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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 Anguilla

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 Anguilla 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 Mrs. Candis Niles, Director of Tourism in the Anguilla Tourist Board for her support and assistance; as well as the Ministry of Finance, Economic Development, Investment, Commerce & Tourism, in particular Dr. Aidan Harrigan, Permanent Secretary, and Ms. Gina Brooks.

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
- Anguilla Renewable Energy Office
- The Department of the Environment
- Health & Social Development, Ministry of Social Development
- Department of Disaster Management
- Ministry of Finance, Economic Development, Investment, Commerce and Tourism
- Department of Physical Planning

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) - Anguilla. 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.

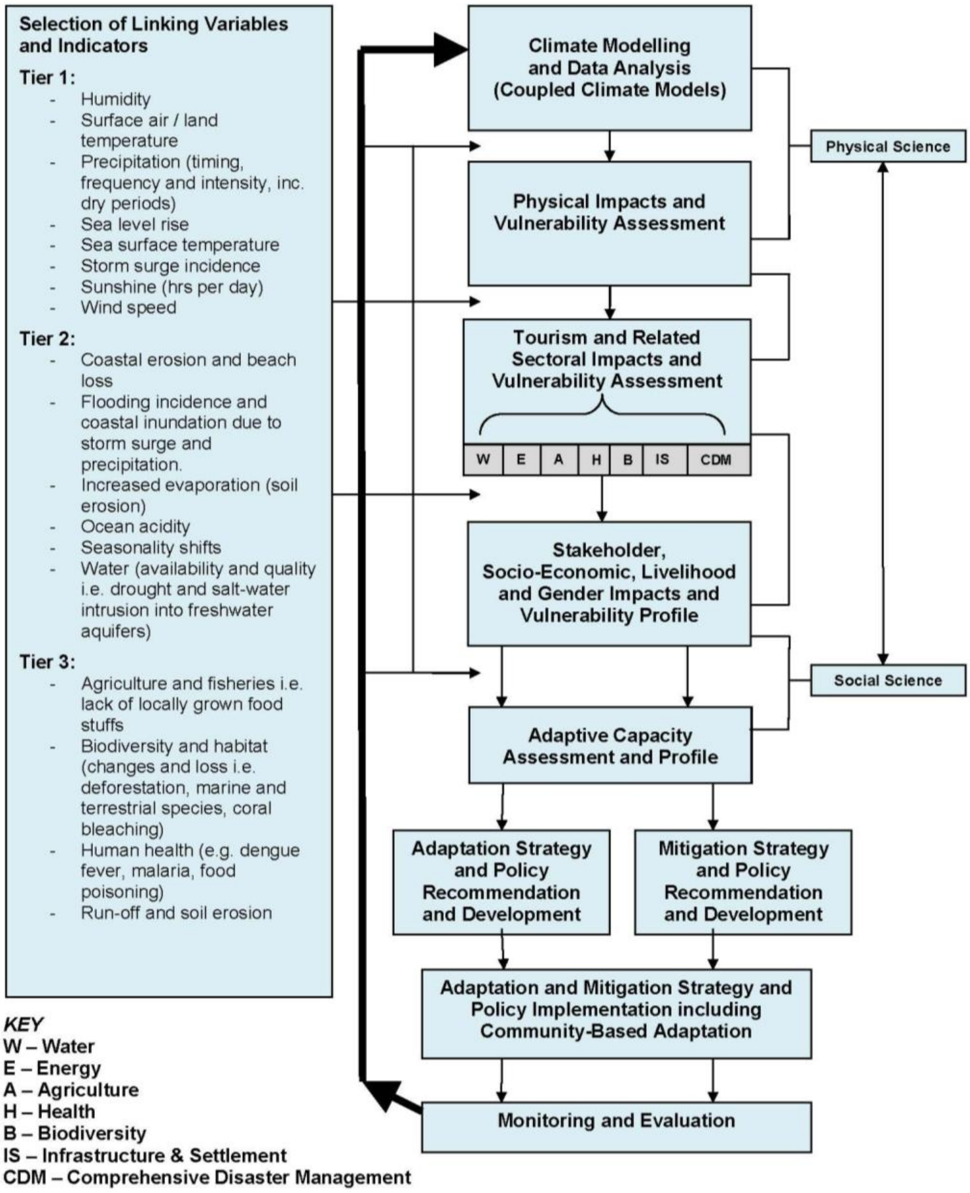
The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change, 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 Flow Chart on the following page) are as follows: a) Climate Modelling and Data Analysis (including analysis of key 'Tier 1' climate variables linking the climate modelling to physical impacts and vulnerabilities) b) Physical Impacts and Vulnerability Assessment c) Tourism and Related Sector Vulnerability Assessments (including examination of the sectors of water, energy, agriculture, biodiversity, health, infrastructure and settlement, and comprehensive disaster management) d) Development of Vulnerability Profile with stakeholders taking account of socio-economic, livelihood and gender impacts (including evaluation of 'Tier 2' linking variables and indicators such as coastal inundation) e) Adaptive Capacity Assessment and Profiling f) Development of Adaptation and Mitigation Strategies and Policy Recommendations (action planning). The final stages depicted in the flow chart focusing on the implementation of policies and strategies at ministerial/government level and the implementation of actions at community level, using a community-based adaptation approach, are proposed to be implemented as part of the forthcoming CCCRA process as projects to be funded by other donors post the country profile stage.

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



CCCRA Profiling Flow Chart

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

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

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

LIST OF ABBREVIATIONS AND ACRONYMS

AIC -------------------- Aviation-induced clouds
ANT------------------- Anguilla National Trust
AMMP --------------- Anguilla Marine Monitoring Programme
ANWS---------------- Anguilla National Warning System
AOSIS ---------------- Alliance of Small Island States
APD------------------- Air Passenger Duty
AR4 ------------------- Fourth Assessment Report (IPCC)
AREO----------------- Anguilla Renewable Energy Office
ASTER---------------- Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ------------------ Business as Usual
CAD------------------- Caribbean Application Document
CAP ------------------- Common Alerting Protocol
CAREC --------------- Caribbean Epidemiology Centre
CARICOM ----------- Caribbean Community
CBD------------------- Convention on Biological Diversity
CCCCC---------------- Caribbean Community Climate Change Centre
CCCRA --------------- CARIBSAVE Climate Change Risk Atlas
CCRIF----------------- Caribbean Catastrophe Risk Insurance Facility
CDB------------------- Caribbean Development Bank
CDEMA -------------- Caribbean Disaster Emergency Management Agency
CDM------------------ Clean Development Mechanism (in the context of Energy/Emissions)
CDM------------------ Comprehensive Disaster Management
CDMS ---------------- Comprehensive Disaster Management Strategy
CDRU----------------- CARICOM Disaster Response Unit
CEHI ------------------ Caribbean Environmental Health Institute
CEMP ---------------- Comprehensive Emergency Management Plan
CERMES ------------- Centre for Resource Management and Environmental Studies
CFP ------------------- Ciguatera Fish Poisoning
CITES ----------------- Convention on International Trade in Endangered Species
CO_2 ------------------- Carbon Dioxide
COP------------------- Conference of Parties
CPACC --------------- Caribbean Planning for Adaptation to Climate Change
CRFM ---------------- Caribbean Regional Fisheries Mechanism
CRI -------------------- Climate Risk Index
CRID------------------ Regional Disaster Center – Latin America and the Caribbean
CROSQ--------------- Caribbean Regional Organisation for Standards and Quality
CTO------------------- Caribbean Tourism Organization
CUBiC ---------------- Caribbean Uniform Building Code
CZM ----------------- Coastal Zone Management
DANA ---------------- Damage and Needs Assessment
DDM ----------------- Department for Disaster Management
DF--------------------- Dengue Fever
DFID------------------ Department for International Development (UK)
DFMR ---------------- Department of Fisheries and Marine Resources
DHF------------------- Dengue Hemorrhagic Fever
DJF-------------------- Seasonal period of December, January, February
DMC------------------ Disaster Management Committee
DOE ------------------ Department of Environment
DRM------------------ Disaster Risk Management
DRR------------------- Disaster Risk Reduction

ECACC---------------- Enhancing Capacity for Adaptation to Climate Change in the Caribbean UK Overseas Territories
ECDG------------------ Eastern Caribbean Donor Group
ECDG------------------ Eastern Caribbean Donor Group for Disaster Management
ECE -------------------- Energy Conservation and Efficiency
ECLAC---------------- United Nations Economic Commission for Latin America and the Caribbean
EIA --------------------- Environmental Impacts Assessment
EFZ--------------------- Exclusive Fishery Zone
EM-DAT -------------- The International Disaster Database
ENSO ------------------ El Niño Southern Oscillation
EOC-------------------- Emergency Operations Centre
EU-ETS---------------- European Union Emissions Trading System
EU---------------------- European Union
FAO-------------------- Food and Agriculture Organization
GCM------------------- Global Circulation Model
GCP-------------------- Ground Control Points
GDEM ---------------- Global Digital Elevation Model
GDP ------------------- Gross Domestic Product
GGCA ----------------- Global Gender and Climate Alliance
GHG ------------------- Greenhouse Gas
GIS -------------------- Geographic Information System (GIS)
HAA ------------------- Health Authority of Anguilla
HAB ------------------- Harmful Algal Blooms
HFA-------------------- Hyogo Framework for Action
IATA ------------------- International Air Transport Association
ICC --------------------- International Code Council
ICZM ----------------- Inter Coastal Zone Management
IDB--------------------- Inter American Development Bank
IEA --------------------- International Energy Agency
IOC -------------------- Intergovernmental Oceanographic Commission
INSMET -------------- The Meteorological Institute of the Republic of Cuba
IPCC ------------------- Intergovernmental Panel on Climate Change
ISDR ------------------- International Strategy for Disaster Reduction
ITCZ-------------------- Inter-tropical Convergence Zone
IVM -------------------- Integrated Vector Management
MDGs ----------------- Millennium Development Goals
MEA ------------------- Multilateral Environmental Agreement
MFEDICT ----------- Ministry of Finance, Economic Development, Investment, Commerce and Tourism
MFT ------------------- Ministry of Finance and Tourism
MHSD --------------- Ministry of Health and Social Development
MPA ------------------- Marine Protected Area
MSMEs -------------- Micro, Small and Medium-sized Enterprises
NASA ------------------ National Aeronautical and Space Administration
NBSAP --------------- National Biodiversity Strategy and Action Plan
NEMS ---------------- National Environmental Management Strategy and Action Plan
NGO ------------------- Non-governmental Organisation
NOAA ---------------- National Oceanic and Atmospheric Administration
NO_x ------------------- Nitrous Oxide
OECD------------------ Organization of Economic Co-operation and Development
OTEP ------------------ Overseas Territories Environment Programme
PAHO ----------------- Pan-American Health Organization
RCM ------------------- Regional Circulation Model
REM ------------------- Riley Encased Methodology
RH --------------------- Relative Humidity

RNAT ----------------- Regional Needs Assessment Team
RTK ------------------- Real Time Kinematic
SCP ------------------- Strategic Country Programme
SIDS ------------------ Small Island Developing States
SLR-------------------- Sea Level Rise
SST-------------------- Sea Surface Temperature
TESA ----------------- Trade in Endangered Species Act
TDS ------------------- Total Dissolved Solids
TIN ------------------- Triangular Irregular Network
TSDP ----------------- Tourism Sector Development Project
TSG ------------------ The Solutions Group Ltd
UKOT----------------- United Kingdom Overseas Territories
UKOTCF ------------- United Kingdom Overseas Territories Conservation Forum
UNDP ---------------- United Nations Development Programme
UNEP----------------- United Nations Environment Programme
UNESCO ------------ United Nations Educational, Scientific and Cultural Organisation
UNFCCC ------------- United Nations Framework Convention on Climate Change
UWI ------------------ University of the West Indies
VAT ------------------- Value Added Tax
WASS ---------------- Wide Area Augmentation System
WEF ------------------ World Economic Forum
WHO ----------------- World Health Organisation
WWTS --------------- Wastewater Wetlands Treatment System

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 UKaid from the 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 Anguilla

Anguilla is already experiencing some of the effects of climate variability and change. According to the Government of Anguilla, the major issues of climate change are sea level rise (SLR) and the likelihood of more intense weather systems and periods of drought.

Detailed climate modelling projections for Anguilla 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 **Sandy Ground** to climate change; and
2. project sea level rise and storm surge impacts on **Cove Bay, Rendezvous Bay, Sandy Ground** and **Island Harbour**.

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 infrastructure dominates Sandy Ground which is low-lying and prone to flooding when the salt pond breaches.
- There is only one main access road into and out of the area.
- Hurricanes are the main concern for residents
- Since 1995, increases in the number of storms and hurricanes and their intensity have been reported, most of these occurring within the 16 year period between 1995 and 2010.
- Most of Sandy Ground's resident are older and tend not to heed evacuation warnings.

Vulnerable coastlines

- A series of tropical storms in the 1990s severely reduced many of Anguilla's beaches.
- 1 m SLR places 63% of the major tourism properties at risk; increasing to 70% under a 2 m SLR scenario.
- 0.5 m SLR places 11% of Sandy Ground's beach at risk; increasing to 48% under a 1 m scenario.
- Changes in the coastal profile due to extensive beach loss would transform coastal tourism in Anguilla, with implications for property values, insurance costs, destination competitiveness.

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 Anguilla

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

Temperature: Regional Climate Model (RCM) projections indicate increases between 2.4˚C and 3.1˚C in mean annual temperatures by the 2080s, in the higher emissions scenario.

Precipitation: General Circulation Model (GCM) projections of rainfall span both overall increases and decreases, ranging from -34 to +13 mm per month by 2080 under the scenario with slow economic growth and technological change. Most projections tend toward decreases. The RCM projections, driven by HadCM3 boundary conditions, indicate large decrease in annual rainfall (-11%) when compared to simulations based on ECHAM4 (-1%).

Sea Surface Temperatures (SST): GCM projections indicate increases in SST throughout the year. Projected increases range from +0.7˚C and +2.7˚C by the 2080s across all three emissions scenarios.

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

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

Figure 1: Erosion at Rendezvous Bay (Anguilla)

The majority of infrastructure and settlements in Anguilla, including government, health, commercial and transportation facilities, are located on or near the coast and these 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.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the Anguilla Ministry of Finance, Economic Development, Investments and Commerce to complete detailed coastal profile surveying.

To evaluate the vulnerability of beaches and coastal infrastructure to SLR and storm surge, Cove Bay, Rendezvous Bay, Sandy Ground and Island Harbour were surveyed. Additionally, 1 m and 2 m SLR scenarios and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential risks to major tourism resources.

Results of these surveys indicate that 1 m SLR places 63% of the major tourism properties at risk; increasing to 70% under a 2 m SLR scenario (See Table 1).

Figure 2: High Resolution Coastal Profile Surveying with GPS

Table 1: Impacts associated with 1 m and 2 m SLR in Anguilla

		Tourism Attractions		Transportation Infrastructure	
		Major Tourism Resorts	Sea Turtle Nesting Sites	Major Road Networks	Port Lands
SLR	1.0m	63%	31%	28%	100%
	2.0m	70%	43%	30%	-

It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure. Such changes in the coastal profile would transform coastal tourism in Anguilla, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees. Moreover, the beaches themselves are critical assets for tourism in Anguilla, with a large proportion of beaches being lost to inundation and accelerated erosion even before resort infrastructure is damaged.

Table 2 highlights the beach area losses for four resorts in Anguilla: Cove Bay/Merry Wing, Island Harbour, Sandy Ground and Rendezvous Bay. With a 0.5 m SLR, over 60% of the highly valued beach resource at Cove Bay/Merry Wing would be inundated. With a 1 m sea level rise, all study sites would be more than 48% inundated. With a 2 m SLR all but Sandy Ground would become completely inundated, with all beach areas lost with a 3 m SLR. The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive that these beach areas along with the prevailing climate are the island's main tourism attractions.

Table 2: Beach Area Losses at Four Major Resort and Tourism Areas in Anguilla

	Cove Bay/ Merry Wing		Island Harbour		Sandy Ground		Rendezvous Bay	
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	27381	60%	1130	21%	2755	11%	20780	46%
1.0m	12177	87%	1650	53%	9392	48%	10036	68%
2.0m	6022	100%	2487	100%	11692	93%	14594	100%
3.0m	109	100%	-	-	1675	100%	26	100%

Figures 3 and 4 clearly illustrate that the longer term erosion response of the shoreline to a 1 m sea level rise would have significant implications for the shoreline and the loss of a total of high value properties.

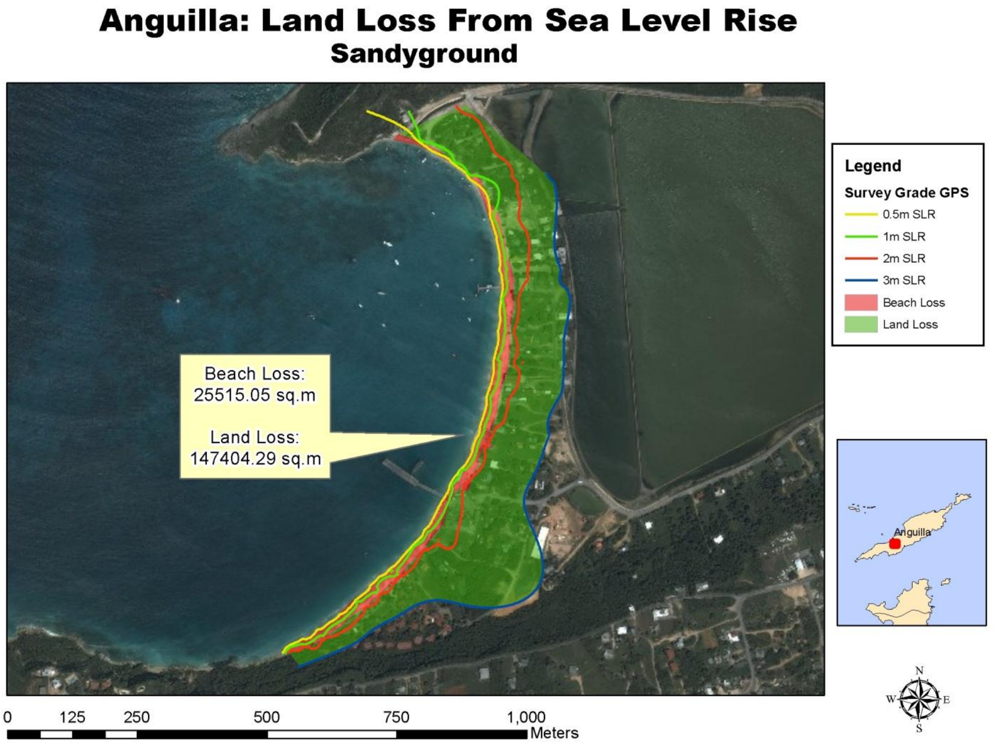


Figure 3: Total Land Loss, Sandy Ground, Anguilla

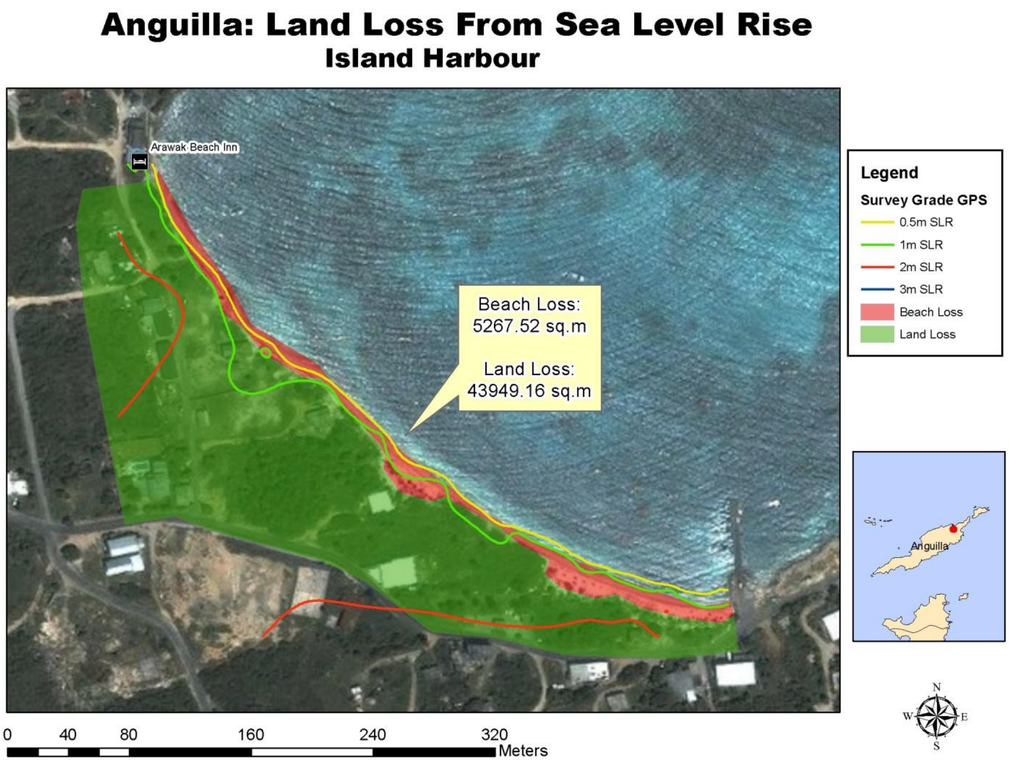


Figure 4: Sea Level Rise Vulnerability in Island Harbour, Anguilla

The high resolution imagery provided by the techniques utilised in this project component is essential to assess the vulnerability of infrastructure and settlements to future SLR but its ability to identify individual properties also makes it a very powerful risk communication tool. Having this information available for community / resort level dialogue on potential adaptation strategies is highly valuable.

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. Hard engineering structures such as levees and sea walls can be used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. Unfortunately, this approach may be expensive and provides no guarantee of equivalent protection following extreme events. Adaptation options should be implemented in the framework of integrated coastal zone management (ICZM) and all decisions need to take into account the broad range of stakeholders involved in decision-making in the coastal zone. Interventions should also benefit coastlines in light of both climate and non-climate stresses.

Tourism in Anguilla is clearly highly dependent on the attractiveness of the natural coastal environment, which has been shown to be vulnerable to SLR. More detailed analysis of the impacts of SLR for major tourism resorts, critical beach assets and supporting infrastructure (e.g. transportation) is needed to accurately assess the implications for inundation and erosion protection. A necessary part of this evaluation is to identify the land that can be used for tourism infrastructure and future development under a managed retreat response to SLR.

All levels of government and administration in Anguilla need to embark on a coordinated communication campaign to inform and raise awareness of SLR impacts and costs for decision makers within the tourism sector including operators, investors, planners, developers, policy makers, architects and communities.

Community Livelihoods, Gender, Poverty and Development

More than 50 residents and workers from Sandy Ground participated in our research which included vulnerability mapping, 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 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.

Unlike most other communities which participated in CARIBSAVE's research, poverty is not easily identified in the area. However, the climate-related issues experienced here are similar to those in other coastal communities around Anguilla and the region.

Community Characteristics and Experiences

Sandy Ground's main features include:

- It serves as the main port for the island allowing for trade, and was once a major constituent of the former salt production and export industry.
- It is currently dominated by tourism infrastructure, with a large concentration of bars, restaurants, and accommodation facilities (hotels and guesthouses)

- Large summer festivities are hosted yearly in the area, including boat racing activities and beach parties, and the popular August Day carnival – a national celebration.
- There are also some historic sites in Sandy Ground, including the Pump House (bar), the White House and an archaeological site. Other livelihood activities in Sandy Ground include snorkelling and dive operations, sailing and charter boat operations and a sailing school.
- It provides many tourism attractions which employ many of its residents such as:
    - Diving excursions to the offshore islands – Sandy Island, Prickly Pear and Dog Island (within the national marine park system)
    - Sailing and sport-fishing

Figure 5: The beautiful but vulnerable Sandy Ground in Anguilla

The diversity of infrastructure, business and activities that take place in Sandy Ground makes it a site of socio-economic, cultural and historic significance. As such, the good health and vibrant state of natural (especially coastal and marine) resources are crucial for the sustainability of the tourism-dependent businesses in Sandy Ground.

As in other communities studied, climate variability and change have already impacted natural resources. Community members have been observing changes which they have attributed to climate change such as:

- higher day-time temperatures – reportedly sometimes "unbearable";
- an increase in the number of mosquitoes;
- increased beach erosion in Road Bay; and
- the experience of both temperature extremes in the night (very hot and very cold).

However, unlike observations in other communities, there was no marked difference in rainfall patterns. This is consistent with observed data for rainfall over the period 1960-2006.

Other concerns included the deterioration of coral reefs which is partially blamed on marine vessels since they discharge waste in the marine environment in Sandy Ground but reefs are also damaged by the passage of storms and hurricanes.

However, the main climate-related concern of Sandy Ground residents is that of hurricanes. Before Hurricane Luis in 1995, the last major hurricane to impact Anguilla was in 1960, and as a result Anguillans were relatively unprepared for the 1995 event. The accompanying winds, rough seas and most significantly, heavy rainfall caused severe damage in Anguilla generally, but especially in the Sandy Ground area where approximately 10 properties were completely destroyed, including a few homes, one beach bar and restaurant. The destruction of the restaurant resulted in the temporary disruption of services and revenue generation, however, business operations resumed shortly after as an outdoor enterprise until the new structure was rebuilt.

Since 1995, increases in the number of storms and hurricanes and their intensity have been reported by community members, most of these occurring within the 16 year period between 1995 and 2010. Hurricane Lenny in 1999 severely impacted houses on the sediment bar from storm surge and flooding, and roads were blocked temporarily. The sediment bar itself was breached during past hurricanes by the Road Salt Pond, and the force of the water flowing from the pond to the sea caused significant damage to houses that were built on the bar.

Prior to the period of heavy storm activity, pre-fabricated houses had become very popular in Anguilla, but these structures, especially the roofs, were found to be very vulnerable to damage from even the weakest storms. Since then, the building code has been more strictly enforced and it would appear that the compliance has helped to reduce some impacts, such that recent systems passing within the last decade have caused less severe damage to buildings. Damage mainly consisted of flooding damage and loss of trees (fruit trees, palm trees on beaches) and other vegetation. The lessons learnt from the impact of stronger hurricanes have therefore contributed to resilience building at the household level in Sandy Ground, but key vulnerabilities remain.

Characteristics of the Sandy Ground area that make it peculiarly vulnerable include its relatively large aging population and the fact that there is only one main access road for vehicles into and out of the community. When this was blocked in previous storms it resulted in some persons being unable to travel to and from the community for work or for personal errands. There are undeveloped pathways, but these can only be traversed by foot. This singular roadway has implications for access of emergency vehicles if needed and even though there has been a call to develop a second access path to and from the community, this path has not been completed.

Even though gender inequality is not deemed to be an issue within the community, some roles are clearly dominated by either men or women:

- Women are more vocal and visible on issues of social and community development and protection. This may stem from their traditional roles as caretakers of the family in general, but mainly of dependent householders (children, the elderly).
- Men tend to be less vocal on social issues but there are few that were identified as having particularly strong personalities and were advocates for certain community development issues.
- Male headed households had higher rates of asset ownership than female headed households; but there was little disparity in the use of natural assets, where only a slightly larger proportion of male respondents are more dependent on natural resources than female respondents.
- In the event of a disaster, men attend to more manual tasks, such as affixing shutters, and ensuring that the roof is as secured as possible, whereas women stock up on essential supplies (e.g. foodstuff, medication, water, batteries).

There is, however, a strong culture of independence amongst women in the community which transcended from previous times when many men left the country to work overseas (e.g. the Dominican Republic). As a result, women believe that they are capable of fending for themselves in hurricane events.

Residents are aware of the dangers they face from living in the area, and during the approach of severe weather, they are normally advised to evacuate. However, since Sandy Ground is home to an older demographic, most residents tend not to heed evacuation warnings and prefer to stay with their property and loved ones regardless of the outcome. This clearly poses a significant risk to them in the event of a major hurricane, and can potentially (and unnecessarily) place additional burden on emergency response and recovery resources during and after the event.

Generally, residents in Sandy Ground are able to manage the low to moderate climate-related impacts but even with little damage to property, Sandy Ground residents face other challenges to restore their livelihood activities.

- In the aftermath of hurricanes or storms, utility services often take a long time to be restored in the area.
- The Road Salt Pond becomes a concern during heavy, continuous rainfall, as this will likely result in some localised flooding.

To alleviate some of these challenges, a monitoring system for water levels in the pond including an Early Warning System and Zoning Plan would be of benefit to residents to alert them of possible breaching and areas of inundation. As the pond water rises, warnings of increasing scale/rank would be issued so that the community is aware of any precautions that need to be taken.

A strong mooring is needed for the resident Police emergency vessel which is currently harboured in St. Martin during storms and is therefore not available to the community at critical times. This department should also own a dinghy (which they do not currently have) that would allow for easier and faster response times in some cases. Regular fishing vessels also require moorings to be used at night and during storms.

Given the demographic profile of Sandy Ground, it is important to identify opportunities for, and encourage younger persons to engage in, community level disaster mitigation activities. Such a programme can be implemented through collaboration between the District Disaster body and the Community (through a community-based and –run disaster management group or council) and should include a multi-hazard warning system within the community.

Agriculture and Food Security

Anguilla has invested very few of its thirty-five square miles towards organised agriculture such that it contributes only 2.4% to the national economy. However, over the past few years the Government of Anguilla has made plots of Crown Land in the Valley and Wallblake available for the cultivation of fruits, vegetables, and crops such as corn and pigeon peas through the use of traditional and modern methods.

As expected, the food import bill for Anguilla is exceptionally high but there are opportunities for reducing this. For example, the Anguilla Statistics Department reports that in 2010, Anguilla imported 99 tonnes (99,000 kg) of tomatoes and local farmers produced approximately 15 tonnes. Local consumption of tomatoes is about 114 tonnes per annum and with over 637 acres of arable land available in Anguilla, production potential for tomatoes and other staple foods is promising if even half of this acreage is used.

Table 3: Value of Selected Food Imports to Anguilla 2005 – 2008 (EC $ 000)[i]

Items	2005	2006	2007	2008
Poultry	3,676	3,723	4,728	5,424
Other meat	4,190	4,675	5,375	5,320
Fish	3,088	3,815	4,332	4,307
Dairy	4,474	5,059	6,319	5,974
Eggs and egg substitutes	170	245	388	505
Vegetables	4,829	5,610	6,452	5,686
Fruits and nuts	3,426	4,099	4,444	3,486
Coffee. Tea	388	396	423	450
Rice	602	695	992	1,356
Flour	704	809	949	1,444
Oils and fats	891	1,148	1,226	1,392
Margarine	661	432	502	645
Sugar	17,138	12,624	623	540
Water	2,305	3,103	4,328	4,377

(Source: Anguilla Statistical Department, 2010)

According to the Labour Force Survey, only 2% of the working population is employed within the agriculture and fisheries sector and this figure includes no women. However, in recent years, young persons have been slowly moving into the sector recognising that there are potentially lucrative markets which can be acquired with commitment, new technology and hard work. CalTel Farms and Island Greens are two such examples of Anguillan enterprises that are owned and managed by young men.

The main factor influencing food security in Anguilla is the poor quality of land resources available for facilitating widespread agriculture. Local arable soils in Anguilla are heavily degraded, infertile, low in organic matter, and have the potential to become unstable. Poor agricultural land management practices have also accelerated the degradation of arable soils which are reportedly sold as top soil for use in developmental projects. In terms of social vulnerability, the scarcity of agricultural communities in Anguilla is itself a threat to agriculture and food security. Farmers are economically vulnerable from the point of view that they do not have access to funding for agro-technologies that would increase production and adaptive capacity to climate change. In response to these challenges, the Agricultural Department has been helping farmers in the use of organic methods through the Soils Amelioration Project to enhance their agriculture production efficiency, build their capacity to apply agriculturally sustainable practices, and create a sector that is more resilient to the constantly fluctuating weather patterns.

Other vulnerabilities are exposed through climate-related events. Hurricane Luis, a category 4 system, hit the island in 1995 and damages to the agriculture sector at that time were estimated to be US $98,000 in physical infrastructure; US $30,000 for direct losses to crops; and US $5,000 for indirect production losses. Full recovery of Anguilla's pre-disaster size and production levels took approximately two growing seasons with clear adverse economic impacts for farmers and the economy as a whole.

Policymakers for agriculture in Anguilla should be prepared to take a more proactive role in the development of climate change legislation for the implementation of adaptation projects that address the impacts of climate change. The industry should seek to increase local production of staple foods such as cassava, sweet and Irish potatoes and yams using cultivars that meet the challenges of the changing climate. The Anguilla Department of Agriculture should work with the established farmers' associations to:

[i] Anguilla Statistics Department. (2010). *National Accounts Statistics 2009*. The Valley: ASD.

a) revive lands that are currently fallow and put them back into cultivation using new agro-technology as a follow-on to the Soil Amelioration Project;

b) develop a local 'eat what you grow project' featuring staple foods and other produce;

c) introduce grow-box projects into primary and secondary schools' programmes as part of extra-curricular activities or within integrated science courses; and

d) organise farmers in the communities where they are scattered; coordinate planting and harvesting of produce for the land that is brought back into production; provide guidelines on standards and use of appropriate technology etc; and provide a centralised location for trade between farmers and local consumers.

The expected results are improved capacity of local farmers to grow climate resilient crops, increased participation of youth in agriculture, and more support and use of locally produced food.

Energy and Tourism

Tourism is an increasingly significant energy consumer and emitter of greenhouse gases (GHG) both globally and in the Caribbean. Anguilla is emitting 4.0 t CO_2 per capita, which is very close to the global annual average of 4.3 t CO_2 per capita. This high emissions rate results from a small local population and the fact that current tourism related energy use and associated emissions are estimated to be the equivalent of 76% of 'official' national emissions. Specific emissions and energy consumption come from aviation (41%), accommodation (22%) and cruise ships (20%), with lifecycle emissions accounting for 15% of overall emissions.

Anguilla currently produces its electricity with imported diesel fuel, from one central generating plant owned and run by ANGLEC. The National Energy Policy for 2008-2020 guides energy production and promotes the use of incentives and taxation to encourage energy efficiency, investment in renewable energy, purchase of efficient appliances and efficient vehicles. A related policy, the National Climate Change Policy, recommends diversifying the tourism product to promote low carbon, energy efficient and environmentally friendly development and developing a financing mechanism to facilitate that transition. These types of adaptation and mitigation initiatives will be central to Anguilla's efforts for sustainable development as a country and as a major tourism destination in the vulnerable Caribbean region. This will also become more as visitor preferences may evolve to favour low-carbon destinations.

Available statistics for electricity production show considerable growth in electricity generation and fuel consumption (see Table 4). It is unclear, how trends will develop given that tourism investments have been halted or delayed because of the global financial crisis in 2008. No further information could be found on bunker fuels, gasoline, or emissions of greenhouse gases.

Table 4: Growth trends in energy consumption in Anguilla, 2001-2009

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Gross generation (MWh)	53,000	55,000	58,000	62,032	72,041	79,507	88,999	89,502	91,223
Net generation (MWh)				55,755	63,601	70,561	78,854	78,934	79,918
Fuel used (thousand IG)	2,900	3,100	3,300	3,500	4,233	4,399	4,830	4,872	4,839

(Source: ANGLEC, 2006; ANGLEC, 2010)

The Government of Anguilla identifies its dependence on fossil fuels as a threat to its economy with the growing number of vehicles and imports of consumer goods, as well as the production of fresh water, being key issues in energy management. Wind and solar power are to be developed to reduce the island's dependence on fossil fuels in the short term and to achieve energy independence in the long term. Overall, the Government seeks to promote Anguilla as a "worldwide leader in environmental responsibility, to the benefit of local pride and competitiveness in the tourist industry, and as a model of these values among other island communities and beyond". The Government underlines its belief that its energy policy will help the island gain promotional advantage, and thus be beneficial for tourism.

Potential impacts of climate change on the energy sector include 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.

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. 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. In 2008, Hurricane Omar affected both the power station and the transmission and distribution system with the switchboard at the power station out of service for 12 hours due to rainwater penetration.

In the aftermath of extreme weather, the process of restoring transmission and proper operation of generating facilities depends on road access and the amount of supplies available to replace infrastructure components that have been damaged or destroyed. The vulnerability of the sector to extreme weather events therefore has even greater implications for increasing the recovery period and extending the loss of productivity in all other sectors within the country following an event.

Model projections for Anguilla suggest an increase in mean annual temperatures, as well as the number of 'hot' days and nights to as much as 95% of the days per year by 2080, and a possible disappearance of 'cold' nights. National energy demand and consumption for heating and cooling purposes may increase in response to extremes in diurnal temperatures.

Adaptation and mitigation options in this sector are clearly outlined in the National Energy Policy and as such, are recommended here. In order to develop the renewable energy sector the Policy identifies the need for establishing and updating legislation and regulations for promoting energy efficiency and utilisation of renewable energy as well as implementing appropriate pricing policies to ensure that adequate energy supplies are delivered to all economic sectors efficiently. The use of incentives to encourage private sector investments in renewable energy technologies and the promotion of renewable energy through the educational system and public awareness campaigns are also considered to be important strategies. It is also recommended that the feasibility of blending fossil fuels with bio-fuels for electricity generation should be assessed to reduce consumption of fossil fuels. However, there are notably no specific policy recommendations for cruise ship or air transportation, two of the largest contributors to emissions and energy consumption in the tourism sector.

There are additional policy recommendations regarding the administration and promotion of the energy independence campaign and accessing international financing sources through the carbon credit market. An important component of the former is developing a 'brand' for the awareness campaign based on an analysis of all stakeholder groups requirements; creating a network among civic, church, educational, and community groups to gain input, support, and participation in the Plan and its implementation; and coordinate efforts with the Anguilla Tourist Board and the Anguilla Hotel and Tourism Association toward marketing and educating tourists about Anguilla's Energy Independence Plan.

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

Water Quality and Availability

Freshwater resources in Anguilla exist only subterranean, below which is located denser layers of salt water. As a consequence, this water is described as brackish and is generally considered to be unfit to drink. In addition, the groundwater yield is insufficient to meet the long-term needs of the island. Anguilla has therefore utilised a mixture of ground water and desalinated water to supply its water needs over the years. The Crocus Bay Water Treatment Facility owned by the private company Aqua Design was the main water provider which sourced water from Crocus Bay on the west of the island and processed it into potable water through reverse osmosis. There are also a number of desalination plants run by the private sector, specifically geared towards tourism.

Table 5 shows the cost per 1,000 gallon for water in Anguilla which has one of the highest water rates in the Caribbean. The cost of water increased when the Anguilla Water Authority became a private entity and this has had a direct effect on the ability of the poorest sector of the territory to purchase potable water. It is therefore not surprising that some of the water which is unaccounted for is lost to theft.

Table 5: Water tariff for domestic and non-domestic users in Anguilla

Category	Water Usage (Imperial Gallons per Month)	Rate $EC ($US)
Small 'Domestic' Customers	≤ 1,000	$ 40.00 ($14.80) minimum
Small 'Domestic' Customers	1,000-3,000	$60.00 ($22.20) per 1,000 gallons
Small 'Domestic' Customers	3,000-5,000	$80.00 ($29.60) per 1,000 gallons
Small 'Domestic' Customers	> 5,000	$100.00 ($37.00) per 1,000 gallons
Large 'Commercial' Customers	0-10,000	$1,200.00 ($444.00) per 1,000 gallons
Large 'Commercial' Customers	10,000-20,000	$10.00 ($3.70) per 1,000 gallons
Large 'Commercial' Customers	20,000-40,000	$80.00 ($29.60) per 1,000 gallons
Large 'Commercial' Customers	>40,000	$60.00 ($22.20) per 1,000 gallon

Conversion rate utilised: EC $1=US $0.37
(Source: Anguilla Water Authority, 2011)

Limited ground water resources are not the only concerns in this vulnerable sector. The Government of Anguilla closed down wells on the island due to pollution from dumped batteries, waste oil from toxic power station and gas station used oils, waste from package plants, pesticides and from septic tanks which could be easily leaked due to the porous nature of the soil[ii,iii]. Subsequently, plans have been made to develop a series of new bore wells in the Valley Bottom area to increase potable supply.

To manage water resources the Water Corporation of Anguilla Act 2008 was devised to transform the Water Authority of Anguilla in to a state-owned water corporation. Almost 80% of the 2008 Budget for The Ministry of Infrastructure, Communications, Utilities, Housing, Agriculture and Fisheries was allocated to the Water Corporation. This demonstrates the priority placed on water resources as well as the high costs involved in management of this resource and its demand on the island. In recent years expenditure has focused on road works and simultaneous replacement and installation of water pipelines and the improvement of drainage infrastructure in some areas.

The main factor of concern to water resources is Anguilla's proneness to drought conditions. Rainfall in Anguilla is generally low , experiencing average annual rainfall of approximately 960 mm per year but this can range between as low as approximately 450 mm to as high as 2,000 mm depending on the number and intensity of storms affecting the island in a given year. Increased frequency of drought could cause "Such environmental change [that it] would increase the vulnerability of Anguilla communities and might constrain sustainable development over the next few decades, unless adaptive measures are taken now"[iv].

During heavy rainfall events freshwater supplies are vulnerable to flooding and contamination from sewerage systems. Past weather patterns and climate regimes have also reduced mobility and services for extended periods of time, which has had an effect on fuel delivery due to poor sea conditions. This in turn has the potential to affect the operational costs of water produced from desalination.

As a means of coping with historically low rainfall, the use of cisterns is traditional and extensive on the island. While the quality of water is considered to be good, installing and refilling cisterns incurs additional costs to consumers. Water may also be purchased from water trucks and again stored in cisterns but this is considered to be a very expensive option.

An assessment undertaken in the Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla has provided an impact rating for climate change in the water sector and has a suite of recommendations which should be implemented. Stakeholders have identified drought as a future 'certainty', with 'extremely severe' impacts and 'already happening'. A water quality monitoring programme, particularly for groundwater should be established in tandem with efforts to protect aquifers from surface contamination through increased land owner responsibility. The Department of Environment recognises several issues which affect water quality, including sand mining, hill capping or slope reduction, pond filling, soil relocation, water table penetration and pollution, and land clearing.

[ii] Mitchell, D. (2007). *Water Standards, Corruption-Free Anguilla.* Accessed 29/08/2011, from http://corruptionfreeanguilla.blogspot.com/2007/06/water-standards.html

[iii] Richardson, A. (2009). *Environmental Health Annual Report 2009*. Anguilla: Health Protection Department, Environmental Health Unit, Ministry of Health and Social Development, Government of Anguilla.

[iv] Sear, C., Hulme, M., Adger, N., and Brown, K. (2001). *The impacts of global climate change on the UK Overseas Territories, technical report and stakeholder survey*. UK: Natural Resource Institute, Medway Campus, University of Greenwich and Tyndall Centre for Climate Change Research, University of East Anglia, University Plain.

Comprehensive Natural Disaster Management

Anguilla has been quite fortunate in that it has not had many direct hurricane impacts but there are still cases of damages that suggest some level of vulnerability, such that in the last decade Anguilla's disaster management system has been reviewed and evaluated. Since these hazards are hydro-meteorological, climate change is likely to increase the occurrence of disasters, or at least emergency situations, in Anguilla.

The Valley, the capital city, is located in a sinkhole; a common feature of limestone topography. This location makes the city prone to flooding as water is likely to sit in the large sinkhole during, and following, heavy rainfall events as it did during Hurricane Lenny in 1999. The flood map in Figure 6 shows a large, contiguous part of the main city is vulnerable, necessitating the planning of evacuation routes.

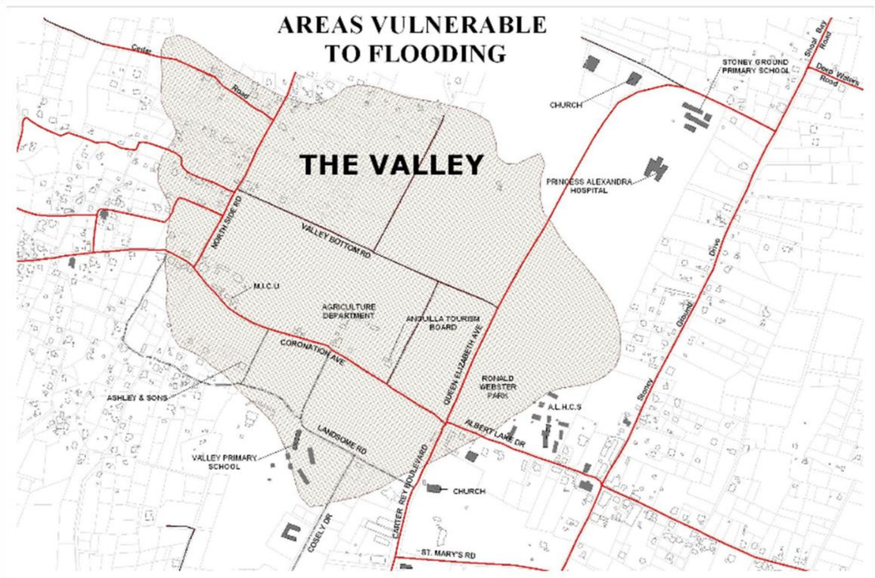


Figure 6: Flood map of The Valley, Anguilla

(Source: Forward Planning Unit, Physical Planning Department, Sept, 2005)

Despite its limited experience with hurricanes, on August 30, 2010 Hurricane Earl battered Anguilla causing damages to roofs at the airport, a primary school and cultural centre as well as some housing. Only 9 persons required shelter for a short time but electricity was off island-wide (including the hospital, desalination plant, the sea port and government secretariat). Tropical Storm Fiona followed closely behind but only 30% of the island had power restored by then. Further damages were also experienced in the agricultural sector where a hydroponic farm roof was damaged and all plants were lost. Seven boats also ran aground. Housing damages were quite minimal with only 2-3 houses destroyed and over 25 damaged.

Preliminary assessments by the Caribbean Disaster Management Agency (CDEMA) estimate damages to the tourism sector at EC $135,000,000. Lenny also caused extensive coastal erosion resulting in the construction of a seawall in Maunday's Bay the next year (see Figure 7).

Figure 7: Seawall under construction in Maunday's Bay, Anguilla

Disaster management in Anguilla is led by the Department for Disaster Management (DDM). Since 2004, Anguilla's Department for Disaster Management (DDM) has fully embraced the Regional Comprehensive Disaster Management (CDM) Strategy into the national CDM Strategy (CDMS). Much of the challenge of the DDM office is its small budget and the small number of staff. The National Disaster Management Act was reviewed in 2008 and is a well developed document. A notable strength of the Act is that enforcement powers are well defined and not limited to a single authority but spread to police officers as well. Another area where Anguilla has made good progress is disaster preparedness. The development of an integrated early warning system that reaches all of Anguilla is an important investment in technology that will provide on-going reduction of the risks from natural hazards. Other initiatives aimed at the reducing the effects of disasters exist.

The Department for Disaster Management (DDM) has a Public Outreach and Education Plan and Strategy and the Hazard Inspection Programme and Strategy that operate throughout the communities on the island. The recent Tsunami Ready programme aims to prepare communities for tsunami hazards specifically, but given the small size of the island and the location of The Valley near to the coast this programme will prepare for other hazards as well. A Tsunami Evacuation Map has been made for the launch of a month-long awareness campaign of the tsunami hazard.

Despite these efforts, more remains to be done in order to develop effective responses to climate change. Improvement of national level data availability and collect, manage and update databases within a national agency is critical. There is no meteorological service available in Anguilla 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.

It is also important for the Government of Anguilla to work with relevant tourism stakeholders to develop and implement the existing sustainable tourism plans with a focus on diversification of the tourism product toward the least vulnerable areas.

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.

Anguilla's propensity for drought conditions has implications for the health sector as episodes of dry weather and drought conditions can contribute to the spread of disease linked to inadequate water supply and sanitation, as well as asthma and other respiratory diseases.

There is very limited formal research or documentation of climate change and its potential impacts in Anguilla but an increase in illnesses due to airborne pollutants, contamination of water supplies, increase demand for healthcare and medical services, resurgence of certain communicable diseases, increase in water-borne diseases and increased thermal stress have been identified as the main vulnerabilities of the country's health sector in the document "The Potential Effects of Global Climate Change on Anguilla, British West Indies". Other diseases associated with climate change include ciguatera poisoning, legionnaires and leptospirosis, which can become more prevalent as seas warm and precipitation increases.

While climate change was not directly mentioned in the National Strategic Plan for Health 2009 -2014, by strengthening the areas of vector surveillance, mosquito control, rodent control, and surveillance of diarrhoea-related morbidity, as well as food safety, air and water quality as well as waste disposal, the ability of the health sector to adapt to changes in diseases patterns and any other impacts will also increase. This comprehensive study of the various health issues that Anguillans face is a positive indication of the type of valuable information which will help in climate change adaptation.

Anguilla has also experienced increasing heat waves in recent times. Gridded temperature observations have shown an increase at an average rate of 0.1˚C per decade over the period 1960-2006 which is expected to increase by at least 0.8-2.9˚C for the GCM ensemble by the 2080s. RCM projections indicate the potential for more rapid increases. Though these predicted changes up to the 2080's are averaged and dispersed over a relatively long time span, episodic increases in temperature could impact vulnerable groups at a given point in time. The potential impacts may be multi-sectoral as water supplies and the agriculture sector also have implications for health.

Despite its dry climate, mosquitoes are prevalent - breeding in cisterns and rock holes. Climate change projections indicate the potential for overall decreases in rainfall events which might decrease mosquito proliferation once water storage facilities and infrastructure do not contribute to mosquito breeding sites. Anguilla is therefore undertaking a number of initiatives to control the spread of infestations.

Respiratory infections in Anguilla have been on the rise in the last four years. 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 particularly those with respiratory diseases and those with pulmonary and cardiac diseases.

Sanitation concerns and drought are mainly linked to food-borne diseases such as gastroenteritis. Gastroenteritis cases have been reported since 1981 but increases in trends have been seen reported since 2000. The Country Poverty Assessment for Anguilla states "It should also be noted that, in Anguilla, the incidence of health conditions (e.g. infectious or waterborne diseases, low birth weights, infant diarrhoea) is almost non-existent". Therefore emphasis is not placed on food- and water-borne diseases known to be prevalent in the rest of the region. However, it is important to consider that there may be a rise of such diseases if water resources become scarcer coupled with higher unemployment rates and deterioration in the social condition. A constant threat exists with cholera being transplanted into the port via the ballast water. Consequently, continuous surveillance is required to monitor this situation.

Table 6: Reported cases of gastroenteritis in Anguilla between 2000 and 2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sum of Gastroenteritis < 5 yrs	79	42	24	67	41	72	158	114	68	45
Sum of Gastroenteritis ≥ 5 yrs	68	47	28	129	63	122	345	317	218	209

(Source: Caribbean Epidemiology Centre (CAREC), 2008a; 2008b; 2010)

Health indicators reveal that Anguilla has a health status comparable to that experienced in other westernised countries with next to no instances of the diseases or conditions traditionally associated with poverty. However, vulnerable groups exist.

There have been two strategic health plans in recent years. The 2003–2008 National Strategic Plan for Health was developed in 2003 and among its designations was provisioning for the operation of the

Anguilla Health Authority. This plan has been followed up by the National Strategic Plan for Health 2009 - 2014 which was prepared in 2009.

To enhance Anguilla's efforts in maintaining a high standard of public health in the face of climate change it is important to improve the use of technology with regard to vector-borne diseases. An Early Disease Warning System that considers temperature signatures for vector borne diseases can be considered, however this must be validated. Also, given the importance of tourism to the economy, an assessment of tourism, health and climate change linkages would provide an indication of destination substitution if tourism related health problems increased as a result of climate change.

Marine and Terrestrial Biodiversity and Fisheries

Anguilla is described as being "embraced by unrivalled white beaches and breathtaking turquoise seas"; an ideal vacation destination. This description highlights the importance of the Anguilla's natural resources to tourism. The importance of biological diversity to the national economy is also reflected in the relative contributions to the Gross Domestic Product (GDP) of economic sectors such as fisheries and construction that are dependent on natural resources. Subsequently employment, livelihoods and the well-being of the Anguillan population is inseparably tied to the protection and management of its biodiversity.

Approximately 550 species of vascular plants (321 of them are native) grow on the island and one of these species, the Anguilla Bush *Rondeletia anguillensis* in the Rubiaceae family (coffee), is unique to Anguilla. The type of vegetation on the island has limited the terrestrial vertebrate fauna to 14 species of reptiles (12 lizard species, one species of snake and one species of land tortoise), five species of bats (Anguilla's only native terrestrial mammals) and about 135 species of migratory and resident birds. At least 3 species of marine turtle nest on various beaches around the coastline and numerous fish and other marine life may be found around seagrass beds and along one of the most important largely unbroken reefs in the eastern Caribbean.

Anguilla's wetlands, consisting of mangroves and salt ponds, are of significant local importance to its biodiversity and provide invaluable goods and services to the population. Formerly widespread mangrove areas have been reduced to a few small areas. On the mainland, mangroves occur in 10 sites on the margins of seven saline ponds covering just 0.9 km^2 in total.

Although the natural environment forms the foundation of the island's economic activity, food security, and livelihoods it is being subjected to a combination of complex localised threats as well as the global threat of climate change. Over-exploitation and indiscriminate clearing of land for development have replaced much of the natural vegetation on Anguilla with degraded evergreen woodland consisting of small trees, scrub brush and cacti, interspersed with scattered areas of grassland. Run-off from construction sites also contributes to the degradation of coral reefs, which are themselves an important source of beach sand and play a role in the dynamics of sand movement. Such activities have had negative impacts that increase the vulnerability of Anguilla's wetlands to climate change.

Extensive reefs are found around the island, with the 17 km-long reef along the north-east coast considered to be one of the most important largely unbroken reefs in the eastern Caribbean and are very important to Anguilla's dive tourism (see Figure 8).

Anguilla's shallow reef habitats are generally in a poor state of health with low hard coral cover and high levels of macro-algae. A recent report from The Anguilla Marine Monitoring Programme (AMMP) notes that over the last 20 years hard coral cover has declined by 70% from an average 13.95% in 1990 (an average over nine sites), to only 4.1% in 2010 (an average over 10 sites). In some areas such as the Forest Bay and Sandy Hill Bay, the decline in coral cover is 90% and 74% respectively[v]. The cumulative effects of a number of natural and human-induced factors, including a proliferation of coral diseases, coral bleaching events, nutrient loading, hurricanes and the regional die-off of the long-spined sea urchin *Diadema antillarum* have resulted in the degradation of coral reefs.

Figure 8: Location of valuable coral reef ecosystems surrounding Anguilla

(Source: UNEP-WCMC)

The fisheries sector contributes an average of 2.5% annually to GDP, which may initially seem to be a small figure; but when the dollar value (Table 7) and number of persons employed are taken into consideration the significance of the fisheries sector becomes more apparent. However, since the mid 1980s lobster fishers have been reporting a decline in catches and fishers have to travel further distances to maintain or increase their catches.

Table 7: Fisheries contribution to GDP in Constant Prices 2000-2009 (EC $M)

Economic Activity	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fishing	8.63	8.90	9.08	10.20	11.21	12.32	12.70	13.81	14.84	13.64

(Source: Anguilla Statistics Department, 2009)

Observed mean annual temperatures over Anguilla have increased at an average rate of 0.1˚C per decade over the period 1960-2006. Anguilla's vegetation is adapted to the dry weather and saline conditions and may be better able to tolerate these changes in climate than many of the plant species found on other islands in the region. However, prolonged periods of drought and salt water intrusion as a result of SLR will likely have adverse impacts on vegetative cover and by extension the terrestrial animal species that inhabit these areas. SLR also poses the greatest threat to mangroves and wetlands potentially confining and even overcoming wetland vegetation if it is obstructed from migrating inland due to coastal infrastructure. Coral reefs and seagrass beds are critical ecosystems for Anguilla's fisheries and are highly sensitive to localised changes in climate.

Hurricane Luis in 1995 caused an almost total loss of mangroves in Anguilla. One mangrove stand that was severely damaged by Hurricane Luis and again by Hurricane Lenny was the mixed mangrove stand found in Little Harbour. Mangrove species exhibit different responses to storm damage and a forest's community structure could thus be changed by tropical storms and hurricanes. The long term effects of extreme events on mangrove stands are uncertain but will most likely mean a reduction in the many important services

[v] Anguilla News. (2010). Status of Anguilla's Marine Resources: 2010. Retrieved 2011; from Anguilla News: http://www.anguillanews.com/enews/index.php/permalink/3540.html

provided by these ecosystems. The recommended approach is therefore to actively preserve and restore mangrove communities in order to maintain the economic and ecological benefits they offer.

During the 1990s Anguilla's beaches appeared to be experiencing net erosion attributable to a series of tropical cyclones that affected that region. Hurricane Luis struck in 1995 and caused much damage to coastal and marine ecosystems including extensive erosion of the beach at Mead's Bay where it retreated inland by 30 m. Four years later, in 1999, Hurricane Lenny caused even further damage to those same dunes. The beaches have shown signs of partial recovery but have still not returned to the pre-hurricane state. Changes to the beachscape will affect recreation activities as well as the livelihoods of those employed in fisheries, water-sports and other such related activities. Intensified tropical cyclones and accompanying storm surges will also impact on nesting areas and threaten the survival of species such as marine turtles, iguanas and shore birds.

Several national agencies share the responsibility for environmental management. In recent years Anguilla has made progress in some areas of environmental management. Using aerial photography the Government of Anguilla has undertaken a mapping exercise of coastal and sub-littoral habitats of all islands in order to develop an accurate method of marine habitat mapping for the analysis of the marine ecosystem in order to develop a procedure for marine and coastal resource management. Such information needs to be fully integrated into environmental and tourism policy and practices.

Since little is understood about the long-term effects of climate change on Caribbean fisheries, assessments on the potential impacts on fishing, fish processing, trade and fisheries technical support services related to artisanal fisheries should be carried out. The establishment of marine protected areas (MPAs) is also of benefit to help the marine environment adapt to climate change. A strategy could be developed and employed which:

- establishes a more effective fish sanctuary management and enforcement system for coastal communities;
- enhances the capacity of resource managers and users to be more resilient to climate change; and
- establishes 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.

Mangrove restoration and protection around Anguilla will improve the health of fish nurseries and coral reefs thus benefitting the livelihoods of those engaged in marine-based activities. Proposed MPAs will also benefit from the presence of mangrove trees, which filter pollutants and provide protection to fish and crustaceans allowing them to increase in size and abundance.

Conclusion

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

The CCCRA explored recent and future changes in climate in Anguilla 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.

Including Anguilla, the CARIBSAVE Climate Change Risk Atlas has worked with 15 countries, a multitude of stakeholders and a wide variety of sectors across the Caribbean. As a result, in addition to the crucial national stakeholder sectoral analyses and practical strategy development the CCCRA provides robust and meaningful cross-regional comparisons in communities and sectors which lead to the identification of effective actions, skills and knowledge transfer, lessons learnt and the opportunities for increased future resilience and sustainability.

1. GLOBAL AND REGIONAL CONTEXT

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

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

The IPCC (IPCC, 2007b) also notes that small islands are particularly vulnerable to the effects of climate change, including 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 *et al*., 2008). This should be seen in the light of Dulal *et al.,* (2009, p.371) conclusion that:

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

Climate change has, since the publication of the 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. The nations of the Caribbean Community (CARICOM)[1] contribute less than 1% to global greenhouse gas (GHG) emissions (approximately. 0.33%[2]) (World Resource Institute, 2008), yet these countries are expected to be among the earliest and most severely impacted by climate change in the coming decades, and are least able to adapt to climate change impacts (Nurse *et al.*, 2009).

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 *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).

Anguilla has prepared a "Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla" (DOE, 2009) and more recently a draft Climate Change Policy (Government of Anguilla, n.d.-3). Both were formulated through a series of national consultations between 2008 and 2010, funded by the United Kingdom Department for International Development (DFID) and managed by the Caribbean Community Climate Change Centre (CCCCC) under the three year regional Enhancing Capacity for Adaptation to Climate Change in the Caribbean UK Overseas Territories (ECACC) Project. The Green Paper examines various elements of Anguilla's social, institutional, infrastructural, environmental, economic characteristics from a holistic perspective as a means of assessing the territory's resources to strategically plan for addressing issues in relation to climate change and Anguilla's response to it. Since the primary economic sector (tourism) is located along the coast, the Green Paper states that strong policies and mechanisms to mitigate the potential impacts of climate change are needed. It is anticipated that the "Green Paper will generate informed discussion about a viable climate change strategy for Anguilla, and

[1] Members of CARICOM: Anguilla (Associate), Antigua and Barbuda, The Bahamas, Barbados, Belize, Bermuda (Associate), British Virgin Islands (Associate), Cayman Islands (Associate), Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands (Associate).

[2] The Caribbean Islands contribute about 6% of the total emissions from the Latin America and Caribbean Region grouping and the Latin America and Caribbean Region is estimated to generate 5.5% of global CO_2 emissions in 2001 (UNEP, 2003).

that it will ultimately lead to the development, adoption and implementation of such a strategy" (DOE, 2009). The draft Climate Change Policy was due to be finalised at a National consultative workshop in April 2011 and be submitted to the House of Assembly in May 2011 for consideration and approval (Government of Anguilla, n.d.-3).

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, *et al*., 2008).

These impacts are highlighted for Anguilla in the draft Climate Policy and a number of specific activities are outlined for government to undertake in transitioning to sustainable tourism (Government of Anguilla, n.d.-3). These are referred to in the relevant sections of this report.

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

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

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

> *It is important to 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, *et al.*, 2008). International tourists are averse to political instability and social unrest, and negative tourism-demand repercussions for climate change security hotspots, many of which are believed to be in developing nations, are already evident (Hall *et al*., 2004).

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and Climate*

The island of Anguilla is the most northerly of the Leeward Islands with an approximate area of 91 km^2 (26 km long and 5 km wide). The island is relatively, flat and low lying with a long coastline (the highest point is Crocus Hill just 65 m above sea level; 64 km of coastline) (Doe, 2009; Halcrow Consultants Limited, 2002). Some areas of cliff are found on the northern side of the island, with flatter areas in the south and southeast. There are 33 white sandy beaches around the island (ATB, n.d.), which are comprised mainly of calcareous algal sands, coral and shell fragments, and sometimes pebbles (DOE, 2009)[3].

The geology is primarily limestone with some clay marls overlaying volcanic rocks that are exposed in a small part of the island at Pelican Point, Crocus Bay, Road Bay and Little Bay. Reddish brown patches of soil can be found in pockets of the limestone in several areas across the island (DOE, 2009). There are no streams or rivers on the island, but several ponds, some of which were once used for the production of salt (Halcrow Consultants Limited, 2002).

Anguilla also has several off-shore cays and uninhabited islets, the largest of which are Prickly Pear East, Prickly Pear West, Dog Island, Scrub Island, Anguillita and Sombrero Island (Doe, 2009; Halcrow Consultants Limited, 2002). There are extensive reefs off the north coast and fringing reefs along most of the south coast with the 17 km-long reef along the north-east coast considered to be one of the most important largely unbroken reefs in the eastern Caribbean (DOE, 2009).

Much of the natural vegetation on Anguilla is sparse scrub oak with scattered areas of grassland. There are small areas of mangrove and the brackish ponds are important for both resident and migratory waterfowl (egrets, herons, stilts and ducks). There is a rich variety of sea birds (frigate birds, brown boobies, pelicans and assorted gulls) (Doe, 2009; Halcrow Consultants Limited, 2002). The considerable biodiversity of national, regional and international significance on the main island and its cays have yet to be fully evaluated (DOE, 2009). The Environmental Charter includes guiding principles and a set of mutual commitments by the UK Government and the Government of Anguilla in respect of integrating environmental conservation into all sectors of policy planning and implementation (OTEP, 2001).

There is no meteorological service available in Anguilla and so weather forecasts are provided by Antigua and Barbuda. In the absence of site specific climatology from a national meteorological office, the gridded data from the climate modeling is presented here to describe the climate of Anguilla, supported by generic descriptions found in the literature. The climate modeling, Section 3, uses gridded global or regional datasets of observed weather, with a grid resolution of 0.5° or greater. The data comes from weather stations across the globe or records of sea surface temperature in marine areas from voluntary observation ships that is then averaged within each grid cell. Coverage can therefore be sparse in less populated areas or away from shipping lanes (McSweeney *et al.,* n.d.).

According to this data the observed mean temperature in Anguilla is 26.2°C, varying from 25-27.2°C through the year. The Green Paper on Climate Change describes the climate as dry, tropical and is in agreement with various government websites that report monthly mean temperature at 27°C, with extremes of 18 to 30°C (DOE, 2009; ATB, n.d.).

[3] The Green Paper on Climate Change reports that there are 22 beaches (DOE, 2009).

The CCCRA climate modeling data reports that mean monthly precipitation is 117.8 mm, varying from 85.1-160.2 mm depending on the season (see Section 3). This would equate to annual mean precipitation of 1,414 mm and an annual range of 1,021.2 mm to 1,922.4 mm. The Green Paper reports slightly different values with mean annual rainfall of 965 mm and a range from 457 mm to over 2,030 mm depending on the number and intensity of storms that pass through. These extremes are quite possible since gridded data tends to smooth out extremes in observations. The dry season is between January and June and wet season from July to December, coincident with the hurricane season (DOE, 2009). The Country Poverty Assessment reports that rainfall is low with an annual average of 889 mm (Halcrow Consultants Limited, 2002).

Wind data from the gridded information shows that wind speeds average 7.1 m/s with peak speeds in December through to February and again between June and August. Observations reported in the Green Paper indicate a range of wind speeds between 4.0 and 7.6 m/s blowing primarily from the east and east-southeast. The island is periodically hit by hurricanes and tropical storms, including seven such events occurring between 1995 and 2008: Luis (1995), Bertha (1996) Georges (1998), Jose (Oct 1999), Lenny (Nov 1999), Debbie (Aug 2000) and Omar (Oct 2008). However, hurricanes and storms pass near to the island every season causing much coastal damage as a result of their wind and wave action, or their torrential rain (DOE, 2009).

2.2. *Socio-economic Profile*

Anguilla is a small, middle-income island and a British Dependent Territory (Doe, 2009; Halcrow Consultants Limited, 2002). There are a number of population estimates available with the last census indicating a population of 11,561 (51% female: 49% male) (DOE, 2009). More recent estimates put the population between 15,000 and 16,000 for 2009/10 and United Nations Economic Commission for Latin America and the Caribbean (ECLAC) report that the population is classified as entirely urban (ECCB, 2009; ECLAC, 2010a). A new census was carried out in May 2011 (Government of Anguilla, n.d.-1) and once the data have been analysed more accurate assessments will be available. The capital is The Valley and is located in the centre of the island.

Despite its size Anguilla:

> *has produced some of the region's highest economic growth rates, especially during the late 1980's. This growth was a direct consequence of the Government's emphasis on up-market tourism, a decision which led to a period of rapid construction, (new hotels, rental villas, and condominiums), and which substantially expanded the island's tourism sector. … One of the major impacts of this economic boom was that it was instrumental in reducing unemployment in Anguilla from about 26% in the mid 1980s to barely 1% in 1990. This improved financial trend continued into the beginning of the 21st Century as the economy of Anguilla has witnessed rapid expansion in recent years (DOE, 2009).*

Table 2.2.1 shows rapid growth in GDP in Anguilla between 2003 and 2007, before stalling in 2008 and then declining in 2009. According to the United Nations Development Programme (UNDP) Anguilla had been badly affected by Hurricane Lenny in 1999 resulting in a 0.3% decline in the economy in 2000. This was followed by the recovery shown, as a result of rapid expansion in the tourism and construction sectors. The importance of tourism is described in more detail in Section 2.3. The recent financial downturn, resulted in a 2008 growth rate of 3.78% and the overall deficit for 2009 was approximately EC $80.42 million, with fiscal reserves virtually zero at the end of 2009 (UNDP, n.d.). Some level of economic security is achieved by having a large number of small businesses with 67% having less than four employees, rather than depending on a handful of major employers (Halcrow Consultants Limited, 2002).

Table 2.2.1: Gross Domestic Product for Anguilla 2000-2010

Year	Gross Domestic Product Market Prices In Constant 1990 Prices EC $ (millions)
1999	227.78
2000	230.62
2001	236.66
2002	233.26
2003	239.39
2004	291.04
2005	315.25
2006	397.90
2007	470.82
2008	477.07
2009	355.48

(Source: ECCB, 2009; ECCB, 2003)

Anguilla's size and lack of natural resources has resulted in an economy driven by the services sector (80% of GDP: tourism 60% and offshore banking) and supported by the secondary sector (18% of GDP: construction and utilities) (Halcrow Consultants Limited, 2002; UNDP, n.d.; RLB, 2010). Another important source of income is remittances from emigrants (UNDP, n.d.). It should be noted however, that a number of sectors also revolve around tourism; most construction activity, fishing (especially lobster) and transportation in Anguilla is tourism driven (Halcrow Consultants Limited, 2002). Table 2.2.2 gives a breakdown of the contributions by sector. The information is presented as percentage of GDP in Figure 2.2.1.

Table 2.2.2: Sector GDP at factor cost in constant 1990 prices (EC $million)

Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Agriculture	5.82	5.37	5.09	5.86	5.95	6.37	6.50	6.78	7.52	7.84	8.01
Mining & Quarrying	1.77	1.88	1.69	1.63	2.63	3.55	4.08	5.55	8.33	8.91	6.24
Manufacturing	2.35	2.43	2.48	2.51	2.75	2.07	5.02	5.47	7.07	6.91	4.49
Electricity & water	5.16	5.59	6.42	7.01	7.28	7.77	8.96	10.28	11.08	10.97	9.87
Construction	29.92	27.91	23.83	21.82	22.52	31.16	34.42	50.67	83.97	98.61	44.37
Wholesale & retail	13.97	14.43	13.71	12.23	12.95	13.52	14.87	17.02	18.63	17.16	12.01
Hotels & restaurants	59.10	55.33	60.57	55.54	59.27	68.20	78.43	92.17	98.10	86.26	71.60
Transport & communication	32.45	34.28	32.93	34.25	32.06	39.18	42.96	45.89	57.34	64.31	57.02
Banks & insurance	23.98	30.15	36.78	32.9	34.97	43.99	45.49	48.30	70.14	81.69	82.51
Real estate & housing	6.24	6.34	6.47	6.67	6.83	6.95	7.09	7.30	7.59	7.979	8.05
Government services	24.86	25.84	26.95	27.81	29.09	30.81	31.98	35.12	36.44	38.17	40.08

(Source: Halcrow Consultants Limited, 2002; ECCB, 2009)

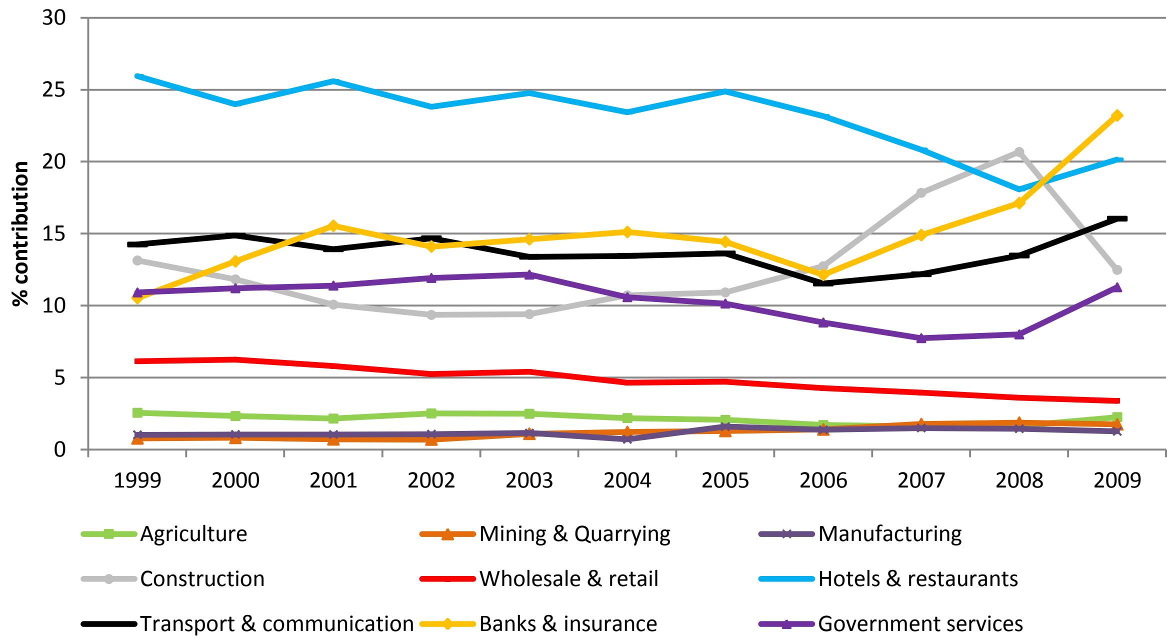


Figure 2.2.1: Percentage contribution to GDP by sector

Until 2005 the structure of the economy was fairly stable and dominated by the hotel and restaurant, government services, construction, banks and insurance, and transport and communication sectors, reflecting the policy of developing the economy on the twin pillars of tourism and financial services (DOE, 2009). Their dominance has remained in the last few years, but their relative contributions have changed considerably. The contribution of hotels and restaurants will be covered in Section 2.3.

In 2009, banking and insurance became the key contributor to GDP (UNDP, n.d.) Banking and insurance doubled its share between 1986 and 2000 reflecting the development of commercial banking on Anguilla rather than offshore banking activities (Halcrow Consultants Limited, 2002). Since then, substantial additional effort has been put into the development of the island's offshore financial sector, which is small, but growing rapidly (DOE, 2009). In an attempt to regenerate interest and reactivate the economy, the Anguilla Tourist Board and the Government of Anguilla as well as other agencies are actively promoting the island as not only a premier tourist destination, but also trying to tap into its financial potential as the offshore jurisdiction for discerning investors (DOE, 2009).

In 2008, the construction sector was the largest contributor to GDP, but this sector saw a decline over 58.9% in 2009 due to the financial crisis (UNDP, n.d.; ECLAC, 2010b). The global financial crisis lead to a slowdown in the sector in 2008 and subsequent slump in 2009 as major private sector projects encountered financing difficulties (ECCB, 2009; ECLAC, 2010b). It is noted that the health of the construction industry has been closely related to tourist activity, with increases in tourism spurring growth in construction (RLB, 2010; DOE, 2009). Additionally, real estate property sales dropped in 2008, as investors became more cautious of the financial market. The cancellation or delay in projects resulted in the laying off of workers. The following projects suffered from lack of financing (DOE, 2009):

- Construction of The Flag project at Temenos was stopped
- The Flag's golf course development at Rendezvous Bay was closed
- Expansion plans for Altamer at Shoal Bay West were delayed
- The Rendezvous Bay Hotel was delayed
- Privee at Shoal Bay East was postponed
- Fairmont Anguilla at Forest Bay was also put on hold
- Development on Shoal Bay East has not yet proceeded

Agricultural output continues to grow (1986-2009), but its share in the economy has declined given the dominance of the other sectors described above (Halcrow Consultants Limited, 2002).

Population growth was low between 1960 and 1984, but since then has increased to an average annual rate of 3.2%, which is very high by Caribbean standards. Between 1984 and 1992, almost two thirds of the population increase was due to immigration from other Caribbean islands. Since 1992 however, the majority of the increase has been due to the natural increase of the Anguillian population and returning residents. In 2002 just over a quarter of the population was non-Anguillian and Anguillans comprised 65% of the employed labour force (Halcrow Consultants Limited, 2002).

According to the 2001 census, the labour force comprised 64% of the population and participation rates were 80% for males and 68% for females, with the key sectors being tourism (29%) and construction (15%) (DOE, 2009). By 2007, the demand for labour in the tourism construction sector had increased to the point where an additional 2,000 labourers had to be recruited mainly from India and China (DOE, 2009). The unemployment rate was 8.3% in 1999, 6.7% in May 2001 and 7.8% in July 2002. The increase in July 2002 is attributed to the month in which the Survey of Living Conditions was undertaken (in July school leavers are looking for work and employment levels drop as the tourist season slows) and the general slowdown in the Anguillian economy following the slowdown in tourism after the 9/11 terror attacks (Halcrow Consultants Limited, 2002; UNDP, n.d.). The Survey also found that 6.5% of workers have more than one job and seasonality of the tourism sector impacts on employment with 7% of those surveyed working for four months or less in the previous year (Halcrow Consultants Limited, 2002).

The Country Poverty Assessment found that the level of indigence or severe poverty is very low (2% of households) indicating that almost all Anguillians can satisfy their basic food needs. Around 20% of households in Anguilla are poor; which equates to 23% of the population (Halcrow Consultants Limited, 2002). As seen in a number of islands in the Caribbean there appears to be a problem of the 'working poor' since 70% of poor households in Anguilla have at least one person working and 30% have two or more workers. There is a greater concentration of the working poor in the tourism sectors and in manual and service occupations with wages in the hotel and restaurant sector 70% of the overall median and 55% of the median level for domestic workers. It is noted that in Anguilla, in contrast to other countries in the Caribbean, most poor households enjoy a reasonable standard of living, owning their property, having good access to education and health services and at least one person in employment (Halcrow Consultants Limited, 2002).

Recent political issues in Anguilla have meant uncertainty regarding some policies and the roles of some institutions. This type of political instability and pressure can be damaging to the future development of the country and its ability to adapt to the threats posed by climate change.

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 mentioned in Section 2.2, the Government of Anguilla decided to develop the tourism industry as early as the 1980s and focus on the luxury market (Doe, 2009; Halcrow Consultants Limited, 2002). Tourism also drives a number of other activities so that the overall contribution to the economy is of the order of 60% (Halcrow Consultants Limited, 2002; UNDP, n.d.; RLB, 2010; DOE, 2009). However, the hotels and restaurant sub-sector only contributed 20% of GDP in 2009 (ECCB, 2009) or 22.6% according to the Caribbean Tourism Organisation (Caribbean Tourism Organisation, n.d.). This heavy reliance on tourism makes the economy vulnerable to the economic fortunes of the industrialised nations that are the source markets and on creating a favourable investment climate in the destination (DOE, 2009). In 2002, the Country Poverty Assessment noted that "the dependence of Anguilla's economy on tourism is so great that virtually every household would eventually be affected if this sector experienced a sustained downturn: construction would dry up and government revenues would fall leading to a reduction in government spending, including wages and benefits" (Halcrow Consultants Limited, 2002). Table 2.3.1 and Figure 2.3.1 demonstrate how visitor arrivals and tourist expenditure have fluctuated over the last 15 years.

Table 2.3.1: Visitor Arrivals and expenditure 1995-2010

Year	Stopovers	Cruise Ship Passengers	Expenditure (US $ million)
1995	36,280	68,555	48.5
1996	35,413	48,741	48.0
1997	40,506	70,684	57.2
1998	41,092	69,922	58.1
1999	43,726	59,947	56.5
2000	40,642	68,680	55.2
2001	47,940	57,030	61.0
2002	43,970	67,150	55.3
2003	46,915	62,367	61.7
2004	53,987	66,801	69.2
2005	62,084	81,102	85.9
2006	72,962	94,283	107.4
2007	77,652	86,415	114.5
2008	68,284	59,577	102.1
2009	57,891	54,224	84.8
2010	61,998	56,413	

(Source: Halcrow Consultants Limited, 2002; Caribbean Tourism Organisation, n.d.; Statistics Department, n.d.; OECS, 2010)

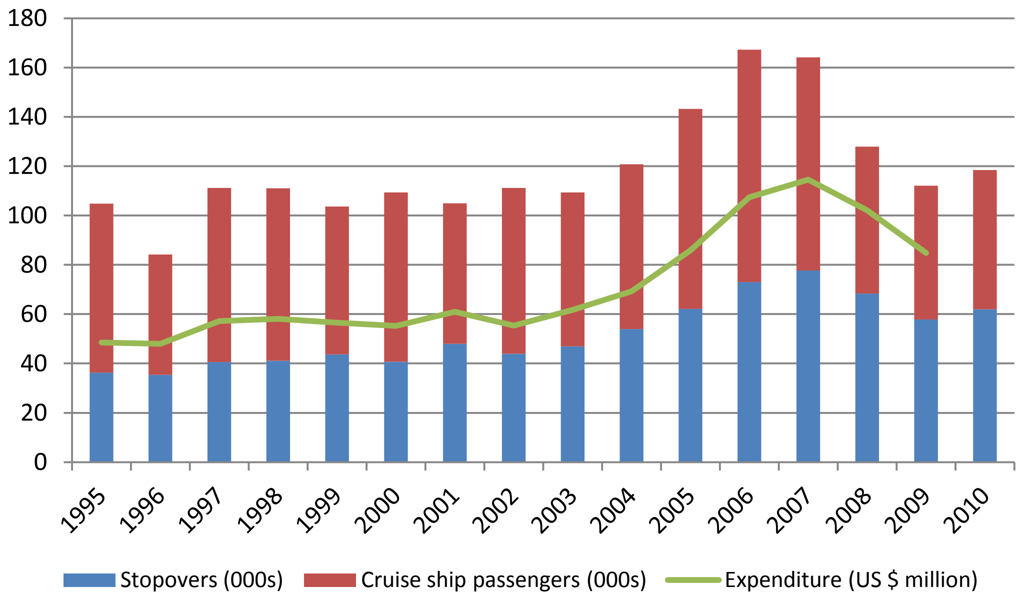


Figure 2.3.1: Tourist arrivals and expenditure

In 1982, there were just 17,000 visitors to the island, but by 2000, this had increased to 112,000 (Halcrow Consultants Limited, 2002). At that time, stay-over tourists provided 95% of the expenditure despite the high number of excursionists (mainly day-trippers from St. Martin) and winter tourists spent, on average, US $220/day while summer tourists spent an average of US $160/day (Halcrow Consultants Limited, 2002). As can be seen in Figure 2.3.1, the more recent boom in the tourism sector started in 2004 and continued until 2006 before declining marginally in 2007. Levels of expenditure followed the same pattern, peaking in 2007, which is coincident with the peak in stopover arrivals. As mentioned previously, this boom resulted in rapid growth in the construction sector, which explains why the market share of hotels and restaurants appears to decline during this period (Figure 2.2.1).

The principle markets for Anguilla in 2009 were the US (58.9%), Europe (12.9%) and the Caribbean (22.3%) (Caribbean Tourism Organisation, n.d.). The observed reduction in arrivals in 2008 through to 2010 is a result of the economic downturn in these source markets (DOE, 2009); stay-over visitors declined by 18% in 2009 (ECLAC, 2010b). In 2008 value added in the hotel and restaurant sector declined by 12.1% (ECCB, 2009) with a further reduction in 2009 (see Table 2.2.2). The drop in tourist arrivals coincides and is partly responsible for the slowing down of Anguilla's economy in 2008 (see Table 2.2.1) (DOE, 2009). The number of rooms has declined from 746 in 2005 to 602 in 2008 (Caribbean Tourism Organisation, n.d.), and average length of stay has declined from 9.7 days in 1993 to 8 days in 2009 (Caribbean Tourism Organisation, n.d.; Statistics Department, n.d.).

It has also been noted that Anguilla's tourism industry was affected by the 2008 spike in oil prices which dramatically increased energy costs for tourism facilities. "While the beginning of 2008 saw rising oil prices, the last three months of the year saw declining prices, a factor due mainly to the global financial crisis. While most airlines and cruise ship companies willingly passed the increased costs onto customers, the opportunity that presented itself at the end of 2008 saw very few transportation companies reflecting the lower oil prices in their tickets/fares" (DOE, 2009).

In 2007 the Executive Council approved The Tourism Sector Development Project (TSDP), which was subsequently launched in July 2008 (Government of Anguilla, n.d.-2). The first phase was a socio-economic impact analysis of selected tourism projects and a survey to assess the attitudes of citizens and residents towards tourism and tourists (DOE, 2009). The results confirmed the likely socio-economic strain on Anguilla and its residents from planned and existing tourism products over the next decade. However, the attitudinal survey indicated that most Anguillans had a very positive view of tourism and held the strong belief that decisions related to tourism development should rest with the State. Moreover, local people wanted to be more involved in decision-making and monitoring the tourism product at the community level (Government of Anguilla, n.d.-2).

The second phase of the TSDP is the development of a Tourism Master Plan with the Government of Anguilla (GOA) receiving financing from the Caribbean Development Bank (CDB) toward the cost of the preparation of a Sustainable Tourism Master Plan for the period 2010-2020 (RLB, 2010). Development of the plan is underway with a series of visioning workshops being held in November 2010 and February 2011 (Government of Anguilla, 2011; Government of Anguilla, n.d.-2). The shared vision coming out of the workshops to date is to maintain the low volume-high value strategy that Anguilla has been pursuing, thereby ensuring that the warm relationship between Anguillans and visitors is maintained. The Master Plan will elaborate the policy framework for development, management, monitoring and long term sustainability of the tourism sector looking at diversification, institutional capacity, and marketing (Government of Anguilla, n.d.-2).

It has already been acknowledged that the health of the sector depends heavily on the economic situation in source market countries, but tourism in Anguilla also faces other threats. According to the Green Paper most tourism infrastructure and activities are located in the coastal zone and significant capital investment assets and infrastructure could be affected by coastal flooding (DOE, 2009). Hurricane Lenny resulted in some of the major five star hotels on the island being forced to close for over a year while refurbishment of the property took place. This affected the island's GDP and also negatively impacted the livelihood of its employees (DOE, 2009). Similarly, tourism in the 2001/2002 winter season was severely affected by the 9/11 terrorist attacks and its effect on American travel with stay-over arrivals dropping in 2002 (Halcrow Consultants Limited, 2002).

Employment in the tourism sector has been described in Section 2.2, with 29% of the labour force employed in the sector in 2001 and heavy dependence on the sector especially amongst poor households (over 25% of poor households are wholly dependent on tourism) (Halcrow Consultants Limited, 2002). The up-market, luxury nature of the product results in a high staff to guest ratio, at 3-3.5 staff to one guest and the seasonality of the industry (4-5 months) results in staff lay-offs and hotel/restaurant closures. Some hotels, however, are known to close for only two months and to pay staff 80% of their regular wages during the closed period (Halcrow Consultants Limited, 2002).

3. CLIMATE MODELLING

3.1. *Introduction to Climate Modelling Results*

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

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

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

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

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

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

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

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

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

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

3.2. *Temperature*

Observations from the gridded temperature datasets indicate that mean annual temperatures over Anguilla have increased at an average rate of 0.1˚C per decade over the period 1960-2006. The observed increases have been more rapid in the seasons JJA and SON at the rate of 0.14˚C per decade.

General Circulation Model (GCM) projections from a 15-model ensemble indicate that Anguilla can be expected to warm by 0.5˚C to 1.8˚C by the 2050s and 0.8˚C to 2.9˚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 Anguilla compared to the GCM ensemble median projections for the A2 scenario. In particular, RCM simulations driven by ECHAM4 indicate temperature increases that are higher than any of the models in the GCM ensemble in all seasons. RCM projections indicate increases of 3.1˚C and 2.4˚C in mean annual temperatures by the 2080s, when driven by the ECHAM4 and HadCM3 respectively, compared with GCM ensemble projections of 1.7-2.9˚C for that period.

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

Table 3.2.1: Observed and GCM projected changes in temperature for Anguilla.

Anguilla: Country Scale Changes in Temperature												
	Observed Mean 1970-99	Observed Trend 1960-2006		*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
	(˚C)	(change in ˚C per decade)		*Change in ˚C*			*Change in ˚C*			*Change in ˚C*		
			A2	0.3	**0.7**	0.8	0.9	**1.3**	1.8	1.7	**2.4**	2.9
Annual	26.2	0.10*	*A1B*	0.2	**0.7**	1.0	1.0	**1.5**	1.7	1.1	**2.0**	2.8
			B1	0.2	**0.7**	0.8	0.5	**1.1**	1.3	0.8	**1.4**	2.0
			A2	0.3	**0.7**	0.9	1.0	**1.3**	1.8	1.7	**2.4**	2.9
DJF	25	0.07	*A1B*	0.2	**0.7**	1.1	0.9	**1.5**	1.8	1.2	**2.1**	2.9
			B1	0.3	**0.7**	0.8	0.5	**1.1**	1.4	0.7	**1.4**	2.2
			A2	0.2	**0.6**	0.8	0.7	**1.3**	1.7	1.5	**2.2**	2.8
MAM	25.6	0.08*	*A1B*	0.1	**0.6**	1.0	0.9	**1.4**	1.6	1.0	**2.0**	2.6
			B1	0.1	**0.6**	0.9	0.4	**1.1**	1.5	0.6	**1.3**	2.0
			A2	0.2	**0.7**	0.8	0.8	**1.2**	1.7	1.7	**2.2**	2.8
JJA	27.2	0.14*	*A1B*	0.2	**0.6**	0.9	1.0	**1.4**	1.7	1.0	**1.9**	2.8
			B1	0.2	**0.6**	0.8	0.5	**1.0**	1.2	0.8	**1.3**	1.9
			A2	0.3	**0.8**	1.0	1.0	**1.4**	1.9	1.8	**2.5**	3.1
SON	27	0.14*	*A1B*	0.2	**0.7**	1.2	1.0	**1.5**	2.0	1.3	**2.1**	3.0
			B1	0.3	**0.7**	1.0	0.7	**1.1**	1.4	0.9	**1.4**	2.0

Table 3.2.2: GCM and RCM projected changes in Anguilla under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
			Change in ˚C	
	GCM Ensemble Range	1.7	**2.4**	2.9
Annual	*RCM (ECHAM4)*		**3.1**	
	RCM (HadCM3)		**2.4**	
	GCM Ensemble Range	1.7	**2.4**	2.9
DJF	*RCM (ECHAM4)*		**3.2**	
	RCM (HadCM3)		**2.7**	
	GCM Ensemble Range	1.5	**2.2**	2.8
MAM	*RCM (ECHAM4)*		**3.1**	
	RCM (HadCM3)		**2.7**	
	GCM Ensemble Range	1.7	**2.2**	2.8
JJA	*RCM (ECHAM4)*		**3**	
	RCM (HadCM3)		**2.3**	
	GCM Ensemble Range	1.8	**2.4**	3.2
SON	*RCM (ECHAM4)*		**3.3**	
	RCM (HadCM3)		**2.1**	

3.3. *Precipitation*

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

GCM projections of future rainfall for Anguilla span both overall increases and decreases with wide variations, but tend towards decreases in more models. Projected rainfall changes in annual rainfall range from -34 to +13 mm per month (-55% to +29%) by the 2080s across three emissions scenarios. The overall decreases in annual rainfall projected by GCMs occur largely through decreased JJA and SON rainfall, but these changes are less consistent between models.

RCM projections of rainfall for Anguilla are strongly influenced by the driving GCM providing boundary conditions. Changes projected by the RCM driven by HadCM3 are generally greater than ECHAM4-driven simulations. Driven by ECHAM4, RCM rainfall projections indicate small increases in DJF and MAM and decreases in JJA and SON resulting in a moderate decrease of 1 mm (-1%) in total annual rainfall. When driven by HadCM3, RCM projects an increase in MAM and large decreases in JJA (-38%) and SON (-30%) rainfall resulting in a large decrease in total annual rainfall (-11%).

Table 3.3.1: Observed and GCM projected changes in precipitation for Anguilla.

Anguilla: 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	-10	**-2**	4	-19	**-3**	10	-34	**-6**	7
			A2	-6	**-2**	9	-8	**-2**	9	-20	**-5**	13
Annual	117.8	0.3	*A1B*	-8	**-1**	9	-9	**-2**	7	-11	**-3**	7
			B1	-9	**0**	6	-12	**0**	4	-9	**0**	8
			A2	-6	**-1**	4	-6	**0**	6	-23	**0**	3
DJF	85.1	2.6	*A1B*	-7	**0**	5	-5	**-1**	5	-14	**0**	8
			B1	-7	**-1**	11	-18	**-1**	11	-25	**-3**	1
			A2	-5	**0**	7	-14	**-2**	6	-14	**-2**	4
MAM	93	-1.4	*A1B*	-4	**0**	12	-10	**0**	7	-8	**0**	6
			B1	-17	**-2**	5	-29	**-7**	10	-64	**-16**	2
			A2	-18	**-4**	13	-22	**-10**	15	-51	**-7**	12
JJA	130	-0.8	*A1B*	-20	**-2**	28	-24	**-4**	1	-22	**-8**	6
			B1	-15	**-5**	12	-21	**-4**	30	-55	**-9**	23
			A2	-13	**1**	19	-23	**-3**	45	-33	**0**	42
SON	160.2	1	*A1B*	-24	**-4**	12	-28	**0**	20	-25	**-5**	23

Table 3.3.2: GCM and RCM projected changes in Anguilla under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
			Change in mm	
	GCM Ensemble Range	-34	**-6**	7
Annual	*RCM (ECHAM4)*		**-1**	
	RCM (HadCM3)		**-24**	
	GCM Ensemble Range	-9	**0**	8
DJF	*RCM (ECHAM4)*		**4**	
	RCM (HadCM3)		**0**	
	GCM Ensemble Range	-25	**-3**	1
MAM	*RCM (ECHAM4)*		**6**	
	RCM (HadCM3)		**13**	
	GCM Ensemble Range	-64	**-16**	2
JJA	*RCM (ECHAM4)*		**-6**	
	RCM (HadCM3)		**-54**	
	GCM Ensemble Range	-55	**-9**	23
SON	*RCM (ECHAM4)*		**-10**	
	RCM (HadCM3)		**-55**	

Table 3.3.3: Observed and GCM projected changes in precipitation (%) for Anguilla.

Anguilla: 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	-16	**-4**	8	-31	**-6**	22	-55	**-14**	15
Annual	117.8	0.3	*A1B*	-23	**-3**	21	-35	**-2**	19	-33	**-8**	29
			B1	-22	**-1**	13	-19	**-2**	7	-30	**-5**	16
			A2	-14	**0**	16	-30	**-1**	13	-42	**0**	24
DJF	85.1	3	*A1B*	-21	**-2**	13	-39	**1**	13	-33	**-2**	9
			B1	-19	**3**	14	-19	**-3**	12	-38	**-2**	24
			A2	-20	**-7**	17	-42	**-2**	35	-45	**-10**	3
MAM	93	-1.5	*A1B*	-33	**3**	28	-39	**-6**	17	-35	**-7**	10
			B1	-23	**2**	21	-29	**0**	16	-38	**0**	21
			A2	-20	**-7**	4	-47	**-10**	27	-71	**-24**	8
JJA	130	-0.6	*A1B*	-19	**-8**	36	-36	**-15**	43	-57	**-18**	34
			B1	-33	**-6**	24	-26	**-8**	2	-34	**-10**	17
			A2	-29	**-3**	11	-35	**-4**	33	-66	**-10**	26
SON	160.2	0.6	*A1B*	-26	**1**	16	-37	**-2**	29	-48	**0**	48
			B1	-29	**-3**	14	-26	**0**	21	-42	**-10**	26

Table 3.3.4: GCM and RCM projected changes in Anguilla under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
			% Change	
	GCM Ensemble Range	-55	**-14**	15
Annual	*RCM (ECHAM4)*		**-1**	
	RCM (HadCM3)		**-11**	
	GCM Ensemble Range	-42	**0**	24
DJF	*RCM (ECHAM4)*		**7**	
	RCM (HadCM3)		**3**	
	GCM Ensemble Range	-45	**-10**	3
MAM	*RCM (ECHAM4)*		**12**	
	RCM (HadCM3)		**19**	
	GCM Ensemble Range	-71	**-24**	8
JJA	*RCM (ECHAM4)*		**-9**	
	RCM (HadCM3)		**-38**	
	GCM Ensemble Range	-66	**-10**	26
SON	*RCM (ECHAM4)*		**-15**	
	RCM (HadCM3)		**-30**	

3.4. *Wind Speed*

Observed mean wind speeds from the ICOADS mean monthly marine surface wind dataset demonstrate increasing trends around Anguilla in all seasons over the period 1960-2006. The increasing trend in mean annual wind speed is 0.3 ms^{-1} per decade. It is greatest in SON at the rate of 0.43 ms^{-1} per decade.

Mean wind speeds over Anguilla generally show a very small increase in GCM projections. Projected changes in annual average wind speed range between -0.1 and +0.5 ms^{-1} by the 2080s across the three emission scenarios. Both increases and decreases are seen in all seasons across the 15-model ensemble.

RCM projections based on two driving GCMs lie within the range of changes indicated by the GCM ensemble. RCM simulations project a decrease in wind speed in DJF and an increase in JJA. Driven by ECHAM4, the RCM indicates a very small change in wind speeds in all seasons except for DJF when the change is -0.5 ms^{-1} by the 2080s under the A2 scenario. Driven by HadCM3, the RCM projects relatively large increases in wind speeds in JJA (+0.7 ms^{-1}) and SON (+0.6 ms^{-1}) by the 2080s.

Table 3.4.1: Observed and GCM projected changes in wind speed for Anguilla.

Anguilla: Country Scale Changes in Wind Speed												
	Observed Mean 1970-99	Observed Trend 1960-2006		*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	(ms^{-1})	*(change in ms^{-1} per decade)*		*Change in ms^{-1}*			*Change in ms^{-1}*			*Change in ms^{-1}*		
			A2	-0.1	**0**	0.2	-0.2	**0**	0.2	-0.1	**0.2**	0.5
Annual	7.1	0.30*	*A1B*	-0.3	**0**	0.1	-0.3	**0**	0.4	-0.2	**0.1**	0.2
			B1	-0.2	**0**	0.2	-0.1	**0**	0.2	-0.1	**0.1**	0.2
			A2	-0.3	**0**	0.6	-0.7	**-0.1**	0.4	-0.7	**0.1**	0.6
DJF	7.4	0.34*	*A1B*	-0.2	**0**	0.5	-0.3	**0.4**	0.5	-0.4	**0.1**	0.4
			B1	-0.2	**-0.1**	0.5	-0.1	**0.1**	0.2	-0.3	**0**	0.5
			A2	-0.3	**-0.1**	0.4	-0.8	**0.2**	0.7	-0.3	**0.2**	0.9
MAM	6.8	0.24*	*A1B*	-0.4	**0.1**	0.5	-0.5	**0**	0.6	-0.6	**0.2**	0.8
			B1	-0.5	**0.1**	0.4	-0.3	**0.1**	0.4	-0.3	**0.1**	0.5
			A2	-0.3	**0**	0.3	-0.2	**-0.1**	0.1	-0.2	**0.1**	0.4
JJA	7.6	0.19*	*A1B*	-0.5	**0**	0	-0.2	**0**	0.2	-0.2	**0**	0.7
			B1	-0.2	**0**	0.1	-0.1	**0**	0.3	-0.1	**0**	0.2
			A2	-0.3	**-0.1**	0.3	-0.3	**0.1**	0.2	-0.5	**0.2**	0.7
SON	6.6	0.43*	*A1B*	-0.7	**0**	0.3	-0.5	**0**	0.4	-0.2	**0**	0.3
			B1	-0.3	**0.1**	0.3	-0.4	**0.1**	0.2	-0.4	**0**	0.5

Table 3.4.2: GCM and RCM projected changes in Anguilla under the A2 scenario.

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

3.5. *Relative Humidity*

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

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

RCM projections indicate small increases in RH over Anguilla in all seasons. But, these increases are smaller than those predicted by the GCM ensemble except in SON, when both RCM simulations project over 1.0% increase in RH.

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 Anguilla.

Anguilla: 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**			**0.8**			**1.1**	
Annual	78.3	-0.11	*A1B*	-0.3	**0.2**	0.6	-0.6	**0.4**	1.3	-0.8	**0.6**	1.4
			B1	-0.3	**0.2**	0.6	-0.4	**0.3**	0.8	-0.7	**0.6**	0.9
			A2		**0.0**			**0.7**			**1.3**	
DJF	77.2	0.22	*A1B*	-1.0	**0.4**	0.8	-0.1	**0.5**	1.3	0.0	**0.8**	1.9
			B1	-0.6	**0.4**	1.3	-0.3	**0.8**	1.6	-0.2	**0.8**	1.0
			A2		**0.3**			**0.8**			**0.8**	
MAM	77.8	-0.15	*A1B*	-0.3	**0.1**	0.7	-0.4	**0.3**	1.3	-0.7	**0.2**	1.8
			B1	-0.5	**0.1**	0.7	-0.4	**0.1**	0.7	-0.6	**0.4**	1.0
			A2		**0.1**			**0.7**			**1.2**	
JJA	79	-0.25	*A1B*	-0.7	**0.3**	0.8	-1.1	**0.5**	1.4	-1.4	**0.4**	1.5
			B1	-0.5	**0.4**	0.7	-0.9	**0.5**	0.9	-1.2	**0.6**	1.4
			A2		**0.0**			**0.7**			**0.9**	
SON	79.1	-0.22	*A1B*	-0.6	**0.3**	0.8	-0.9	**0.6**	1.3	-1.0	**0.4**	1.6
			B1	-0.9	**0.2**	0.6	-0.8	**0.3**	1.0	-0.7	**0.5**	1.1

Table 3.5.2: GCM and RCM projected changes in Anguilla under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	Median	Max
			Change in %	
	GCM Ensemble Range		1.1	
Annual	RCM (ECHAM4)		1	
	RCM (HadCM3)		0.6	
	GCM Ensemble Range		1.3	
DJF	RCM (ECHAM4)		1.1	
	RCM (HadCM3)		0.3	
	GCM Ensemble Range		0.8	
MAM	RCM (ECHAM4)		1.3	
	RCM (HadCM3)		0.2	
	GCM Ensemble Range		1.2	
JJA	RCM (ECHAM4)		0.6	
	RCM (HadCM3)		0.4	
	GCM Ensemble Range		0.9	
SON	RCM (ECHAM4)		1	
	RCM (HadCM3)		1.4	

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 Anguilla by 0.79 hours per decade over the period 1983-2001. The strongest increase is seen In JJA at the rate of 1.23 hours per decade.

The number of sunshine hours is projected to increase slightly into the 21st Century in Anguilla by most GCMs, particularly in wet season reflecting reduction in average cloud fractions. The model ensemble, however, spans both increases and decreases in all seasons and across emissions scenarios. Changes in annual average sunshine hours span -0.8 to +0.9 hours per day by the 2080s under scenario A2. The median increases projected by the GCM ensemble are large in JJA and SON, but with changes spanning -1.3 to +1.6 and -0.6 to +1.2 hours per day respectively.

Comparison between GCM and RCM projections of sunshine hours for Anguilla shows that the RCM projections generally lie toward the higher end of the range of changes projected by the GCM ensemble. RCM projections indicate increases of roughly an hour per day in mean annual sunshine hours by the 2080s. Both RCM simulations indicate large increases in sunshine hours in JJA (1.3-1.5 hours per day) and in SON (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 Anguilla.

Anguilla: 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	-0.1	**0.0**	0.3	-0.4	**0.0**	0.5	-0.8	**0.3**	0.9
Annual	6.3	0.79*	*A1B*	-0.2	**0.0**	0.3	-0.5	**0.0**	0.6	-0.6	**0.0**	0.6
			B1	-0.4	**0.1**	0.4	-0.3	**0.0**	0.2	-0.5	**0.0**	0.5
			A2	-0.3	**0.1**	0.6	-0.3	**0.2**	0.4	-0.7	**0.1**	0.4
DJF	7	0.53	*A1B*	-0.3	**0.1**	0.2	-0.2	**0.0**	0.5	-0.5	**0.1**	0.4
			B1	-0.2	**0.0**	0.2	-0.3	**0.1**	0.2	-0.4	**0.0**	0.3
			A2	-0.3	**0.1**	0.3	-0.5	**0.1**	0.7	-0.8	**0.1**	0.7
MAM	6.6	0.84	*A1B*	-0.4	**0.0**	0.2	-0.4	**0.0**	0.5	-0.8	**0.0**	0.6
			B1	-0.5	**0.0**	0.8	-0.5	**0.0**	0.3	-0.6	**-0.1**	0.6
			A2	-0.5	**-0.1**	0.4	-0.8	**0.2**	1.1	-1.3	**0.5**	1.4
JJA	5.9	1.23*	*A1B*	-0.5	**0.1**	0.7	-1.1	**0.0**	1.6	-1.1	**0.3**	1.6
			B1	-0.5	**0.0**	0.7	-0.6	**0.1**	0.6	-0.8	**0.3**	1.2
			A2	-0.4	**0.1**	0.5	-0.4	**0.1**	0.4	-0.2	**0.4**	1.2
SON	5.5	0.46	*A1B*	-0.4	**0.0**	0.5	-0.9	**0.0**	0.7	-0.6	**0.2**	0.9
			B1	-0.5	**0.1**	0.4	-0.4	**0.1**	0.4	-0.5	**0.2**	0.7

Table 3.6.2: GCM and RCM projected changes in Anguilla under the A2 scenario.

		Projected changes by the 2080s SRES A2		
		Min	*Median*	*Max*
		Change in hours		
	GCM Ensemble Range	-0.8	**0.3**	0.9
Annual	*RCM (ECHAM4)*		**0.8**	
	RCM (HadCM3)		**1.3**	
	GCM Ensemble Range	-0.7	**0.1**	0.4
DJF	*RCM (ECHAM4)*		**0.6**	
	RCM (HadCM3)		**0.7**	
	GCM Ensemble Range	-0.8	**0.1**	0.7
MAM	*RCM (ECHAM4)*		**0.3**	
	RCM (HadCM3)		**1**	
	GCM Ensemble Range	-1.3	**0.5**	1.4
JJA	*RCM (ECHAM4)*		**1.3**	
	RCM (HadCM3)		**1.5**	
	GCM Ensemble Range	-0.2	**0.4**	1.2
SON	*RCM (ECHAM4)*		**1.2**	
	RCM (HadCM3)		**1.9**	

3.7. *Sea Surface Temperatures*

The HadSST2 gridded dataset indicate statistically significant increasing trend of 0.09˚C per decade in mean annual surface air temperatures around Anguilla. In particular, large increasing trends are observed in JJA (0.11˚C per decade) and in SON (0.12˚C per decade) in the waters surrounding Anguilla.

GCM projections indicate increases in sea-surface temperatures throughout the year. Projected increases range between +0.7˚C and +2.7˚C by the 2080s across all three emissions scenarios. The range of projections under any single emissions scenario spans roughly around 1.0 to 1.5˚C.

Table 3.7.1: Observed and GCM projected changes in sea surface temperature for Anguilla.

Anguilla: 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	0.4	**0.6**	0.8	1.0	**1.2**	1.7	1.6	**1.9**	2.7
Annual	27.3	0.09*	*A1B*	0.2	**0.6**	1.0	0.9	**1.4**	1.6	1.1	**2.2**	2.6
			B1	0.2	**0.6**	0.7	0.5	**1.0**	1.2	0.7	**1.3**	1.8
			A2	0.5	**0.6**	0.7	1.1	**1.2**	1.7	1.6	**2.2**	2.8
DJF	26.4	0.06	*A1B*	0.2	**0.6**	0.9	0.9	**1.4**	1.6	1.1	**2.1**	2.6
			B1	0.2	**0.6**	0.8	0.5	**1.0**	1.3	0.7	**1.3**	1.9
			A2	0.5	**0.6**	0.9	1.0	**1.2**	1.6	1.5	**2.2**	2.7
MAM	26.4	0.07	*A1B*	0.1	**0.6**	0.9	0.9	**1.4**	1.6	1.0	**2.0**	2.5
			B1	0.2	**0.6**	0.8	0.4	**1.0**	1.3	0.6	**1.3**	1.8
			A2	0.3	**0.7**	0.8	1.0	**1.2**	1.6	1.6	**2.0**	2.7
JJA	28	0.12*	*A1B*	0.2	**0.6**	0.9	0.9	**1.5**	1.6	1.0	**2.2**	2.6
			B1	0.1	**0.5**	0.7	0.6	**1.0**	1.1	0.8	**1.2**	1.8
			A2	0.4	**0.7**	0.9	1.0	**1.3**	1.8	1.5	**2.1**	2.9
SON	28.3	0.11*	*A1B*	0.2	**0.7**	1.1	1.0	**1.5**	1.9	1.2	**2.4**	2.8
			B1	0.2	**0.6**	0.8	0.6	**1.1**	1.3	0.8	**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 Anguilla.

GCM projections indicate increases in the frequency of 'hot' days by 35-95% of days and 'hot' nights by 35-94% of nights annually by the 2080s. The rate of increase varies substantially between models for each scenario, but is very similar throughout the year. 'Cold' days and nights do not occur at all in most models by the 2080s.

Table 3.8.1: Observed and GCM projected changes in temperature extremes for Anguilla.

Anguilla: 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	**47**	63	52	**72**	95
Annual			*A1B*				39	**48**	61	44	**66**	80
			B1				28	**37**	49	35	**47**	53
			A2				62	**69**	94	93	**97**	99
DJF			*A1B*				50	**73**	90	82	**95**	99
			B1				31	**47**	65	47	**66**	83
			A2				56	**74**	95	91	**98**	99
MAM			*A1B*				43	**77**	93	68	**98**	99
			B1				20	**50**	74	37	**76**	83
			A2				49	**79**	94	86	**98**	100
JJA			*A1B*				57	**80**	92	63	**95**	99
			B1				33	**60**	80	50	**80**	88
			A2				72	**89**	98	94	**99**	100
SON			*A1B*				75	**89**	99	90	**98**	100
			B1				50	**73**	88	74	**80**	95
Frequency of Hot Nights (TN90p)												
			A2				37	**46**	62	51	**74**	94
Annual			*A1B*				39	**48**	60	44	**64**	78
			B1				28	**37**	47	35	**47**	56
			A2				59	**65**	93	92	**96**	99
DJF			*A1B*				49	**68**	89	78	**93**	98
			B1				29	**47**	64	45	**62**	82
			A2				55	**71**	94	90	**97**	99
MAM			*A1B*				44	**75**	92	70	**96**	99
			B1				21	**48**	74	40	**73**	81
			A2				46	**76**	93	83	**98**	100
JJA			*A1B*				56	**78**	92	65	**95**	99
			B1				31	**62**	80	49	**77**	89
			A2				74	**86**	98	96	**99**	100
SON			*A1B*				75	**87**	98	90	**99**	100
			B1				50	**72**	90	73	**85**	95

Anguilla: 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 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**	1	0	**0**	0
			A2				0	**0**	0	0	**0**	0
MAM			*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	1	0	**0**	0
			A2				0	**0**	0	0	**0**	0
JJA			*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	5	0	**0**	0
			A2				0	**0**	0	0	**0**	0
SON			*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	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**	1	0	**0**	1
			A2				0	**0**	0	0	**0**	0
MAM			*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	1	0	**0**	0
			A2				0	**0**	1	0	**0**	0
JJA			*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	6	0	**0**	0
			A2				0	**0**	1	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 Anguilla.

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 -21% to +8% by the 2080s.

Maximum 1-day rainfall shows no consistent change by the 2080s, but maximum 5-day rainfall tends to decrease in model projections ranging from -23 mm to +16 mm annually by the 2080s.

Table 3.9.1: Observed and GCM projected changes in rainfall extremes for Anguilla.

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

Anguilla: Country scale changes in Rainfall Extremes												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
Maximum 5-day Rainfall (RX5day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2				-10	**-2**	13	-23	**-6**	15
Annual			*A1B*				-9	**-5**	15	-12	**-2**	7
			B1				-9	**-2**	22	-11	**-2**	16
			A2				-10	**0**	4	-4	**-1**	18
DJF			*A1B*				-5	**0**	7	-10	**-1**	4
			B1				-9	**-1**	7	-9	**0**	11
			A2				-6	**-2**	12	-10	**-3**	3
MAM			*A1B*				-6	**-1**	3	-11	**-4**	3
			B1				-5	**-2**	2	-5	**-2**	6
			A2				-14	**-5**	9	-34	**-3**	1
JJA			*A1B*				-15	**-4**	11	-36	**-6**	9
			B1				-12	**-2**	11	-14	**-2**	10
			A2				-10	**0**	11	-14	**-4**	17
SON			*A1B*				-8	**-2**	23	-14	**0**	12
			B1				-10	**0**	19	-12	**-1**	19

3.10. *Hurricanes and Tropical Storms*

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

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

Several analyses of global (e.g. Webster *et al.*, 2005) and more specifically North Atlantic (e.g. Holland and Webster, 2007; Kossin *et al.,* 2007; Elsner *et al.,* 2008) hurricanes have indicated increases in the observed record of tropical storms over the last 30 years. It is not yet certain to what degree this trend arises as part of a long-term climate change signal or shorter-term inter-decadal variability. The available longer term records are riddled with in homogeneities (inconsistencies in recording methods through time) - most significantly, the advent of satellite observations, before which storms were only recorded when making landfall or observed by ships (Kossin *et al.,* 2007). Recently, a longer-term study of variations in hurricane frequency in the last 1,500 years based on proxy reconstructions from regional sedimentary evidence indicate recent levels of Atlantic hurricane activity are anomalously high relative to those of the last one-and -a -half millennia (Mann *et al.,* 2009).

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

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

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

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

Table 3.10.1: Changes in Near-storm rainfall and wind intensity associated with Tropical storms in under global warming scenarios.

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

3.11. *Sea Level Rise*

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

There are large regional variations 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

Sea level rise rates at observation stations		
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 Keys, Florida	2.78 (+/- 0.60)	1971-2006

(Source: NOAA, 2009)

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

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

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

Table 3.11.2: Projected increases in sea level rise from the IPCC AR4

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

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

3.12. *Storm Surge*

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

1. Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed
2. Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms
3. Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm.

Sections 3.10 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 ANGUILLA

Vulnerability is defined as the "inherent characteristics or qualities of social systems that create the potential for harm. Vulnerability is a function of exposure… and sensitivity of [the] system" (Adger, 2006; Cutter, 1996 cited in Cutter et al. 2008, p. 599). Climate change is projected to be a progressive process and therefore vulnerability will arise at different time and spatial scales affecting communities and sectors in distinct ways. Participatory approaches to data collection were implemented in the Sandy Ground area to provide additional community-level data and field surveys at Cove Bay, Rendezvous Bay, Sandy Ground and Island Harbour 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 Anguilla.

According to the Government of Anguilla, the major issues of climate change are SLR and the likelihood of more intense weather systems and periods of drought. Rising sea levels are seen as the greatest potential impact, especially during intense storm swell conditions. The Department for Fisheries and Marine Resources is a government agency that makes the provision for protection of coastal ecosystems and habitats that directly and indirectly contribute to the stabilisation and protection of the coastline from extreme climatic events.

4.1. *Water Quality and Availability*

4.1.1. Background

Anguilla does not possess any lakes or rivers due to its porous limestone base which does not create conditions suitable for such topographical features. The freshwater present on the island exists subterranean, below which is located denser layers of salt water (Mukhida and Gumbs, 2006). This karst topography gives rise to groundwater located in pockets as well as one major lens in the Valley area. As Parr and Rogers (2002) describe "This water is brackish (typical total dissolved solids (TDS) concentration of 1,300 mg/l in the Valley aquifer and 2,500- 3,000 mg/l in other aquifers), and is generally considered to be unfit to drink. In addition, the groundwater yield is not sufficient to meet the long-term needs of the island". The capital, The Valley had the third largest share of the population, accounting for 10% of the total population of Anguilla in 2001. The other two populous administrative divisions were South Hill (13.4%) and North Side (10.4%) (Devonish, 2009).

Anguilla has utilised a mixture of ground water and desalination water to supply its water needs over the years as the territory's demand is greater than its supply. The Crocus Bay Water Treatment Facility owned by the private company Aqua Design was the main water provider which sourced water from Crocus Bay on the west of the island and processed it into potable water through reverse osmosis (The Anguillian, 2008). According to the 2005 Budget Speech of Anguilla, the company was delivering approximately 500,000 gallons of water per day during that period of time (MFT, 2005). However, water produced through desalination does not meet the water demand from all consumers on the island and is increasingly being supplemented by groundwater supplies.

The territory's groundwater well systems, which once was the main supply of water throughout the island, was closed down and abandoned due to contamination issues in the past (PAHO, 2007a). However, focus has again returned to the use of well water as plans were devised to develop a series of bore wells in the

Valley Bottom area (The Anguillian, 2008). The 2009 Government Budget allocated resources for the Valley well field and pump station in 2008 (MFEDICT, 2008). This year, a 10 year agreement to build a 500,000 gallon brackish water plant was signed between the Water Corporation of Anguilla and The Solutions Group Ltd (TSG) (The Anguillian, 2011a). Other wells that are privately operated produce water for commercial purposes including wells in Farrington, Mount Fortune in East End and Welches (Mitchell, 2007).

There are also a number of desalination plants run by the private sector, specifically geared towards tourism (PAHO, 2007a). One such plant is the Temenos Anguilla Sea Water Reverse Osmosis Plant which was commissioned by a private company, the Flag Anguilla Luxury Properties, LLC. The plant which has the capacity to produce 1.25 million gallons of water per day, can produce 480,000 gallons per day of potable water and with the remaining water used as irrigation water for the 18-hole golf course. This plant was completed in 2004. Other private water suppliers that source water from various wells on the island include the Anguilla Water Suppliers Ltd of Water Swamp, Charlie's Quick Water Delivery Service of Long Road and Vanterpool Water Delivery Services (Mitchell, 2007).

Rainfall in Anguilla is generally low , experiencing average annual rainfall of approximately 960 mm per year but this can range between as low as approximately 450 mm to as high as 2,000 mm depending on the number and intensity of storms affecting the island in a given year (DOE, 2009). Indeed, hurricanes and tropical storms hit Anguilla frequently – there were seven hurricanes between 1995 and 2008 (DOE, 2009).

Piped borne water, sourced from desalination plants is supplied by the Anguilla Water Department. Water is also sourced in other ways through the use of cisterns. Rainwater harvesting is utilised where rainwater is channelled to and stored in cisterns; water sourced in this way is free (Hope-Ross, 2004). There were some 1,251 cisterns on the island according to 2001 census data, though this figure may be much higher as it only takes into account households without private piped water (Government of Anguilla, n.d.-5). The use of cisterns is traditional and extensive on the island as a means to cope with the low rainfall patterns. While the quality of water is considered to be good, installing and refilling cisterns incurs additional costs to consumers (Halcrow Consultants Limited, 2002). Water may also be purchased from water trucks and again stored in cisterns, but this is considered to be a very expensive option. Another source of water involves the exploitation of bore holes but legal permission is required (Hope-Ross, 2004).

There is no central sewerage system on the island; septic tank soakaways are the main method used to treat sewage (PAHO, 2007a). Access of rural population to safe drinking water and excreta discharge was 97% between 1996 – 1998 (Halcrow Consultants Limited, 2002) while the 2001 country census found that 93% of the population used flush toilets, while 3.8% of households used pit latrines (PAHO, 2007a).

The estimated unaccounted for water in Anguilla was, 30% in 2005 (MFT, 2005) and 70% in 2008 of water purchased. Approximately 50% of the 2008 figure is due to theft of water (The Anguillian, 2008). Other major losses are due to damages in the piping system (MFT, 2005). The Country Poverty Assessment of Anguilla has found that water costs are considered to be high (Halcrow Consutlants Limited, 2002) which may be part of the reason that water is stolen. Additionally some standpipes were removed in certain areas resulting in the need for households dependent on this supply of water to source water further distances from their homes or from neighbours (Halcrow Consultants Limited, 2002). Indeed there were 206 standpipes in 1992 but only 59 in 2001 (Government of Anguilla, n.d.-5). There have been attempts by the Social Development Department to have the Anguilla Water Authority subsidise water (the first 1,000 gallons) for households who receive public assistance (Halcrow Consultants Limited, 2002). The percentage of persons that have stated that they utilise public water is relatively low. According to the 2001 census, 4.7% of the population use public sources of water which includes standpipes, cisterns, public wells (PAHO, 2007a). However, the circumstances of the population may have changed due to the deterioration of

Anguilla's economy between the 2001 census and the year 2008. Table 4.1.1 details the main water sources for households based on date from the 2001 census.

Table 4.1.1: Main source of water for households according to 2001 census data

	Cistern not piped	Private catchment piped	Public, piped into dwelling	Public, piped into yard	Public standpipe	Public well/tank	Other	Not stated
District Total	1,251	1,472	493	203	59	26	88	138
Percentage distribution (%)	34.8	41.0	13.7	5.7	1.6	0.7	2.4	-

(Source: Government of Anguilla, n.d. -5)

The water sector of Anguilla has few stakeholders. The main ones include the Anguilla Water Department, the Anguilla Water Co-operation, the Water Laboratory, hotels with desalination technology, private water suppliers, water trucking companies and the Anguilla National Trust.

In recent years expenditure has focused on road works and simultaneous replacement and installation of water pipelines in areas. In the 2009 Government Budget such places included North Side, Sea Feathers, Rock Farm, Sandy Hill, South Valley, North Valley, Stoney Ground School entrance, Campus A and Campus B. As noted earlier, rehabilitation of the Valley well field and pump station was also undertaken in 2008 (MFEDICT, 2008). In total in 2008, \$1.7 million dollars was spent on water development, and \$6.0 million on road works while the territory's recurrent expenditure that year was \$205.23 million. In the 2010 Government Budget, \$0.8 million was spent on road works at "the North Side link to Stoney Ground, roads in Island Harbour, the Quarter and other roads such as Liberty Road, the Long Path and the Stoney Ground Road". These works were undertaken to replace water supply lines, relocate utilities and improve of drainage infrastructure (MFEDICT, 2010).

Table 4.1.2: Water tariff for domestic and non-domestic users in Anguilla

	Water Usage (Imperial Gallons per Month)	Rate $EC ($US)
Small 'Domestic' Customers	≤ 1,000	$ 40.00 ($14.80) minimum
Small 'Domestic' Customers	1,000-3,000	$60.00 ($22.20) per 1,000 gallons
Small 'Domestic' Customers	3,000-5,000	$80.00 ($29.60) per 1,000 gallons
Small 'Domestic' Customers	> 5,000	$100.00 ($37.00) per 1,000 gallons
Large 'Commercial' Customers	0-10,000	$1,200.00 ($444.00) per 1,000 gallons
Large 'Commercial' Customers	10,000-20,000	$10.00 ($3.70) per 1,000 gallons
Large 'Commercial' Customers	20,000-40,000	$80.00 ($29.60) per 1,000 gallons
Large 'Commercial' Customers	>40,000	$60.00 ($22.20) per 1,000 gallon

Conversion rate utilised: EC $1=US $0.37
(Source: Anguilla Water Authority, 2011)

Table 4.1.2 shows the cost per 1,000 gallon for water in Anguilla. The cost of water increased when the Anguilla Water Authority became a private entity. They increased the cost of water which had a direct effect on the ability of the poorest sector of the territory to purchase potable water (Halcrow Consultants Limited, 2002). Anguilla has one of the highest water rates in the Caribbean, estimated at US $26.83/1,000 gallons. Countries with higher water rates include the Cayman Islands at US $74.97/1,000 gallons which is mainly due to the fact that all of its water is produced from seawater reverse osmosis and St. Kitts at US $32.3/1,000 gallons where water is sourced from both surface and groundwater supplies (Meyer-Steele, 2010). Aside from country specific factors and the price of oil, the cost of desalinated water is dependent on the scale of operations which effectively ties into economics as a larger plant produces water more efficiently. It is also dependent on the water sale agreement/lease as an agreement for a longer period of time would such as 20 years, would be more affordable than one required during a drought period emergency required for a period of only a few months of the year (Meyer-Steele, 2010).

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

A study entitled "The Potential Effects of Global Climate Change on Anguilla, British West Indies" identified the availability of freshwater as a resource vulnerable to climate change and that had the potential to affect economic activities in the territory (Hodge, 2004). Aside from the concern of the high cost of desalination water, there is also the issue of water quality from groundwater sources. The Government of Anguilla closed down wells on the island due to pollution concerns. The sources of contamination of Anguilla's ground water include dumped batteries, waste oil from toxic power station and gas station used oils, waste from package plants, pesticides and from septic tanks which could be easily leaked due to the porous nature of the soil (Mitchell, 2007; Richardson, 2009). The overall rapid development and increase in population of Anguilla in the last 20 years has also taken its toll on the environment (Richardson, 2009).

Table 4.1.3 shows impact ratings for certainty, severity and urgency of climate change impacts in the water sector, based on an assessment undertaken in the Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla. It also gives a summary of the varied issues related to water resources in the territory (DOE, 2009).

Table 4.1.3: Climate Change Response Chart

Climate Change Event/s	Certainty 1. Absolutely 2. Very Likely 3. Likely 4. Less Likely 5. Unlikely	Severity of threat/impact 1. Extreme 2. Very High 3. High 4. Low 5. Very Low	Urgency 1. Happening Regularly 2. Happening now (once per season) 3. Happening <5yrs (immediate threat) 4. Happening 5-10yrs (short term threat) 5. Happening 10-50yrs (long term)
Increase in the intensity of Hurricanes	1	2	1
- increase vector, pests and water borne diseases	2	3	3
Sea Level Rise	1	1	1
- Salt water intrusion	2	2	3
Change in Precipitation	1	1	1
- increase vector, pests and water borne diseases	1	1	3
- stress on critical infrastructure	1	3	3
- water quality/availability	1	2	3
Changing Weather Patterns	1	1	1
- impact on agricultural product/practices	1	2	3
- impact on Sewage treatment	2	4	1
- changes in fresh water supply (quality and quantity)	2	3	2
More extreme droughts, floods, tornadoes	1	1	1
- impact in finance sector	1	3	2
- more stress on natural resources	1	2	1
Tourism Sector	-	-	-
- increased operating costs; heat/cooling, insurance, water, etc	1	1	1
- increased water use	1	2	2

(Source: Taken from DOE, 2009)

Drought in Anguilla

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.

Anguilla is prone to drought conditions as it is one of the drier islands of the Caribbean region, experiencing average annual rainfall of approximately 960 mm per year but can range between as low as 450 mm to as high as 2,000 mm depending on the number and intensity of storms affecting the island in a given year (DOE, 2009) as such rainfall is often the passage of easterly waves, tropical depressions and tropical storms (Chase, 2008). As much as 65% of rainfall may be recorded during rainy season which spans June to December (Chase, 2008). GCM projections indicate a tendency for the likely reduction in precipitation in Anguilla by the 2080's. RCM models also indicate the potential for larger decreases in rainfall (See Section 3, Climate Modelling).

The effects of less rainfall represent one of the areas of greatest concern in Anguilla's water sector due to its already limited water resources and the importance of water to the tourism sector. Increased frequency of drought could cause "Such environmental change [that it] would increase the vulnerability of Anguilla communities and might constrain sustainable development over the next few decades, unless adaptive measures are taken now" (Sear *et al*., 2001). In the Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla it summarised that heat waves and drought conditions in the past have resulted in the need for increased water resources. Such events also caused crop harvests to fail and reduced crop yields, which in turn resulted in the need for increased importation. Increased importation subsequently resulted in increases in food prices (DOE, 2009). The territory is particularly vulnerable in El Nino years which puts Anguilla at risk "from seasonal drought, variable water supply and diminishing water resources" (Sear *et al*., 2001).

Globally, agricultural water use comprises around 70% of total water extractions (Wisser *et al.*, 2008) yet, in the drier, warmer environment expected under climate change in the Caribbean, irrigation water demand is likely to increase, exacerbating the effects of decreases in water availability (Döll, 2002). Drier periods in the future would mean less water available for irrigation (Hodge, 2004) and increased evaporative demands under climate change may lead to reductions in irrigation efficiency (Fischer *et al.*, 2007). Careful consideration will need to be given to efficient irrigation practices and technology to reduce wastage and increase the amount of water reaching the crop, estimated to be as low as 40% worldwide (Pimentel *et al.*, 1997). Agricultural output in Anguilla is already affected by the high cost of water along with low annual rainfall values combined with unsuitable soils (Halcrow Consutlants Limited, 2002).

Coastal Aquifers and the Potential for Saline Intrusion

Coastal aquifers are threatened by seawater intrusion with rising sea levels, exacerbated by a decrease in groundwater recharge through over-abstraction and decreasing precipitation (Bates *et al*., 2008; Lewsey *et al*., 2004; Werner and Simmons, 2009). A rise in sea level as low as 0.1 m may cause a decreases in aquifer thickness of more than 10 m (Bobba *et al*., 2002), leading to substantial declines in freshwater availability. Reductions in groundwater recharge to inland aquifers can also lead to seawater intrusion if they are next to saline aquifers (Chen *et al*., 2004), indicating a potential knock-on effect where coastal aquifers become saline due to 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 mm 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).

Rising sea level could affect ground water resources through salinisation of coastal aquifers in Anguilla (DOE, 2009; Sear *et al*., 2001). Saline intrusion into soils is also cause for concern (DOE, 2009).

Flooding

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

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

Numerous areas are low lying and vulnerable to storm surge, storm run-off and sea level rise. Low-lying areas include Sandy Ground, East End and the Valley (Bottom) and other coastal areas such as Island Harbour (DOE, 2009). Hurricane Lenny dumped as much as 4.6 m of water in some places of Anguilla causing widespread flooding. It took around two weeks for waters to recede (Hodge, 2004). During heavy rainfall events freshwater supplies are vulnerable to flooding and contamination from sewerage systems (Hodge, 2004). Past weather patterns and climate regimes have also reduced mobility and services for extended periods of time, which has had an effect on fuel delivery due to poor sea conditions (DOE, 2009). This in turn has the potential to affect the operational costs of water produced from desalination.

4.2. *Energy Supply and Distribution*

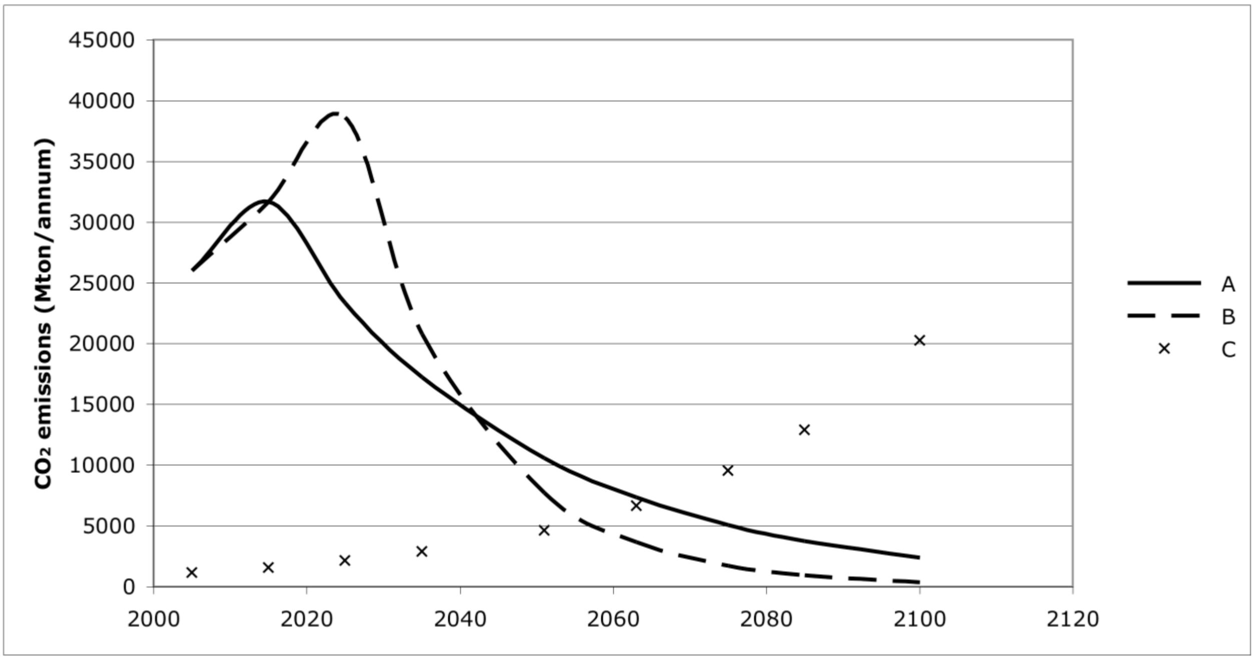
4.2.1. Background

A global perspective

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

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

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



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

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

(Source: Scott *et al.*, 2010)

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

The Caribbean perspective

It is widely acknowledged that the Caribbean accounts for only 0.2% of global emissions of CO_2, with a population of 40 million, i.e. 0.6% of the world's population (Dulal *et al.*, 2009). Within the region, emissions are however highly unequally distributed between countries (Figure 4.2.2). For instance, Trinidad & Tobago, as an oil-producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. Anguilla is, so far, emitting about as much (4.0 t CO_2, in 2006; UNSTATS, 2009) on a per capita basis as the world annual average of 4.3 t CO_2. In the future, global emissions have to decline considerably below 4.3 t CO_2 per year; the IPCC suggests a decline in emissions of 20% by 2020 (IPCC, 2007), corresponding to about 3 t CO_2 per capita per year, a figure that also considers global population growth. While there is consequently room for many countries in the region to increase per capita emissions, including in particular Haiti, many of the more developed countries in the Caribbean, including Anguilla, will need to adjust per capita emissions budgets downwards, i.e. reduce national emissions in the medium-term future.

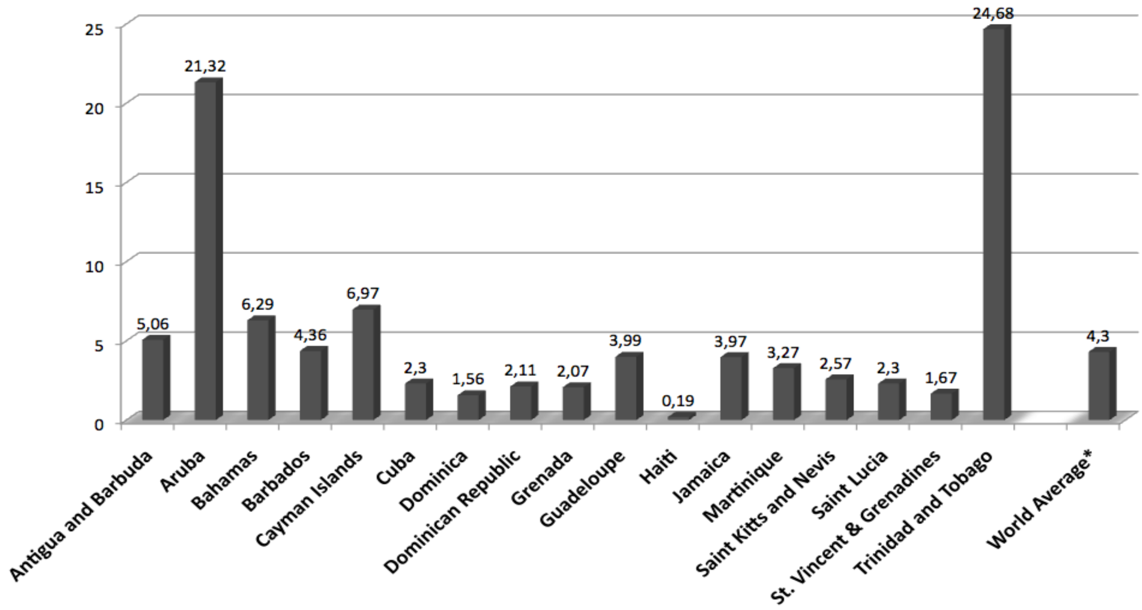


Figure 4.2.2: Per capita emissions of CO_2 in selected countries in the Caribbean, 2005

(Source: Hall *et al*., 2009)

Important in the context of this report is that in most Caribbean countries, tourism is a major contributor to emissions of greenhouse gases (Simpson *et al*., 2008; see also country reports in the Risk Atlas). As these emissions are not usually quantified, the purpose of this assessment is to look in greater detail into energy use by the sector.

Anguilla

Tourism's overall contribution to the Anguilla economy is of the order of 60% (Halcrow Consultants Limited, 2002; UNDP, n.d.; RLB, 2010; DOE, 2009), with the hotels and restaurant sub-sector contributing 20% of GDP in 2009 (ECCB, 2009) or 22.6% according to the Caribbean Tourism Organisation (Caribbean Tourism Organisation, n.d.). Tourist arrivals grew from 36,280 in 1995 to 61,998 in 2010, with a peak of 77,652 in 2007. The number of cruise ship passengers has oscillated considerably between a low of 48,741 in 1996 to a peak of 94,283 in 2006 and has stabilised at around 57,000 in the last three years (Halcrow Consultants Limited, 2002; Caribbean Tourism Organisation, n.d.; Statistics Department, n.d.; OECS, 2010). Along with the growth in tourism, and the economy more generally, it can be assumed that there has also been growth in energy consumption.

Anguilla currently produces its electricity with imported diesel fuel, with one central generating plant owned and run by ANGLEC, which currently holds a monopoly on production and distribution of electricity island-wide (B. Barry, Anguilla Renewable Energy Office personal communication, April 6, 2011). Available statistics for electricity production (see Table 4.2.1) show considerable growth in electricity generation and fuel consumption. It is unclear how trends will develop given that tourism investments have been halted or delayed because of the global financial crisis in 2008. No further information could be found on bunker fuels, gasoline, or emissions of greenhouse gases.

Table 4.2.1: Growth trends in energy consumption in Anguilla, 2001-2009

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Gross generation (MWh)	53,000	55,000	58,000	62,032	72,041	79,507	88,999	89,502	91,223
Net generation (MWh)				55,755	63,601	70,561	78,854	78,934	79,918
Fuel used (thousand IG)	2,900	3,100	3,300	3,500	4,233	4,399	4,830	4,872	4,839

(Source: ANGLEC, 2006; ANGLEC, 2010)

In the absence of detailed data on fuel use in tourism, the following section provides a bottom-up analysis to derive an estimate of emissions in this sector (Table 4.2.2).

Table 4.2.2: Assessment of CO_2 emissions from tourism in Anguilla, data for various years.

Tourism sub-sector	Energy use	Emissions	%	Assumptions
Aviation[1)]	5,976 t fuel	18,825 t CO_2	41	Bottom-up calculation based on market shares
Road transport[2)]	52 t fuel	156 t CO_2	<1	Including tourists, not day visitors
Cruise ships[3)]	2,864 t fuel	9,164 t CO_2	20	Based on global average
Accommodation[4)]	10.2 GWh	10,189 t CO_2	22	Based on energy statistics from Barbados
Activities[5)]	-	1,563 t CO_2	3	Global average
Sub-total		39,896 t CO_2	87	
Indirect energy use (factor 1.15)		5,984 t CO_2	15	To account for life-cycle emissions
Total	8,892 t fuel	45,880 t CO_2	100	

1) Aviation fuels: there were 57,891 tourist arrivals in 2009, with major markets including the USA (58.9%), Europe (12.9%) and the Caribbean (22.3%) (Caribbean Tourism Organisation, n.d.). Consequently, aviation would have consumed (bunker fuel approach, i.e. only including fuels for travelling from Anguilla to country of origin): USA (34,098 tourists x 2,765 pkm (New York) x 0.120 kg CO_2 = 11,314 t CO_2), Europe (7,468 tourists x 6,601 pkm (London) x 0.120 kg CO_2 = 5,916 t CO_2), Caribbean (12,910 tourists x 500 pkm x 0.120 kg CO_2 = 775 t CO_2) plus other countries (5.9%; 3,416 tourists x 2,000 pkm x 0.120 kg CO_2 = 820 t CO_2), i.e. 18,825 t CO_2.
2) Road Transport: 57,891 international tourist arrivals in 2009, with each tourist travelling an assumed 20 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 2.7 kg CO_2 per tourist, totalling 156 t CO_2, or about 52 t of fuel. Cruise tourists are not included.
3) At the standard per day value (global average) of 169 kg CO_2 per passenger (Eijgelaar *et al*., 2010), the 54,224 cruise passengers in 2009 would have caused emissions of 9,164 t CO_2 (assuming one day of cruise travel is ascribed to Anguilla).
4) According to a study carried out in Barbados in 2010, hotels (n=22) used on average 22 kWh of energy per guest night. This value is also used for Anguilla. At an average length of stay of 8 nights in 2009, the 57,891 guests would have stayed 463,128 nights, with a corresponding energy use of 10.2 GWh. Beth Barry (Anguilla Renewable Energy Office, personal communication, April 27, 2011) reports that the island's tourism sector accounts for approximately 8MW of island wide consumption, i.e. 2/3 of the overall average of 12 MW. Electricity production is assumed to be less efficient in Anguilla, and a value of 1 kg CO_2 per kWh is assumed here, resulting in emissions of 10,189 t CO_2.
5) Activities are included with the global assumption of 27 kg CO_2 per tourist, as provided in UNWTO-UNEP-WMO, (2008). Given the energy-intense character of many activities in tropical environments, including boat trips, scenic drives, helicopter flights, diving, the use of jet skis, or water skiing, this value may be conservative. The 57,891 tourists would thus have caused emissions from activities corresponding to 1,563 t CO_2. As energy use for activities will be partially fossil fuel, and partly electricity based, it is difficult to translate these values into energy use.

(Source: DEFRA, 2010; Halcrow Consultants Limited, 2002; Caribbean Tourism Organisation, n.d; Statistics Department, n.d.; OECD, 2010; UNWTO-UNEP-WMO, 2008; UNWTO, 2010)

Table 4.2.2 shows the distribution of energy use by tourism sub-sector. Note, however, that this estimate is based on various assumptions and does not reflect the considerably greater overall amount of energy needed to maintain the tourism system of Anguilla. Results indicate that emissions from tourism accounted for 45,880 t CO_2 in 2009. Given an estimated 4 t CO_2 per capita per year, and a population of about 15,000 people, total emissions would have been in the order of 60,000 t CO_2 in 2009. The estimate of tourism emissions calculated indicates that the sector would correspond to 76% of national emissions.

Policy response to energy challenges

Anguilla identifies its dependence on fossil fuels as a threat to its economy with the growing number of vehicles and imports of consumer goods, as well as the production of fresh water, being key issues in energy management. Wind and solar power are to be developed to reduce the island's dependence on fossil fuels in the short term and to achieve energy independence in the long term (Government of Anguilla, 2008). Overall, the Government seeks to promote Anguilla as a "worldwide leader in environmental responsibility, to the benefit of local pride and competitiveness in the tourist industry, and as a model of these values among other island communities and beyond" (Government of Anguilla, 2008: 6).

The most important aspects of Anguilla's National Energy Policy, which was approved in December 2009, include:

- i) reducing the island's dependence on fossil fuels for power generation and transportation;
- ii) using locally available renewable resources such as wind and solar power and providing finance;
- iii) developing technological education and expertise in the renewable power generation sectors in Anguilla to create a local skill base including the establishment of a long-term task force to stay abreast of innovations in renewable energy technologies;
- iv) promoting "aggressive" energy efficiency measures amongst government, civil society and the private sector, including the enhancement of performance in the electricity sector;
- v) making a transition from primarily diesel-based to renewably-based power generation;
- vi) developing a legislative framework for customer-generated renewable power and building broad community involvement; and
- vii) shifting fiscal incentives in the transport sector from fossil fuel powered vehicles to those that are powered by hybrid, electric and hydrogen technologies.

The Government underlines its belief that its energy policy will help the island gain promotional advantage, and thus be beneficial for tourism:

> *A calculated effort to turn Anguilla "green" in fundamental and meaningful ways will be an enormous boon to the promotional efforts of public institutions and private entities that are so reliant on the tourist trade. An Anguilla that can someday boast that its source of energy is sunshine and cool breezes and its mode of transport is essentially oil free will remain an island of choice for the conscious and discerning visitor, and an island remaining true to its natural heritage (Source: Government of Anguilla, 2008: 9).*

In order to develop the renewable energy sector the Policy identifies the need for establishing and updating legislation and regulations for promoting energy efficiency and utilisation of renewable energy as well as implementing appropriate pricing policies to ensure that adequate energy supplies are delivered to all economic sectors efficiently. The use of incentives to encourage private sector investments in renewable energy technologies and the promotion of renewable energy through the educational system and public awareness campaigns are also considered to be important strategies. It is also recommended that the feasibility of blending fossil fuels with bio-fuels for electricity generation should be assessed to reduce consumption of fossil fuels.

The strategies identified for the transportation sector include incentives and taxation policies that promote the importation of smaller engine, more fuel-efficient and diesel-powered vehicles and hybrid, flexi (biofuel-based) and electric vehicles. It is also stated that fuel-efficient vehicle import standards will be established along with data collection on vehicle imports and vehicle emission standards will be rigorously enforced. Public transport will be revisited with the establishment of a reliable, frequent, high-quality mass transport system using a high efficiency fleet. There are no specific policy recommendations for cruise ship or air transportation, two of the largest contributors to emissions and energy consumption in the tourism sector.

Efficiency in the generation, distribution and use of electricity is another area of focus in the National Policy with recommendations to look at partnering with neighbouring utilities for collective purchasing and fuel storage, implementing time-of-use tariffs and demand tariffs to reduce customer electricity usage (Demand Side Management) and promoting energy efficient technologies for generation, transmission and distribution. Promotion of energy conservation to customers through product labelling and standards as well as incentives for energy efficient lighting and new high-efficiency appliances and disincentives for incandescent bulbs, inefficient refrigerators, air conditioners etc. is put forward as a recommendation. Regular monitoring of the operational efficiency of the utility and making appropriate amendments to the Electricity Act and associated Regulations are also identified as tasks to be completed. Some alternative agreements identified that could be developed include partnering with customers with large standby generator facilities to provide additional capacity if or when required and allowing feed-in from small independent renewable energy sources such as solar panels and wind turbines. A National Energy Code for buildings, which addresses building for energy efficiency is required and should demand that all new buildings meet or exceed minimum standards that provide a cost effective degree of energy efficiency through natural lighting and ventilation, air-conditioning through extensive shading, water heating, and electrical power requirements. Energy audits should be introduced as regular and standard practice in all commercial, industrial and residential structures.

Some of the suggestions for financing the move to renewable energy and greater energy efficiency include accessing international financing resources through the carbon credit market, commercial bank financing with special rates for consumers and businesses investing in energy saving and renewable energy solutions and venture capital financing for research development and pilot testing of renewable and alternative energy technologies and systems. Tax concessions to consumers and businesses investing in energy saving and renewable energy solutions should also be provided.

There are additional policy recommendations regarding the administration and promotion of the energy independence campaign. These include: establishing a permanent Energy Committee for the overall supervision and co- ordination of the Energy Policy, with a professional PR/Marketing/Outreach position as a permanent member or consultant; developing a ‘brand’ for the awareness campaign based on an analysis of all stakeholder groups requirements; creating a network among civic, church, educational, and community groups to gain input, support, and participation in the Plan and its implementation; and coordinate efforts with the Anguilla Tourist Board and the Anguilla Hotel and Tourism Association toward marketing and educating tourists about Anguilla’s Energy Independence Plan.

The Anguilla Renewable Energy Office (AREO) was founded in 2008 to promote a transition to renewable energy production on Anguilla. The Anguilla Model is a 10-year plan to achieve a replicable (in other small island states) transition from Anguilla's traditional fossil-fuel based economy to a renewable energy based economy (McQuillan, 2011). Funds have been sourced through the Government of Anguilla and the [UK] Overseas Territories Environment Programme (OTEP) to support a local Renewable Energy Co-ordinator position and to establish the Office. "The project's initial goals are to seek energy efficiencies nationwide and to establish substantial renewable energy production on Anguilla in the shortest possible time-frame, … This first phase deployment will focus on solar, wind, and waste-to-energy technologies" (AREO, n.d.). The office is currently focusing on facilitating a change to Anguilla's Electricity Act that will allow for grid integration of customer-sited renewable energy systems as well as an agreement between ANGLEC and independent power producer Windwatt LLC, the group that has implemented a small wind farm in Nevis (B. Barry, Anguilla Renewable Energy Office, personal communication, April 27, 2011). Other areas to be pursued under the Anguilla Model include solar photo-voltaic and hot water, waste stream management and waste-to-energy, electric transportation and soil building and local food production (B. Barry, Anguilla Renewable Energy Office, personal communication, April 27, 2011).

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 stabilizing temperatures at 2°C by 2100 is taken seriously, both regulation and market-based instruments will have to be implemented to cut emissions of greenhouse gases. Such measures would affect the cost of mobility, in particular, air transport, being a highly energy- and emission-intense sector. The following sections will discuss past and future energy costs, the challenges of global climate policy and how these interact to create vulnerabilities in the Anguilla tourism sector and the vulnerability of the energy sector infrastructure to the physical impacts of climate change.

Energy costs

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

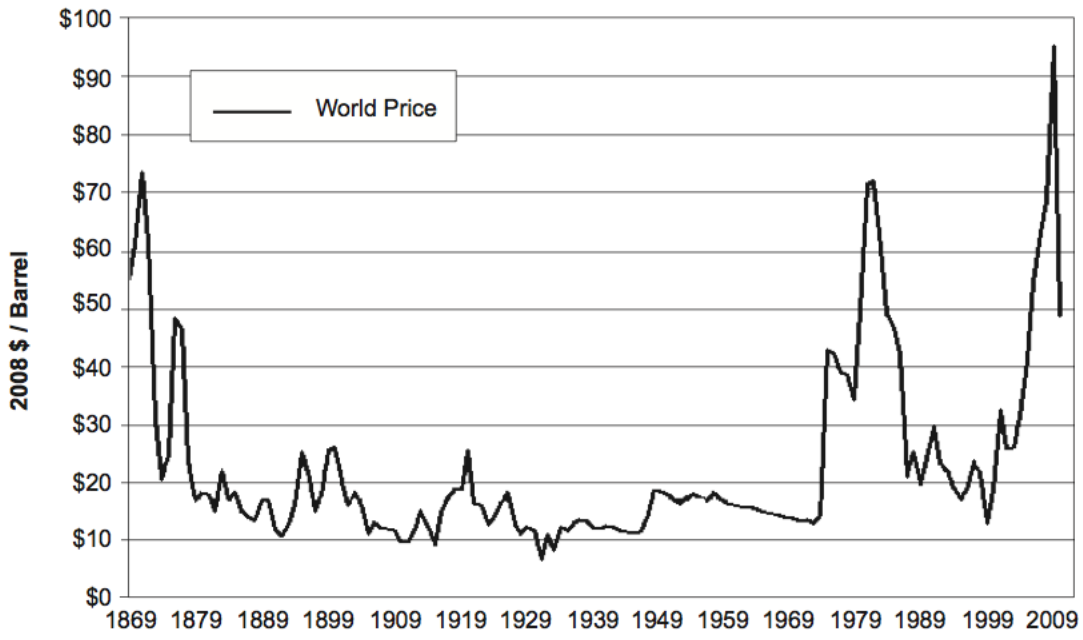


Figure 4.2.3: Crude oil prices 1869-2009

(Source: after Williams, 2010)

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

These findings are relevant for the tourism system as a whole because mobility is a precondition for tourism. Rising oil prices will usually be passed on to the customer, a situation evident in 2008, when many airlines added a fuel surcharge to plane tickets in order to compensate for the spike in oil prices. Increased travel costs can lead to a shift from long haul- to shorter-haul destinations. The cost of energy is one of the most important determinants in the way people travel, and the price of oil will influence travel patterns, with some evidence that in particular low-fare and long-haul flights are susceptible to changes in prices (e.g. Mayor and Tol, 2008). Moreover, it deserves mention that oil prices are not a simple function of supply and demand, 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 from 2002 to 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, the International Air Transport Association (IATA) projected the average 2008-price of a barrel of oil at US $87, up 6% from the average price level in 2007 (IATA, 2007). In early 2008, IATA corrected its projection of fuel prices to an average of US $106 per barrel for 2008, an increase of 22% over its previous estimate. However, in July 2008, oil prices reached US $147 per barrel, and IATA corrected its forecast for average oil prices in 2008 to almost US $142 per barrel, a price 75% higher than a year ago (IATA, 2008). In autumn 2008, again seemingly unexpected by the overwhelming majority of actors in tourism, the global financial system collapsed due to speculation of financial institutions with various forms of investment. As a result, the global economy went into recession, and by the end of 2008, oil prices had reached a low of US $40 per barrel.

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

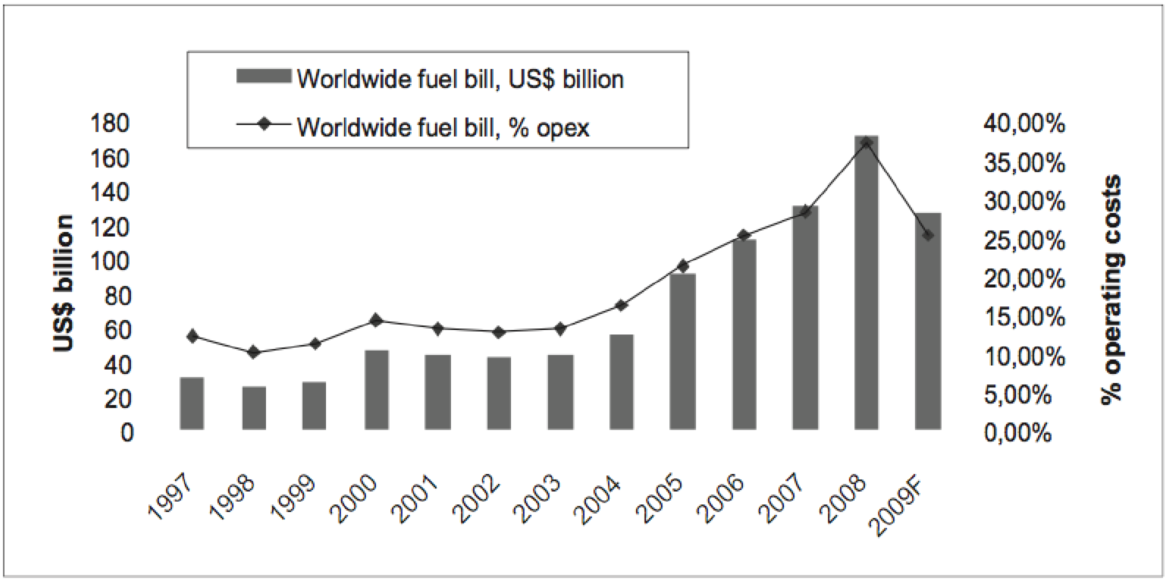


Figure 4.2.4: Fuel costs as part of a worldwide operating cost

(Source: IATA, 2009)

Climate policy

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

As of November 1, 2009, the UK introduced a new air passenger duty (APD) for aviation, which replaced its earlier, two-tiered APD. The new APD distinguishes four geographical bands, representing one-way distances from London to the capital city of the destination country/territory, and based on two rates, one for standard class of travel, and one for other classes of travel (Table 4.2.3).

Table 4.2.3: UK air passenger duty as of November 1, 2009

Band, and approximate distance in miles from	In the lowest class of travel (reduced rate)		In other than the lowest class of travel* (Standard rate)	
	From November 1, 2009 to October 31, 2010	From November 1, 2010	From November 1, 2009 to October 31, 2010	From November 1, 2010
Band A (0-2,000)	£11	£12	£22	£24
Band B (2,001-4,000)	£45	£60	£90	£120
Band C (4,001-6,000)	£50	£75	£100	£150
Band D (over 6,000)	£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).

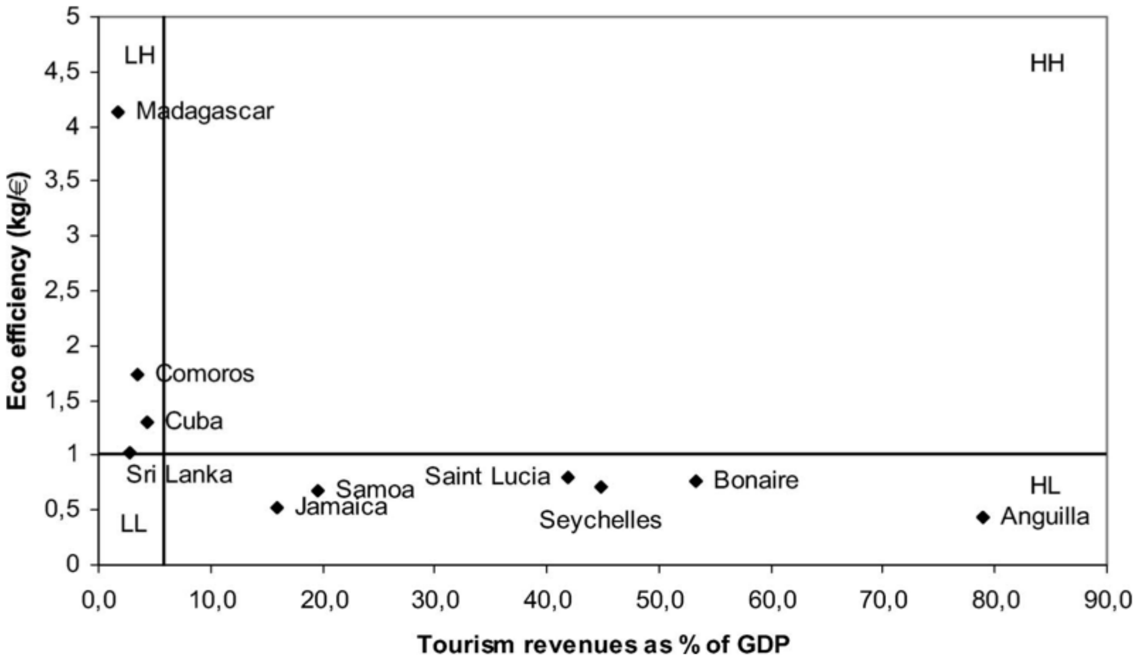
There is consequently growing consensus among business leaders and policy makers that emissions of greenhouse gases represent a market failure. The absence of a price on pollution encourages pollution, prevents innovation, and creates a market situation where there is little incentive to innovate (Organization of Economic Co-operation and Development (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 4.2.5 shows this for various islands, expressed as a risk assessment considering the share of tourism revenues as percentage of GDP and the energy intensity of the tourism product expressed as eco-efficiency. According to this analysis Anguilla has an extremely high dependency on tourism revenue, even though the eco-efficiency is favourable.



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

Figure 4.2.5: Vulnerability of selected islands, measured as eco-efficiency and revenue share

(Source: Gössling *et al*., 2008)

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

The implications of the EU ETS for tourism in island states were modelled by Gössling *et al*. (2008). The study examined the implications of the EU-ETS for European outbound travel costs and tourism demand for ten tourism-dependent less developed island states with diverse geographic and tourism market characteristics. It confirmed that the EU-ETS would only marginally affect demand to these countries, 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 emphasize that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020 (Source: Pentelow and Scott, 2010).*

A detailed case study of Jamaica further revealed the different sensitivity of market segments (package vacations) to climate policy and oil price related rises in air travel costs (Pentelow and Scott, 2010; see also Schiff and Becken, 2010 for a New Zealand study of price 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 (Small Island Developing States (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.

Anguilla’s energy production is entirely based on one diesel powered plant with efforts underway to look at wind, solar and waste-to-energy systems. Potential physical climate change impacts specific to traditional energy production systems as well as the renewable technologies being considered by the Government for Anguilla 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 Anguilla 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. In 2008, Hurricane Omar affected both the power station and the transmission and distribution system with the switchboard at the power station out of service for 12 hours due to rainwater penetration and some poles uprooted and a transformer needing replacement (ANGLEC, 2009).

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) and it would be recommended that any wind power systems installed in Anguilla have similar capabilities. In the aftermath of extreme weather, the process of restoring transmission and proper operation of generating facilities depends on road access and the amount of supplies available to replace infrastructure components that have been damaged or destroyed. The vulnerability of the sector to extreme weather events therefore has even greater implications for increasing the recovery period and extending the loss of productivity in all other sectors within the country following an event (U.S. Department of Energy/National Energy Technology Laboratory, 2007; IPCC, 2007b; Contreras-Lisperguer & de Cuba, 2008).

Model projections for Anguilla suggest an increase in mean annual temperatures, as well as the number of ‘hot’ days and nights to as much as 95% of the days per year by 2080, and a possible disappearance of ‘cold’ nights (see Section 3). National energy demand and consumption for heating and cooling purposes may increase in response to extremes in diurnal temperatures and this was acknowledged by residents at the National Stakeholder Workshop. Higher temperatures have also been shown to reduce the efficiency of energy generation at thermal power plants, similar to the Corito Power Station in Anguilla, which was also acknowledged by the energy sector participant at the National Stakeholder Workshop. 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 Section 4.1). Similar impacts are likely to apply to waste-to-energy systems.

Anguilla is pursuing renewable energy projects utilising wind and solar power. 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 are inconclusive for projections of wind speed changes (see Section 3). Similarly, changes in solar radiation incidence and increases in temperature can impact the effectiveness of electrical generation by photovoltaic cells and solar thermal energy collection. The projected increase in the number of sunshine hours for Anguilla over the next few decades, however, increases the viability of using photovoltaic technology – even if only on the basis of increasing incidence of sunshine (IPCC, 2007b; Contreras-Lisperguer & de Cuba, 2008).

Climate change, ocean-based impacts on the energy system include storm surge events and SLR. These processes are a threat primarily to infrastructure located within the coastal zone, and within the impact range of these events.

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

4.3. *Agriculture and Food Security*

4.3.1. Background

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

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

4.3.2. The Importance of Agriculture to National Development

Agriculture contributes only 2.4% to Anguilla's economy, thus agriculture has a high import dependence (Anguilla Statistics Department, 2010). Crop and livestock production is done on a very small scale, although fishing is an important cultural and economic activity. Little of the island's thirty-five square miles is devoted to organised agriculture, but efforts are now being made to encourage wider cultivation of fruits, vegetables, and crops such as corn and pigeon peas.

4.3.3. An Analysis of the Agricultural Sector in Anguilla

Samuel (2011) discerns that the agricultural system in Anguilla is replete with opportunities from the point of view that local production of vegetables, fruit, fish, meats, eggs and dairy products are miniscule in comparison to the dollar value of food imported into the island. The food import bill is approximately 87 million EC dollars and the fresh vegetable and fruit bill is over 18 million EC dollars. The table below shows the value of selected food imports in Anguilla for the period 2005 to 2008.

Table 4.3.1: Value of Selected Food Imports to Anguilla 2005 – 2008 (EC $ 000)

Items	2005	2006	2007	2008
Poultry	3,676	3,723	4,728	5,424
Other meat	4,190	4,675	5,375	5,320
Fish	3,088	3,815	4,332	4,307
Dairy	4,474	5,059	6,319	5,974
Eggs and egg substitutes	170	245	388	505
Vegetables	4,829	5,610	6,452	5,686
Fruits and nuts	3,426	4,099	4,444	3,486
Coffee. Tea	388	396	423	450
Rice	602	695	992	1,356
Flour	704	809	949	1,444
Oils and fats	891	1,148	1,226	1,392
Margarine	661	432	502	645
Sugar	17,138	12,624	623	540
Water	2,305	3,103	4,328	4,377

(Source: Anguilla Statistical Department, 2010)

The Government of Anguilla has made plots of Crown Land in the Valley and Wallblake available for farming; and over the past few years vegetable production, through the use of traditional and modern methods, has increased as illustrated in the table below.

Table 4.3.2: Production of Field Crops by Quantity (Tons) & Value (EC $): 2007 - 2009

Crops	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Corn (maize)	3.57	42,840	4.5	31,500	7	49,000
Sorghum	0.04	800	1.5	30,000	2	40,000
Pigeon peas	1.87	29,920	2.5	40,000	3	48,000
Sweet potatoes	0.94	9,400	2	20,000	3	30,000
Sweet peppers	1.95	17,550	3.5	35,000	4	36,000
Limes	0.03	240	0.03	210	0.3	2,400
Mangoes	0		0.5	3,000	0.5	3,000
Cabbage	0.54	2,700	3.5	21,000	4.5	22,500
Lettuce	24.325	109,463	0	112,500	0	
Pumpkin	0.56	3,080	1	6,000	2.5	13,750
Carrots	0.06	480	0.06	480	1	8,000
Tomatoes	9.00	103,500	10	120,000	11	125,500
Yams	0.25	2,000	0.25	2,000	0.5	4,000
Egg plants	1.87	13,090	4.5	36,000	5	35,000
Onions	0		0		0.2	1,200
Broad beans	0		0		1	7,000
Water melon	19.39	87,255	2	10,000	3	13,500
Sweet gourd	0		0		0.25	1,000
Pawpaws	0		0.25	1,500	1	6,000
Beets	0.01	60	0.02	120	0.02	120
Kale, thyme and parsley	0.36	21,600	0.5	30,000	0.5	30,000
Cucumber	5.95	44,625	6.5	52,000	6.5	48,750
Broccoli	0		0.5	4,000	0.5	4,000
String beans	0		0.25	2,000	0.25	2,000
Chives	0.69	6,900	1	10,000	1	10,000
Cassava	0.28	1,960	0.25	2,250	0.25	1,750
Okra	0		0		0	
Total	**71.686**	**487,483**	**46.11**	**569,560**	**68.77**	**557,220**

(Source: Anguilla Statistical Department, 2010)

Anguilla has the propensity to cut down on some of its food imports and save foreign exchange by creating an enabling environment for farmers to produce and supply a greater percentage of staple foods. The statistical department reports that in 2010, Anguilla imported 99 tonnes (99,000 kg) of tomatoes and local farmers produced approximately 15 tonnes. Local consumption of tomatoes is about 114 tonnes per annum and with over 637 acres of arable land available in Anguilla, production potential for tomatoes and other staple foods is promising if even half of this acreage is used.

4.3.4. Women and Youth in Anguillan Agriculture

According to the Labour Force Survey (Anguilla Statistics Department, 2001), only 2% of the working population is employed within the agriculture and fisheries sector. Of these approximately 135 persons, none are women. However, Samuel (2011) observes that in recent years, young persons have been slowly moving into the sector recognising that there are potentially lucrative markets that can be acquired with commitment to new technology and hard work. CalTel Farms and Island Greens are two such examples of Anguillan enterprises that are owned and managed by young men.

Furthermore, since the youth represent the majority in food consumption In Anguilla, Samuel (2011) suggests that local organisations such as The Anguilla National Youth Council and the National Youth Ambassador Corps should be actively involved in transforming local agriculture.

4.3.5. Climate Change Related Issues and Agricultural Vulnerability in Anguilla

Like other Caribbean countries, Anguilla’s agriculture sector is susceptible to periods of drought and excessive heat interspersed with extreme weather events. Storm surges caused by tropical storms and hurricanes also have the potential to wipe out crops on this very flat island. Hurricane Earl in 2010 caused extensive damage throughout the island and while the monetary value of damage to the agriculture sector has not been substantiated, some comparison can be made to when Hurricane Luis, which was also a category 4 system, hit the island in 1995. Damages to the agriculture sector at that time were estimated to be US $98,000 in physical infrastructure US $30,000 for direct losses to crops and US $5,000 for indirect production losses (ECLAC, 1995). Full recovery of Anguilla’s pre-disaster size and production levels took approximately two growing seasons.

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

According to background data from a Soils Amelioration Project launched in July 2010 by the Agriculture Department and the Environmental Department, local arable soils in Anguilla are heavily degraded, infertile, low in organic matter, and have the potential to become unstable. Added to this, approximately 40% of the arable land around the island is fallow or potentially being developed with infrastructure (UKOTCF, 2010). The main vulnerability feature influencing food security in Anguilla is the paucity of land resources available for facilitating agricultural resilience.

A second vulnerability factor is poor agricultural land management practices that accelerate the degradation of arable soils. Arable lands account for roughly 639 acres on the island but 60% of this is shared between agricultural production and infrastructural development especially in the Valley area which is Anguilla's food belt. Arable soils are consistently sold as top soil for use in developmental projects

(UKOTCF, 2010). The degrading of agricultural property by excavation obstructs food production and leads to destruction of an expensive and irreplaceable resource.

4.3.7. Social Vulnerability of Agricultural Communities in Anguilla

While in most Caribbean countries, there is a distinction made between rural and urban areas to broadly describe the residential location of their populations and to illustrate differences in the socioeconomic features, neither a political nor geographical classification of rural and urban areas has been established in Anguilla over its history of census (CARICOM, 2001).

The scarcity of agricultural communities in Anguilla is itself a threat to agriculture and food security. The critical social vulnerability factor in this regard is the lack of social adjustment to building agricultural capacity for Anguillans to produce their own food in the face of a changing climate. A second vulnerability factor is farmers' resistance to change and the need to transform their traditional or conventional crop production and animal husbandry practices into more efficient production systems (Samuel, 2011).

4.3.8. Economic Vulnerability: Climate Change & Agricultural Outputs in Anguilla

One of the problems faced by potential and existing farmers in Anguilla is access to funding for the start up of agricultural projects, and for agro-technology to improve production. Samuel (2011) observes that traditional farmers in Anguilla attain significantly lower yields and subsequently lower incomes in comparison to the few commercial farmers who have adapted modern agro-technologies in their enterprises. This reality has created a significant financial gap between the two groups and poses a challenge for improving agricultural resilience and climate change adaptation because the farmers using traditional methods of producing crops operate on over 70% of the arable land under cultivation on the island.

While there are no statistics on food production for Anguilla, Samuel (2011) indicates that Anguillan farmers successfully grow vegetables and herbs including corn, melons, cucumbers, chives, cauliflower, sweet peppers, cabbage, broccoli, mint, thyme, parsley, celery, tomato, hot peppers and basil.

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 approximately 75% of travellers become ill while abroad, most often from infectious diseases; morbidity is most often due to diarrhoea or respiratory infections (Sanford, 2004). It is also important because it can have consequences for tourism destination demand which is a significant contributor to the GDP of SIDS.

The potential effects of climate change on public health can be direct or indirect 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).

There is very limited formal research or documentation of climate change and its potential impacts in Anguilla. Hodge (2004) identified an increase in illnesses due to airborne pollutants, contamination of water supplies, increase demand for healthcare and medical services, resurgence of certain communicable diseases, increase in water-borne diseases and increased thermal stress as the main vulnerabilities of the country’s health sector in the document “The Potential Effects of Global Climate Change on Anguilla, British West Indies”.

More recently, in 2009 initial national consultations were held by the Department of Environment of the Government of Anguilla on the issue of climate change and its implications for the country’s development. This consultation took place in collaboration with the Caribbean Community Climate Change Centre (CCCCC) and the United Kingdom Department for International Development (DFID). The ultimate aim of these talks was to develop a Climate Change Adaptation Strategy and Action Plan and a Public Awareness and Education Programme. Diseases and therefore public health were identified as one of the key local challenges (DOE, 2009). These consultations resulted in the preparation of the “Draft Green Paper: working document to assist with the formulation of a Climate Change Strategy for Anguilla” which reiterated and expanded on these vulnerabilities and the possible impacts on the health sector of the country (DOE, 2009).

In some respects, Anguilla may be less vulnerable to climate change impacts than other Caribbean countries because “health indicators reveal that Anguilla has a health status comparable to that experienced in other westernised countries with next to no instances of the diseases or conditions traditionally associated with poverty" (Halcrow Consultants Limited, 2002). Table 4.4.1 shows some statistics relevant to the health care sector of Anguilla.

Table 4.4.1: Selected Statistics relevant to the Health Sector of Anguilla

Population	13,000 (2007)[1]
Unemployment rate	5.8% (2011)[2]
Poverty rate	7.8% (2002)[3]
Expenditure on Public Health	4.2 % of GNP (2001)[3]
Life Expectancy at Birth	74.3 (males)/80.3 (females) yrs (2007)[1]
Crude birth rate (per 1,000)	14.3 (2007)[1]
Crude death rate (per 1,000)	4.4 (2007)[1]
Hospital beds per 10,000 persons	30.6 (2002)[3]

(Sources: PAHO, 2007a; The Anguillian, 2011c ; Halcrow Consultants Limited, 2002)

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. Anguilla is prone to hurricanes, tropical storms and flooding, being particularly vulnerable because the highest point on the island is Crocus Hill at 65m above sea level (Opadeyi *et al.*, 2003). In the "Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla" loss of life is considered 'likely' to occur, with an extreme severity of impact and is viewed as an immediate threat to the island.

Past hurricane and tropical storm activity over Anguilla has affected the country; for instance in 1999 Hurricane Lenny caused significant economic damage. The damages to the health sector amounting to US $410,410 (PAHO, 2007a). Significant stretches of Anguilla's coastal areas are low lying and thus also vulnerable to sea level rise and resultant increase in coastal erosion and/or inundation (DOE, 2009). During such events infrastructure may be damaged and in the case of the health sector the East End Hospital was flooded due to rains brought on by Hurricane Lenny (Hodge, 2004). Displacement of persons and loss of shelter are also important because of the associated mental and physical health impacts.

From observed data North Atlantic hurricanes and tropical storms appear to have increased in intensity during the last 30 years and modelling projections indicate that the trend is expected to continue in the future, specifically due to intensification of weather phenomena rather than increases in frequency (See Section 3).

Increased temperature and the effect of heat

Increasing temperatures can result in heat stress in a population and heat wave events have been found to be associated with short-term increases in mortality globally (Confalonieri *et al.*, 2007) as well as morbidity related to heat exhaustion and dehydration (Hajat *et al.*, 2010; Sanford, 2004). 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 Anguilla diseases of the circulatory system were the leading causes of deaths between 1995-2001 (Halcrow Consultants Limited, 2002) and between 2001-2005 (PAHO, 2007a). This data represents a potentially vulnerable sub-population within the country.

Anguilla has also experienced increasing heat waves in recent times (DOE, 2009). Gridded temperature observations have shown an increase at an average rate of 0.1˚C per decade over the period 1960-2006 which is expected to increase by at least 0.8-2.9˚C for the GCM ensemble by the 2080s. RCM projections indicate the potential for more rapid increases (see Section 3). Though these predicted changes up to the 2080's are averaged and dispersed over a relatively long time span, episodic increases in temperature could impact vulnerable groups at a given point in time. The potential impacts may be multi-sectoral as water supplies and the agriculture sector also have implications for health.

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 travellers when choosing destinations. Additionally, exposure to higher temperatures may also contribute to increase in skin diseases; a consideration that becomes more relevant as temperatures increase (Confalonieri *et al*., 2007). 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, 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 Anguilla.

4.4.3. Indirect Impacts

Increase in Vector-Borne Diseases

In Anguilla, with its dry tropical climate, mosquitoes are prevalent breeding in cisterns and rock holes (PAHO, 2007a). Hales *et al*. (2002) summarises that "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 the human population (Hales *et al*., 2002). Climate change projections indicate the potential for overall decreases in rainfall events (see Section 3) which might decrease mosquito proliferation once water storage facilities and infrastructure do not contribute to mosquito breeding sites.

Another important consideration for vector borne diseases is that incurred from the tourism industry. In 2010, there were 61,998 stopover visitors, and 56,413 cruise ship passengers to the island (OECS, 2010). There was an overall 5% increase in both tourist groups in 2010 over 2009 figures to Anguilla. While this data is lower than previous years due to global economic challenges and a decline in the tourism sector. For instance there were 77,652 stopover visitors in 2007 and 94,283 cruise ship passengers in 2006, the highest figures for the decade. Nonetheless, this influx of people from non-endemic areas represents a potentially susceptible population to vector borne disease infections if Anguilla became endemic for dengue fever and its vector *Aedes aegypti*.

Anguilla is acutely aware of its mosquito situation and undertakes a number of initiatives to control the spread of infestations. In the "Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla" threat due to an increase pests/vectors/water borne diseases is considered 'very likely' to occur, with an expectant 'high' severity of impact and is viewed as an immediate threat with the possibility of occurring in the next five years (DOE, 2009).

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 *Aedes aegypti*. Population growth, urbanisation and modern transportation are believed to have contributed to its resurgence in recent times (Gubler, 2002).

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

Dengue fever is 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 1800s (Pinheiro and Corber, 1997).

Transmitted by the *Aedes aegypti* mosquito vector, dengue fever is the only vector borne disease of note in Anguilla and the mosquito is widespread in the country. During the period from 2001 to 2005 there were 49 cases across the island, including one case of dengue haemorrhagic fever (PAHO, 2007a). However, data from CAREC reported 72 cases for the same time period. The Environmental Health Annual Report 2009 noted that "There were probably cases of dengue. However due to the lack of confirmation testing said could not be determine, thereby posing a significant risk of death from improper treatment and diagnosis" (Richardson, 2009). Therefore the impact in the island may be higher. However during subsequent years of 2006, 2007 and 2009 there were no cases of dengue or dengue haemorrhagic fever. However there were two and seven cases of each respectively reported in 2008 (CAREC, 2008a, 2010).

It is important to note that infection of one serotype does not confer immunity against another serotype. Therefore re-infection complicates the course of the disease (Gubler, 1998) and can lead to dengue haemorrhagic fever and dengue shock syndrome (Levett *et al*., 2000). As noted previously, 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 weather 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.* Water storage and mosquito breeding are also very important in Anguilla due to the high number of cistern used among households on the island.

Other diseases such as malaria and yellow fever, that have transmission rates and host vector breeding rates that are altered by climate changes, were either less than 10% between 1995 -2001 (Halcrow Consultants Limited, 2002) or not reported between 2001 -2005 (PAHO, 2007a). However, there was one confirmed case of malaria in 2002 (PAHO, 2007b). The potential for disease transmission is thought to be non-existent in Anguilla because in a study of malaria in the Caribbean, none of the 29 species of *Anopheles* – the mosquito responsible for the spread of malaria – present in the region were identified in Anguilla. However, the study stressed the point that although no species were recorded, this did not necessarily signify an absence of the vector (Rawlins *et al*., 2008).

Drought, air quality and respiratory illnesses

Anguilla is prone to drought conditions as it is one of the drier islands of the Caribbean region, experiencing average annual rainfall of approximately 960 mm per year but can range between as low as 450 mm to as high as 2,000 mm depending on the number and intensity of storms affecting the island in a given year (DOE, 2009). GCM projections indicate a tendency for the likely reduction in precipitation in Anguilla by the 2080s. RCM models also indicate the potential for larger decreases in rainfall (See Section 3). This constitutes a vulnerability to the health sector as episodes of dry weather and drought conditions can also contribute to the spread of disease linked to inadequate water supply and sanitation.

In a study entitled "The Potential Effects of Global Climate Change on Anguilla, British West Indies" freshwater was identified as a resource vulnerable to climate change with the possibility of associated health impacts (Hodge, 2004). It also identified asthma and other respiratory diseases as a cause for concern on the island. Indeed increased incidence of asthma, influenza, respiratory diseases and acute respiratory infections due to increases in particulate air pollutants and changing air composition have also been identified in the Inter-governmental Panel for Climate Change (IPCC) Fourth Assessment for the Health Sector (Confalonieri *et al*., 2007). There were 29 and 39 influenza-like reported cases in 2006 and 2007 respectively (CAREC, 2008a), 38 cases in 2008 and three in 2009 (CAREC, 2010). Similarly, acute respiratory infections have been on the rise in the last four years as Table 4.4.2 shows. At least in one other Caribbean island, namely Saint Lucia, analysis of disease data for asthma, bronchitis and respiratory infections showed a seasonal disease pattern (Amarakoon *et al*., 2004). Further research may yield similar trends in other Caribbean islands.

Table 4.4.2: Fever and Respiratory Systems (acute respiratory infections) under and over 5 years between 2006-2009

Year	2006	2007	2008	2009
Fever and Respiratory symptoms (ARI) < 5 yrs	412	469	437	477
Fever and Respiratory symptoms (ARI) ≥ 5 yrs	267	455	935	792

(Source: CAREC, 2008a; CAREC, 2010)

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 which also affects Caribbean islands such as Anguilla.

Sanitation concerns and drought are mainly linked to food-borne diseases such as gastroenteritis. Gastroenteritis cases have been reported since 1981 but increases in trends have been seen reported since

2000. In 2006 the highest number of reported cases of gastroenteritis for both under and over five year age categories were observed with 158 and 345 cases respectively (CAREC, 2008a, 2008b, 2010; see Table 4.4.3). There has been a steady decline over the last three years. The standard of living and quality of health care and health education in Anguilla make the threat lower than that for other islands.

Table 4.4.3: Reported cases of gastroenteritis in Anguilla between 2000 and 2009

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sum of Gastroenteritis < 5 yrs	79	42	24	67	41	72	158	114	68	45
Sum of Gastroenteritis ≥ 5 yrs	68	47	28	129	63	122	345	317	218	209

(Source: CAREC, 2008a; CAREC, 2008b,CAREC, 2010)

Water Supply, sanitation and associated diseases

The Country Poverty Assessment for Anguilla states "It should also be noted that, in Anguilla, the incidence of health conditions (e.g. infectious or waterborne diseases, low birth weights, infant diarrhoea) is almost non-existent" (Halcrow Consultants Limited, 2002). Therefore emphasis is not place on food- and water-borne diseases known to be prevalent in the rest of the region. There may be a rise of such diseases if water resources become scarcer coupled with higher unemployment rates and deterioration in the social condition. A constant threat exists with cholera being transplanted into the port via the ballast water. Consequently, continuous surveillance is required to monitor this situation.

The Anguilla 2001 country census revealed that 93% of the population used flush toilets, while 3.8% of households used pit latrines (PAHO, 2007a). This contributes to high standards of sanitation though there have been reported cases of conditions that could promote the spread of communicable diseases during Environmental Health Officer inspections as recent as 2009 (Richardson, 2009). Special mention will be made for Legionnaires disease.

Legionnaires disease - Legionnaires disease is associated with water 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°C and 45°C. As a result it thrives in stored hot water environments such as in spas, hot tubs and humidifiers which forms a suitable reservoir for harbouring the bacteria. In addition it also thrives in natural waters, pipes, distribution systems, air conditioners, showers and cooling towers (Fisman *et al*., 2005; Rose *et al*., 2001).

It is therefore a disease of relevance in the tourism industry, having been the cause of illness on a number of cruise ships (Fisman *et al*., 2005) and tourist hotels in various parts of the world. However, in the Caribbean region, research on the prevalence of the disease is limited to work at a hotel in Antigua conducted by Hospedales *et al* (1997) and the quality of potable water in hospitals in Trinidad and Tobago by Nagalingam *et al* (2005). Nonetheless its relevance to health and climate change in Anguilla is evident, given the high dependence on the tourism sector. 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

Anguilla does not have a significant agricultural sector owing to its size and low annual rainfall so it therefore has to import substantial amounts of food. For instance in 2002, 20% of the average total expenditure was spent on food (Government of Anguilla, n.d.-5). The availability of food could have consequences for the health of the population, particularly the poorest sectors of the society. 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 Anguilla. While only 5.8% of the population is defined as poor according to the 2008/2009 Country Poverty Assessment, another 17.7% are vulnerable and many fall within this group (The Anguillian, 2011c). This leaves a substantial section of the population vulnerable to food security and food related diseases. One issue that deserves attention is that of Ciguatera fish poisoning.

Ciguatera fish poisoning – The Caribbean region is a well-known for the food poisoning illness called ciguatera fish poisoning (CFP) (Tester *et al*., 2010). Surveys conducted in the Caribbean in the 1980s, 1970s and 1960s found that ciguatera was more prevalent in islands north of Martinique (Olsen *et al*., 1984). Anguilla is located several islands north of Martinique in the Caribbean archipelago. The water surrounding Anguilla on the Anguilla Shelf was mapped with as having 'infrequent' CFP. A more recent ciguatera assessment by Tester *et al* (2010) estimated the Annual Ciguatera Fish Poisoning incidence in Anguilla to be 11.7 per 10,000 which reviewed the years 1980-1996 and 1999- 2006. In 2006 there were 22 cases of ciguatera and 14 cases in 2007 (CAREC, 2008a), 15 cases in 2008 and 9 cases in 2009 (CAREC, 2010) which is roughly consistent estimates of (Tester *et al*., 2010).

An increase in the incidence of ciguatera may arise as seas become warmer due to climate change, triggering harmful algal blooms increase (HABs) and their toxins to 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, 2008a).

Increased precipitation and vector borne diseases

Aside from mosquito vectors, rodents present a health threat due to their ability to spread diseases. The likelihood of these events are difficult to predict because while rainfall patterns are expected to decrease, storms and hurricanes can dump high volumes of water on the island in a short period of time, creating suitable conditions for rodent infestation. One disease of note that is transmitted by rodents is *Leptospirosis.*

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 leptospirosis (Hales *et al*., 2002), infection can occur from other wild or domestic animals such as dogs that come into contact with water, damp soil, vegetation or any other contaminated matter (Gubler *et al*., 2001). Flood waters contaminated with faecal matter and urine from infected rats is often associated with, and is one of the main causes of leptospirosis outbreaks and spread (Gubler *et al*., 2001; Hales *et al*., 2002; Moreno, 2006; Sachan and Singh, 2010). Further, as stated in the IPPC Fourth Assessment report "there is good evidence to suggest that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human–pathogen–rodent contact" (Confalonieri *et al*., 2007) and the seasonal patterns of leptospirosis has recently been demonstrated in Trinidad by Mohan *et al* (2009).

Leptospirosis has been found to be one of the diseases of importance contracted by travellers (Jansen *et al*., 2005) and could therefore have implications for tourists.

There are not many cases of leptospirosis in Anguilla. According to CAREC data there was 1 case in 2003, zero cases in 2004, 3 cases in 2005 and zero cases 2006, 2007, 2008 and 2009 (CAREC, 2008a, 2010). The incidence of leptospirosis may be higher, but in under-reporting of cases may be due to a low index of suspicion as has been the case in Trinidad and Tobago (Mohan *et al*., 2009). The island does however have households with a rodent problem and the incidence of rodents has been found to be associated with areas that have large numbers of old cars and appliances such as in Island harbour Blowing point, South Hill and West End (Richardson, 2009). This situation is different from that in other countries. For instance in the Caribbean island, Barbados, the disease is associated with sanitation and agricultural workers which comprise the group with the highest risk (Everard *et al*., 2005) but in Trinidad exposure to leptospirosis and contracting the disease was not necessarily limited to occupational groups (Mohan *et al*., 2009).

4.5. *Marine and Terrestrial Biodiversity and Fisheries*

4.5.1. Background

Anguilla is described as being "embraced by unrivalled white beaches and breathtaking turquoise seas"; an ideal vacation destination. This description highlights the importance of the Anguilla's natural resources to its key economic sector, tourism. The importance of biological diversity to the national economy is also reflected in the relative contributions to the Gross Domestic Product (GDP) of economic sectors such as fisheries and construction that are dependent on natural resources and the latter inextricably linked to the tourism industry. Subsequently employment, livelihoods and the well-being of the Anguillian population is inseparably tied to the protection and management of its biodiversity.

Approximately 550 species of vascular plants (321 of them are native) grow on the island and one of these species, the Anguilla Bush *Rondeletia anguillensis* in the Rubiaceae family (coffee), is unique to Anguilla. The type of vegetation on the island has limited the terrestrial vertebrate fauna to 14 species of reptiles (12 lizard species, one species of snake and one species of land tortoise), five species of bats (Anguilla's only native terrestrial mammals) and about 135 species of migratory and resident birds. At least 3 species of marine turtle nest on various beaches around the coastline and numerous fish and other marine life may be found around seagrass beds and along one of the most important largely unbroken reefs in the eastern Caribbean. Invertebrate species have not been sully assessed but there are at least 30 species of stony, reef-building corals, at least 20 different types of sponges, two species of commercially harvested lobster and one species of conch.

Although the natural environment forms the foundation of the island's economic activity, food security, and livelihoods it is being subjected to a combination of complex localised threats as well as the global threat of climate change. In fact, climate change is recognised as one of the greatest threats to the biological diversity. Impacts of global climate change on the species include:

- Changes in distribution
- Ecosystem composition
- Increased rates of extinction
- Changes in patterns of reproduction
- Changes in migration patterns

Ecosystems have long demonstrated the ability to adapt to changing environments however it is believed that current and projected rates of climate change will exceed the rate of adaptation jeopardizing the survival of many species. Further compounding this issue is that human activity continues to degrade habitats and reduce species numbers thus increasing the vulnerability of biodiversity to climate change impacts. The following sections will assesses the vulnerability and adaptive capacity of the island's biodiversity and fisheries sectors to climate change within the context of those ecosystems that are most significant to tourism and its related sectors.

Terrestrial vegetation

Approximately 550 plant species have been identified in Anguilla, however, over 200 of these are non-native (UKOT & DOE, 2011; IUCN, 2011). One species, the *Rondeletia anguillensis*, a shrub in the coffee family (Rubiaceae) is Anguilla's sole endemic plant. The low-rainfall, limestone substrate and thin dry soils of Anguilla lend little support for a diversity of vegetation. Winds are also a determining factor in the type of plants found on the island so that trees that are normally capable of growing up to 20 ft are often half that height. Furthermore over-exploitation and indiscriminate clearing of land for development have replaced much of the natural vegetation on Anguilla with degraded evergreen woodland consisting of small trees, scrub brush and cacti, interspersed with scattered areas of grassland (Figure 4.5.1). The present evergreen tropical bushland covers an estimated 60% or 55 km^2 of the island; the extent of other woodland, including that of other islands and cays is unknown (FAO, 1998; FAO, 2010).

The limited vegetated areas provide habitat for a small variety of wildlife. The reptiles of Anguilla and its offshore cays consist of 14 lizard species, three of which are endemic, three species of snake and one species of land tortoise. Populations of the Lesser Antillean Iguana are threatened on the island as a result of tree felling and grazing by feral goats. The loss of vegetation has meant not only defragmentation and destruction of habitat but also a loss of essential ecosystem services. Soil erosion, flooding, coastal sedimentation, loss of shade have resulted from mismanagement of Anguilla's forests and shrub lands. A small percentage of the population, generally those in poorer rural areas, use wood for cooking and charcoal production. Wattles are the main material used for fish traps by local fishers and a small quantity of fence posts are produced from white cedar trees (FAO, 1998). Other plants are used for medicinal purposes, artistic wood carving and boat building.

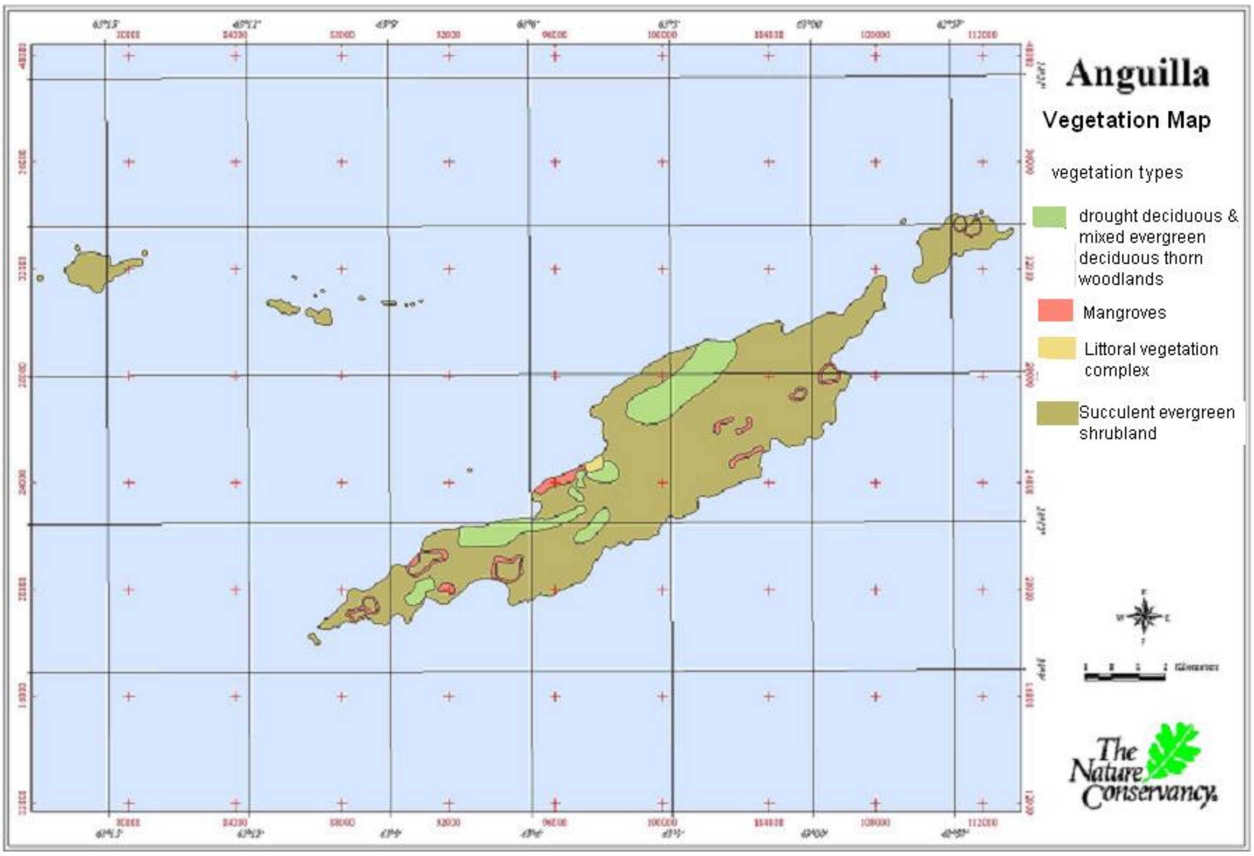


Figure 4.5.1: Vegetation map of Anguilla

Importance and status of wetlands

Anguilla's wetlands, consisting of mangroves and salt ponds, are of international importance to its biodiversity and provide invaluable goods and services to the population. Although limited, the existing mangrove stands provide essential nurseries for juvenile fish, habitat for marine species and avifauna and are part of a nutrient exchange system with associated coral reefs and seagrass beds. The vegetation can reduce the impact of cyclonic winds, protects the coastline from erosion by waves and plays a role in the maintenance of coastal water quality by filtering sediments from land-based activities such as farming and construction. The plants and trees found in salt ponds stabilise soils thereby helping to prevent soil erosion and protect against flooding by absorbing heavy rainfall. Saline ponds are of considerable importance for over 135 species of resident and migratory waterfowl as well as a rich variety of shore birds (DOE, 2009; Halcrow Consultants Limited, 2002). Among the various bird species that inhabit these wetlands are the endangered roseate terns, least terns and red-billed tropic birds, a species of special concern (UKOTCF, 2005).

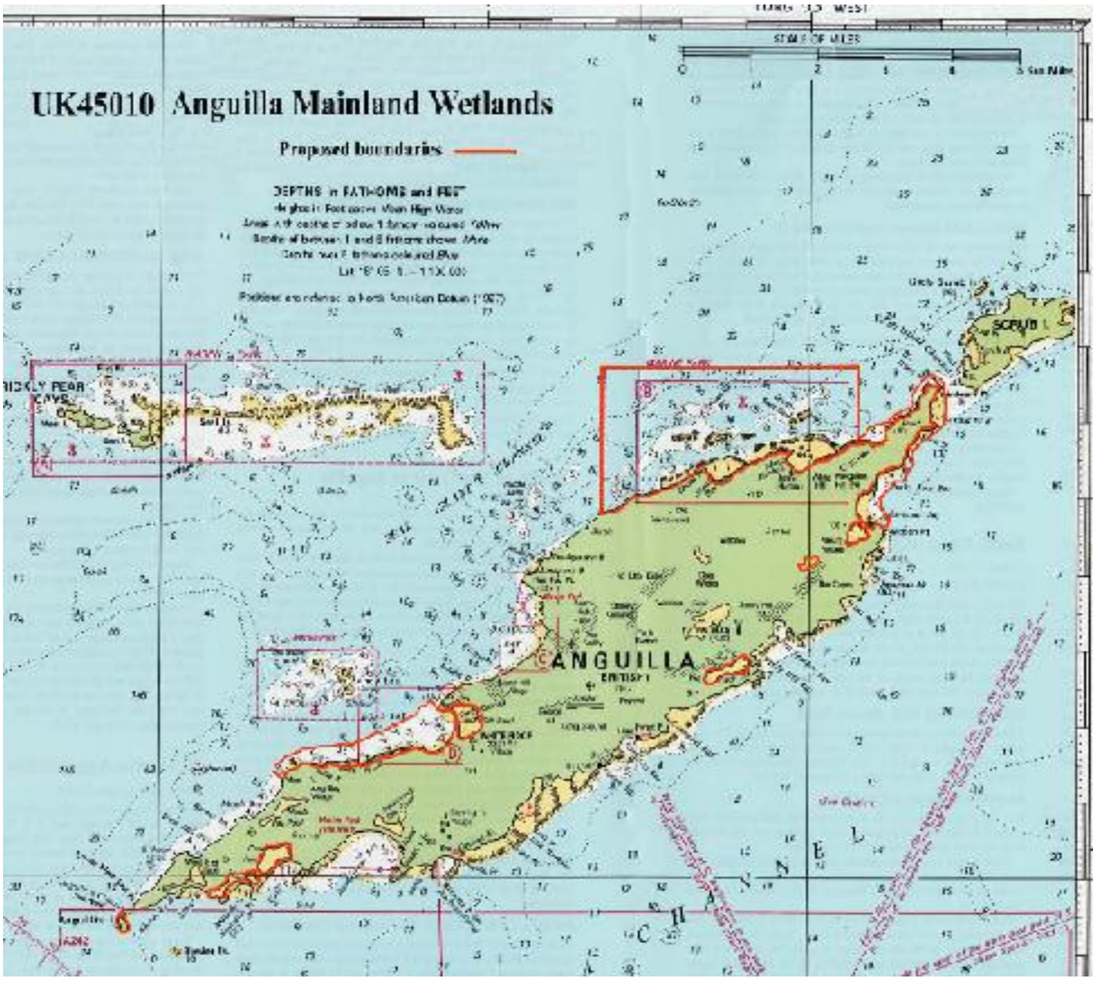


Figure 4.5.2: Location of wetlands and proposed wetland boundaries in Anguilla

(Source: UKOTCF, 2005)

Formerly widespread mangrove areas have been reduced to a few small areas. On the mainland, mangroves occur in 10 sites on the margins of seven saline ponds covering just 0.9 km^2 in total. Other mangrove stands are found along three saline ponds on the adjacent Scrub Island (FAO, 2005). Red mangrove (*Rhizophora mangle*) is the dominant species; black (*Avicennia germinans* and *Avicennia schaueriana,)*, white (*Laguncularia racemosa)* and buttonwood (*Conocarpus erectus)* mangrove trees as well as the golden leather fern (*Acrostichum aureum,* are also present. Site modification for development purposes has led to the local extinction of some of these mangrove species on other Caribbean islands such as Barbados.

As part of a general policy to encourage and facilitate development, the Government has made decisions that have put pressure on the functioning of these important wetlands. The development of resorts and luxury homes have removed mangrove trees, hampered their regeneration after cyclonic events and compromised the health of salt pond ecosystems. For example, a basketball court and a playing field were built over a salt pond and property development continues to encroach on their margins. Dredging of sand from salt ponds has been regarded as a conservation alternative to sand mining from beaches. Such activities have had negative impacts that increase the vulnerability of Anguilla's wetlands to climate change.

Importance and status of beaches

There are 33 white sandy beaches around the island (ATB, n.d.), which are comprised mainly of calcareous algal sands, coral and shell fragments, and sometimes pebbles (DOE, 2009)[4]. Beaches are dynamic ecosystems that provide habitat to marine reptiles, crustaceans and a wide variety of shorebirds. Three species of globally threatened sea turtles, which depend on beaches and coastal vegetation to support their foraging and nesting behaviours, have been documented on Anguilla. The island has many sand dunes that function as important reservoirs of sand, habitat for coastal plants and a line of defence for inland areas from erosive high energy waves during storms. The vegetation that grows on beaches acts as a natural windbreak to protect coastal infrastructure from wind damage. Beaches are one of Anguilla's main attractions and thus support a multi-million dollar tourism industry through recreational use and through use by the fisheries sector.

Much of Anguilla's tourism is located along beaches that have been identified as among the most threatened on the island (Homer, 2005). A boom in tourism expenditure over the past decade resulted in rapid growth in the construction sector, uncontrolled sand mining and development that have damaged and even destroyed many sand dunes in Anguilla. Coastal development disrupts the natural cycle of accretion and erosion of sandy beaches because impermeable structures erected too close to the shoreline reflect waves and accelerate the rate of erosion of sand. This not only makes beaches less attractive, but is also costly and dangerous because reduced beach width allows waves to break further inshore and wear away at the foundation of homes, resorts and condominiums. Run-off from construction sites also contributes to the degradation of coral reefs, which are themselves an important source of beach sand and play a role in the dynamics of sand movement. Coastal development can impact on beach ecosystems in yet another way: artificial lighting at night interferes with nesting of adult turtles and disorients hatchlings as they attempt to make their way to the sea. As a result thousands of hatchlings may die annually.

Importance and status of coral reefs

Extensive reefs are found around the island, with the 17 km-long reef along the north-east coast considered to be one of the most important largely unbroken reefs in the eastern Caribbean (Figure 4.5.3). Reefs are a significant feature of Anguilla's marine environment providing a source of sand to the island's famous beaches. As can be seen from Figure 4.5.4 coral reefs are also very important to Anguilla's dive tourism. Reefs act as natural breakwaters and protect lives and property of the low-lying islands and cays from erosive wave action by dissipating the energy of incoming waves.

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[4] The Green Paper on Climate Change reports that there are 22 beaches (DOE, 2009).

Anguilla's shallow reef habitats are generally in a poor state of health with low hard coral cover and high levels of macro-algae. A 1990 assessment of Anguilla's marine environment concluded that it was in relatively good condition with little evidence of human impact. However a more recent report from The Anguilla Marine Monitoring Programme (AMMP) notes that over the last 20 years hard coral cover has declined by 70% from an average 13.95% in 1990 (an average over nine sites), to only 4.1% in 2010 (an average over 10 sites). In some areas such as the Forest Bay and Sandy Hill Bay, the decline in coral cover is 90% and 74% respectively (Anguilla News, 2010). The cumulative effects of a number of natural and human-induced factors, including a proliferation of coral diseases, coral bleaching events, nutrient loading, hurricanes and the regional die-off of the long-spined sea urchin *Diadema antillarum* have resulted in the degradation of coral reefs. Anguilla suffered a massive *Acropora palmata* die-off in the 1980s, probably caused by white band disease. Offshore sites had the highest cover, with lower macro-algal cover and higher relative biomass of fish indicating the impact of human activity on the more readily accessible nearshore areas. Coral recruitment appears low in all locations (Bouchon *et al*., 2008). Waste disposal, from land and from yachts, is a concern to the heath on coral reefs around Anguilla. Studies have confirmed that infections caused by the human pathogen *Serratia marcescens* have contributed to precipitous losses in the common Caribbean elkhorn coral, *Acropora palmata*, culminating in its listing under the United States Endangered Species Act (Sutherland *et al*., 2011).

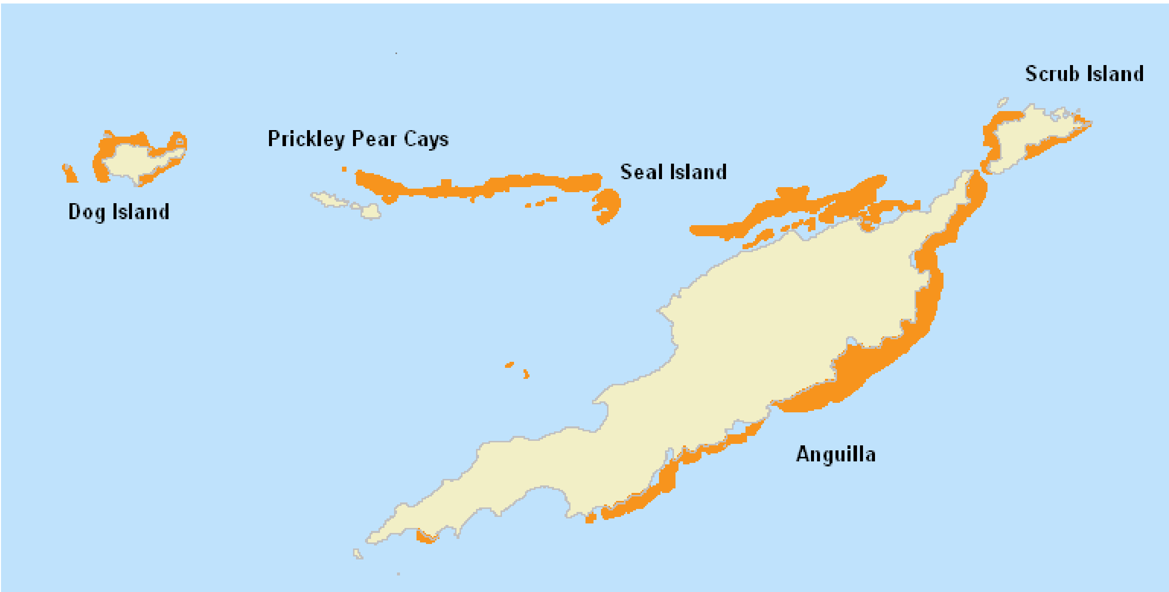


Figure 4.5.3: Location of reefs around Anguilla and associated cays

(Source: UNEP-WCMC)

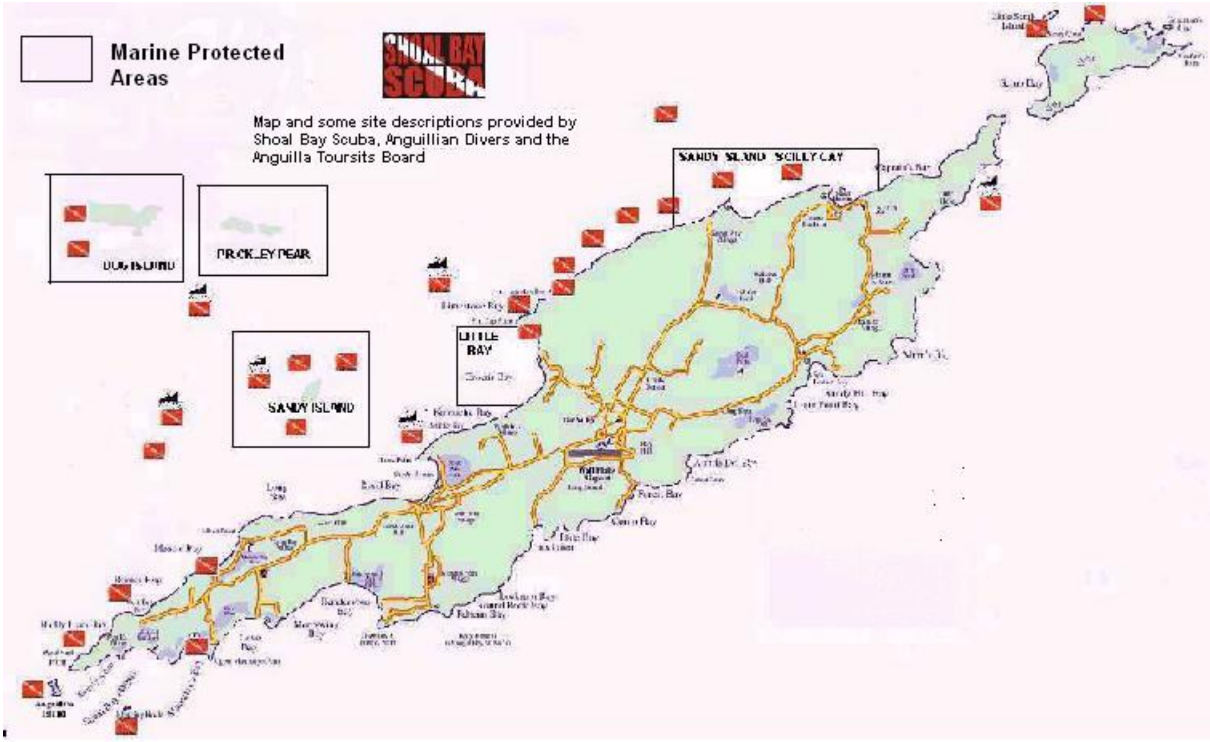


Figure 4.5.4: Dive sites and Marine Protected Areas

(Source: Shoal Bay Scuba)

Importance and status of seagrass beds

Seagrass beds form part of a complex integrated coastal system with coral reefs and mangroves. These underwater ecosystems are areas of high productivity producing more than 4000 g C/m^2/yr, contributing significantly to tropical reef and other nearshore communities. They are important for stabilizing the sea bed and providing habitat to juvenile fish and commercially important species such as conch and lobster. Seagrasses are particularly important to Anguilla as nursery grounds for inshore fish and as habitat for crabs and other invertebrates because of the limited extent of the island's mangrove forests. They also play a role in maintaining the clarity of seawater, and important service to recreational activities such as snorkelling and Scuba diving.

Coastal mapping and anecdotal evidence indicate that over the last ten years, the total area of seabed covered by seagrass has declined dramatically (Mukhida, n.d). Anchoring by boats can cause physical damage and heavy sedimentation from coastal construction and storm water run-off can overwhelm the delicate blades of grass, blocking out essential sunlight thus reducing the primary productivity of this ecosystem. Land-based run-off can also result in nutrient overloading of coastal waters which encourages the growth of opportunistic macroalgae. Seagrasses are sensitive to changes in the surrounding water that they are also considered to be important "indicator species" of the general health of coastal ecosystems.

Importance and status of fisheries

Fishing has historically played an important role in the livelihoods of Anguillians. Anguilla's Exclusive Fishery Zone (EFZ) extends 200 miles into the Atlantic Ocean to the north of the island; the most productive areas being coral reefs and seagrass beds (FAO, 1998). The fisheries sector contributes an average of 2.5% annually to GDP, which may initially seem to be a small figure; but when the dollar value (Table 4.5.1) and number of persons employed are taken into consideration the significance of the fisheries sector becomes more apparent. Approximately 400 artisanal fishers harvest Anguilla's fisheries resources generally from within a 40 mile (64 km) radius off shore. The primary target is lobster as it is the most profitable species;

deep slope finfish such as snappers, a small quantity of pelagics (dolphin fish, wahoo, marlin etc.) and queen conch are also harvested. An estimated 95% of lobster and 90% for finfish is landed in Anguilla with the other catch sold directly on nearby islands (Anguilla Statistics Department, 2009). Prior to the expansion of the tourism industry fish was a main export product but now most of the island's catch is consumed locally. The diversity of species found on the coastal shelf is important to the country's most important industry not only for food but also for sport fishing and dive tourism.

Table 4.5.1: Fisheries contribution to GDP in Constant Prices 2000-2009 (EC $M)

Economic Activity	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fishing	8.63	8.90	9.08	10.20	11.21	12.32	12.70	13.81	14.84	13.64

(Source: Anguilla Statistics Department, 2009)

Since the mid 1980s lobster fishers have been reporting a decline in catches. Over-fishing of fin fish species is also evident by the fact that fishers have to travel further distances to maintain or increase their catches (Anguilla Statistics Department, 2009). Increased pressure is also being placed on reef fish, including parrotfish, which are used to bait crayfish traps. The decline in number and diversity of fish species threatens the ecological balance of Anguilla's marine environment. Parrotfish in particular help maintain the health of coral reefs by feeding on the algae that grows on the surface of the reef and could smother it if not kept in check. A single large parrotfish browsing on corals can contribute an estimated 2-3 tonnes of sand per year (Karleskint, Turner, & Small, 2009). This sandy sediment is essential for Anguilla's white sand beaches and for the growth of the seagrass. In addition to direct fishing pressure, Anguilla's fish biodiversity is also threatened by negative impacts on coral reefs, seagrasses and wetlands (as outlined earlier) which provide essential habitat for various life stages of many species of fish and invertebrates.

Turtles

Until 1995, there was a turtle fishery in Anguilla that harvested thousands of green turtles and hundreds of hawksbill turtles annually. At least three species of marine turtles, hawksbill, leatherback and green turtle, are known to nest on Anguilla's shores. Loggerhead turtles have also been fished in the surrounding waters but there are no reliable records of their nesting activity on Anguilla. Marine turtle stocks are globally shared and are an important part of the country's marine biodiversity; they provide an attraction for eco-tourists who can observe turtle nesting for a small fee. As of 1995, a 5-year moratorium was declared on all turtles and turtle products and was further extended to 2005, after which a 15 year moratorium was put in place by the Government of Anguilla. Although public perception is such that turtle populations are increasing, the official position of the Department of Fisheries and Marine Resources is that numbers are dwindling and better stock assessment is required (The Anguillian, 2006). Illegal harvesting still occurs but for the most part the moratorium has reduced the fishing pressure on marine turtles. Damage to seagrass beds and beaches however continue to degrade their nesting and foraging grounds.

4.5.2. Vulnerability of Biodiversity and Fisheries to Climate Change

Vulnerability of terrestrial vegetation

The existing climate and soil types found in Anguilla naturally limit the variety and extent of its vegetation. Observed mean annual temperatures over Anguilla have increased at an average rate of 0.1˚C per decade over the period 1960-2006. Projected annual changes in temperature over Anguilla by the year 2080 indicate increases spanning 0.8-2.9˚C, with some Regional Climate Model (RCM) projections indicating even more rapid increase in temperature of 3.1˚C and 2.4˚C in mean annual temperatures by the 2080s. Additionally GCM projections of precipitation generally indicate changes in annual rainfall of -34 to +13 mm per month by 2080 under scenario A2. Anguilla's vegetation is adapted to the dry weather and saline conditions and may be better able to tolerate these changes in climate than many of the plant species found on other islands in the region. However prolonged periods of drought and salt water intrusion as a result of SLR will likely have adverse impacts on vegetative cover and by extension the terrestrial animal species that inhabit these areas.

Vulnerability of wetlands

It is anticipated that global climate change will aggravate the impacts of current human stressors on mangroves and reduce their natural resilience to harsh conditions. Observed and GCM ensemble projections of temperature change in Anguilla will probably not have adverse direct impacts on the country's mangrove forests. However, mangroves could be indirectly impacted by long-term temperature changes since increased temperatures will damage coral reefs which shelter mangroves from wave action. Reduced levels of precipitation would reduce mangrove productivity and increase their exposure to very saline water. Sea level rise (SLR) is expected to pose the greatest climate change threat to mangroves (McLeod & Salm, 2006). A rise in sea level is projected to affect wetlands by either expanding or confining their habitat. SLR and salt water intrusion will increase soil salinity and may allow wetland vegetation to spread. On the other hand, if mangroves and other vegetation associated with salt ponds are obstructed from migrating inland due to coastal topography and coastal infrastructure, they may be over-come by SLR and eventually lost. Anguilla's salt ponds are fed by underground water sources and their level of salinity tends to fluctuate dramatically between and during the wet and dry seasons. SLR and changes in precipitation, particularly the projected trend towards drier weather, will affect the water level and salinity of salt ponds thus impacting on the organisms that use these areas for feeding and habitat.

Hurricane Luis in 1995 caused an almost total loss of mangroves in Anguilla (Bouchon *et al.*, 2008). One mangrove stand that was severely damaged by Hurricane Luis and again by Hurricane Lenny was the mixed mangrove stand found in Little Harbour. Studies in Anguilla before and after Hurricane Luis in 1995 showed that the mortality rate of the mangroves varied between 68% and 99% as a result of the category 4 hurricane (Bythell, Cambers, & Hendry, 1996). Mangrove species exhibit different responses to storm damage and a forest's community structure could thus be changed by tropical storms and hurricanes. The long term effects of extreme events on mangrove stands are uncertain but will most likely mean a reduction in the many important services provided by these ecosystems. The recommended approach is therefore to actively preserve and restore mangrove communities in order to maintain the economic and ecological benefits they offer.

Vulnerability of 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. This translates to decreased aesthetics, smaller areas for recreation and reduced carrying capacity of beach ecosystems. Narrowing 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. More dramatic changes can occur to the beach profile during a single extreme weather event and although recovery occurs it may not be to pre-hurricane conditions. Anguilla's beaches are extremely vulnerable to the high winds, storm waves and sea surges experienced during tropical storms and hurricanes. During the 1990s Anguilla's beaches appeared to be experiencing net erosion attributable to a series of tropical cyclones that affected that region (UNESCO, 2003). Hurricane Luis struck in 1995 and caused much damage to coastal and marine ecosystems including extensive erosion of the beach at Mead's Bay where it retreated inland by 30 m (Figure 4.5.5) and erosion of the sand dunes at Cove Bay that separated the salt pond from the sea. Four years later, in 1999, Hurricane Lenny caused even further damage to those same dunes. The beaches have shown signs of partial recovery but have still not returned to the pre-hurricane state (UNESCO, n.d.). The frequency of events did not allow sufficient time for beaches to recover in between events (Scott *et al.*, 2006).

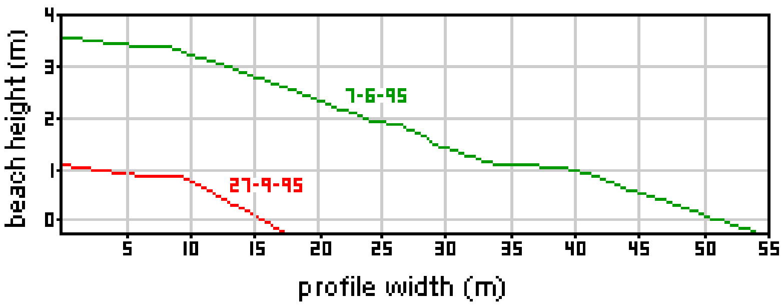


Figure 4.5.5: Beach profiles at Meads Bay, Anguilla, before and after Hurricane Luis

(Source: Cambers, 1997)

Observed and projected increases in the intensity of hurricanes does not bode well for the future of beaches in Anguilla. The reduced aesthetic appeal will mean reduced quality of one of the island's key tourist attractions. Changes to the beachscape will affect recreation activities as well as the livelihoods of those employed in fisheries, water-sports and other such related activities. Intensified tropical cyclones and accompanying storm surges will also impact on nesting areas and threaten the survival of species such as marine turtles, iguanas and shore birds (Simpson *et al*., 2010). Climate change impacts on the biodiversity of beaches may also be realised in the effects that warmer average daily temperatures may have on marine turtles. Studies indicate that incubation temperature influences the sex of baby turtles therefore warmer temperatures may skew sex ratios in developing eggs and thereby reduced the reproductive capacity of sea turtles. Such impacts will mean a loss of potential revenue for the country's expanding tourism industry and disruption of marine ecosystem balance.

This year, particularly between the months of July and August, an exceptionally large amount of Sargassum fluitans, otherwise known as 'the sargassum seaweed', washed ashore causing concerns among visitors and residents of Anguilla. Although not confirmed as a climate change related event, the phenomenon is thought to be as a direct result of more than usual intense tropical storm activity in the Sargasso Sea. These floating mats of vegetation arrive in the Caribbean region annually but this year they appear to be doing so in unusually large quantities. Fishers have complained that their nets and lines become entangled in the Sargassum and there is concern over the risk of disease and invasive species that may accompany the seaweed. Anguilla's Department of Environment has notified the general public that the seaweed poses no immediate public health threats however the large volume and weight of seaweed washed up on some beaches is unsightly and poses a problem for the tourism industry as well as a major expense and logistical challenge for governments who opt to collect and dispose of the Sargassum. If this event is indeed related to cyclonic storms that have formed in the Atlantic during the 2011 hurricane season then coastal and marine environmental managers should prepare for the likelihood of these events occurring with increased frequency in the near future.

Figure 4.5.6: Unusual amount of Sargassum seaweed washed up on a Caribbean beach
(August 2011; Source: Richard Roach)

Vulnerability of coral reefs

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 Anguilla for the period 1960-2006 with the highest change during JJA (+0.12˚C). GCM projections indicate increases in SST throughout the year ranging from +0.7˚C and +2.7˚C by the 2080s across all three emissions scenarios. RCM projections indicate increases of 3.1˚C and 2.4˚C in mean annual temperatures over Anguilla by the 2080s. Corals are sensitive to temperature changes and are stressed by changes of about 1°C above average seasonal temperature. In response to elevated SST corals expel the symbiotic green algae (xooxanthellae) causing them to appear white, hence the term "bleached". Local dive operators reported bleaching during the region wide bleaching event in 2005 however the extent of corals impacted is unknown (Bouchon *et al.*, 2008). 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 (IPCC, 2007). Increased frequency of bleaching episodes means reduced recovery time for coral polyps and greater likelihood of mortality. Of further concern is that warmer oceanic waters will facilitate the uptake of anthropogenic CO_2 which creates additional stress on coral reefs. Increased CO_2 fertilization may change seawater pH, potentially having a negative impact on coral and other calcifying organisms since more acidic waters can dissolve and thus weaken the skeletal structure of such organisms (Hofmann *et al*., 2010).

Other climate related impacts are expected from SLR and extreme events. Rising sea levels may reduce the amount of available light necessary for the photosynthetic processes of corals, and hurricanes can cause extensive structural damage to coral reefs. The ruggedness of a reef helps to break up waves and disperse wave energy thereby protecting the shoreline from wave impact. However, in so doing coral reefs can be broken apart and even uprooted from the substrate. Reportedly over 60% of the island's live corals were devastated by Hurricane Luis in 1995 (Mukhida & Gumbs, n.d.). *Acropora palmata* (elkhorn coral) reefs were destroyed, thereby increasing the susceptibility of the coastline to wave erosion. Climate change may increase the intensity of tropical cyclones and hinder the recovery of corals from damages experienced from previous events.

Figure 4.5.7: Reef debris, Cove Bay, Anguilla, after Hurricane Luis

(Source: Cambers, 1997)

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). The cumulative impacts of climate and non-climatic stressors can take a heavy toll on Caribbean reefs; it is therefore important to reduce the impacts of those stressors over which there is a measure of control e.g. overfishing, pollution and siltation.

Vulnerability of seagrass beds

Climate change presents a relatively new threat to seagrass ecosystems and as such there has been little study on its impacts on seagrass. 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 seagrass 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 decreases 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 seagrass stands have been shown to increase local pH. The impact of increased SST on seagrass beds in the Caribbean is uncertain since studies have suggested that the photosynthetic mechanism of tropical seagrasses becomes damaged at temperatures of 40-45°C (Campbell *et al*., 2006).

Hurricanes can uproot these aquatic plants and often beaches are strewn with mats of dead seagrass after a hurricane. This was the case when Hurricane Luis damaged 45% of Anguilla's seagrass beds (Mukhida & Gumbs, n.d.). Periods of intense rainfall are likely to cause soil erosion and coastal sedimentation, thus increasing the turbidity of waters surrounding seagrass beds, smothering plants and blocking essential light.

Figure 4.5.8: Dead seagrass, Rendezvous Bay, Anguilla, after Hurricane Luis

(Source: Cambers, 1997)

Vulnerability of fisheries

As previously discussed, climate change will have negative impacts on coral cover, seagrass beds and mangrove ecosystems that are all important to various life stages of commercial fish. A loss or partial loss of these nursery habitats will therefore reduce the abundance and diversity of reef fish. Fishers in some of the Eastern Caribbean islands have reported reduced catches and have attributed this to recent changes in ocean currents that they believe are affecting fish distribution. Warmer waters may indeed drive pelagic species away from the tropics in search of cooler temperatures and could potentially alter breeding patterns. Severe fluctuations in SST and local salinities could also compromise larval development and subsequently fish stocks.

An additional concern is that warmer temperatures will increase the frequency of algal blooms as well as the likelihood of ciguatoxin infection, a potentially fatal toxin to humans that accumulates in the tissues of some species of fish (BEST, 2001; BBC, 2010). Since 1980 a number of large-scale fish mass mortalities have occurred in the Caribbean Region but were poorly documented or researched (Williams & Bunkley-Williams, 2000). During one particular event in 1999 a number of islands in the Southern Caribbean reported thousands of various fish species washed ashore daily between the months of July and September. The cause remains inconclusive but various theories were presented including bacterial infection, high water temperature, increase of nutrients and decreased oxygen (PAHO, 2000). Although the direct cause of the mass mortality is undetermined, what is certain is the impact that such fill-kills have had on economies and livelihoods. The National Fisheries Division of Saint Vincent and the Grenadines, estimated a US $192,000 loss due to the decrease in fish landing and a US $120,000 loss of fish exports to Martinique. Furthermore there was a 75% drop in fishing and fish vending activities and an unknown loss due to a decline in the consumption of fish among nationals and tourists (PAHO, 2000). Anguilla's fisheries is closely tied to the tourism industry and as such negative impacts on one or both sectors could potentially devastate the island’s economy and have severe social impacts for fishers, their families and communities .

Despite these concerns, little is understood about the long-term effects of climate change on Caribbean fisheries. A report from the Marine Resource Governance in the Eastern Caribbean Project of the Centre for Resource Management and Environmental Studies (CERMES) at the University of the West Indies has noted that while the impacts of climate change on marine ecosystems are well recognised, insufficient research has been carried out into the potential impacts on fishing, fish processing, trade and fisheries technical support services related to artisanal fisheries.

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

4.6.1. Background

Small islands have much of their infrastructure and settlements located on or near the coast, including tourism, government, health, commercial and transportation facilities. With its high-density development along the coast, the tourism sector is particularly vulnerable to climate change and sea level rise. Anguilla is an important tourism destinations where the threat of SLR has been identified as a particular concern in both the short and long-term. This section of the report will focus on the coastal vulnerabilities associated with 'slow-onset' impacts of climate change, particularly inundation from SLR as it relates 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 (Anguilla) and local scale (Cove Bay, Rendezvous Bay, Sandy Ground and Island Harbour), 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).

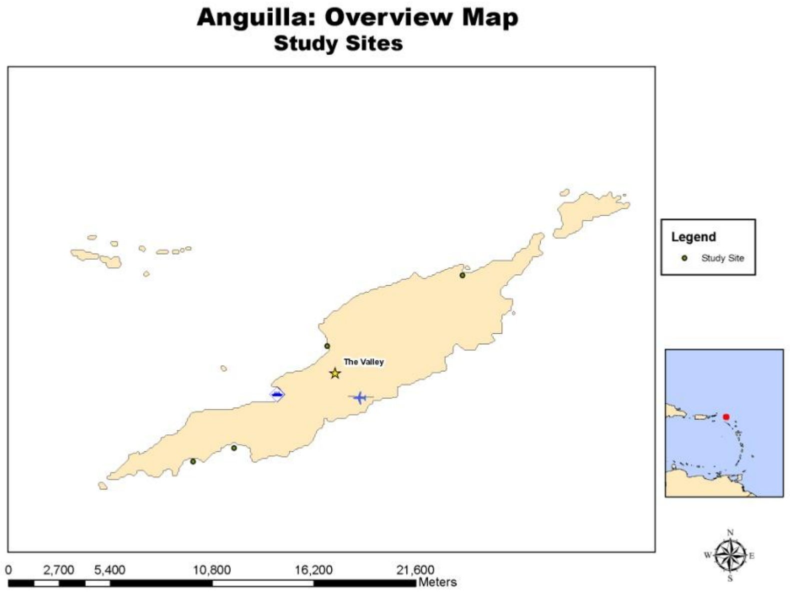


Figure 4.6.1: Anguilla- Overview Map

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 Anguilla are in Cove Bay, Rendezvous Bay, Sandy Ground and Island Harbour including resorts that lie at less than 6m 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 Anguilla, with a large proportion of beaches being lost to inundation and accelerated erosion even before resort infrastructure is damaged.

4.6.2. Vulnerability of Infrastructure and Settlements to Climate Change

As outlined in Section 3, there is overwhelming scientific evidence that SLR associated with climate change is projected to occur in the 21st Century and beyond, representing a chronic threat to the coastal zones in Anguilla. The sea level has risen in the Caribbean at about 3.1mm/year from 1950 to 2000 (Church *et al*, 2004). Global SLR is anticipated to increase as much as 1.5 m to 2 m above present levels in the 21st Century (Rahmstorf, 2007; Vermeer & Rahmstorf, 2009; Grinsted *et al*., 2009; Jevrejeva *et al*., 2008; Horton *et al*., 2008. It is also important to note that recent studies of the relative magnitude of regional SLR also suggest that because of the Caribbean's proximity to the equator, SLR will be more pronounced than in some other regions (Bamber *et al*., 2009; Hu *et al*., 2009).

Based on the sea level rise scenarios for the Caribbean (see Section 3) and consistent with other assessments of the its potential impacts (e.g. Dasgupta *et al.,* 2007 for the World Bank), 1.0 m and 2.0 m sea level rise scenarios were calculated to assess the potential vulnerability of major tourism resources across Anguilla. Figure 4.6.2 illustrates that the impacts of beach erosion are already being seen in Anguilla.

Figure 4.6.2: Erosion at Rendezvous Bay (Anguilla)

To examine the exposure of Anguilla to sea level rise, the research grade Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) data set recently publically released by the National Aeronautical 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 on the methodology). These assessments were used to calculate the impacts of sea level rise on the whole island.

Table 4.6.1 identifies what tourism infrastructure would be at risk of inundation from a 1 m and 2 m SLR scenario nationally. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 63% of the major tourism properties at risk, with 70% at risk with a 2 m SLR. Sea turtle nesting sites are also at risk, with 31% impacted with a 1 m SLR and 43% with a 2 m SLR scenario.

Transportation is also highly vulnerable in Anguilla, with 100% of ports at risk to a 1 m rise in sea level, and 30% of road networks to be impacted under a 2 m SLR.

Table 4.6.1: Impacts associated with 1 m and 2 m SLR in Anguilla

		Tourism Attractions		Transportation	
		Major Tourism Resorts	Sea Turtle Nesting Sites	Major Road Networks	Ports
SLR	1.0m	63%	31%	28%	100%
	2.0m	70%	43%	30%	-

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 Anguilla Ministry of Finance, Economic Development, Investments and Commerce to complete detailed coastal profile surveying. Using survey grade GPS equipment CARIBSAVE field teams conducted survey transects (perpendicular to the shoreline) at four locations in Anguilla 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 Anguilla. 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.

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 0.015-0.2 metres while the horizontal accuracy had a mean average of 0.015-0.2 m accuracy. Each transect point measurement was averaged over 10 readings taken at one 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 30 readings at one 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.

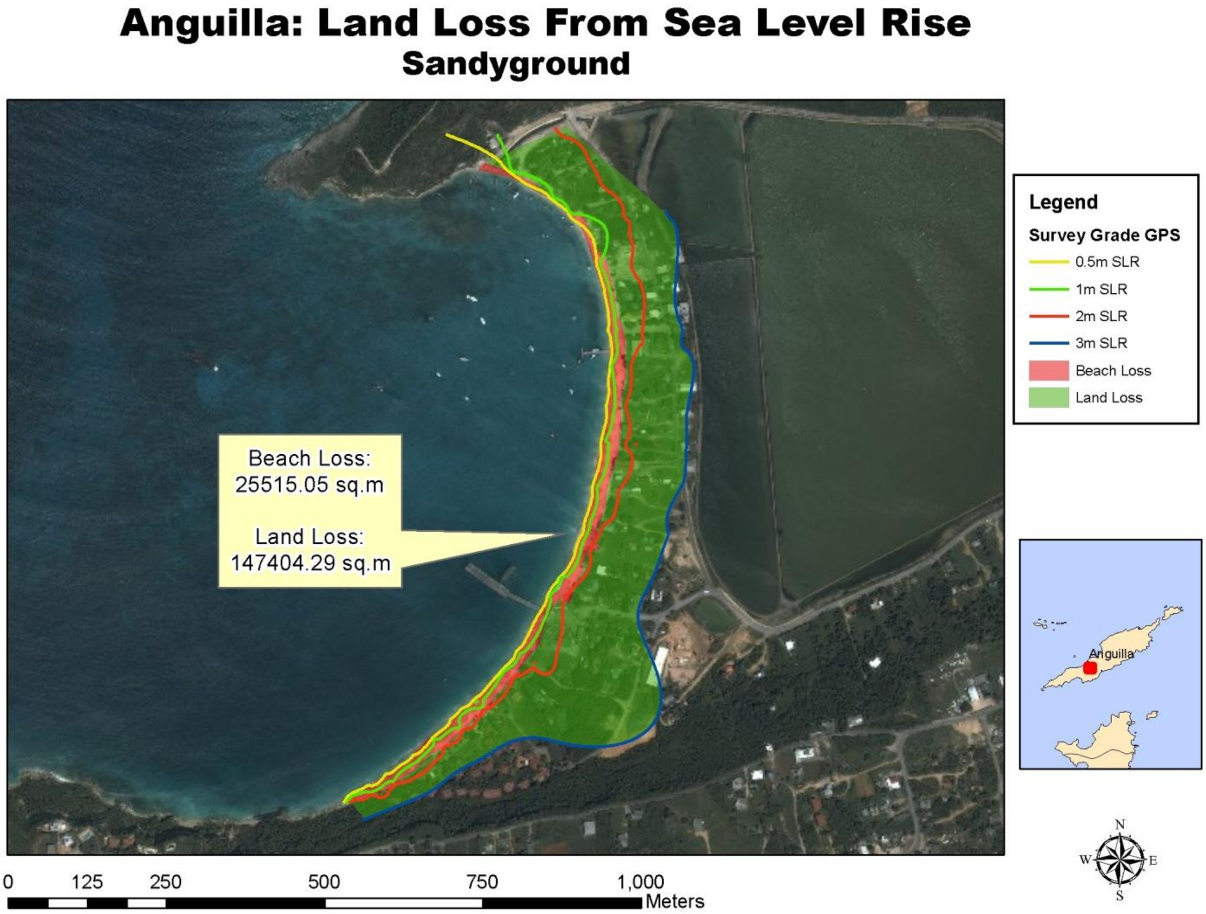


Figure 4.6.3: Total Land Loss, Sandy Ground, Anguilla

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 Rendezvous Bay, Anguilla, showed a 1 m flood scenario resulted in a total loss of more than 30,816 m^2 of beach area and a 3 m flood scenario resulted in a loss of 45,436 m^2 of land area.

Figure 4.6.3 and Figure 4.6.4 clearly illustrate that the long term inundation of the shoreline from a 1 m sea-level rise (green contour) would have significant implications for the shoreline and result in the loss of high value properties. Wave action and ocean currents will exacerbate the rate of land loss.

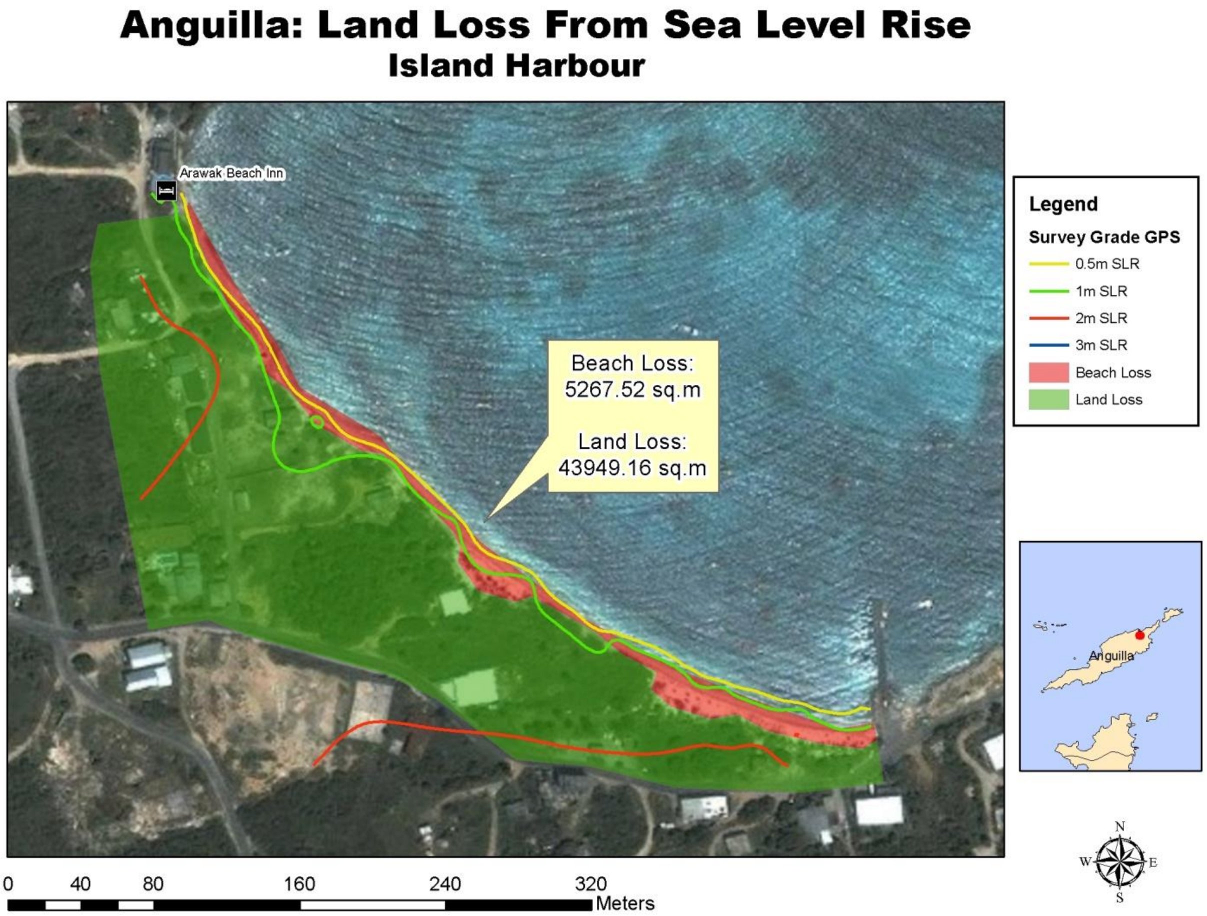


Figure 4.6.4: Sea Level Rise Vulnerability in Island Harbour, Anguilla

Table 4.6.2 highlights the beach area losses for four resorts in Anguilla (Cove Bay/Merry Wing, Island Harbour, Sandy Ground, Rendezvous Bay) based on the local survey information. With a 0.5 m SLR, over 60% of the highly valued beach resource at Cove Bay/Merry Wing would be inundated. With a 1 m sea level rise, all study sites would be more than 48% inundated. With a 2 m SLR all but Sandy Ground would become completely inundated, with all beach areas lost with a 3 m SLR. The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive that these beach areas along with the prevailing climate are the island’s main tourism attractions.

Table 4.6.2: Beach Area losses at Four Major Resort and Tourism Areas in Anguilla

	Cove Bay/ Merry Wing		Island Harbour		Sandy Ground		Rendezvous Bay	
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	27381	60%	1130	21%	2755	11%	20780	46%
1.0m	12177	87%	1650	53%	9392	48%	10036	68%
2.0m	6022	100%	2487	100%	11692	93%	14594	100%
3.0m	109	100%	-	-	1675	100%	26	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 Anguilla, 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 such, managing disaster risks requires a cross-sectoral understanding of the interdependent pressures that create vulnerability as well as demanding cooperation of various sectors; the same is true for climate change adaptation.

4.7.2. Natural Hazards in the Caribbean and Anguilla

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

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

Anguilla is low-lying island with the highest point reaching less than 80 m above sea level, thus the risk of landslide is generally quite low while there are some areas, such as Sandy Ground where the threat of landslide is present (personal communication, R. Bellers, Feb 2, 2012). The risk of storm surge and coastal flooding is significantly greater and is most likely to be associated with heavy rainfall events resulting from low pressure systems. Anguilla has one of the lowest occurrences of major hurricane impacts in the region, with just nine since 1492 (Trotz *et al*., 2004). Nevertheless, its location in the Atlantic Hurricane Belt does mean that hurricanes pass nearby every year and there is great potential for a serious impact to cause major damages to the island. The risk from geological hazards in Anguilla is less notable and limitations on data availability restrict the discussion of these hazards.

4.7.3. Case Study Examination of Vulnerability in Anguilla

Flooding Vulnerability

The Valley, the capital city, is located in a sinkhole; a common feature of limestone topography. This location makes the city prone to flooding as water is likely to sit in the large sinkhole during, and following, heavy rainfall events.

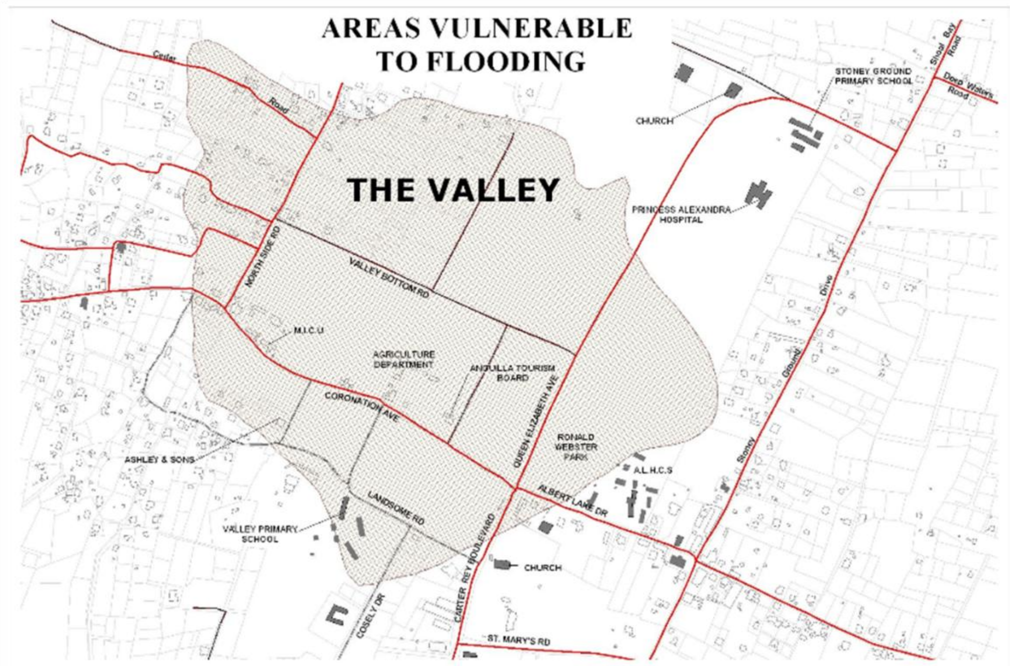


Figure 4.7.1: Flood map of The Valley, Anguilla
* Shaded area is area at risk of flooding
(Source: Forward Planning Unit, Physical Planning Department, Sept, 2005)

The flood map in Figure 4.7.1 shows a large, continuous part of the main city is vulnerable to this hazard. In 1999, rainfall following the passage of Hurricane Lenny created flooding damages. During this storm The Valley was transformed to a lake with water as deep as 14 feet (4.3 m) in some places (Cambers, 1999). Flood damages were experienced in government buildings and all government vehicles were also submerged. Lenny also caused extensive coastal erosion resulting in the construction of a seawall in Maunday's Bay the next year.

The need for evacuation routes in various communities to reduce vulnerability has been acknowledged in Anguilla. The recent Tsunami Ready programme aims to prepare communities for tsunami hazards specifically, but given the small size of the island and the location of The Valley near to the coast this programme also serves to prepare for other hazards. Most recently a Tsunami Evacuation Map has been made for the launch of a month-long awareness campaign of the tsunami hazard (CDEMA, 2011). Evacuation routes and maps do not reduce the exposure to these hazards, but they do build capacity in the community when accompanied with appropriate education and awareness building. Anguilla is therefore making positive efforts to reduce vulnerability.

Hurricane Vulnerability

Anguilla is exposed to hurricanes and review of a recent hurricane impact will serve to reveal some of the vulnerability concerns. In late August and September 2010 Hurricane Earl passed through the Caribbean Basin leaving behind exceptional rainfall and creating storm surges. On August 30, 2010 Earl, a category 2 hurricane, battered Anguilla causing damages to roofs at the airport, a primary school and cultural centre as well as some housing (CDEMA, 2010b). The high exposure of many structures and vulnerability to high winds is demonstrated by these impacts. Only 9 persons required shelter thus individuals and residential homes are quite resilient to hurricane impacts. However, electricity was off island-wide including the hospital, desalination plant, port and government secretariat (CDEMA, 2010b) – an indication of greater public infractructure and utility vulnerability in Anguilla. Further damages were also experienced in the agricultural sector where a hydroponic farm roof was damaged and all plants were lost.

Figure 4.7.2: Hurricane Earl damages in Anguilla
(Source: http://www.anguilla-beaches.com/anguilla-weather-in-august-september.html)

In summary, damages were experienced across the island and in many sectors. Flood, as well as wind damages impacted public utilities, government offices, health care centres and the agriculture and tourism sectors. These impacts highlight the widespread vulnerability of infrastructure to both wind and water damages. Further discussion of the specific vulnerability of individual sectors is located in more detail in sections 4.2 Energy Supply and Distribution; 4.3 Agriculture and Food Security, 4.4 Human Health. Fortunately, Anguilla's membership in the Caribbean Catastrophe Risk Insurance Facility (CCRIF) allowed them to get a payout to cover these damages. A payment of just over US $4 million was made 14 days after Earl (CCRIF, 2011). Housing damages were quite minimal with only 2-3 houses destroyed and over 25 damaged (CDEMA, 2010c). The strong resistance of the housing stock is a result of major impacts that occurred during Hurricane Donna (1960) which damaged 90% of the housing stock; now homes have been constructed with concrete roofs which withstand wind damages much better (personal communication, R. Bellers, February 2, 2012).

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

4.8.1. Background

According to the Country Poverty Assessment Report for Anguilla, it was estimated at the time of research that virtually every household would be affected eventually to one degree or another if the tourism sector was to experience a sustained decline. Although this was observed in 2001, this trend is likely to be the case now, given the continued heavy dependence on tourism Halcrow Consultants Limited, 2002).

Currently, the level of poverty in Anguilla is low by Caribbean standards, around 20% of households and 23% of the population. Severe poverty is also very low at around 2% of households. In general, poverty in Anguilla is not as easily distinguished as perhaps other parts of the Caribbean. Housing, and basic facilities such as water and electricity, school attendance and health levels are little different from those of not poor households. This may suggest significant efforts on the part of the government to reduce inequalities and stigmas associated with poverty.

However, even though poverty in Anguilla has decreased substantially over the last two decades, it is notable that over 25% of poor households are wholly dependent on tourism, compared to one-sixth of all households. Therefore any factors that affect tourism, will impact these households significantly. This vulnerability is exacerbated by the high cost of living which means that any reduction in income can have a serious impact on household finances, especially given that almost all food is imported and is subject to import duties.

The Country Poverty Assessment Report for Anguilla reported that there is little correlation between gender and income poverty. Women are however at risk from poverty in a number of ways: their earning potential is lower due to substantial wage differentials across all occupations categories; and despite increasing labour force participation and equal education opportunities, prevailing traditional views concerning their roles mean that they still have primary responsibility for child rearing and domestic work even as they are increasingly contributing to household incomes. Poor mothers are usually forced to settle for menial and sometime part-time work in order to meet household demands of child-rearing and making some measure of income.

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. Already vulnerable groups include women, children and the nation's poor, owing to their lack of access to resources and opportunities which translates into low resilience and exposes them more to climate change impacts than other groups.

Poverty is an important factor in vulnerability, and climate change and poverty are inextricably linked, particularly as the poor are and will continue to be the most affected. The impacts of climate change undeniably aggravate the issue of poverty in all societies, and especially where poverty is extreme and widespread (Figure 4.8.1 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 *et al*., n.d.). Conversely, climate change itself and the impacts it presents are also augmented by these same conditions of poverty, where the lack of access to resources and services almost dictates unsustainable environmental practices for survival (e.g. intense use of fossil fuels which promotes deforestation and contributes to greenhouse gas emissions, mismanagement of agricultural land and resources which encourages soil erosion, and decline in quality and output) (UNFPA, 2007; Kettle *et al*., n.d.).

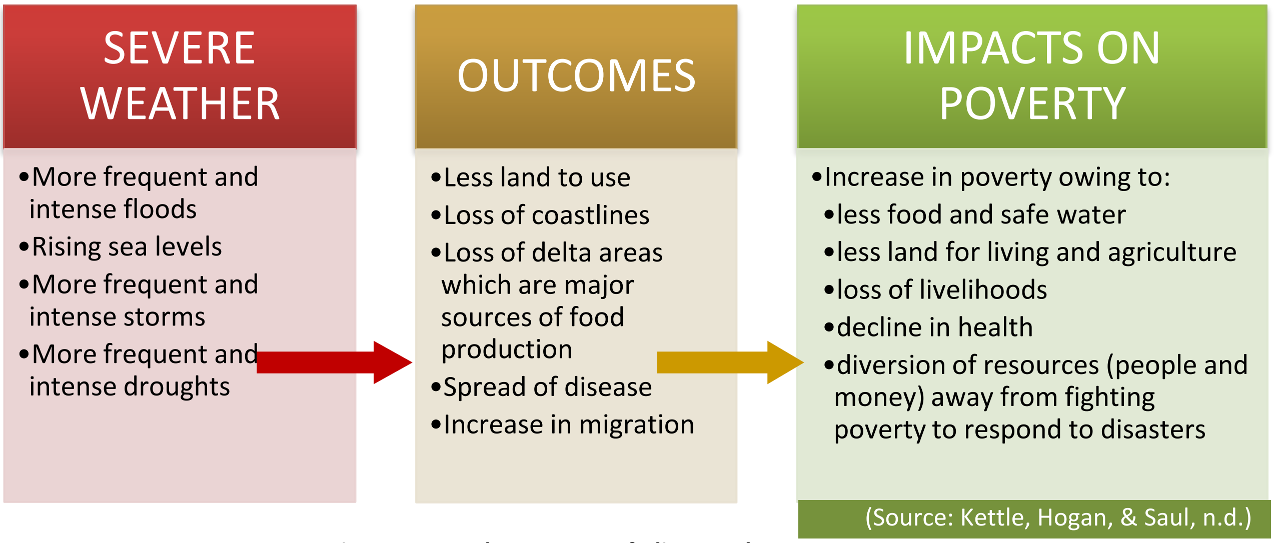


Figure 4.8.1: The Impacts of Climate Change on Poverty

Gender is given special consideration in assessing human vulnerability owing to the different roles and circumstances associated with men and women in society, and especially in disaster preparation and response. The Training Manual on Gender and Climate Change developed by the Global Gender and Climate Alliance (GGCA) highlights that gender-based vulnerability is not influenced by a single factor, but takes into account a number of factors, especially in the case of women who tend to have less or limited access to assets when compared to men. These factors have been identified as determinant factors of vulnerability and adaptive capacity, and include physical location, resources, knowledge, technology, power, decision-making, potential, education, health care and food (Global Gender and Climate Alliance, 2009).

The size and composition of an individual or social group's asset base (natural, physical, social, human and financial) will determine to what extent they will be affected by, and respond to climate change impacts. A larger quantity and/or diversity of assets imply greater resilience and adaptive capacity. Conversely, a lack of assets will predispose individuals to increased vulnerability. Women therefore, who tend to have less access to assets and resources will bear disproportionate impacts from climate change on their livelihoods and general well-being, exacerbating existing risks and revealing other hidden issues (Global Gender and Climate Alliance, 2009). The potential effects of climate change impacts (both direct and indirect) on women are highlighted in Table 4.8.1.

Table 4.8.1: Direct and indirect risks of climate change and their potential effect on women

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

(Source: Global Gender and Climate Alliance, 2009)

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

Presented in the Climate Modelling Section of this document are the likely changes to occur for given climate and ocean variables for Anguilla over the next few decades. Based on the assessment of outputs produced by both Regional and Global Climate Models, it is projected that:

1. the mean annual temperature and the number of 'hot' days and nights will increase
2. It is likely that more intense cyclones will result from warmer sea surface temperatures, although this is not conclusive.
3. Future rainfall projections include both increases and decreases in total annual rainfall. However, most models indicate in a decline in rainfall.
4. The number of 'cold' days and nights will be nominal by the 2080s.
5. 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.

In light of these changes in climate, the risks to vulnerable social and livelihood groups increase. Hurricanes in particular are of great concern, and the potential impacts of a major hurricane especially on the local tourism industry are tremendous. 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. Hurricanes Omar (2008) and Earl (2010) were two of the more recent systems to affect Anguilla. In October 2008, the passage of Hurricane Omar (Category 3 at the time) resulted in damage to tourism and residential infrastructure, power transmission lines, blocked roads and severe beach erosion. The island's airport and seaports were affected; temporarily offsetting air and sea traffic, and several boats and cargo vessels were affected. Two hotels suffered roof damage and a number of smaller tourism enterprises were temporarily without power and therefore unable to operate, even if they were spared from damage (CDERA, 2008).

Other inferences can be made based on the projections from 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. 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 Anguilla – 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: Sandy Ground, Anguilla

Overview

Sandy Ground was selected as the community in which to implement the *Community Vulnerability and Adaptive Capacity Assessment* methodology developed by The CARIBSAVE Partnership based on the established criteria and recommendations from the Government of Anguilla. Sandy Ground is located to the South West of Anguilla, within Road Bay. It has a beach and a salt pond and a narrow spit of land in between which holds a village, bars, restaurants, customs house and piers. At the time of the 2001 population census, there were approximately 274 residents living in the area (Anguilla Statistics Department, 2002). Unlike other communities which were researched, and consistent with earlier statements on poverty in this country, poverty is not easily distinguished in the area. Sandy Ground serves as the main port for the island allowing for trade and export, and was a major constituent of the former salt production and export industry. Tourism infrastructure is situated in Sandy Ground, with a large concentration of bars, restaurants, and accommodation facilities and attractions. These tourism facilities employ many of the residents in Sandy Ground, thereby providing a source of income for households. Large summer festivities are hosted yearly in the area, including boat racing activities and beach parties, and the popular August Day carnival – a national celebration. There are also some historic sites in Sandy Ground, including the Pump House (bar), the White House and an archaeological dig site. The diversity of infrastructure, business and activities that take place in Sandy Ground makes it a site of socio-economic, cultural and historic significance. As such, the good health and vibrant state of natural (especially coastal and marine) resources are crucial for the sustainability of the tourism-dependent businesses in Sandy Ground.

The CARIBSAVE *Community Vulnerability and Adaptive Capacity Assessment* methodology employed participatory tools to determine the context of this community's exposure to hazards, and a livelihood approach to assess its adaptive capacity. All data were disaggregated by gender and the three main means of data collection were: (i) a community vulnerability mapping exercise and discussion which were the main activities in a participatory workshop; (ii) 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) were evaluated to determine the adaptive capacity of households and consequently the entire community. Even though observations were specific to some parts within the study area, overall findings (assessments of vulnerability and adaptive capacity) are assumed to be representative for the entire community.

Natural Resources and Community Livelihoods

Tourism is a major employer within the community, and some of the tourism related livelihoods in Sandy Ground include bar and restaurant management and operations, snorkelling and dive operations, historic attractions, sailing and charter boat operations and accommodation facility operations (hotels and apartments). Some persons also take tourists out on recreational fishing excursions, although fishing is practised mainly for subsistence.

Natural resources within the immediate Sandy Ground area include coastal and marine resources including a salt pond and wide sandy beaches. Clear, nearshore waters attract persons for sea-baths and snorkelling, and healthy and attractive reef systems with an abundance of marine biodiversity (although further offshore) help to enhance the local diving experience. Diving excursions normally occur around the offshore islands – Sandy Island, Prickly Pear and Dog Island – which are all within the national marine park system and usually accessed from Sandy Ground.

The available coastal and marine resources also support small, informal fisheries activities and the abundance in commercial fish species allows some fishermen to sail out from Sandy Ground daily to ply their trade, sell their products to the public to derive income to support their families. While dry weather is preferred, fishing may only be interrupted with extreme weather instability which would cause high winds and rough sea swells. Some fishermen even risk going out to sea in conditions that would otherwise deter persons from venturing outdoors.

The Salt Pond in the Sandy Ground area was previously another important natural resource, as it supported livelihoods (salt extraction) during times where salt export was a major industry in Anguilla. However, the industry has since declined and extraction activities have ceased. The pond generally does not present many negative issues for persons within the community, but has been known to breach its banks in periods of persistent and heavy rainfall. This would then result in flooding and impact on homes and livelihoods in the area.

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

Among the residents living in the Sandy Ground area, individual perspectives on climate change and their risk of being affected vary, but most residents consider their knowledge of it to be average. Residents have reported observed changes in some weather patterns and to the state of the natural environment within recent times. These include:

- Day-time temperatures are increasing and are sometimes unbearable.
- On some occasions, there is a significant difference in the night- time temperature resulting in two extremes being experienced in the same night.
- Unlike other coastal communities throughout the Caribbean, there were minimal observations of changing rainfall patterns.
- There appeared to be no significant increase (outside of storm-related weather) or decrease in rainfall. Most homes have cisterns owing to Anguilla's traditional experience with low annual rainfall, making water harvesting at the household level a necessity. Most householders also invest in rainwater harvesting because they consider the public water supply extremely unreliable. Many residents also purchase bottled water for consumption.
- Increasing sightings of mosquitoes have been reported, in much greater numbers than before. The increase in mosquito population however, is more likely as a result of uncovered cisterns which would provide a breeding space - and not untreated stagnant water following rainfall as is suspected to be the case in some other Caribbean communities. Despite increasing numbers, the species most commonly seen is **not** the Aedes Egypti mosquito, which provides a small measure of relief for the community as there is a lesser threat of Dengue fever.

Anguilla, as a part of the eastern island chain, is vulnerable to impacts of extreme low pressure systems every year during the Tropical Atlantic Hurricane Season. Every year, these systems result in destruction and loss of property, livelihoods and lives in extreme cases; with economic losses in the order of US millions of dollars across the Caribbean. The intensity (and possibly frequency) of tropical storms and hurricanes are projected to increase with time, and therefore losses may also increase commensurately. Before 1995, the last major hurricane to impact Anguilla was in 1960. Since 1995, with the passage of Hurricane Luis, subsequent increases in the number of hurricanes and their intensity have been reported by community members. Most of the systems impacting the country and community within the last 5 decades were concentrated within the 16-year period between 1995 and 2010.

Apart from direct climate impacts, community residents have observed some changes in the surrounding natural environment, some of which can make natural systems more vulnerable to climate change impacts. Coral reefs were reported to have deteriorated significantly over recent times, possibly caused by pollution from improper solid waste disposal. Marine vessels are blamed in part for discharging waste in the marine environment in Sandy Ground and it is suggested this discharge is encouraging the breeding of sea lice which has affected sea bathers. An apparent lack of enforcement of regulations pertaining to designated marine park areas is also said to contribute to the decline of the marine environment. Reefs are also significantly affected by physical damage caused by the passage of storms and hurricanes, which make water turbulent and choppy – and aggressive environment for shallow water reefs.

Persons in Sandy Ground reportedly have a great respect for marine biodiversity. There is very little overfishing in the immediate area and the overfishing that *does* occur is blamed on foreign (non-national) fishermen. Whales also frequent the Sandy Ground Bay area. In mid-2011 at the time of research, it was reported that the whales stayed in the area for almost four months longer than usual, possibly owing to favourable water conditions. They usually migrate out of the area from February, but were sighted as late as June. No formal whale watching programmes are in operation because whales migrate with their young and mothers can be aggressive. Community members and fishermen respect this and therefore make an effort not to disturb the creatures.

The beach is an important local resource; however, there is some concern about the possibility of severe beach erosion affected the beach along Road Bay, not only from storms, but also reportedly from development activities and coastal in neighbouring areas.

Impacts of Weather and Climate on Community Livelihoods and Development

Hurricanes are the most serious weather events to affect Sandy Ground. As indicated previously, the last major hurricane before 1995 was experienced in the 1960s, which is approximately a 35- to 40-year gap in between these systems. As a result, Anguillans were relatively unprepared for Hurricane Luis in 1995, which was a particularly strong system at the time of passing. The accompanying winds, rough seas and most significantly, heavy rainfall caused severe damage in Anguilla generally, but especially in the Sandy Ground area. Approximately 10 properties in Sandy Ground were completely destroyed, including a few homes, one beach bar and restaurant. The destruction of the restaurant resulted in the temporary disruption of livelihoods and income flows for a number of residents who managed and worked at the restaurant. However, business operations resumed shortly after as an outdoor enterprise until a new structure was built to house the restaurant.

Hurricane Lenny in 1999 was another strong system that severely impacted on Sandy Ground. Houses on the sediment bar were seriously affected by storm surge and flooding, and roads were blocked temporarily. The sediment bar itself was breached during past hurricanes by the Road Salt Pond, and the force of the water flowing from the pond to the sea caused significant damage to houses that were built on the bar. There is only one path of vehicular access in and out of Sandy Ground and when this was blocked it resulted in some persons unable to travel to and from the community for work or for personal errands. There are undeveloped pathways, but these can only be traversed by foot. This singular roadway has implications for access of emergency vehicles if needed and presents a considerable vulnerability to this community. There were previous proposals to develop a second access path to and from the community, but this path has not been completed.

Within more recent times, although some systems have impacted the island, these systems were not as intense when compared to Hurricanes Luis and Lenny. Between 1995 and 1999 when these two systems impacted Anguilla, pre-fabricated houses became very popular in Anguilla, but these structures, especially the roofs were found to be very vulnerable to damage from even the weakest hurricanes. Since then, it is reported that the building code was more strictly enforced to ensure that houses could withstand the passage of storms. Adherence to the building code has helped to reduce the vulnerability of Anguillans to some hurricane impacts, so that recent systems passing within the last decade had less of an impact on households and mainly consisted of minor water damage and loss of trees (fruit trees, palm trees on beaches) and other vegetation. The lessons learnt from the impact of stronger hurricanes has therefore contributed to resilience building at the household level in Sandy Ground, and residents are now very knowledgeable about correct building practices and proper preparation for hurricane events.

Residents are aware of the dangers they face from living in the area, and during the approach of severe weather, they are normally advised to evacuate. However, it is notable that Sandy Ground is home to an older demographic and as such most residents tend not to heed evacuation warnings and prefer to stay with their property and belongings regardless of the outcome. However, on the other hand, it poses a significant risk to them in the event of a major hurricane, and can potentially (and unnecessarily) place additional burden on emergency response and recovery resources during and after the event.

Roles in Community Development and Disaster Management

In Sandy Ground, community development and leadership roles are considered to be shared by both men and women. At the level of Government, a locally-based representative is elected to represent the interests and concerns of the communities within his/her designated area to government. Currently the representative is a male, but females are not restricted from contesting elections and have done so in the past. Within the community itself, women make decisions within their households and for the community moreso than men, but responsibilities are shared generally. There are also a few community-based organisations that contribute towards the development of Sandy Ground, including the Sandy Ground Community Group and the Beautification Club. These groups brings persons with shared interests together to work towards a common goal within the community, and also serve as a social capital mechanism for members who may be able to call upon others within the group in times of need.

Some issues exist in Sandy Ground in relation to leadership and community development. Some residents perceive that there is a disconnect between the decision makers and persons who live and work in Sandy Ground, such that community concerns are not adequately attended to, and plans are sometimes developed for Sandy Ground with little input from the community itself. There is also another concern that a predominantly older demographic occupies Sandy Ground, with very few young people in the community to help further any future initiatives. The community therefore recognises that there is a need to involve and integrate the younger persons within the community and to build the community spirit within them, so that they may speak out on issues affecting the area, and become champions for the community when the need arises.

Gender inequality is not deemed to be an issue within the community. However, some roles are dominated by either men or women. Women are more vocal and visible on issues of social and community development and protection. This may stem from their traditional roles as caretakers of the family in general, but mainly of dependent householders (children, the elderly). Women tend to be more observant of issues, participate more in meetings and forums. Men tend to be less visible than women on social issues, but there are few that were identified as having particularly strong personalities and were vocal on community development issues.

The Department of Disaster Management (DDM) of the Government of Anguilla is responsible for disaster management in all areas of Anguilla, including Sandy Ground and community members voiced their satisfaction with the work of the DDM. There is a National Disaster Management Committee, which has various sub-committees, one of which deals with community disaster management (shelters, distribution of resources, etc.) for all communities. However, there is no specific community level branch of the DDM, in which each community has a community based disaster management committee/group. The DDM however, *does* work with the Red Cross Society and with local Soroptimist Clubs to augment national disaster management efforts (especially in post-disaster recovery and relief).

Despite the yearly threat of hurricanes, and the need to be prepared, very few residents have home insurance. There is a very low level of confidence in insurance companies amongst residents, and citizens of Anguilla in general. Many community residents had paid for home insurance for years, and were unable to claim (or claim without difficulty) in the aftermath of previous hurricane events. Very few people have home insurance against damage and loss of property. Residents who *do* have home insurance may likely have acquired it through a home mortgage plan administered by local banks. Most persons prefer to save their money as a form of a personal insurance fund which is used for urgent or major repairs when needed. In other cases, some employers (especially some hotels) pay a percentage of the employee's insurance as an employment benefit, and the percentage paid by the employer may increase each year. This has assisted a few employees to minimise their personal vulnerability to climate-related impacts.

Gender roles in disaster management at the community level are somewhat distinct. Men may attend to more manual tasks, such as affixing shutters, and ensuring that the roof is as secured as possible, whereas women stock up on essential supplies (e.g. foodstuff, medication, batteries). There is, however, a strong culture of independence amongst women in the community which transcended from previous times where many men left the country to work overseas (e.g. – the Dominican Republic). As a result, women had to fend for themselves under hurricane situations. During recovery situations, men will inspect the household and surroundings to determine what damage or losses may have been suffered after a hurricane or flood, and women will ensure that the family or household members are well. Both men and women go around the community to check on neighbours, and men will look to commence repairs as soon as possible. In the aftermath of hurricanes or storms, utility services work to restore power and water throughout the island. However, this process is considered to be very drawn out after a strong low pressure system or hurricane. Consequently, persons regarded the dependence on public utilities to be a main hindrance to restoring normality after a storm.

5. ADAPTIVE CAPACITY PROFILE FOR ANGUILLA

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

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

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

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

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

5.1. *Water Quality and Availability*

5.1.1. Policy

The Draft Climate Change Policy of Anguilla has a number of policy objectives related to water resources and other sectors. For instance it advocates for the inclusion and development of rainwater harvesting infrastructure in all tourism type facilities. Water resources are also broadly addressed with respect to agriculture as "conserve and protect agricultural lands and water sources for agricultural production" and in the health sector via the regulation of sources/points of pollution (Government of Anguilla, n.d. -3). Previous to this document, the Draft Green Paper: a working document to assist with the formulation of a Climate Change Strategy for Anguilla, recommended the creation of a National Climate Change Strategy and Action Plan. It also recommended the establishment of a National Environmental Council which would make the process of environmental management a more cohesive one (DOE, 2009). It is assumed that water resource management initiatives will fall under the purview of such a council.

The Water Corporation of Anguilla Act 2008 was devised to transform the Water Authority of Anguilla in to a state owned Water Corporation. The Water Corporation has the exclusive right to supply piped born water in Anguilla and powers to groundwater for treatment and distribution. The Land Development (Control) Act is important in water resources management in Anguilla as its objectives of land development permission and regulation of activities can affect water catchment areas in the territory. Similarly, the Bill for Environment Protection which will give rise to the Environment Protection Act will be important for the protection of the integrity of the territory's ecosystems which have a direct association with protection of water quality (DOE, 2009).

The National Environmental Management Strategy 2005 – 2009 makes brief mention of water resources via two recommendations under Principle 10: Prevent and Control Pollution and Manage Waste, of the St. George's Declaration of Principles for Environmental Sustainability in the OECS. These are that monitoring and reporting on the storage, collection and disposal of solid wastes at district levels and circulation of reports to all Ministries and that the number of sites and frequency of water quality monitoring be should be expanded, which are the responsibility of the Environmental Health Unit (Homer, 2005).

The Water Department has suffered from technical and financial losses for most of the last decade (MFEDICT, 2008). In 1999 the Water Department's operating deficit stood at $1.3 million (MFT, 2005). The privatisation of this institution into the Water Corporation sought to increase the efficiency of the water production and distribution on the island. The government undertakes initiatives to protect the water industry such as supporting rainwater catchment systems (Chase, 2008), increasing customs duties on bottled water entering the country and giving preferential treatment to local water producing companies (MFEDICT, 2010). This last initiative seeks to aid in job creation and development of the water sector as a sustainable and viable business entity in the country.

5.1.2. Management

A number of organisations are involved in water resource management in Anguilla. The Water Corporation of Anguilla, which began operations in 2008, is responsible for the management of the territory's water supplies. The corporation is a private entity and according to the Bill for the Water Corporation Act 2008, its main responsibilities include the management and operation of piped water, management and maintenance of all public water infrastructure on the island, the development of the waterworks system to areas that require water resources and it also has the power to extract groundwater resources for pipe distribution purposes.

The Public Utilities Commission assists in regulating the activities of the water sector (MFT, 2005). The Environmental Health Department, established in 2005, has responsibility for conservation of biodiversity and environmental management and waste management (PAHO, 2007a). The Physical Planning Department also has a role in managing natural resources and which has some overlap water resource management (DOE, 2009). The Anguilla National Trust is a major non-governmental stakeholder (Chase, 2008) and contribute to the protection of catchment areas through their conservation and preservation of the natural beauty of landscapes. The Statistics Department which stores data generated and is therefore important when such information is needed to inform policy-makers (Hope-Ross, 2004). The Water Laboratory, which is part of the Ministry of Health and Social Development is responsible for monitoring water which includes water produced by major hotels located on the western coast (PAHO, 2007a).

The Anguilla Water Department is responsible for the provision of water which is sourced from desalination plants as described in the vulnerability section above. It is also responsible for the "planning, construction, operation, and maintenance of the water supply" as well as water infrastructure (PAHO, 2007a).

The National Anguilla Trust, the Anguilla Tourist Board and the Department of Environment has produced a brochure on climate change entitled 'Climate Change and You' which include quick tips, climate change facts and actions that can be taken to combat climate change. Some of those related to water resources included installing water-saving devices, keeping gutters and spouts clear of debris, planting of drought-tolerant plants and avoiding the over-use of pesticides and fertilisers as well as other water pollutants such as engine oil (Personal Communication, 10/01/2011, Gina Brooks-Hodge).

Almost 80% of the 2008 Budget for The Ministry of Infrastructure, Communications, Utilities, Housing, Agriculture and Fisheries was allocated to the Water Corporation (MFEDICT, 2008). This demonstrates the priority placed on water resources as well as the high costs involved in management this resource and its demand on the island. Such high investments are undertaken both as an investment for the population as well as for the tourism sector.

Freshwater management in Anguilla has been found to be neglected as a result of the absence of regulatory measures, incentives or appropriate decision making tools. However, areas of positive action can be seen by their promotion of rainwater harvesting and the use of desalination (Chase, 2008). Anguilla also has intentions to supply water as well as electricity to French St. Martin (MFEDICT, 2010).

5.1.3. Technology

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

There is limited information available in report form of the activities of the Anguilla Water. However, in the past they conducted monthly reports of production and consumption of water resources both in values and volume figures (Hope-Ross, 2004). The Environmental Health Unit and the Water Laboratory work together to address related to water quality, sewage and wastewater issues (Richardson, 2009). For instance, attention to monitoring cisterns and pipe systems in public and private facilities such as the hospital, clinics, schools, prison, nursing and day care centres was identified as a priority for the Water Laboratory due to water quality concerns (Richardson, 2009). The need for further training and the provision of technical capacity in the Water Laboratory to address the pesticide contamination concerns was also identified in the Environmental Health Unit 2009 report (Richardson, 2009).

As stated in the vulnerability section, the unaccounted for water was estimated at 70% in 2008. To address this significant loss, plans were devised to implement a loss reduction programme. This involved the implementation of an automatic water metering system, establishing a district metering system and utilizing pressure zoning (The Anguillian, 2008). In terms of water quality, the 2008 Budget Address made provisions for the commissioning of a new Water Laboratory Building (MFEDICT, 2007).

5.2. *Energy Supply and Distribution*

5.2.1. Policy

As evident from current energy documents in many countries both in the Caribbean and outside, tourism is not central in the consideration of wider strategies to reduce energy use (Brewster, 2005; Haraksingh, 2001). Yet, as this document has shown for Anguilla, its 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-carbonize 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. Taxation is generally more acceptable if taxes are earmarked for a specific use, which in this case could for instance include incentives for the greening of tourism businesses. Tax burdens would then be cost-neutral for tourism, but help to speed up the greening of the sector. If communicated properly, businesses as well as tourists will accept such instruments, and the economic effect can be considerable. The Maldives charge, for instance, US $10 per 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), for instance, outlines that there is a huge potential to use solar energy. Both economical and non-economical technical solutions to reduce the energy-dependency of islands in the Caribbean could thus be implemented based on regulation, market-based approaches and incentives, as well as through financing derived from voluntary and regulatory carbon markets. Policy intervention is however needed to initiate these processes. Overall, Haraksingh (2001: 654; see also Headley, 1998) suggests that:

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

Anguilla has laid the groundwork for future renewable energy and energy efficiency initiatives through the National Energy Policy for 2008-2020 (Government of Anguilla, 2008). The Policy includes recommendations for the use of incentives and taxation to encourage energy efficiency, investment in renewable energy, purchase of efficient appliances and efficient vehicles. However, more effort and resources are required to develop the action plan that will lead to meaningful implementation, particularly with regard to the major energy consuming sectors currently not considered, i.e. shipping and aviation.

The Draft Climate Change Policy outlines a number of activities to be undertaken in the tourism sector specifically in pursuit of a climate resilient, energy efficient and low carbon economy. With regards to energy the Policy recommends diversifying the tourism product to promote low carbon, energy efficient and environmentally friendly development and developing a financing mechanism to facilitate that transition. The Policy also speaks to issues of energy security stating that the Government will implement the Energy Policy, climate proof the bulk fuel port and storage facilities, undertake a cost-benefit analysis for burying all utilities and legislate the requirement to bury utilities in all new developments (Government of Anguilla, n.d.-3).

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 be the third most relevant energy sub-sector. This is however dependent on whether fuels are bunkered in the respective island or not. Even where this is not the case, however, it deserves to be noted that the tourism systems of islands receiving cruise tourists are depending on oil bunkered elsewhere.

Tourism management is primarily concerned with revenue management, as the ultimate goal of any economic sector is to generate profits and jobs. A general critique of tourism management in this regard must be that it is too occupied with revenue, rather than profits as well as multiplier effects in the economy. This is an important distinction because profits have been declining in many tourism sub-sectors, such as aviation, where revenues have been increasing through continuously growing tourist volumes, while profits have stagnated. This is equally relevant for average length of stay, which is falling worldwide: to maintain bed-night numbers, destinations have consequently had to permanently increase tourist numbers. For instance, in the case of Anguilla, average length of stay has fallen 1.7 days over the last 1 ½ decades (from 9.7 days in 1993 to 8.0 days in 2009) (Caribbean Tourism Organisation, n.d.; Statistics Department, n.d.). Working pro-actively to increase average length of stay is consequently a highly relevant management task.

In an attempt to look at both profits and emissions of greenhouse gases, a number of concepts have been developed. One of the most important overall objectives can be defined as 'reduce the average energy use/emissions per tourist'. In the case of Anguilla, average emissions per tourist are already comparably low, i.e. corresponding to emissions of 750 kg CO_2 per tourist for air travel. Table 5.2.1 also 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 in 2004, but caused 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
1st market	**USA**	**USA**	**USA**	**USA**
Emissions ratio	0.8	0.5	0.8	0.9
2nd market	**UK**	**Netherlands**	-	**UK**
Emissions ratio	2.5	1.6		2.0
3rd market	-	-	-	**Barbados**
Emissions ratio				0.1
4th market	-	-	-	**Canada**
Emissions ratio				1.0

(Source: Gössling *et al.* 2008)

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

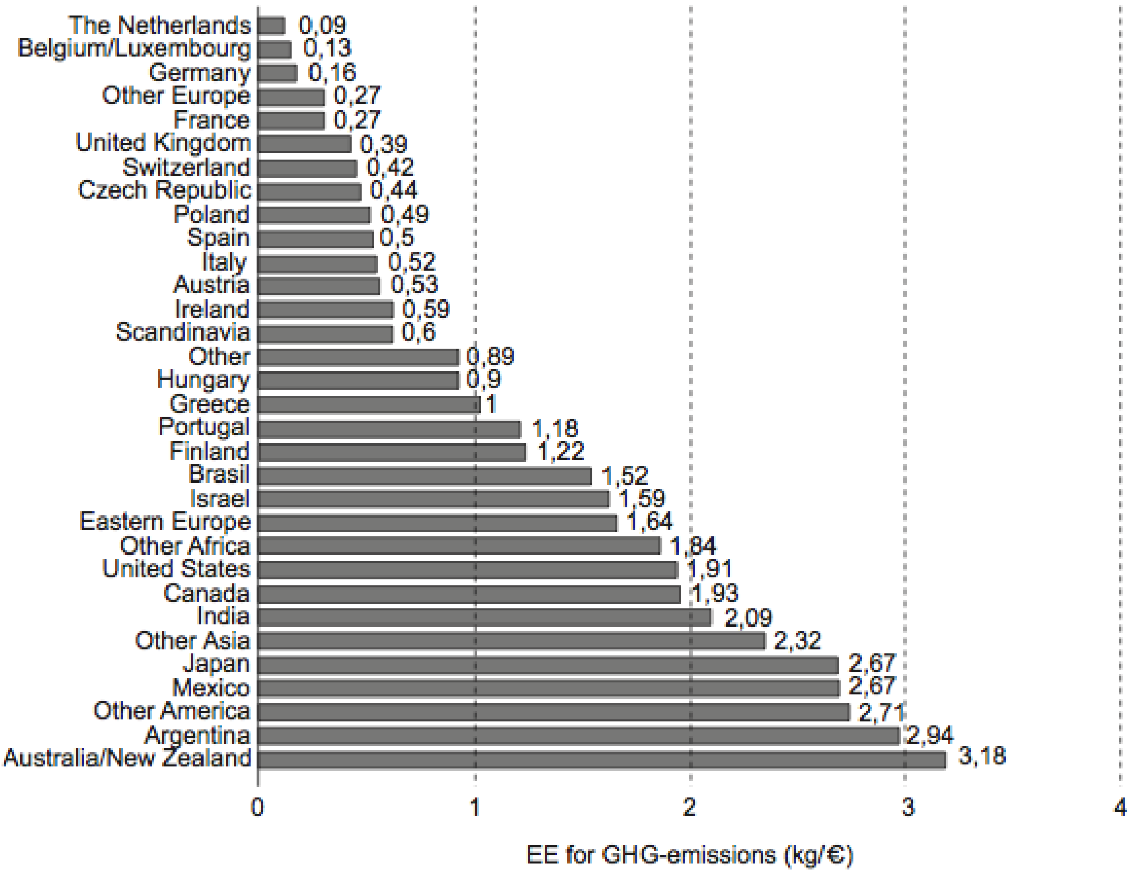


Figure 5.2.1: Eco-efficiencies of different source markets, Amsterdam

(Source: Gössling *et al*. 2005)

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

In Barbados, a survey carried out in February 2011 to better understand tourist perspectives on spending, length of stay, climate change and mitigation, yielded some interesting results. In this regard, 71% of respondents stated that they would have liked to stay longer, and 61% stated that they had spent less money than planned. It is likely that similar results could be found throughout the region, and further research needs to be carried out to identify how this potential can be realised: 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, 2010), 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).

With regard to management of the energy infrastructure ANGLEC has coped well in the past restoring power to the country following Hurricane Omar in 2008 with power restored to 90% of the country within 2 days and the system restoration substantially completed within five days with assistance from local lines contractors and heavy equipment contractors (ANGLEC, 2009). The Company has experienced difficulty in obtaining adequate and reasonably priced commercial insurance coverage for Transmission and Distribution assets and has therefore established a Self Insurance Fund to provide coverage for in the event of natural disasters or similar catastrophic events. To further mitigate the risk, the Company also continues to upgrade the transmission and distribution system to withstand higher categories of wind velocities (from 120 mph to 130 mph). Following Hurricane Omar EC $277,748 was withdrawn to cover expenses (ANGLEC, 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 five to seven years, while longer times are not favourable. While this would support investments into any technology with payback times of up to seven years, it means that alternative forms of financing are needed for some of the more expensive renewable energy technologies with longer payback periods. Most developing countries can look 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, such as electricity generation from biomass, renewable energy projects, or capture of CH_4, 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. However, as an Overseas Territory of the United Kingdom, Anguilla would be classified as an Annex I country and therefore ineligible to act as a host country for CDM. The National Energy Policy lists the carbon credit market as a mechanism to help finance the transition to energy independence (Government of Anguilla, 2008), since the UK Government has carbon abatement targets that it must attain. Therefore the Government of Anguilla should work with the UK Government to identify measures through which Anguilla can reduce carbon emissions, and obtain funding.

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

Anguilla is vulnerable to rising oil prices and global climate policy. However, there are various tools that can be employed to reduce energy use in the country, possibly in the order of an estimated 20% within 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, as initiated through the National Energy Policy.
- Vast options exist to reduce energy demand through carbon management. In particular, this includes a rethinking of markets based on their eco-efficiency, this can potentially lead to increasing turnover and declining energy costs, while also bringing greater attention to the diversification of markets. Carbon management also means to address average length of stay, and measures to stimulate spending: evidence indicates that there is considerable scope to increase both. Maintaining 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. The National Energy Policy has laid the groundwork for initiatives in this area.
- Finally, voluntary payments for carbon offsetting may be used as means to reduce energy use, and to increase the share of renewable energy in national energy mixes.

5.3. *Agriculture and Food Security*

5.3.1. Policy

The Government of Anguilla, through its Department of Agriculture, promotes and support agricultural industry for community and economic development (Anguilla Budget Address, 2009). Although agriculture is done on a very small scale, the development of Agriculture is perceived as a potential avenue to address economic pressures and foster youth development in the context of Anguilla. The Department of Agriculture collaborates with the National Farmers' Association to promote and increase the production of vegetables, fruits, and livestock.

5.3.2. Technology

There is evidence to suggest that increased use of current agro-technologies can significantly enhance agricultural resilience in Anguilla. According to Samuel (2011) local tomato production figures increased from about five tons per annum in 2005 to 15 tons in 2008 owing to application of modern technology. The Agricultural Department has been helping farmers in the use of organic methods, and the recent Soils Amelioration Project is helping farmers to produce some of the fertilizers necessary for the soil, without having to purchase it; and to reduce the amount of water required over time. The project is intended to enhance local agriculture production efficiency, build farmers' capacity to apply agriculturally sustainable practices, and create a sector that is more resilient to the constantly fluctuating weather patterns.

5.3.3. Farmers' Adaptation - Initiatives and Actions

Resh (2011) has been using hydroponic farming to supply the CuisinArt Resort in Anguilla since 1999. The large-scale hydroponic farm originated out of the need to have a steady supply of fresh vegetables in an environment where there was limited arable soil and no source of fresh water. The farm grows arugula, cucumbers, peppers, tomatoes, and herbs in pots, on vines, and in flat trays and provides the three restaurants at CuisinArt with a constant supply of produce.

The greenhouse is built to withstand a 150 mph hurricane but Resh (2011) admits that the hydroponic farm is not profitable because the scale of the operation is very small and the farm is labour-intensive. It costs 35% more to operate the hydroponic farm compared with what it would cost to bring in the equivalent in produce.

5.3.4. Summary

Anguilla's agricultural sector is vulnerable to climate change because it is miniscule in scale, is challenged by drought, and damage caused by hurricane winds; and local farmers have not totally embraced new agro-technologies that are suited for dealing with varying climate.

5.4. *Human Health*

5.4.1. Policy

In the draft Climate Change Policy of Anguilla, the Environmental Health Act and Food Safety Act are carded to be enacted and implemented (Government of Anguilla, n.d.-3). The Environmental Health Act was created through the modification of an older Public Health Act. The regulations in this document mostly focus on the public sector, including the Food Hygiene Regulation, and specifically deal with the regulation of the Ministry of Health (PAHO, 2007a). The draft Environmental Protection Act also to be enacted and implemented, has a role in pollution prevention (Government of Anguilla, n.d.-3). The National Health Policy and the National Food and Nutrition Policy were expected to be completed in 2009 according to the 2009-2014 National Strategic Plan for Health (MHSD, 2009). The Health Authority Act 2004 allowed for the establishment of the Anguilla Health Authority, a statutory co-operation whose functions are separate from the Ministry of Health and will be briefly described in the following section (PAHO, 2007a). The Government has also sought to strengthen National Legislation in conjunction with International Health Regulations (Richardson, 2009).

With regards to climate change, there is currently no Climate Change Policy, the document is however in its drafting stage this year and therefore was not available for review for this report. Due to the prominence of influenza in birds and humans, a National Surveillance Policy was developed in 2005 (PAHO, 2007a). The Avian Influenza Pre-Pandemic Plan of Anguilla was subsequently developed in 2006. The activities of the plan included the creation of a planning group, development of the plan, surveillance including human, animal and lab testing and provisions for the treatment of patients (Government of Anguilla, 2006). As noted in the above section, there has been a decline in the incidence of influenza-like illnesses in between 2006 and 2009. The reduction may be in part due to interventions contained in the above policy and plan.

There have been two strategic health plans in recent years. The 2003–2008 National Strategic Plan for Health was developed in 2003 and among its designations was provisioning for the operation of the Anguilla Health Authority (PAHO, 2007a). This plan has been followed up by the National Strategic Plan for Health 2009 -2014 which was prepared in 2009. The latter is summarised here. The plan was divided into a number of areas. While climate change was not directly mentioned, by strengthening these areas, this essentially contributes to the ability of the health sector to adapt to changes in diseases patterns and any other impacts that may arise. The areas of relevance to climate change included Health Systems Development, Health Services, Human Resource Management and Development, Family Health, Food Nutrition and Physical Activity, Communicable Diseases and Environmental Health. Within these areas, aside from the overall drive to increase training of personal from all the subdivisions, some of the expected outcomes based on specific indicators contained in the document include (MHSD, 2009):

Health Services *– increase in the utilisation of primary health care services by 25% above the 2008 level*

Family Health *– incidence of acute respiratory infections among children decreased by 35% by 2014*

Communicable diseases *– at least 95% of Communicable diseases reported fully investigated over the period 2009 to 2014*

- *Protocols for the handling, transportation and storage of laboratory samples enforced over the period 2009-2014*

- *Capacity of Ministry of Health to strengthen the response of its surveillance system increased over the period 2009-2014*

- *Medical record keeping for public health surveillances improved and maintained over the period 2009-2014*

Environmental health – *reduce the breeding of the mosquitoes and other vectors in the community by 5% house index over the period 2009 to 2014*

- *Public education on vector control issues increase by 25% by 2014*

- *Decline in the incidence of illnesses from the most common forms of vector borne pathogenic organisms over the period of the 2009 to 2014*

- *Technical capacity strengthened in collecting and analysing baseline surveillances data of vector borne illness by 2011*

- *Decline in the incidence of illnesses from the most common forms of food borne pathogenic organisms over the period of 2009 to 2014*

- *Programme for monitoring major sewage treatment plants adopted by end of 2014.*

Anguilla is vulnerable to climate change due to its reliance on primary imports, geopolitical dependence, disparities in economic well-being, limited development of social infrastructure among other issues (Tompkins *et al*., 2005). Due to the global recession in 2010, there were significant declines in GDP that affected the country. The positive economic situation of the island in general does not allow it to access financial assistance from abroad. As noted in the Country Poverty Assessment 2002 of Anguilla "Because of Anguilla's relatively high income, foreign assistance including subventions from the U.K. Government, are expected to decline, leaving the Anguillan Government to make do with its own tax revenues" (Halcrow Consultants Limited, 2002). As such revenues from external sources will be important in strengthening the country's ability to adapt and improve the social infrastructure of the country. This is particularly important because the success of Anguilla's health policies is hinged on government's ability to control unemployment rates (Halcrow Consultants Limited, 2002). In addition to this, just over a quarter of the population is non-Anguillan (Halcrow Consultants Limited, 2002). This has been due to the overall growth of the country's tourism sector and concomitant development. However, as a consequence of this increase in foreign labour, additional burden has been placed on the country's ability to deliver health care (PAHO, 2007b). While non-citizen immigrants have access to health care, they "pay twice as much for every kind of treatment except for medication and intravenous fluids" (PAHO, 2007a).

The health sector's inability to operate using a fee for service strategy led to a statement in the 2009 National Budget; "While some important strides have been made the HAA remains bedevilled by the question of finances and is reliant on Central Government for 85% of its annual recurrent expenditure budget and 100% of the capital expenditure budget" (MFEDICT, 2008). One avenue to cope with this problem is the development of a National Health Fund system, which is hoped, will make the Health Authority better able to support itself.

Table 5.4.1: Total expenditure on health as a % of GDP

Year	2000	2001	2002	2003	2004	2005
% of GDP	4.1	4.7	5.3	5.4	5.9	5.0

Source: (PAHO, 2007b).

Nonetheless, significant expenditure in the health sector has occurred in recent years. In 2008 the Health Authority was able to complete "the maternity wing, upgrade of the surgical theatre, creation of a Stabilisation Room in the Intensive Care Unit, Upgrade of Health Centres, Hurricane Shutters for the Miriam Gumbs Senior Citizens Home and purchase of medical equipment" (MFEDICT, 2008).

5.4.2. Management

The Ministry of Health oversees health care and "the Minister is charged with formulating policy, setting standards and protocols for health care, conducting monitoring and evaluation, and determining technical procedures for regulating public and private health facilities" in Anguilla (PAHO, 2007a). The Ministry of Health and Social Development consists of a number of departments including the Department of Social Development, the Department of Health Protection (which includes the Environmental Health Unit), the Water Laboratory and the Directorate of Health Services Quality Management (PAHO, 2007a). The Department of Health Protection which consists of a Chief Medical Officer, a Surveillance Officer and an Epidemiologist, is also very important in garbage collection and disposal, which is important in controlling vectors such as mosquito breeding sites and sites suitable for rats to breed (MFEDICT, 2008). This in turn has an important function to the tourism industry of Anguilla. Every year the department conducts a Vector Awareness Programme in the month of October. Other departments that the Health Sector liaises with include the Physical Planning Department of the Ministry of Infrastructure, Communications, Utilities, Housing, Agriculture and Fisheries.

The Health Authority of Anguilla (HAA), established in 2004, deals directly with the delivery of public primary and secondary health care services and its management in Anguilla. The HAA is not a governmental department, but a semi-autonomous statutory board (PAHO, 2007c). The decentralisation of health allowed for increased sustainability and improved quality of health care in Anguilla (Richardson-Lake, 2006).

The health care network on the island consists of the 36-bed Princess Alexander Public Hospital and five health centres namely West End Health Centre, East End Health Centre, Welches Polyclinic, South Hill Health Centre and The Valley Health Centre which are located in three administrative health districts. The Hughes Medical Centre is the only private hospital in Anguilla and also has laboratory facilities. Besides a medical lab at the Princess Alexandra Hospital, there is no public health laboratory mainly due to cost of operations and low sample volume. Samples are usually sent to Saint Lucia or CAREC (PAHO, 2007a). There is also a private clinic called Hotel de Health (MHSD, 2009). Individual health care is also accessed abroad due to close proximity to other countries such as St. Martin, Puerto Rico, and St. Thomas (MHSD, 2009). Persons may also be sent to Barbados, Trinidad and Tobago and other islands to receive tertiary-level health care whose transfer costs are financed by the government (PAHO, 2007a).

Halcrow Consultants Limited (2002) summarised the health care system in Anguilla as follows "13% of respondents who used a medical facility during the past year used a hospital overseas and 4% used the hospital or clinic in St. Martin. Most people used a private doctor in Anguilla (29%) or either the hospital or

Public Health Centre (25% each).” As such a significant portion of the country is not represented in the statistics taken and therefore is not representative of the status of the health in Anguilla. It is assumed that this sector of the society is catered for in the follow up Country Poverty Assessment due to be completed this year.

Many of the climate change related issues of the health sector are the responsibility of the Department of Health Protection and its sub-unit, the Environmental Health Unit which divides the country into four environmental health districts who are the overseen by 4 environmental health officers (Richardson, 2009). For instance, dengue surveillance is the responsibility of this department. They are also responsible for all measures to control mosquito populations such as using fish as a biological controlling agent, ovi-trapping and malithion fogging operations in areas that mosquitoes breed, including hotel grounds. The department inspectors conduct routine monitoring, surveillance and inspection of swamps and cemeteries for mosquito breeding grounds. Rodenticide is also sold by the department for revenue and to encourage the suppression of rodent populations in households. There are also initiatives to remove bulk waste from properties as these have been found to encourage breeding of rodents and other pests (Richardson, 2009).

They are also responsible for the surveillance of diarrhoea-related morbidity particularly due to salmonella and other food-borne diseases that have queues related to improper hygiene and sanitation conditions (PAHO, 2007b). While this should be targeted from a home based approach, the food sector is also a very important avenue to regulate the spread of food and water-borne diseases. As such there is a Food Safety Program which promotes food safety training, appropriate certification and requires that food handles attain permits which are renewed biannually (PAHO, 2007a; Richardson, 2009).

This Department of Health Protection also has the responsibility to measure air and water quality, and regulation and management of excreta and waste disposal (PAHO, 2007b). They do this partly through the surveillance of communicable diseases such as through the reporting of the “number of cases of fever and respiratory symptoms, fever and neurological symptoms, fever and haemorrhagic symptoms, gastroenteritis, and fever with no other symptoms” which is sent to the Caribbean Epidemiology Centre weekly (PAHO, 2007a). They have also conducted other exercises such as the through the Environmental Health Unit that sanitised all schools in 2009 for the pandemic influenza H1N1 (Richardson, 2009). The department has taken an approach of developing and strengthening linkages with stakeholders. Amongst the numerous types of complaints reported to the Environmental Health Unit in 2009 were 32 vector nuisances, 24 hygiene and sanitation, 16 sewage and 20 burning and dust pollution complaints. Of these, 91% were investigated which demonstrates the aggressive stance the unit takes with environmental health issues (Richardson, 2009).

The National Anguilla Trust, the Anguilla Tourist Board and the Department of Environment has produced a brochure on climate change entitled ‘Climate Change and You’ which include quick tips, climate change facts and actions that can be taken to combat climate change. Some of those related to health included keeping gutters and spouts clear of debris and buying locally-produced foods, (Personal Communication, 10/01/2011, Gina Brooks-Hodge). However, it fails to make direct reference to health and the spread of infectious diseases.

5.5. *Marine and Terrestrial Biodiversity and Fisheries*

Adaptation requires "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007). The adaptive capacity of ecosystems then is the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability, or future climate conditions (Brooks & Adger, 2005). Despite global action to reduce greenhouse gases, climate change impacts on biodiversity are unavoidable due to climate inertia. Natural ecosystems have long demonstrated the ability to adapt to changes in their physical environment. The rate at which climatic change occurs may exceed the rate at which ecosystems can adapt. Furthermore, natural environments, which are already stressed by human activities have compromised ability to cope with and to adapt to climate change. This adaptive capacity assessment thus considers the country's ability to conserve its biodiversity through managing sustainable resource use and the capacity to implement strategies to protect its natural environment.

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

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

Table 5.5.1: Biodiversity: Six Principles for Climate Change Adaptation

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

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

5.5.1. Policy

As a United Kingdom Overseas Territory (UKOT) and a member of various regional groupings, Anguilla's natural resource management policies are subject to a wide range of influences. Anguilla's economic dependency on tourism and by extension its natural environment and biodiversity has led the Government to adopt the policy to protect natural scenic areas (such as beaches, historic sites, and marine life) from further damage through proper use of those resources.

Approved in 2005, the Anguilla National Environmental Management Strategy and Action Plan (NEMS) for 2005-2009 is a policy intended to engage all Government departments and agencies to address the social, ecological and economic demands of Anguilla's natural resources. The document sets out 17 principles that will guide programmes in environmental management over the long term and was developed based on five key policy documents that provide broad guidance for the sustainable use of natural resources in Anguilla. These are:

1. The UK White Paper on Partnership for Progress and Prosperity;
2. Anguilla Environment Charter;
3. Strategic Country Programme (SCP);
4. Native Plant and Animal Habitat Conservation (Biodiversity) Policy and
5. The St. George's Declaration of Principles for Environmental Sustainability in the OECS that was signed by the Government of Anguilla in April 2001.

Principles 3 and 17 of Anguilla's NEMS recognise the need to improve on legal and institutional frameworks and to negotiate and Implement Multi-lateral Environmental Agreements. In order for Anguilla to sign onto important Multilateral Environmental Agreements (MEAs), these agreements must be extended by the United Kingdom. Before extension is approved by the UK, national legislation that will support the MEAs must first be in place. The Ministry of Environment is currently working on developing a comprehensive set of environmental policies and laws. In preparation to meet obligations under the Convention on Biological Diversity (CBD) the National Biodiversity Strategy and Action Plan (NBSAP) was prepared to guide conservation and protection of Anguilla's biodiversity relative to the country's socio-economic needs. Anguilla's Trade in Endangered Species Act (TESA) is the local legislation that gives effect in Anguilla to the Convention on Trade in Endangered Species of wild fauna and flora (CITES).

The NEMS acknowledges the country's failure to integrate environmental policies and standards into tourism policy and practices. Shortcomings include inadequately addressing carrying capacity issues, improper waste disposal including that from yachts, the certification of hotels and beaches and the control of beach activity.

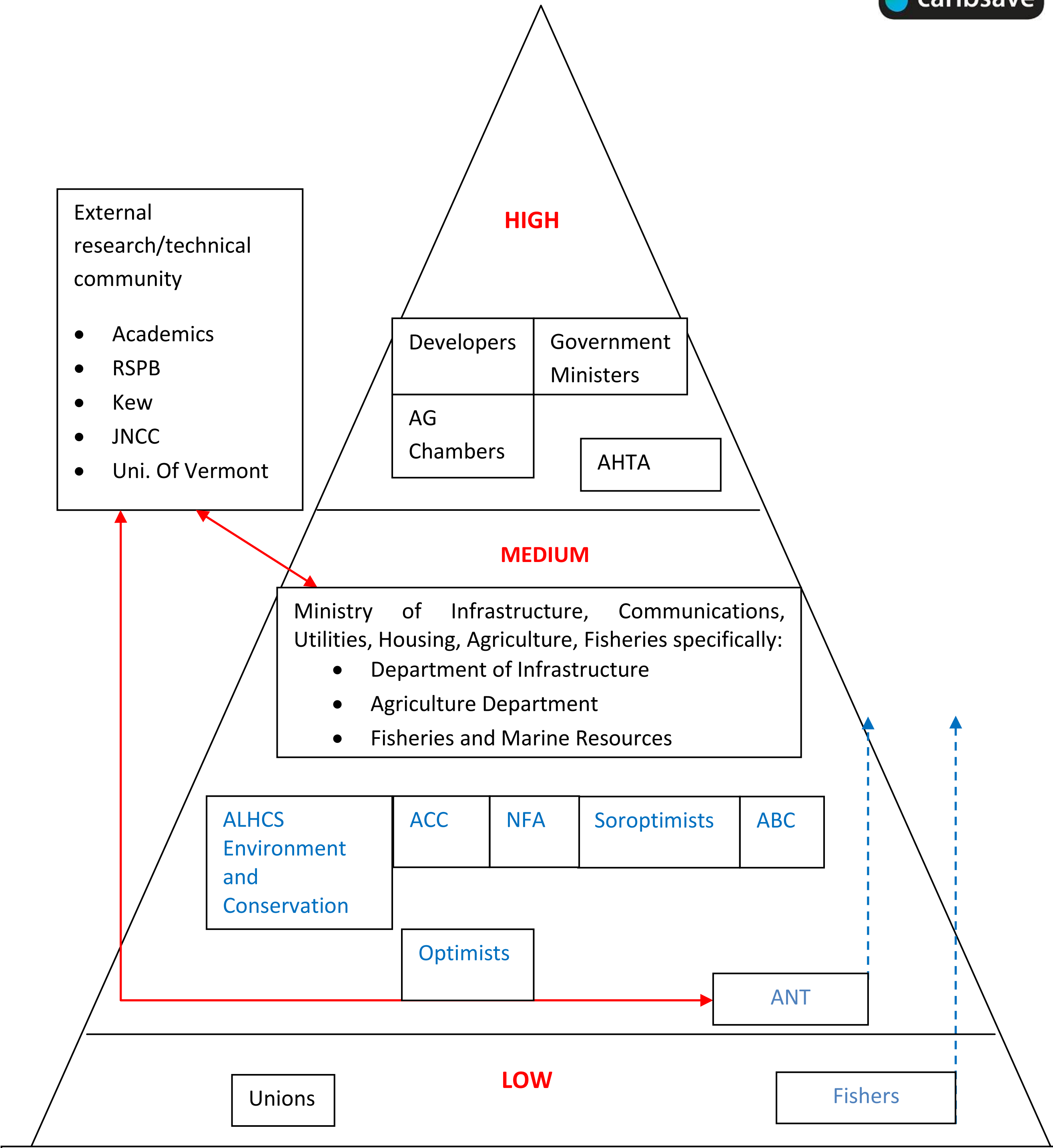
5.5.2. Management

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). In Anguilla, various agencies have been entrusted with the responsibility for environmental management and at times their jurisdiction overlaps. The Anguilla National Trust (ANT) was established in 1993 to act as custodian of Anguilla's heritage, preserving and promoting the island's natural environment and its archaeological, historical and cultural resources. The Department of Fisheries and Marine Resources (DFMR) and the Department of Environment are also responsible for management of natural resources.

In recent years Anguilla has made progress in some areas of environmental management but other issues remain of serious concern and are worsening. There has been significant progress in fisheries management; the available data relating to fishing has improved considerably due to an annual survey carried out by the DFMR. The Department has also had a vibrant ongoing beach-monitoring programme since 1991 (UNESCO, 2003). Waste management, however, is still as a significant problem. Reports from Anguilla express concern at deficiencies in monitoring and implementation of regulations due to low priority being allocated, rather than an overall shortage of official personnel or funding (UKOTCF, 2009). Various MEAs such as the Convention on Biological Diversity (CBD), the Ramsar Convention and the Convention on the

Conservation of Migratory Species of Wild Animals (CMS) recognise environmental impact assessment as an important tool for helping ensure that development is planned and implemented with biodiversity in mind. It is concerning, especially with the expansion of the tourism industry, that developments in Anguilla have taken place without Environmental Impact Assessments (EIAs) or even if these are available they cannot be accessed by the public (UKOTCF, 2009).

An assessment of the key stakeholders who have decision-making powers in biodiversity conservation in Anguilla highlighted the overall relative weakness of civil society in decision-making and policy influence (Figure 5.5.1). It appears, however, that groups mandated primarily with social development have greater influence than those focusing specifically on environmental issues as a result of the respective importance accorded to these sectors by government and the wider society. Concern has also been raised on the limitations that the Government subvention places on ANT's ability to engage in outspoken advocacy or lobbying (CANARI, 2009).



Key

ABC=Anguilla Beautification Club

ACC = Anguilla Christian Council

ALHCS + Albena Lake Hodge Comprehensive School

ANT = Anguilla National Trust

JNCC = Joint Nature Conservation Committee

NFA = National Farmers Association

RSPB = Royal Society for the Protection of Birds

Organisations in blue are civil society organisations (or potential ones). The dotted arrows for ANT and Fishers represent different perspectives at the meeting as to their level of power.

Figure 5.5.1: Influence/Decision-Making Power on Activities That Relate to the Conservation or Destruction of Biodiversity

(Source: CANARI, 2009)

Marine Protected Areas

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

Since the 1980's, through the assistance of the Eastern Caribbean Natural Area Management Program (ECNAMP), Anguilla developed a system of marine protected areas (MPA) for the purpose of protecting areas of high ecological value from human activity (CEP, 1996). In 1993, five marine parks were established: Dog Island (10 km^2), Prickly Pear (33 km^2), and Sandy Island (5 km^2) while the remaining two lie adjacent to Anguilla's mainland at Little Bay (1 km^2) and Shoal Bay-Island Harbour (19 km^2); all are located on the north northwest side of the island. The Department of Fisheries and Marine Resources is currently responsible for the management of these Parks under the Marine Parks Act (1982) which is further supported by the Marine Parks Regulations (1993), the Fisheries Protection Act (1986), and the Cruising Permit Act (1980). However no managing body has been designated by the Government of Anguilla.

A 2004 assessment of the effectiveness MPA management has shown that inconsistent interventions by the DFMR have led to management failures related to poor planning, little commitment to implementation, resource allocation constraints, dependence on external donor support, almost no monitoring and evaluation, and an inability to address concerns raised from feedback (Homer, 2005). Such failures are evidenced by baseline data collected in four of the Marine Parks that showed coral cover between 0.5% and 24.5% across a variety of reef habitats but low coral cover was more common, averaging only 9.5% (Bouchon *et al*, 2008). One of the objectives of Little Bay Marine Park is to protect one of Anguilla's most extensive seagrass beds, however, disregard for park regulations have resulted in the degradation of Little Bay's seagrasses both inside and outside the boundaries of the park. The poor state of environmental health within a protected area is disturbing as it is indicative of even worse conditions of areas that are not protected.

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). Principle 15 of the NEMS document promotes cooperation in the fields of science, technology and other research in support of sound and sustainable natural resource and environmental management, and the sustainable development of human resources. The Government of Anguilla has begun to take steps towards incorporating technology in biodiversity conservation particularly with regards to marine and coastal ecosystems. Coastal and sub-littoral habitats of all islands and reefs of the Anguilla group have been surveyed and mapped as part of the Anguilla Marine Resources Inventory Project administered by the Government of Anguilla, funded by ODA (Blair Myers *et al*., 1995; Sheppard *et al.,* 1995). Based on aerial photography a detailed GIS-based atlas was produced allowing for relatively straightforward updating when facilities in the territory permit.

Seven members of the Department of Fisheries and Marine Resources (DFMR) recently participated in a national Caribbean Fisheries Information System (CARIFIS) training workshop. CARIFIS is a fisheries database currently being used in the 17 member states of the Caribbean Regional Fisheries Mechanism (CRFM) to store information on fisheries including data collected through biological research programmes.

Under the CDB-UNESCO beach and coastal management project, updated beach change database and software were installed at the DFMR and three persons from this agency were trained in the data analysis and in the use of the 'Beach Profile Analysis' programme. The software and database were also installed at the Department of Physical Planning, and three officers in that department were also trained in its use.

Another innovative use of technology is the Department of Environment's e-Learning courses available through an interactive website. The website is still in developmental stages but currently offers a collection of free and paid short courses on Anguilla's environmental management policies and programmes, EIAs, and other environmental issues. With upwards of 40% of the population using the internet this has the potential for being an effective way of building awareness of biodiversity issues on the island.

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

Table 5.6.1: Summary of Adaptation Policies to reduce the vulnerability of Anguilla 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 centralized 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 costly and not ideal in sparsely populated areas. For densely populated cities, a seawall may be worth the investment when the costs of the protected lands are taken into account.

Unfortunately, the effectiveness of this approach may not withstand the test of time nor withstand against extreme events. Protective infrastructure not only requires expensive maintenance which can have long-term implications for sustainability, but adaptations that are successful in one location may create further vulnerabilities in other locations (IPCC, 2007b). For example, sea walls can be an effective form of flood protection from SLR, but scouring at the base of the 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 minimise the impact of flooding caused by SLR.

5.6.2. Technology – Soft Engineering

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

5.6.3. Policy

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

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

The concept of physical planning, particularly with regard to development control and coastal management is relatively recent to Anguilla. For example, The Department of Physical Planning, which holds the majority of responsibility for coastal zone management, was established in 1990, with coastal management only coming into place thereafter (Roberts-Hodge, 2001). In addition to the Department of Physical Planning, the management of Anguilla's coastal areas is highly fragmented, with the Department of Fisheries and Marine Resources, Department of Lands and Surveys, and the Environmental Health Unit also managing the coastal zones. Each department has responsibility for varying aspects of management and enforcement, with supporting legislation also dispersed amongst these agencies (Roberts-Hodge, 2001).

Also relatively recent to Anguilla is the establishment of coastal development setback guidelines. In 1996, the Department of Physical Planning established development setbacks and used the distances as a guideline in its decision-making on coastal development proposals (Cambers, 1997). This was done in the interest of Anguilla's economic wellbeing to ensure that new coastal developments would be sustainable. Developers have the right to appeal such decisions, often overturning the decision and successfully reducing setback distances (Roberts-Hodge, 2000).

The setback guidelines are calculated based on the vegetation line for specific beaches based on their particular behaviour, characteristics, erosional history and use (Cambers, 1997). Based on the data for individual beaches, four categories were determined; (1) 18 m landward of the vegetation line; (2) 30 m landward of the vegetation line; (3) 45 m landward of the vegetation line; (4) 92 m landward of the vegetation line. The assigned categories for Anguilla beaches are illustrated in Figure 5.6.1. An exception to these setbacks is beach bars and restaurants, which are allowed to develop 8m landward of the vegetation line (Cambers, 1997). Development setbacks on cliffs are 12 m from the cliff edge. For low rocky shores it is 30 m landward from the vegetation line. On sandy cays, development is restricted to piled, wooden structures (Cambers, 1997).

The Government of Anguilla recognises the imminent threat of climate change on the island and has subsequently been developing a climate change policy, including an adaptation strategy and action plan. This policy is part of the Climate Change in the UK Overseas Territories Project (Brown, 2008). The overall aim of the project is to aid the Government of Anguilla in establishing a framework of action for the public and private sector, as well as individuals and communities. The framework outlines incentives (funds), institutions (top-down and bottom-up) and instruments (policies) that Anguilla can implement to support and build capacity for climate change adaptation and mitigation. Among priority issues of concern that are being addressed in the framework is sea level rise. The intention is to have a finalised draft policy by 2011 (The Anguillian, 2011d).

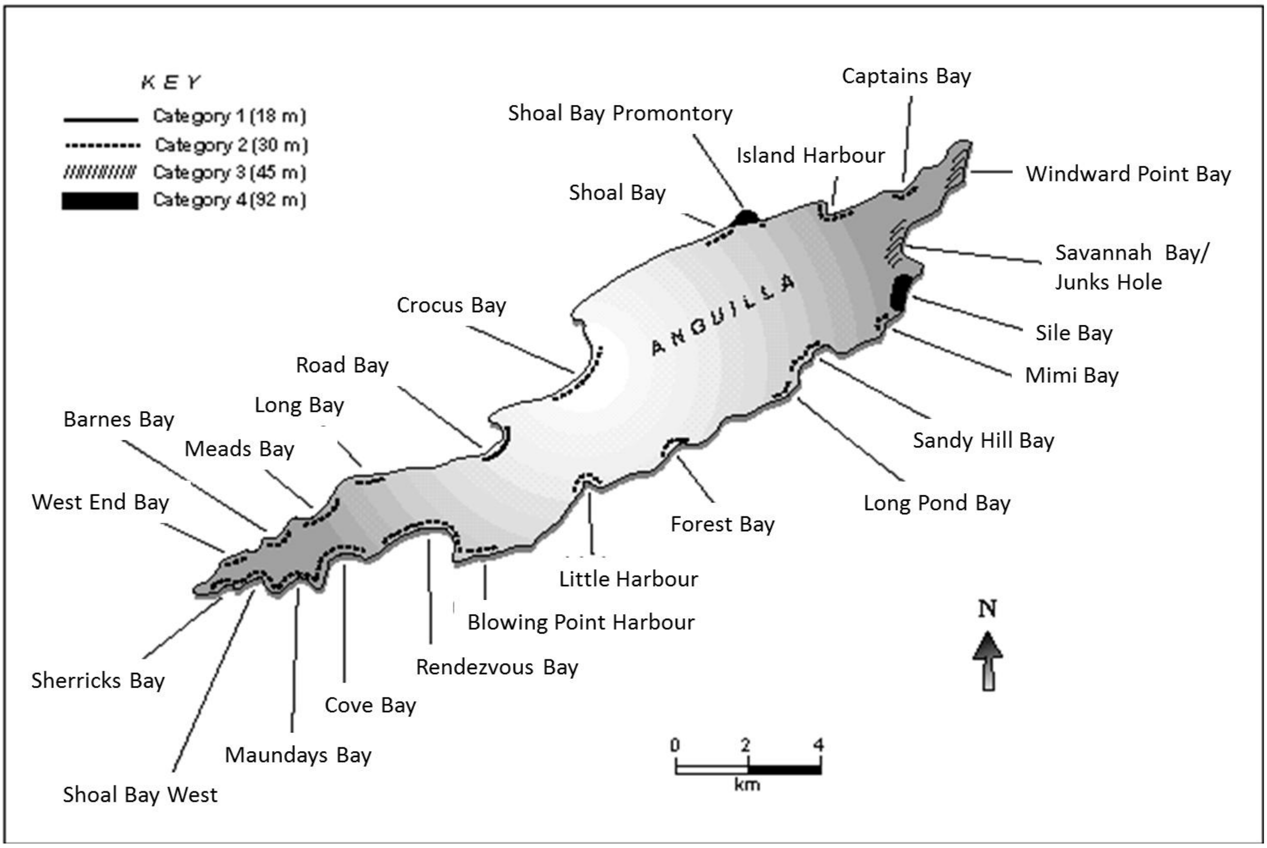


Figure 5.6.1: Coastal Setback Categories for Beaches in Anguilla

(Source: Cambers, 1997)

5.7. *Comprehensive Natural Disaster Management*

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

5.7.1. Management of Natural Hazards and Disasters

The disaster management system can be thought of as a cycle where preparedness, mitigation[5] and adaptation activities (disaster prevention) are the focus prior to a disaster impact. Following an impact the management focus becomes response, recovery and reconstruction (disaster relief). These two parts of the disaster management system work together and also impact the broader social, economic, ecological and political system (see Figure 5.7.1).

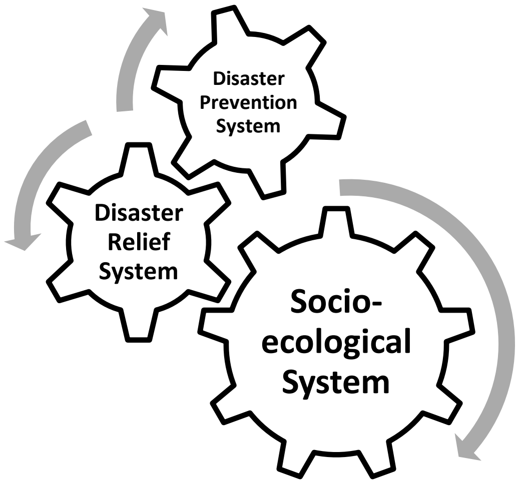


Figure 5.7.1: Relationship of the Disaster Management System and Society

Caribbean Disaster Management and Climate Change

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

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

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

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

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

To address disaster management in the Caribbean tourism sector, CDEMA, with the support of the Inter-American Development Bank (IDB) and in collaboration with the 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 2008).

Finally, the link between CDM and climate change cannot be ignored. Projections for the region suggest that more extreme temperatures and more intense rainfall in certain seasons could lead to a greater number of hydro-meteorological disasters. Many of the hazards facing Caribbean countries already pose threats to lives and livelihoods and climate-related events are regular occurrences. This has been recognised with the mention of climate change in the CDM strategy. The CCCRA report will not only offer improvements to the existing disaster management framework in the region, but will also offer pragmatic strategies for action which will build resilience in the Caribbean to the predicted impacts from climate change.

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

GOAL **Regional Sustainable Development enhanced through Comprehensive Disaster Management**			
PURPOSE **'To strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change.**			
OUTCOME 1: Enhanced institutional support for CDM Program implementation at national and regional levels	**OUTCOME 2:** An effective mechanism and programme for management of comprehensive disaster management knowledge has been established	**OUTCOME 3:** Disaster Risk Management has been mainstreamed at national levels and incorporated into key sectors of national economies (including tourism, health, agriculture and nutrition)	**OUTCOME 4:** Enhanced community resilience in CDERA states/ territories to mitigate and respond to the adverse effects of climate change and disasters
OUTPUTS *1.1 National Disaster Organizations are strengthened for supporting CDM implementation and a CDM program is developed for implementation at the national level* *1.2 CDERA CU is strengthened and restructured for effectively supporting the adoption of CDM in member countries* *1.3 Governments of participating states/ territories support CDM and have integrated CDM into national policies and strategies* *1.4 Donor programming integrates CDM into related environmental, climate change and disaster management programming in the region.* *1.5 Improved coordination at national and regional levels for disaster management* *1.6 System for CDM monitoring, evaluation and reporting being built*	***OUTPUTS*** *2.1 Establishment of a Regional Disaster Risk Reduction Network to include a Disaster Risk Reduction Centre and other centres of excellence for knowledge acquisition sharing and management in the region* *2.2 Infrastructure for fact-based policy and decision making is established /strengthened* *2.3 Improved under-standing and local /community-based knowledge sharing on priority hazards* *2.4 Existing educational and training materials for Comprehensive Disaster Management are standardized in the region.* *2.5 A Strategy and curriculum for building a culture of safety is established in the region*	***OUTPUTS*** *3.1 CDM is recognized as the roadmap for building resilience and Decision-makers in the public and private sectors understand and take action on Disaster Risk Management* *3.2 Disaster Risk Management capacity enhanced for lead sector agencies, National and regional insurance entities, and financial institutions* *3.3 Hazard information and Disaster Risk Management is integrated into sectoral policies, laws, development planning and operations, and decision-making in tourism, health, agriculture and nutrition, planning and infrastructure* *3.4 Prevention, Mitigation, Preparedness, Response, recovery and Rehabilitation Procedures developed and Implemented in tourism, health, agriculture and nutrition, planning and infrastructure*	***OUTPUTS*** *4.1 Preparedness, response and mitigation capacity (technical and managerial) is enhanced among public, private and civil sector entities for local level management and response* *4.2 Improved coordination and collaboration between community disaster organizations and other research/data partners including climate change entities for undertaking comprehensive disaster management* *4.3 Communities more aware and knowledgeable on disaster management and related procedures including safer building techniques* *4.4 Standardized holistic and gender-sensitive community methodologies for natural and anthropogenic hazard identification and mapping, vulnerability and risk assessments, and recovery and rehabilitation procedures developed and applied in selected communities.* *4.5 Early Warning Systems for disaster risk reduction enhanced at the community and national levels*

(Source: CDEMA, 2010)

5.7.2. Management of Disasters in Anguilla

The organisation of disaster management in Anguilla is led by the Department for Disaster Management (DDM). To assist with the policy side of disaster management there is a National Disaster Management Advisory Committee which meets regularly to review policies and create subcommittees to meet the operational needs of disaster management in Anguilla (Government of Anguilla, 2008). The Advisory Committee is comprised of the Governor, a Government Minister and representatives from various Ministries, the fire and police services, the Anguilla Tourist Board and other organisations as deemed appropriate by the Governor of Council (Government of Anguilla, 2008).

In the last decade Anguilla's disaster management system has been reviewed and evaluated. Since 2004, Anguilla has fully embraced the Regional Comprehensive Disaster Management (CDM) Strategy into the national CDM Strategy (CDMS). "Anguilla's capabilities for risk reduction and disaster response remain inappropriate to the risks faced and their likely consequences. Until a more coherent emphasis is placed on risk reduction and building a culture of safety to known hazards, Anguilla's continued progress and the well being of its population remains at risk" (Michael, 2004). Much of the challenge of the DDM office is its small budget and the small staff they are able to cover in the current budget.

Disaster management in Anguilla was identified to be insufficient following a Department for International Development (DFID) study of the Disaster Management Capabilities in the Caribbean Overseas Territories (Michael, 2004). Capacities were said to be lower than many other Caribbean islands. In response, DFID provided technical assistance to generate a national strategy that would bring Anguilla's disaster management system up to the standards of CDEMA Participating States (Michael, 2004). An experienced consultant was hired as Director in 2006 and her role was to build capacity and strengthen the disaster management system for Anguilla. As a result, the DDM now has an updated Disaster Management Act (2008) and Sector Plans for disasters (Department for Disaster Management, 2010). The end of the Director's contract has led to the hire of a local Anguillian as the new DDM Director (The Anguillian, 2011b). This experienced young woman is already taking strides to continue this positive momentum with the execution of a tsunami awareness campaign (CDEMA, 2011).

Anguilla has also made progress in the development of sectoral plans for disaster management. In the National HFA Progress Report (2010), the DDM lists staff shortages as a limiting factor in the monitoring and evaluation of the multi sectoral platform for disaster risk reduction (DRR). The sector plans for disaster management can help guide activities that current staff execute thus some progress on DRR can be made whether it is regularly monitored or not. While staffing shortages in the DDM still exist, current goals include empowering communities with knowledge about hazards and a multi-hazard warning system (The Anguillian, 2011b); both efforts that should help Anguilla reduce disaster losses and build resilience. While climate change considerations are not explicit in the policies and technology, the current Tsunami Ready programme is evidence that Anguilla and the DDM are aware of the threat of increasing impacts in the Caribbean.

5.7.3. Technology

Coastal Protection

In the Caribbean, investments in structural works are often used to protect coastlines. The use of groynes, breakwaters and sea walls are popular methods to control coastal erosion processes and safeguard developments from damaging wave actions. Although these structures do provide some relief from impacts, they generally only offer 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 disaster when the size of the structure is incongruent with an event (e.g. sea wall structures, if broken or damaged, can add debris and exacerbate flooding and erosion). Further discussion of the structural responses to climate change and SLR and storm surge can be found in Section 3.

Technology for Vulnerability Assessment

Technology can enhance disaster management at all stages of the disaster management cycle. In Anguilla, flood hazard maps for disaster preparedness exist from the years 2000 and 2003 (Trotz *et al*., 2004). In addition, vulnerability assessments have resulted in drainage and slope stability studies, coastal erosion assessments of beach resources and a structural assessment of critical facilities (e.g. schools and shelters) between 1996 and 2000 (Trotz *et al*., 2004). The use of mapping techniques that provide a visual representation of hazard risks and vulnerable populations are essential to DRR and offer the definitive evidence decision makers want when allocating budget funds. Most recently, as part of the draft national climate change policy, Anguilla aims to "undertake vulnerability mapping to determine high risk areas …and designate vulnerable zones requiring climate change risk management plans and appropriate engineering design for construction" (Government of Anguilla, n.d. -3).

Public Education

A newly appointed Communications Officer is drafting a National Communications Policy and Plan that will enable the creation of a Disaster webpage as well as policy procedures and protocols for a National Warning System (Department for Disaster Management, 2010). The Department for Disaster Management (DDM) has a Public Outreach and Education Plan and Strategy and the Hazard Inspection Programme and Strategy that operate throughout the communities on the island (Department for Disaster Management, 2010). Also, there are non-governmental organisations (NGOs) that assist during emergencies, including the Red Cross and Soroptomists.

In September 2011, Anguilla has launched a tsunami awareness programme (CDEMA, 2011). This is a month-long education and awareness campaign aimed at providing vital information to the public. The Tsunami Ready programme also shares an evacuation map that allows community members to understand how to respond during a tsunami and which areas near their homes are safe. The draft Climate Change Policy for Anguilla also outlines the need for greater community participation in activities such as vulnerability mapping (Government of Anguilla, n.d. -3). Together these programmes are building community adaptive capacity.

Early Warning Systems (EWS)

The Anguilla National Warning System (ANWS) was created to protect public safety during emergency situations and merge disparate systems into one common interface (Klute, 2008). Along with the ANWS, Anguilla has commenced the implementation of a Common Alerting Protocol (CAP) (Klute, 2008). Policy for the ANWS defines threshold of risk and the type of alert issues (warning, evacuation etc.). The CAP is a communication mechanism that ensures all at-risk groups receive simultaneous and consistent information (Klute, 2008). The first two phases of the CAP are already implemented and CAP is being integrated into day-to-day activities in Anguilla. Warnings are sent via email, cell phone SMS, and radio. The final phase will complete the legislative requirements for the ANWS and generate alerts to non-English speakers so that all groups, in all parts of the island receive and understand the alerts (Klute, 2008).

The recent efforts in tsunami early warning enhance the ANWS. Anguilla aims to be the first "Tsunami Ready" country in the English-speaking Caribbean (CDEMA, 2011). The DDM has made good progress in this area, with the support of community organisations, emergency managers and international and regional partners such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the Intergovernmental Oceanographic Commission (IOC) and the National Oceanic and Atmospheric Administration (NOAA) (CDEMA, 2011). Together these two initiatives are providing Anguillians with good information about pending danger and also providing good information on how best to react during emergencies. Anguilla is commended for their progress in this area.

5.7.4. Policy

Across the Caribbean policies to adapt to and manage climate change impacts are becoming more common. The strong relationship between disasters and climate change create a policy arena where both issues can be managed under similar governance mechanisms.

The National Disaster Management Act (2008) outlines the roles of the Director, Advisory Committee, Emergency Operations Centres, Shelters and other officers (Government of Anguilla, 2008). These roles inform how and when these roles change as a result of emergency situations. There are also protocols for the designation of 'specially vulnerable areas' and for their approval. Further, the Act outlines the alert protocols for pending impacts, environmental impact assessments and hazard inspections among other related activities (Government of Anguilla, 2008). The requirement for public participation is an important part of the Act and there is a clear relationship between the DDM and the *Gazette* newspaper.

The National Disaster Management Act appears to be a well developed document. A notable strength of the Act is that enforcement powers are well defined and not limited to a single authority, but spread to police officers as well. The regular review process is also an important part of keeping an up-to-date piece of legislation that will continue to keep hazards to a minimum and maintain an effective disaster management system in Anguilla.

Development Planning and Construction Techniques

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). Anguilla's building code takes into consideration CUBiC standards (Gibbs, 1998); whether they have an official CAD is not clear.

The creation of a building code for the entire region is a difficult undertaking. Though many of the islands face similar hazards, the hazards themselves sometimes have conflicting structural requirements for protection. For example, heavy structures are more resistance to high winds, while lighter structures resist earthquakes better (Gibbs, 1998). Not only then would a regional building code have to consider the diversity of hazards facing the islands of the Caribbean, but each country would also have to be able to prioritise hazard risks on their island or find some middle ground of resistance against the various hazards present.

Construction techniques can impact on the stability and resistance capacity of a structure. In Anguilla many of the construction labourers come from India and China. Although these persons are no doubt capable and likely guided by local architects, they may require some additional training in order to ensure known local hazards are considered in structures. The Disaster Management Act does make mention of hazard inspection and so the on-going enforcement of those regulations must be a part of regular building inspections so that labourers use the appropriate techniques, not simply the techniques they are most familiar with.

Catastrophe Insurance Coverage

Re-insurance within the Caribbean region has generally been provided by international insurance companies. However, the classification of the region as a catastrophe zone, thus being high risk, means that insurance premiums remain very high for those who seek insurance. The Caribbean is home to the first risk pooling facility designed to limit financial impacts of catastrophic hurricanes and earthquakes in Caribbean member countries, by providing short-term liquidity when the policy is triggered (CCRIF, 2011). Originally, the insurance index was based on degree of shaking during earthquakes or wind speed for hurricane events and the member country would qualify for a pay-out based on their policy and the level of damages deemed to be associated with either wind or shaking. Recently, the need to also consider water damages has been noted. As a result, the CCRIF has continued to make progress on an ‘Excess Rainfall product’ which is anticipated for the beginning of the 2011-2012 policy year starting on June 1, 2011 (CCRIF, 2011).

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 Sandy Ground community to determine household and community access to five livelihood assets (financial, physical, natural, social and human). Livelihood strategies (combinations of assets) are evaluated to determine the adaptive capacity of households and consequently communities.

A total of 38 respondents were surveyed, 17 of whom were male, 20 female, and no gender was indicated on one survey instrument. Six respondents did not indicate the gender of the head of household, and therefore only 32 surveys are analysed on the basis of the gender of the head of household. When analysis is performed on the gender of the respondent, 37 surveys are included.

5.8.1. Demographic Profile of Respondents

Residency in the Community

Respondents were generally long-time residents of Anguilla, with 73% (N= 27) of the sample indicating that they had lived in their community for a minimum of 20 years. Female and male respondents displayed a similar distribution in terms of length of time in their community, though female respondents were generally in their community for a longer term than the male respondents.

Table 5.8.1: Length of Residency in Parish / Community

Residency	Male		Female		TOTAL	
Less than 1 year	0	0%	0	0%	0	0%
1 - 5 years	2	12%	1	5%	3	8%
6 - 10 years	1	6%	0	0%	1	3%
11 - 15 years	0	0%	1	5%	1	3%
16 - 20 years	3	18%	0	0%	3	8%
Over 20 years	10	59%	17	85%	27	73%

Age Distribution

The sample was fairly evenly divided across age categories, but with the bulk of respondents being over 45. However, when disaggregated based on sex of respondent, males were generally younger than the female respondents.

Table 5.8.2: Age Distribution of Sample

Age	Male		Female		TOTAL	
Under 25	1	6%	0	0%	1	3%
25 - 34	6	35%	1	5%	7	19%
35 - 44	2	12%	2	10%	4	11%
45 - 54	3	18%	4	20%	7	19%
55 - 59	1	6%	3	15%	4	11%
Over 60	4	24%	10	50%	14	38%

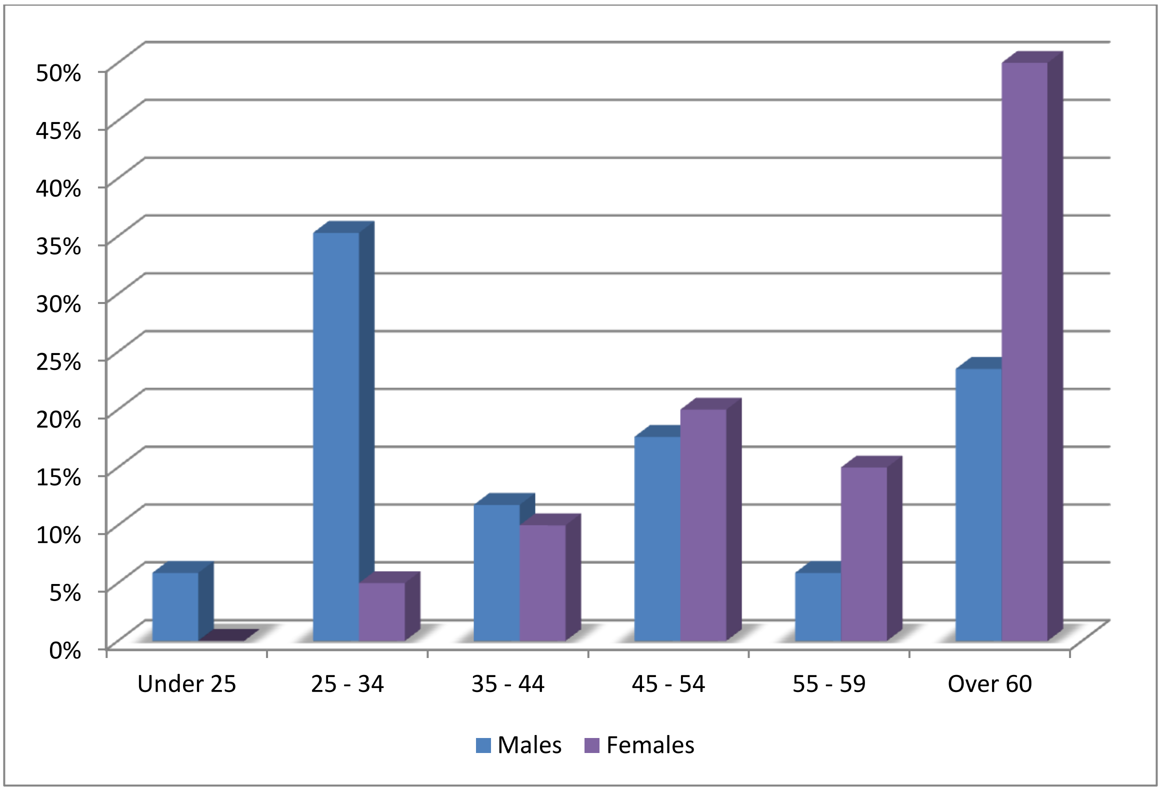


Figure 5.8.1: Age of Respondents

Household Form and Structure

Thirty-eight per cent of the respondents were married and 38% were single. 16% of respondents indicated being involved in a visiting relationship. One female respondent was widowed. No one was separated, and two were divorces.

Table 5.8.3: Relationship Status of Respondents

Status	Male		Female		TOTAL	
Single	7	41%	7	35%	14	38%
Single (Visiting Relationship)	4	24%	2	10%	6	16%
Married	6	35%	8	40%	14	38%
Separated	0	0%	0	0%	0	0%
Other/Common Law	0	0%	0	0%	0	0%
Divorced	0	0%	2	10%	2	5%
Widowed	0	0%	1	5%	1	3%

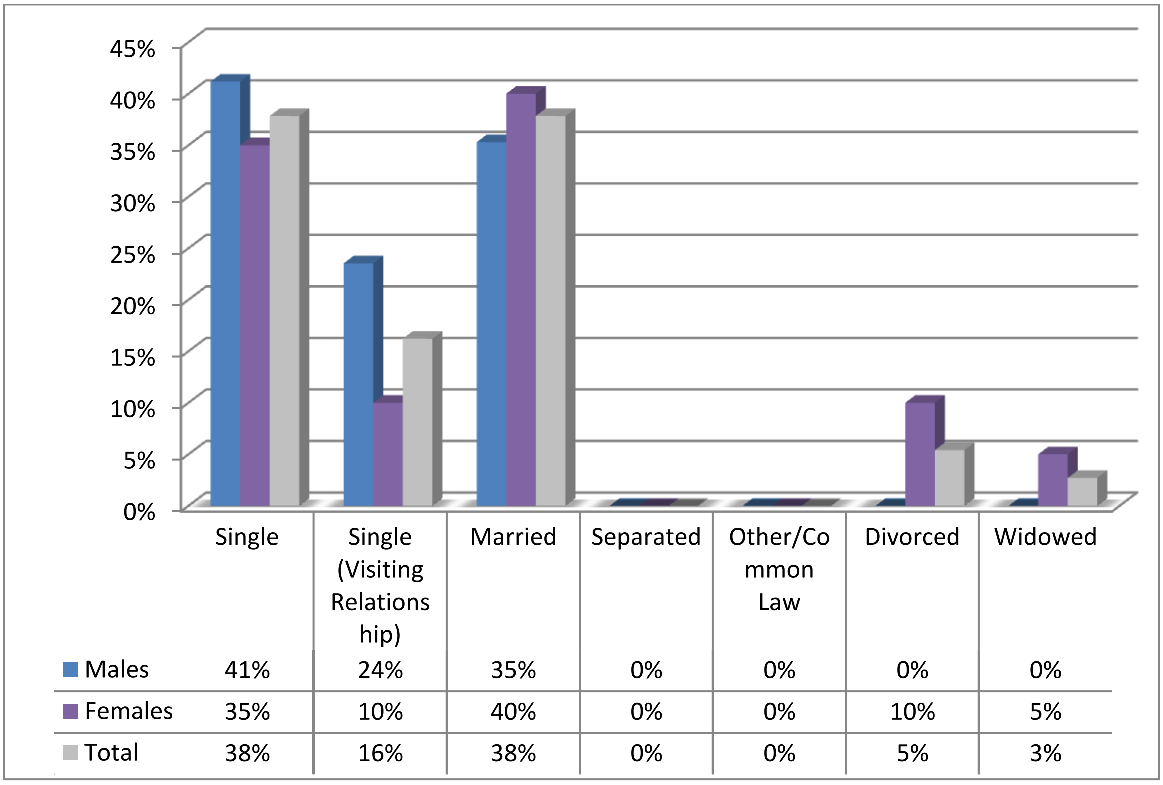


Figure 5.8.2: Relationship Status of Respondents

Household Headship

Only 65% of the male respondents indicated being the head of their household, whereas 90% of female respondents indicated being their head of household. The percentage of male headed households was also significantly smaller compared to the percentage of female headed households (see Table 5.8.4 and Table 5.8.5).

Table 5.8.4: Perception as Head of Household

Perceived as Head of Household	Sex of Respondent			
	Male		Female	
Yes	11	65%	18	90%
No	6	35%	2	10%

Table 5.8.5: Household Headship

Gender of Respondent	Male Headed Households		Female Headed Households		Sample (n=32)	
Male	11	92%	2	10%	13	41%
Female	1	8%	18	90%	19	59%
Total (as % of sample)	12	38%	20	63%	32	100%

With regards to household size, 19% (N=7) of respondents indicated that they lived alone. Another 47% of respondents belonged to households with between two and three persons, 31% belonged to households with four or five persons. One respondent (3% of the sample) indicated belonging to a household of eight or nine persons. There were dissimilar distributions based on the gender of the respondent. Female respondents generally belonged to larger households, though the difference is not significant.

Table 5.8.6: Family Size by Sex of Head of Household

Size of Household	Sex of Household Head					
	Male		Female		TOTAL	
1	2	17%	4	20%	6	19%
2 - 3	7	58%	8	40%	15	47%
4 - 5	3	25%	7	35%	10	31%
6 - 7	0	0%	0	0%	0	0%
8 - 9	0	0%	1	5%	1	3%

5.8.2. Education and Livelihoods

The largest proportion of the sample (N=13 /35%) indicated that they had completed a primary level of education. Twelve respondents indicated completing a secondary level of education (ten completed ordinary level, and two completed advanced level). Four respondents (11%) indicated completing community college, and three respondents (8%) indicated completing technical/vocational studies. Five respondents (14% of sample) indicated completing tertiary level studies.

Table 5.8.7: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		TOTAL	
Primary	5	29%	8	40%	13	35%
Secondary (Ordinary Level)	6	35%	4	20%	10	27%
Secondary (Advanced Level)	1	6%	1	5%	2	5%
Community College	1	6%	3	15%	4	11%
Technical - Vocational Institute	0	0%	3	15%	3	8%
Teacher's College	0	0%	0	0%	0	0%
Tertiary	4	24%	1	5%	5	14%

One-third of the sample indicated having basic education (Primary School level), which potentially places this fairly large group at a disadvantage in securing employment paying above minimum wage; whereas a higher level of education implies a greater probability of access to more positions in the job market, and secondary school education is a basic requirement in many sectors. In the long term, persons unable to reach these levels in the market have to survive and sustain themselves on minimal earnings, and this reduces their ability to absorb and recover from negative economic or natural events.

Table 5.8.8: Sample Distribution by Main Income Earning Responsibility

Are you the main income earner?	Sex of Respondent					
	Male		Female		TOTAL	
Yes	12	71%	12	60%	24	65%
No	5	29%	8	40%	13	35%

In terms of main income earning responsibility, analysis shows that males were more likely to bear this role in the household, compared to females. It also follows that the percentages of male breadwinners and male respondents who were household heads are similar. On the other hand, there were more female respondents who were household heads, compared to those who were actually household breadwinners (see Table 5.8.8).

Table 5.8.9 shows that the breadwinners sampled comprise most of the employed respondents. The overall employment rate amongst the sample is relatively low – only slightly higher than the unemployment rate. Referring to Table 5.8.2, slightly more than 60% of the sample fall within the working age range (15-65), and the unemployment rate is comparable to the percentage of the sample that falls outside of the working age range. In terms of gender however, the female unemployment rate is higher than that of the males. The dependency ratio/working age range could also be a factor here, but in any case it suggests that women have a gap in financial security.

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	11	65%	11	55%	22	59%
No	6	35%	9	45%	15	41%

Approximately 19% of female headed households (N = 3), and 8% of male headed households (N=2) recorded earning less than USD 500 per month. Of the entire sample, 12% of respondents earned between US $500 and US $750 per month, 9% earned between US $750 and US $1,000, between US $1,001 and US $1,250, and between US $1,251 and US $1,500 each. Another 27% earned more than US $1,500 per month. The smallest, and largest, income ranges are dominated by female headed households, although male headed households were generally better-off income-wise compared to female headed households (see Figure 5.8.3).

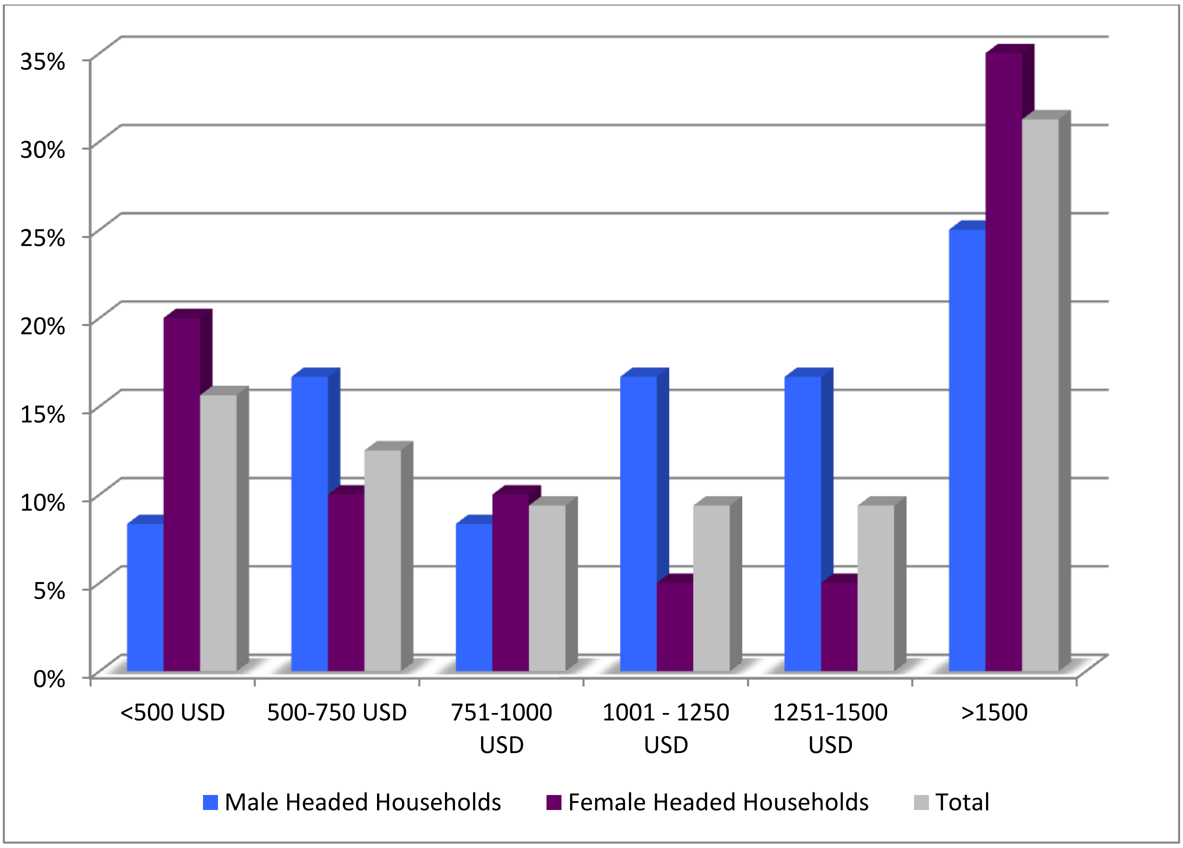


Figure 5.8.3: Sample Distribution by Average Monthly Earnings

In terms of employment in the tourism sector, 38% of the respondents indicated working in the tourism sector, 24% indicated that they didn't, and 38% didn't respond.

Table 5.8.10: Labour Market Participation: Involvement in the Tourism Sector

Are you involved in income generating activity	Male		Female		TOTAL	
Yes	7	41%	7	35%	14	38%
No	4	24%	5	25%	9	24%
Didn't respond	6	35%	8	40%	14	38%

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

Employment Sector	Male		Female		TOTAL	
Administration	0	0.0%	0	0.0%	0	0.0%
Agriculture	0	0.0%	0	0.0%	0	0.0%
Banking/Financial	1	5.9%	0	0.0%	1	2.7%
Building/Construction	0	0.0%	0	0.0%	0	0.0%
Domestic worker	0	0.0%	0	0.0%	0	0.0%
Education	0	0.0%	0	0.0%	0	0.0%
Manufacturing	2	11.8%	0	0.0%	2	5.4%
Mechanical/Technical	1	5.9%	0	0.0%	1	2.7%
Retail Sales and Services	0	0.0%	0	0.0%	0	0.0%
Health Services	0	0.0%	2	10.0%	2	5.4%
Government Worker	1	5.9%	0	0.0%	1	2.7%
Information Technology	0	0.0%	0	0.0%	0	0.0%
Science/Technology	0	0.0%	0	0.0%	0	0.0%
Self Employed	1	5.9%	1	5.0%	2	5.4%
Student	0	0.0%	0	0.0%	0	0.0%
Transportation	0	0.0%	0	0.0%	0	0.0%
Did not answer	11	64.7%	16	80.0%	27	73.0%
Other	0	0.0%	1	5.0%	1	2.7%

Table 5.8.12: 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	2	11.76%	4	20.00%	6	16.22%
Restaurant Workers	1	5.88%	0	0.00%	1	2.70%
Craft sellers or vendors	0	0.00%	0	0.00%	0	0.00%
Informal tour guides	0	0.00%	1	5.00%	1	2.70%
Privately owned business	2	11.76%	3	15.00%	5	13.51%
Other	1	5.88%	0	0.00%	1	2.70%
Did not answer	11	64.71%	12	60.00%	23	62.16%

5.8.3. Food Security

Overwhelmingly respondents (97%) indicated that their food supply was procured from grocery stores or super markets. Additional sources of food included Traditional Markets (3.1%) and Community Shops (6.3%) and 3.1% of the respondents grew their own food.

Table 5.8.13: Source of Food

Source of Food	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Grown by Family	0	0.0%	0	0.0%	0	0.0%	1	5.6%	1	3.1%
Grocery store / Super market	11	100%	1	100%	1	50.0%	18	100%	31	96.9%
Open air / Traditional market	1	9.1%	0	0.0%	0	0.0%	0	0.0%	1	3.1%
Community	0	0.0%	0	0.0%	0	0.0%	2	11.1%	2	6.3%
Barter	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

When asked about the adequacy of the household food supply, all but one respondent (one male) indicated an adequate supply throughout the year. Given the small sample size a definitive conclusion cannot be made in regards to gender and food adequacy, but more research in this area could provide further insights.

Table 5.8.14: Adequacy of Food Supply

Adequacy of Food Supply	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Yes	10	90.9%	1	100%	2	100%	17	94.4%	30	93.8%
No	1	9.1%	0	0.0%	0	0%	0	0.0%	1	3.1%

5.8.4. Financial Security and Social Protection

15.6% of respondents (N = 5) received financial support from family friends and 3.1% (N=1) received support from 'other' sources. Given the very small sample of respondents receiving support it is difficult to make any conclusions on the basis of gender.

Table 5.8.15: 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%	0	0.0%	0	0.0%
Family Friend	0	0.0%	0	0.0%	1	50.0%	4	22.2%	5	15.6%
Religious Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Charitable Organisation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Government	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	1	9.1%	0	0.0%	0	0.0%	0	0.0%	1	3.1%

A quarter of respondents gave financial support to religious organisations, 12.5% gave money to charitable organisations and 9.4% gave financial assistance to family friends.

Table 5.8.16: 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	0	0.0%	0	0.0%	0	0.0%	3	16.7%	3	9.4%
Religious Organisation	1	9.1%	1	100%	1	50.0%	5	27.8%	8	25.0%
Charitable Organisation	0	0.0%	0	0.0%	0	0.0%	4	22.2%	4	12.5%
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 access to credit, very few respondents indicated access credit. 21.9% of respondents accessed commercial bank loans and 12.5% used a sou-sou or partner. Proportionally, female respondents accessed more credit than male respondents.

Table 5.8.17: Distribution by Access to Credit

Sources to Credit	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Commercial Bank Loan	1	9.1%	0	0.0%	0	0.0%	6	33.3%	7	21.9%
Credit Union Loan	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Sou Sou / Partner	1	9.1%	0	0.0%	0	0.0%	3	16.7%	4	12.5%
Other	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Over half of respondents generally believed that in the instance of job loss or the occurrence of some natural disaster, their financial reserves would last less than six months.

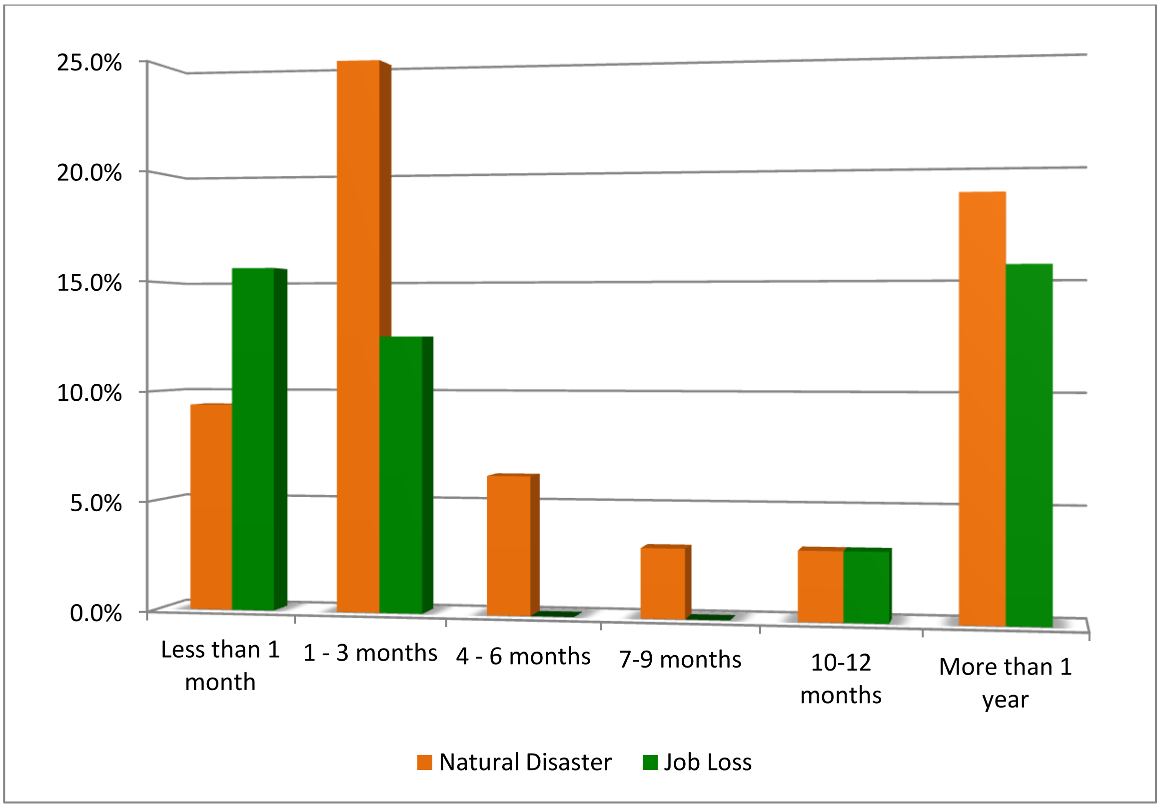


Figure 5.8.4: Financial Security: Job Loss or Natural Disaster

In relation to job loss, 15.6% of respondents indicated that they would have financial coverage for less than one month. 12.5% of respondents indicated they would have reserves for between one and three months. Only one respondent indicated they would have reserves for between seven months to one year, and five respondents indicated they would have financial reserves for more than one year. Eight respondents indicated that they didn't know how long their financial reserves would last.

Table 5.8.18: Sample Distribution by Financial Security: Job Loss

Financial Security	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	0	0.0%	1	100%	0	0.0%	4	22.2%	5	15.6%
1 - 3 months	3	27.3%	0	0.0%	0	0.0%	1	5.6%	4	12.5%
4 - 6 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
7 - 9 months	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	1	5.6%	1	3.1%
More than 1 year	3	27.3%	0	0.0%	1	50.0%	1	5.6%	5	15.6%
Do not know	3	27.3%	0	0.0%	1	50.0%	4	22.2%	8	25.0%

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

The perception of ability to support the household is a particularly useful indicator of resilience and would be important in determining the ways in which households adapt in the face of a natural / climate related event.

Table 5.8.19: Sample Distribution by Financial Security: Natural Disaster

Financial Security	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Less than 1 month	0	0.0%	0	0.0%	0	0.0%	3	16.7%	3	9.4%
1 - 3 months	4	36.4%	0	0.0%	0	0.0%	4	22.2%	8	25.0%
4 - 6 months	0	0.0%	1	100%	0	0.0%	1	5.6%	2	6.3%
7 - 9 months	0	0.0%	0	0.0%	0	0.0%	1	5.6%	1	3.1%
10 - 12 months	0	0.0%	0	0.0%	0	0.0%	1	5.6%	1	3.1%
More than 1 year	3	27.3%	0	0.0%	1	50.0%	2	11.1%	6	18.8%
Do not know	3	27.3%	0	0.0%	1	50.0%	6	33.3%	10	31.3%

In terms of social protections provisions, 53.1% of respondents indicating having health insurance. 18.8% have a private pension and 25% have a government pension. In terms of insurance, 15.6% have insurance against hurricane damage and fire damage, and 12.5% have insurance against flood, 9.5% have insurance against storm surge. There were similar rates of coverage for male and female headed households.

Table 5.8.20: Sample Distribution by Social Protection Provisions

Social Protection Provision	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Health Insurance	6	54.5%	1	100%	0	0.0%	10	55.6%	17	53.1%
Private Pension Savings Plan	1	9.1%	0	0.0%	1	50.0%	4	22.2%	6	18.8%
National Insurance / Government Pension	3	27.3%	0	0.0%	0	0.0%	5	27.8%	8	25.0%
Home Insurance - Hurricane Damage (water/wind)	2	18.2%	0	0.0%	0	0.0%	3	16.7%	5	15.6%
Home Insurance - Flooding	2	18.2%	0	0.0%	0	0.0%	2	11.1%	4	12.5%
Home Insurance - Storm Surge	1	9.1%	0	0.0%	0	0.0%	2	11.1%	3	9.4%
Home Insurance - Fire	2	18.2%	0	0.0%	0	0.0%	3	16.7%	5	15.6%

5.8.5. Asset Base

Ownership of assets, like provision of social protection, was generally moderate for respondents. The highest proportion of respondents indicated ownership of houses (81.3%), land (81.3%) and private business (25%). Generally, male headed households had higher rates of asset ownership than female headed households.

Table 5.8.21: Sample Distribution by Ownership of Assets: Capital Assets

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
House	6	54.5%	1	100%	1	50.0%	18	100%	26	81.3%
Land	7	63.6%	1	100%	2	100%	16	88.9%	26	81.3%
Livestock	0	0.0%	0	0.0%	0	0.0%	3	16.7%	3	9.4%
Industrial/Agricultural	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Commercial Vehicles	0	0.0%	0	0.0%	0	0.0%	1	5.6%	1	3.1%
Private Business	2	18.2%	0	0.0%	1	50.0%	5	27.8%	8	25.0%
None	3	27.3%	0	0.0%	0	0.0%	1	5.6%	4	12.5%

A further examination of assets revealed that respondents most often indicated having radios (100%), television sets (90.7%), mobile phones (84%), DVD Players (78.1%) and landline telephones (71%) in their homes. Approximately 59% of respondents indicated having a desktop computer, while 34.4% indicated having laptops. There were similar rates of electronic asset ownership between males and females.

Table 5.8.22: Sample Distribution by Ownership of Assets: Appliances / Electronics

Asset / Amenity	Male Headed				Female Headed				Sample	
	Male		Female		Male		Female			
Computer (Desktop)	8	72.7%	1	100.0%	1	50.0%	9	50.0%	19	59.4%
Computer (Laptop)	2	18.2%	1	100.0%	1	50.0%	7	38.9%	11	34.4%
Internet	6	54.5%	1	100.0%	1	50.0%	11	61.1%	19	59.4%
Television	10	90.9%	1	100.0%	2	100.0%	16	88.9%	29	90.6%
Video Player/Recorder	5	45.5%	1	100.0%	2	100.0%	9	50.0%	17	53.1%
DVD Player	9	81.8%	1	100.0%	2	100.0%	13	72.2%	25	78.1%
Radio	11	100.0%	1	100.0%	2	100.0%	18	100.0%	32	100.0%
Telephone (Land line)	6	54.5%	1	100.0%	0	0.0%	16	88.9%	23	71.9%
Telephone (Mobile)	9	81.8%	1	100.0%	2	100.0%	15	83.3%	27	84.4%

Predominantly the sample most normally had access to private, motorised vehicles (11%), public transit (11%) and to 'other' transportation (46%). Only male respondents had access to private motorised transportation.

Table 5.8.23: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male		Female		TOTAL	
Private motorised vehicle	4	24%	0	0%	4	11%
Private non-motorised vehicle	0	0%	0	0%	0	0%
Public transit	1	6%	3	15%	4	11%
None	1	6%	1	5%	2	5%
Other	17	100%	0	0%	17	46%

The largest proportion of respondents (N=32/86%) indicated that their home was made of blocks and cement and 3% (N=1), indicated their house was made of brick and mortar. There is little difference between male and female respondents.

Table 5.8.24: Sample Distribution by Ownership of Assets: House Material

House Material	Male Headed		Female Headed		TOTAL	
Brick and Mortar	1	6%	0	0%	1	3%
Blocks and Cement	15	88%	17	85%	32	86%

Respondents indicated that they had moderate access to sanitation conveniences, with 96.9% of respondents sampled indicating that they always had access to liquid waste disposal and 100% always had access to indoor water-flush toilets. 100% of respondents always had access to garbage collection. There was little difference between male and female headed households.

Table 5.8.25: Sample Distribution by Ownership of Assets: Access to Sanitation Conveniences

Amenity	Access	Male Headed	Female Headed	Sample
Liquid Waste Disposal	Always	100.0%	95.0%	96.9%
	Sometimes	0.0%	5.0%	3.1%
	Never	0.0%	0.0%	0.0%
Indoor water-flush toilets	Always	100.0%	100.0%	100.0%
	Sometimes	0.0%	0.0%	0.0%
	Never	0.0%	0.0%	0.0%
Garbage collection	Always	100.0%	100.0%	100.0%
	Sometimes	0.0%	0.0%	0.0%
	Never	0.0%	0.0%	0.0%

5.8.6. Power and Decision Making

Both female and male respondents indicated high levels of responsibility for decision making at level of the household, informal and formal community. 88.2% males and 85% of females indicated having a role in the decision making at the household level. At the informal community level, males (23.5%), and females (5%) indicated having a role in decision making. At the formal community level, only females (25%) indicated having a role in decision making.

Table 5.8.26: Power and Decision Making

Site of Decision	Males		Females		TOTAL	
Household	15	88.2%	17	85.0%	15	88.2%
Informal Community	4	23.5%	1	5.0%	4	23.5%
Formal Community	0	0.0%	5	25.0%	0	0.0%

Table 5.8.27: Power and Decision Making: Intra-Household

Site of Decision	Male Headed						Female Headed					
	Male		Female		Total		Male		Female		Total	
Household	11	100.0%	1	100.0%	12	100.0%	2	100.0%	15	83.3%	17	85.0%
Informal	4	36.4%	0	0.0%	4	33.3%	0	0.00%	1	5.6%	1	5.0%
Formal Community	0	0.0%	1	100.0%	1	8.3%	0	0.00%	4	22.2%	4	20.0%

5.8.7. Social Capital and Safety Networks

Both male and female respondents were slightly active in their community. 50% of females and only 5.9% of males respondents reported belonging to a social group within the community.

Table 5.8.28: Social Networks: Community Involvement

Membership	Male		Female	
Yes	1	5.9%	10	50.0%
No	15	88.2%	8	40.0%

With regards to support system male respondents tended to rely on relatives inside and outside their households for physical help and personal advice. Males also relied on all avenues of support (except for religious organisations) for financial advice. For Financial help, female respondents relied on friends and relatives. Females relied on all forms of support except government agency and non-religious charities for personal advice; relying most heavily on family and friends.

Table 5.8.29: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	Female	Male	Female	Male	Female
Relative (within the household)	52.9%	70.0%	35.3%	45.0%	47.1%	45.0%
Relative (outside the household)	11.8%	25.0%	17.6%	15.0%	5.9%	15.0%
Family friend	5.9%	30.0%	17.6%	40.0%	5.9%	20.0%
Religious Organisation	0.0%	0.0%	5.9%	25.0%	0.0%	0.0%
Non-religious Charity	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%
Government Agency	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%

5.8.8. Use of Natural Resources

Subsistence

Generally, natural resource use for subsistence was moderate. The most important resources used for subsistence were ocean resources. Respondents indicated that the sea (32.4%), coral reefs (35.1%) and mangroves (21.6%) were very important. Agricultural land (35.1%) and the bush/forest (29.7%) were also identified as being very important by respondents.

Livelihood

In terms of livelihoods, the sea was indicated as being the most important with 40.5% of respondents identifying the sea as being very important for livelihoods. 35.1% of the sample indicated that the coral reefs and agricultural land were very important for livelihoods.

Recreation

Generally, little importance was given for the importance of natural resources for recreation. The most important resource for recreation is the sea, with 56.8% of the sample indicating that the sea was very important for recreation.

Table 5.8.30: 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	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	37	100.0%	37	100.0%	37	100.0%
Sea	Very Important	12	32.4%	15	40.5%	21	56.8%
	Somewhat important	1	2.7%	1	2.7%	2	5.4%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	24	64.9%	21	56.8%	14	37.8%
Coral Reefs	Very Important	13	35.1%	13	35.1%	13	37.1%
	Somewhat important	0	0.0%	0	0.0%	1	2.9%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	24	64.9%	24	64.9%	21	60.0%
Mangrove	Very Important	8	21.6%	8	21.6%	7	18.9%
	Somewhat important	3	8.1%	3	8.1%	4	10.8%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	26	70.3%	26	70.3%	26	70.3%
Agricultural Land	Very Important	13	35.1%	13	35.1%	12	32.4%
	Somewhat important	0	0.0%	0	0.0%	1	2.7%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	24	64.9%	24	64.9%	24	64.9%
Bush and Forest	Very Important	11	29.7%	9	24.3%	9	24.3%
	Somewhat important	5	13.5%	3	8.1%	3	8.1%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	21	56.8%	25	67.6%	25	67.6%
Mountain	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	37	100.0%	37	100.0%	37	100.0%
Caves	Very Important	4	10.8%	1	2.7%	4	10.8%
	Somewhat important	7	18.9%	3	8.1%	7	18.9%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	26	70.3%	33	89.2%	26	70.3%
Wild Animals	Very Important	0	0.0%	0	0.0%	0	0.0%
	Somewhat important	0	0.0%	0	0.0%	0	0.0%
	Not at all important	0	0.0%	0	0.0%	0	0.0%
	None / Do Not Use	37	100.0%	37	100.0%	37	100.0%

When further disaggregated on the basis of sex, there was little disparity in the use of natural assets, where a slightly larger proportion of male respondents being more dependent on natural resources than female respondents.

Table 5.8.31: Use and Importance of Natural Resources, by Sex of Respondent (%)

RESOURCE	Importance	Subsistence		Livelihood		Recreation	
		Male	Female	Male	Female	Male	Female
River / Stream	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Sea	Very Important	23.5%	40.0%	35.3%	45.0%	41.2%	70.0%
	Somewhat important	5.9%	0.0%	5.9%	0.0%	5.9%	5.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	70.6%	60.0%	58.8%	55.0%	52.9%	25.0%
Coral Reefs	Very Important	29.4%	40.0%	29.4%	40.0%	40.0%	35.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	70.6%	60.0%	70.6%	60.0%	60.0%	60.0%
Mangrove	Very Important	17.6%	25.0%	17.6%	25.0%	17.6%	20.0%
	Somewhat important	11.8%	5.0%	11.8%	5.0%	11.8%	10.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	70.6%	70.0%	70.6%	70.0%	70.6%	70.0%
Agricultural Land	Very Important	29.4%	40.0%	29.4%	40.0%	29.4%	35.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	70.6%	60.0%	70.6%	60.0%	70.6%	60.0%
Bush and Forest	Very Important	29.4%	30.0%	29.4%	20.0%	29.4%	20.0%
	Somewhat important	5.9%	20.0%	0.0%	15.0%	0.0%	15.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	64.7%	50.0%	70.6%	65.0%	70.6%	65.0%
Mountain	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Caves	Very Important	5.9%	15.0%	5.9%	0.0%	11.8%	10.0%
	Somewhat important	17.6%	20.0%	17.6%	0.0%	17.6%	20.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	76.5%	65.0%	76.5%	100.0%	70.6%	70.0%
Wild Animals	Very Important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Somewhat important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Not at all important	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	None / Do Not Use	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Agriculture

Only six respondents indicated they were involved in the agriculture sectors, and five responded as to their water availability. Five respondents indicated they always had access to reliable water.

Table 5.8.32: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	0	0.0%	5	25.0%	5	15.6%
Sometimes	0	0.0%	0	0.0%	0	0.0%
Never	0	0.0%	0	0.0%	0	0.0%

5.8.9. Knowledge, Exposure and Experience of Climate Related Events

Respondents indicated varying levels of knowledge in relation to all climate related events. For hurricanes, 15.6% indicated they had average knowledge and 81.3% indicated they had very good knowledge. Respondents indicated having the worst knowledge of landslides, with 56.3% indicating they had poor knowledge, likely because landslides are not a threat for this community.

When examined on the basis of ender of respondent, there was a small difference between male and female headed households. Female headed households generally showed slightly higher level of knowledge of climate related events.

Table 5.8.33: Knowledge of Climate Related Events

EVENT	Knowledge	SAMPLE[1]	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	3.1%	0.0%	0.0%	0.0%	0.0%	5.6%	5.0%
	Average	15.6%	18.2%	0.0%	16.7%	0.0%	16.7%	15.0%
	Very Good	81.3%	81.8%	100.0%	83.3%	100.0%	77.8%	80.0%
Flooding	Poor	6.3%	9.1%	0.0%	8.3%	0.0%	5.6%	5.0%
	Average	40.6%	54.5%	100.0%	58.3%	0.0%	33.3%	30.0%
	Very Good	53.1%	36.4%	0.0%	33.3%	100.0%	61.1%	65.0%
Storm Surge	Poor	37.5%	54.5%	0.0%	50.0%	0.0%	33.3%	30.0%
	Average	21.9%	9.1%	100.0%	16.7%	0.0%	27.8%	25.0%
	Very Good	40.6%	36.4%	0.0%	33.3%	100.0%	38.9%	45.0%
Drought	Poor	25.0%	36.4%	0.0%	33.3%	0.0%	22.2%	20.0%
	Average	28.1%	36.4%	100.0%	41.7%	0.0%	22.2%	20.0%
	Very Good	43.8%	27.3%	0.0%	25.0%	100.0%	50.0%	55.0%
Landslides	Poor	56.3%	81.8%	100.0%	83.3%	0.0%	44.4%	40.0%
	Average	28.1%	9.1%	0.0%	8.3%	50.0%	38.9%	40.0%
	Very Good	12.5%	9.1%	0.0%	8.3%	50.0%	11.1%	15.0%

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

Despite knowledge gaps with regards to the technical aspects of the various climate related events, respondents showed various levels of awareness of the appropriate course of action to be taken in the instance such an event occurred:

- In the event of a Hurricane, 96.9% of the sample was aware of what to do, without having to ask for assistance.
- In the instance of Flooding, a slightly less proportion of respondents sampled (87.5%) were aware of appropriate action to take, without asking for assistance
- In the instance of a Storm Surge, 68.8% of respondents sampled were aware of the appropriate action to take, without asking for assistance

- In the instance of a Drought, 65.6% of respondents sampled were aware of appropriate action to take, without asking for assistance
- In the event of a Landslide 40.6% of respondents were aware of what should be done.

Table 5.8.34: Knowledge of Appropriate Response to Climate Related Events

EVENT	Knowledge	SAMPLE[1]	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	96.9%	100.0%	100.0%	100.0%	100.0%	94.4%	95.0%
	No	3.1%	0.0%	0.0%	0.0%	0.0%	5.6%	5.0%
	Don't Know	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flooding	Yes	87.5%	81.8%	0.0%	75.0%	100.0%	94.4%	95.0%
	No	9.4%	18.2%	0.0%	16.7%	0.0%	5.6%	5.0%
	Don't Know	3.1%	0.0%	100.0%	8.3%	0.0%	0.0%	0.0%
Storm Surge	Yes	68.8%	54.5%	100.0%	58.3%	100.0%	72.2%	75.0%
	No	25.0%	45.5%	0.0%	41.7%	0.0%	16.7%	15.0%
	Don't Know	6.3%	0.0%	0.0%	0.0%	0.0%	11.1%	10.0%
Drought	Yes	65.6%	54.5%	0.0%	50.0%	100.0%	72.2%	75.0%
	No	25.0%	45.5%	0.0%	41.7%	0.0%	16.7%	15.0%
	Don't Know	31.3%	0.0%	100.0%	8.3%	0.0%	50.0%	45.0%
Landslides	Yes	40.6%	36.4%	100.0%	41.7%	100.0%	33.3%	40.0%
	No	34.4%	45.5%	0.0%	41.7%	0.0%	33.3%	30.0%
	Don't Know	18.8%	9.1%	0.0%	8.3%	0.0%	27.8%	25.0%

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

When questioned around the perceived risk of climate related events to their households, respondents most often indicated a High Risk of Hurricanes (62.5%). 59.4% thought there was a high risk of flooding and 37.5% felt there was a high risk of storm surge. 15.6% thought there was a high risk of drought, and 3.1% thought they were at high risk of landslides.

Table 5.8.35: Perceived Level of Risk of Climate Related Events: Household

EVENT	Risk Level	SAMPLE[1]	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	9.4%	27.3%	0.0%	25.0%	0.0%	0.0%	0.0%
	Low Risk	28.1%	27.3%	0.0%	25.0%	0.0%	33.3%	30.0%
	High Risk	62.5%	45.5%	100.0%	50.0%	100.0%	66.7%	70.0%
Flooding	No Risk	3.1%	9.1%	0.0%	8.3%	0.0%	0.0%	0.0%
	Low Risk	34.4%	36.4%	0.0%	33.3%	50.0%	33.3%	35.0%
	High Risk	59.4%	54.5%	100.0%	58.3%	50.0%	61.1%	60.0%
Storm Surge	No Risk	25.0%	36.4%	0.0%	33.3%	0.0%	22.2%	20.0%
	Low Risk	34.4%	45.5%	100.0%	50.0%	0.0%	27.8%	25.0%
	High Risk	37.5%	18.2%	0.0%	16.7%	100.0%	44.4%	50.0%
Drought	No Risk	46.9%	54.5%	0.0%	50.0%	0.0%	50.0%	45.0%
	Low Risk	34.4%	45.5%	100.0%	50.0%	50.0%	22.2%	25.0%
	High Risk	15.6%	0.0%	0.0%	0.0%	50.0%	22.2%	25.0%
Landslides	No Risk	62.5%	45.5%	0.0%	41.7%	50.0%	77.8%	75.0%
	Low Risk	28.1%	36.4%	100.0%	41.7%	50.0%	16.7%	20.0%
	High Risk	3.1%	9.1%	0.0%	8.3%	0.0%	0.0%	0.0%

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

Similar to patterns observed in relation to perceived risk to respondents' community. Of interest respondents reported higher levels of risk to climate related event for the community than they did for their own households with regards to all hazards.

Table 5.8.36: Perceived Level of Risk of Climate Related Events: Community

EVENT	Risk Level	Sample	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	3.1%	9.1%	0.0%	8.3%	0.0%	0.0%	0.0%
	Low Risk	6.3%	9.1%	0.0%	8.3%	0.0%	5.6%	5.0%
	High Risk	90.6%	81.8%	100.0%	83.3%	100.0%	94.4%	95.0%
Flooding	No Risk	3.1%	9.1%	0.0%	8.3%	0.0%	0.0%	0.0%
	Low Risk	12.5%	18.2%	0.0%	16.7%	50.0%	5.6%	10.0%
	High Risk	81.3%	63.6%	100.0%	66.7%	50.0%	94.4%	90.0%
Storm Surge	No Risk	18.8%	27.3%	0.0%	25.0%	0.0%	16.7%	15.0%
	Low Risk	18.8%	27.3%	100.0%	33.3%	0.0%	11.1%	10.0%
	High Risk	40.6%	0.0%	0.0%	0.0%	100.0%	61.1%	65.0%
Drought	No Risk	31.3%	54.5%	0.0%	50.0%	0.0%	22.2%	20.0%
	Low Risk	40.6%	45.5%	100.0%	50.0%	50.0%	33.3%	35.0%
	High Risk	25.0%	0.0%	0.0%	0.0%	50.0%	38.9%	40.0%
Landslides	No Risk	40.6%	54.5%	0.0%	50.0%	0.0%	38.9%	35.0%
	Low Risk	34.4%	27.3%	100.0%	33.3%	0.0%	38.9%	35.0%
	High Risk	25.0%	18.2%	0.0%	16.7%	100.0%	22.2%	30.0%
1: Where respondents did not indicate an option, the total percentage of respondents sum up to less than 100%								

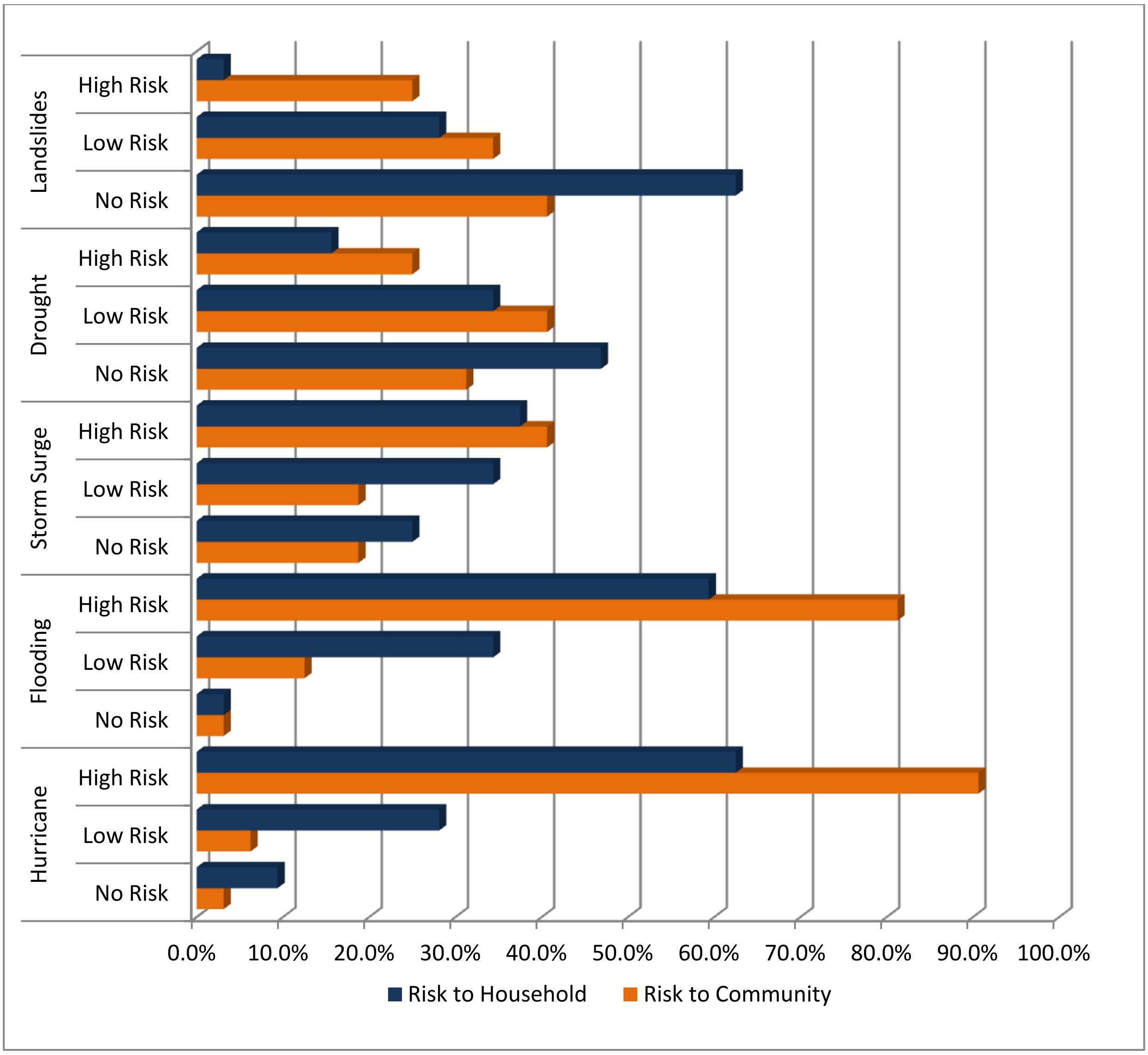


Figure 5.8.5: Perception of Risk for Climate Related Events

Similar to perceptions of risk of climate related events, respondents consistently reported higher levels of support received within the community than in their respective households, during climate related events. The greatest disparity was observed in structure improvements received, and availability of relief supplies.

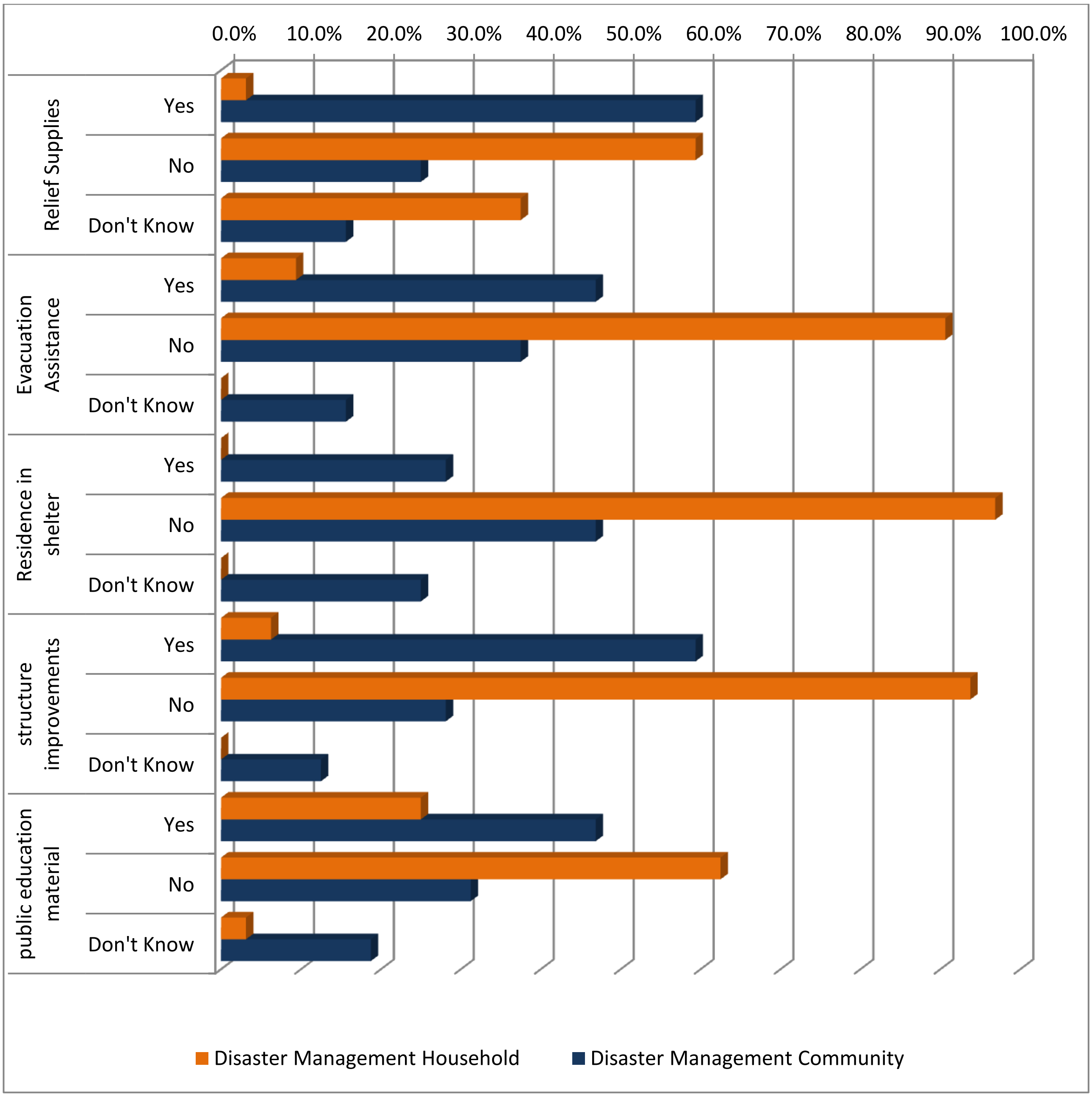


Figure 5.8.6: Support during Climate Related Events

5.8.10. Adaptation and Mitigation Strategies

Very few residents reported having adopted any of the adaptation and mitigation strategies below to reduce the current and future impacts of weather and climate on their well-being, their households and their livelihoods. However, community members are generally confident that their homes are safe in a hurricane. The options selected by residents included selling assets to raise money, seeking external assistance and borrowing money, reducing expenses, and reducing the household size to reduce the level of burden. Other means of adaptation not listed also seem to be in practice by residents. Overall, 10% or less of the sample indicated engaging in any given adaptation strategy, which is a significant finding in relation to the level of preparedness and relative resilience of community members to climate change impacts.

Table 5.8.37: Adaptation and Mitigation Strategies

STRATEGY	Event	Sample	Male Headed			Female Headed		
			Male	Female	Total	Male	Female	Total
SELLING ASSETS	Hurricane	1	0	0	0	0	1	1
	Flooding	0	0	0	0	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
BORROWING MONEY	Hurricane	1	0	0	0	0	1	1
	Flooding	0	0	0	0	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
SEEKING ASSISTANCE	Hurricane	2	1	0	1	0	0	1
	Flooding	1	1	0	1	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
REDUCING EXPENSES	Hurricane	2	0	0	0	0	2	2
	Flooding	0	0	0	0	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
STARTING A NEW LIVELIHOOD ACTIVITY	Hurricane	0	0	0	0	0	0	0
	Flooding	0	0	0	0	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
DECREASING HOUSEHOLD SIZE	Hurricane	2	0	0	0	0	2	2
	Flooding	0	0	0	0	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0
OTHER ACTIVITY	Hurricane	3	1	0	1	0	2	2
	Flooding	1	1	0	1	0	0	0
	Storm	0	0	0	0	0	0	0
	Drought	0	0	0	0	0	0	0
	Landslide	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	0

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:

- **Develop an in-depth water quality monitoring programme, particularly for groundwater.** Groundwater quality is a major concern in Anguilla and has previously led to the closure of wells on the island due to pollution concerns. Sources of contamination of the groundwater include dumped batteries, waste oil from the power station and gas stations, waste from package plants, pesticides and septic tanks (Mitchell, 2007; Richardson, 2009). The overall rapid development and increase in population of Anguilla in the last 20 years has also contributed (Richardson, 2009). A programme of groundwater quality monitoring for pollutants and salinity is needed, particularly in view of vulnerability to sea level rise and salination. The Water Corporation in collaboration with private sector desalination plants, the Water Laboratory and the Environmental Health Unit, should ensure that there is adequate groundwater quality monitoring.
- **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 already highlighted in the National Energy Policy, since the cost of fuel and therefore electricity is unlikely to decrease, regardless of the climate outcome. It is likely that ANGLEC already have the capacity to undertake these assessments and could develop a consultant arm of the business to provide and auditing service.
- **Epidemiology data with climate signals:** Further research is needed to link the epidemiology of diseases in Anguilla with climate data. More detailed information, especially presenting temporal, environmental and climatological data, is needed. The Draft Green Paper notes the need to "Collect health and climate data which would enable the establishment of correlations, which will act as indicators for appropriate intervention options" (DOE, 2009). This data collection effort would need to be lead by the Ministry of Health in close collaboration with the Antigua and Barbuda meteorological service and/or CIMH (in the absence of a national meteorological office).
- **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. The Strategic Plan for the Statistical System of Anguilla 2005-9 stated that "While the availability of health statistics is sparse, the little that is available is in much demand. This is partly due to the amount of research that is being done in social and health programming" (Hope-Ross, 2004). This approach will allow for validation of hypotheses and for developing a "culture" for systematic review and the conversion of knowledge into policy and planning.
- **Inventory 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. The Department of Physical Planning is responsible for coastal zone management and should therefore initiate this assessment. If necessary, consultants with the appropriate skills should be hired to undertake the evaluation.
- **Improve national level data availability and collect, manage and update databases within a national agency.** There is no meteorological service available in Anguilla 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. In emergency decision

making, the availability of timely and good data is imperative to successful response. In addition, the inclusion of a long term record for meteorological data allows decision making to be based on the conditions and trends specific to Anguilla. Furthermore, Anguilla needs to improve the digital mapping data to include more than elevation, soils, buildings and roads (Trotz *et al*., 2004). Disaster management decision making would be enhanced by having more detailed land use, water course, geology and utility data in a digital GIS system available to DDM as well as other ministries. Together this data would enhance disaster risk reduction actions and climate change adaptation considerations to prevent maladaptation actions which could generate further risks. Such a large data collection initiative will require collaboration from many agencies, but might be best placed with the Department of Lands and Surveys. Input will be needed from ANGLEC, Department of Physical Planning, Water Corporation, Department of the Environment, the Department for Disaster Management and the Anguilla National Trust.

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:** Anguilla already has a building code that has been successful in addressing structural integrity under storm conditions. It should however be reviewed with regard to other areas that increase resilience under a changing climate, i.e. energy efficiency and emission reduction, mandatory water collection infrastructure and sea level rise considerations. The need for a National Energy Code has also been identified in the National Energy Policy.
- **Agricultural policy:** Policymakers for agriculture in Anguilla should be prepared to take a more proactive role in the development of climate change legislation for mitigation actions, and implementation of adaptation projects that address the impacts of climate change.
- **Integrate SLR into the design of all coastal structures:** Environmental Assessments and construction permits for coastal structures should be required to take into account the most recent estimates of SLR from the scientific community. The Department of Physical Planning needs to assess all projects that involve building, maintaining, or modifying infrastructure in coastal areas at risk of SLR to ensure that the new developments take into account SLR. The cost of reconstruction after flood damage is often higher than modifying structures in the design phase.
- **Integrate SLR into Government insurance policies:** Insurance policies that account for the long-term risks of SLR will enable landowners to properly assess coastal protection and retreat options. The Government of Anguilla 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 Anguilla.
- **Incorporate SLR and climate change into local and regional 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 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 with relevant tourism stakeholders to

implement the recently drafted sustainable tourism plan 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. Tourism development is also competing with natural ecosystems like mangroves, placing the existing infrastructure at even greater risk. Anguilla's image as a high-end tourism destination draws a distinct tourist and so the preservation of the quality product will be paramount to the long-term success of the industry in this small island economy. Because Anguilla has such a large dependence on tourism, any damages or wide-spread losses to the industry will have major impacts on the island's residents. As recommended in the draft climate change policy, the need for business continuity planning in the tourism sector is needed. Disaster risk reduction measures at tourism plants is an advantageous strategy as it encourages owners to protect their investment over the medium and long term which will result in continued livelihood opportunities for Anguillians.

- **Review and ensure that climate change is adequately addressed in the Tourism Sector Disaster Plan**: While a Tourism Sector Disaster Plan exists, it is important to keep reviewing it and maintaining the training of those in the tourism industry. Climate change must be a significant consideration as well. Because funding shortages in the DDM prevent much work beyond their current efforts, it is recommended that they explore private sector partnerships where a tourism sector agency can take a leadership role in the development of disaster risk reduction and climate change adaptation activities for the sector. The DDM can then act as a consultant, providing them with relevant data on 'specially vulnerable areas' and the provision of other hazard data.

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 Anguilla in the past, but the recommendations are frequently not implemented for a number of reasons, lack of resources being commonly cited. By establishing a framework by which government, private sector entities and civil society can work more effectively together, the probability of implementation and widespread 'buy-in' to the numerous initiatives increases. It is not possible for any one group to achieve the changes that are needed alone and government must ensure that national policy goals and challenges faced are transparent and publicly available so that solutions can be discussed and negotiated between groups. Gaining support for initiatives is also facilitated through education and awareness, Section 6.1.4.

The data and information produced through the various initiatives described in Section 6.1.1 must be communicated and made available through networks in each sector and across sectors. This is especially true for the idea of a green economy that will require the restructuring of economic systems towards establishing a low-carbon society. It is thus important to document and communicate progress to create positive opinion in large parts of society.

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

- **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 and input from the community assessments highlighted specific areas that need additional efforts in education and awareness:

- Disaster risk reduction and emergency preparedness at the household level.
- 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. The Anguilla Renewable Energy Office has been undertaking an extensive education and marketing campaign that should be both commended and continued.
- Some diseases such as malaria and diarrhoea are entirely preventable therefore both locals and tourists should be provided with continued health education as a crucial element in sustainable disease prevention.
- The level of awareness of SLR impacts and costs needs to be raised for all levels of the Anguillian Government and administration to inform decision makers within the tourism sector including operators, investors, planners, developers, policy makers, architects and communities.
- Promotion of using sustainable fish and seafood species.

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 and films can be effective tools in influencing human behaviour. In addition, building awareness of the issues mentioned above can be better embraced when the message is conveyed by a respected figure.

6.2. *Water Quality and Availability*

In their 2009 Draft Green Paper, developed to help formulate a climate change strategy for Anguilla, the Department of the Environment made a number of recommendations in relation to water resources (DOE, 2009). These should be implemented as part of a broad Integrated Water Resources Management (IWRM) Plan, which was also recommended in the Green Paper. Given the number of vulnerabilities and issues described in Sections 4.1 and 5.1, IWRM is a no-regret option because it will address current problems regardless of the outcome of climate change, but at the same time increase resilience to future changes.

Short term

Consider the development of mechanisms to facilitate Integrated Water Resources Management (IWRM). The Water Corporation of Anguilla has the responsibility for managing the water supply and must work with all relevant departments to facilitate the development of and IWRM mechanism. 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. Specific issues that need addressing in Anguilla and that have not already been identified in the Draft Green Paper include:

- **Develop and increase the efficiency of agricultural irrigation.** In light of the high importation and expenditure on food crops imported to Anguilla, it is recommended that some inclusion be made in this area. The need for protection of water for agriculture was identified as a priority in the Climate Change Policy. This would need to be led by the Department of Agriculture in collaboration with the Water Corporation.
- **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 on Anguilla, these models should be developed urgently in order to effectively mitigate the effects of climate change on freshwater resources and aid decision-making. It is possible that this type of work will require capacity that is not currently available in the Water Corporation and may therefore need to be undertaken through the relevant regional research institute or by a private consultant.
- **Develop measures to protect aquifers from surface contamination and protect water quality, through increased land owner responsibility.** The Department of Environment recognises several issues which affect water quality, including sand mining, hill capping or slope reduction, pond filling, soil relocation, water table penetration and pollution, and land clearing (DOE, 2009). While Anguilla's limited land area with rapidly increasing population is a great challenge to environmental protection, positive measures can be taken to increase community responsibility for water resources, particularly through consultation and education. Focus should also be given to the implementation of robust waste management schemes to avoid contamination of groundwater. Areas of particular importance for groundwater recharge should be identified and given special protection. The Department of the Environment, Water Corporation and Environmental Health Department should therefore collaborate with the Department of Physical Planning in developing the land-use plans highlighted in Section 6.1.2. A specific recommendation for wastewater treatment is included in Section 6.6.

6.3. *Energy Supply and Distribution*

Short term

Define national action plans: Anguilla has prepared a National Energy Policy that has already identified the areas that must be addressed in pursuing energy independence "greening" the island. A detailed action plan is now needed to ensure that the commendable policies are actually implemented. This should be spearheaded by the Anguilla Renewable Energy Office in association with ANGLEC and Windwatt LLC. As part of the action planning, an assessment of the sustainability of Anguilla's energy systems should be prioritised, especially in the case of future renewable energy sources that depend on climate and priority coastal infrastructure such as power plants. These assessments should include outputs from climate change modelling scenarios and involve energy sector authorities and national and regional specialists with support from international organisations where necessary. Establishing greater energy security and increasing energy efficiency will alleviate some of the financial pressures already being experienced, making this a no-regret initiative.

6.4. *Agriculture and Food Security*

Medium term

Develop a programme to increase production of staple crops: Promoting the production of staple foods such as cassava, sweet and Irish potatoes and yams using cultivars that meet the challenges of the changing climate will increase national food security and decrease imports for domestic consumption. The Anguilla Department of Agriculture can work with the established farmers' associations to:

a) revive lands that are currently fallow and put them back into cultivation using new agro-technology as a follow on to the soil amelioration project

b) develop a local 'eat what you grow project' featuring staple foods and other produce

c) introduce grow box projects into primary and secondary schools' programmes as part of extra-curricular activities or within integrated science courses.

Specifically, the Department of Agriculture must be prepared to organise farmers in the communities where they are scattered; coordinate planting and harvesting of produce for the land that is brought back into production; provide guidelines on standards and use of appropriate technology; and provide a centralised location for trade between farmers and local consumers. The expected results are improved capacity of local farmers to grow climate resilient crops, increased participation of youth in agriculture, and more support and use of locally produced food. It is a no-regret option since it will improve access to healthy, local produce and reduce the currently high food import bill. This initiative will also assist with certain health issues in Anguilla, in particular the high occurrence of lifestyle diseases.

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. This type of research would be best carried out by tertiary research institutions in the region, utilising data collected in the health and tourism sectors. Additional data would be available from national tropical disease centres in source market countries. The collection of such data would be labour intensive, but would be a valuable contribution to health research and understanding the wider, indirect impacts of climate change. Potential collaboration with CEHI, CCCCC, CAREC and PAHO should also be explored.

Build a supply of public health resources for the surveillance, prevention and control of vector borne diseases: The Environmental Health Unit of the Department of Health Protection is responsible for vector surveillance and control. Gubler (2002) has stated that the resurgence of diseases, and particularly vector borne diseases, has been "compounded by complacency about infectious diseases in general and vector-borne diseases in particular, and a lack of public health resources for research, surveillance, prevention, and control programs." Rawlins *et al*., (2008) have also made the salient point that it is "important for us to record in detail the Malaria situation in the Caribbean region, so that health decision makers may be aware of how acute the situation really is, and how much emphasis should be rightly placed at preventing the re-occurrence of the disease in the region". It is therefore recommended that the Integrated Vector Management (IVM) Programme approach of the WHO be adopted. Diseases that have a climate change signal in Anguilla 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).

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. The Department of Fisheries and Marine Resources is currently responsible for the existing parks. 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. Anguilla therefore needs clear and enforced legislation to protect mangroves from being cleared for development, see Section 6.1.2 and the development of a land-use plan. The existing setback guidelines are one way of ensuring mangrove protection, but at present developers often succeed in overturning decisions.

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, the Department of Fisheries and Marine Resources and the Anguilla National Trust might be best placed to lead this initiative with substantial support from communities and NGOs. It must also be supported by a strong land-use plan that allocates and protects areas of mangrove from future development.

Medium term

Construct/restore Wastewater Wetland Treatment Systems (WWTS): This option for wastewater treatment would be a viable solution for addressing issues of water quality and limited resources for irrigation mentioned in Section 6.2. A study on hotel sewage package treatment plants in Saint Lucia found that the highest quality effluent was at a wetland treatment system for a medium-sized hotel (UNEP, 1998). Wetlands naturally act as bio-filters to remove contaminants from wastewater. Sewage is first pre-treated with screening and settling, the wastewater then flows into a three-tiered, free-water-surface wetland system dug into a hill. The wetland effluent passes through a filter and then is disinfected with an ultraviolet lamp. WWTS are a low maintenance, low energy and cost effective alternative to conventional treatment options. They also add aesthetic and habitat values. Priority sites for constructed/restored wetlands should include hotels and tourist related operations, especially those near fish sanctuaries and other important ecosystems. This strategy provides an opportunity to strengthen collaboration between the tourism, planning, water and environment departments. Hotels that utilise the WWTS may also benefit from gaining preferred status as eco-friendly establishments. This type of system would essentially be a private sector initiative, but will need support from the various regulatory ministries such as the Department of Health Protection, Physical Planning Department and the Department of the 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 Anguilla'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 to information. The Department of Fisheries and Marine Resources could initiate this recommendation and look for sponsorship from the private sector, perhaps with assistance from the Anguilla National Trust or other suitable NGO. The guide could 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 Anguilla through the Department of Physical Planning, local resort owners and local building authorities are encouraged to collaborate with members of the research community to help develop a cost benefit analysis of coastal protection. This no-regret option will assist decision-makers with existing problems regardless of the future outcomes of climate change.

In addition to refining estimates of costs to rebuild infrastructure (particularly in areas with high-density coastal development), there is an important need to investigate the response of international tourists and the private sector to the impacts of coastal erosion to test adaptation strategies in the tourism sector. By completing a cost-benefit analysis, decision makers will be able to identify the best adaptation options to adopt and can begin to move forward in reducing the vulnerability of settlements and infrastructures in vulnerable areas.

Commence coastal protection adaptation planning early: The Government of Anguilla (Department of Physical Planning) needs to work with local stakeholders, including the tourism sector, 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 Anguilla should be a priority for future research. This will enable the identification of the degree to which Anguilla 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 could be instigated by the Ministry of Finance or the Ministry of Social 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 in close collaboration with the Department of Physical Planning. Substantial consultation should be undertaken with the private tourism sector to ensure that there is buy-in to any future plans for retreat.

Review and develop policies and legal framework to support coordinated retreat from high-risk coastal areas. The land use plans highlighted in 6.1.2 must support coordinated retreat from high-risk coastal areas. The Government of Anguilla 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, but more importantly they need to be enforced.

6.8. *Comprehensive Natural Disaster Management*

Following the national review of progress on the HFA goals the DDM has already identified many strengths and weaknesses for disaster management in Anguilla. Additional recommendations coming out of this research are given here.

Short term

Update building regulations and hire building inspectors, in permanent positions, with responsibility for reviewing all construction on the island. In addition to the building code review outlined in Section 6.1.2, the DDM, along with the Physical Planning Department, must collaborate to conduct a needs assessment with the objective of identifying financial resources and personnel requirements that would improve enforcement of the existing building code. The needs assessment would also address the physical and technical requirements for hiring more building inspectors. A regional standard on building materials and practices would help to reduce losses to individual families and also alleviate some of the pressure on shelters because more people would be able to stay in their own homes during emergencies. Anguilla should therefore continue to assist with the development of a regional code, however, since national regulations or building codes do exist, the challenge remains enforcement. This is a no-regret option given the problems that have been highlighted in various sections of this study. There are a number of vulnerabilities to current climate conditions that are sustained through poor construction and planning.

Medium term

Conduct capacity building and technical training programs for DDM employees so that recent technical programmes in hazard assessment and community vulnerability reduction can be sustained. To achieve CDEMA's goals under the Comprehensive Disaster Management Strategy and Plan, the prioritisation of technical training within the Participating States' disaster offices is required. 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 in GIS, hazard mapping and storm monitoring at the local and national level. In this way, the DDM can manage risks better and also have a better understanding of vulnerability in the communities across Anguilla. Related capacity building is likely needed in meteorological data collection and monitoring within the national weather service, given that data is currently coming from the neighbouring Antigua and Barbuda meteorological station.

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

Installation of safe moorings: A particularly strong mooring is needed for the resident Police emergency vessel which is currently harboured in St. Martin during storms and is therefore not available to the community at critical times. This department should also own a dinghy (which they do not currently have) that would allow for easier and faster response times in some cases. Regular fishing vessels also require moorings to be used at night and during storms.

Establish a Community Buddy system: Sandy Ground already has an informal means of checking on persons – usually family members and friends. However, since there are many older persons in the community, it will be critical to know where these persons reside and under what circumstances (if they live alone, have care-givers, are on essential medication, are incapacitated, etc.). These persons should be checked on prior to and after severe weather events by a designated community member who is responsible for a particular geographic area. Similarly, a "Phone Tree" should be established so that a group of persons is responsible for calling or checking on someone else before and after a disaster such as a hurricane. A response time should be pre-determined to suggest whether someone may be in trouble or not. This type of system can be established easily by the community themselves, perhaps with assistance from the DDM, and is a no-regret option since it aids with response to current climate extremes.

Promote education and awareness of climate change and associated hazards within the community. Despite the knowledge of climate change that exists within the community, residents themselves see a need for more awareness building activities as outlined in Section 6.1.4. Particular focus is needed for schools and the youth to empower them to communicate climate change. Similarly community residents would be empowered to increase their own resilience to climate change. In communities, an attitude seems to exist of "Each One Teach One" which would contribute to the sustainability of messages and capacities to respond to climate change.

Medium term

Monitoring system for water levels in the Salt Pond: This should include an Early Warning System and Zoning Plan to alert the community of possible breaches and areas of inundation. As the pond water rises, warnings of increasing scale/rank would be issued so that the community is aware of any precautions that need to be taken. A threshold would also need to be identified for when the pond should be artificially and safely drained. One community-based agency should be responsible for recording data and issuing the warnings. The agency should be assisted by the DDM and possibly the Department of Lands and Surveys for technical assistance on monitoring systems.

Retrofit a suitable existing structure to serve as a hurricane shelter: There are currently no hurricane shelters in the Sandy Ground area. Whilst residents have a culture of not abandoning their homes – reportedly because they do not wish to leave their possessions - in anticipation of stronger storms associated with climate change, a hurricane shelter would be of benefit to the community. However, the identified building should have other uses throughout the year. One possible building is the Old Anguilla Rum Distillery which could also serve as a community centre, meeting/conference facility and storage area. There is also a very large yard next to it where boats can be held during hurricane and storm events. This initiative should be instigated through the DDM perhaps in collaboration with the Ministry of Social Development. Having a safe storage location for vessels would also help address the issue of safe moorings during storms, but probably only for smaller vessels.

Establish a community disaster mitigation programme: Given the demographic profile of Sandy Ground, it is important to identify opportunities for, and encourage younger persons to engage in, community level disaster mitigation activities. Such a programme can be implemented through collaboration between the DDM and the community by establishing a community-based and –run disaster management group or council. Efforts should also be made to include a multi-hazard warning system within the community. One such system has already been described above for breaches of the Salt Pond. In fact many of the other recommendations put forward by the community could become components of this community programme. As with other recommendations, this is a no-regret option because it addresses current needs and vulnerabilities regardless of the potential future impacts of climate change.

Build capacity to strengthen the resilience of livelihoods in coastal communities to climate change: This should be done by using the proven approach of Action Research, whereby selected individuals gain practical knowledge through first-hand experience and personal exchanges. This type of initiative is best implemented regionally. Specific activities include:

- *Establishment of Action Learning groups* from selected communities;
- *Sharing lessons and providing opportunities* to learn how linkages between micro-, small and medium-sized enterprises (MSMEs) provide effective adaptation to climate change, can expand markets and promote business sustainability, through:
    - workshops

- knowledge networks
- *Analysing and addressing constraints to adaptation;*
- *Training for alternative livelihoods and value-added products.*

Long term

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

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

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

- *Improve institutional capacity in key agencies to implement gender sensitive policy or gather gendered data.* This is needed due to the lack of gender experts involved in policy design and implementation around climate change; the lack of awareness or gender training of key staff in ministries and statistics offices responsible for climate change data and policies; and a general disconnect between the reality of poor people's (and particularly under-represented women's) lives and policy makers.

7. CONCLUSION

7.1. *Climate Modelling*

Recent and future changes in climate in Anguilla 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*

Anguilla does not possess any lakes or rivers due to its porous limestone base; freshwater present on the island exists subterranean, below which is located denser layers of salt water (Mukhida and Gumbs, 2006). Rainfall in Anguilla is generally low and average annual rainfall varies depending on the number and intensity of storms affecting the island in a given year (DOE, 2009). Hurricanes and tropical storms hit Anguilla frequently – there were seven hurricanes between 1995 and 2008 (DOE, 2009).

Anguilla has utilised a mixture of groundwater and desalination water to supply its water needs over the years as the territory's demand is greater than its supply. Water produced through desalination does not meet the water demand from all consumers on the island and is increasingly being supplemented by groundwater supplies. The territory's groundwater well systems, which once was the main supply of water throughout the island, was closed down and abandoned due to contamination issues in the past (PAHO, 2007A). However, focus has again returned to the use of well water. There are also a number of desalination plants run by the private sector, specifically geared towards tourism (PAHO, 2007A). Water is also sourced in other ways through the use of cisterns. Rainwater harvesting is utilised where rainwater is channelled to and stored in cisterns (Hope-Ross, 2004). Water may also be purchased from water trucks and stored in cisterns. There is no central sewerage system on the island; septic tank soakaways are the main method used to treat sewage (PAHO, 2007a). Access of rural population to safe drinking water and excreta discharge was 97% between 1996 – 1998 (Halcrow Consultants Limited, 2002) while the 2001 country census found that 93% of the population used flush toilets, while 3.8% of households used pit latrines (PAHO, 2007a).

The estimated unaccounted for water in Anguilla was, 30% in 2005 (MFT, 2005) and 70% in 2008 of water purchased. Approximately 50% of the 2008 figure is due to theft of water (The Anguillian, 2008). Other major losses are due to damages in the piping system (MFT, 2005). The Country Poverty Assessment of Anguilla has found that water costs are considered to be high (Halcrow Consutlants Limited, 2002) which may be part of the reason that water is stolen.

Freshwater in Anguilla has been identified as a resource vulnerable to climate change and with the potential to affect economic activities in the territory (Hodge, 2004). Aside from the concern of the high cost of desalination water, there is also the issue of water quality from groundwater sources. Anguilla is prone to drought conditions as it is one of the drier islands of the Caribbean region. The effects of less rainfall represent one of the areas of greatest concern in Anguilla's water sector due to its already limited water resources and the importance of water to the tourism sector. Heat waves and drought conditions in the past have resulted in the need for increased water resources (DOE, 2009). Such events also caused crop harvests to fail and reduced crop yields, which in turn resulted in the need for increased importation. The territory is particularly vulnerable in El Nino years. Drier periods in the future would mean less water available for irrigation (Hodge, 2004) and increased evaporative demands under climate change may lead to reductions in irrigation efficiency (Fischer *et al.*, 2007). Agricultural output in Anguilla is already affected by the high cost of water along with low annual rainfall values combined with unsuitable soils (Halcrow Consutlants Limited, 2002). Numerous areas in Anguilla are low lying and vulnerable to storm surge, storm run-off and sea level rise. During heavy rainfall events freshwater supplies are vulnerable to flooding and contamination from sewerage systems (Hodge, 2004). Rising sea level could affect groundwater resources through salinisation of coastal aquifers in Anguilla (DOE, 2009; Sear *et al*., 2001), and saline intrusion into soils is also cause for concern (DOE, 2009).

There Draft Climate Change Policy for Anguilla mentions water resources with respect to the agriculture, tourism industry and health in its policy objectives. The Draft Green Paper recommended the creation of a

National Climate Change Strategy and Action Plan. It also recommended the establishment of a National Environmental Council which would make the process of environmental management a more cohesive one (DOE, 2009). It is assumed that water resource management initiatives will fall under the purview of such a council.

The following recommendations are made, in addition to those in the Draft Green Paper (DOE, 2009):

1. Develop and increase the efficiency of agricultural irrigation.
2. Develop computer models of groundwater flow to account for the impact of sea-level rise on groundwater levels.
3. Develop an in-depth water quality monitoring programme, particularly for groundwater.
4. Develop measures to protect aquifers from surface contamination and protect water quality, through increased land owner responsibility.

7.3. *Energy Supply and Distribution*

There can be little doubt that tourism is an important and growing energy-consuming sector in the Caribbean. If this growth continues, vulnerabilities associated with higher energy prices as well as global climate policy will grow concomitantly.

Any Caribbean nation's ambition should thus be to reduce its energy use and to increasingly use renewable energy produced in the region. In practice, this appears to be hampered by the lack of detailed databases on energy use by sub-sectors, which is a precondition for restructuring energy systems. To this end, Francis *et al*. (2007: 1,231) suggest that:

> *Finally, given the absence of a more detailed database on energy consumption and GDP in Haiti, Barbados, and Trinidad and Tobago, further research can be directed at two important issues. First, with wider data on energy consumption and GDP (total and sectoral), a decomposition analysis could be undertaken, which can add value by identifying the main drivers, a useful approach to the formulation of effective policies.*

These insights also apply for other islands. While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of 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.

7.4. *Agriculture and Food Security*

The state of agriculture and food security in Anguilla, as they relate to climate change, revolves around two key priorities which are:

- Increasing quantity of commercial crops for domestic use,
- Developing adaptation and mitigation options through application of new agro-technologies.

Farmers in Anguilla have demonstrated the ability to produce food through the use of traditional and modern methods. Considering the large sums of foreign exchange being spent on importing products the Government of Anguilla, through their Department of Agriculture needs to facilitate increased production and marketing of local produce.

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 and leptospirosis. 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 Anguilla. 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, potable and accessible water supply related issues and the spread of acute respiratory infections. It is further evident that these factors can have an impact on other sectors, most notably the tourism. While Anguilla's economy is stronger than many others in the Caribbean, the current economic circumstances are likely to affect employment rates, which is likely to alter the social structure of the country and increase the percentage of vulnerable persons in society. However, the country's Environmental Health programme is well developed and the current low incidence of communicable diseases on the island works in favour of Anguilla's ability to adapt to climate change and climate variability. Nonetheless the impact of climate change on health in Anguilla 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 Anguilla 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*

Anguilla's biodiversity and range of ecosystems may be limited in comparison to that of other islands in the Eastern Caribbean but are nonetheless the basis for much of the economy and livelihoods of its inhabitants. The poor soils and sparse vegetation, low levels of rainfall and its location within the Caribbean Hurricane Belt make Anguilla's natural resources inherently vulnerable to climate related events such as tropical cyclones, SLR, and fluctuations in precipitation and temperature. The rapid expansion of the tourism industry, the boom in construction and an ad hoc approach to planning have also increased the vulnerability of certain coastal areas.

Anguilla's coastal and marine ecosystems such beaches, coral reefs and seagrasses are likely to be adversely affected by SLR, increased intensity of extreme events, increased SST and changes in precipitation patterns. While there may be little that the country can do with regards to mitigating the drivers of climate change, Anguilla can act to reduce those direct local stressors on its environment that compromise ecosystem health and thus increase the vulnerability of species to climate change impacts. 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 harsh climate.

The Anguilla National Trust (ANT), the Department of Fisheries and Marine Resources, the Department of Environment and other agencies that are mandated with environmental protection have demonstrated willingness towards environmental conservation. Authorities have acknowledged, though, that there are short comings in the fragmentation and weak enforcement of some environmental legislation. While consideration is being given to filling gaps and strengthening linkages between sectors it must be borne in mind that climate change is already impacting the Caribbean and its effects are expected to accelerate with time. Immediate action must therefore be taken if Anguilla is to preserve its biodiversity.

Strengthening the adaptive capacity of the country's ecosystems in the face of climate change can only be achieved within the context of collaboration between stakeholders. The recommendations outlined in this document are in keeping with some of the principles laid out in the NEMS document. These recommendations are cross sectoral and seek especially to engage the private sector, a sector that is often overlooked in the framework of natural resource management. The recommended actions will also help to increase public awareness of climate change impacts on Anguilla's biodiversity and empower citizens to fulfil their role 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 Anguilla is vulnerable to climate change and sea level rise. Tourism, an important sector of the economy, is also the key activity taking place in the island's coastal areas. Given the importance of tourism, Anguilla 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 Anguilla 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 Anguilla is to help curb development in vulnerable areas and protect vulnerable tourism assets.

The Government of the Anguilla needs to improve 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 Anguilla 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 Anguilla.

7.8. *Comprehensive Natural Disaster Management*

Anguilla has made significant progress in recent years in the area of disaster management. The revision of the Disaster Management Act in 2008 and the current Tsunami awareness campaign are positive examples of advancements in the disaster management system in Anguilla. The extremely small size of the disaster management team limits their ability to improve all weaknesses at once, but every effort brings Anguilla a step closer to resilience. As the largest economic sector, the participation of the tourism industry in disaster management efforts is important and continued collaboration is encouraged.

The natural hazards facing Anguilla 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 tangible activities that can assist in continuing the efforts of the DDM and also encourage disaster risk reduction in other important sectors in Anguilla, namely tourism. Disaster management is led by the DDM, but can only be successful when it is part of everyday decision making across the spectrum of sectors and communities.

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

It is well documented, that women and men are differently affected by the effects of climate variability and change. Reasons include the different responsibilities men and women assume in relation to care work, income generating work, as well as their different levels of dependency on natural resources, knowledge and capacities to cope with the effects because of differences in the access to education and information systems.

Research findings support this in that, even though gender inequality is not deemed to be an issue within the community, some roles are clearly dominated by either men or women. Women are more vocal and visible on issues of social and community development and protection. Further, male headed households had higher rates of asset ownership than female headed households; but there was little disparity in the use of natural assets, where a slightly larger proportion of male respondents being more dependent on natural resources than female respondents. So gender as a factor in vulnerability suggests that both genders have vulnerability but for different reasons.

Generally, residents in Sandy Ground are able to manage the low to moderate climate impacts. The Road Salt Pond becomes a concern if it is close to cresting during heavy, continuous rainfall, as it will result in some localised flooding. This aside, impacts from tropical storms and hurricanes are of greatest concern, given the coastal and low-lying location of the community. Sandy Ground's location makes it vulnerable to all hurricane-related impacts: wind damage, flooding and water damage, and storm surge impacts. In previous instances, there was extreme loss of property and disruption of livelihoods. However, community residents have adapted over time to withstand hurricanes and major hurricanes, and they remain very confident in the structural integrity of their homes and buildings since they report that the building code has been strictly enforced.

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