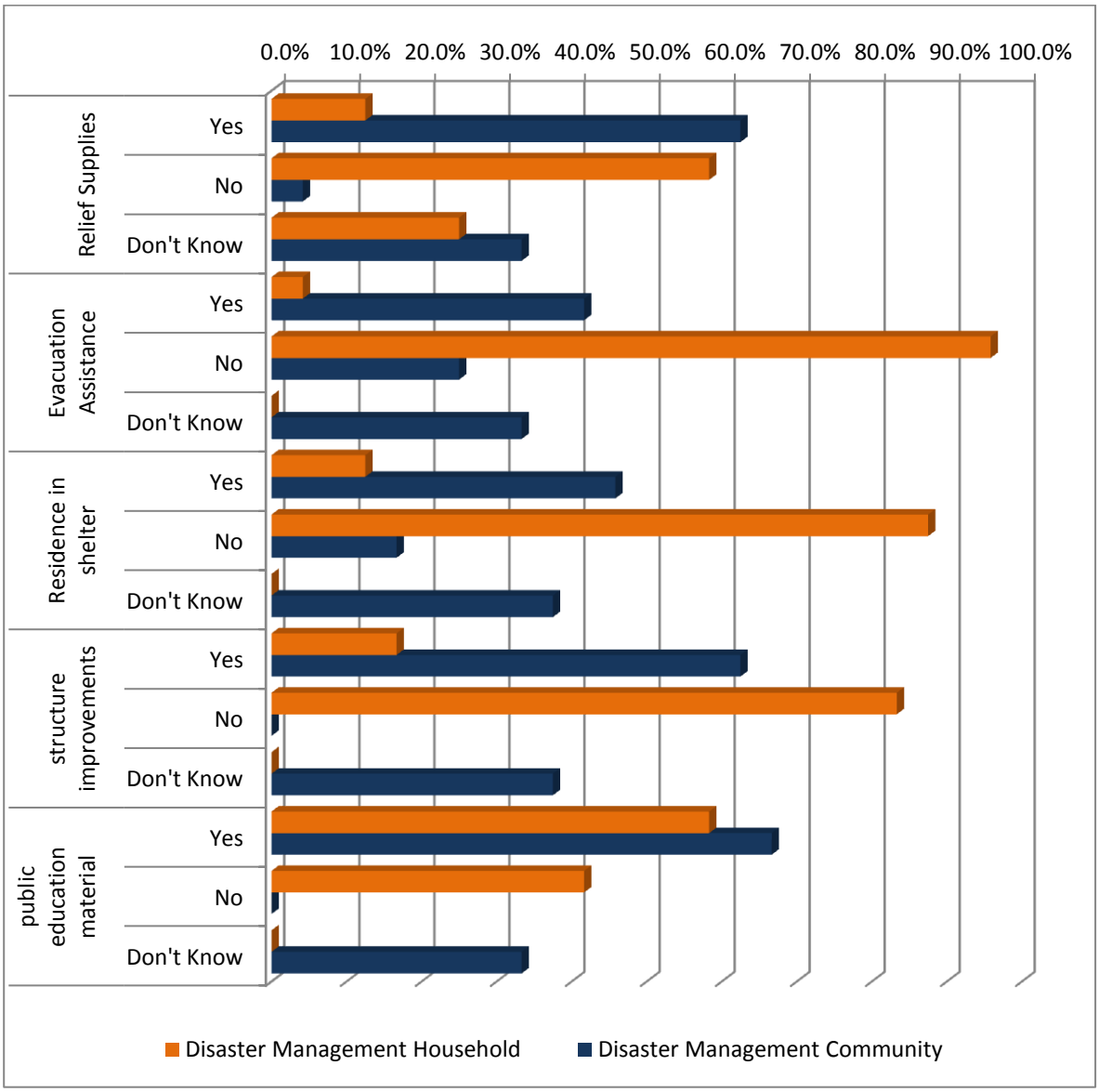


Figure 5.8.6: Support during Climate Related Events

5.8.11. Adaptation and Mitigation Strategies

Very few respondents indicated that any adaptation or mitigation strategies were employed to protect themselves, their households and their livelihoods against impacts of extreme weather. The most popular action taken was to reduce household expenses. Other respondents indicated borrowing money or starting a new livelihood activity. In most cases, these actions were taken in response to hurricane events. Response actions to flooding, drought and storm surge were less popular, and no actions were indicated in response to landslide events (see Table 5.8.35). The relative absence of resilience building actions amongst the sample is of great concern, as it has implications for household and overall community vulnerability to future weather and climate change impacts.

Table 5.8.35: Household Adaptation and Mitigation Strategies

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

6. RECOMMENDED STRATEGIES AND INITIAL ACTION PLAN

The following recommendations have been developed in consultation with national and community stakeholders through the use of various participatory tools. They support the main objective of the CCCRA which is to provide a scientific (physical and social) basis to support decision making, policy and planning by governments, communities and the private sector that increase resilience of economies and livelihoods to climate change. The recommendations are also consistent with the strategies and programmes identified in the *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change* endorsed by the CARICOM Heads of State.

Recommendations are presented as an initial plan of action with a brief description of the intervention, the national and/or local stakeholders involved and the expected benefits, and are categorised according to short-, medium- and long-term interventions. All recommendations are considered 'No-regret' or 'Low-regret' strategies. 'No-regret' strategies seek to maximise positive and minimise negative outcomes for communities and societies in climate-sensitive areas such as agriculture, food security, water resources and health. This means taking climate-related decisions or actions that make sense in development terms, whether or not a specific climate threat actually materialises in the future. 'Low-regret' adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components, for example installing larger diameter drains or hurricane shutters at the time of initial construction or refurbishment (World Bank, 2012).

Each one or a group of recommendations can be further developed into a concept note or project proposal with a full action plan, with much of the supporting information found in this document. Earlier sections of this report have provided the rationale for recommended interventions based on the vulnerabilities and adaptive capacity identified for key sectors.

6.1. *Cross Cutting Actions*

The following activities must be undertaken in the short-term, across a number of sectors, to ensure the success of the more specific and practical recommendations presented in later sections. These cross-cutting actions provide the necessary foundation, in terms of information and data, development policy, awareness raising and cross-sectoral linkages from which wider actions to combat the threat of climate change on future development can be legitimised. With this foundation, future actions and the allocation of resources to adaptation and mitigation activities are more easily justified because decisions can be based on current information, as well as common goals and a widespread understanding of the severity of the threat.

6.1.1. Data collection, monitoring and evaluation

It is evident in a number of sectors that the lack of data and inadequate monitoring and evaluation procedures inhibit the ability of the relevant agencies to plan and manage a number of resources. Monitoring and evaluation is essential if progress is to be demonstrated. By collecting and sharing the information gathered, Section 6.1.3, it is possible to gain even greater support amongst stakeholders.

Specific areas and suggestions for data collection, monitoring and evaluation include:

- **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 Nevis 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 national level data availability and collect, manage and update databases within a national agency to better inform decision making and improve early warning systems:** There is no meteorological service available in St. Kitts or Nevis, and so weather forecasts are provided by Antigua and Barbuda. Data must be readily available to local decision makers and should not be left depending on diplomatic relations with other countries. Especially in emergency decision making, the availability of good data quickly is imperative to successful response. In addition, the inclusion of a long term record for meteorology data allows decision making to be based on the conditions and trends specific to Nevis.

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 Physical Planning Division 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 Nevis.
- **Incorporate SLR and climate change impacts into local and national land use development plans as well as tourism master plans.** Undertake national-level consultation with Government ministries responsible for land use planning and tourism 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:
    - 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. NDMD, the Ministry of Tourism and the Department of Development and Planning should collaborate on this project to create a sustainable tourism plan that is in line with other sustainable development goals in Nevis.
    - 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.

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 Nevis 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 and education is needed with regard to extreme events and climate change:

- Climate change issues in general;
- Continue efforts by the NDMD on disaster risk reduction and emergency preparedness at the household level. The information videos on their website are a good initiative.
- 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 benefits and value of protected areas;
- The level of awareness of SLR impacts and costs needs to be raised for all levels of the Nevisian 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. NDMD can work with the Red Cross to develop a culturally appropriate communication plan that will not only communicate the vital information Nevisians 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 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 Nevis 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 and raising awareness of the need for water conservation at both the household and hotel level, Sections 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

Consider the development of mechanisms to facilitate Integrated Water Resources Management (IWRM): One of the functions of the Nevis Water Department is to establish an integrated water resource management plan. Acknowledging the need for such a programme is an important step towards improved water resource management on the island. The basis of IWRM is that different users of water are interdependent: 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. 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. As such cooperation with the Department of Planning, the Environmental Health Department, Department of Environment, Department of Agriculture, Public Works Department and the Public Health Department will be required since all of these agencies have legislative roles in water management. In addition, various private sector stakeholders and the general public will need to be consulted.

Specific components of an IWRM plan that have been highlighted in this research for Nevis are:

- **Develop measures to protect aquifers from surface contamination:** 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. Programs should also be implemented to reduce pollution of groundwater by pesticides and other pollutants, including establishing penalties for discharging pollutants into drainage systems, sensitive potable water zones and marine areas (MOSD, 2007). Hydrological risk zones and groundwater recharge areas should be identified and protected. The latter component should feed into the land-use planning recommendation in Section 6.1.2.
- **Water infrastructure should be developed and maintained 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.
- **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, in order 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 sea level rise on groundwater levels:** Numerical models of ground-water have been used elsewhere to establish

how sea level rise impacts on aquifer thickness and saline intrusion (e.g. Bobba, 2002). Due to the particular vulnerability of aquifers in St. Kitts and Nevis, these models should be developed urgently in order to effectively mitigate the effects of climate change on freshwater resources.

- **Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation:** Nevis has a number of activities that demand considerable quantities of water, for instance golf courses and the tourism industry, particularly cruise ships. Waste water from domestic and tourism use can be recycled to produce irrigation water, either for agriculture or the irrigation of golf courses. One particular option for wastewater treatment and potential re-use has been recommended in the Biodiversity section, 6.6.

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. A specific proposal for using geothermal energy in agriculture is included in Section 6.4. 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 agencies, such as Tourism and the Nevis 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, emissions 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. There are already plans to ensure that taxation on motor vehicles and fuels are adequate to encourage the use of public transport. Price levels 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. Government ambitions to reduce electricity prices in St. Kitts and Nevis could counteract efforts at energy efficiency.

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 instigate 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

Continuing 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 & 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 are resilient 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.

Medium term

The creation of a project for the integration of renewable energy on farms in Nevis: The aim is to promote the use of environmentally sound energy solutions in the agricultural sector, which would be in line with the objectives of the draft Energy Policy and Plan, Section 4.2. The Nevis Island Administration web portal asserts that the proposed geothermal energy plant in Nevis has remarkable opportunities for agricultural applications as well as the potential to contribute significantly to climate change mitigation. Research has

shown that the use of geothermal energy is suited to implementing technologically advanced growing techniques, substantially reducing the total area under cultivation while maintaining overall levels of production. A project in collaboration with the Nevis Island Department of Agriculture can be developed to utilise available geothermal energy not only for electrical power production on local farms, but also to enhance existing greenhouse cultivation by controlling heating and humidity. A greenhouse project specifically for improving growing performance by directly using the carbon dioxide present in geothermal steam is another possible option. Small farmers from the Nevis Growers' Co-operative and agro-producers stand to benefit from this arrangement. Additionally, support from key partners such as FAO and IICA will be needed to facilitate the transfer of knowledge at the farm level.

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 Nevis has found numerous ways to adapt to the range of health issues described. This type of research would be best carried out by tertiary 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 up a supply of public health resources for the surveillance, prevention and control of Vector Borne Diseases: The Public Health Department is responsible for 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 and Nevis 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 Nevis 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 Department of Planning and Development and the Fisheries Division. 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 (Nevis has an extended setback requirement of 152m along one stretch of coastline where mangrove currently exists). Nevis 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.

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 Fisheries Division might be best placed to lead this initiative with substantial support from communities and NGOs, such as the Nevis Historical and Conservation Society.

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 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 departments such as Public Health, Planning and Development, and Environment.

Promote Sustainable Seafood: 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 island's 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 of information. The Fisheries Division 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 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 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 other than improve building techniques and establish set-backs for new buildings. The government of Nevis needs to work with local stakeholders, including the Nevis Historical and Conservation 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 Nevis should be a priority for future research. This will enable the identification of the degree to which Nevis 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 a 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 Nevis 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

Work with relevant tourism stakeholders to develop and implement tourism sector disaster plans, with a focus on vulnerability reduction and hazard mitigation: Climate change threatens to degrade, and possibly destroy the Caribbean tourism industry and impacts on a single island may be transferred to other islands since tourists often view the region as one destination. The tourism industry in Nevis, must work with relevant stakeholders (particularly the private hotel operators) to generate preparedness and response plans for the industry. This work should include exploration of opportunities for tourism development and activities away from the high risk areas. The Ministry of Tourism, Nevis Tourism Authority and NDMD should collaborate on this initiative with the private sector as a no-regret option to reducing vulnerability to current extreme events.

Medium term

Conduct capacity building and technical training programs for NDMD employees so that the current technical deficiencies can be remedied and skills gained: While training may already be offered, technical expertise is needed at the office at all times (IPCC, 2007b). To achieve CDEMA's goals under the Comprehensive Disaster Management Strategy and Plan, the prioritisation of technical training within the Participating States' disaster offices should be a priority. The RNAT team and the CARICOM Disaster Response Unit (CDRU) 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, the disaster office and community committees can manage risks better and have a better understanding of the vulnerability in communities across Nevis. Lack of technical equipment was also cited as a deficiency that demands parallel action if the disaster department is to function at its full potential. Also, "insufficient equipment (e.g computers) and other technologically up to date implements, impacts training and emergency operations" (NEMA, 2007). Therefore investments in equipment are needed at the same time as improved training programmes. The need for improved collaboration between national and community based disaster management organisations, 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 NDMD: 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 Nevis (GFDRR, 2010, p. 225). Nevis 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 Nevis. 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 NDMD. The benefit would then be a set of capable staff that can continue to work on disaster risk reduction and preparedness in Nevis.

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

Assess and refurbish hurricane shelters in the area: Strong and durable public buildings are normally used as provisional hurricane shelters in the event that members of the public feel unsafe in their own dwellings and wish to take shelter elsewhere. This is especially the case with low- to middle-income households whose housing structures are perceptibly less able to withstand physical hurricane impacts. All of the government-designated shelters (especially community centres) need to be of a standard that can withstand extreme hurricanes. There are some concerns about the condition of shelters in the St. Thomas area. Structural assessments and repairs should be conducted on buildings used as hurricane shelters to improve their integrity and minimise possible damage and discomfort of occupants during a hurricane. This can be an initiative led by the government or private sector. Reliable and credible contractors should be hired to make repairs and carry out any necessary retrofitting. The provision of safe shelter could also contribute to the tourism disaster plans recommended in Section 6.8, especially for smaller tourism properties that are unable to provide adequate shelter themselves. The NDMD must seek financing as suggested in Section 6.8 and work with the community to prioritise the areas that need attention.

Awareness and Education: While some persons in the community have experienced some events, it is acknowledged that there is generally a lack of awareness of extreme weather events, and more so of climate change. As outlined in greater detail in Section 6.1.4, the issues to be addressed are interrelated so a co-ordinated effort for public awareness is needed to avoid repetition of work by different groups. Activities can target church groups, school groups and communities to teach persons how to recognise hazards and vulnerabilities. At present, preparedness and protection measures tend not to be consistent, and focus mainly on hurricanes, but attention also needs to be placed on long term, less extreme changes like gradual temperature change or rainfall variability. This recommendation falls in line with the following recommendation on collaboration between the community and the disaster agency.

Medium term

Explore and capitalise on opportunities for collaboration between national-level and community-based disaster and emergency management organisations to improve community preparedness and resilience: This recommendation would be strongly supported by other recommendations in Section 6.8. Community-based disaster management groups or organisations can be effective mechanisms for engaging and directing entire communities in all stages of disaster management: preparation, mitigation, response and recovery; and acting as a liaison body between national emergency and disaster management entities and

the community. A network of organisations with responsibility for disaster management at the community level is becoming a popular strategy amongst Caribbean Islands, and has been beneficial on previous occasions for quick response and efforts in minimising hazard impacts at the community level, thereby reducing the demand and strain on national response resources.

While there are District Disaster Committees (see Comprehensive Natural Disaster Management Section), there is no community level group with specific responsibility for disaster management activities and it is recommended such a group be established. This group can work with the District Disaster Committee and the Nevis Disaster Management Department (NDMD), with a multi-hazard disaster management approach in mind, to facilitate training and education activities such as drills and simulations, first aid training, search and rescue training and community-specific hazard warning and response procedures.

Upgrades for emergency service departments (fire, police, health) in the area to better serve community residents when needed: There is a lack of physical resources by the fire and police services to deal with a variety of situations. This significantly limits response time and the extent to which department personnel can assist in the event of an emergency (caused by a natural hazard or otherwise). Given the need for these services in the community, the potential benefits to residents, and the fact that the services fit within the broader scope of national disaster and emergency management, strong consideration should be given to conducting needs assessment exercises within these departments to determine resource gaps, and ultimately seek to fill these gaps over time.

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 that draws on the lessons and progress in development policy and particularly the recognition of the importance of gender differences if policies are to be sustainable, effective and benefit all sectors of the population. Achieving sustainable and effective responses to climate change, therefore, requires attention to the underlying power relations and gender equalities which create vulnerability both to poverty and climate hazards, and a more gender-sensitive approach which takes into account and evaluates the differing and potentially inequitable access which men and women have to economic, ecological, social and human resources, institutions, governance and infrastructure. These factors could be addressed through a project to:

- *Provide gender disaggregated data and evidence on the impacts of climate change* to show how men and women are being affected differently by climate-related changes, whether direct impacts such as extreme weather conditions or disasters, water shortages, food insecurity or changes in land use or indirect secondary impacts such as access to energy, changes in employment opportunities, sectoral impacts (such as in agriculture, tourism and fisheries), and increased migration or conflict.

- *Conduct a gender- analysis on the social impacts of current policies on adaptation and mitigation* and how they may benefit or adversely affect men and women in different ways. Even when policies have clear gender-related statements or objectives, rarely do they have the mechanisms in place to integrate gender at programme level or to measure the impact of the policies from a gendered perspective. Economic cost-benefit analyses often overlook the social implications and there is a lack of methodology for measuring the gendered impacts of current policies.

- *Improve institutional capacity in key agencies to implement gender sensitive policies or gather gendered data.* This is needed due to the lack of gender experts involved in policy design and

implementation around climate change; the lack of awareness or gender training of key staff in ministries and statistics offices responsible for climate change data and policies; and a general disconnect between the reality of poor people's (and particularly under-represented women's) lives and policy makers.

7. CONCLUSION

7.1. *Climate Modelling*

Recent and future changes in climate in Nevis have been explored using a combination of observations and climate model projections. Whilst this information can provide us with some very useful indications of the changes to the characteristics of regional climate that we might expect under a warmer global climate, we must interpret this information with due attention to its limitations.

- Limited spatial and temporal coverage restricts the deductions we can make regarding the changes that have already occurred. Those trends that might be inferred from a relatively short observational record may not be representative of a longer term trend, particularly where inter-annual or multi-year variability is high. Gridded datasets, from which we make our estimates of country-scale observed changes, are particularly sparse in their coverage over much of the Caribbean, because spatial averages draw on data from only a very small number of local stations combined with information from more remote stations.

- Whilst climate models have demonstrable skill in reproducing the large-scale characteristics of the global climate dynamics, there remain substantial deficiencies that arise from limitations in resolution imposed by available computing power, and deficiencies in scientific understanding of some processes. Uncertainty margins increase as we move from continental/regional scale to the local scale as we have in these studies. The limitations of climate models have been discussed in the context of tropical storms/hurricanes, and SLR in the earlier sections of this report. Other key deficiencies in climate models that will also have implications for this work include:

    - Difficulties in reproducing the characteristics of the El Niño – Southern Oscillation (ENSO) which exerts an influence of the inter-annual and multi-year variability in climate in the Caribbean, and on the occurrence of tropical storm and hurricanes.

    - Deficiencies in reliably simulating tropical precipitation, particularly the position of the Inter-tropical Convergence Zone (ITCZ) which drives the seasonal rainfalls in the tropics.

    - Limited spatial resolution restricts the representation of many of the smaller Caribbean Islands, even in the relatively high resolution Regional Climate Models.

We use a combination of GCM and RCM projections in the investigations of climate change for a country and at a destination in order to make use of the information about uncertainty that we can gain from a multi-model ensemble together with the higher-resolution simulations that are only currently available from two sets of model simulations. Further information about model uncertainty at the local level might be drawn if additional regional model simulations based on a range of differing GCMs and RCMs were generated for the Caribbean region in the future.

7.2. *Water Quality and Availability*

Groundwater is the main source of water in Nevis where there are 14 active wells (USACE, 2004), however, compared to larger St. Kitts, water is considered to be less available on Nevis due to rainfall patterns as a result of the lower elevations of its central mountains, absence of significant springs and prominence of a layer of silica pan covered with a layer of clayey soils that inhibits the prolific water infiltration (MHE, 2001). According to the Water Services Department, water resources are considered sufficient to meet current water demands on the island (Mr Morris, personal communication, 28/06/2011). However, the average annual rainfall is 1170 mm which is lower than St. Kitts and lower than other islands in the Caribbean.

The water sector in Nevis is vulnerable to climate change in a number of ways. Hurricane activity can impact on water infrastructure. Sea level rise can contaminate coastal aquifers with saline water. There have also been reports of heavy metal contaminants in ground water resources (USACE, 2004). The majority of population utilises septic tanks and this therefore leaves the concern that of biological contamination of aquifers (Kairi Consultants Limited, 2009b). When there is heavy precipitation, resultant flooding impacts on the water quality in springs increasing turbidity levels and can introduce bacteriological contaminants.

When droughts occur in Nevis, they generally last for between 2 to 3 months. The Nevis Water Department usually issues public notices for consumers to conserve water. Depending on the severity water rationing is carried out. The agriculture sector is most affected during drought conditions. It is estimated that if there is a 10 to 20% decline in annual precipitation ground water recharge rates would be affected, as Mr Morris of the Nevis Water Services Department summaries “we would have more frequent droughts, our surplus would be at risk and our storage would suffer” (Mr Morris, personal communication, 28/06/2011).

While there are approximately 14 active wells in Nevis, some have been abandoned in the past due to their low yields (ECLAC, 2003). The freshwater/saltwater interface is estimated to be at 20 m in coastal areas (USACE, 2004). However, some wells are considered to be naturally brackish and the water is also high in calcium, but has been used has irrigation water and for landscaping (ECLAC, 2003). Nevis has begun to utilise bedrock drilling at higher elevations over coastal aquifers to counter the threat of saline intrusion and to exploit new sources of water resources (Mr Morris, personal communication, 28/06/2011).

As in St. Kitts, the Watercourses and Waterworks Ordinance 1956 is the main legislation that governs management of water resources in Nevis. There is no legislation that directly addresses water conservation but there are a number of other pieces of legislation that have some role in water resources management in the island. A new Water Resources Management Act is being drafted and is expected to be completed at this end of 2011. Nevis does not have a National Sanitation policy, septic tanks and soakaways are most widely used in the country. The Nevis Water Department is responsible for production, distribution and water quality in Nevis.

The following recommendations are made:

1. Develop measures to protect aquifers from surface contamination and protect water quality.
2. Develop and enforce robust land management policies to reduce the discharge of pollutants including sediments, sewage and agro-chemicals into water systems.
3. Water infrastructure should be developed to reduce vulnerability during drought events and after major storms and hurricanes.
4. Assess the possibility of broad scale implementation of localised waste water recycling schemes and legislation, including for agricultural irrigation.

5. Increase water conservation measures, particularly in the tourism industry.
6. Undertake broad consultation over the licensing of abstraction for private water supply.
7. Develop computer models of groundwater flow to account for the impact of sea level rise on groundwater levels.
8. Undertake public education in water resources.
9. Consider the development of mechanisms to facilitate Integrated Water Resources Management (IWRM).

7.3. *Energy Supply and Distribution*

There can be little doubt that tourism is an important and growing energy-consuming sector in the Caribbean. If this growth continues, vulnerabilities associated with higher energy prices as well as global climate policy will grow concomitantly. 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 greenhouse gases, it also appears clear that energy demand in all islands could be substantially reduced at no cost, simply because the tourism sector in particular is wasteful of energy, and because carbon management allows for the restructuring of markets. Furthermore, technological options to develop renewable energy sources exist, and can be backed up financially by involving carbon markets as well as voluntary payments by tourists. In order to move the tourism sector forward to make use of these potentials, it appears essential that policy frameworks focusing on regulation, market-based instruments and incentives be implemented.

St. Kitts and Nevis have, in form of the National Energy Policy Draft and the National Energy Action Plan (MOPWUEH, 2011b,c), two 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 windpower 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 sectors, 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 and Acute Respiratory Infections. 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 Nevis. 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 on other sectors, most notably the tourism. The current debt crisis will affect the ability to address issues of poverty, which represent one of

the most vulnerable groups in Nevis to climate change and climate variability. Therefore the impact of climate change on health in Nevis 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 Nevis 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 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*

Nevis 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 (challenges faced by many SIDS in the Caribbean region) reduce the island's capacity to adapt to the expected impacts of global warming.

While the Government of St. Kitts and Nevis recognises the importance of ecosystems to sustainable development it needs to enhance political will and to increase its capacity to manage and protect 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 Nevis 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 its inhabitants.

The island's coral reefs face pressure from over-fishing, eutrophication and siltation; 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 individual species of flora and fauna. Strengthening the adaptive capacity of Nevis' 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 Nevis 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 Nevis is vulnerable to climate change and sea level rise. 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, Nevis will be particularly affected with annual costs as a direct result of sea level rise. If action is not taken to, 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 Nevis 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 Nevis is to help curb development in vulnerable areas and protect vulnerable tourism assets.

The government of Nevis 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 Nevis do not suffer from the consequences of potential increased sea level rise. 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 Nevis.

7.8. *Comprehensive Natural Disaster Management*

St. Kitts and Nevis have advanced many initiatives that address the threats they face from natural hazards. Despite the small size of the National Emergency Management Agency (NEMA), and its sub-agency the Nevis Disaster Management Department (NDMD), progress is being made on public awareness and capacity building. Beyond NEMA and the NDMD, 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 be.

The natural hazards facing Nevis 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 NDMD and also encourage disaster risk reduction in other important sectors in Nevis. 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*

Climate change is a very present and serious threat, and a number of social and economic groups are inherently vulnerable; including women, children, the poor, the elderly, the disabled and persons working in volatile, climate sensitive livelihood sectors. Government efforts have seen a reduction in poverty within the last decade. However, close to half of the local population were collectively rated as poor, or considered vulnerable to falling into poverty. There is a dire situation of the working poor, many of whom are involved in volatile sectors, and tourism in particular employs large numbers of unskilled or low-skilled women.

Any crisis, natural or economic, will make the situations of these groups more severe. The impact of Hurricane Omar in 2008 highlighted, and further deepened vulnerabilities, which came out in research in the Jessups and Cotton Ground communities. In the tourism sector, several persons were laid off, with immediate financial impacts on their households. Women in particular, who depended heavily on their work in tourism, were severely disadvantaged and their families suffered significantly as a result. Persons that work in sectors with linkages to the tourism industry – such as agriculture and fisheries – were also heavily impacted with the reduction in business from a primary market.

Within the Jessups and Cotton Ground communities, social capital and ownership/access to assets are strong points in their adaptive capacity to climate change, and most households appear to be in a relatively stable financial position. However, some concerns arise from low levels of financial security, household protection by means of insurance, and an absence of strategies following the outcome of past climate events to be better prepared for future impacts. Slight gender differences arose out of the household survey, but few highlight any significant disadvantages for men or women in relation to each other.

In the face of climate change and the threat that it poses to Caribbean societies and economies, the comprehensive integration of poverty, gender and livelihood issues into climate change impact and vulnerability assessment and planning processes is essential to developing appropriate adaptation strategies. Recommendations put forward to address vulnerability and adaptive capacity concerns range from infrastructural assessments and development, networking and collaboration, training and education activities and policy reform to incorporate gender and poverty lenses. These are only some of the activities that can be implemented in the short and long term, and will require efforts at all levels and across sectors to build the resilience of communities like Cotton Ground and Jessups to the impacts of climate change.

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